Report

Public Environmental Review

Christmas Creek Iron Ore Mine Expansion

Released for Public Review
23 March 2015
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Fortescue
The New Force in Iron Ore

	Public Environmental Review: Christmas Creek Iron Ore Mine Expansion		**CC-RP-EN-0071**
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This document was prepared based on preliminary information supplied by:

STRATEGEN
environmental consultants

INVITATION TO MAKE A SUBMISSION

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal. The environmental impact assessment process is designed to be transparent and accountable, and includes specific points for public involvement, including opportunities for public review of environmental review documents. In releasing this document for public comment, the EPA advises that no decisions have been made to allow this proposal to be implemented.

Fortescue Metals Group proposes to expand operations at the Christmas Creek Mine in the Pilbara region of Western Australia. In accordance with the *Environmental Protection Act 1986*, a Public Environmental Review (PER) has been prepared that describes this proposal and its likely effects on the environment. The PER is available for a public review period of four weeks from 23 March 2015, closing on 20 April 2015.

Comments from government agencies and from the public will help the EPA to prepare an assessment report in which it will make recommendations to government.

Where to get copies of this document

Printed and CD copies of this document may be obtained from Sean McGunnigle (Manager, Environmental Approvals, Fortescue Metals Group) at 87 Adelaide Terrace, East Perth, WA, 6982 and 6218 8888 at a cost of $10. The document/s may also be accessed through the proponent's website at www.fmgl.com.au.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Electronic submissions will be acknowledged electronically. The proponent will be required to provide adequate responses to points raised in submissions. In preparing its assessment report for the Minister for Environment, the EPA will consider the information in submissions, the proponent's responses and other relevant information. Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the *Freedom of Information Act 1992* (FOI Act), and may be quoted in full or in part in each report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the PER document or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific proposals in the PER document:

- clearly state your point of view
- indicate the source of your information or argument if this is applicable
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues raised are clear. A summary of your submission is helpful
- refer each point to the appropriate section, chapter or recommendation in the PER document
- if you discuss different sections of the PER document, keep them distinct and separate, so there is no confusion as to which section you are considering
- attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name
- address
- date
- whether and the reason why you want your submission to be confidential.

The closing date for submissions is: 20 April 2015

The EPA prefers submissions on PER documents to be made at https://consultation.epa.wa.gov.au. Alternatively, submissions can be

- posted to: Chairman, Environmental Protection Authority, Locked Bag 10, EAST PERTH WA 6892 or
- delivered to the Environmental Protection Authority, Level 8, The Atrium, 168 St Georges Terrace, Perth,.

If you have any questions on how to make a submission, please ring the Office of the EPA on 6145 0803.

EXECUTIVE SUMMARY

Fortescue Metals Group Ltd (Fortescue), as the Proponent, proposes to expand iron ore mining and processing operations at the existing Christmas Creek Mine (Christmas Creek) in the Pilbara region of Western Australia (the Proposal).

This document is a Public Environmental Review (PER) for the Proposal and has been prepared in accordance with Part IV of the *Environmental Protection Act 1986* (EP Act). This document also satisfies the requirements for assessment under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in accordance with the *Agreement between the Commonwealth of Australia and the State of Western Australia Relating to Environmental Impact Assessment*.

Proposal Overview

The Proposal involves increasing the rate of ore production to allow peaks of up to 85 million tonnes per annum (Mtpa). Mine life has been modelled for 14 years to 2028, and the mine footprint will expand from 10,135 hectares (ha) to approximately 17,956 ha within a 33,000 ha Development Envelope.

The Proposal also involves:

- abstraction and injection of up to 110 gigalitres per annum (GL/a) of groundwater (an increase of up to 60 GL/a)
- construction and operation of additional tailings storage facilities and waste rock storage facilities
- construction and operation of additional conveyors and haul roads for ore transport
- construction and operation of additional surface water management infrastructure.

Key Characteristics

A summary of the Proposal is provided in Table ES1, with key physical and operational characteristics of the Proposal summarised in Table ES2 and Table ES3.

Table ES1: Proposal Summary

Proposal Title	Christmas Creek Iron Ore Mine Expansion
Proponent Name	Fortescue Metals Group Limited
Short Description	The proposal is for the expansion of the Christmas Creek Mine and includes modification/expansion or development of additional: • mine pits • ore stockpiles • remote crushing hubs and conveyors • mobile crushing and screening • ore processing facilities and train loading facilities • waste rock storage facilities • tailings storage facilities • growth medium storage areas • power station and power distribution infrastructure • roads and borrow pits • surface water management infrastructure • water bores, injection borefields, reticulation, transfer, storage and settlement ponds, evaporation basins and pipeline infrastructure • desalination facilities • accommodation facilities and wastewater treatment plants • bulk and satellite fuel storage • laboratory, warehouses, laydown area, workshops, washdown facilities, maintenance facilities • explosives and chemical storage • administration buildings • communications infrastructure • laydown and storage facilities.

Table ES2: Physical Elements

Element	Location	Existing Approval	Proposed Extent
Mine pits and associated infrastructure	Figure 9 Mine Development Envelope, Disturbance Footprint and Mine Infrastructure Zones	Statement 707 Clearing up to 10,135.5 ha Development envelope undefined	Clearing of no more than 17,956 ha Development envelope of 33,000 ha (includes the injection zone)

Table ES3: Operational Elements

Element	Location	Existing Approval	Proposed Extent
Dewatering	Figure 10 Indicative Injection and Dewatering Zones	Statement 871 Up to 50 GL/a	Up to 110 GL/a
Water Supply	Figure 10		Up to 35 GL/a, supplied from mine dewatering, desalination, transfer from nearby mine sites and an external water supply borefield.
Injection of surplus water from dewatering	Figure 10 Indicative Injection Zone	Statement 871 Up to 42.5 GL/a	Up to 110 GL/a of surplus water.
Waste rock	Figure 9 Indicative Waste Rock Zone		Disposal of up to 322 Mtpa to WRSFs to a life of project maximum of 3,800 Mt. *Note: approximately 213 Mtpa of waste rock is currently produced at the existing operation.*
Tailings	Figure 9 Indicative Tailings Zone		Disposal of up to 11 Mtpa to TSFs to the life of project maximum of 144 Mt. *Note: approximately 4 Mtpa of tailings is currently produced at the existing operation.*
Mine pits	Figure 9	Statement 707 Pit Backfilling is an approved activity	Mine pits will be backfilled to at least above pre-mining water table.

Justification for the Proposal

Fortescue has identified a requirement to extend the mine footprint on the basis of an improved understanding of the extent and nature of the resource, and external demand for iron ore products. The international demand for iron ore has experienced strong growth in the last ten years, predominantly driven by increased steel production in China. The long term demand for iron ore is not likely to change as China and India continue to urbanise even though the market has recently contracted in response to the global financial crisis.

Fortescue believes there will be a continued long term growth in the steel industry, notwithstanding short-term fluctuations in steel demand.

Implementation of the Proposal provides the opportunity to contribute to the creation of employment and training opportunities for local and indigenous community members, royalties and taxation payments from the sale of iron ore, and supports the development of ancillary industries in Western Australia.

Stakeholder Consultation

Consultation associated with the development and operation of the Christmas Creek mine site began during scoping for the original mine site approval in 2005. This consultation allowed Fortescue to discuss the Christmas Creek operations with stakeholders and gain valuable feedback. This feedback was also considered during the development of the Proposal.

Fortescue has continued liaising with key stakeholders throughout the operation of the Christmas Creek mine site. This includes ongoing consultation with indigenous groups, pastoralists and government regulators. A consultation program was developed specifically for this Proposal.

Limited issues have been raised in consultation undertaken to date. The issues raised by stakeholders are addressed in this PER.

Key Environmental Factors

Key environmental factors relevant to the Proposal were identified through the scoping process undertaken for the Environmental Scoping Document and the outcomes of environmental studies and investigations undertaken to date. Key environmental factors addressed in this PER are:

- hydrological processes
- inland waters environmental quality
- flora and vegetation
- terrestrial fauna

- subterranean fauna
- rehabilitation and mine closure
- offsets.

In accordance with the EPBC Act Referral Decision issued by the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (Reference: EPBC 2013/7055), Matters of National Environmental Significance (MNES) of relevance to the Proposal are:

- listed threatened species and communities
- listed migratory species.

Impact Assessment Summary

Fortescue has completed a range of specialist biological, botanical, hydrological, hydrogeological and heritage investigations for the Proposal, in accordance with Regulatory guidelines. These investigations have formed the basis for assessing the potential environmental impacts and risks associated with the Proposal. To manage the potential impacts and risks, Fortescue has developed design considerations, mitigation measures and environmental management commitments. These reflect measures already in place for the existing Christmas Creek mine where appropriate. These measures have been developed so that the Proposal will be constructed and operated in an environmentally responsible manner.

A summary of the environmental factors, management objectives, potential impacts, proposed management strategies and predicted environmental outcomes for the Proposal are shown in Table ES4.

Residual Impacts and Offsets

Based on the assessment of residual risk, the Proposal will result in the following significant residual impacts which may require offsets under Commonwealth legislation:

- direct disturbance of approximately 7,752 ha of native vegetation with the following attributes:
    - approximately 14 ha of Marsh habitat type, potentially suitable for the Night Parrot and Australian Painted Snipe
    - approximately 2,255 ha of potential breeding and foraging habitat for the Night Parrot
    - approximately 1,117 ha of potential foraging habitat for the Pilbara Olive Python.

Based on the assessment of residual risk, the Proposal will result in the following significant residual impacts which may require offsets under State legislation:

- direct disturbance of 14 ha of Marsh habitat type, which is significant as a watercourse/wetland, habitat/potential habitat for Migratory birds and habitat/potential habitat for fauna protected under the EPBC Act and/or WC Act
- direct disturbance of 1,117 ha of Drainage Line and Alluvial Plain habitat type, which is significant as a watercourse/wetland, habitat/potential habitat for Migratory birds and habitat/potential habitat for fauna protected under the EPBC Act and/or WC Act
- direct disturbance of 2,255 ha of Low Hill habitat type, which is significant as habitat/potential habitat for fauna protected under the EPBC Act and/or WC Act.

Following consultation with the Department of Parks and Wildlife (DPaW) and DSEWPaC and in accordance with current conditions of approval for the Christmas Creek Water Management Scheme, Fortescue has developed an Offsets Plan. The plan identifies the key threats to EPBC Act listed threatened species and communities impacted by Fortescue operations and outlines landscape scale management strategies to address these threats in an area of over 450,000 ha. Key management actions of the plan include:

- feral herbivore control
- baiting for feral predators such as cats and foxes
- weed management
- fire management.

The Plan will be implemented in consultation with other parties including the DPaW, pastoralists, Rangelands NRMs and other resources proponents, to support the implementation of consistent management approaches in an efficient and targeted manner.

Fortescue proposes the extension of these management activities to offset the impacts of this Proposal. It is proposed that the Proposal will contribute funding for the implementation of the Offsets Plan. Specific details of the offset strategy for this Proposal are subject to further consultation and agreement by state and Commonwealth regulators.

Environmental Acceptability

Fortescue believes that the Proposal can be implemented in a manner which will meet the EPA's objectives. The avoidance and mitigation measures will ensure that environmental impacts are kept to the minimum necessary to implement the Proposal and have proposed an offset strategy to provide for the enhancement of environmental factors impacted by the Proposal. Fortescue will continue to demonstrate its commitment to environmental compliance in the implementation of the Proposal.

On the basis of the findings of this PER, the Proposal is considered environmentally acceptable if implemented in accordance with the management measures and offset commitments made within the PER document.

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Table ES4: Summary of Impacts and Proposed Management Measures

Environmental Factor	EPA Objective	Relevant Guidance	Existing Environment	Potential Impacts	Management Strategies	Predicted Outcomes
Hydrological Processes	To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected.	*Western Australian Water in Mining Guideline* (DoW 2013) *Pilbara Regional Water Plan* (DoW 2010a) *National Principles for the Provision of Water for Ecosystems* (ANZECC/ARMCANZ 1996) *Pilbara Water in Mining Guideline* (DoW 2009) *Environmental and Water Assessments Relating to Mining and Mining-related Activities in the Fortescue Marsh Management Area* (EPA 2013d)	**Surface Water** Christmas Creek is located to the north of the Fortescue Marsh, which lies in the Upper Fortescue River catchment, which has an area of approximately 26,000 km^2. The Fortescue Marsh is an extensive, intermittent wetland, occupying an area of approximately 1,000 km^2, typically around 100 km long by 10 km wide. Following significant rainfall events, runoff from the upper Fortescue River catchment drains to the Fortescue Marsh, which can result in flooding of the entire Fortescue Marsh area. Surface water flow processes at Christmas Creek include channel flow and sheet flow. Existing mine pits and waste rock storage facilities affect surface water flows by potentially diverting watercourses or sheet flows and capturing rainfall within mining areas, reducing the catchment area for downstream flows. **Groundwater** Regionally, groundwater movement within the Christmas Creek area is driven by rainfall recharge on the elevated flanks of the Fortescue Valley and surrounding plateau. Southward flow of the topographically driven fresh groundwater is opposed by the northward pressure gradient associated with deeper, density driven saline groundwater. As a result, a saline interface develops with fresh/brackish water overlying saline/hypersaline groundwater. The fresh/brackish water lens is likely thickest beneath the transition zone between the Chichester ranges and the Fortescue Marsh Basin. Groundwater flow in the Christmas Creek area is strongly controlled by local scale and regional scale stratigraphy and topography and is often enhanced along faults and discontinuities. Large-scale groundwater abstraction for the purpose of mining below the watertable has occurred at Christmas Creek since 2011. In 2013/2014, Fortescue abstracted 40.3 GL of groundwater and injected 20.4 GL. The Christmas Creek Water Management Scheme has been developed to manage dewatering and injection activities.	• Mine dewatering may cause an expansion of area of drawdown, potentially affecting any groundwater dependent ecosystems that may be present in the drawdown area, decreasing surface water residence times in the Fortescue Marsh and yintas. • Injection of water may cause areas of mounding, including surface expression of injected water; potentially affecting any ecosystems sensitive to waterlogging that may be present in the mounding area. • Mine infrastructure may modify channel flow patterns and cause erosion, shadowing and changes to surface flow volumes.	Impacts associated with changes to groundwater levels are mitigated through the implementation of hierarchical contingency measures, ordered by response to impacts of increasing severity as follows: 1. The primary contingency measures involve adjustment of dewatering wellfield configurations and dewatering rates or adjustment of the location and injection rates of the injection wellfields. 2. Localised mitigation of temporary groundwater level changes through case specific contingencies such as surface irrigation. 3. Temporary reduction in dewatering or injection rates while further investigations into potentially unacceptable and unexpected occurrence are undertaken. 4. Permanent reduction in dewatering or injection rates, where these are determined to be appropriate, in consultation with the DoW. 5. Cease dewatering or injection and investigate alternatives. Fortescue will implement the *Surface Water Management Plan,* 100-PL-EN-1015 (Appendix 2B, Fortescue 2014i). Management measures detailed in the *Surface Water Management Plan* which are relevant to hydrological processes include: • Minimise clearing and vegetation disturbance so that flow regimes are minimally impacted. • Locate, design, construct and operate drainage infrastructure to design specifications which reflect risk assessment outcomes in minimising interference and disruption of natural surface water flows and quality. • Where possible, align haul/access roads with existing transport corridor or approved disturbance corridors so that surface water flow regimes are minimally impacted. • Design mine pits to be internally draining. Rainfall to be managed via sumps and potentially discharged directly to the environment. • Design bunding of pits, dumps, and iron ore stockpiles to minimise impact to surface water flow volume, flow regimes and turbidity. • Contain and appropriately manage contaminated stormwater prior to release to the environment. • Where appropriate, re-establish natural stream and drainage flows to resemble original drainage patterns, including	• Up to 110 GL/a will be abstracted for the purpose of dewatering, of which up to 35 GL/a will be used for processing and dust suppression with the remainder injected back into the aquifer. • Drawdown along the fringe of the Fortescue Marsh is predicted to be no more than 2.3 m. • With the cessation of dewatering, groundwater level drawdown in the mining area decreases from over 35 m at the end of mining (2028) to about 5 m after ten years (2038) and to about 3 m after 20 years (2048). Approximately 45% of the area affected by drawdown is completely recovered after 50 years. • Mounding along the fringe of the Fortescue Marsh is predicted to be no more than 2 m. Potential impacts of mounding from injection are predicted to be short term and localised. No mounding is expected post closure. • No impact is expected in terms of residence time of surface water in the Fortescue Marsh. • Any potential impact to station supply bores will be managed through well modification or substitution with an appropriate water source if water supply is affected.

Environmental Factor	EPA Objective	Relevant Guidance	Existing Environment	Potential Impacts	Management Strategies	Predicted Outcomes
					rehabilitation of major drainage channels. The *Groundwater Management Plan* (100-PL-EN-0029) (Fortescue 2014b) allows Fortescue to minimise the direct and indirect impacts of groundwater management activities on groundwater quality and quantity at Fortescue operations. Management measures detailed in the *Groundwater Management Plan* which are relevant to hydrological processes include: • Ensure location, design, construction and operation of water management infrastructure reflects risk assessment outcomes in minimising environmental impacts. • Where dewatering infrastructure may significantly impact on surface water flows in areas of sheet flow dependent Mulga communities, ensure appropriate drainage infrastructure is incorporated into the project design. • Where possible, utilise water from dewatering for onsite activities, such as dust suppression and OPF operations. • When injecting excess dewater into a compatible aquifer utilise methods outlined in the Operational Policy 1.01 *Managed Aquifer Recharge in Western Australia* (DoW 2011). • When construction or maintenance activities results in dewatering volumes in excess of what can be disposed of in accordance with the applicable Groundwater Operating Strategy, adopt temporary alternative disposal options as outlined in the *Dewatering Discharge Contingency Procedure* CH-PR-EN-0003 (Fortescue 2014c). • Develop and implement a groundwater monitoring program in accordance with an approval, license or works approval issued under the EP Act, an approval under the EPBC Act, a licence issued under the RIWI Act.	
Inland Waters Environmental Quality	To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.	*Western Australian Water in Mining Guideline* (DoW 2013) *Pilbara Regional Water Plan* (DoW 2010a) *National Water Quality Management Strategy* (NWQMS) (ANZECC/ARMCANZ 2000) *State Water Quality Management Strategy* (Government of Western Australia 2001) *Mining and Mineral Processing - Mine dewatering: Water*	**Surface Water** Surface water runoff entering the Fortescue Marsh is generally of low salinity and turbidity, though turbidity increases significantly during large floods. During flooding events, salts deposited from previous drying episodes are redissolved and water entering the Fortescue Marsh becomes moderately saline. As the water evaporates, the salts are further concentrated, become hypersaline and deposition occurs leaving traces of surface salts. This process has led to the aquifer below the Fortescue Marsh becoming hypersaline.	• Abstraction of groundwater may lower water levels which may result in oxidisation of potential acid sulphate soils and/or increase the salinity of groundwater near dewatering locations. • Injection of saline water may cause alterations to groundwater and surface water quality, which can potentially affect beneficial uses such as station bores. • Operation of TSFs, WRSFs and open pit walls has the potential to result in acid or metalliferous drainage from the potential	The *Surface Water Management Plan* 100-PL-EN-1015 was prepared in order to minimise the direct and indirect impacts of Fortescue's activities on surface water at Fortescue operations. Management measures detailed in the *Surface Water Management Plan* which are relevant to inland waters environmental quality include: • Minimise clearing and vegetation disturbance so that flow regimes are minimally impacted. • Conduct a risk assessment to determine the likelihood of a change to the surface water regime, including in areas where sheet flow dependent Mulga communities have been identified, that	• The potential for dewatering activities to oxidise potential acid sulphate soils (ASS) in the Fortescue Marsh is not expected, as the level of drawdown is likely to be within the natural fluctuation range of the watertable beneath the Fortescue Marsh under most climatic scenarios. • No significant impacts are expected in relation to acid and/or metalliferous drainage (AMD). • Post-development changes in velocity in the 2-year and 100-year ARI events are expected to be localised and to not cause significant increases in erosion or changes in water quality entering Fortescue Marsh. • Impacts from clearing and disturbance are not expected, as management measures

Environmental Factor	EPA Objective	Relevant Guidance	Existing Environment	Potential Impacts	Management Strategies	Predicted Outcomes
		Quality Protection Guidelines No. 11 (WRC 2000) *Guidelines for Groundwater Protection in Australia* (ARMCANZ and ANZECC 1995) *National Principles for the Provision of Water for Ecosystems* (ANZECC/ARMCANZ 1996) *Pilbara Water in Mining Guideline* (DoW 2009) *Environmental and Water Assessments Relating to Mining and Mining-related Activities in the Fortescue Marsh Management Area* (EPA 2013d)	Fortescue conducts regular surface water quality monitoring of creeklines and yintas. **Groundwater** The *Christmas Creek Groundwater Operating Strategy* (CC-PH-HY-0002) provides a detailed framework for monitoring water quality at Christmas Creek. The Operating Strategy is approved for implementation by DoW. In accordance with the Operating Strategy, water quality parameters, including: major ions, metals, electrical conductivity, field pH, lab pH, total dissolved solids and total suspended solids are recorded from the Christmas Creek Water Management Scheme (CCWMS) monitoring bores on a biannual basis. In addition, electrical conductivity at the CCWMS monitoring bores is measured in the field on a monthly basis. Results of groundwater quality monitoring for the period of August 2010 to July 2013 are described in the Christmas Creek Triennial Groundwater Monitoring Review (CC-RP-HY-0039). A summary of key information from this review is provided below. **Mining Area** *Marra Mamba Formation* The salinity of groundwater within the mining area has increased significantly in close proximity to the active dewatering areas due to the horizontal inflow of saline groundwater (from the Oakover Formation) induced by the steep hydraulic gradient and upwards migration of saline water due to depressurisation of the overlying brackish aquifers. This is an expected outcome of mine dewatering in this hydrogeological system. Groundwater electrical conductivity is generally low in the northern area of the mine site along the base of the outcropping Marra Mamba Formation (MMF). This is due to the groundwater recharge that occurs via rainfall and infiltration of through the outcropping MMF. Electrical conductivity increases to the south in the Oakover Formation aquifer and the Wittenoom Formation which occurs on the northern edge of the Fortescue Marsh. Limited saline upconing is evident from dewatering, which is due to the saline water existing in the lower MMF, which has a lower hydraulic conductivity and is	oxidisation of potentially acid forming (PAFF) material, which may affect surface and groundwater quality. • Mine infrastructure may affect water quality through erosion and sedimentation, from earthworks and clearing, and through chemical spills and wastewater. • Creation of temporary or permanent pit lakes following the cessation of dewatering activities may result in decreased surface water quality through processes such as evapotranspiration leading to hypersalinity.	may lead to unacceptable environmental or safety impacts. • Locate, design, construct and operate drainage infrastructure to design specifications which reflect risk assessment outcomes in minimising interference and disruption of natural surface water flows and quality. • Incorporate appropriate drainage infrastructure into the project design where sheet flow dependent Mulga communities have been identified and significant impacts from changes to sheet flow regimes are likely. • When culverts are used in areas with sheet flow dependent Mulga communities to be protected, install sheet flow redistribution structures downstream and immediately upstream of the culverts where sheet flow shadowing is unacceptable. • Where appropriate, re-establish natural stream and drainage flows to resemble original drainage patterns, including rehabilitation of major drainage channels. The *Groundwater Management Plan* (100-PL-EN-0029) allows Fortescue to minimise the direct and indirect impacts of groundwater management activities on groundwater quality and quantity at Fortescue operations. Management measures detailed in the *Groundwater Management Plan* (100-PL-EN-0029) which are relevant to inland waters environmental quality include: • Ensure location, design, construction and operation of water management infrastructure reflects risk assessment outcomes in minimising environmental impacts. • Where dewatering infrastructure may significantly impact on surface water flows in areas of sheet flow dependent Mulga communities, ensure appropriate drainage infrastructure is incorporated into the project design. • Contain generators/pumps used for test pumping to reduce the risk of a hydrocarbon spill and potential soil and groundwater contamination. • When construction or maintenance activities results in dewatering volumes in excess of what can be disposed of in accordance with the applicable Groundwater Operating Strategy, adopt temporary alternative disposal options as outlined in the *Dewatering Discharge Contingency Procedure* CH-PR-EN-0003 (Fortescue 2014c).	will be undertaken to limit clearing in erosion prone areas and rehabilitation will occur progressively throughout the Proposal area. • All surface flow from potentially contaminated areas will be contained. • At closure, major drainage lines will be re-established to resemble their original alignments and levels, and rehabilitated. • No permanent pit lakes will occur. The Proposal is not expected to result in significant adverse impacts to inland waters environmental quality from implementation of the Proposal. The mitigation measures described will ensure the minimisation of downstream water quality impacts, as has already been implemented on site. In considering the outcome as described, the Proposal is expected to meet the EPA objective for inland waters environmental quality to maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.

Environmental Factor	EPA Objective	Relevant Guidance	Existing Environment	Potential Impacts	Management Strategies	Predicted Outcomes
			groundwater is flowing towards the abstraction bores. *Tertiary Detritals* Natural groundwater electrical conductivity gradients in the Tertiary Detritals increase steeply to the south towards the Fortescue Marsh. Electrical conductivity around the mining area is fresh-brackish due to better connectivity with the brackish MMF aquifer. The presence of a shallow freshwater lens is not evident from the data that has been collected to date. **Saline Injection Area** Injection of saline groundwater into the Oakover Formation has caused pressurisation of the aquifer in the vicinity of the borefield. The pressure gradient has advanced vertically to some extent however no impacts have been recorded at the watertable. Some decrease in salinity of the Oakover Formation around the saline injection borefield has occurred due to the injection of lower electrical conductivity water than the native hypersaline groundwater. **Fringe of the Fortescue Marsh** Minor pressurisation of the Oakover Formation is observed in the area fringing the Fortescue Marsh. No impacts are observed at the watertable, where cycles of watertable rise and fall, driven by marsh flooding and recharge, still persist. Naturally hypersaline shallow groundwater exists along the northern edge of the Fortescue Marsh.		• Ensure chemicals and hydrocarbons are managed in accordance with the *Chemical and Hydrocarbon Management Plan* (100-PL-EN-0011) to reduce the risk of soil or groundwater contamination.	
Flora and Vegetation	To maintain representation, diversity, viability and ecological function at the species, population and community level.	EPA Position Statement No. 2 *Environmental Protection of Native Vegetation in Western Australia - Clearing of Native Vegetation, with particular reference to the Agricultural Area* (EPA 2000a) EPA Position Statement No. 3 *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002) EPA Guidance Statement No. 51 *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004b) *National Strategy for Conservation of Australian Biodiversity* (Australian Government 1996)	The Proposal area occurs within the Fortescue Botanical District of the Eremaean Botanical Province, where the vegetation is typically open, and frequently dominated by Spinifex, Wattles and occasional Eucalypts. Vegetation comprises a mosaic of low woodland with Mulga in valleys and hummock grasslands, low open tree steppe with Snappy Gum (*Eucalyptus leucophloia*) over Limestone Spinifex (*Triodia wiseana*), and Kanji (*Acacia pyrifolia*) over Soft Spinifex (*Triodia pungens*) and Limestone Spinifex hummock grasslands. A total of 24 broad vegetation types (VTs) and vegetation associations (VAs) and two mosaics (combining two existing vegetation types) occur within the Survey Area. The Survey Area includes 17 floristic groups which are equivalent to the 14 VTs of the creeks, plains and slopes and	• Clearing of vegetation will directly reduce the extent of vegetation communities, and may disturb conservation significant flora species or ecological communities. • Groundwater abstraction will lower groundwater levels and may affect potentially groundwater-dependent vegetation. • Alterations to surface water flows can affect downstream vegetation communities. • Spread of weeds from vehicle movements, introduced/imported material, earthworks or surface and/or subsurface water flow have the potential to introduce and spread weed species. • Dust generation due to earthworks and vehicle	Impacts to vegetation and flora will be managed using the following management plans: • *Significant Flora and Vegetation Management Plan* (45-PL-EN-0017). • *Vegetation Health Monitoring and Management Plan* (CC-PL-EN-0004). • *Rehabilitation and Revegetation Management Plan* (45-PL-EN-0023). • *Surface Water Management Plan* (100-PL-EN-1015). Key management measures include: • record significant flora and vegetation in the internal GIS and record keeping systems, and inform DPaW of any new populations or communities discovered, as required • avoid clearing in areas of priority flora where possible, or identify priority flora on the ground by appropriate signage and fencing/flagging prior to clearing	• Disturbance of approximately 7,821 ha, consisting of 7,752 ha of native vegetation (approximately 17,956 ha of total disturbance when combined with existing mine within a Development Envelope of 33,000 ha) for the mine expansion and associated infrastructure. • No clearing or indirect disturbance will occur to the Fortescue Marsh PEC (P1). • Up to 4,924 ha of Mulga vegetation will be directly affected by the Proposal and up to 439 ha of sheet flow dependent Mulga will be indirectly affected by altered surface water regime; however, Mulga communities are well represented in the region. • No indirect impacts will occur to Mulga vegetation as a result of groundwater drawdown or mounding. • Up to 355 ha of GDE vegetation (VT01) will be directly affected by the Proposal and up to 1.1 ha could potentially be indirectly affected by groundwater drawdown;

Environmental Factor	EPA Objective	Relevant Guidance	Existing Environment	Potential Impacts	Management Strategies	Predicted Outcomes
		National Strategy for Ecologically Sustainable Development (Australian Government 1992)	one floristic group which is equivalent to VA1 – VA9 of the samphire flats of Fortescue Marsh. The condition of vegetation in the ranges from Excellent to Completely Degraded. Three PECs occur within 50 km of the Proposal: • Priority 1: Fortescue Marsh PEC (Marsh Land System) • Priority 3: Stony saline clay plains of the Mosquito Land System • Priority 3: Fortescue Valley Sand Dunes. At Christmas Creek, changes in groundwater levels may cause impacts to vegetation through: • drawdown on vegetation that may be groundwater-dependent (samphire, and River Red Gum and Coolibah) • mounding on vegetation that may be intolerant of waterlogging (Mulga). A total of 14 priority flora have been recorded within the Study area, comprising five species of Priority 1, one Priority 2, six Priority 3 and two Priority 4.	movements has the potential to smother vegetation. • On-site ignition sources that could result in increased fire frequency/intensity that may favour the establishment of weeds and prevent the regeneration of native vegetation.	• manage dewatering activities and water discharge to minimise drawdown impact on GDEs such as the fringing vegetation of the Fortescue Marsh • report and investigate unauthorised disturbance of significant flora or vegetation • clearing to be undertaken progressively. A procedure of internal review and approval of all proposed vegetation clearing and ground disturbance activities is required prior to the commencement of works (GDP). Potential impacts to significant vegetation communities, such as Mulga and samphire communities, from drawdown and mounding will be managed through the adaptive management approach outlined in the *Christmas Creek Groundwater Operating Strategy* (CC-PH-HY-0002) and the *Groundwater Management Plan* (100-PL-EN-0029). This is described in more detail under the Hydrological Processes environmental factor.	however, VT01 is well represented in the region. • No direct impacts to samphire vegetation will result from the Proposal, and no indirect impacts to samphire vegetation through groundwater drawdown are expected. • Clearing for the Proposal and potential indirect impacts to vegetation will not compromise any vegetation system by taking it below the "threshold level" of 30% of its pre-clearing extent. • No change in the conservation status of conservation significant flora species is expected. • Rehabilitation will restore some of the vegetation values of the pre-existing landscape. The Proposal is not expected to result in a change in status of conservation significance flora and is not expected to represent a significant impact to VTs and VAs. Geographical distribution, productivity, and ecosystems are expected to be maintained through management and mitigation measures. In considering the outcome as described, the Proposal is expected to meet the EPA objectives for vegetation and flora to maintain representation, diversity, viability and ecological function at the population and community level.
Terrestrial Fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.	EPA (2002) Position Statement No. 3 - *Terrestrial Biological Surveys as an Element of Biodiversity Protection* EPA (2004c) Guidance Statement No. 56 - *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* EPA (2009) Guidance Statement No. 20 - *Sampling of Short Range Endemic Fauna for Environmental Impact Assessment in Western Australia*	The Christmas Creek area supports a total of 313 vertebrate fauna species; 43 mammals, 165 birds, 99 reptiles and 6 amphibians. Based on searches of databases and literature from within 50 km of the Survey Area, results from previous surveys and findings of current surveys have indicated there is a potential for 23 species of conservation significant vertebrate fauna to occur within the area. Of the species with potential to occur, seven have been recorded: • Pilbara Olive Python (Vulnerable, Schedule 1) • Eastern Great Egret (Migratory, Schedule 1) • Rainbow Bee-eater (Migratory, Schedule 3) • Peregrine Falcon (Schedule 4) • Australian Bustard (Priority 4) • Western Star Finch (Priority 4) • Northern Short-tailed Mouse (Priority 4). Four habitat types occur at Christmas Creek: • Drainage Line and Alluvial Plain • Marsh • Low Hill • Stony Plain.	• Clearing of habitat may reduce the capacity of the habitat to support fauna. • Groundwater abstraction and injection will affect groundwater levels, which may indirectly affect groundwater-dependent vegetation (potential fauna habitats). • Alteration to surface water flows can affect downstream fauna habitats. • Vehicle movements can cause mortality of fauna during construction and ongoing operations. • Presence of artificial water bodies may attract native and non-native fauna resulting in drowning or reliance on artificial water sources.	Impacts to terrestrial fauna will be managed using the *Conservation Significant Fauna Management Plan* (100-PL-EN-0022). Key management objectives include the following: • undertaking clearing in stages and along one front to allow fauna to vacate the area, and large mature habitat trees will be retained, where possible • undertaking progressive rehabilitation • providing opportunity for native animals encountered on site to move on if there is no threat to safety of personnel • restricting vehicles, machinery and personnel to designated areas and tracks • disposing of food scraps and other waste in covered waste facilities to ensure introduced or other animals are not attracted to the site • recording all incidents involving fauna and reporting to site environmental staff • capping all exploration drill holes on completion of drilling program • inducting all staff on fauna management procedures prior to mobilising to site, and training appropriate site representatives in snake handling techniques and providing equipment to safely handle snakes	• Approximately 7,752 ha of fauna habitat will be directly disturbed by the Proposal with the majority of this occurring in the Low Hill habitat type. • There will be some direct impact to Stony Plain, Low Hill, Drainage Line and Alluvial Plain habitat as a result of clearing, but very little clearing is proposed within the Marsh habitat. • Up to 1.1 ha of Drainage Line and Alluvial Plain habitat could potentially be indirectly impacted as a result of groundwater abstraction and injection activities. This area is located outside the southern boundary of the Development Envelope. • There will likely be some localised impacts to fauna species due to clearing activities. However, the Proposal is not expected to significantly affect regional abundance or range of any conservation significant taxa. • Significant regional impact to fauna is not expected as all the habitats that occur within the Development Envelope also occur extensively outside the Development Envelope. • The Proposal will not conflict with the WC Act, as no fauna species will cease to exist or have its conservation status affected as a result of the implementation of the Proposal.

Environmental Factor	EPA Objective	Relevant Guidance	Existing Environment	Potential Impacts	Management Strategies	Predicted Outcomes

					• providing updated information regarding fauna management to personnel during operations by way of toolbox meetings, site health, safety and environment (HSE) meetings, training and awareness sessions and visual displays in prominent on-site locations.
					Indirect impacts to fauna resulting from impacts to fauna habitat through drawdown and mounding are presented under the Hydrological Processes environmental factor.
						• Significant regional impact to SRE species is not expected to occur as a result of the Proposal:
						  ◦ three Priority 2 SRE species may occur in the Fortescue Marsh, but this habitat is unlikely to be impacted by the Proposal
						  ◦ three potential SRE species recorded within the Development Envelope are likely to occur in the wider region, based on the wide distribution of the preferred habitat types (Drainage Line and Alluvial Plain).
						• The Proposal is not expected to result in significant impacts to species listed as Endangered or Vulnerable under either the WC Act or EPBC Act (Section 12).
						• Annual surveys will continue to determine the presence/absence of the Night Parrot in the vicinity of the Proposal, potentially adding to the body of knowledge available on this rare species.
						As demonstrated, the Proposal will not result in a change in the status of fauna of conservation significance; will not represent a significant clearing of habitat types; and will not significantly affect the regional distribution of fauna species. Geographical distribution, productivity, and ecosystems will be maintained through management and mitigation measures.
						In considering the outcome as described, the Proposal is expected to meet the EPA objectives for terrestrial fauna.

Subterranean Fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.	EPA Environmental Assessment Guideline No. 12 *Consideration of subterranean fauna in environmental impact assessment in WA* (EPA 2013b) EPA Guidance Statement 54a *Sampling methods and survey considerations for subterranean fauna in Western Australia* (EPA 2007)	*Stygofauna* Stygofauna sampling yielded 2486 specimens representing 69 species from 13 higher level taxonomic groups. This is considered to represent a rich stygofauna community for the Pilbara region. Five stygofauna species have only been recorded from the likely impact areas associated with the Proposal. Four of these species have only been recorded within the drawdown impact area and three are considered to be possibly restricted in range. *Troglofauna* Troglofauna sampling yielded 249 specimens representing 29 species from 13 Orders. This is considered to represent a moderately rich troglofauna community for the Pilbara region. Of the 20 species currently known only from the Survey Area, 12 were restricted to the proposed impact area: nine were recorded only within the proposed mine pits and three were recorded only within the area of groundwater mounding	• Abstraction of ore and waste rock may result in physical loss of habitat. • Groundwater abstraction and associated drawdown may result in loss of habitat. • Injection may cause mounding of groundwater and changes in salinity which may result in loss of habitat.	• Management and monitoring of groundwater will be undertaken through implementation of the DoW approved *Christmas Creek Groundwater Operating Strategy* (CC-PH-HY-0002). • Ongoing implementation of the *Subterranean Fauna Survey Plan* (45-PL-EN-0010) (Fortescue 2011f). • GDPs will be required prior to commencement of activities. • Hydrocarbons and chemicals will be appropriately stored and bunded to minimise the potential for spillage. • Spill kits will be provided and maintained in all areas where hydrocarbons and chemicals are stored or used. • Drainage from areas likely to be contaminated with hydrocarbons or chemicals (such as workshops) will be captured and treated (for example through oil-water separators).	• Four species of stygofauna recorded only within the Proposal drawdown impact area, and one species which has been recorded within the Cloudbreak and Proposal drawdown areas. The threat to four of the stygofauna species is considered to be low. • The threat to the stygofauna species Canthocamptidae sp. B02 is uncertain because of limited information on the biology of the species, however the range of other copepods in the area suggests that this species is likely to have a range extending beyond the Proposal impact area. • There were 12 species of troglofauna with restricted distributions recorded within the Proposal area. Eight of these are considered likely to extend beyond the impact areas, while the remaining four comprise two species that may be exposed to minor habitat loss as a result of groundwater mounding, and two other species that will be affected by habitat loss resulting from pit excavation. • No subterranean fauna species recorded at the approved Cloudbreak or Roy Hill Stage 1 mine is reliant on the occurrence of

Environmental Factor	EPA Objective	Relevant Guidance	Existing Environment	Potential Impacts	Management Strategies	Predicted Outcomes
			associated with injection. Four species are considered to be possibly restricted in range. Geological information suggests that habitat for both stygofauna and troglofauna is likely to be well connected and extend outside the Development Envelope.			species within the Proposal footprint to ensure conservation of that species. The Proposal is not expected to represent an impact to subterranean fauna habitat from pit excavations and groundwater drawdown and mounding. Further investigations will be undertaken to understand the species present in the area and their distribution and management measures will be implemented to manage impacts. In considering the outcome as described, the Proposal is expected to meet the EPA objectives for subterranean fauna to maintain representation, diversity, viability and ecological function at the species, population and assemblage level.
Matters of NES	The EPBC Act objectives are to: • provide for the protection of the environment, especially MNES species • conserve Australian biodiversity • provide a streamlined national environmental assessment and approvals process • enhance the protection and management of important natural and cultural places • control the international movement of plants and animals (wildlife), wildlife specimens and products made or derived from wildlife • promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources.	• Significant Impact Guidelines 1.1 – *Matters of National Environmental Significance* • *National Recovery Plan for the Northern Quoll Dasyurus hallucatus* • *EPBC Act Environmental Offsets Policy*	Based on previous surveys, database and literature searches, seven Threatened fauna species and six Migratory bird species listed under the EPBC Act have the potential to occur within the Proposal area. Threatened species: • Night Parrot (possible) • Northern Quoll (unlikely) • Australian Painted Snipe (possible) • Greater Bilby (unlikely) • Pilbara Olive Python (recorded) • Pilbara Leaf-nosed Bat (unlikely) • Northern Marsupial Mole (highly unlikely) Migratory species: • Australian Painted Snipe (possible, as listed above) • Fork-tailed Swift (possible) • Cattle Egret (likely) • Eastern Great Egret (recorded) • Oriental Plover (possible) • Rainbow Bee-eater (recorded). A small area of potentially critical denning habitat, suitable for the Northern Quoll, was identified to the north of Christmas Creek. Targeted surveys of this area did not record any Quolls.	• Clearing of habitat may reduce the capacity of the habitat to support fauna. • Inappropriate fire regimes may indirectly impact on some MNES species through a reduction of foraging habitat or a reduction in cover resulting in increased predation. • Groundwater abstraction and injection will affect groundwater levels, which may indirectly affect groundwater-dependent vegetation (potential fauna habitats). • Alteration to surface water flows can affect downstream fauna habitats. • Trenching has the potential to provide temporary barriers for fauna movement as well as risk of stress, injury or fatality during construction where trenches are required. • Vehicle movements can cause mortality of small and sedentary fauna.	Management of potential impacts on fauna from this Proposal are also addressed in the *Conservation Significant Fauna Management Plan*, 100-PL-EN-0022 (Fortescue 2013c) and includes the following key management actions: • Clearing will not be undertaken outside authorised areas as defined under the GDP process. • Significant fauna habitat will be spatially identified and where appropriate, demarcated on site. • Surface water storage facilities will have management measures such as fauna egress. • Vehicles speeds will be restricted across the Proposal area. • Off road driving or driving on restricted access routes will be prohibited other than for emergency situations. • Rehabilitation of disturbed areas within the pipeline corridors not required to remain open post-construction will be implemented. • Low noise equipment will be used where practicable and all activities will be carried out in accordance with statutory requirements and appropriate standards. • Lighting will be directed onto construction or operational areas. Management and monitoring of groundwater will be undertaken through implementation of the DoW approved *Christmas Creek Groundwater Operating Strategy* (CC-PH-HY-0002).	• Approximately 7,752 ha of potential MNES habitat will be directly disturbed by the Proposal with the majority of this occurring in the Stony Plain habitat type. • Clearing will not be undertaken in the rocky escarpment habitat which is potentially critical denning habitat for the Northern Quoll. • Approximately 14 ha (<0.1%) of the Marsh habitat type (potentially suitable habitat for the Night Parrot, Australian Painted Snipe and Greater Bilby) will be directly disturbed as a result of the Proposal. • Approximately 2,255 ha (16%) of Low Hill habitat (potential foraging habitat for the Night Parrot and Northern Quoll) will be directly disturbed as a result of the Proposal. • Approximately 1,117 ha (13%) of Drainage Line and Alluvial Plain habitat (potentially suitable foraging habitat for the Pilbara Olive Python and Pilbara Leaf-nosed Bat) will be directly disturbed as a result of the Proposal. • Surveys will continue annually as required to determine the presence/absence of the Night Parrot in the vicinity of the Proposal. The Proposal is not expected to result in significant impacts to: • species listed as Endangered or Vulnerable under the EPBC Act • Migratory bird species listed under the EPBC Act. With the management and mitigation measures in place, the Proposal will not significantly affect MNES.

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1. INTRODUCTION

Fortescue Metals Group Ltd (Fortescue), as the Proponent, proposes to expand iron ore mining and processing operations at the existing Christmas Creek Mine (Christmas Creek) in the Pilbara region of Western Australia (the Proposal). The location is presented in Figure 1.

The Proposal includes an expansion of the existing mining footprint for additional mine pits, permanent waste landforms, tailings disposal, conveyors, roads, drainage and other associated mine infrastructure. The expansion will enable iron ore production to continue at an increased rate incorporating peaks of up to 85 million tonnes per annum (Mtpa) for approximately 14 years and will increase the disturbance footprint from 10,135 hectares (ha) to 17,956 ha. To support ongoing mining below the water table, dewatering will increase from a maximum of 50 gigalitres per annum (GL/a) to a maximum of 110 GL/a. Up to 110 GL/a of surplus brackish and saline water will be injected into targeted receiving aquifers, with up to 35 GL/a utilised on site for processing and potable water supply.

The current water management approach of separating brackish and saline water for injection will continue to ensure the potential effects on water quality in the receiving aquifers are minimised. Construction of the Proposal is scheduled to commence in 2015, following receipt of approvals.

1.1 Background

The Proposal represents an expansion of the Christmas Creek mining operation, and was referred to the Environmental Protection Authority (EPA) on 31 October 2013 under section 38 of the *Environmental Protection Act 1986* (EP Act). The Proposal was determined by the EPA as requiring assessment at the level of Public Environmental Review (PER) with a four week public comment period.

Under the *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2012*, the EPA prepared the Environmental Scoping Document (ESD) (Appendix 1). The ESD identified the environmental factors of the Proposal and the environmental studies required to allow an environmental impact assessment. The draft ESD was issued to the Proponent on 27 February 2014, with the final ESD issued on 17 May 2014.

The Proposal was referred to Department of the Environment (DoE) on 13 November 2013 under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Proposal was determined by DoE to be a Controlled Action, with the following controlling provisions:

- listed threatened species and communities
- listed migratory species.

The assessment approach for the Controlled Action is under the bilateral agreement between the Australian Government and the State, as described in *An agreement between the Commonwealth of Australia and the State of Western Australia relating to Environmental Impact Assessment* (DoE 2013a).

1.2 Purpose of this Document

The purpose of this PER is to present an environmental impact assessment of the Proposal for public review and consideration by EPA and DoE. The PER includes a detailed impact assessment and description of proposed mitigation and management measures for the environmental factors identified in the ESD (Appendix 1). Further details on the requirements of the ESD are presented in Section 5.1.

1.3 Proposal Location

The Proposal is located in the Shire of East Pilbara, approximately 111 km north of Newman (Figure 1). The Proposal layout is presented in Figure 2.

The Christmas Creek mine is part of the Pilbara Iron Ore and Infrastructure Project, which involves a series of iron ore mines in the Pilbara region of Western Australia, and rail and port infrastructure for export of iron ore through Port Hedland. A railway system links the Herb Elliott Port facilities located at Anderson Point, Port Hedland, with the Cloudbreak, Christmas Creek and Solomon mines (Figure 1). The layout of the existing Christmas Creek Mine is presented in Figure 3.

1.4 Existing Approvals

1.4.1 *Environmental Protection Act 1986*

The Pilbara Iron Ore and Infrastructure Project has been referred and approved under Part IV of the EP Act in a number of stages:

- Stage A Project: Port and a north-south railway from north of the Chichester Ranges in the Central Pilbara to Port Hedland (Ministerial Statement 690)
- Stage B Project: Christmas Creek and Mindy Mindy mines and an east-west rail spur (Ministerial Statement 707)
- Cloudbreak Iron Ore Project: Cloudbreak Life of Mine (Ministerial Statement 899)
- Port Facility Upgrade: Anderson Point Port Hedland, Dredging and Wharf Construction, Third Berth (Ministerial Statement 771)
- Solomon Iron Ore Project (Ministerial Statement 862).

Development of Christmas Creek as a component of the Stage B Project (the Original Proposal) was authorised by the Minister for the Environment upon issue of Ministerial Statement 707 (MS707) on 16 December 2005 and has since undergone subsequent amendments.

The Christmas Creek Water Management Scheme (CCWMS) was referred to the EPA in 2010. The CCWMS involved an expansion of the dewatering and injection scheme at Christmas Creek to allow access to additional ore below the water table. The EPA set a level of assessment of 'Assessment on Referral Information' for this Proposal. The CCWMS was approved under Ministerial Statement 871 in August 2011.

Additional licences and works approvals granted under the EP Act are outlined in Table 1.

Table 1: Licences and Works Approvals Currently in Operation at Christmas Creek

Number	Date	Description
Licence L8454/2012/1	23/08/2010 to 22/08/2015	Processing of ore, mine dewatering, electric power generation, sewage facility, bulk storage of chemicals and landfill.
Works Approval W5120/2012/1	07/05/2012 to 06/05/2015	CCY2 Fuel Storage: Construction of five hydrocarbon storage facilities
Works Approval W5210/2012/1	09/08/2012 to 08/08/2015	Windich Tailings Storage Facility #1: Construction of in-pit tailings storage facility.
Works Approval W5363/2013/1	15/04/2013 to 14/04/2016	Vasse Above Ground Tailings Storage Facility: Construction of above-ground tailings storage facility.
Works Approval W5425/2013/1	15/07/2013 to 14/07/2016	Windich Tailings Storage Facility #2: Construction of in-pit tailings storage facility.

1.4.2 *Environment Protection and Biodiversity Conservation Act 1999*

The establishment of the Christmas Creek mine was originally referred under the EPBC Act in 2004. This proposal was determined as not being a Controlled Action and a formal assessment was not required (EPBC 2004/1897). The CCWMS was referred under the EPBC Act in October 2010, underwent formal assessment, and was subsequently approved pursuant to EPBC 2010/5706.

The Project approved under Ministerial Statements 707 and 871 has been taken as the baseline case against which an assessment of additional potential impact resulting from the implementation of the Proposal has been made.

1.5 Tenure

The Proposal is located within the Hillside and Roy Hill pastoral leases, and falls within tenements granted under the *Iron Ore (FMG Chichester Pty Ltd) Agreement Act 2006*. It includes the leases and licences listed in Table 2.

Table 2: Tenure

Lease Category	Reference Numbers
Mining Lease	M46/320, M46/321, M46/322, M46/323, M46/324, M46/325, M46/326, M46/327, M46/328, M46/329, M46/330, M46/331, M46/332, M46/333, M46/334, M46/335, M46/336, M46/337, M46/338, M46/339, M46/340, M46/341, M46/342, M46/343, M46/344, M46/345, M46/346, M46/347, M46/348, M46/349, M46/350, M46/351, M46/352, M46/353, M46/354, M46/355, M46/402, M46/403, M46/405, M46/406, M46/412, M46/413, M46/414, M46/415, M46/416, M46/417, M46/418, M46/419, M46/420, M46/421, M46/422, M46/423, M46/424
Miscellaneous Licence	L46/49, L46/54, L46/55, L46/56, L46/58, L46/66, L46/86, L46/87, L46/99, L46/111
General Purpose Lease	G46/7

Figure 4 presents a map showing the areas subject to the various forms of tenure.

1.6 Document Structure

In accordance with the requirements of the *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2012*, this document contains the following information:

1. A description of the Proposal and alternatives considered, including alternative locations with a view to minimising environmental impacts (refer Section 4).
2. Identification of the key issues (and a list of the environmental factors associated with these issues) and their relative significance (refer Section 5).
3. Details of stakeholder consultation (refer Section 6).
4. A description of the physical and social environment (refer Section 2).
5. Discussion and analysis of the direct and indirect impacts of the Proposal, in a local and regional context. For an assessment of the impacts of the Proposal with respect to the key environmental factors, refer to Sections 7 through 11.
6. Potential impacts to matters of national environmental significance (MNES) are addressed in Section 12.
7. Findings of surveys and investigations undertaken. The results of these studies inform the assessments of the key environmental factors presented in Sections 7 through 11. The technical reports are presented as appendices with the findings incorporated throughout the document.
8. A mine closure strategy is presented in Section 13.
9. Identification of offsets, where appropriate, after all other steps in the mitigation sequence have been exhausted (refer Section 14).
10. Identification of management measures to mitigate significant adverse impacts are presented in Sections 7 through 14 and summarised in the Executive Summary with relevant environmental management plans provided in Appendix 2.

11. Spatial datasets, information products and databases are provided as appendices.

A glossary of terms, abbreviations, acronyms and units and a list of references is provided at the end of the document.

The appendices contain copies of relevant technical study reports referenced in this PER and Geographical Information System data files. These can be found on a data CD/DVD-ROM inside the back cover of this report or on the disc containing the electronic version of this report.

1.7 Proponent Details

The Proponent for this Proposal is:

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1.8 Assessment Approach

1.8.1 Applicable Legislation

In addition to the EP Act and the EPBC Act, implementation of the Proposal would require compliance with other key Australian legislation and regulations. These are listed below.

Further to these statutory requirements, a range of other guidelines, standards and policies are relevant to the Proposal. The applicable standards, policies and guidelines are listed in Section 1.8.2.

Australian Government Legislation

The Proposal has been declared a controlled action by the Federal Minister for Environment and will be assessed by DoE according to the terms of the bilateral agreement between the Commonwealth of Australia and the State of Western Australia. The bilateral agreement is authorised under section 45 of the EPBC Act. Under the terms of the bilateral agreement, the EPA will provide its assessment report and any other assessment documentation, including this PER, to DoE upon completion of its assessment. DoE considers impacts from the Proposal to MNES. An assessment of impacts to MNES is provided in Section 12.

Other key Australian Government legislation relevant to the environmental aspects of this Proposal includes:

- *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*
- *Native Title Act 1993*
- *National Greenhouse and Energy Reporting Act 2007*.

State Legislation

Other significant legislation that applies to the Proposal is the *Iron Ore (FMG Chichester Pty Ltd) Agreement Act 2006*. This act ratifies and authorises the implementation of an agreement between the State and Fortescue regarding the mining of iron ore by Fortescue in the Pilbara region of the State. It allows for the development of mining of iron ore by Fortescue within a defined area of the Chichester Ranges, and defines the assistance to be provided by the State.

Other Applicable Legislation

Other legislation relevant to the Proposal may include:

- *Aboriginal Heritage Act 1972* (AH Act)
- *Biosecurity and Agriculture Management Act 2007* (BAM Act)
- *Bush Fires Act 1954*
- *Conservation and Land Management Act 1984* (CALM Act)
- *Dangerous Goods Safety Act 2004*
- *Dangerous Goods (Transport) Act 1998*
- *Health Act 1911*

- *Heritage of Western Australia Act 1990*
- *Land Administration Act 1997*
- *Mining Act 1978*
- *Mines Safety and Inspection Act 1994*
- *Occupational Health and Safety Act 1984*
- *Rights in Water and Irrigation Act 1914* (RIWI Act)
- *Soil and Land Conservation Act 1976*
- *Pollution of Waters by Oil and Noxious Substances Act 1987*
- *Wildlife Conservation Act 1950* (WC Act).

1.8.2 Standards, Guidelines and Policies

Assessment of the environmental impacts of the Proposal is based on various Position Statements and Guidance Statements. Standards, guidelines and policies related to specific environmental factors or individual aspects of the Proposal are listed in the individual sections relevant to the environmental factor being addressed. The generic documents considered relevant to assessment by the EPA are:

- *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2012*
- *Guidelines for Preparing a Public Environmental Review* (EPA 2012a)
- EPA Position Statement No. 7: *Principles of Environmental Protection* (EPA 2004a)
- Environmental Assessment Guidelines (EAG) No. 6: *Timelines for Environmental Impact Assessment of Proposals* (EPA 2013a)
- EAG No. 1: *Environmental Assessment Guideline for Defining the Key Characteristics of a Proposal Environmental Protection Act 1986* (EPA 2012b)
- EAG No. 8: *Environmental Assessment Guideline for Environmental factors and objectives* (EPA 2015)
- EAG No. 9: *Environmental Assessment Guideline for Application of a significance framework in the environmental impact assessment process* (EPA 2013c).

1.8.3 Other WA Approvals

In addition to any requirements for implementation of the Proposal under Part IV of the EP Act, the Proposal may require:

- works approvals and licences under Part V of the EP Act
- groundwater abstraction licences under the RIWI Act
- approval to disturb Aboriginal sites under section 18 of the AH Act.

1.9 Proposal Justification

Fortescue has identified a requirement to extend the mine footprint on the basis of an improved understanding of the extent and nature of the resource, and external demand for iron ore products. The international demand for iron ore has experienced strong growth in the last ten years, predominantly driven by increased steel production in China. The long term demand for iron ore is not likely to change as China and India continue to urbanise even though the market has recently contracted in response to the global financial crisis.

Fortescue believes there will be a continued long term growth in the steel industry, notwithstanding short term fluctuations in steel demand.

1.9.1 Benefits of Proposal

The Proposal would result in community benefits for Australia and Western Australia through:

- royalties and taxation payments from the sale of iron ore products
- employment and training opportunities
- encouragement in the growth of ancillary industries in WA.

The Proposal is anticipated to provide contractual and full-time employment opportunities to local communities. Further employment opportunities would be created by the flow-on effects to service industries and other sectors of the economy.

Fortescue is committed to providing jobs and employment to local indigenous people through its' Vocational Training and Employment Centre (VTEC) developed as part of Land Access Agreement negotiations between Fortescue and traditional claimant groups. VTEC works by identifying employment opportunities within Fortescue, and with contractors who work with Fortescue, then developing courses using TAFE and other training organisations to provide indigenous people in the Pilbara with the necessary skills for those jobs.

1.9.2 Consequences of Not Proceeding

The consequences of not proceeding with this Proposal would be the early closure of Christmas Creek and the need to open another mine to balance the loss of production to Fortescue.

1.9.3 Alternatives Considered

The alternative would be to close the Christmas Creek mine once the currently approved project has been completed. Extending the life of the mine allows for more efficient use of existing mine infrastructure and long term community and employment benefits. Siting of infrastructure has been carried out to limit the disturbance footprint.

2. PHYSICAL ENVIRONMENTAL SETTING

2.1 Climate

The climate of the Pilbara is characterised as arid-tropical with two distinct seasons including a hot summer (October to April) and mild winter (May to September). The Pilbara is one of the hotter areas in Australia, with an extreme temperature range, rising up to 50°C during the summer and dropping to around 0°C in winter (BoM 2014).

The Pilbara region has highly variable rainfall dominated by the occurrence of tropical cyclones mainly from January to March. Tropical cyclones bring sporadic and drenching rainfall events. With the exception of these large events, rainfall can be erratic and localised due to thunderstorm activity. Rainfall from a single site may not be representative of the spatial variability of rainfall over a wider area. During winter, cold fronts sometimes reach the Pilbara region producing light winter rains.

Mean monthly maximum temperatures at Newman range from 39°C in January to 23°C in July and mean monthly minimum temperatures range from 25°C in January to 6°C in July (BoM 2014). Average annual (pan) evaporation in the area is approximately 2,600 mm per year (BoM 2014), which greatly exceeds annual rainfall and consequently contributes to the arid environment. The monthly temperature and rainfall characteristics at Newman are presented in Plate 1, together with evaporation data from Wittenoom (the closest centre with evaporation measurements).

2.2 Geology

The Proposal area is located in the Hamersley Basin area of the granitoid Pilbara Craton. The east-west running Fortescue Valley lies between the Chichester and Hamersley ranges. At the base of the valley lies the Fortescue Marsh and Chichester Plains. The Proposal is located on the Chichester Plains.

The Christmas Creek ore deposits are located within the Hamersley Basin, where granitoid rocks of the Archaean Pilbara Craton are overlain by sedimentary groups. From the base of the formation upwards, the Granitoid rocks of the Pilbara Craton are overlain by the Archaean Fortescue Group, which is then overlain by the Archaean-Proterozoic Hamersley Group (Fortescue 2013a).

The Jeerinah Formation at the top of the Fortescue Group marks the base of the main ore body and is sub-divided into a number of members, with the Roy Hill Shale being the uppermost (Figure 5, Fortescue 2013a). This is overlain by the Marra Mamba Formation (MMF). The weathered or mineralised section of the Nammuldi Member of the MMF is the ore that is mined at Christmas Creek. To the south of the mine, the Nammuldi Member is overlain by more recent sediments, including tertiary clays and alluvium that forms the soils of the Fortescue Marsh.

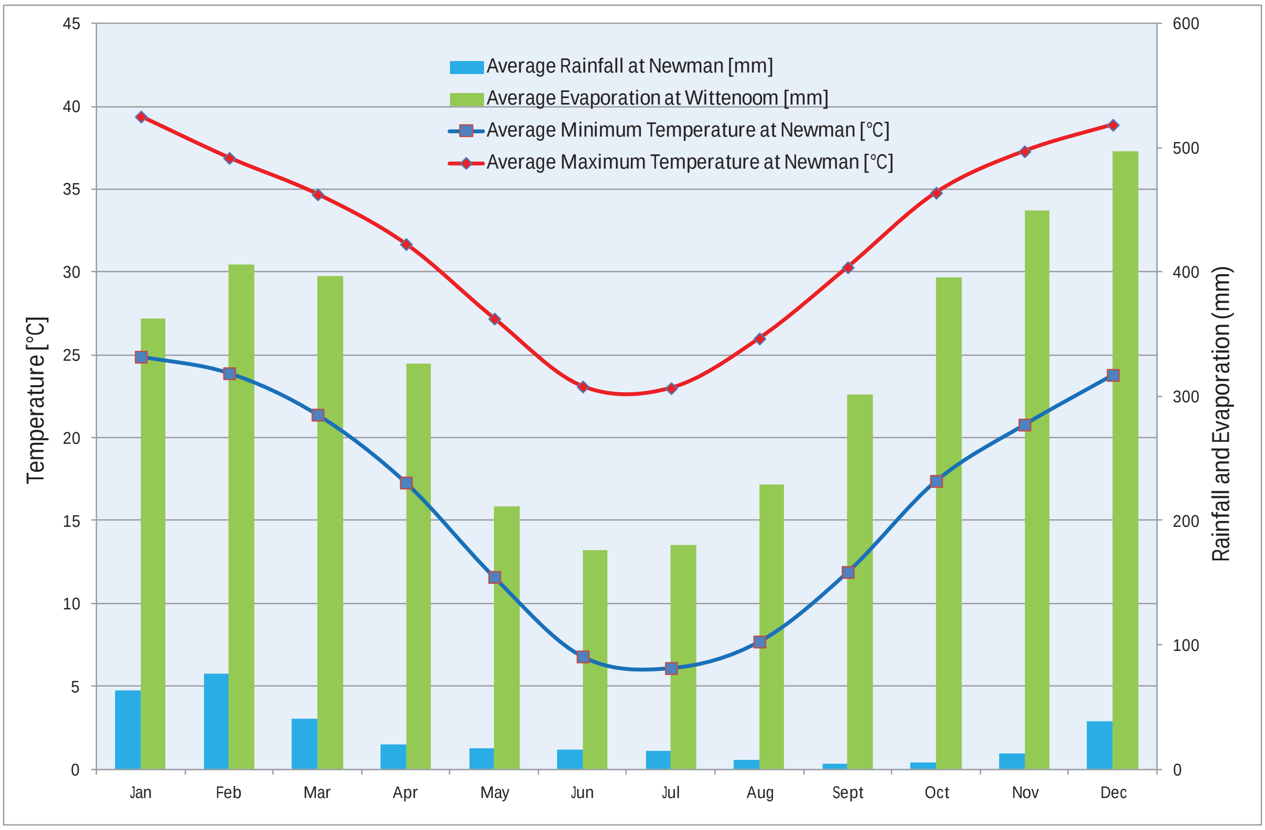

Plate 1: Mean Monthly Climate Characteristics

2.2.1 Geochemical Characteristics

Ore

The Christmas Creek ore predominantly consists of a mixture of hematite, goethite and martite (Fortescue 2013a). The ROM ore is approximately 57% iron.

Waste Rock and Tailings

A number of geochemical characterisation studies have been recently undertaken at Christmas Creek. They are included in Appendix 3, and summarised below.

Geochemical Assessment of Waste Material – Christmas Creek Mine

URS Australia Pty Ltd (URS) were commissioned by Fortescue to complete a preliminary geochemical waste assessment Christmas Creek. Static Acid Base Accounting (ABA) and multi-element solids and leachate laboratory testing was undertaken on 208 waste rock samples and two tailings samples (URS 2014, Appendix 3A).

The test work followed the ABA methodology, whereby the acid generation capacity of the sample material is calculated by determining the maximum potential acidity (MPA) that can be generated from the oxidation of sulphide minerals relative to its acid neutralising capacity

(ANC). The difference between the MPA and ANC value is referred to as net acid producing potential (NAPP).

On the basis of the ABA results, samples may be classified into one of the following categories (AMIRA 2002):

- Barren
- Non-acid Forming (NAF)
- Potentially Acid Forming (PAF)
- Uncertain.

No waste rock or tailings samples were classified as PAF. Based on the review of the analytical results for ABA, one waste rock sample was classified as NAF, while the rest of the samples were classified as NAF (Uncertain). The majority of samples also had total sulphur values below 0.1%S, and were therefore classified as Barren. The tailings sample was classified as NAF (Uncertain) and Barren. As such, the tailings and waste rock materials represented by the samples analysed are therefore considered unlikely to generate acid drainage resulting in environmental impact or requiring management.

To assess the potential for elemental enrichment, tailings and waste materials solid samples were tested for multi-element composition. The results are compared to standard median soil abundance values to evaluate the extent of elemental enrichment, which is reported as a geochemical abundance index (GAI) value. In general, a GAI of 3 or greater is considered as enrichment to a level that may warrant further examination to assess their environmental significance. Testing showed that Fe was enriched in the majority of samples, with a GAI of 3 recorded. This is as expected for a mining operation targeting iron ore. No other metals or metalloids were recorded at levels greater than a GAI of 2.

Multi-element analyses for the total metals concentration of waste materials were compared to *Department of Environment and Conservation Contaminated Sites Management Series Guidelines – Assessment Levels for Soil, Sediment and Water* (DEC 2010). The criteria chosen are the interim sediment quality guideline values (ISQG). The waste rock and tailings materials tested did not exceed WA DEC (now Department of Parks and Wildlife - DPaW) ISQG high trigger values for soils and sediments for the majority of metals. The only exceptions were:

- As was reported above the ISQG high trigger value in three waste rock samples
- Ni was reported above the ISQG high trigger value in 39 waste rock samples.

These metals are commonly found enriched in the vicinity of the ore zones of iron ore deposits and BIF materials in the Pilbara, and none were recorded above a GAI of 3.

In addition to the net acid generating (NAG) and NAPP values (and ANC/MPA ratio) which provide an indication of the potential for acid generation from a sample, metal leachability tests

were conducted to predict the potential for metalliferous and/or saline drainage. The leachate values have been compared to the *Australian and New Zealand Environment and Conservation Council (ANZECC) Guidelines for Fresh and Marine Water Quality* (ANZECC 2000) trigger values for the protection of freshwater species in slightly to moderately disturbed ecosystems in upland rivers. These triggers values are not considered relevant given the primary receptor is the Fortescue Marsh, which is a hypersaline feature.

TDS ranged from less than the limit of reporting to 194 mg/L indicating that the leachates are non-saline. The pH ranged from 6.08 to 9.04 indicating neutral to moderately alkaline conditions in the leachates. This is an indication that the waste rock materials tested are considered unlikely to cause saline or acidic drainage.

The results of the leachate testing indicated that the waste rock and tailings samples reported concentrations below the ANZECC trigger values except for Al, As, B, Cd, Cr, Cu, Pb, Mn, Hg, Ni and Zn. Draft site specific assessment criteria has since been developed for the mine, but given no analytes were above the GAI, a comparison of the leachate concentrations with the site specific assessment criteria is not considered necessary.

Full details of the tests conducted and results are provided in the report by URS (2014) (Appendix 3A).

Vasse Waste Rock Storage Facility and Eyre Pit

Tetra Tech was engaged to conduct preliminary representative geochemical and geotechnical characterisation of the Christmas Creek Mine Site in 2012 (Tetra Tech 2013, Appendix 3B). Tetra Tech conducted the characterisation on samples taken from the Vasse Waste Rock Storage Facility (WRSF) and the Eyre Pit.

Ten bulk samples of in situ waste rock material were collected from the Eyre Pit for geochemical analysis. Bulk samples of waste rock material were collected at the Vasse WRSF from 29 test pits. Only the samples taken from the Vasse WRSF were subject to both geochemical and geotechnical characterisation.

All samples were analysed for total element concentrations, to identify metals or metalloids of potential concern, and assessed for leaching potential with simulated precipitation according to the Australian Standard Leachate Procedure (ASLP). In addition, acid-base accounting was conducted on 65 samples in order to predict the potential acid drainage. A total of eight samples were also investigated by quantitative x-ray diffraction (XRD).

A visual inspection of the excavated rock indicated that the Vasse WRSF appears to be relatively homogenous with respect to lithological/mineralogical components. Mineralogical analysis of the sampled waste rock from both the pit and WRSF identified predominantly iron oxide minerals, as expected.

Elemental analysis of the samples revealed the waste rock to have a low sulphur content and the associated calculations indicate that the waste has a low acid generation potential. The results of the elemental analysis were screened to identify elements with relatively high concentrations as compared to average crustal abundance. This method identified two elements with notionally high concentrations; these being arsenic and antimony.

ASLP analysis of the waste rock samples identified relatively high concentrations of aluminium, cadmium, chromium, lead and zinc in multiple samples.

Polarised Light Microscopy identified no asbestiform materials.

A preliminary review of the Christmas Creek groundwater chemistry revealed that statistically significant changes have been seen in the results for Barium, Iron and Zinc; each appearing to have increased over time. The groundwater concentrations for Ba and Zn are below the newly-developed site specific trigger values for the mine. The mean post disturbance concentration for Ba (0.055 mg/L) is less than the draft site specific trigger value of 0.16 mg/L. The mean post disturbance concentration for Zn (0.035 mg/L) is less than the draft site specific trigger value of 0.51 mg/L. An ongoing groundwater monitoring program will be undertaken in accordance with the approved *Christmas Creek Groundwater Operating Strategy* (CC-PH-HY-0002).

This report also presents the geotechnical analyses of the samples collected from the Vasse WRSF. The analytical tests included Moisture Content, Particle size distribution, Atterberg Limits, Emerson Crumb Dispersion, Falling Head Permeability, Direct Shear, Consolidation Oedometer, Triaxial shear, Slake Durability, Moisture/Density Relationship.

Full details of the tests conducted and results are provided in the report by Tetra Tech (2013) (Appendix 3B).

Windich Waste Rock and Tailings Assessment

Golder Associates Pty Ltd (Golder) was engaged to undertake a preliminary assessment of the potential for acid and metalliferous drainage (AMD) from the deposited tailings and waste rock for the Windich in-pit tailings storage facility located at Christmas Creek. The information in the Golder (2013) report has been used as an analogue for in-pit tailings at the proposed expanded Christmas Creek as similar materials will be used.

The focus of the program was on the acid generating potential and metalliferous leaching potential of the waste rock and tailings. Tailings samples and the waste rock samples were collected from the existing ore processing facility (OPF) and waste stockpiles.

The following tests were carried out on these samples:

- Mineralogical analysis using XRD
- Chemical composition of solids (total elemental analysis)

- ABA plus paste pH testing
- Net acid generating (NAG) testing
- Short term leach tests using the synthetic precipitation leaching procedure (SPLP)
- Tailings water quality testing (tailings supernatant).

A summary of the findings was that the waste rock samples and the tailings samples have a low potential to produce acidic drainage and will most likely produce neutral drainage are based on the following:

1. No sulphides were identified during mineralogical analysis.
2. Measured total sulphur concentrations were very low to low (0.037% to 0.169%).
3. Average NAG pH values and paste pH values were both neutral.
4. Leachate and tailings supernatant samples were neutral to slightly alkaline.
5. Tailings samples are classified as NAF.
6. Waste rock samples are classified as NAF or Uncertain-PAF.

Full details of the tests conducted and results are provided in the geochemical characterisation report by Golder (2013) (Appendix 3C).

2.3 Landscape

2.3.1 Biogeography

The Interim Biogeographic Regionalisation of Australia (IBRA) bioregions are defined as large land areas characterised by broad, landscape-scale natural features and environmental processes that influence the functions of entire ecosystems. Their purpose is to capture the large-scale geophysical patterns that occur across the Australian continent (Thackway & Cresswell 1995). These patterns influence fauna assemblages at the broad scale.

The Proposal area is located in predominantly in the Fortescue Plains subregion of the Pilbara bioregion (DoE 2013b). A small section of the Proposal area is situated in the Chichester subregion, also part of the Pilbara bioregion (Figure 6).

The Fortescue Plains subregion comprises mainly alluvial plains and river frontage, with extensive salt marsh, Mulga-bunch grass, and short grass communities on alluvial plains in the east and deeply incised gorge systems in the west (Kendrick 2001). An extensive calcrete aquifer (originating within an ancient drainage valley) feeds numerous permanent springs in the central Fortescue, supporting large permanent wetlands with extensive stands of river red gum and cadjeput Melaleuca woodlands. A key feature of the Fortescue Plains subregion is the Fortescue Marsh (Kendrick 2001).

The Chichester subregion is underlain by the northern section of the Pilbara Craton, and comprises undulating Archaean granite and basalt plains include significant areas of basaltic ranges (Kendrick & McKenzie 2001). The extensive plains support a shrub steppe characterised by *Acacia inaequilatera* over *Triodia wiseana* (formerly *Triodia pungens*) hummock grasslands, while *Eucalyptus leucophloia* tree steppes occur on ranges (Kendrick & McKenzie 2001).

2.3.2 Land Systems, Landforms and Soils

An inventory of the Land Systems occurring in the Pilbara region was completed by van Vreeswyk *et al*. (2004). The Land Systems present in the vicinity of the Proposal area are:

- McKay Land System – hills, ridges, plateaux remnants and breakaways of meta sedimentary and sedimentary rocks supporting hard spinifex grasslands
- Newman Land System – rugged jaspilite plateaux, ridges and mountains supporting hard Spinifex grasslands
- Jamindie Land System – stony hardpan plains and rises supporting groved Mulga shrublands, occasionally with Spinifex understorey
- Boolgeeda Land System – stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands and Mulga shrublands
- Turee Land System – stony alluvial plains in the vicinity of the Fortescue Marsh supporting tussock grasslands
- Cowra Land System – plains fringing the Marsh Land System and supporting snakewood and Mulga shrublands with some halophytic undershrubs
- Warri Land System – low calcrete platforms and plains supporting Mulga and Senna shrublands
- Marsh Land System – lake beds and flood plains subject to regular inundation supporting Samphire shrublands, salt water couch grasslands and halophytic shrublands
- Calcrete Land System – low calcrete platforms and plains supporting shrubby hard spinifex grasslands on alluvial plain.

The dominant land systems within the Proposal area are the Newman, Jamindie and Turee land systems (Figure 7).

The predominant soils of the region are Tertiary aged colluvium, characterised by angular fragments of Banded Iron Formation (BIF), chert and shale. The hill flanks consist of ferruginous gravely soils that form extensive sheets of scree. The floodplains of the Fortescue Valley have sheets of silty and sandy soils with clay contents increasing in the low lying areas of the Fortescue Marsh.

3. SOCIO-ECONOMIC SETTING

3.1 Social Setting

The Proposal area is located within the Shire of East Pilbara within the Pilbara Region. Almost half of the population resides in Newman, located approximately 111 kilometres (km) south of the Proposal Area. The economic base of Shire of East Pilbara is mining and pastoral grazing. There are a number of other mines in the Fortescue Marsh area, being:

- Cloudbreak, located immediately to the west of the Proposal area
- Roy Hill (proponent, Hancock Prospecting, located immediately east of the Proposal area)
- Marillana (proponent, Brockman Resources, located on the southern side of Fortescue Marsh).

The closest residence is the Roy Hill Station located approximately 18 km from the Proposal area.

3.1.1 Land Use

The land uses in the vicinity of the Proposal area are pastoral and mining.

3.1.2 Conservation Areas

There are currently no areas of conservation tenure located in proximity to the Proposal Area (i.e. within 20 km). DPaW is proposing that portions of the Mulga Downs, Hillside, Marillana and Roy Hill stations associated with the Fortescue Marsh be excluded from the renewal of pastoral leases in 2015 and be added to the conservation estate or managed by conservation agreement (EPA 2013d) (Figure 8). Parts of the existing Christmas Creek Mine fall within the proposed conservation estate. Potential impacts to the proposed conservation areas as a result of the Proposal are addressed in Section 9.7.

3.1.3 Other Tenure

The Proposal is located on the Hillside, Roy Hill and Bonney Downs Pastoral Leases. These areas are shown on Figure 8.

3.2 Heritage and Native Title

3.2.1 Native Title

The Proposal is located entirely within the Nyiyaparli Native Title boundary (WCO5/6). In October 2005, Fortescue secured a Land Access Agreement (LAA) covering all the claim area of the Nyiyaparli people.

Issues of native title and Aboriginal heritage are managed through this agreement, including: financial and non-financial obligations; environmental and Aboriginal heritage obligations; and consultation provisions.

3.2.2 Aboriginal Heritage

The Fortescue-Nyiyaparli LAA includes comprehensive provisions about cultural heritage protection, detailing how Fortescue and the Traditional Owners will deal with heritage matters. The LAA sets out how heritage surveys are conducted as well as the consultation process in the event that Fortescue needs to make a section 18 application to use land containing a heritage site.

In line with Fortescue's LAA with the Nyiyaparli People, Fortescue consults regularly with the Traditional Owners over all aspects relating to the identification, protection and management of their cultural heritage, consistent with the Cultural Heritage Principles agreed between Fortescue and the Traditional Owners as set out in the LAA. The Nyiyaparli People have established a Heritage Subcommittee to consult with Fortescue over heritage matters. Fortescue will continue to consult with the Nyiyaparli people throughout implementation of the Proposal.

Aboriginal heritage surveys (archaeological and ethnographic) continue to be conducted in and around the expansion area and during construction activities at Christmas Creek. Heritage surveys have been undertaken across the wider Chichester area (Cloudbreak and Christmas Creek) since 2003. For Christmas Creek, approximately 530 archaeological heritage place and one ethnographic heritage place remains in situ within the Proposal area. Approximately an additional 680 archaeological heritage places have been salvaged during Christmas Creek development. These places comprise artefact, mythological, repository, ceremonial, grinding patch, scarred tree, rock shelter, reduction and quarry places.

Direct Disturbance to Land

All new ground disturbances require a Fortescue Ground Disturbance Permit (GDP) prior to works commencing. All areas of proposed ground disturbing activities are subject to both archaeological and ethnographic survey prior to approval of a GDP. The aim of these surveys is to identify whether Aboriginal heritage sites and other heritage places exist, and if so, the extent

and significance of these heritage places so that Fortescue can minimise impacts to heritage during planning.

Aboriginal Heritage Place Delineation

Aboriginal heritage place perimeters are identified by the Archaeologists and Traditional Owners during heritage surveys and demarcated using pink/black survey tape tied to shrubs and trees. This is the accepted marker for Aboriginal heritage place boundaries across Fortescue project areas. In areas of proposed activity, the Heritage team then returns to these places and installs fencing markers using star pickets with pink/black heritage flags on pins. Prior, or during this return visit, the heritage place is assessed for any potential impact that may result from the proposed scope of works specified in the relevant GDP and additional conditions may be applied to approval to mitigate risk of impact.

Approved Disturbance to Aboriginal Heritage Sites

Where identified Aboriginal heritage sites meeting AH Act criteria cannot be avoided by mining operations, the Fortescue will apply to the Minister for permission under section 18 of the AH Act to use the land containing the Aboriginal heritage site.

The Minister may grant consent or deny the application to use the land containing Aboriginal heritage site(s) and may impose conditions on the consent including the condition to salvage a site or to conduct further recording and analysis.

Once section 18 consent has been received, the required mitigation is completed prior to disturbance work proceeding.

Blasting

Blasting regularly carried out during mining and construction activities has the potential to impact heritage sites in close proximity. Fortescue has developed a blasting procedure for application near Aboriginal Heritage sites. The procedure ensures that risks associated with fly rock and blast vibrations are managed appropriately to avoid impact to Aboriginal heritage sites.

Disturbance by Personnel

Fortescue does not consider unauthorised visitation to Aboriginal heritage places to be a significant issue for the Proposal. Construction/mining workers are managed with a series of management controls in place including inductions, training and the clear delineation of heritage sites.

Fortescue has a comprehensive staff education program which raises awareness of Aboriginal cultural heritage. It is company policy that all personnel working on Fortescue projects attend a general site induction prior to commencement of work. At Christmas Creek, which includes Aboriginal engagement/Cross Cultural Awareness training as compulsory for all Fortescue employees.

Indirect Disturbance

Alteration of surface water flow may potentially affect Aboriginal Heritage sites through erosion. Erosion is a common process in the Pilbara due to the intense nature of cyclonic rainfall events and the lack of vegetation that holds soil in place. This is shown by the high turbidity of surface flows. Reducing the area over which a stream can spread in a storm event by construction of mining landforms can result in an increase in stream velocity, and hence erosion potential around the location of the change. If large enough, these changes could potentially result in erosion of Aboriginal heritage sites such as middens or artefact scatters.

Analysis of changes to stream velocity in the 1 in 5, 1 in 20 and 1 in 100 year storm events was undertaken by Worley Parsons (2014) (Section 7). The impact of the proposed mine layout in 2017 compared to 2013 (existing scenario) on these flood events was modelled. The primary impacts of these changes are a temporary reduction in channel flow in some areas, and some areas that were formerly wet around becoming dry. These post-development changes are more likely to result in a decrease in erosion than an increase, and so no indirect impacts to Aboriginal Heritage site are expected as a result of the Proposal.

3.2.3 Non-Indigenous Heritage

In Western Australia, the *Heritage of Western Australia Act 1990* provides for the conservation of places identified to have significance to the cultural heritage of the State. Under the Act, places identified as meeting the criteria outlined in Section 47 are placed on the State Register of Heritage Places. Places of Commonwealth heritage significance are protected under Part 15 of the EPBC Act and include World Heritage properties, National Heritage places and Commonwealth Heritage places.

A search of the State Register of Heritage Places was conducted in May 2014. The State Register recognises the value and importance of heritage places value to Western Australia and is managed by the Heritage Council.

No non-indigenous heritage sites were identified as occurring or expected to occur within the Proposal Area.

4. PROJECT DESCRIPTION

4.1 Existing Operations at Christmas Creek

Mining commenced at Christmas Creek in 2008. Existing mine operations at Christmas Creek are being undertaken in accordance with Ministerial Statements 707 and 871.

Mining at Christmas Creek is carried out using a combination of conventional open pit truck and shovel mining and open pit strip mining, progressively opening new pits and backfilling completed pits. This method minimises double-handling of overburden and allows for progressive closure and rehabilitation. The overall mine process is summarised as follows:

1. Mine pit designs and schedules are developed from geological data to optimise recovery according to market requirements. Mine planning is undertaken in a number of ways, such as:
    - life of mine planning; long-term planning
    - two to five-year planning; medium-term planning to allow responsiveness to market conditions and more detailed geological data
    - short-term planning; allows scheduling of mining activities on a short-term basis, to allow for equipment and contractor management in current work areas.
2. Prospective mine areas are subject to grade control drilling, to further define the resource prior to mining.
3. Mine areas are cleared of vegetation and pre-stripped of topsoil. Vegetation and topsoil are stockpiled for use in rehabilitation activities.
4. Overburden is removed, primarily using excavators, using drilling and blasting where required. Overburden is then taken by truck to permanent storage areas or backfilled into the mined-out sections of the pit.
5. The CCWMS allows for mining of ore below the natural water table and consists of a number of dewatering bores which lower the groundwater level in mining areas. Abstracted groundwater is piped to various storage ponds, settlement ponds or transfer ponds, from where it is either re-used on site or injected into various aquifers via a network of injection bores.
6. Ore is mined from various pits using surface miners and excavators.
7. Ore is transported to various run of mine (ROM) pads by truck, from where it is sent for crushing, either at a remote crushing hub (RCH) or at crushing facilities near the OPFs.
8. Ore is processed through one of the two OPFs, or using mobile crushing and screening facilities operating at Christmas Creek.
9. Tailings produced in the OPFs are currently piped to tailings storage facilities (TSFs). These TSFs are located in and above mined-out pits. Tailings slurry is deposited into the TSF via a

series of spigots. The tailings settle over time, with excess supernatant water being decanted for re-use or evaporated.

10. Processed ore is placed in train carriages using a train loader, for transport to Port Hedland via the existing Fortescue rail network.
11. Once mining is completed in a pit and backfilling is undertaken to a level above the natural groundwater level, the pit is contoured and rehabilitated, as are any external above-ground WRSFs.

Christmas Creek currently produces a fines ore product. Approximately 50 Mtpa of product is produced along with 213 Mtpa of waste rock and 4 Mtpa of tailings. Up to 50 GL/a of dewatering is approved, with up to 42.5 GL/a permitted to be injected into the aquifers.

4.2 Proposal Overview

The Proposal involves increasing the rate of ore production to allow peaks of up to 85 Mtpa. Mine life has been modelled for 14 years to 2028, and the mine footprint will expand from 10,135 ha to approximately 17,956 ha within a 33,000 ha Development Envelope.

The Proposal also involves:

- abstraction and injection of up to 110 GL/a of groundwater (an increase of up to 60 GL/a)
- construction and operation of additional TSFs and WRSFs
- construction and operation of additional conveyors and haul roads for ore transport
- construction and operation of additional surface water management infrastructure.

4.3 Key Characteristics

A summary of the Proposal is provided in Table 3, with key physical and operational characteristics of the Proposal summarised in Table 4 and Table 5.

Table 3: Proposal Summary

Proposal Title	Christmas Creek Iron Ore Mine Expansion
Proponent Name	Fortescue Metals Group Limited
Short Description	The proposal is for the expansion of the Christmas Creek Mine and includes modification/expansion or development of additional: • mine pits • ore stockpiles • remote crushing hubs and conveyors • mobile crushing and screening • OPFs and train loading facilities • WRSFs • TSFs • growth medium storage areas • power station and power distribution infrastructure • roads and borrow pits • surface water management infrastructure • water bores, injection borefields, reticulation, transfer, storage and settlement ponds, evaporation basins and pipeline infrastructure • desalination facilities • accommodation facilities and wastewater treatment plants • bulk and satellite fuel storage • laboratory, warehouses, laydown area, workshops, washdown facilities, maintenance facilities • explosives and chemical storage • administration buildings • communications infrastructure • laydown and storage facilities.

Table 4: Physical Elements

Element	Location	Existing Approval	Proposed Extent
Mine pits and associated infrastructure	Figure 9 Mine Development Envelope, Disturbance Footprint and Mine Infrastructure Zones	Statement 707 Clearing up to 10,135.5 ha Development envelope undefined	Clearing of no more than 17,956 ha Development envelope of 33,000 ha (includes the injection zone)

Table 5: Operational Elements

Element	Location	Existing Approval	Proposed Extent
Dewatering	Figure 10 Indicative Injection and Dewatering Zones	Statement 871 Up to 50 GL/a	Up to 110 GL/a
Water Supply	Figure 10		Up to 35 GL/a, supplied from mine dewatering, desalination, transfer from nearby mine sites and an external water supply borefield.
Injection of surplus water from dewatering	Figure 10 Indicative Injection Zone	Statement 871 Up to 42.5 GL/a	Up to 110 GL/a of surplus water.
Waste rock	Figure 9 Indicative Waste Rock Zone		Disposal of up to 322 million tonnes per annum (Mtpa) to WRSFs to a life of project maximum of 3,800 million tonnes. *Note: approximately 213 Mtpa of waste rock is currently produced at the existing operation.*
Tailings	Figure 9 Indicative Tailings Zone		Disposal of up to 11 Mtpa to TSFs to the life of project maximum of 144 million tonnes. *Note: approximately 4 Mtpa of tailings is currently produced at the existing operation.*
Mine pits	Figure 9	Statement 707 Pit Backfilling is an approved activity	Mine pits will be backfilled to at least above pre-mining water table.

4.4 Proposed Disturbance

The Proposal incorporates an increase of the approved disturbance area, from 10,135.5 ha to 17,956 ha. The additional disturbance of 7,821 ha, consists of up to 7,752 ha of native vegetation and 69 ha of land previously disturbed under existing approvals. These previously disturbed areas include land cleared by external parties (mainly pastoral stations), and land cleared by Fortescue under other approvals, such as Native Vegetation Clearing Permits or Programmes of Work. The Development Envelope, existing approved footprint (consisting of both the disturbance undertaken to date and the planned disturbance under existing approvals) and the Proposal area (an indicative disturbance footprint) are shown in Figure 2.

4.5 Implementation of Existing Approvals

Existing primary approvals for the Christmas Creek Mine and CCWMS, gained under both the EP Act and EPBC Act, will continue to be implemented, as approved, for the duration of the assessment of this Proposal. This includes:

- Ministerial Statement 707
- Ministerial Statement 871

- EPBC Controlled Action 2010/5706.

4.6 Schedule

The Proposal will commence immediately following approval, and will be progressively implemented. There are no defined stages of expansion associated with the Proposal.

4.6.1 Minor or Preliminary Works

It is anticipated that some Minor or Preliminary Works approvals may be required prior to approval being granted under Part IV of the EP Act. If required, request for EPA consent to Undertake Minor or Preliminary Works, will be made in accordance with Section 41A (3) of the EP Act. Activities which are likely to be subject to a request include:

- construction of dewatering and injection infrastructure (including pipework, transfer/settlement ponds and bores)
- advance dewatering of near-future mining areas.

4.7 Ore Reserves

The Chichester Ore Reserve as at June 30, 2013, (incorporating both Christmas Creek and Cloudbreak operations), was 1,517 Mt, at an average iron (Fe) grade of 57.6%, (Table 6). Approximately 30% of this tonnage is proved ore reserve.

Ore Reserves for the operating properties are stated on a dry product basis and exclude stockpiles. Company production and sales reporting is based on wet tonnes with a typical free moisture content of 9%, as shipped. The 2013 Ore Reserve estimates reflect:

- updates to the various resource models
- ongoing reconciliation with ore sales
- the long term marketing and product strategy
- impacts of ore beneficiation through wet processing plants
- synergies arising from producing a blended product from multiple sites and ore types.

Table 6: Chichester Ore Reserves as at June 2013[1]

Category	Product Tonnes (Mt)	Iron Fe%	Silica SiO_2%	Alumina Al_2O_3%	Phos P%	Loss on Ignition (LOI%)
Proved	449	57.6	5.01	2.27	0.045	8.1
Provable	1,069	57.6	4.74	2.47	0.048	7.9
Total	1,517	57.6	4.82	2.41	0.047	8.0

Ore Reserve table notes:

(a) The Chichester Ore Reserve includes the Cloudbreak and Christmas Creek deposits.

(b) The diluted mining models used to report the 2013 Ore Reserves are based on updated Chichester Mineral Resource models reported in 2012. Diluted mining models are validated by reconciliation against historical production.

(c) The increase in Proved Ore Reserve reflects the increase in the proportion of higher confidence Measured Mineral Resource associated with ongoing infill drilling.

(d) Typical feed upgrade factors through Chichester wet OPFs are Fe 1.025, silica 0.80, alumina 0.75 with a mass yield of 84%.

4.8 Material Balances

The materials balance and processing amounts associated with the current mine plan at Christmas Creek are provided in Table 7 and Table 8. The tables show indicative volumes only, actual volumes will be dependent on market requirements and fine-scale resource definition determined using infill drilling which is undertaken in advance of mining commencing in each new pit area.

Table 7: Indicative Materials Balance

	Average Annual (Mtpa)	High Annual (Mtpa)	TOTAL to 2028 (Mt)
Ore	55	66	889
Overburden	201	263	3,221
Internal Waste	38	59	600

Short-term peaks in ore production may occur, up to a run rate of 85 Mtpa.

Table 8: Processing Amounts

Milestone	Average Annual (pa)	High Annual (pa)	TOTAL to 2028
Product (Mt)	46	55	745
Tails (Mt)	9	11	144
Tails (Mm^3)	6	7	96

[1] Tonnage figures have been rounded and as a result the figures may not add up to the totals quoted.

4.9 Proposal Description

A summary of the overall process involved in operation of the Proposal is provided below.

4.9.1 Pit Sequencing and Configuration

Fortescue has developed a pit sequence for mining in order to deliver an iron ore product that meets customer specifications. Product is mined and blended to provide the required target ROM ore, product tonnages and grades for each year of the life of mine. This blending optimisation ensures maximum possible resource utilisation. An indicative pit sequence is shown in Figure 11.

Overland conveyors may be installed over a number of stages as mining moves across the ore body to transport ROM ore to the OPF (Figure 3). Westward movement of mining along the ore body will necessitate establishment of satellite hubs to support the mining activities.

4.9.2 Pre-Stripping

The total area of disturbance at Christmas Creek will be up to 17,956 ha, of which 10,135 ha is already approved for disturbance. Pre-stripping is required to remove vegetation and topsoil prior to the commencement of mining activities. Vegetation and topsoil are generally removed together and the material removed is either transported to areas of active rehabilitation or stockpiled for future use. Areas subject to weed infestations will be cleared separately and the soil and vegetation from these areas will be buried to prevent further weed infestations.

4.9.3 Christmas Creek Water Management Scheme

About 70% of iron ore at Christmas Creek is below the water table, and mine dewatering is undertaken to minimise water ingress into mining pits. Mining below the water table commenced in November 2011. Mine dewatering, including associated water management activities (the CCWMS) are approved under an Assessment on Proponent Information (API) approval (Ministerial Statement 871) granted in 2011.

The CCWMS as approved in 2011 involved increasing the amount of mine dewatering and the injection of abstracted groundwater within the Christmas Creek area to allow mining of iron ore to continue below the water table for a period of approximately five years. The scheme was implemented to meet the following objectives:

- to maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected

- to ensure that emissions do not adversely affect environmental values or the health, welfare or amenity of people and land uses by meeting statutory requirements and acceptable standards.

The main management measures include the following:

1. Reuse water on-site where possible to minimise use requirements.
2. Mitigate the extent of drawdown from mine dewatering by injecting excess water into two zones; one to the south, adjacent to Fortescue Marsh, and two areas to the east and west of mining operations.
3. Monitor groundwater bores for abstraction volumes, groundwater levels, electrical conductivity and chemical analysis.
4. Monitor surface water quality at major creek crossings and the Fortescue Marsh.
5. Monitor vegetation health for phreatophytic species, Mulga communities and samphire communities.

This management philosophy is proposed to continue for the expanded Proposal.

A detailed hydrogeological assessment of the Proposal was undertaken by Fortescue (2013a), and included the following elements:

1. Hydrogeological data and conceptual model for the groundwater and surface water hydrology.
2. The development of a numerical model.
3. The groundwater abstraction and injection management strategy.
4. The results of dewatering and injection simulations, including volumes and water level changes.
5. The method and results of sensitivity and uncertainty analysis.

To assess potential groundwater-quality impacts from the ongoing implementation of the CCWMS on the near-marsh environment, a 2-D numerical modelling assessment for the Chichester Range was undertaken. This work concluded that the groundwater salinity of the shallow aquifer, adjacent to Fortescue Marsh, is not significantly affected by mine dewatering and saline water injection.

Groundwater level recovery after mine closure was simulated and suggested that groundwater drawdown in the mining area decreases from over 35 m at the end of mining to about 5 m after ten years, and to about 3 m after 20 years. More detail on the hydrogeological assessment is provided in Section 7.

4.9.4 Mining Method

Drill and Blast

Drilling and blasting is used to allow areas of hard rock overburden to be removed. Drilling and blasting will be undertaken in accordance with current operational procedures, which generally incorporate the following steps:

1. A series of holes are drilled into the rock.
2. The holes are filled with explosives and detonated.
3. The rock breaks up or collapses after detonation and the rock rubble is then removed.
4. The cleared rock face is ready for drilling and the steps are repeated.

Approximately 40,000 tonnes of bulk explosives will be used per year.

Strip Mining

Mining will continue to be undertaken using the same mining methodology currently in place, consisting of conventional truck and shovel mining and strip mining. Typically, strip mining involves pits being developed in thin strips, around 150-200 m wide by 800 m long. Each mining area is mined to suit a particular set of constraints and requirements. As such, the following is a description of a typical mining sequence, and the specific activities will vary for each mining area.

When mining commences in a new pit, the overburden is removed from the first two adjacent strips and placed just beyond the ore body limits close to the last strip to be mined in the sequence. Ore is then mined from the first strip.

When the ore from the first strip is removed, the removal of overburden from the third strip commences and material is backfilled into the void of the first strip, while ore is mined concurrently in the second strip.

When the ore in the second strip is removed, removal of overburden from the fourth strip commences and material is backfilled into the void of second strip, while concurrently mining the ore in the third strip. This process progresses through the mining area.

When the ore from the penultimate strip is removed, waste from the first strip (stockpiled nearby) is backfilled into that void. When the ore from the last strip is removed, the remainder of the stockpiled waste from the first two strips is backfilled into the final void. Completed pits are backfilled at minimum to the pre-mining groundwater level. The strip mining process is shown diagrammatically in Plate 2. Waste rock and overburden material are generally removed using a combination of shovels, excavators and trucks. The majority of overburden is used to backfill completed pits. In some cases, permanent WRSFs outside of pit boundaries are required.

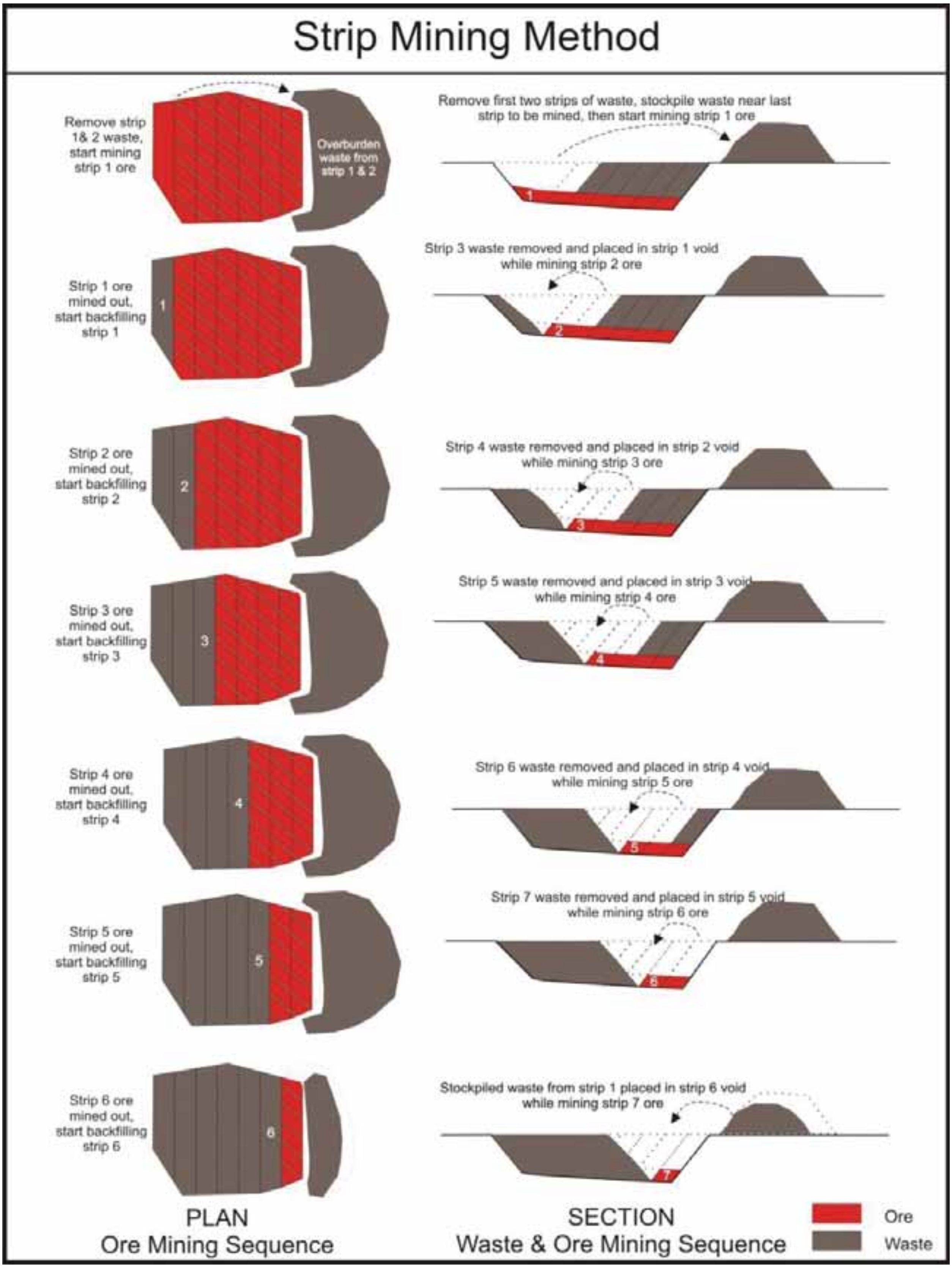

Plate 2: **Strip Mining Process**

Mining Equipment

Mining will continue to be undertaken using the same equipment used for the currently approved Project. The majority of ore and internal waste is removed using surface miners. Surface miners operate by cutting a shallow layer of ore (up to 650 mm in depth) and crushing the ore into a manageable size. Depending on the type of surface miner, the ore is either left in windrows for collection by dozers and front-end loaders, or is transported directly to trucks using an in-built conveyor. Ore which is not accessible to surface miners will be mined using excavators following the typical truck and shovel mining methodology.

Trucks transport the mined ore to a ROM pad. As part of the Proposal, trucks will be used to transport mined ore for shorter distances, and road trains or overland conveyors will be used for longer haul distances.

Mining equipment typically used on site includes:

- Wirtgen and Vermeer surface miners
- industry-standard large front-end loaders such as Caterpillar
- industry-standard excavators such as Terex and Komatsu
- industry standard large ‘off highway’ trucks and road trains such as Terex, Komatsu and Caterpillar.

4.9.5 Waste Rock Management

Waste rock is generally backfilled into mined out pits, as described in Section 4.9.4 . For areas where this is not practicable, external WRSFs are required. These facilities may be temporary or permanent. Additional external WRSFs will be required as part of the Proposal (Figure 9). Approximately 3,800 Mt of waste rock material from the mine will be sent to dedicated in-pit or external WRSFs. An average of 239 Mtpa of waste, including overburden and internal waste, will be produced at Christmas Creek. Highs of up to 322 Mtpa may occur. Actual movements of waste and ore are subject to change according to the product strategy and customer or market conditions.

Waste rock removed by surface miners is preferentially used in-pit for backfill purposes and is generally not used in external waste rock landforms.

4.9.6 Remote Crushing

An RCH currently operates approximately 6.5 km east of the main processing facilities at Christmas Creek (Figure 3). The RCH sizes the mined material to prepare it for processing in the OPF. The RCH consists of:

- ROM bin
- mineral sizer
- gyratory crusher
- crushed ore vault.

Once material has been crushed, it is transported to OPF2 by an overland conveyor.

4.9.7 Ore Processing

Ore Stockpiling and Management

ROM pads are used to store ore according to ore grade, and to allow some blending of ore to occur prior to processing. Small ROM pads are located adjacent to active pits. Ore is either trucked directly from the pit or from the small ROM pads to one of the two major ROM pads at Christmas Creek located directly north of the RCH and the OPFs (Figure 3).

Additional ROM pads will be developed adjacent to future pit areas and crushing hubs as part of the Proposal.

Mobile Crushing and Screening

Mobile crushing and screening facilities operate as required at Christmas Creek and are used for a number of purposes, such as:

- providing support for the OPFs in production of ore, during maintenance or shutdowns of OPFs and also during normal operations
- preparing construction materials for onsite civil earthworks and construction of onsite facilities, including roads, TSFs and ROM pads, and for blast-stemming materials
- producing crushed stemming material required for blasting activities.

Ore Processing Facilities

There are currently two OPFs in operation at Christmas Creek (Figure 3).

OPF1 produces a fines product, and consists of the following major components:

- primary crushing
- wet scrubbing
- wet screening plant
- crushing area (includes secondary and tertiary crushers)
- de-sanding plant (and tailings transfer)

- stockpiles for two ore products
- train loader.

OPF2 also produces a fines product, and consists of the following components:

- primary crushing (for surface miner and drill and blast ROM ore)
- coarse ore storage
- wet scrubbing of ROM feed
- wet screening plant
- jig plant (to remove shale material)
- crushing area (includes secondary and tertiary crushers)
- desanding plant (and tailings transfer)
- stockpiles for two ore products
- stacker
- reclaimer.

Products from both OPFs and any mobile crushing facilities are stockpiled and conveyed or trucked to the train loading station for transport to Port Hedland.

On average, approximately 55 Mtpa of ore will be processed (with highs up to 66 Mtpa). The OPFs will produce approximately 46 Mtpa of saleable fines product (with highs up to 55 Mtpa), along with an average of 9 Mtpa of tailings.

4.9.8 Tailings Management

Tailings are generally managed at Christmas Creek using either below or above-ground, in-pit TSFs. The existing TSFs are above the water table.

Whilst in-pit TSFs are still likely to be the preferred option, alternative tailings management methods have been investigated, which include in-pit below water table TSFs and stand-alone TSFs. These types of TSFs may be used at Christmas Creek, in addition to the in-pit above water table TSFs that have been used to date at Christmas Creek.

Tailings Properties

Tailings are produced by the OPFs, and generally comprise the physical properties outlined in Table 9.

Table 9: Tailings Properties

Item	Parameter
Slurry density ex-plant	48 - 56%solids (54% average)
Particle density	3.8 t/m^3
Final tailings Settled Density (average)	1.5 t/m^3
Particle size distribution	77% passing 75 microns and 2 microns
Plasticity Index	7%/low plasticity clay/silt
Hydraulic conductivity	1.0x 10^{-9} m/s
Tailings beach slope	1%

Tailings Storage Facilities

Fortescue currently operates three Tailings Storage Facilities at Christmas Creek:

- Vasse TSF
- Windich TSF1
- Windich TSF2.

The existing facilities are all constructed within mined-out pits. Vasse TSF currently incorporates tailings from OPF1 stored both below and above pre-mining ground level. The Windich TSFs currently provide below-ground storage of tailings from OPF2.

In the existing TSFs, deposition occurs from above the pre-mining water table only. For future TSFs which will be developed at Christmas Creek, Fortescue proposes to commence deposition of tailings below the pre-mining water table, where suitable.

The option for storage of tailings below the pre-mining water table has been investigated by SRK Consulting (Australasia) Pty Ltd (SRK) at an existing pit at Christmas Creek. This report has been used as an analogue for in-pit tailings storage across the proposed expanded Christmas Creek. The SRK (2014) report investigates three scenarios:

- Scenario 1: No backfilling of pit void (to gauge groundwater recharge)
- Scenario 2: Backfilling with waste rock to pre-mining water level and tailings above (permitted base case)
- Scenario 3: Backfilling from the base of the pit with tailings only (proposed alternative case).

The SRK (2014) report investigates the extent of the groundwater rebound based on current mining and production schedules, the prediction of the groundwater recovery with tailings deposition from the base of the pit and the potential impacts and mitigation measures required for the three scenarios.

Full details of the investigation is provided in the report by SRK (2014) (Appendix 4), with the following a summary of results.

The Scenario 1 (no backfilling) was modelled in order to determine baseline groundwater recharge characteristics. Not backfilling the pit would result in the formation of a pit lake that would represent an indefinite groundwater sink. Fortescue will ensure that all completed pits are filled with either waste or tailings to pre-mining groundwater level at minimum; as such Scenario 1 (no backfill) will not be progressed under this Proposal.

Neither Scenario 2 (backfill with waste/tailings), nor Scenario 3 (backfill with tailings only) are expected to result in a long term loss of groundwater. Both backfill scenarios are expected to cause localised groundwater mounding during operations, with a longer term dissipation of a phreatic surface that would persist in the tailings deposit above the water table. Due to the lower TDS concentration of the tailings, the TDS of the groundwater locally may be lowered. However, the effect is expected to be minimal.

SRK (2014) states that the consequences of implementing Scenario 3 (backfill with tailings only) for the Flinders pit would be indistinguishable from Scenario 2 (backfill with waste/tailings) and should not have any significant impacts on the regional groundwater system and its groundwater dependant ecosystems.

Fortescue will prepare a detailed design for each proposed tailings storage facility prior to the commencement of construction of the facility. Detailed design will incorporate assessment of geotechnical stability of the facility during construction and operation.

4.9.9 Services and Utilities

Accommodation

Currently, two accommodation camps are operated on site, Karntama Village and Christmas Creek Village, with a total capacity of 2,600 people. Minor upgrades and expansions to the existing accommodation facilities may be required as part of the Proposal.

Wastewater Management

Three licensed wastewater treatment plants are installed at Christmas Creek (Figure 3) and these plants treat wastewater generated at the accommodation camps. Treated effluent is either reused for dust suppression purposes or disposed of by irrigation.

Small wastewater treatment facilities, such as biomax units are also used for crib huts, workshops and office areas around the site. Effluent from these small units is either disposed into leach drains or transported to the licenced facilities for treatment.

No major changes to wastewater facilities are anticipated as a result of the Proposal. Any additional facilities or changes to existing facilities required will be managed under Part V of the EP Act.

Airport

The Graeme Rowley Aerodrome at Christmas Creek currently operates flights between Christmas Creek, Perth and other regional centres. The Aerodrome is located 3 km south-west of Karntama Village (Figure 3). No major airport infrastructure upgrades are anticipated to be required as part of the Proposal.

Buildings and Laydown Areas

The majority of the buildings, offices, washdown areas and workshops on site are located within two major areas, which are referred to as Central Contractors Yard 1 (CCY1) and Central Contractors Yard 2 (CCY2). CCY1 is located adjacent to the OPFs and CCY2 is located approximately 2 km east of the RCH (Figure 3).

Additional laydown areas, storage areas, heavy vehicle parking areas and contractor office areas will be located throughout the site, generally adjacent to active pit and work areas.

Fuel Storage and Refuelling

The major fuel supply areas at Christmas Creek are located at:

- bulk fuel storage facility (2 x 3.25 ML tanks)
- CC1 fuel farm (34 x 105 kL tanks)
- CC2 fuel farm (8 x 105 kL tanks).

Smaller volumes of fuel are also stored in Satellite Fuel Storage Facilities, generally located adjacent to active pit and work areas.

Expansion of the bulk fuel storage may be required as part of the Proposal. Additional Satellite Fuel Storage Facilities will be developed adjacent to proposed pits and work areas.

Explosives Storage

Explosives are stored at the Christmas Creek Magazine Compound and at the CC2 Ammonium Nitrate Facility. The Magazine Compound stores high explosives and detonators along with ammonium nitrate and diesel fuel, and is located 3.5 km south-east of the Karntama Village (Figure 3). The CC2 Ammonium Nitrate Facility stores ammonium nitrate and diesel fuel, and is located 5 km south-east of the RCH (Figure 3). Minor expansions of the existing Ammonium Nitrate Facilities may be required, and similar facilities may be developed in closer proximity to active mine areas as mining progresses.

Waste Management

Solid waste will be generated during construction and operational phases from clearing of native vegetation, disposal of chemical storage containers, plastic, paper, wood, scrap metal, tyres, rubber, batteries and domestic solid (including putrescibles) wastes.

Waste will be predominately disposed of in the existing onsite landfill, located 2 km south-east of Karntama Village, which manages up to 4000 t/a of waste (Figure 3).

Two bioremediation facilities are located at Christmas Creek, which will continue to be used for the management of hydrocarbon-contaminated soils on site.

Roads

Christmas Creek can be accessed by road from the Chichester Road, which links the site to the Marble Bar-Nullagine Road to the east, or via the Cloudbreak-Christmas Creek Road to the west.

Roads within Christmas Creek include light vehicle access roads and heavy vehicle haul roads. Roads are primarily unsealed. Additional haul roads and light vehicle access roads will be developed within the Development Envelope as part of the Proposal.

Communications

Primary communication at Christmas Creek is via UHF radio. A number of radio towers operate around the site to ensure adequate signal strength. Additional radio towers will be installed as part of the proposal.

Telecommunications including telephone, fax and internet are used across the site.

4.9.10 Resource Requirements

Water Supply

Up to 35 GL/a of potable and process water will be required for operation of Christmas Creek. Fresh and brackish water is currently sourced from abstraction for mine dewatering as part of the approved CCWMS. Water is also transferred between Christmas Creek and Cloudbreak, through the Hillside East borefield infrastructure.

As discussed in Section 4.2, additional fresh to brackish water sources are expected to be required to supplement the water supplied through the CCWMS. Additional sources of water include:

- expansion and operation of a desalination plant (included in this PER)
- an external borefield (would be subject to separate approvals)

- transfer of water from nearby mine sites (including Cloudbreak, as approved by EPA).

Desalination Plant

A reverse osmosis desalination plant may be required at Christmas Creek to provide fresh water for the washing of saline ore. If required, the desalination plant will likely be constructed around 2017.

The volume of desalinated water required will depend on the salinity of the ore at time of extraction and effectiveness of the washing process. This will be determined by trials prior to the construction of the desalination plant. The plant would utilise between 18 and 68 GL/a saline water (electrical conductivity between 6,000 and 150,000 µS/cm) and provide approximately 6 to 34 GL/a of fresh water (electrical conductivity less than 1,500 µS/cm), with the excess water being released as brine (electrical conductivity approximately 150,000 µS/cm). The brine will be combined with the saline water abstracted during mining and injected into the saline injection area.

The power demand of the desalination plant is estimated at 5 to 20 megawatts (MW) depending on the size of the plant.

Energy

The Christmas Creek Power Station, located south of OPF2 (Figure 3), is a diesel-fuelled power station which can produce up to 54 MW. The power station has been operating well below this approved maximum capacity. In 2013/2014, the power station produced 22.2 MW of power and in 2014/2015 it is currently operating at an annualised run rate of 27.3 MW. Minor upgrades or expansions to the power station will be required to support the proposed mining and processing activities, however, an increase to the existing capacity is not expected. Given that the power station is operating at a reduced capacity, additional power to support the proposed desalination plant would be able to be produced by the existing plant under current approvals.

5. ENVIRONMENTAL IMPACT ASSESSMENT METHODOLOGY

This section identifies the environmental factors relevant to the Proposal and overall assessment methodology. It also discusses consistency of assessment of the Proposal with the EPA Principles of Environmental Protection (EPA 2004a).

5.1 Key Environmental Factors

The key environmental factors for the Proposal were identified in the ESD (Appendix 1) prepared by the EPA (see Section 1.1). Table 10 lists the key factors, the Proposal component to which they are relevant, and the section of this environmental assessment document in which the impacts are considered.

Table 10: ESD Requirements Addressed in the PER

ESD Requirement	Relevant Section of the PER
General	
A separate section identifying MNES that occur or have the potential to occur within the project area, discussing how any potential impacts on MNES have been avoided and mitigated and discussing any proposed offsets to address significant residual impacts on MNES.	Section 12 and Section 14
Key Proposal Characteristics table informed by environmental factors.	Table 3, Table 4, Table 5
All technical reports, modelling and referenced documents (not currently in the public domain) used in the preparation of the PER should be included as appendices to the document	Appendices 1 to 7
Detailed assessment of each of the preliminary key environmental factors identified, namely: • flora and vegetation • terrestrial fauna • subterranean fauna • hydrological processes • inland waters environmental quality • rehabilitation and mine closure (integrating factor) • offsets (integrating factor)	Sections 7 to 14
Flora and Vegetation	
Detailed description of the cumulative impacts associated with the proposal, including direct impacts from clearing, and indirect impacts such as groundwater drawdown, groundwater mounding, surface discharge of excess groundwater, altered drainage, changes in water quality, dust emissions and fragmentation of vegetation.	Sections 9.5 to 9.8
Show how and to what extent clearing and indirect impacts will affect the 2015 Pastoral Exclusion Area proposed and agreed by Government to be acquired for conservation purposes.	Section 9.7.1
Figures showing the extent of clearing and indirect loss of vegetation and conservation significant flora species, including but not limited to threatened and/or priority ecological communities, declared rare flora, priority flora and new flora species.	Figure 44, Figure 47 to Figure 62
Consolidate vegetation and flora reports incorporating information from all relevant previous and new studies.	Section 9.3, Appendix 6
Level 2 flora and vegetation surveys in areas that are likely to be directly or indirectly disturbed as a result of the proposal including the proposed injection infrastructure zone. Details of the scope, timing (survey season/s) and methodology for surveys used must be provided. Follow up targeted surveys may be required based on the results of the baseline survey for conservation significant flora and vegetation.	Section 9.3, Appendix 6
Analysis of the extent of clearing and indirect impacts to assist in the determination of the significance of impacts, including impacts on vegetation units, threatened and priority	Section 9.7

ESD Requirement	Relevant Section of the PER
ecological communities, threatened and priority flora, species identified as significant consistent with Guidance Statement 51, vegetation units identified as significant consistent with Guidance Statement 51, groundwater dependent vegetation and proposed conservation reserve (2015 Pastoral Exclusion Area).	
Baseline mapping of weed affected areas in any area likely to be directly or indirectly impacted by the Proposal.	Section 9.4.10, Figure 45
Discussion of the proposed management, monitoring and mitigation methods to be implemented.	Section 9.9
Demonstrate that all practicable measures have been taken to reduce the area of the Mine Development Envelope based on progress in the proposal design and understanding of environmental impacts with a view to minimising impacts on other land users.	Section 9.6
Terrestrial Fauna	
Desktop study of information available to provide a comprehensive listing of vertebrate fauna and SRE invertebrate fauna known or likely to occur in the habitats present, and identification of conservation significant fauna species likely to occur in the area. Consideration of species listed under both the WC Act and the EPBC Act, and species listed by DPaW as Priority Fauna to include, but not necessarily be limited to the following threatened species: • Night Parrot (*Pezoporus occidentalis*) • Northern Quoll (*Dasyurus hallucatus*) • Pilbara leaf-nosed bat (*Rhinonicteris aurantia*, Pilbara form) • -Greater Bilby (*Macrotis lagotis*) • Olive Python (Pilbara subspecies) (*Liasis olivaceus barroni*) • Great Egret, White Egret (*Ardea alba*). • Any priority Fauna species Identified in a Level 1 survey as likely to occur in the proposal area. For each relevant conservation significant species, provide baseline information on their abundance (including known occurrences), distribution, ecology, and habitat preferences at both the site and regional levels.	Section 10.3 Appendix 7
Level 1 reconnaissance vertebrate and SRE invertebrate fauna survey and mapping of habitats including specialised habitats associated with Fortescue Marsh, identification and mapping of important, rare or unusual habitat types within areas to be impacted, in accordance with Guidance Statements 56 and 20. This should also consider other areas outside the proposed impact footprint to determine whether the most suitable areas have been chosen for location of infrastructure. Particular consideration should be given to habitat types that provide important ecological function e.g. riparian vegetation, protected area buffer zones, refugia, important habitat corridors, wetlands, areas of conservation significance or geological features which may support unique ecosystems.	Section 10.3 Appendix 7
Analysis of the extent of clearing, including percentages of habitat types to be cleared or otherwise impacted, to assist in determination of significance of impacts. Information, including maps, to differentiate habitat on the basis of use e.g. breeding habitat, migration pathways, feeding habitat. Consideration of whether the remaining habitat has adequate carrying capacity.	Section 10.7
Level 2 fauna surveys in areas likely to be directly or indirectly impacted as a result of the proposal. Surveys are to be undertaken in accordance with Guidance Statements 20 and 56 and, where available, species-specific survey guidelines for relevant species listed under the EPBC Act. Additional targeted surveys for conservation significant fauna as required.	Section 10.3 Appendix 7
For each relevant listed threatened species, provide: • information on the conservation value of each habitat type from a local and regional perspective, including the percentage representation of each habitat type on site in relation to its local and regional extent • if a population of a listed species is present on the site, its size and the importance of that population from a local and regional perspective and potential percentage loss of the conservation significant species locally due to loss of habitat.	Section 10.7 Table 52

ESD Requirement	Relevant Section of the PER
Discussion of known existing threats to the species, whether or not attributable to the proposed action, with reference to relevant impacts from the proposed action (including taking into consideration any relevant guidelines, policies, plans and statutory provisions).	Section 10.7
Discussion of potential direct/indirect (including downstream) and cumulative impacts to fauna as a result of the Proposal, and quantitative data on impacts of the proposal to species of conservation significance.	Section 10.8
Where vegetation to be cleared provides habitat for EPBC listed species, assessment of habitat quality in terms of site condition and context and species stocking rate, as described in the EPBC Act Offsets Assessment Guide.	Section 12.3, 12.5, 14
Detailed information demonstrating that an impact will not occur for all listed threatened species that are not likely to be impacted by the Proposal but for which suitable habitat is present and could be impacted.	Section 10.7, 12.5
Discussion of proposed management, monitoring and mitigation methods to be implemented including an assessment of the effectiveness of the methods, any statutory or policy basis for the methods.	Section 10.9, 12.7
Subterranean Fauna	
Conduct surveys within areas to be impacted and in surrounding areas in accordance with Guidance Statement 54a.	Section 11.3
Results of the subterranean fauna surveys and discuss the potential for direct and indirect impacts to subterranean fauna including consideration of altered water regimes and nutrient flows.	Section 11.6
Discuss proposed management, monitoring and mitigation methods to be implemented.	Section 11.8
Hydrological Processes	
Detailed description of the design and location of the proposal with the potential to impact surface water or groundwater.	Section 4
Characterisation of baseline hydrological and hydrogeological regimes.	Section 7.3
Conceptual model of the surface and groundwater systems, incorporating the extent of connectivity between surface and ground water systems. The modelling should be consistent with Australian Government National Water Commission's Australian Groundwater Modelling Guidelines (2012).	Section 7.3.4, 7.7.1
Discuss effectiveness of current water management scheme and provide comparison of its actual operation versus what was predicted including discussion of accuracy. Also detail any problems with how the system has operated and what management measures have been taken where it is not operating as expected.	Section 7.3.1, 7.3.4 Appendix 5
Investigation of groundwater drawdown, and mounding due to ground water abstraction and injection associated with the Proposal. Analysis and discussion of impacts to groundwater levels and flows taking into consideration the cumulative impacts with other proposals.	Section 7.6.2, 7.7
Have groundwater modelling independently peer reviewed at each stage of the modelling. Determine the following in consultation with the Department of Water: • the scope and timing of pump tests and surveys to determine geological cross sections • the scope and timing of each stage of the modelling • the selection of the independent peer reviewer.	Section 7.3.4, Appendix 5 Section 6
Analysis, discussion and assessment of surface water and groundwater impacts associated with the Proposal together with cumulative impacts with other projects and referred proposals (including the BHPBIO strategic proposal) for which relevant information is publicly available.	Section 7.7
Discuss the proposed management, monitoring and mitigation to prevent groundwater and surface water impacts as a result of implementing the proposal.	Section 7.8
Inland Waters Environmental Quality	
Characterisation of baseline hydrological regimes and water quality.	Section 7.3

ESD Requirement	Relevant Section of the PER
Conceptual model of the surface and groundwater systems, incorporating groundwater quality and the extent of connectivity between surface and ground water systems and Fortescue Marsh.	Section 7.3.4, 7.7.1
Hydrological investigation to determine what effect groundwater abstraction, injection, surface discharge and modified drainage will have on the surface water and groundwater quality and quantity of the area.	Section 8.6
Have hydrological modelling for this assessment independently peer reviewed at each stage of the modelling. The scope of the modelling, timing of each stage of the modelling and the independent peer reviewer should be endorsed by the Department of Water. The modelling should be consistent with Australian Government National Water Commission's Australian Groundwater Modelling Guidelines (2012).	Section 7.3.4, Appendix 5 Section 6
Undertake a comprehensive review of surface water and groundwater quality collected from the existing mining operation at the site. Identify any adverse changes caused by the mining operation and outline avoidance, minimisation and management methods to be used to prevent further impacts.	Section 8.3
Characterisation of waste rock and other materials and acid and metalliferous drainage risk assessment.	Section 8.6.3
Description of the design, location and extent of discharges of the proposed waste facilities, and any other elements of the proposal with the potential to impact surface water or groundwater quality.	Section 8.6.4 Figure 9
Model cumulative impacts with other mines in the catchment (currently operating and referred proposed mines, including the BHPBIO strategic proposal, where information is publicly available). Develop strategies and controls to minimise the impacts.	Section 8.7
Confirm whether or not pit lakes may form and provide details of potential backfill options. If pit lakes may form, provide an assessment of the long term contamination of any pit lakes remaining after mining and the potential impact on groundwater and surface water quality with particular attention to possible impacts on Fortescue Marsh.	Section 8.6.5
Discuss proposed management, monitoring and mitigation methods to be implemented during construction, operation and following closure to ensure that the EPA's objective for this factor is met.	Section 8.8
Rehabilitation and Mine Closure (Integrating Factor)	
Desktop study of successful and unsuccessful rehabilitation strategies and outcomes in similar geologies and vegetation types in the Pilbara. Including a discussion of the different methodology and success rates for the various proposed disturbance types including: • created landforms (e.g. waste rock dump, tailings storage facility) • short-term disturbances (e.g. borrow pits and access tracks) • long-term disturbances (e.g. construction camp, permanent accommodation village and administration buildings) • linear and/or fragmentation disturbances (e.g. roads, power lines, bore fields)	Section 13.2.3
Waste characterisation including static and kinetic test results and water quality monitoring results for drainage from existing waste storage facilities to enable a thorough assessment of Acid and Metalliferous Drainage risk posed by the project. If Potentially Acid Forming (PAF) material is identified, provide mine scheduling detail to demonstrate that PAF material is not disturbed during mining and/or that effective strategies will be in place to ensure PAF material is adequately managed should it be exposed and/or disturbed.	Section 13.2.4, 2.2.1, 8.6.3.
Physical characteristics of the waste materials and proposed locations and geotechnical design detail (including slope stability) for the waste landforms, including the WRSFs. Proposed management and monitoring for the waste landforms, and contingencies to make landforms secure and non-polluting in the event of unexpected or temporary closure	Section 13.2.4, 2.2.1, 8.6.3.
Prepare a Rehabilitation and Mine Closure Plan consistent with the Department of Mines and Petroleum (DMP) and EPA Guidelines for Preparing Mine Closure Plans. Include completion criteria and closure objectives addressing native vegetation and habitat for significant flora and fauna. Consult with the Department of Parks and Wildlife on rehabilitation and closure	Mine closure summary presented in Section 13. Full Draft MCP is

ESD Requirement	Relevant Section of the PER
objectives within the proposed conservation reserve. Establish and measure vegetation and fauna reference sites to inform completion criteria.	enclosed as Appendix 8E
Determine requirements for, and sources of, soil and seed for rehabilitation. A conclusive discussion on backfill options (including 'worst case scenario') is also required.	Section 13.4.1
If pit lakes may form, provide an assessment of the potential for long term contamination of any pit lakes remaining and the potential impacts on groundwater quality and surface water quality.	N/A
Discussion of proposed management, monitoring and mitigation methods to be implemented including post-mining land use and areas to be rehabilitated.	Section 13.5.6, 13.6
Discussion of proposed monitoring of linkages of specialised habitats to demonstrate that rehabilitated areas function as ecological corridors for conservation significant fauna.	Section 13.5.6
Offsets (Integrating Factor)	
Residual impacts and draft program of environmental offsets that adheres to the relevant policy/guidance documents	Section 14
Residual impacts with regard to MNES and assess the significance of the impacts.	Section 14
Completed Environmental Offsets Reporting Form and any offsets required and proposed in the PER.	Section 14

5.2 Assessment of Key Environmental Factors

The key environmental factors associated with the Proposal are addressed in this environmental assessment document in the following format:

- key statutory requirements, EPA environmental objective, policy and guidance relevant to the environmental factor or the Proposal
- the existing environment
- findings of surveys and investigations
- description of factor
- potential sources of impact (environmental aspects)
- evaluation of options or alternatives to avoid or minimise impact
- assessment of likely direct and indirect impacts
- assessment of cumulative impact
- management measures and performance standards
- predicted environmental outcomes against environmental objectives.

6. STAKEHOLDER CONSULTATION

Consultation associated with the development and operation of the Christmas Creek Mine began during scoping for the original mine approval in 2005. This consultation allowed Fortescue to discuss the project with stakeholders and gain valuable feedback. This feedback was also considered during the development of the Proposal.

Fortescue has continued liaising with key stakeholders throughout the operation of the Christmas Creek mine. This includes ongoing consultation with indigenous groups, pastoralists and government regulators. A consultation program was developed specifically for this Proposal. The objectives of the consultation program included the following:

- to identify and engage key stakeholders
- to identify and verifying areas of stakeholder concern for social and environmental values
- to establish a robust consultation approach and demonstrate that appropriate and effective consultation has been undertaken
- to assess stakeholder issues/concerns so that proposed impacts are minimised to as low as reasonably practicable.

Key consultation activities included the following:

- correspondence to potentially impacted parties providing information on the Proposal, requesting feedback and offering detailed briefings
- workshops and meetings with decision making authorities to discuss and obtain feedback on the Proposal
- one-on-one briefings and feedback sessions with specific stakeholders.

A summary of specific consultation undertaken during the development of the Proposal is provided in Table 11. Information about the ongoing consultation with pastoralists, Traditional Owners and Roy Hill Iron Ore Pty Ltd is provided in Sections 6.1, 6.2 and 6.3.

Fortescue will continue to consult with specific agencies and other stakeholders as appropriate throughout the assessment and implementation of the Proposal.

6.1 Traditional Owners

The Proposal is located entirely within the Nyiyaparli Native Title claim (WCO5/6). Fortescue has a LAA with the Nyiyaparli people which includes comprehensive provisions about cultural heritage protection. Fortescue consults regularly with Traditional Owners over all aspects relating to the identification, protection and management of their cultural heritage, consistent with the Cultural Heritage Principles agreed between Fortescue and the Traditional Owners as

set out in the LAA. Fortescue will continue to consult with the Nyiyaparli people throughout implementation of the Proposal.

6.2 Pastoralists

Fortescue has established strong relationships with pastoralists in the Pilbara in particular those impacted by Fortescue activities. A dedicated liaison team is in regulator contact with these pastoralists. Fortescue will continue to consult with relevant pastoralists throughout implementation of the Proposal.

An access agreement is in place with Hillside Pastoral Station, which outlines Fortescue responsibilities in preparing for and undertaking works within the Pastoral Lease boundary.

6.3 Roy Hill Iron Ore

Fortescue also undertakes regular consultation with Roy Hill Iron Ore as detailed in the *Stakeholder Consultation Reinjection Management Plan,* CC-PL-EN-0006 (Fortescue 2011a, Appendix 2A). A series of meetings were held in 2011, where the anticipated dewatering and injection associated with the CCWMS was discussed in detail. A set of monitoring bores was established, adjacent to the Roy Hill tenement boundary, at the eastern extent of the Fortescue tenements associated with Christmas Creek. A monitoring regime and trigger levels were agreed by Fortescue and Roy Hill Iron Ore. This monitoring has been incorporated into Fortescue's groundwater monitoring for the CCWMS. Fortescue will continue to consult with Roy Hill Iron Ore as required throughout implementation of the Proposal.

6.4 Department of Parks and Wildlife

Fortescue will undertake specific consultation with DPaW in regards to the proposed Fortescue Marsh Conservation Reserve. DPaW will be a key stakeholder in ongoing mine closure planning.

Table 11: Consultation Summary

Stakeholder	Date	Form of Consultation and Issues Raised	Relevant Section
Office of the Environmental Protection Authority (OEPA)	Regular	Monthly meetings to discuss current and proposed Fortescue Projects, focus on project and assessment timelines and scopes.	N/A
DoE	Regular	Weekly – monthly phone meetings to discuss current and proposed Fortescue projects, focus on project and assessment timelines, project scope and ratification of management plans.	N/A
Department of Environment Regulation (DER)	Regular	Monthly meetings to discuss implementation of existing projects and proposed activities which could require approval under Part V.	N/A
Roy Hill Iron Ore	Regular	Provision of data for water level monitoring bores on the shared mining boundary between Roy Hill Iron Ore operations and Christmas Creek. Data is provided on a 6 monthly basis at minimum.	Section 7
OEPA	17/03/2010	Presentation and meeting to discuss the proposed way forward for Chichester Project expansion. For Christmas Creek: • CCWMS API to cover 5 years of increased dewatering • Life of mine assessment (15+years of ongoing operations).	Sections 4, 6
Wildflower Society	18/10/2010	General presentation. Discussing Solomon, Cloudbreak and Christmas Creek, including CCWMS, environmental studies undertaken, expansion of infrastructure and management of impacts to flora and fauna.	Section 4
EPA and DEC	08/11/2011	Site visit of Nyidinghu and Christmas Creek project areas.	N/A
DSEWPaC (now DoE)	17/11/2010	General presentation for Fortescue expansion projects, incorporating CCWMS	Section 4
DSEWPaC (now DoE)	25/03/2011	Presentation and meeting to discuss offsets strategies. Discussion regarding existing and proposed conditions for Solomon, Rail, Christmas creek and Cloudbreak	Section 14
DSEWPaC (now DoE)	11/04/2011	General presentation for Fortescue expansion projects, incorporating CCWMS	Section 4
OEPA	23/06/2011	Formal introduction to Christmas Creek 'Life of Mine' Project (general overview and anticipated timeframes), along with discussion on approval of CCWMS (Ministerial Statement 871) and s45C for access road.	Section 4
DSEWPaC (now DoE)	03/08/2011	General presentation on Fortescue Projects (T155 and T355). Formal introduction to Christmas Creek 'Life of Mine' Project (general overview and anticipated timeframes), along with discussion on approval of CCWMS	Section 4
Community	08/08/2011	General presentation on Fortescue Projects (T155 and T355). Formal introduction to Christmas Creek 'Life of Mine' Project (general overview and anticipated timeframes), along with discussion on approval of CCWMS	Section 4
OEPA	09/08/2011 10/08/2011 01/09/2011 14/09/2011	Series of meetings with general OEPA staff, including Colin Murray, Anthony Sutton and Darryl Watkins.	Section 4

Stakeholder	Date	Form of Consultation and Issues Raised	Relevant Section
Roy Hill Iron Ore	06/09/2011 27/09/2011 11/10/2011 02/11/2011	Series of meetings regarding groundwater management between Roy Hill Iron Ore and Fortescue operations. Discussion of modelling outcomes, monitoring strategies, trigger levels and management and contingency actions.	Section 7
Department of Water (DoW)	15/11/2011	Meeting in Karratha with Environmental approvals and Hydrogeology teams to present update on Fortescue expansions. Including discussion on the development of the hydrogeological model to assess impacts associated with increased dewatering and injection.	Sections 4, 7, 8
OEPA	16/05/2012	Presentation outlining the Proposal, including brief project description and details of studies and surveys being undertaken	Section 4
DSEWPaC (now DoE)	23/05/2012	Presentation of several projects (Christmas Creek, Nyidinghu and North Star). Details of potential MNES (threatened species) and indicative project timelines.	Section 4, 12
DSEWPaC (now DoE)	26/06/2012	Site visit to Christmas Creek and Nyidinghu project areas.	N/A
DSEWPaC (now DoE)	03/07/2012	Presentation and meeting, implementation of offset conditions. Discussions regarding strategic land management and existing offset conditions.	Section 14
DOW	24/01/2013	Meeting to discuss overlap of EP Act Part V (category 6 mine dewatering) with DoW 5C licence requirements. Also discussion regarding current DoW assessments and departmental structure.	Section 1.4
DSEWPaC (now DoE)	21/03/2013	Meeting to discuss existing conditions in relation to the Proposed expansion. Can any changes be undertaken within existing CCWMS Controlled Action?	Section 12
OEPA	12/06/2013	Meeting with OEPA regarding Proposal, potential for assessment of increased dewatering under s45C. S45C application was subsequently submitted to EPA.	Sections 1.4, 4
DSEWPaC (now DoE)	16/07/2013	Further meeting to discuss existing conditions in relation to the Proposed expansion. Discussion of EIA assessment approach, whether the proposal may constitute a Controlled Action, and whether it can be incorporated into the existing Controlled Action with amendment to conditions.	Section 4, 12
DSEWPaC (now DoE)	21/08/2013	Discussion on Strategic Land Management Plan and Night Parrot Research Plan as part of offsets negotiations.	Section 4, 12, 14
DSEWPaC (now DoE)	20/09/2013	Pre-referral presentation of Proposal, discussion about occurrences of MNES across Christmas Creek, existing monitoring and mitigation measures for MNES.	Section 12
OEPA	28/10/2013	Pre-referral discussion and presentation for the Proposal. Discussions regarding impact assessment methodology and potential level of assessment. Case put forward for API.	Sections 1.4, 4
DoW	15/11/2013	Meeting with DoW and Hydrogeology team, discussing current Fortescue projects. Included presentation and discussion of modelling for the Proposal, as well as indicative drawdown and mounding areas.	Section 7
DoW	17/01/2014	Meeting to discuss the implementation of the CCWMS, preparation of the Triennial Review and Chichester Operations. Update on modelling undertaken for the Proposal and timing for submission of data.	Section 7
DoE	01/05/2014	DoE site visit to Christmas creek and Cloudbreak. Members of the Assessment and Post-Assessment Teams toured both sites and visited the Fortescue Marsh. Key discussions included extent of dewatering impacts, mining methodologies, CCWMS and infrastructure, Mulga vegetation, Samphire vegetation.	N/A

Stakeholder	Date	Form of Consultation and Issues Raised	Relevant Section
DoW	26/06/2014	Meeting to discuss triennial reports and operating strategies. Discussion of upcoming projects and changes over the next 12 months, including discussion of the Proposal.	Section 7
Roy Hill Station	18/07/2014	Letter sent to provide an update on the Proposal and invitation for further consultation	Sections 4, 6
Hillside Station	18/07/2014	Letter sent to provide an update on the Proposal and invitation for further consultation	Sections 4, 6
Bonney Downs Station	18/07/2014	Letter sent to provide an update on the Proposal and invitation for further consultation	Sections 4, 6
Roy Hill Iron Ore	20/11/2014	Meeting with Roy Hill Iron Ore to discuss planned progression of dewatering and injection activities by both sites, provision of water level monitoring data, potential water sharing strategies.	Section 7

7. HYDROLOGICAL PROCESSES

7.1 Relevant Environmental Objectives, Legislation, Policies and Guidelines

7.1.1 EPA Objective

The EPA applies the following objective to the assessment of proposals that may affect hydrological processes:

> *To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected.*

7.1.2 Regulatory Framework

Protection of hydrological processes is covered by the RIWI Act.

The RIWI Act makes provision for the regulation, management, use and protection of water resources, to provide for irrigation schemes, and for related purposes. Within this, the Act requires the construction of wells and groundwater abstractions (including dewatering) in proclaimed areas to be licensed. The Proposal lies within the proclaimed Pilbara Groundwater Area and Pilbara Surface Water Area. The site is consequently subject to such licensing, which is administered by the DoW under delegation from the Minister for Water.

Groundwater abstraction licences typically specify annual limits on the groundwater volumes that may be abstracted and include a range of conditions, including requirements for monitoring and reporting on aquifer behaviour. The approval of an abstraction licence will require DoW to approve a Water Management Plan and Groundwater Operating Strategy, in line with the *Western Australian Water in Mining Guideline* (DoW 2013) and *Pilbara Regional Water Plan* (DoW 2010a).

There is no federal water legislation relevant to this Proposal.

Guidance and Position Statements

The following documents are relevant in setting the framework for identification and assessment of impacts to hydrological processes in the Proposal area:

National

In 1996, ANZECC together with the Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) developed the *National Principles for the Provision of Water for Ecosystems* (ANZECC/ARMCANZ 1996). These national principles aim to improve the approach to water resource allocation and management and to incorporate the water requirements of the environment in the water allocation process. The overriding goal of the

principles is to provide water for the environment to sustain and, where necessary, restore the ecological processes and biodiversity of water-dependent ecosystems.

State

Water in Mining Guideline

The *Western Australian Water in Mining Guideline* (DoW 2013) has been based on and replaces the *Pilbara Water in Mining Guideline* (DoW 2009). The *Western Australian Water in Mining Guideline* (DoW 2013) is designed to provide advice on water management issues that need to be considered in mine planning. The guideline outlines mine planning objectives for water including the need to:

- ensure that fit-for-purpose water is used wherever possible and high-quality water is used only in situations where it is essential or no other suitable water source is available, and with the fewest adverse effects
- maximise water-use efficiency at all mine sites, particularly water-deficient sites, to reduce the need for water to be abstracted from the environment
- minimise the adverse effects of the abstraction and release of water on environmental, social and cultural values
- use a monitoring and evaluation process, to adaptively manage the effects of abstractions and releases on the water resources (DoW 2013).

Pilbara Regional Water Plan

The *Pilbara Regional Water Plan* (DoW 2010a) was prepared to set strategic directions management and development of water resources in the Pilbara. The Pilbara Regional Water Plan aims to develop water resources in a sustainable manner to maintain and enhance 'the natural environment, cultural and spiritual values, quality of life and economic development'.

Fortescue Marsh Guidance

The EPA guidance *Environmental and Water Assessments Relating to Mining and Mining-related Activities in the Fortescue Marsh Management Area* (Fortescue Marsh Guidance) (EPA 2013d) was developed by the OEPA in consultation with DoW, the then-DEC (now DPaW) and Department of State Development. The objectives of the guideline include:

- providing agreed guidance on the management of impacts relating to mining and associated infrastructure that is necessary to protect the water regime and environmental values of the Fortescue Marsh
- providing guidance to proponents of mining and mining activities on the values and objectives of the Fortescue Marsh.

The Fortescue Marsh Guidance divides the area around the Fortescue Marsh into a number of management zones with identified environmental values, management objectives and standards. For the purpose of the Fortescue Marsh Guidance, the Proposal is located in Zone 3A: Kulbee Alluvial Flank, which is considered to be one of the zones of 'lowest environmental significance' (EPA 2013d). Objectives for the management of hydrological processes in Zone 3A are:

- maintain the natural flow regime at the Fortescue Marsh boundary
- protect the hydrological and ecological integrity of major tributaries entering the Fortescue Marsh
- protect the natural pools and springs
- manage overland surface water flows to protect Mulga woodlands (EPA 2013d).

7.2 Surveys and Investigations

The following surveys have been undertaken with respect to hydrological processes at Christmas Creek:

- *Christmas Creek 5-year Hydrogeological Modelling Assessment* (Fortescue 2010a)
- *Hydrogeological Assessment of the Christmas Creek Life of Mine Water Management Scheme* (Fortescue 2013a, Appendix 5A)
- *Fortescue Marsh: Synthesis of Eco-hydrological Knowledge* (Equinox 2013, Appendix 5E)
- *Modelling Analysis of Mining Dewatering Impact on Soil Water Availability to the Samphire Vegetation on the Fringe of Fortescue Marsh* (Fortescue 2013b, Appendix 5F)
- *Christmas Creek Life of Mine Expansion Surface Water Investigation and Impact Assessment* (Worley Parsons 2014, Appendix 5G).

7.3 Description of Factor

7.3.1 Surface Water Hydrological Regime

Christmas Creek is located to the north of the Fortescue Marsh (Figure 2). The Fortescue Marsh lies in the Upper Fortescue River catchment, which has an area of approximately 26,000 km^2 (Worley Parsons 2014). The Upper and Lower Fortescue River catchments are separated by the Goodiadarrie Hills (Equinox 2013). The Goodiadarrie Hills, approximately 120 km west of Christmas Creek prevent flow from the upper catchment entering the lower catchment.

West from the Goodiadarrie Hills, the Lower Fortescue River Catchment drains to the coast, whereas east from the hills the Fortescue Marsh receives drainage from the upper Fortescue River catchment. The alluvial outwash fan from the Weeli Wolli Creek system abutting the Goodiadarrie Hills is believed to be partially responsible for obstructing the Fortescue River and forming the Fortescue Marsh.

The Fortescue Marsh is an extensive, intermittent wetland, located on the floor of the Fortescue Valley and bound by the Chichester Range to the north and the Hamersley Range to the south, occupying an area of approximately 1,000 km^2 , typically around 100 km long by 10 km wide (Fortescue 2013a). The Fortescue Marsh has an elevation of around 400 m AHD. Following significant rainfall events (greater than 90 mm/month), runoff from the upper Fortescue River catchment drains to the Fortescue Marsh, which can result in flooding of the entire Fortescue Marsh area. Broad scale flooding occurs at a frequency of about once every five to seven years (DEC 2009a). During smaller runoff events, isolated pools form on the Fortescue Marsh at the main drainage inlets.

On the southern and northern flanks of the Fortescue Valley, numerous creeks discharge to the Fortescue Marsh (Worley Parsons 2014). Rainfall runoff from the valley sides initially drains down-gradient as overland flow before concentrating in defined flow channels. In this process, surface retention, vegetation, infiltration and other mechanisms absorb water from the runoff stream. In steep areas, the runoff processes are rapid with relatively low losses, and defined drainage channels are typically in close proximity. In the lower slope areas, the runoff processes are slow with relatively higher losses and greater distances between defined drainage channels.

Where defined drainage channels from the steeper slopes enter the lower slope areas, the channels typically have a reduced discharge capacity and in many instances become less defined, braided, or may even completely disperse in flat areas. In these reducing slope channels, runoff tends to overspill the main channel flow zones and spread over a wider front. In some of the lower slope areas, vegetation communities (scrub and Mulga woodlands) have developed. These are dependent on seepage water provided by the overland flow process. In these areas, the overland flow process has been termed sheet-flow. Conversely, the Fortescue River, Weeli Wolli Creek, and other main channels entering the Fortescue Marsh typically support Eucalyptus woodlands on their banks and floodplains and the flow process is termed channel flow.

Surface water runoff to the Fortescue Marsh is of low salinity and turbidity, runoff turbidity however significantly increases during peak periods of flooding. Following a significant event that floods the whole Fortescue Marsh area, the ponded water may be over 4 m deep in the lower elevation areas. Water stored on the Fortescue Marsh slowly dissipates through the processes of seepage and evaporation. During the evaporation process, the water salinity levels increase and as the ponded areas recede, traces of surface salt can be seen. During the seepage process, as the ponds evaporate, increasingly more saline water is believed to seep into the valley floor alluvial deposits.

The Fortescue Marsh is listed in the *Directory of Important Wetlands in Australia* (Environment Australia 2001) and is listed by the DPaW as a Priority 1 Priority Ecological Community. The listing in the *Directory of Important Wetlands in Australia* is on the basis of the following criteria:

- it is a good example of a wetland type occurring within a biogeographic area in Australia
- it is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system / complex
- it is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail
- the wetland is of outstanding historical or cultural significance.

The Fortescue Marsh system includes riverine floodplains and seasonal/intermittent freshwater lakes (greater than 8 ha in area) or floodplain lakes (Environment Australia 2001).

The major catchments of the Fortescue Marsh can be broadly split into three zones:

1. Southern Fortescue Marsh Catchments (including Mindi Mindi Creek, Coondiner Creek and Weeli Wolli Creek). The Weeli Wolli Creek catchment includes the major tributaries of Yandicoogina Creek and Marillana Creek.
2. Northern Fortescue Marsh Catchments (including from east to west Goman Creek, Sandy Creek, Kagurunga-Dandu Creek, Murandu Creek, Youngs Creek, Christmas Creek and Kulbee Creek, as well as unnamed creeks).
3. Upper Fortescue River Catchments upstream of the Roy Hill gauge including clockwise from the north, Kulkinbah Creek, Kondy Creek, Jigalong Creek, Caramulla Creek, Jimblebar Creek, Fortescue River below Opthalmia Dam and Kalgan Creek (Worley Parsons 2011).

The Christmas Creek Mine is located in the Northern Fortescue Marsh Catchments, within the catchment of Kagurunga-Dandu Creek, Murandu Creek, Youngs Creek, Christmas Creek, Kulbee Creek and three unnamed creeks (Figure 13, Worley Parsons 2014).

The three catchment zones demonstrate common characteristics of a well-defined dendritic drainage system with identifiable creek lines in the upper catchment transitioning into lower relief zones in the lower catchments, where flows become distributed forming overlapping alluvial fans (sheet flow areas) (Worley Parsons 2014).

Fortescue (2010b) reports on an analysis of satellite images used to map the Fortescue Marsh shoreline over a 10 year period. A digital terrain model based on terrain data capture in 2010 was used to estimate water volumes for each of the satellite images. The report noted the following:

- The highest estimated water level and volume (407.0 m Australian Height Datum (AHD) and 794 GL) was from the June 2000 image, coinciding with the highest inflows

from Weeli Wolli Creek. This is likely to have been supplemented by other major inflows from across the entire Fortescue Marsh Catchment.

- The eastern and western sections of the Fortescue Marsh do not connect hydraulically until water levels reach 406.3 m AHD (corresponding to a storage volume of approximately 320 GL). The majority of the Fortescue Marsh Catchment area discharges into the eastern part of the basin during low flow events while the major inflows into the western basins are from Weeli Wolli Creek (during low flow events) and catchments from Goman Creek and further west.

The Fortescue Marsh and some semi-permanent water pools or “yintas” along the northern shoreline have been identified as having cultural significance. Worley Parsons (2014) identifies ten yintas in the vicinity of Christmas Creek Mine (Figure 13). The yintas are located at low points in the Fortescue Marsh topography or at breaks in the slope and are thought to be associated with seasonal surface water flows. Each of the yintas is associated with large catchments draining the Chichester Ranges (Goode 2009).

Surface Water Flow Processes

Surface water flow in and around the Proposal area takes several different forms, covering different areas (Worley Parsons 2014). From an environmental perspective, the most important forms are:

- channel flow: convergent flow to large creek channels and adjacent floodplains in the steeper upland areas
- sheet flow: overland flow in a broad shallow front in flatter areas closer to the Fortescue Marsh.

Channel Flow

Channel flow zones are associated with large catchments that predominantly drain the steep upland areas, rather than the flatter terrain closer to the Fortescue Marsh. This surface flow has potential for large convergent flows associated with major flood events. These are likely to be associated with high velocities in large, well defined channels. Small, more frequent flows are generally confined to the channel. Breakouts into the adjacent floodplains occur during larger and less frequent flood events (Worley Parsons 2014). The main channels are usually devoid of vegetation. Vegetation on the adjacent floodplains includes *Eucalyptus victrix* (Coolibah), *E. camaldulensis* (River Red Gum) open woodlands and Scrub to Low Open Woodland dominated by Acacia species (ENV 2013a).

Closer to the Fortescue Marsh, the channels often diverge, forming braided streams and alluvial fans (Worley Parsons 2014).

Sheet Flow

Sheet flow occurs where overland flow moves down-slope while maintaining a broad shallow front. Sheet flow occurs in relatively flat areas, where there is no convergence of flow, such that sheet flow zones are maintained over large areas. Sheet flow occurs over extensive areas within and to the south of the Proposal area. These flat areas occur where the terrain has been formed by remnant alluvial fans (Worley Parsons 2011). Sheet flow is unlikely to occur during small rainfall events as it only occurs when the intensity or volume of rainfall exceeds the local capacity for infiltration.

Sheet flow processes are important for the banded Mulga (*Acacia aneura*) communities common in the mid to lower slopes of the Chichester Range, including within the Christmas Creek area. Mulga in these areas occur in bands, where relatively dense groves of Mulga in low lying areas are interspersed with slightly elevated inter-grove areas that contain grasses or less dense areas of Mulga (Worley Parsons 2011).

Water infiltration rates are generally higher in grove areas where sheet-runoff from inter-grove areas collects and infiltrates in the groves (UWA 2010).

Current Operations: Surface Water

Mine pits and WRSFs affect surface water flows by potentially diverting watercourse and sheet flows and capturing rainfall within mining areas, reducing the catchment area for downstream flows. This can result in 'shadowing', which are areas that receive less flow than previously because surface flow processes have been interrupted or diverted. Shadowing can affect both channel flow and sheet flow processes, and can also be caused by linear infrastructure, such as roads and pipelines.

Mine pits and WRSFs can cause previously dry areas to become inundated (ponding). Mine areas are designed to be internally draining during operation to minimise potential downstream water quality impacts from turbidity and potential contamination. However, the effect of this drainage design isolates the mine area from the catchment area of the downstream creek lines and sheet flow areas, which reduces the amount of water received by these downstream ecosystems. This effect persists post-mining, as WRSFs continue to have higher infiltration rates than the original landform.

7.3.2 Regional Hydrogeology

In a regional sense, groundwater movement within the Christmas Creek area is driven by rainfall recharge on the elevated flanks of the Fortescue Valley and surrounding plateau. The topographically driven groundwater moves southwards towards the valley as shown in Figure 12.

The Upper Fortescue Valley is a closed catchment with drainage terminating at the Fortescue Marsh. Groundwater quality at Christmas Creek varies from fresh in the north at the Chichester Range recharge areas (Electrical Conductivity (EC) of <1,500 µS/cm) to hypersaline at proximity of the Fortescue Marsh (EC of >80,000 µS/cm). Closed catchment conditions have caused evapo-concentration beneath the surface of the Fortescue Marsh creating hypersaline groundwater which migrates downwards and then laterally, driven by increasing density.

Southward flow of the topographically driven fresh groundwater is opposed by the northward pressure gradient associated with density driven saline groundwater. As a result, a saline interface develops with fresh/brackish water overlying saline/hypersaline groundwater. The fresh/brackish water lens is likely thickest beneath the transition zone between the Chichester ranges and the Fortescue Marsh Basin.

Groundwater flow in the Christmas Creek area is strongly controlled by local scale and regional scale stratigraphy and topography and is often enhanced along faults and discontinuities. While variable, hydraulic properties can generally be described by lithological unit.

7.3.3 Local Geology and Hydrogeology

Characterisation of the hydrogeology of Christmas Creek has been based on field investigations undertaken since 2005. This work has identified the hydrological properties of the geological formations outlined in Section 2.2 (Figure 5, Table 12). The ore body itself forms a semi-continuous aquifer underlain by zones of lower hydraulic conductivity, predominantly the Roy Hill Shale (Table 12).

To the south of the mine, the MMF is overlain by the Wittenoom Formation (predominately Wittenoom Dolomite) (Table 12). In the mineralised MMF where mining will occur, the Wittenoom Dolomite is largely absent. In the Fortescue Marsh area, the calcrete and silcrete Oakover Formation lies above the Wittenoom Formation (Table 12). These calcretes and silcretes are sedimentary products formed through the evaporation of water precipitating calcium carbonate and silicon dioxide over geological time periods.

Further south, towards the edge of the Fortescue Marsh, the MMF is overlain by Alluvial Clays and Tertiary Detritals (Fortescue 2013a). The Tertiary Detritals consist of layers of clays, silts and minor sandy gravels (Fortescue 2013a, Table 12).

Table 12: Geological Units and Associated Hydrological Properties

Geological Unit	Geological Description	Hydrological Properties
Roy Hill Shale	Deepest formation. Mudstone and chert.	Generally low hydraulic conductivity, although there are zones of relatively enhanced hydraulic conductivities associated with structures, faults zones and weathering.
Unmineralised Nammuldi Member of MMF	Chert and banded iron formation.	Relatively low hydraulic conductivity, with enhanced hydraulic conductivity along faults.
Mineralised Nammuldi Member of MMF (including hardcap)	Ore body consisting of hematite, goethite and martite.	Semi-continuous brackish to saline aquifer with relatively high hydraulic conductivity and storage coefficient. Unconfined to partially confined near the Chichester Range, and partially confined to confined in the south where overlain by alluvial clay layers. The hardcap can be porous and has a very high hydraulic conductivity.
Wittenoom Formation	Massive crystalline dolomite with a weathered clay layer at the top.	Generally a low hydraulic conductivity layer within the vicinity of Christmas Creek Mine. Upper zone generally weathered and clay dominant. More permeable zones may have developed in areas associated with faulting. Regionally the weathered (Karstic) zone has high localised hydraulic conductivity where present.
Oakover Formation	Calcretes and silcretes formed under lake or riverine conditions, in a layer up to 20 m thick.	High hydraulic conductivity. This aquifer is confined to semi-confined by the overlying clays and silts. Approximately 20 m thick. Current injection practices have confirmed hydraulic disconnection between the Oakover Formation and overlying watertable within the Tertiary Detritals.
Alluvial Clay	Thick consolidated red-brown clay unit near and under the Fortescue Marsh.	Low hydraulic conductivity, most likely a confining layer. Variable thickness, approximately 20 m thick.
Tertiary Detritals	Generally unconsolidated clays, silts and minor sandy and gravely layers. Distribution is semi-continuous.	Aquifers occur in coarser soil types within this formation, including clayey gravels. Temporary perched aquifers may also develop when gravely/sandy creek bed deposits are saturated during creek flow events. The aquifers are semi-confined to unconfined. Usually 10-20 m in thickness.

Source: after Equinox 2013, Fortescue 2013a

Connectivity between Formations

Connectivity between aquifers is important in the context of Christmas Creek, partially because increased connection may allow mixing of hypersaline and fresher waters and impact the volumes which will need to be abstracted in order to achieve dewatering. Groundwater salinity at Christmas Creek varies from brackish in the Chichester Ranges to hypersaline underneath the Fortescue Marsh (Fortescue 2013a). From an environmental impact assessment perspective, the most important connections are those between:

- Oakover Formation and mineralised MMF
- Tertiary Detritals and mineralised MMF
- Tertiary Detritals and Oakover Formation.

Oakover Formation and Mineralised Marra Mamba Formation

There is variable connection between the mineralised MMF aquifer and the Oakover Formation, with connection restricted by the presence of the lower hydraulic conductivity unmineralised MMF near the Oakover Formation. Where connection occurs, it facilitates linkage of hypersaline water in the Fortescue Marsh and surrounding areas and the fresher aquifer system located along the Chichester Range. Dewatering activities in areas with pronounced connection will result in larger abstraction volumes when compared to areas with limited or no connection.

Tertiary Detritals and Mineralised Marra Mamba Formation

There is a strong hydraulic connection between the mineralised MMF aquifer (near the current and proposed mining area) and the overlying Tertiary Detritals. Brackish leakage from the Tertiary Detritals may reduce the amount of drawdown due to abstraction from the mineralised MMF aquifer.

Tertiary Detritals and Oakover Formation

The shallow groundwater at the fringe of the Fortescue Marsh, within the Tertiary Detritals is generally separated from the deeper aquifer systems by the presence of low permeability Alluvial Clay. At the fringe of the Fortescue Marsh the Alluvial Clays restrict water movement between the shallow Tertiary Detritals aquifer and the underlying Oakover Formation. This disconnection has been proven by the operation and monitoring of the current saline injection system. Injection of saline water into the Oakover Formation, and subsequent localised pressure increase, has not significantly impacted the watertable within the Tertiary Detritals (Fortescue 2014a).

7.3.4 Groundwater Levels and Flow

Groundwater Levels and Trends

Baseline groundwater levels (measured as freshwater equivalent hydraulic head) in the Tertiary Detritals at Christmas Creek vary from approximately 403 m AHD at the edge of the Fortescue Marsh to approximately 411 m AHD at the northern extent of the Tertiary Detritals (Fortescue 2010a; 2013a). The corresponding baseline groundwater level in the MMF/Oakover Formation varies from 403 to 413 m AHD (Fortescue 2010a; 2013a). Different groundwater levels are observed in the different geological units as a result of the disconnection between the Tertiary Detritals and the Oakover Formation. In the field, the discrete groundwater levels are measured by screening groundwater bores at the appropriate depth, in order to accurately reflect the water level of the targeted geological unit.

Groundwater levels in the Tertiary Detritals vary seasonally in response to erratic rainfall patterns. Observed water levels fell approximately 1 to 1.5 m between 2007 and 2010 in

response to the lack of rain since the flooding of the Fortescue Marsh in 2006 (Fortescue 2013a). Average annual water level fluctuations can be up to approximately 2 m.

Ponding on the Fortescue Marsh, resulting from high intensity rainfall events, is directly related to groundwater level responses observed in the Tertiary Detritals (Fortescue 2013a). When significant ponding occurs on the Fortescue Marsh, groundwater levels in the Tertiary Detritals have been observed to increase by up to 1.5 m. This relationship is most apparent at the fringe of the Fortescue Marsh, with changes to groundwater levels decreasing with distance from the Fortescue Marsh (Fortescue 2013a). Figure 12 presents the changes in Fortescue Marsh hydrology between flood and inter-flood periods.

Density Driven Flow

Density gradients due to salinity differences are considered to be an important driving force for groundwater flow in the area. Groundwater quality at Christmas Creek varies from fresh in the north at the Chichester Range recharge areas (EC of <1,500 µS/cm) to hypersaline at proximity of the Fortescue Marsh (EC of >80,000 µS/cm).

The density contrast between saline groundwater and fresh groundwater results in a pressure gradient causing groundwater movement in the opposite direction to the topographically driven flows which tend to occur from the Chichester Ranges towards the Fortescue Valley.

Groundwater Recharge

Primary mechanisms for groundwater recharge are:

- infiltration recharge from direct rainfall and local streamflow on MMF outcrop and Tertiary Detritals
- infiltration recharge associated with ponding on the Fortescue Marsh
- inflow from basement aquifers to the north of the Proposal area.

Direct rainfall recharge to the Tertiary Detritals and MMF is considered to be low in the Christmas Creek area, reflecting the low rainfall and high evaporation of the region.

Recharge is enhanced in creeks and areas of streamflow. Areas of outcrop and subcrop with drainage incisions can have direct connection between surface water and underlying permeable lithologies.

Groundwater Discharge

Based on the evolution of groundwater within the upper Fortescue Valley, the groundwater system beneath the Fortescue Marsh is considered a closed system with limited outflow to the west beneath the Goodiadarrie Hills. Discharge is therefore interpreted to only occur through evaporation and evapotranspiration processes beneath and fringing the Fortescue Marsh

(Figure 12). Discharge would be greatest when water levels are high, following recharge events and lowest after a prolonged dry period when the extinction zone for evaporation or evapotranspiration (from the watertable) is reached.

Water Balance

Fortescue (2013a) developed a simplified water balance for the Fortescue Marsh and Chichester Range areas for flooding, interflood and prolonged dry conditions (Table 13).

- Under flooded conditions, the groundwater system is being recharged. The ponded water formed on the Fortescue Marsh following significant rainfall (average volume of around 300 GL) results in around 30 GL of water entering the shallow groundwater system.
- Under interflood conditions, the groundwater system is still receiving around 0.5 GL of recharge from the Chichester Ranges; however, discharge (evaporative) through and fringing the Fortescue Marsh is dominant.
- Under the prolonged dry condition, the system is effectively static (not receiving recharge or discharging).

The water balance is designed to estimate inputs and outputs from the Fortescue Marsh and Chichester Range (Table 13).

Table 13: Simplified Water Balance

Region	Area	Recharge/Input (GL/a)	Discharge/Output (GL/a)
Flooded Condition	Chichester Range	6	0
	Fortescue Marsh	30	0
	Net Recharge of 36 GL/a		
Interflood Condition	Chichester Range	0.5	0
	Fortescue Marsh	0	30
	Net Discharge of 29.5 GL/a		
Prolonged Dry Condition	Chichester Range	0	6
	Fortescue Marsh	0	0
	Net Discharge of 6 GL/a		

Source: Fortescue 2013a

Current Christmas Creek Water Management Scheme

Groundwater abstraction for mining purposes has occurred at Christmas Creek since 2009 and at Cloudbreak since 2006. Prior to 2011, groundwater abstraction at Christmas Creek was limited to small volumes required for dust suppression water (Fortescue 2013a).

Below watertable mining commenced at Christmas Creek in November 2011 with groundwater abstracted via bores and sump pumps located within and adjacent to mining pits, consistent

with Ministerial Statement 871 (Table 14). The location of production (dewatering) bores used over the last three years is provided in Figure 14.

Table 14: Christmas Creek Abstraction and Injection Volumes 2010-2013

Financial Year	Volume Abstracted (GL/a)	Volume used on Site (GL/a)	Volume Injected (GL/a)
2010/2011	0.9	0.9	0
2011/2012	10.2	7.3	2.9
2012/2013	34.4	13.8	20.6
2013/2014	40.3	17.6	20.4

Source: Fortescue 2013a

Dewatering water surplus to mining and processing requirements is disposed of by injection into the groundwater resource. The location of injection bores used in the last three years is provided in Figure 15. Groundwater abstraction can result in groundwater drawdown (also known as a cone of depression), and injection can result in mounding of the watertable. These concepts are discussed in more detail in the following sections.

Dewatering

The process of dewatering involves abstraction from a target aquifer. The volume of water required to be abstracted depends on the hydrological properties of the target aquifer and depth of water above the ore body, i.e. if the ore body is deeper, then a higher rate and greater volume of dewatering will be required to enable mining to occur.

Removal of groundwater results in a 'cone of depression' around the dewatering area, where groundwater levels drop in response to the pumping (see A in Plate 3 compared to B which shows resting watertable levels). The area over which the cone spreads depends on the duration, rate and volume of abstraction required.

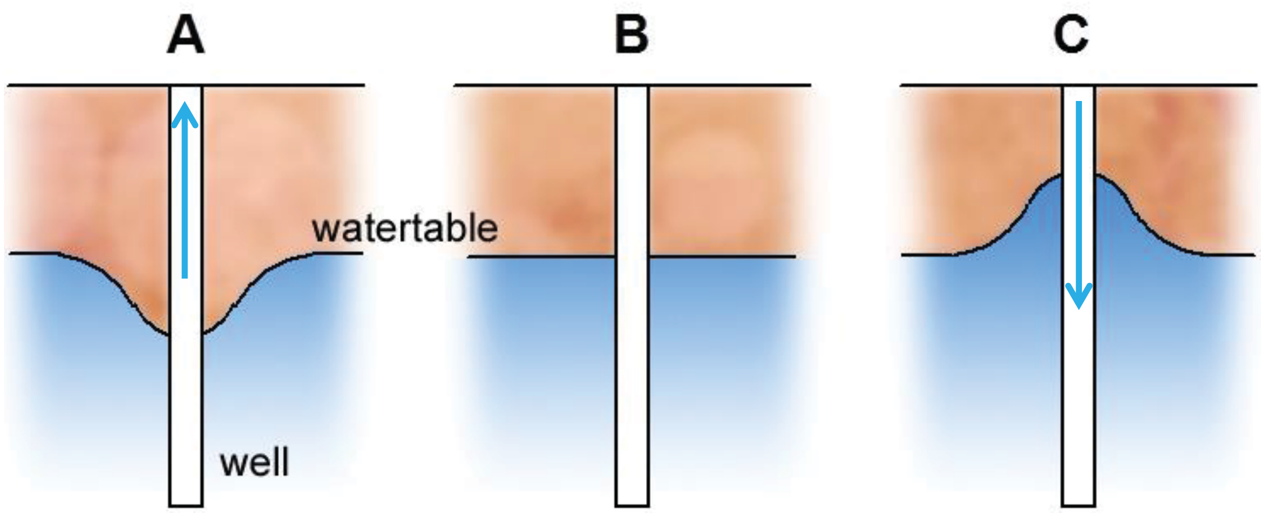

Plate 3: Simplified Concept of Groundwater Level Changes

If groundwater levels are higher (as occurs during a wet period or in areas where groundwater is closer to the surface), a greater volume (and rate) of dewatering is also required. This increases the area over which drawdown occurs.

Injection

Mounding is caused by injection of water into a groundwater body, forming a mound around the injection bore, as shown in (C) of Plate 3.

Water abstracted to allow mining is used for ore processing and dust suppression, as required. Excess water is injected into the aquifer. The volume injected depends on the volume being abstracted and the volume required for ore processing and dust suppression.

Brackish and saline water streams are kept separate under the CCWMS. Saline water is injected into the saline injection area between the Fortescue Marsh and the mine, predominantly into the Oakover Formation. The brackish water is used for ore processing and dust suppression or transferred to Cloudbreak for similar uses as it is better suited to these purposes. Excess brackish water is injected into injection zones in the mineralised MMF to the east and west of the mine, as this enables future re-abstraction and use for operational purposes if required.

Overall, the majority of the water abstracted and injected is saline, as such a greater portion of injection will occur in the saline injection area.

Drawdown & Mounding – Impacts to the Watertable

The key groundwater resource from an impact perspective is the shallow watertable present in the Tertiary Detritals geological unit. Abstraction occurs across all geological units to the depth of the base of the mine pits to allow mining of the ore body. Whilst dewatering of the MMF will unavoidably result in dewatering of the overlying Tertiary Detritals (watertable) the spatial extent of this drawdown at the watertable is limited by the relatively low horizontal and vertical permeability of this deposit.

Injection is primarily associated with the Oakover Formation to the south of active mining. Although injection into this unit will result in a localised pressure increase within the deep unit, this response is not always directly observed in the free watertable associated with the Tertiary Detritals due to the presence of the low permeability Alluvial Clays between the two geological units. This unit dissipates the mounding response observed at the watertable even with pressurisation of the underlying deep aquifer.

Operations to Date

Fortescue has been compliant with all requirements of the *Christmas Creek Groundwater Operating Strategy* (CC-PH-HY-0002) (Fortescue 20132h Appendix 5C) in the implementation

of the CCWMS to date (Fortescue 2013a). Water level changes due to dewatering and injection activities have followed the expected trends (Fortescue 2013a), including:

- the groundwater level has been lowered in the MMF aquifer and overlying Tertiary Detritals in the below watertable mining (and dewatering) area
- the groundwater level has risen and subsequently started to recede in the MMF aquifer and overlying Tertiary Detritals aquifer in the brackish injection area to the east and west of the below watertable mining area
- groundwater levels have risen in the Oakover Formation in the saline injection area and to a lesser extent in the near-marsh area
- groundwater levels in the Tertiary Detritals in the saline injection area and near-marsh areas have displayed cyclical periods of rise and fall in response to climatic induced groundwater recharge events
- the salinity of groundwater abstracted from dewatering operations has increased in response to depletion of the brackish water resource in the dewatering area; salinity has remained relatively constant in the MMF in the brackish injection zones; and salinity has remained relatively stable in the Oakover Formation and overlying alluvial aquifer in the saline injection and near-marsh areas.

The performance of the CCWMS is reported in the *Christmas Creek Triennial Aquifer Review: August 2013 to July 2013* (Fortescue 2014a, Appendix 5D). This document is provided as a draft, as it has not yet undergone final review and approval by the DoW.

The existing CCWMS includes a series of trigger levels for investigation and changes in practices related to both groundwater levels and vegetation health.

Groundwater trigger levels are defined as:

- Class 1 trigger levels, that have been set as an early warning and signal potential future breaches of Class 2 levels
- Class 2 trigger levels that are based on regulatory requirements and may cause potential impacts to vegetation due to either excessive mounding or drawdown.

The current network of monitoring bores (Figure 16) is used to monitor groundwater levels to allow comparison against trigger levels. Between August 2010 and June 2013, Class 1 trigger levels for groundwater were exceeded on 71 occasions (Fortescue 2013a). No Class 2 trigger levels were reached during this period. The Class 1 triggers have primarily related to groundwater level changes in the Oakover Formation that have not been reflected in superficial groundwater levels of the Tertiary Detritals (Fortescue 2013a). Management of operations (e.g. use of different injection areas) have been undertaken in response to Class 1 triggers where appropriate (Fortescue 2013a).

The current management measures outlined in the *Christmas Creek Groundwater Operating Strategy* CC-PH-HY-0002 (Fortescue 2012d, Appendix 5C) have been effective in preventing any breaches of Class 2 triggers.

Development of Numerical Groundwater Model

Fortescue developed a numerical hydrogeological model for the Proposal which was based on the latest conceptual and operational data. Numerical modelling has been completed using the FEFLOW modelling package, which allows the modelling of density driven flow. The model has been based on geological observations and has been augmented with additional information including:

- preliminary information assembled under research managed by the University of Western Australia through an Australian Research Council (ARC) Linkage project
- acquisition and interpretation of high-precision LIDAR (light detection and ranging) surface elevation data across the Fortescue Marsh, which has been used to develop a high precision Digital Elevation Model
- use of historical LANDSAT imagery to assess the system response to flooding events
- calibration of the model against monitoring data from the existing dewatering activities.

The report on the modelling undertaken by Fortescue is provided in Appendix 5A.

The model provides a basis for predicting the magnitude and location of groundwater level changes and to identify areas of groundwater level change near the fringe of the Fortescue Marsh. The predicted changes in groundwater level include natural groundwater level fluctuations, which may result in changes of several metres.

To investigate the impacts of variations in climatic conditions, modelling has been undertaken using three rainfall sequences, representing average, dry and wet climate scenarios based on rainfall at the nearby Newman weather station dating back to 1970 (Fortescue 2013a).

The average rainfall sequence was generated using 1973, 1984, 2001, 2006, and 2008 as base years. These five years have annual precipitation closest to the long-term average rainfall at Newman of 338 mm/year. Using 90 mm/month as the threshold value for Fortescue Marsh flooding, there are 11 flood events in the 18-year life of mine sequence.

Dry and wet rainfall sequences were also developed to investigate the impacts of dry and wet conditions on dewatering and injection. These were based on the same years as the average rainfall sequence. The dry sequence contains five flood events during the 18-year scenario.

The model is consistent with the *Australian Groundwater Modelling Guidelines* (Australian Government National Water Commission 2012). The *Hydrogeological Assessment of the Christmas Creek Life of Mine Water Management Scheme* (Fortescue 2013a) is presented in Appendix 5A.

Peer Review of the Numerical Model

The numerical groundwater model was peer reviewed by HydroConcept, who considered it to be 'representative and based on a robust conceptual understanding' (HydroConcept 2013, Appendix 5B.

7.4 Potential Impacts

Activities or aspects of the Proposal that have the potential to affect hydraulic processes, not considering mitigation measures, include:

- mine dewatering may cause an expansion of area of drawdown, potentially affecting any groundwater dependent ecosystems that may be present in the drawdown area, decreasing surface water residence times in the Fortescue Marsh and yintas
- injection of water may cause areas of mounding, including surface expression of injected water, potentially affecting any ecosystems sensitive to waterlogging that may be present in the mounding area
- mine infrastructure may modify channel flow patterns and cause erosion, shadowing and changes to surface flow volumes.

This section focuses on the potential impacts of the Proposal on groundwater and surface water regimes and the proposed mitigation measures to minimise those impacts. Impacts associated with changes to water quality are discussed in Section 8, impacts to vegetation resulting from changes in groundwater and surface water regimes are discussed in Section 9 and impacts to subterranean fauna are discussed in Section 11.

7.5 Evaluation of Options or Alternatives to Avoid or Minimise Impact

7.5.1 Groundwater

The primary option to avoid impacts would be to prevent further mining below the watertable. However, this would mean early closure of the Christmas Creek mine and not accessing the majority of the available ore. This would:

- limit utilisation of the existing infrastructure, including ore processing facilities, roads, rail and pits
- require mining in other locations, with associated impacts to the environment, to provide iron ore resources.

This is not considered to be a viable option.

Abstraction of groundwater for mining purposes (dewatering and mine water supply) requires consideration of the management of excess water abstracted. Fortescue has considered

options for managing excess water in line with the Department of Water hierarchy of water management methods, being (in order of preference) (DoW 2009a):

1. Efficient on-site use - used for fit-for-purpose activities (such as processing and dust suppression).
2. Transfer to meet other demand, including other proponents in the area and public water supply.
3. Injection back into the aquifer at designated sites.
4. Controlled release to the environment where the excess water release is allowed to flow (either through a pipe or overland) into a designated water course or wetland.

Fortescue will supply all processing and dust suppression needs at Christmas Creek with the abstracted water which is of suitable quality, in accordance with the preferred water management method above. There are limited external demands for water in the area, as other mines in the area are also below watertable with excess available water. The remaining abstracted water will be injected into local aquifers under the CCWMS as per management Option 3 above, for the conservation and protection of water sources and sensitive environments such as the Fortescue Marsh. Controlled release to the surface will only be used during system failures or in exceptional circumstances when major maintenance is being undertaken on the system, as discussed in Section 7.6.1.

The CCWMS allows Fortescue to actively avoid or minimise impacts to groundwater levels, using the system of tailored management where water can be directed to specific areas for injection or storage.

As the CCWMS has proven to be effective, with no breaches of Class 2 triggers being recorded to date, no other options for managing groundwater have been considered. Continual improvement of the CCWMS occurs as part of the annual and triennial review process required under the *Christmas Creek Groundwater Operating Strategy* CC-PH-HY-0002 (Fortescue 2012d, Appendix 5C).

7.5.2 Surface Water

The scope to consider alternative locations for this Proposal to avoid or minimise impact is limited as the location of the mine is dictated by the extent of the ore resource. Surface water drainage paths at Christmas Creek generally run in a north-south direction, towards the Fortescue Marsh and the entire proposed Christmas Creek mine is almost 40 km long with an east-west alignment. As such, drainage has been a key consideration in mine planning. There is some flexibility with locations of linear infrastructure and WRSFs and minimising disturbance to surface water regimes within these constraints has been incorporated into the mine planning by ensuring that final WRSFs are generally outside of major creek line flood areas.

The most significant means of avoiding surface water impact in the Proposal is the CCWMS. This system will ensure that under normal circumstances, all water not required for mining will be injected back into the aquifer rather than discharged to the surface. Groundwater modelling of the CCWMS indicates that no surface expression of groundwater will occur as a result of injection activities (Fortescue 2013a). Discharge to the surface will only occur as a contingency measure.

Contingency Discharge (or controlled surface water discharge) is a licensed water disposal method, instigated for operational ‘contingency’ reasons (including lack of injection capacity due to construction delays and flooding of pits due to significant rainfall events). Discharge volumes are reported to DER in accordance with Fortescue regulatory requirements. The groundwater abstraction licence allows surface water discharge to be used as a means of discharging excess water from dewatering abstraction; however, this has not been required at Christmas Creek to date.

Open cut mining changes landforms in order to extract the target ore and manage the waste rock or overburden. Pits, stockpiles and WRSFs will alter the local surface water regime by diverting or capturing water that would otherwise be transported downstream. Mining at Christmas Creek uses progressive backfilling where possible to reduce the pit and stockpile areas that are active at any given time. This process reduces the impact of mining upon the surface water regime of the area as the landforms can be stabilised and rehabilitated as the mining face progresses. All significant creek lines that require diversion within the Christmas Creek Mine will be re-established to resemble natural flow paths where appropriate as part of the progressive rehabilitation work.

7.6 Assessment of Modelled Direct and Indirect Impacts

7.6.1 Surface Water: Mine Infrastructure

As outlined in Section 7.3.1, mine pits, TSFs and WRSFs affect surface water flows by potentially diverting upstream flows and capturing rainfall within mining areas, reducing the catchment area for downstream flows. Channel waterways may also be diverted around mine pits and waste dumps, resulting in altered flow regimes and volumes.

This can result in areas of shadowing that receive less flow than previously because surface flow processes have been interrupted or diverted. Shadowing can affect both channel flow and sheet flow processes. Mine pits, TSFs and WRSFs can also act to prevent water flowing downstream.

The presence of mine infrastructure and diversions of waterways around mine pits may result in changes to flood extents and flow velocities. The mine pits and waste rock dumps are separated from the surrounding catchments, resulting in a reduction in catchment areas and

consequently flows. Runoff from upstream is diverted around the WRSFs and mine pits. All surface water diversions will still flow into the Fortescue Marsh.

Rainfall onto WRSFs infiltrates due to the WRSF design. The top of WRSFs are typically finished off as a level surface and surrounded by windrows to capture surface runoff. Some waste material is placed in unlevelled piles, creating an uneven surface. For paddock-dumped waste, water is generally absorbed into the uneven and uncompacted surface material. In both cases, little or no surface runoff occurs from the WRSFs, particularly during low flow events. In larger flow events, pits and WRSFs may absorb water and act as blockages to flow, causing downstream water shadows to form.

Operations at Christmas Creek undertake a range of measures to prevent impacts on surface water regimes. These measures may include:

- pipelines being raised or buried at appropriate intervals within sheet flow areas, to prevent obstruction of surface water flows
- construction of major stream crossings for major roads using cement stabilising at the stream bed level
- rock spalls downstream of major stream floodways to dissipate energy and reduce flow velocities
- where a raised crossing is required, this is kept as low as possible to permit flood debris to be carried over it in peak flows without obstruction
- water management infrastructure such as culverts or floodways will be selected on a site-by-site basis using a risk-based assessment informed by a hydraulic assessment of the site.

The impact of the current mine on surface water regimes at Christmas Creek is considered to be minimal (Fortescue 2009a). The impact of mine pits, TSFs and WRSFs on the surface hydrology of the site has been modelled by Worley Parsons (2014, appendix 5G). The study aimed to estimate the likely impact of the development on aspects of the surface water characteristics. The study assessed:

- changes to flood patterns in channel flow areas
- sheet flow shadowing
- changes to flow volumes passing through the site and reaching the Fortescue Marsh (described in Section 7.7.1).

This section refers primarily to the Worley Parsons (2014) study, which is presented in full in Appendix 5G. All information in the section below is from this study, except where otherwise referenced.

Channel Flow Flood Patterns

The main receiving water bodies downstream of the Proposal are major creek lines and yintas in smaller rainfall events and the broader Fortescue Marsh in larger flood events. The catchment areas of these waterbodies may be reduced during and following mining due to:

- pit areas being internally draining during mining and not allowing surface water to overflow from the pit
- high infiltration rates in porous waste dumps resulting in surface water infiltrating rather than flowing.

Water that infiltrates rather than forming runoff at Christmas Creek will enter the groundwater system within the Fortescue Marsh catchment.

Modelling was undertaken to assess the impacts of the mine on channel flow, in terms of both flow velocity and depth of inundation. The depth of inundation is a key factor in terms of impacts on vegetation that may rely on streamflow in more frequent events as a water supply. The modelling investigated the impact of the mine infrastructure on the flow patterns of the 1 in 5-year, 1 in 20-year and 1 in 100-year Average Return Interval (ARI) storm. The impact of the proposed mine layout in 2017 compared to 2013 (existing scenario) on these flood events was modelled.

The primary impacts of these changes are a temporary changes in flow depth (decreased in some areas and increased in other areas while diversions are in place). Some areas which would be expected to receive flows at particular events are now expected to be dry, and other areas that would be expected to be dry are now expected to receive flows. Changes to flow depth and areas of inundation are presented in Figure 17 , Figure 18 and Figure 19. In summary:

1. An area of 100 ha that was wet in the 1 in 5-year ARI event will become dry, should that event occur in 2017 (Figure 17). This represents 2.4% of total area of inundation in this event.
2. An area of 139 ha that was wet in the 1 in 20-year ARI event will become dry, should that event occur in 2017 (Figure 18). This represents 2.7% of total area of inundation in this event.
3. An area of 49 ha that was wet in the 1 in 100-year ARI event will become dry, should that event occur in 2017 (Table 15, Figure 19). This represents 0.8% of total area of inundation in this event.

Table 15: Potential Impact Areas for Changes in Inundation Associated With Creek Lines between Year 1 and Year 5

Event	Not Impacted (ha)	Wet Areas Becoming Dry (ha)	Dry Areas Becoming Wet (ha)	Total Area of Inundation (ha)
1 in 5-year ARI	4,127	100	34	4,160
1 in 20-year ARI	5,161	139	23	5,184
1 in 100-year ARI	5,932	49	18	5,950

Source: Worley Parsons 2014

The areas of change are relatively small when compared to the total area of inundation. The area experiencing changes is smaller in the 1 in 100-year ARI event than the smaller events. This indicates that the areas experiencing change are predominantly areas that would experience inundation during less frequent flood events. In the majority of cases, the change relates to the frequency of inundation experienced, rather than whether inundation will be experienced.

Sheet Flow Shadowing

Impacts on sheet flow areas were assessed by Worley Parsons in a qualitative manner (Worley Parsons 2014, Appendix 5G). The sheet flow areas were mapped according to topography and inspection of aerial photography to identify the presence of sheet flow dependent Mulga groves (Figure 20). Areas of sheet flow were identified as being either:

- directly affected by construction of infrastructure including haul roads, pits and waste rock dumps
- indirectly affected by upstream blockage of sheet flow
- not affected.

The areas of impact were determined based on the relative location of infrastructure and the flow areas. Sheet flow is considered to be restored at a 45 degree angle from the direct impact zones. The impact on sheet flows was calculated using the life of mine footprint.

Of the 6,142 ha sheet flow area identified by Worley Parsons (2014), 3,415 ha will not be impacted by either sheet flow shadowing or clearing (Table 16). 439 ha of vegetation that will not be cleared will be indirectly impacted by sheet flow shadowing (Table 16). The total area of impact is shown in Figure 20.

Table 16: Sheet Flow Impact Areas

Level of Impact	Area (ha)	Percentage of Sheet Flow Area (%)
Sheet flow area directly impacted	2,288	37
Sheet flow shadowing	439	7
No impact	3,415	56
Total	**6,142**	**100**

Source: Worley Parsons 2014

The impact of sheet flow shadowing on sheet flow dependent vegetation is discussed in Section 9.7.3.

Surface Flow as a Contingency for Dewatering Injection System

Surface flow will only be considered as a method of discharge for water if adequate injection capacity is not available due to a system failure or maintenance requirements. If uncontrolled, this process could lead to creation of new flow paths and erosion. In line with the *Dewatering Discharge Contingency Procedure* CH-PR-EN-0003 (Fortescue 2014c) and any relevant Part V Licence conditions, contingency discharge of water will only occur at designated creek line discharge points. This procedure allows for discharge of up to 35 ML/d of fresh or brackish water for periods of up to 21 days under limited circumstances (Fortescue 2014c). Monitoring of water quality and turbidity is required during the process (Fortescue 2014c). The potential impact of any discharge is considered to be limited and can be managed adequately through this process.

7.6.2 Groundwater: Dewatering and Injection

The impacts of dewatering and injection result in drawdown from dewatering and mounding from injection. Dewatering is centred on the area being mined at a given point in time and will move as mining progresses. The drawdown effects will consequently be concentrated in the area being mined, and are located higher in the landscape where depths to groundwater are greater. The volume and location of dewatering changes as the area being mined moves as shown in Figure 21 to Figure 25. Modelled water levels are the results of applying a basic dewatering and injection regime. Ongoing optimisation of this regime throughout operations will enable finer control of the system to allow impacts associated with groundwater levels to be further minimised. As such, the impacts described in the sections below can be considered conservative.

Abstraction and Injection Volumes

Dewatering and injection volumes over the life of mine under an average rainfall sequence are presented in Table 17. The predicted average annual dewatering volume over the period 2014 to 2028 is 40.5 GL/a. Of this, an average of 9.7 GL/a will be utilised in processing and dust

suppression and the remaining 30.8 GL/a will be injected (Table 17). The peak dewatering volume is estimated at 74 GL/a (Table 17). During the last few years of mining, the volume of water used is reduced as a result of scaling down operations and the requirement to inject saline water (Table 17). Use of saline water is undesirable in ore processing as it may cause problems during processing, transport and sale of ore.

Table 17: Modelled Dewatering and Injection Volumes

Financial Year	Volume Abstracted (GL/a)	Volume used on Site (GL/a)	Volume Injected (GL/a)
June 2014	50	12	38
June 2015	73.5	12	61.5
June 2016	32.2	12	20.2
June 2017	35.5	12	23.9
June 2018	39.3	12	27.3
June 2019	44.2	12	32.8
June 2020	69.0	12	57.4
June 2021	45.7	12	34.3
June 2022	44.4	12	33.4
June 2023	56.6	12	45.0
June 2024	44.6	12	32.7
June 2025	24.6	6	18.9
June 2026	19.5	6	13.8
June 2027	17.8	6	11.8
June 2028	10.9	0[2]	11.1
Average Annual	**40.5**	**9.7**	**30.8**
Cumulative (GL)	**608**	**150**	**462**

Source: Fortescue 2013a

The volume of water abstracted and injected depends on climatic conditions as well as the properties of the MMF orebody and Oakover Formation. Hydraulic properties are variable within aquifers and there is always a possibility that values will be different from that predicted based on core samples, pump testing and observed behaviour. As a consequence, modelling was undertaken using a range of climatic scenarios and varying the hydraulic conductivities and storage properties of the MMF and Oakover Formation to investigate the sensitivity of dewatering rates to changes in these parameters (Table 18). The highest average and peak dewatering rate occurred when the horizontal hydraulic conductivity [K_h] of the ore body was increased to 120 m/d (Table 18). In this scenario, the average dewatering rate was 57.5 GL/a and the peak dewatering rate was 108.8 GL/a (Table 18).

[2] Mine water use is reduced in the final years of operation as a result of scaled down operations, requirement to inject water and likelihood that an external water source will be required by this point. In the final year, more water will be injected than abstracted as water stored in transfer and sedimentation ponds is injected.

Table 18: Abstraction Volumes under various Sensitivity Scenarios

Sensitivity Case	Hydraulic Property				Average Dewatering Rate	Peak Dewatering Rate
	Oakover Formation		MMF			
	Vertical Hydraulic Conductivity (m/d)	Specific Storage (m^{-1})	Vertical Hydraulic Conductivity (m/d)	Specific Yield (m^{-1})	GL/a	GL/a
Base Case	200	1.00E-04	60	0.03	40.5	73.5
Wet	200	1.00E-04	60	0.03	43.3	77.2
Dry	200	1.00E-04	60	0.03	39.7	72.1
High Oakover conductivity	400	1.00E-04	60	0.03	49.4	60.2
Low Oakover conductivity	100	1.00E-04	60	0.03	34.3	60.2
High Ore Body conductivity	200	1.00E-04	120	0.03	57.5	108.8
Low Ore Body conductivity	200	1.00E-04	30	0.03	31.2	56.1
High Ore Body specific yield	200	1.00E-04	60	0.045	40.9	73.5
Low Ore Body specific yield	200	1.00E-04	60	0.015	40.1	72.1
High Oakover specific yield	200	5.00E-04	60	0.03	40.9	73.5
Low Oakover specific yield	200	2.00E-05	60	0.03	37.3	73.5

Source: Fortescue 2013a

The rainfall sequence in the 'wet' case was developed based on the wettest 14 consecutive years in a modelled rainfall dataset over 1000 years. The 'dry' sequence was developed based on the driest 14 consecutive years the dataset. As such, the likelihood of each of the three rainfall cases actually occurring is not equally distributed.

Life of Mine Groundwater Levels

Continuation of mining in 2014 will result in drawdown in the central part of the Christmas Creek Mine (Figure 21). Brackish water will continue to be injected to the west of the mine, resulting in some mounding in this area (Figure 21). Injection of saline water will occur to the south of the mine to prevent drawdown effects approaching the Fortescue Marsh (Figure 21). The injection volume peaks in 2015 and then reduces, resulting in the model showing a decrease in mounding impacts to the west over time (Figure 22). The high permeability and storage capacity of the Oakover Formation indicates that injecting water results in a small change in groundwater levels when compared with injecting water into a low permeability aquifer.

Modelled drawdown of 1 m reaches the northern fringe of the Fortescue Marsh in 2016. Mounding in the east is no longer apparent by 2020, and the area of drawdown remains relatively stable around the Fortescue Marsh until 2020 (Figure 23). The model does not predict any mounding after 2020.

In 2021, the mine expands in both easterly and westerly directions which results in an expansion of drawdown to the east and west (Figure 24). The largest area of drawdown is

present in 2028, the last year of mining (Figure 25). At this time, the edge of the Fortescue Marsh experiences less than 2 m of drawdown, with areas in the east experiencing less than 1 m of drawdown (Figure 25).

Comparison of Potential Impacts under Different Rainfall Sequences

A comparison of the behaviour of groundwater levels due to climatic and mine influences was undertaken by modelling the impacts of mining under the wet, dry and average rainfall sequences at existing monitoring bore locations near the edge of the Fortescue Marsh (Figure 26).

The magnitude of drawdown and mounding can change based on rainfall conditions because:

- less dewatering and injection may be required during drier periods
- increased injection due to increased dewatering and elevated water levels in the Fortescue Marsh may mitigate drawdown in wetter periods.

Groundwater levels under both natural and mining conditions are significantly affected by climate, with watertable increases of greater than 3 m being recorded following large rainfall events.

There are five bores located adjacent to the Fortescue Marsh, south of the Christmas Creek mine (Figure 26); these are CCFMM01, CCFMM02, CCFMM03, CCFMM04 and CCFMM05. Modelling was undertaken for each of the three rainfall sequences under two scenarios, one incorporating dewatering and injection to support mining activities and another with no mining activities.

CCFMM01 is located adjacent to the Fortescue Marsh at the western edge of the Christmas Creek mine (Figure 26). Until late 2017, groundwater levels at this location are dominated by injection, with groundwater levels with mining being up to 1.5 m greater than those without mining occurring (Figure 27). From late 2017, groundwater levels in the two scenarios (i.e. with mining and without mining) remain similar until approximately 2022 (Figure 27). The magnitude of impacts is similar under all three rainfall sequences, although drawdown is slightly greater under the dry sequence in the final years.

CCFMM02 is located adjacent to the Fortescue Marsh, east of CCFMM01 (Figure 26). Until late 2017, the modelling indicates groundwater levels at this location are dominated by injection, with groundwater levels with mining being up to 0.5 m greater than those without mining occurring (Figure 28). From late 2017, groundwater levels in the two scenarios (i.e. with mining and without mining) remain similar until approximately 2022 (Figure 28). After this time, drawdown starts to dominate. The magnitude of impacts is similar under all three rainfall sequences, although drawdown is slightly greater under the dry sequence in the final years.

CCFMM03 is located to the south of the centre of the Proposal Area (Figure 26). The influence of water levels in the Fortescue Marsh due to rainfall can be clearly observed in the peaks and

troughs in the wet sequence with and without mining (Figure 29). This area experiences limited mounding under all rainfall sequences until 2016 (Figure 29). After 2016, drawdown begins to occur under all rainfall sequences (Figure 29). Drawdown is generally less than 1 m except after 2024 (Figure 29). The magnitude of impacts is similar under all three rainfall sequences, but drawdown in later years is greater (approximately 2 m) under the dry rainfall sequence.

CCFMM04 is located to the east of CCFMM03 (Figure 26). This area also experiences limited mounding under all rainfall scenarios until 2016, after which drawdown predominates (Figure 30). Again, drawdown increases after 2024 in all scenarios, but is more pronounced with the dry and average rainfall sequences (Figure 30).

CCFMM05 is located to the east of CCFMM04, where the distance between the mine and the Fortescue Marsh is greater (Figure 26). Groundwater levels at this location are more strongly influenced by surface water levels in the Fortescue Marsh, as shown by the peaks and troughs in the groundwater levels (Figure 31). The influence of the mine at this location is limited, with less than 0.5 m of drawdown being observed (Figure 31).

Post-closure Groundwater Levels

Groundwater levels were modelled for a period of 50 years post-closure. Following closure, impacts slowly recede from the edge of the Fortescue Marsh as recovery occurs (Figure 32 to Figure 36). At one year post closure, approximately 57,000 ha are predicted to be experiencing drawdown, with 30% of that area experiencing a drawdown of greater than 5 m. After five years, only 8,000 ha is expected to experience a drawdown of greater than 5 m, with the majority experiencing 2-3 m of drawdown. By year 20, the magnitude of drawdown has reduced to a maximum of 4 m. By year 50, the maximum drawdown is expected to be less than 3 m with an approximate extent of 32,000 ha (a 45% recovery in drawdown extent from year 1 post closure).

Groundwater levels at the near-marsh Monitoring bores are predicted to fully recover by 20 years post-closure (Figure 35).

Monitoring of groundwater levels following closure is expected to be undertaken until it can be demonstrated that there is no major deviation from the modelled recovery. This is expected to be achieved within five years.

Potential Impacts on Station Bores

Station bores (Figure 26) have the potential to be affected by drawdown and may become dry and unable to be used to supply water for stock. Where mounding occurs, bore supply will not be adversely affected. The four operational station bores are present within the broader Proposal area and may be affected by drawdown, depending on the rainfall scenario.

Where station bores are predicted to be affected by drawdown, the following options will be investigated for implementation:

- modifying well construction (deepen well)
- establishing an alternative water supply (i.e. install another well)
- supplementing water supply at affected well sites.

Any potential impacts on station bores are considered to be manageable to the satisfaction of the landholder and DoW.

Potential Surface Expression of Injected Water

The area of saline injection between the mine and the Fortescue Marsh will change as mining progresses. Moving the areas of injection allows Fortescue to reduce the area of potential impact of mining. By moving the injection area so that the majority of injection occurs between the mine and the Fortescue Marsh, potential impacts to the Fortescue Marsh and potentially groundwater dependent ecosystems can be minimised.

If the quantity of water being injected is greater than the aquifer can manage, waterlogging and the potential creation of new surface flow paths and erosion may result. If the water is saline, this may also cause surface salinity. To mitigate the potential for surface expressions of injected water, each injection bore will be controlled by automatically monitoring water levels to avoid exceeding predetermined criteria. Additional manual monitoring will be undertaken to ensure the automated system is accurately calibrated. Injection is managed so that saline water is injected into the deeper Oakover Formation. This measure minimises the risk of salinisation of the superficial aquifer as the low connectivity between the Oakover Formation and the shallow Tertiary Detritals prevents the saline water moving into the superficial aquifer. As a result of this management system, surface water expression of injected water is not expected to occur.

7.7 Cumulative Impacts

7.7.1 Surface Water Flows to the Fortescue Marsh

The main potential cumulative effect of mining in the Fortescue Marsh catchment is the potential reduction of runoff into the Fortescue Marsh.

The predicted extent of changes to the Chichester sub-catchment water catchments from the Proposal has been examined in the context of predictions regarding the neighbouring Fortescue Cloudbreak operation as well as the Roy Hill Mine (Hancock Prospecting) located east of Christmas Creek).

Modelling (Worley Parsons 2014, Appendix 5G), was undertaken to determine the impact on the flows into the Fortescue Marsh due to the loss of catchment area associated with the Christmas Creek, Cloudbreak and Roy Hill mining projects. The three projects are located in the Chichester subcatchment of the Fortescue Marsh. This modelling investigated the change in flows to the Fortescue Marsh under three scenarios:

- undisturbed scenario without mining
- disturbed scenario, representing the maximum development of all three projects
- restored scenario, where all three mines have been closed and rehabilitated.

Modelling was undertaken using a rainfall series that represented rainfall in the Fortescue Marsh catchment for the period 1984 to 2011 (Table 19).

Table 19: Modelled Annual Average Runoff to the Fortescue Marsh

Source of Inflow	Undisturbed Scenario Contribution		Disturbed Scenario Contribution		Change (undisturbed to disturbed)	Restored Scenario Contribution		Change (undisturbed to restored)
	Volume (GL/a)	%	Volume (GL/a)	%	%	Volume (GL/a)	%	%
Chichester	48	17.2	45	16.1	Loss 1.1%	46	16.4	Loss 0.8%
East Fortescue River	128	45.6	128	46.2	Gain 0.6%	128	46	Gain 0.4%
Southern Flanks	23	8.3	23	8.5	Gain 0.2%	23	8.4	Gain 0.1%
Weeli Wolli Creek	35	12.4	35	12.6	Gain 0.2%	35	12.5	Gain 0.1%
East Hamersley	18	6.3	18	6.4	Gain 0.1%	18	6.3	No change
Direct Rainfall	29	10.2	29	10.3	Gain 0.1%	29	10.3	Gain 0.1%
TOTAL	**281**	**100**	**278**	**100**	**Loss 1.6%**	**279**	**100**	**Loss 0.7%**

Source: Worley Parsons 2014

Average flows in the undisturbed scenario were 281 GL/a (Table 19, Worley Parsons 2014). Modelling indicates that the change to average flows to Fortescue Marsh as a consequence of the development of the three mines is relatively small. During the mining process, the flows are estimated to reduce by 3 GL/a, or approximately 1% of the total flow volume. Following rehabilitation, flows are anticipated to increase slightly to an average of 279 GL/a (Table 19, Worley Parsons 2014). Given the relatively small change in volume and the high variability of annual flows to the Fortescue Marsh, these impacts are considered to be negligible. This change in volumes is also not anticipated to affect surface water residence times in the Fortescue Marsh.

7.7.2 Groundwater Regimes

The predicted extent of drawdown and mounding from the Proposal has been examined in the context of predictions regarding the Cloudbreak mine, immediately to the west of Christmas Creek, as well as the following projects, where drawdown predictions are publicly-available through respective PERs:

- Roy Hill Mine (Hancock Prospecting, located east of Christmas Creek)
- Marillana Mine (Brockman Resources, located on the southern side of the Fortescue Marsh) (Figure 37).

Cumulative impacts would only be expected if the impact from one mine exacerbated the impact from the other through the intersection of the drawdown and/or mounding zones of each mine.

There is no overlap of the drawdown and/or mounding zones of Christmas Creek with those of Marillana, (Figure 37).

Cloudbreak

There is some overlap between the drawdown and/or mounding areas of Cloudbreak and the areas of Christmas Creek (Figure 37). This reflects Fortescue's adoption of a combined approach to water management for its operations in the Chichester Range to optimise Cloudbreak and Christmas Creek water management interactions.

The contours for Cloudbreak represent the last approved year of mine life for Cloudbreak. The area of mounding associated with the eastern injection area of the Cloudbreak mine will subsequently be mined by Christmas Creek (Figure 37). This allows the surplus water injected by Cloudbreak to be abstracted and used for processing and/or dust suppression at Christmas Creek (Fortescue 2013a).

As mining at Christmas Creek progresses, the drawdown will effectively negate the effects of mounding at Cloudbreak.

Roy Hill

The dewatering impact from Christmas Creek is predicted to overlap with that from Roy Hill (Figure 37). In recognition of this overlap, Fortescue and Roy Hill have developed a *Stakeholder Consultation Reinjection Management Plan,* CC-PL-EN-0006 (Fortescue 2011a, Appendix 2A) to address potential water management interactions between the two mines. The *Stakeholder Consultation Reinjection Management Plan* was approved by OEPA in November 2011.

Dewatering activities at both Roy Hill and Christmas Creek are designed to achieve the required lowering of groundwater level, as opposed to maintaining a specified abstraction rate (Fortescue 2013a). Abstraction and associated drawdown from one mine effectively reduces the abstraction rate required to meet the desired groundwater level at the other (Fortescue 2013a). Overlap of the drawdown area is mutually beneficial to meeting the objectives of both Roy Hill and Christmas Creek operations and results in a decreased dewatering abstraction (Fortescue 2013a).

Consequently, the overlap of the two impact areas is considered unlikely to cause a cumulative impact.

7.8 Management Measures and Performance Standards

Fortescue has previously prepared management plans for surface water and groundwater at Christmas Creek. The management of surface water at Christmas Creek is based on the

principle of maintaining flows to the Fortescue Marsh. Modifications to flow paths will be required for periods of up to a few years to allow for mining, but major flow paths will be predominantly reinstated to resemble the original drainage patterns where appropriate in the long term. Progressive dewatering will be limited to active mining areas to minimise dewatering requirements.

7.8.1 Management of Surface Water

Management of potential impacts on surface water process have historically been addressed in the *Chichester Operations Surface Water Management Plan* (45-PL-EN-0015) (Fortescue 2009a) and the *Surface Water Management Plan* (45-PL-EN-0024) (Fortescue 2012c). These Plans have been superseded by the *Surface Water Management Plan* 100-PL-EN-1015, (Fortescue 2014i, Appendix 2B).A summary of this plan is provided below, together with key management actions.

Surface Water Management Plan

The *Surface Water Management Plan* 100-PL-EN-1015 was revised in order to provide consistent management objectives and actions relating to surface water at all Fortescue operations.

Management measures detailed in the *Surface Water Management Plan* which are relevant to hydrological processes include:

- Minimise clearing and vegetation disturbance so that flow regimes are minimally impacted.
- Locate, design, construct and operate drainage infrastructure to design specifications which reflect risk assessment outcomes in minimising interference and disruption of natural surface water flows and quality.
- Where possible, align haul/access roads with existing transport corridor or approved disturbance corridors so that surface water flow regimes are minimally impacted.
- Design mine pits to be internally draining. Rainfall to be managed via sumps and potentially discharged directly to the environment.
- Design bunding of pits, dumps, and iron ore stockpiles to minimise impact to surface water flow volume, flow regimes and turbidity.
- Contain and appropriately manage contaminated stormwater prior to release to the environment.
- Where appropriate, re-establish natural stream and drainage flows to resemble original drainage patterns, including rehabilitation of major drainage channels.

Surface water monitoring is undertaken at Christmas Creek. Monitoring involves the measurement of water quality parameters including TDS, TSS, pH, electrical conductivity and

major ions at a number of major creek crossings and the Fortescue Marsh on a quarterly basis when water is present.

7.8.2 Management of Groundwater

An adaptive management approach to groundwater management is in place at Christmas Creek to monitor and respond to the actual water level changes as a result of dewatering and injection, and is described in the *Christmas Creek Groundwater Operating Strategy* CC-PH-HY-0002 (Fortescue 2012d, Appendix 5C).

Groundwater Management Plan

The *Groundwater Management Plan* 100-PL-EN-0029 (Fortescue 2014b, Appendix 2C) was prepared in June 2014, in order to minimise the direct and indirect impacts of Fortescue's Groundwater management activities on groundwater quality and quantity at Fortescue operations. This Plan supersedes the following management plans:

- *Chichester Operations Groundwater and Bore Management Plan,* 45-PL-EN-0005 (Fortescue 2009b)
- *Dewatering Discharge Contingency Procedure* CH-PR-EN-0003 (Fortescue 2014c).

Management measures detailed in the *Groundwater Management Plan* which are relevant to hydrological processes include:

- Ensure location, design, construction and operation of water management infrastructure reflects risk assessment outcomes in minimising environmental impacts.
- Where dewatering infrastructure may significantly impact on surface water flows in areas of sheet flow dependent Mulga communities, ensure appropriate drainage infrastructure is incorporated into the project design.
- Where possible, utilise water from dewatering for onsite activities, such as dust suppression and OPF operations.
- When injecting excess dewater into a compatible aquifer utilise methods outlined in the *Operational Policy 1.01 Managed Aquifer Recharge in Western Australia* (DoW 2011).
- When construction or maintenance activities results in dewatering volumes in excess of what can be disposed of in accordance with the applicable *Groundwater Operating Strategy*, adopt temporary alternative disposal options as outlined in the *Dewatering Discharge Contingency Procedure* (CH-PR-EN-0003).
- Develop and implement a groundwater monitoring program in accordance with an approval, license or works approval issued under the EP Act, an approval under the EPBC Act, or a licence issued under the RIWI Act.

7.9 Predicted Environmental Outcomes

After application of management and mitigation measures described in Section 7.8, the Proposal is expected to result in the following outcomes in relation to hydrological processes:

1. Up to 110 GL/a will be abstracted for the purpose of dewatering, of which up to 35 GL/a will be used for processing and dust suppression with the remainder injected back into the aquifer.
2. Drawdown along the fringe of the Fortescue Marsh is predicted to be no more than 2.3 m.
3. With the cessation of dewatering, groundwater level drawdown in the mining area decreases from over 35 m at the end of mining (2028) to about 5 m after ten years (2038) and to about 3 m after 20 years (2048). Approximately 45% of the area affected by drawdown is completely recovered after 50 years.
4. Mounding along the fringe of the Fortescue Marsh is predicted to be no more than 2 m. Potential impacts of mounding from injection are predicted to be short term and localised. No mounding is expected post closure.
5. No impact is expected in terms of residence time of surface water in the Fortescue Marsh.
6. Any potential impact to station supply bores will be managed through well modification or substitution with an appropriate water source if water supply is affected.

The predicted environmental outcomes in terms of vegetation impacts as a consequence of hydrological changes are discussed in Section 9.7.2.

The Proposal is not expected to result in significant adverse impacts to hydrological processes. The key mitigation measure is the separation of saline and brackish water and the management of injection to minimise mounding and drawdown effects.

In considering the outcome as described, the Proposal is expected to meet the EPA objective for hydrological processes to maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected.

8. INLAND WATERS ENVIRONMENTAL QUALITY

8.1 Relevant Environmental Objectives, Legislation, Policies and Guidelines

8.1.1 EPA Objective

The EPA applies the following objective to the assessment of proposals that may affect inland waters environmental quality:

> *To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.*

8.1.2 Regulatory Framework

The protection of inland waters environmental quality is primarily governed by Part V of the EP Act, which, among other matters, regulates activities with potential to cause pollution or environmental harm. Regulation of potentially polluting activities is primarily through Works Approvals and associated discharge licensing provisions of the EP Act and regulations.

Guidance and Position Statements

In addition to the *Western Australian Water in Mining Guideline* (DoW 2013), *Pilbara Regional Water Plan* (DoW 2010a) and the Fortescue Marsh Guidance (EPA 2013d) described in Section 7.1, the following documents are relevant in setting the framework for identification and assessment of impacts to hydrological processes in the Proposal area.

National

Water quality guidelines for the protection of marine and freshwater ecosystems have been released under the auspices of the *National Water Quality Management Strategy* (NWQMS) (ANZECC/ARMCANZ 2000). The guidelines provide a comprehensive list of recommended low-risk trigger values for physical and chemical stressors in water bodies, and are applied to five geographical regions across Australia and New Zealand. The NWQMS is supported by the *Guidelines for Groundwater Protection in Australia* (ARMCANZ and ANZECC 1995), which outlines a framework for protecting groundwater in Australia. The guidelines require identification of beneficial uses for groundwater in aquifers, and policy to manage these issues.

A series of guidelines on national water quality management has also been released by the Natural Resource Management Ministerial Council (NRMMC) and, in some cases, in collaboration with the National Health and Medical Research Council (NHMRC) and the Australian Health Ministers Conference. These guidelines address a range of issues including policies and processes for water quality management, water quality benchmarks, groundwater

management, diffuse and point sources, guidelines for sewerage systems, effluent management and water recycling.

State

Water resources policy and guidance in Western Australia relevant to this Proposal includes:

- *Water in Mining Guideline* (DoW 2013)
- *Pilbara Regional Water Plan* (DoW 2010a)
- *Environmental and Water Assessments Relating to Mining and Mining-related Activities in the Fortescue Marsh Management Area* (Fortescue Marsh Guidance) (EPA 2013d)
- *State Water Quality Management Strategy* (Government of Western Australia 2001)
- Water Quality Protection Notes and Guidelines for mining and mineral processing applied by DoW and DMP.

The first three documents are discussed in Section 7.1.

The Government of Western Australia developed the *State Water Quality Management Strategy* in 2001 to supplement the National Water Quality Management Strategy with the objective "to achieve sustainable use of the Nation's water resources by protecting and enhancing their quality while maintaining economic and social development".

The *State Water Quality Management Strategy* proposes that a Water Conservation Plan be developed before a water allocation licence is issued or renewed. The Water Conservation Plan must outline water efficiency objectives and timeframes. Licence conditions can then require implementation of the Water Conservation Plan to an agreed schedule.

In 2000, the Water and Rivers Commission (now DoW) and Department of Minerals and Energy (now DMP) developed a series of Water Quality Protection Notes and Guidelines for mining and mineral processing. These guidelines address a range of mine site issues including dewatering, installation of groundwater monitoring wells, water quality monitoring, stormwater management and acid mine drainage.

The Proposal footprint does not overlay any drinking water source protection areas and as a consequence, DoW has no direct regulatory role with respect to groundwater quality associated with the Proposal. However, it provides a centre of advice to Government on all water matters, including to the EPA, and has a number of associated guidance statements related to groundwater quality.

In setting criteria for water quality impacts, the *Mining and Mineral Processing - Mine dewatering: Water Quality Protection Guidelines No. 11* (WRC 2000) discusses mine dewatering receiving water quality criteria and notes that the appropriate discharge criteria would be set under the licensing provisions of the EP Act. However, there is no comment on

what those criteria might be. These licensing provisions are administered by DER and apply to “prescribed premises”; however, no specific published criteria exist for discharges to water as a receiving environment in areas of non-fresh or non-marine waters.

Two DER (previously Department of Environment) policy statements are relevant to regulation of the proposed development under Part V of the EP Act and associated regulations with respect to impacts on water resources. The two statements are:

- Policy statement: *Works approval, licenses and conditions for prescribed premises* (DoE 2006a)
- Policy statement: *Limits and targets for prescribed premises* (DoE 2006b).

No specific receiving water quality or other environmental criteria are prescribed in the DER policy statements.

8.2 Surveys and Investigations

Groundwater and surface water quality has been investigated through the following surveys and investigations:

- *Christmas Creek Life of Mine Expansion Surface Water Investigation and Impact Assessment* (Worley Parsons 2014, Appendix 5G)
- *Christmas Creek 5-year Hydrogeological Modelling Assessment* (Fortescue 2010a)
- *Hydrogeological Assessment of the Christmas Creek Life of Mine Water Management Scheme* (Fortescue 2013a, Appendix 5A)
- *Flinders In Pit TSF Groundwater Impact Assessment* (SRK Consulting 2014, Appendix 4).

Monitoring of groundwater quality is undertaken as a condition of the Christmas Creek Part V Licence (L8454/2010/1).

8.3 Description of Factor

8.3.1 Groundwater Use and Values

The *Guidelines for Protection of Groundwater Quality in Australia* (ARMCANZ/ANZECC 1995) provide a framework to protect beneficial uses and values of groundwater throughout Australia. The relevant key values for groundwater in the Christmas Creek area under this framework are ecosystem protection, agricultural waters for stock watering and use for industrial purposes (mine process water) by Fortescue.

Groundwater with an electrical conductivity of less than 10,000 µS/cm (brackish water) is considered to have a beneficial use as it is suitable for stock watering (Fortescue 2010a). Groundwater may support partially groundwater dependent vegetation such as River Red Gum and occasionally Coolibah in creeklines. Groundwater also supports yintas and groundwater dependent ecosystems in and around the Fortescue Marsh (Section 9.4.6).

8.3.2 Surface Water Quality

Surface water runoff entering the Fortescue Marsh is generally of low salinity and turbidity, though turbidity increases significantly during large floods (Aquaterra 2005). During flooding events, salts deposited from previous drying episodes are redissolved and water entering the Fortescue Marsh becomes moderately saline (Fortescue 2009a). As the water evaporates, the salts are further concentrated, become hypersaline and deposition occurs leaving traces of surface salts (EPA 2006a). This process has led to the aquifer below the Fortescue Marsh becoming hypersaline.

Sediment loads to the Fortescue Marsh during the large flood events when the Fortescue Marsh fills are high because of the paucity of vegetation in the Pilbara, which allows for extensive soil erosion. On entering the Fortescue Marsh, this sediment quickly precipitates in the still waters (Aquaterra 2005).

Surface water quality monitoring is undertaken on a monthly basis, when recent rainfall has resulted in surface water being present in the creek systems around the Proposal area, and at yintas associated with the Fortescue Marsh. Regular surface water quality monitoring was established at Christmas Creek in October 2011, and sufficient rainfall was received to allow monitoring to take place at the creek systems in the following months:

- January, March and December of 2012
- January, February and December of 2013
- January of 2014.

Monitoring results have previously been compared with ANZECC assessment levels for Tropical Wetlands, Tropical Upland Rivers and Tropical Freshwater Lakes and Reservoirs, as detailed in the *Surface Water Monitoring Guidelines* (45-GU-EN-0002) (Fortescue 2011b). Adoption of these assessment levels has resulted in exceedences of the applied trigger levels being recorded in control sites (located upstream of mine infrastructure) and as such they are not considered to be appropriate assessment levels for this site. Site specific water quality trigger levels for pH, electrical conductivity, turbidity, total nitrogen, total phosphorus and dissolved metals will be determined once sufficient data is available.

Water Quality Monitoring Data: Creek Lines

The most recent creek line surface water quality results (January 2014) are summarised below. Samples were collected over 18 creek locations, incorporating control (upstream) and potential impact sites at Christmas Creek between 20 and 27 January 2014.

Table 20: Creekline Monitoring Data: General Parameters

	EC (µS/cm)	PH	Turbidity (NTU)	TPH (µg/L)
Minimum	31	6.8	5.0	220
Maximum	1540	7.9	1910.0	590
Mean	287	7.3	278.6	307

Table 21: Creekline Monitoring Data: Major Ions

(mg/L)	TP	TN	Na	K	Ca	Mg	Cl	CO_3	HCO_3	SO_4
Minimum	0.01	0.5	2	2	1	1	2	1	6	2
Maximum	0.26	7.5	239	20	48	14	389	1	60	133
Mean	0.05	1.3	30	6	18	6	44	1	32	36

Table 22: Creekline Monitoring Data: Metals

(mg/L)	Al	Fe	Mn
Minimum	0.01	0.05	0.001
Maximum	3.17	7.02	1.160
Mean	0.37	0.65	0.115

Surface water quality monitoring undertaken at Christmas Creek to date has generally exhibited a similarly high range of variability across most parameters as can be seen from the January 2014 results above. The ephemeral nature of local creeklines can lead to high variability in natural water quality during episodic flow events.

Fortescue Marsh

Samples from Moorimooridinina Pool (Yinta 1 on Figure 13) and Kulbee Creek Yinta (Yinta 2 on Figure 13) are taken as representative samples of Fortescue Marsh on a monthly basis, access permitting. The tables below reflect the samples taken in 2014.

Table 23: Fortescue Marsh Monitoring Data: General Parameters

		EC (µS/cm)	PH	Turbidity (NTU)	TDS (mg/L)	TSS (mg/L)
Moorimooridinina Pool	Minimum	368	6.97	16.9	265	<5
	Maximum	1800	9.12	248	1228	20
	Mean	984	8.03	120.7	681	9
Kulbee Creek Yinta	Minimum	193	7.66	14.3	130	<5
	Maximum	418	9.36	1300.0	270	218
	Mean	294	8.39	370.2	196	65

Table 24: Fortescue Marsh Monitoring Data: Major Ions

(mg/L)		Na	K	Ca	Mg	Cl	CO_3	TP	TN	SO_4
Moorimooridinina Pool	Minimum	39	13	21	6	48	50	0.02	0.7	38
	Maximum	238	40	63	23	341	83	0.11	1.2	182
	Mean	125	26	41	13	187	62	0.06	0.9	108
Kulbee Creek Yinta	Minimum	18	8	6	3	18	44	<0.01	0.6	12
	Maximum	55	15	16	8	58	72	0.36	1.9	31
	Mean	34	11	12	6	35	59	0.14	1.1	21

8.3.3 Groundwater Quality

Broad scale baseline characterisation of groundwater was not undertaken prior to the commencement of mining and dewatering at Christmas Creek. Groundwater quality monitoring has however been undertaken at monitoring locations across the site since 2009.

The *Christmas Creek Groundwater Operating Strategy* CC-PH-HY-0002 (Fortescue 2012d, Appendix 5C) provides a detailed framework for monitoring water quality at Christmas Creek. The Operating Strategy is approved for implementation by DoW. In accordance with the Operating Strategy, water quality parameters, including: major ions (Na, K, Ca, Mg, Cl, alkalinity, SO_4 and NO_3), metals: (Al, B, Fe, Cu, Zn, Ag, As, Cr, Pb, Cd, Hg, Ni, Sn, Se, Mn), electrical conductivity, field pH, lab pH, total dissolved solids and total suspended solids are recorded from the CCWMS monitoring bores (Figure 16) on a biannual basis. In addition, electrical conductivity at the CCWMS monitoring bores is measured in the field on a monthly basis.

Each monitoring bore is screened to target specific aquifers. Shallow screened bores target the Tertiary Detritals, whereas deeper screened bores generally target the Oakover Formation or MMF. Monitoring bores are often constructed in a nested arrangement with a number of bores, screened at differing intervals, located at the same site.

The results of water quality monitoring undertaken at Christmas Creek are reported to the DoW in annual and triennial aquifer reviews associated with the Christmas Creek 5C Licence to Take Water, and to the DER as part of the annual environmental monitoring review associated with the Christmas Creek Part V Licence.

Results of the most recent groundwater monitoring are summarised in Table 25, Table 26 and Table 27.

Table 25: Groundwater Monitoring Data: General Parameters

	EC (µS/cm)	PH	Turbidity (NTU)
Min	667	6.5	542
Max	190,000	8	181,000
Mean	73,426	7.3	61,926

Table 26: Groundwater Monitoring Data: Major Ions

(mg/L)	Na	K	Ca	Mg	Cl	$CaCO_3$	SO_4
Min	62	12	32	23	108	29	37
Max	52,200	4,520	650	4,850	69,000	271	25,800
Ave	18,269	1,631	325	1,467	25,692	167	7,815

Table 27: Groundwater Monitoring Data: Metals

(mg/L)	Al	B	Fe	Cu	Zn	Ag	As
Min	Below LOR	0.1	Below LOR	0.0	0.01	Below LOR	Below LOR
Max	0.02	5.3	<1	0.1	0.2	<0.02	<0.02
Ave	0.01	1.3	<1	0.02	0.07	0.001	<0.001
(mg/L)	**Cr**	**Pb**	**Cd**	**Hg**	**Ni**	**Se**	**Mn**
Min	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR	Below LOR
Max	0.015	<0.02	<0.02	<0.0001	0.024	<0.2	9.94
Ave	0.006	0.001	0.0026	<0.0001	0.006	<0.01	1.771

Results of groundwater quality monitoring for the period of August 2010 to July 2013 are described in the *Christmas Creek Triennial Groundwater Monitoring Review* (CC-RP-HY-0039) (Fortescue 2014a, Appendix 5D). A summary of key information from this review is provided below.

Mining Area

<u>Marra Mamba Formation</u>

The salinity of groundwater within the mining area has increased significantly in close proximity to the active dewatering areas due to the horizontal inflow of saline groundwater (from the Oakover Formation) induced by the steep hydraulic gradient and upwards migration of saline water due to depressurisation of the overlying brackish aquifers. This is an expected outcome of mine dewatering in this hydrogeological system.

Groundwater electrical conductivity is generally low in the northern area of the mine site along the base of the outcropping MMF. This is due to the groundwater recharge that occurs via rainfall and infiltration of through the outcropping MMF. Electrical conductivity increases to the south in the Oakover Formation aquifer and the Wittenoom Formation which occurs on the northern edge of the Fortescue Marsh.

Limited saline upconing is evident from dewatering, which is due to the saline water existing in the lower MMF, which has a lower hydraulic conductivity and is groundwater is flowing towards the abstraction bores.

Tertiary Detritals

Natural groundwater electrical conductivity gradients in the Tertiary Detritals increase steeply to the south towards the Fortescue Marsh. Electrical conductivity around the mining area is fresh-brackish due to better connectivity with the brackish MMF aquifer. The presence of a shallow freshwater lens is not evident from the data that has been collected to date.

Saline Injection Area

Injection of saline groundwater into the Oakover Formation has caused pressurisation of the aquifer in the vicinity of the borefield. The pressure gradient has advanced vertically to some extent however no impacts have been recorded at the watertable.

Some decrease in salinity of the Oakover Formation around the saline injection borefield has occurred due to the injection of lower electrical conductivity water than the native hypersaline groundwater.

Fringe of the Fortescue Marsh

Minor pressurisation of the Oakover Formation is observed in the area fringing the Fortescue Marsh. No impacts are observed at the watertable, where cycles of watertable rise and fall, driven by marsh flooding and recharge, still persist. Naturally hypersaline shallow groundwater exists along the northern edge of the Fortescue Marsh.

8.4 Potential Impacts

Activities or aspects of the Proposal that have the potential to affect inland waters environmental quality, not considering mitigation measures, include:

- abstraction of groundwater may lower water levels which may result in oxidisation of potential acid sulphate soils and/or increase the salinity of groundwater near dewatering locations
- injection of saline water may cause alterations to groundwater and surface water quality, which can potentially affect beneficial uses such as station bores
- operation of TSFs, WRSFs and open pit walls have the potential to result in acid or metalliferous drainage from the potential oxidisation of PAF material, which may affect surface and groundwater quality
- mine infrastructure may affect water quality through erosion and sedimentation, from earthworks and clearing, and through chemical spills and wastewater

- creation of temporary or permanent pit lakes following the cessation of dewatering activities may result in decreased surface water quality through processes such as evapotranspiration leading to hypersalinity.

The potential for disruption of surface drainage into the Fortescue Marsh due to mine pits, surface waste dumps and stockpiles is detailed in Section 7.6.1. The potential effects of changes to surface water flow on vegetation (including phreatophytic vegetation, samphire and Mulga) are discussed in Section 9.7.2.

8.5 Evaluation of Options or Alternatives to Avoid or Minimise Impacts

As outlined in Section 7.5.1, options for water management have been considered, with the preferred approaches being:

1. re-use for ore processing and dust suppression where water quality is suitable
2. injection into aquifers, as per the CCWMS
3. surface discharge as a contingency measure.

The CCWMS ensures that saline and brackish water are managed separately to minimise the risk of salinisation of the Tertiary Detritals during injection and to allow for reuse of brackish water to the greatest extent possible.

8.6 Assessment of Likely Direct and Indirect Impacts

8.6.1 Groundwater Abstraction

Assessment of Impacts to Groundwater Quality through ASS

The abstraction of groundwater may expose potential acid sulphate soils (ASS) to oxidising conditions if the watertable falls below historical levels. ASS refers to soils that are rich in iron sulphides that occur in anoxic conditions, below the watertable. These soils are generally associated with current or historical wetlands. If these soils are exposed to atmospheric oxygen (from lowering of the watertable or from excavation and storage above the watertable) these soils can oxidise, producing acid (DEC 2009b). The acidic groundwater can then result in mobilisation of metals, which decreases water quality.

The Fortescue Marsh is an area of extensive low-lying, episodically inundated flats, underlain by a shallow watertable. Inland wetlands with these characteristics have the potential to contain potential ASS in soils below the permanent groundwater level. Dewatering activities that lower the watertable beyond the natural fluctuation range could expose potential ASS to oxidation and subsequent acidification (DEC 2009b).

Based on numerical modelling outputs, dewatering will be confined to the northern fringe of the Fortescue Marsh over the life of the mine (Fortescue 2013a). The magnitude of drawdown beneath the fringe of the Fortescue Marsh is predicted to be less than 2.5 m over the life of the mine, as described in Section 7.6.2. The potential for dewatering activities to oxidise potential ASS in the Fortescue Marsh is considered low as the level of drawdown is likely to be within the natural fluctuation range of the watertable beneath the Fortescue Marsh under most climatic scenarios, as discussed Section 7.6.2. As such, impacts to surface water quality through ASS are not expected to occur.

Assessment of Impacts to Groundwater Quality through Salinisation

Temporary increases in salinity of the groundwater within the MMF are expected in close proximity to the mine pits being dewatered. The increase in salinity is due to horizontal flows from the Oakover Formation. This is currently being experienced, as described in Section 8.3.3 due to dewatering of the Flinders and Windich pit areas. Predicted impacts to water quality near active dewatering sites are expected to be temporary in nature. As the incoming water of higher salinity is being dewatered to allow mining of pits as part of the CCWMS, it is able to be selectively managed according to its measured EC.

8.6.2 Injection of Saline Water

Assessment of Impacts to Groundwater Quality through Injection

Injection of groundwater has the potential to result in changes to groundwater chemistry and salinity. Impacts will largely be avoided by the independent management of saline and brackish water under the CCWMS.

Brackish water, resulting from the dewatering of the shallow Tertiary Detritals, is managed in an independent system of conveyance pipelines, transfer, storage and settlement ponds and injection bores. The brackish water which cannot be used onsite or transferred to Cloudbreak is injected into the Tertiary Detritals within the brackish injection areas. It is then available to be abstracted at a later date if required, for potable or process water requirements.

Saline water generally results from the dewatering of the deeper Oakover Formation and MMF. Smaller volumes may also result from ore washing at the ore processing facilities and the brine product from the desalination process (approximately 150,000 µS/cm). If the brine from desalination, when mixed with saline groundwater to be injected still exceeds the natural salinity associated with the Oakover Formation, small amounts of brackish water can be mixed in to reduce the salinity to within acceptable levels. As such, no additional or different impacts are expected to result from the disposal of desalination water by injection as part of the CCWMS.

The saline water infrastructure consists of conveyance pipelines, settlement, storage and transfer ponds and injection bores. Saline injection generally takes place to the south of the mine infrastructure and targets the Oakover Formation.

The independent management of saline and brackish water, together with injection of excess water into consistent receiving aquifers prevents large scale impacts to water chemistry and electrical conductivity, which could occur if brackish and saline water were mixed and injected into a single aquifer.

Injected saline water enters the saline aquifer at depths well below the free watertable and, given the Oakover Formation has much higher permeability than the overlying Tertiary Detritals, the flow is lateral rather than upward. Therefore, as a rise in the free watertable is not anticipated, the transport of salts to the unconfined aquifer at the surface is not anticipated.

Station bores may also be affected by changes in salinity as these bores may access deeper aquifers where injection of saline water is undertaken. Should station bores become too saline to be used for stock irrigation, response measures will be developed in consultation with the pastoral station manager, as outlined in Section 7.6.2.

Assessment of Impacts to Surface Water Quality through Injection

Impacts to surface water quality can occur as a result of injection if the quantity of water being injected is greater than the storage capacity of the aquifer, leading to mounding of the watertable and surface expression of injected water. In the case of saline injection, this may also result in surface salinity.

The majority of the water to be injected is saline under the CCWMS is saline. As such, it will be injected into the deeper Oakover Formation. Limited connectivity between the Oakover Formation and the overlying Tertiary Detritals results in the likelihood of surface expression being very low. Numerical modelling does not predict any surface expressions of groundwater associated with mounding due to injection (Fortescue 2013a).

Each injection bore will be monitored and water levels will be managed to avoid exceeding pre-determined criteria, in order to ensure that water levels do not rise sufficiently to cause a surface discharge. As a result of the natural hydrogeology and the ongoing implementation of the CCWMS, surface water expression of injected water is not expected to occur. As such, impacts to surface water quality as a result of injection activities are not expected to occur.

8.6.3 Acid and Metalliferous Drainage

Fortescue manages the potential for acid and metalliferous drainage (AMD) across all sites by applying a risk-based approach. This approach includes the identification of at risk material, potential pathways and receptors at each site.

Comprehensive geochemical testing of at risk material is undertaken at each site, as part of a structured, ongoing programme. Results of geochemical testing are then analysed, and the risk of AMD assessed. Further testing is undertaken as required, and specific management

strategies are developed where unacceptable inherent risks are identified. A summary of this process as it relates to Christmas Creek is provided in the following sections.

Potential Sources of Acid and Metalliferous Drainage

AMD has the potential to occur from exposed pit walls, WRSFs and tailings facilities.

Exposed Pit Walls

The blasting and excavation of rock materials exposes minerals to oxidation, which has the potential to generate acidity and leach metals from the rock. This process can affect the quality of both pit wall runoff and groundwater inflow into the pit where acidity and leached metals may accumulate. It is therefore possible that temporary water ponding which forms following significant rainfall or groundwater inflow events (dewatering shutdown) may be acidic and/or metalliferous. This is an important consideration when discharging the water from the pit. There is some potential for seepage of impacted water into groundwater.

Waste Rock Storage Facilities

The temporary or permanent placement of waste rock and overburden can promote oxidation of minerals and generation of AMD if the materials dumped are not geochemically inert. WRSFs are therefore commonly considered to be a potential source of AMD.

The infiltration of rainfall and subsequent percolation through the WRSF can lead to the production of AMD which can seep from below the WRSF into the underlying groundwater or drain from the toe of the WRSF and discharge to surface water channels.

Tailings Storage Facilities

Tailings at Christmas Creek are generated by the processing of ore. The tailings consist of slurry of sand and clay fines.

To date, tailings at Christmas Creek have been deposited into in-pit below ground and in-pit above ground TSFs. The mechanisms for the release of seepage from tailings are lateral or downward migration from the TSF into groundwater, and lateral seepage through TSF walls in the case of in-pit above ground TSFs.

Potential Pathways for AMD to Impact Water Quality

There are two potential pathways by which AMD could affect sensitive receptors including the Fortescue Marsh. The potential pathways of groundwater and surface water are discussed below.

Groundwater

The conceptual hydrogeological model of the Christmas Creek area is presented in detail in Section 7.3. Groundwater flows in the area are generally from the Chichester Ranges in the north, through the Christmas Creek Mine area, towards the Fortescue Marsh in the south (Fortescue 2013a).

The interaction of flows from or through below-ground infrastructure could potentially introduce AMD into groundwater at Christmas Creek.

Surface Water

A description of the surface water regime at Christmas Creek is provided in Section 7.3.1, with catchments shown in Figure 13. In summary, surface water flows are generally from north to south, following the topography from the Chichester Ranges to the Fortescue Marsh (Worley Parsons 2014). Surface water flows occur as channel flow or sheet flow.

The interaction of flows from WRSFs or above-ground TSFs could potentially introduce AMD into surface waters at Christmas Creek.

Design and Operation of Facilities to Avoid or Minimise Impacts

WRSFs and TSFs are designed to avoid or minimise the risks of AMD. Fortescue has developed a number of design guides, procedures and management plans relevant to the design of WRSFs and TSFs, including:

- *Planning for Closure: Design of Mineral Waste Rock Landforms* (100-PR-EN-1017)
- *Planning for Closure: Design Approval for Mineral Waste Rock Landforms* (100-PR-EN-1018)
- *Christmas Creek – Mine Planning Dump Design Parameters* (CC-GU-GE-0001)
- *Planning for Closure: Characterisation of Mineral Waste Rock and Soils* (100-GU-EN-0018).

Key design considerations detailed in these guidance documents include:

- all surface water management features, which can include diversions, bench drains, down-drains and water retention basins, are designed for the 100 year ARI, and/or storm with a duration of 72 hours
- WRSFs are designed to retain water on the surface to promote vegetation growth and control surface discharge
- WRSFs are generally placed directly onto natural ground or unprepared surface (low permeability layer are not placed beneath waste materials)

- surface water drainage surrounding the WRSF encourages the flow of runoff from the WRSF, into local drainage
- TSFs are designed with sufficient freeboard to store water entering the TSF in a significant rainfall event.
- the potential for seepage from TSF structures is assessed during the design phase
- as TSFs at Christmas Creek are predominately located within mined out pits, any seepage to groundwater is generally captured in the dewatering process, and seepage water is mixed with large volumes of natural groundwater being dewatered from mining areas
- TSFs are designed to take into consideration the requirements of:
  - Australian National Committee on Large Dams (ANCOLD) *Guidelines on Tailings Dams* (ANCOLD 2012)
  - the Department of Minerals and Energy (DMP) *Guidelines on the Safe Design and Operating Standards for Tailings Storage* (DME 1999).

Operation of TSF structures is managed to minimise the potential for impacts to surface water and groundwater quality. Optimal operating conditions are determined for each facility, and include factors such as:

- tailings solids concentration range
- management of discharge to create tailings beaches
- removal of supernatant water following settling of tailings material
- maintenance of tailings embankments, discharge infrastructure and decant infrastructure.

Studies have identified that there is a higher risk of leachate from TSFs if the facilities are not operated within optimal solid to supernatant ranges (URS 2014). Fortescue manages TSFs in accordance with the optimal operating conditions for each facility in order to avoid impacts.

Geochemical Testing

The potential for AMD is assessed via geochemical characterisation. Details of the geochemical characterisation studies undertaken at Christmas Creek including the geochemical characteristics of waste rock and tailings at are summarised in Section 2.2.1. The most recent testing was undertaken by URS (2014). A short summary is provided below and the full report is included as Appendix 3A.

Acid base analysis undertaken on 208 waste rock samples and two tailings samples from Christmas Creek, showed that most material is classified as barren (very low in sulphur) and NAF or NAF-Uncertain (URS 2014). As such, the tailings and waste rock materials represented

by the samples analysed are considered unlikely to generate acid drainage resulting in impacts to water quality.

The relative enrichment of ore was tested and as expected for an iron ore operation, testing showed that iron (Fe) was enriched in its elemental form, with a GAI of 3. All other metals were present at a GAI less than or equal to 2. As the GAI levels for all metals (except Fe) were below 3, no further investigations are warranted.

A multi-element analyses of the total metals concentration of waste materials were compared to the *Contaminated Sites Management Series Guidelines – Assessment Levels for Soil, Sediment and Water* (DEC 2010). The waste rock and tailings materials tested did not exceed the ISQG high trigger values for soils and sediments for the majority of metals. The only exceptions were:

- As was reported above the ISQG high trigger value in three waste rock samples
- Ni was reported above the ISQG high trigger value in 39 waste rock samples.

These metals are commonly found enriched in the vicinity of the ore zones of iron ore deposits and BIF materials in the Pilbara, and none were recorded above a GAI of 3.

Metal leachability testing indicated that the waste rock materials tested are considered unlikely to cause saline or acidic drainage, with a maximum TDS of 194 mg/L recorded, and pH between 6.08 and 9.04, indicating neutral to moderately alkaline conditions in the leachates. The results of the leachate testing indicated that the waste rock and tailings samples reported concentrations below the ANZECC trigger values except for Al, As, B, Cd, Cr, Cu, Pb, Mn, Hg, Ni and Zn.

Ongoing Geochemical Testing Programme

Fortescue has an ongoing AMD characterisation programme across the Christmas Creek, Cloudbreak and Solomon mine sites, which aims to progressively characterise the waste rock to be excavated during progressive mining. Fortescue's *Acid Metalliferous Drainage Sampling Plan* 100-PL-EN-1014 outlines the characterisation programme. It is anticipated that up to 468 samples will be taken per year at Christmas Creek, including:

- 320 waste rock
- 104 tailings
- 28 stockpiled ore
- 16 pit wall.

Acid-base accounting will be undertaken on these samples, which will be evaluated using the AMIRA acid rock drainage (ARD) test handbook (AMIRA 2002) in conjunction with the *Department of Industry, Tourism and Resources Australia: Leading Practice in Sustainable*

Development in Mining Handbook (DITR 2007) and the GARD Guide (INAP 2009). Samples will undergo the following analytical tests:

- element analysis by x-ray fluorescence (XRF)
- mineralogical identification by XRD
- ABA
- whole rock/total element analysis
- leaching testing
- asbestos screening.

The *Acid Metalliferous Drainage Sampling Plan* 100-PL-EN-1014 also outlines the ongoing surface water and groundwater monitoring requirements at Christmas Creek. Water quality monitoring will be compared with the ANZECC 95% trigger levels where site specific trigger values are not established.

Fortescue has recently submitted the *Acid and/or Metalliferous Drainage Management Plan* (100-PL-EN-1016, Appendix 2F) required by Condition 12 of Ministerial Statement 899 to the OEPA for approval. This Plan will complement the *Acid Metalliferous Drainage Sampling Plan* described above. Key actions of the draft plan provided to the OEPA include:

- the ongoing testing and assessment of waste material to determine to the risk of AMD
- the ongoing monitoring of groundwater and surface water to detect and assess potential impacts of AMD
- contingency and remediation strategies.

Summary of AMD Risk to Water Quality at Christmas Creek

In summary, Fortescue considers the risk of AMD impacts at Christmas Creek to be low because:

- ABA analysis suggests that the samples analysed are considered unlikely to generate acid drainage resulting in an environmental impact or requiring management (URS 2014)
- Iron (Fe) has a GAI of 3 and all other metals have a GAI 2 or less within the waste rock, which is considered to be representative of background conditions, and is therefore unlikely to have substantial environmental impact risks with regards to metals (URS 2014, Appendix 3A)
- although site-specific water quality criteria for concentrations of dissolved metals are still being developed as data is collected, groundwater and surface water assessments to date have generally not found dissolved metals significantly above the guidance criteria, indicating that the dissolved metals in the leachate of the waste material are

not leaching into the groundwater at levels that pose a risk to human health and/or the environment

- surface water quality indicates neutral acid/base conditions and metal concentrations complied with relevant guidelines or background conditions, indicating that the receptor is unlikely to be impacted by AMD
- Fortescue is implementing an ongoing geochemical testing program to identify at risk material.

8.6.4 Assessment of Impacts to Surface Water Quality from Mine Infrastructure

Mine infrastructure, such as landfill facilities, pits, waste dumps, haul roads, conveyors and pipelines can disrupt surface water flows, as described in Section 8.6.4, and can affect water quality. Water quality can be affected by:

- erosion and sedimentation
- earthworks and clearing
- discharge from landfill facilities, chemical storage areas and wastewater facilities
- discharge of water from mine pits that may contain sediments and hydrocarbons
- discharge of excess abstracted water.

The following sections describe the potential impacts of these aspects.

Erosion and Sedimentation

Mine pits, TSFs and WRSFs affect surface water flows by potentially diverting upstream flows and capturing rainfall within mining areas, reducing the catchment area for downstream flows. Channel waterways may also be diverted around mine pits and waste dumps, resulting in altered flow regimes and volumes. Increases in flow velocities and re-routing of waterways through areas that have not previously experienced large flows can cause increased erosion, resulting in increased water turbidity and sedimentation downstream.

Locations of catchments and creek lines are shown in Figure 13. The estimated cross sectional velocities for 5-year, 20-year and 100-year ARI floods were modelled at selected sections of each creek line for year 5 of the mine and compared to pre-development conditions by Worley Parsons (2014).

For the 5-year ARI flood, the estimated impact of the proposed infrastructure was generally an increase in velocity of channels when compared to the approved footprint. This is considered to be the result of flows being redirected from some channels to others and concentrated in the main channels (Figure 38, Worley Parsons 2014). Velocities in sheet flow areas are not

anticipated to change in the 5-year ARI flood event (Figure 38, Worley Parsons 2014). For the 100-year ARI flood, the model typically showed an increase in flow velocity over a greater area because pits and dumps encroach on the floodplains, reducing the overall flow path width and resulting in a velocity increase (Figure 39). Velocity increases in all events were less than 0.5 m/s (Worley Parsons 2014).

Some erosion would generally be expected to occur in 2-year ARI or greater flood events in the Pilbara area because of the lack of stabilising vegetation and the high flow velocities in channels in major events. This is shown by the high turbidity of surface flows. The post-development changes in velocity in the 5-year ARI events are generally localised and not expected to cause significant increases in erosion.

Water quality currently entering the Fortescue Marsh during floods may be highly turbid (Aquaterra 2005). High turbidity and sediment loads are common in runoff in the Fortescue Valley due to the silty nature of the floodplain soils, paucity of vegetation and intensity of rainfall associated with tropical thunderstorms and cyclonic events. Therefore, the Proposal is not expected to affect water turbidity entering the Fortescue Marsh. Progressive closure will aim to recreate the same level of soil stability as was present prior to mining; and consequently, no long term change to water quality is expected.

Measures to manage erosion and sedimentation at the Christmas Creek Mine will include:

- maintaining natural flow paths where practical to prevent excess erosion
- stabilising and minimising velocity in any new flow diversion structures
- ensuring water that may contain high sediment and contaminant loads (i.e. from mine pits and WRSFs) is captured and treated prior to release.

Measures undertaken by Fortescue to stabilise flow structures and reduce velocity include minimising the use of culverts that constrain flows, and using rock spalls to reduce rock velocity.

As discussed in Section 7.6.1, during operations, the mine pits and WRSFs are designed to drain internally (except in major flood events) and act as closed catchments that do not pass runoff onto downstream areas. These measures effectively prevent excess sediment and any other contaminants present in the pits from entering surface water systems.

The majority of the waste materials will be returned to the mine pits. Where all the materials cannot be placed in the pits, WRSFs will be formed using overburden and other waste materials not suitable for ore processing. The waste material is unconsolidated and creates little runoff during low rainfall events due to high infiltration rates. During high rainfall events, the unconsolidated material is susceptible to erosion, which can affect water quality of downstream flows and potentially lead to sedimentation.

The potential for erosion from WRSFs is mitigated through:

- containing all WRSFs within windrows which will absorb and prevent runoff downstream
- use of perimeter drains designed to minimise erosion to divert upstream flows away from the WRSFs
- flattening the top of WRSFs to encourage infiltration and minimise runoff
- installing berms to minimise channel flow from WRSF embankments
- stabilising and rehabilitating WRSFs as soon as they are complete.

These measures will limit downstream impacts from erosion and sediment movement at Christmas Creek to an acceptable level.

Clearing and Earthworks

Clearing and disturbance for water conveyance infrastructure may lead to the erosion of exposed soils, which may in turn lead to the deterioration in water quality from increased turbidity. This risk is potentially greatest where clearing and earthworks occur on steep slopes with erosive soils.

The Proposal area is gently undulating, and soils are generally stony; therefore, impacts to surface water quality from this aspect are not expected. Management measures will be undertaken to limit changes to surface flow regimes in erosion prone areas, such as burying pipelines at regular intervals and installation of culverts and floodways appropriate to the type of feature being crossed. Rehabilitation of construction earthworks will occur progressively throughout the Proposal area.

Landfill Facilities, Chemical Storage and Wastewater Production

The storage of chemicals, including hydrocarbons, and their use has the inherent potential for leaks or spills to occur and affect surface water quality. Spill prevention and response measures are implemented at Christmas Creek to minimise the risk of chemical spills and leaks, and is outlined in the *Chemical and Hydrocarbon Management Plan*, 100-PL-EN-0011 (Fortescue 2014f).

Hydrocarbon contamination is considered a minor issue, and will be managed through the bunding of hydrocarbon storage and workshop areas, and the treatment of stormwater from this area prior to release using industry standard processes and procedures. As nutrient and hydrocarbon contamination of waters is unlikely to occur, the Proposal is unlikely to reduce dissolved oxygen concentrations in receiving waters due to pollution or algal blooms resulting from increased nutrient concentrations.

As the mine expansion will not result in a long-term increase in workforce numbers, no major changes in wastewater production or generation of putrescible waste are expected.

Surface Discharge from Mine Pits

Surface discharge of water collected in mine pits is conducted as required following significant rainfall events. Rainwater is collected in sumps and is pumped out of the pits. It may be placed in a settlement pond prior to discharge, where this is available and if required. Water quality of any water collected in pits is monitored prior to discharge to the environment.

Surface Discharge of Abstracted Water

Surface flow will only be considered as a method of discharge for water if adequate injection capacity is not available due to a system failure or maintenance requirements. If uncontrolled, this process could lead to the creation of new flow paths and erosion.

In line with the conditions of the Christmas Creek Part V Licence and *Dewatering Discharge Contingency Procedure* CH-PR-EN-0003 (Fortescue 2014c), discharge of water will only occur at designated creek line discharge points in accordance with current approvals. This procedure allows for discharge of up to 35 ML/day of fresh or brackish water for periods of up to 21 days under limited circumstances, and monitoring of water quality and turbidity is required during the process (Fortescue 2009a). The potential impact of any discharge is considered to be limited and can be managed adequately through this process.

8.6.5 Temporary or Permanent Pit Lakes

Under this Proposal, Fortescue will backfill all pits to at least pre-mining groundwater level prior to closure. As such, permanent pit lakes are not anticipated to occur as part of the Proposal. During operations, temporary pit lakes may occur following periods of heavy rain or when dewatering pumps are switched off in a particular area of dewatering.

As any pit lakes will be temporary, there are not expected to be any long term water quality impacts arising from standing water in mined out pits.

8.7 Cumulative Impacts

Impacts to downstream surface water quality from the Proposal are expected to be limited to small changes in sediment load to receiving areas. These changes are expected to be limited to areas immediately downstream of the mine. Impacts from Cloudbreak, Marillana and Roy Hill mines on the sediment loads to the Fortescue Marsh are expected to be similarly small and no cumulative impacts are expected.

Operation of the Proposal is not expected to affect groundwater salinity and will consequently not contribute to any potential cumulative impact.

8.8 Management Measures and Performance Standards

Surface water quality will be maintained by separating clean and potentially mine-affected waters. Potentially affected waters will be treated prior to release. Groundwater quality will be maintained by separating saline and brackish waters during conveyance, storage and injection.

Key management actions currently undertaken at Christmas Creek include:

1. Diverting surface water away from mine pits and WRSFs, and maintaining downstream flow regimes where feasible.
2. Separating surface water from mining areas from clean water. Surface water from mining areas will be pumped to sedimentation ponds prior to release into injection.
3. Minimising the impacts of WRSFs on water quality and quantity through stabilisation to prevent erosion, and berms and perimeter drains to prevent stormwater entering WRSF areas.
4. Disposing of water via surface water flow paths only during emergencies and when maintenance is required.
5. Ensuring that chemical storage is undertaken in a manner that limits potential surface water contamination.
6. Managing clearing and earthworks to minimise erosion.

Management of water quality is documented in the following management plans:

- *Surface Water Management Plan* , 100-PL-EN-1015 (Fortescue 2014i)
- *Chemical and Hydrocarbon Management Plan*, 100-PL-EN-0011 (Fortescue 2014f, Appendix 2D)
- *Fortescue Marsh Hydrology and Vegetation Monitoring and Management Plan*, 100-PL-EN-1013 (Fortescue 2014g, Appendix 2E).

8.8.1 Management of Surface Water

The *Surface Water Management Plan* 100-PL-EN-1015, (Fortescue 2014i, Appendix 2B) provides consistent management objectives and actions relating to surface water at all Fortescue operations.

Management measures detailed in the *Surface Water Management Plan* which are relevant to inland waters environmental quality include:

- Locate, design, construct and operate drainage infrastructure to design specifications which reflect risk assessment outcomes in minimising interference and disruption of natural surface water flows and quality.

- Design mine pits to be internally draining. Rainfall to be managed via sumps and potentially discharged directly to the environment.
- Design bunding of pits, dumps, and iron ore stockpiles to minimise impact to surface water flow volume, flow regimes and turbidity.
- Use erosion minimisation strategies, such as sediment basins, bunding and vegetated batters, to control surface water sediment and water quality from ore stockpiles.
- Reuse run off from infrastructure /activity where possible to ensure turbid water is not discharged to the environment.
- Contain and appropriately manage contaminated stormwater prior to release to the environment.
- Where appropriate, re-establish natural stream and drainage flows to resemble original drainage patterns, including rehabilitation of major drainage channels.

8.8.2 Management of Groundwater

The *Groundwater Management Plan* 100-PL-EN-0029 (Fortescue 2014b, Appendix 2C) was prepared in June 2014, in order to minimise the direct and indirect impacts of Fortescue's groundwater management activities on groundwater quality and quantity at Fortescue operations. This Plan supersedes the following management plans:

- *Chichester Operations Groundwater and Bore Management Plan*
- *Groundwater Discharge Management Plan* M-PL-EN-0001 (Fortescue 2008).

Management measures detailed in the *Groundwater Management Plan* which are relevant to inland waters environmental quality include:

- Ensure location, design, construction and operation of water management infrastructure reflects risk assessment outcomes in minimising environmental impacts.
- Where dewatering infrastructure may significantly impact on surface water flows in areas of sheet flow dependent Mulga communities, ensure appropriate drainage infrastructure is incorporated into the project design.
- Contain generators/pumps used for test pumping to reduce the risk of a hydrocarbon spill and potential soil and groundwater contamination.
- When construction or maintenance activities results in dewatering volumes in excess of what can be disposed of in accordance with the applicable Groundwater Operating Strategy, adopt temporary alternative disposal options as outlined in the *Dewatering Discharge Contingency Procedure* CH-PR-EN-0003 (Fortescue 2014c).
- Ensure chemicals and hydrocarbons are managed in accordance with the *Chemical and Hydrocarbon Management Plan* (100-PL-EN-0011) to reduce the risk of soil or groundwater contamination.

8.8.3 Management of Acid and Metalliferous Drainage

The OEPA is currently reviewing the *Acid and/or Metalliferous Drainage Management Plan* (100-PL-EN-1016, Appendix 2F) required by Condition 12 of Ministerial Statement 899. This plan is intended to complement the *Acid Metalliferous Drainage Sampling Plan* 100-PL-EN-1014 described in Section 8.6.3.

8.9 Predicted Environmental Outcomes

After the application of management and mitigation measures described in Section 8.8, the Proposal is expected to result in the following outcomes in relation to inland waters environmental quality:

1. The potential for dewatering activities to oxidise potential ASS in the Fortescue Marsh is not expected, as the level of drawdown is likely to be within the natural fluctuation range of the watertable beneath the Fortescue Marsh under most climatic scenarios.
2. No significant impacts are expected in relation to AMD.
3. Post-development changes in velocity in the 2-year and 100-year ARI events are expected to be localised and to not cause significant increases in erosion or changes in water quality entering Fortescue Marsh.
4. Impacts from clearing and disturbance are not expected, as management measures will be undertaken to limit clearing in erosion prone areas and rehabilitation will occur progressively throughout the Proposal area.
5. All surface flow from potentially contaminated areas will be contained.
6. At closure, major drainage lines will be re-established to resemble their original alignments and levels, and rehabilitated.
7. No permanent pit lakes will occur.

The Proposal is not expected to result in significant adverse impacts to inland waters environmental quality from implementation of the Proposal. The mitigation measures described will ensure the minimisation of downstream water quality impacts, as has already been implemented on site.

In considering the outcome as described, the Proposal is expected to meet the EPA objective for inland waters environmental quality to maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.

9. FLORA AND VEGETATION

9.1 Relevant Environmental Objectives, Legislation, Policies and Guidelines

9.1.1 EPA Objective

The EPA applies the following objectives to the assessment of proposals that may affect flora and vegetation:

> *To maintain representation, diversity, viability and ecological function at the species, population and community level.*

9.1.2 Regulatory Framework

The protection of flora and vegetation is covered by the following statutes, the more important of which are discussed in further detail below:

- WC Act
- EP Act
- EPBC Act
- CALM Act
- BAM Act.

Wildlife Conservation Act 1950

Native flora in WA is protected under the WC Act with the taking and dealing in such flora prohibited unless carried out in a manner approved under the Act. Special protection is also afforded to threatened (rare) flora declared under the Act via the *Wildlife Conservation Rare Flora Notice* (2 December 2014), including:

- extant taxa considered likely to become extinct or rare (Schedule 1)
- taxa presumed to be extinct (Schedule 2).

This special protection applies to rare flora on both Crown land and private land.

Environmental Protection Act 1986

The EP Act provides for protection of flora and vegetation through assessment of proposals that may have a significant effect on the environment. The EPA assesses proposals to determine whether, if implemented, the impacts of the proposal could be considered environmentally acceptable. Impacts to flora and vegetation are taken into account as part of the assessment

process with special consideration given to any flora listed under WC Act, as well as Priority listed flora, Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs).

Priority listed flora are flora nominated by DPaW that are not listed under the WC Act, but are still considered in need of protection (due to being poorly known, vulnerable to changes in present circumstances, etc.). Priority listing does not confer any additional legal protection. However, impacts to a priority species may be given special consideration when a proposal is being assessed by the EPA, to avoid situations where the species could become a threatened species in future.

TECs and PECs are nominated by DPaW with TECs endorsed by the Minister. They are not listed in accordance with the provisions of any State legislation and; therefore; nomination does not confer any specific legal protection (unless listed under the EPBC Act). Impacts to TECs and PECs may be given special consideration when a proposal is being assessed by the EPA as they generally represent a unique and rare set of interdependent ecological values.

Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act provides for the protection of MNES including threatened species of flora and TECs. Species are listed under a number of different categories including:

- extinct
- extinct in the wild
- critically endangered
- endangered
- vulnerable
- conservation dependent.

TECs are listed under the following categories:

- critically endangered
- endangered
- vulnerable.

Guidance and Position Statements

The following EPA position and guidance statements set the framework for identification and assessment of impacts to flora and vegetation:

- EPA Position Statement No. 2 - *Environmental Protection of Native Vegetation in Western Australia - Clearing of Native Vegetation, with particular reference to the*

Agricultural Area (EPA 2000a): provides an overview of the EPA position on the clearing of native vegetation in Western Australia

- EPA Position Statement No. 3 - *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002): sets out the general principles for assessing biological values in the context of environmental impact assessment
- EPA Guidance Statement No. 51 - *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004b): provides guidance on standards and protocols for terrestrial flora and vegetation surveys, particularly those undertaken for the environmental impact assessment of proposals.

The State and Australian governments have endorsed the *National Strategy for Conservation of Australian Biodiversity* (Australian Government 1996) and the *National Strategy for Ecologically Sustainable Development* (Australian Government 1992) that protects biodiversity. The strategies address the conservation of Australia's biological diversity by defining guiding principles.

As described in Section 7.1.2, the Fortescue Marsh Guidance (EPA 2013d) divides the area around the Fortescue Marsh into a number of management zones with identified environmental values, management objectives and standards. For the purpose of the Fortescue Marsh Guidance, the Proposal is located in Zone 3A: Kulbee Alluvial Flank, which is considered to be one of the zones of 'lowest environmental significance' (EPA 2013d). Objectives relating to the management of native vegetation in Zone 3A are:

- manage impacts to Mulga vegetation
- manage overland surface water flows
- limit extent of native vegetation clearing (EPA 2013d).

Fortescue has considered these objectives when presenting potential impacts (Section 9.7) and management measures (Section 9.9) relating to flora and vegetation.

9.2 Existing Environment

The Proposal area occurs within the Fortescue Botanical District of the Eremaean Botanical Province as defined by Beard (1975). The vegetation of this province is typically open, and frequently dominated by Spinifex, Wattles and occasional Eucalypts. Vegetation comprises a mosaic of low woodland with Mulga in valleys and hummock grasslands, low open tree steppe with Snappy Gum (*Eucalyptus leucophloia*) over Limestone Spinifex (*Triodia wiseana*), and Kanji (*Acacia pyrifolia*) over Soft Spinifex (*Triodia pungens*) and Limestone Spinifex hummock grasslands.

Flora and vegetation types recorded from the Proposal area are generally well represented at a regional scale (ENV 2013a). The Priority 1 PEC 'Fortescue Marsh' is located along the southern section of the Proposal area. Mulga vegetation of the Proposal area is also considered

significant as Mulga vegetation within the Proposal area represents the northern limit of the distribution of this type of vegetation (Van Leeuwin S 2010 pers. comm., ENV Australia 2013a). Some creekline vegetation dominated by *Eucalyptus victrix* (Coolibah) and *E. camaldulensis* (River Red Gum) is potentially a groundwater dependent ecosystem (GDE).

Surveys have recorded 14 Priority species within the Proposal area (ENV 2013a). Several of these (particularly the *Tecticornia* spp.) are restricted to the Fortescue Marsh area. Others, such as *Rhagodia* sp. Hamersley (M Trudgen 17794) (P3) and *Goodenia nuda* (P4) are more widely distributed across the Proposal area and are associated with Mulga communities.

9.3 Surveys and Investigations

Fortescue has utilised the results from a number of specific surveys and investigations to support the assessment of potential impacts of the Proposal on flora and vegetation discussed later in this section (Section 9.7).

Results from previous surveys, listed in Table 28, were used in the analysis completed by ENV (2013a, Appendix 6A), which drew together flora and botanical data relevant to the Proposal area to enable an assessment of the potential impacts of the Proposal. Priority flora and weed records compiled and stored in the Fortescue Environmental Database (Fortescue 2014d) were also included in the ENV (2013a) assessment. The extent of these surveys, where applicable, is shown on Figure 40. The results of these surveys and investigations form the basis for the description of the flora and vegetation factor described in the following section.

Table 28: Flora and Vegetation Surveys and Investigations

Title and Scope of Survey	Reference	Field Work Timing
Christmas Creek Life of Mine flora and vegetation assessment – update • Level 2 vegetation mapping building on previous work • desktop assessment bringing together results of previous work • mapping of potential GDEs along creeks and rivers • delineation of Mulga communities • targeted Threatened and Priority flora search	ENV 2013a, Appendix 6A	March & April/May 2011, April/May & June 2012, May 2013
Vegetation of Fortescue Marsh – portion south of Christmas Creek • Level 2 vegetation mapping and desktop assessment	ENV 2013b	April/May 2012, June 2012, 7-9 May 2013
Christmas Creek Airstrip flora, vegetation and fauna assessment • level 1 flora and vegetation assessment with additional targeted Threatened and Priority flora search • Survey Area of approximately 598 ha for airstrip.	ENV 2011a	February 2011, May 2011
Numerical analysis of floristic data from the Fortescue Metals Group Christmas Creek and Cloudbreak Survey Areas with data from the surrounding Pilbara bioregion of western Australia. • desktop numerical analysis comparing Mattiske (2007), ENV (2013a) and ENV (2011) with 36 studies across the Pilbara bioregion.	Trudgen & Griffin 2011	N/A
Cloudbreak flora and vegetation assessment	ENV 2011b	July–August 2010

Title and Scope of Survey	Reference	Field Work Timing
• desktop assessment and site survey with vegetation mapping • complements Biota 2004a, Biota 2004b, Mattiske 2005a, ATA Environmental 2006, Coffey Environments 2008a, ENV 2009, ENV 2010a.		
Christmas Creek flora and vegetation assessment • desktop assessment and site survey with vegetation mapping • complements Biota 2004a, Biota 2004b, Mattiske 2005a, ATA Environmental 2006, Mattiske 2007 and Coffey Environments 2008a.	ENV 2010a	July–August 2010
Christmas Creek mine area flora and ground truthing assessment • targeted Threatened and Priority flora search • complements Coffey Environments 2008a.	ENV 2009	October 2008
Flora and Vegetation Assessment for the Cloudbreak to Christmas Creek Rail Corridor • desktop assessment and site survey with vegetation mapping and targeted Threatened and Priority flora search • complements Biota 2004b, Mattiske 2005a and ATA Environmental 2006 and incorporates new alignment.	Coffey Environments 2008a	March-April 2008, August 2008
Pre-clearing targeted flora survey GDP 2160 • site survey with vegetation mapping and targeted Threatened and Priority flora search for 8 ha area for Christmas Creek permanent camp • complements Biota 2004b, Mattiske 2005a.	Coffey Environments 2008b	July 2008
Flora and vegetation near Fortescue Marsh • desktop assessment and site survey with vegetation mapping and targeted Threatened and Priority flora search.	Mattiske 2007	September 2006
Proposed Cloudbreak Access Road vegetation assessment – Eastern End • desktop assessment and site survey with vegetation mapping and targeted Threatened and Priority flora search • complements Biota 2004b by extending Survey Area to the east by 4.5 km.	ATA Environmental 2006	July 2006
Flora and vegetation on the Cloudbreak and White Knight Leases • desktop assessment, flora survey and vegetation mapping.	Mattiske 2005a	October–November 2004, May 2005
Review of vegetation condition on the Cloudbreak Lease Area • vegetation condition assessment for impacts of grazing, fire and drought.	Mattiske 2005b	May 2005
Vegetation and flora survey of the proposed Fortescue Stage A Rail Corridor • desktop assessment, flora survey and vegetation mapping.	Biota 2004a	March–April 2004
Fortescue Metals Group Stage B Rail Corridor, Christmas Creek, Mt Lewin, Mt Nicholas and Mindy Mindy mine areas • desktop assessment and site survey with vegetation mapping and targeted Threatened and Priority flora search • complements Biota 2004a.	Biota 2004b	June–October 2004

An additional survey of the Fortescue Marsh was undertaken by DPaW in 2013. Full results of this survey are not yet available; however preliminary results (DPaW 2014b) have been used where applicable in this impact assessment.

A number of research studies have been undertaken or supported by Fortescue in regard to vegetation and flora:

1. UWA/ARC Linkage Project LP0882350 ‘Ecophysiology of stem succulent halophytes subject to changes in salinity and water availability: distinguishing natural dynamics from potential mine related impacts’.
2. CSIRO/UWA Fortescue Marsh pilot study of remote sensing tools for eco-hydrology investigations.
3. UWA assessment of vegetation water use of upland and lowland communities associated with the Fortescue Marsh based on measurements of naturally occurring isotopes.
4. Astron assessment of Mulga root system architecture near Cloudbreak and Christmas Creek.
5. Astron assessment of salt loads and surface salinity near Cloudbreak and Christmas Creek.
6. Astron Soil & Water unsaturated zone modelling of Fortescue Marsh soil profiles and marsh vegetation communities.

Additional information regarding these studies is presented in Appendix 5E (Equinox 2013).

9.4 Description of Factor

9.4.1 Regional Vegetation

Broad scale vegetation mapping of the Pilbara region was first undertaken by Beard (1975) and later digitised and refined by Shepherd *et al*. (2002). Four vegetation systems described by Shepherd *et al.* (2002) occur within the Proposal area (Table 29, Figure 41).

Table 29: Vegetation Systems – Current Extent and Status

Vegetation System	Description	Current Extent (ha)	% pre-European extent remaining	% Current extent held in IUCN class 1 – IV reserves
29	Sparse low woodland; Mulga, discontinuous in scattered groups.	7,910,775	97.7	0.3
173	Hummock grasslands, shrub steppe; kanji over soft spinifex and *Triodia wiseana* on basalt.	1,750,458	97.4	7.5
562	Mosaic: low woodland; Mulga in valleys / Hummock grasslands, open low tree-steppe; snappy gum over *T. wiseana*.	103,662	97.6	0.0
676	Succulent steppe; samphire.	1,979,251	94.6	6.5

Source: Shepherd et al. 2002

9.4.2 Vegetation Types and Associations

ENV (2013a) surveyed areas in and around the Proposal area which had not previously been subject to Flora and Vegetation surveys and completed a synthesis of previous survey work

(Table 28). This synthesis resulted in the development of a single source for mapping of vegetation communities of the Proposal area and surrounds (the Study area).

The synthesis undertaken by ENV (2013a) focused on the most important vegetation communities in the vicinity of the Proposal area (such as vegetation of the Fortescue Marsh, Mulga, potential GDEs and drainage lines), as determined following discussions with DPaW in 2011. A total of 24 broad vegetation types (VTs) and vegetation associations (VAs) and two mosaics (combining two existing vegetation types) occur within the Study area (ENV 2013a) (Table 30, Figure 42).

Mapped VTs and VAs were correlated to the four Beard and Shepherd vegetation systems of the Proposal area where possible (Table 30). Differences exist with the terminology used in the descriptions due to differences in scale (VTs and VAs are local while vegetation systems are regional) and they are based on different methods of categorising and characterising vegetation types (ENV 2013a).

9.4.3 Floristic Analysis

Data from the ENV survey (2013a) was also combined with previous survey data to develop a comprehensive bioregional floristic analysis (Trudgen & Griffin 2011). This floristic analysis is provided as an appendix to the ENV survey (ENV 2013a, Appendix 6A).Statistical analysis of floristic data identified sites belonging to 18 floristic groups at the 600-group level.

The Survey Area includes 17 floristic groups which are equivalent to the 14 VTs of the creeks, plains and slopes and one floristic group which is equivalent to VA1 – VA9 of the samphire flats of Fortescue Marsh.

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Table 30: Vegetation Type and Vegetation Association Descriptions

Habitat	Vegetation type (VT)/ association (VA)	Description	Extent within the Survey Area (ha)	Beard & Shepherd vegetation system	Water use pattern	Conservation significance (ENV 2013a)
Creeklines and drainage lines	VT01	Open woodland of *Eucalyptus victrix, E. camaldulensis* with pockets of *Acacia coriacea* subsp. *pendens* over *Grevillea wickhamii* subsp. *aprica, Petalostylis labicheoides* and *A. tumida* over *Triodia longiceps, Chrysopogon fallax, Themeda triandra* and *Aristida* species	1,910.4	n/a	Contains some groundwater dependent species	None recorded
	VT02	Low woodland to low open forest of *Acacia aneura* var. *aneura, A. citrinoviridis, A. pruinocarpa* over *A. tetragonophylla* and *Psydrax latifolia* over *Chrysopogon fallax*, *Stemodia viscosa, Blumea tenella, Themeda triandra* and *Triodia* and *Aristida* species	5,544.3	n/a	-	Mulga
	VT08	Closed scrub to tall shrubland of *Acacia pruinocarpa, A. tumida, A. ancistrocarpa, A. maitlandii, A. kempeana, A. tetragonophylla* with occasional *Eucalyptus gamophylla* and *Corymbia* spp. over *Triodia epactia*, *Themeda triandra* and *Aristida* species	570.7	n/a	-	None recorded
	VT09	Closed scrub to shrubland of *Acacia ancistrocarpa, A. maitlandii, A. kempeana, A. monticola*, occasional *Eucalyptus gamophylla* and *Corymbia deserticola* over *Senna* species, *Triodia basedowii* and *Aristidea* species	9.4	n/a	-	None recorded
Flats and broad plains	VT03	Low woodland to low open forest of *Acacia aneura* var. *aneura, A. pruinocarpa, A. tetragonophylla, A. tenuissima, Grevillea wickhamii* subsp. *aprica, Psydrax latifolia* over *Dodonaea petiolaris* and *Triodia* and *Aristida* species	6,721.8	29	Partially sheet flow dependent	Mulga
	VT04	Low open woodland of *Acacia aneura* var. *aneura, A. pruinocarpa, A. xiphophylla, A. victoriae* over *A. tetragonophylla, Psydrax latifolia* and *P. suaveolens* over *Ptilotus obovatus* and mixed *Maireana* and *Sclerolaena* species	10,150.6	29	Partially sheet flow dependent	Mulga
	VT10.1	Low open woodland of *Acacia xiphophylla, A. victoriae, A. aneura* var. *aneura* over *A. tetragonophylla, Ptilotus obovatus* and mixed *Senna, Maireana* and *Sclerolaena* species	2,636.8	29	Partially sheet flow dependent	Mulga
	VT10.2	Low open woodland of *Acacia xiphophylla, Acacia aneura, Eremophila platycalyx* subsp. *pardalota* over low open shrubland of *E. cuneifolia, Maireana pyramidata, Senna artemisioides* subsp. *oligophylla* over sparse tussock grassland of mixed species	50.0	29	Partially sheet flow dependent	Mulga

Habitat	Vegetation type (VT)/ association (VA)	Description	Extent within the Survey Area (ha)	Beard & Shepherd vegetation system	Water use pattern	Conservation significance (ENV 2013a)
	VT30.1	High open shrubland of *Acacia synchronicia* with *Senna glaucifolia* (*Sclerolaena* species and other halophytes) over *Aristidea* species	8,023.8	29	-	None recorded
	VT30.1+10.1	Mosaic of VT30.1 and VT10.1, patches of vegetation were too small to map separately	1,064.2	29	Partially sheet flow dependent	Mulga
	VT30.1+04	Mosaic of VT30.1 and VT04, patches of vegetation were too small to map separately	541.0	29	Partially sheet flow dependent	Mulga
	VT30.2	Scattered shrubs of *Acacia synchronicia* over low shrubland to low open shrubland of *Eremophila spongiocarpa, Atriplex bunburyana* and *Sclerolaena cuneata*, over scattered tussock grasses of *Dactyloctenium radulans, Eragrostis pergracilis* and *Panicum decompositum*	1,463.7	29	-	None recorded
	VT30.3	Scattered tall shrubs of *Acacia synchronicia* over low open shrubland of *Senna artemisioides* subsp. *oligophylla* (thinly sericeus), *Atriplex bunburyana* and *Sclerolaena cuneata* over scattered tussock grasses of *Dactyloctenium radulans*	490.1	29	-	None recorded
Ranges, Hills and Hillslopes	VT16	Hummock grassland of *Triodia basedowii* with pockets of *T. epactia* and *T. lanigera* with emergent patches of *Eucalyptus leucophloia, Corymbia deserticola* over *Acacia ancistrocarpa, A. hilliana, A. acradenia, A. pyrifolia, Hakea lorea* subsp. *lorea* over *Goodenia stobbsiana* and mixed *Senna* species	114.2	173 and 562	-	None recorded
	VT17	Hummock grassland of *Triodia basedowii* with pockets of *T. epactia* and *T. lanigera* with emergent patches of *Eucalyptus leucophloia, Corymbia deserticola* over *Acacia ancistrocarpa*, *A. pyrifolia, Hakea lorea* subsp. *lorea* over *Goodenia stobbsiana* and mixed *Senna* and *Ptilotus* species	12,379.2	173 and 562	-	None recorded
Marsh Vegetation	VA01	*Tecticornia* sp. Christmas Creek, *T. auriculata, Muehlenbeckia florulenta* low closed heath over *Eragrostis pergracilis, E. tenellula* scattered tussock grasses and *Cullen cinereum, Nicotiana heterantha, Pterocaulon sphaeranthoides* open herbland	15.1	676	Accesses soil water, groundwater and surface water depending on conditions.	Fortescue Marsh PEC (Priority 1)

Habitat	Vegetation type (VT)/ association (VA)	Description	Extent within the Survey Area (ha)	Beard & Shepherd vegetation system	Water use pattern	Conservation significance (ENV 2013a)
	VA02	*Muehlenbeckia florulenta* shrubland to open heath over *Tecticornia indica* subsp. *bidens* low scattered shrubs to low open shrubland over *Eleocharis papillosa*, *Schoenoplectus dissachanthus* (very) open sedgeland with *Nicotiana heterantha*, *Marsilea hirsuta* open herbland	5,549.9	676	Accesses soil water, groundwater and surface water depending on conditions.	Fortescue Marsh PEC (Priority 1)
	VA03	**Vachellia farnesiana, Acacia ampliceps* open scrub over *Tecticornia* sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063), **Aerva javanica* and *Cullen cinereum* low open shrubland over **Cenchrus setiger*, *Dactyloctenium radulans* and **C. ciliaris* tussock grassland	24.9	676	Accesses soil water, groundwater and surface water depending on conditions.	Fortescue Marsh PEC (Priority 1)
	VA04	*Melaleuca glomerata* open scrub over **Aerva javanica, Tecticornia* spp. low open shrubland over *Cleome viscosa, Nicotiana heterantha, Swainsona kingii* herbland	65.2	676	Accesses soil water, groundwater and surface water depending on conditions.	Fortescue Marsh PEC (Priority 1)
	VA05	*Acacia synchronicia, Melaleuca glomerata, Eremophila youngii* subsp. *lepidota* scattered tall shrubs over *Tecticornia indica* subsp. *bidens, Eremophila spongiocarpa* low open shrubland over *Sporobolus virginicus, *Cenchrus ciliaris, Dactyloctenium radulans* tussock grassland	153.2	676	Accesses soil water, groundwater and surface water depending on conditions.	Fortescue Marsh PEC (Priority 1)
	VA06	*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552), *T. indica* subsp. *bidens, Muehlenbeckia florulenta* low open heath over *Eragrostis pergracilis* (very) open tussock grassland and *Cyperus bulbosus* scattered sedges with *Nicotiana heterantha, Swainsona kingii* scattered to very open herbland	517.5	676	Accesses soil water, groundwater and surface water depending on conditions.	Fortescue Marsh PEC (Priority 1)
	VA07	*Tecticornia indica* subsp. *bidens, T.* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552), *Eremophila spongiocarpa* low open heath to low closed heath over *Eragrostis* spp., *Enneapogon* spp., **Cenchrus* spp. scattered tussock with *Nicotiana heterantha, Pterocaulon sphaeranthoides, Gomphrena kanisii* scattered herbs	2,177.1	676	Accesses soil water, groundwater and surface water depending on conditions.	Fortescue Marsh PEC (Priority 1)

Habitat	Vegetation type (VT)/ association (VA)	Description	Extent within the Survey Area (ha)	Beard & Shepherd vegetation system	Water use pattern	Conservation significance (ENV 2013a)
	VA08	*Tecticornia auriculata* (and T. sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) open heath over *Eragrostis pergracilis, Chloris pectinata* tussock grassland and *Cyperus bulbosus* scattered sedges with *Swainsona kingii*, *Nicotiana heterantha* scattered herbs	216.7	676	Accesses soil water, groundwater and surface water depending on conditions.	Fortescue Marsh PEC (Priority 1)
	VA09	*Acacia synchronicia* scattered tall shrubs over *Tecticornia indica* subsp. *bidens, Eremophila spongiocarpa* low open shrubland over *Eragrostis pergracilis*, **Cenchrus ciliaris* tussock grassland with *Lawrencia densiflora*, *Euphorbia australis*, *Goodenia forrestii* scattered herbs	177.7	676	Accesses soil water, groundwater and surface water depending on conditions.	Fortescue Marsh PEC (Priority 1)
	VA10	*Acacia synchronicia, A. xiphophylla* high shrubland over *Eremophila* spp., *Enchylaena tomentosa* var. *tomentosa, Maireana pyramidata* scattered low shrubs over **Cenchrus ciliaris, Eragrostis pergracilis, Triraphis mollis* very open tussock grassland and *Goodenia forrestii, Sclerolaena cornishiana, Stemodia grossa* scattered herbs	831.4	n/a	Accesses soil water, groundwater and surface water depending on conditions.	None recorded
	VA11	Lake bed likely to support annual herbs and grasses episodically	6,208.2	n/a	Accesses soil water, groundwater and surface water depending on conditions.	None recorded

9.4.4 Vegetation Condition

The Development Envelope contains the existing approved footprint and contains large cleared areas that have been developed for mine pits and associated infrastructure as well as areas of native vegetation. Vegetation within the Proposal area is also intersected in several areas by existing roads and pipeline infrastructure associated with the existing Christmas Creek mine.

The condition of vegetation in the Development Envelope ranged from Excellent to Completely Degraded, according to the Trudgen (1991) vegetation condition scale (ENV 2013a). Areas of mining and associated infrastructure were classified as Completely Degraded. The flats, plains, drainage lines, creeks and rivers were rated from Excellent to Good, with areas of disturbance related to cattle, tracks and introduced weeds, particularly along river frontages. In contrast, areas less attractive to cattle such as hills to the north supported vegetation in Excellent to Very Good condition.

Mulga communities were generally in Very Good condition, depending on the density and types of weeds present, and the extent of soil erosion resulting from cattle grazing.

Fire age ranged from Recent (within the last year) to Very Old (greater than 12 years since the last fire), with the majority of the area characterised by an Old fire age (eight to 12 years since the last fire). Large areas of the hills in the north-east were recently burnt (less than six months prior to surveying), and weeds were generally absent in the burnt area at this early stage of succession. The presence of burnt vegetation did not impact the integrity of the ENV (2013a) survey results, as the assessment included data from the adjacent unburnt areas, and data from previous surveys.

9.4.5 Conservation Significant Vegetation Communities

No TECs protected under the EPBC Act or the EP Act have been recorded within a 50 km radius of the Proposal area (ENV 2013a).

Three PECs occur within 50 km of the Proposal area:

- Priority 1: Fortescue Marsh PEC (Marsh Land System)
- Priority 3: Stony saline clay plains of the Mosquito Land System
- Priority 3: Fortescue Valley Sand Dunes.

The Fortescue Marsh PEC (P1) is located south of the Development Envelope (Figure 41). The stony saline clay plains occurs 35 km east of the Development Envelope. The Fortescue Valley Sand Dunes (P3) is located between 25 and 50 km from the Development Envelope. Based on mapping of vegetation types and associations, the Fortescue Valley Sand Dunes PEC has not been recorded in the Proposal area (ENV 2013a).

In addition to listed PECs, Mulga vegetation is also considered ecologically important, having unusually high biodiversity and providing important habitat for fauna. Mulga vegetation of the Survey Area is also noteworthy as it represents the northern distribution limit of this type of vegetation and the vegetation is in a generally good condition (Van Leeuwin S 2010 pers. comm., Fortescue 2011c).

Fortescue Marsh

The Fortescue Marsh PEC occurs adjacent and to the south of the Proposal area on the Fortescue River, east of Mulga Downs on Marillana and Roy Hills stations. The Fortescue Marsh PEC contains unusual flora including endemic *Eremophila* species and several near endemic, recently described and undescribed samphires (DPaW 2013). Within the Proposal area, vegetation types VA01 to VA09 represent the samphire communities of the Fortescue Marsh PEC (ENV 2013a).

The Fortescue Marsh is a large, episodically inundated marsh, approximately 100 km long and 10 km wide. The Fortescue Marsh is regarded as the largest ephemeral wetland in the Pilbara, and in times of inundation, it supports extensive waterbird breeding (DPaW 2013). Further information on the ecohydrology of Fortescue Marsh is discussed in Section 9.4.6.

The Fortescue Marsh is listed as an Environmentally Sensitive Area (ESA), being listed as a ‘Nationally Important Wetland’ in the *Directory of Important Wetlands in Australia* (Environment Australia 2001), and is listed on the Australian Heritage Commission *Register of the National Estate* as an ‘Indicative Place’ (ENV 2013a).

DPaW recently conducted a vegetation survey of the Fortescue Marsh. Preliminary results indicate that ten species of conservation significance (P1-P3) were recorded, two new taxa were phrase-named from marsh specimens and a number of records represent species range extensions (DPaW 2014b).

Mulga

Mulga vegetation is comprised of trees and shrubs that dominate a large portion of the Western Australian rangelands including the Pilbara, Gascoyne, Murchison and Nullarbor bioregions (ENV 2013a). Mulga vegetation is characterised by *Acacia aneura* and a complex of closely related species. A taxonomic revision on the complex interrelationships of this group was recently completed with support from Fortescue (Maslin & Reid 2012). This review identified 12 species in Western Australia, almost all of which include informal variants with hybrids between species common.

Mulga vegetation is a keystone group in the Australian arid zone, functioning as a repository of significant productivity and biodiversity due to its inherent ability to capture, retain and cycle nutrients, sediments and water resources (Maslin & Reid 2012). Consequently, Mulga vegetation is important to the ecology, functioning and viability of rangeland landscapes (Maslin & Reid 2012). Threatening processes to Mulga in the Pilbara include grazing pressure, feral

animals (stock), changed fire regimes and changes to natural surface hydrology (Kendrick 2001). The Mulga vegetation types in the Proposal area are located to the north of the Fortescue Marsh and on the footslopes of the Chichester Range. These are considered ecologically important due to the following (Van Leeuwin S 2010 pers. comm., Fortescue 2011c):

- they represent the northern limit of distribution of Mulga dominated vegetation
- transitional vegetation communities such as these are typically floristically diverse
- they include areas in very good to good condition, while similar vegetation south of the Fortescue Marsh are in lesser condition
- Mulga vegetation communities are locally less extensive north of Fortescue Marsh than similar communities south of the Fortescue Marsh.

Management of surface water flows to sheet flow dependent Mulga woodlands is the key objective of Management Zone 3a as outlined in the Fortescue Marsh Guidelines (EPA 2013). The Proposal area is within this management zone (Section 7.1).

Mulga vegetation in the Proposal area is represented by vegetation types VT02, VT03, VT04, VT10.1 and VT10.2, and the mosaics of VT30.1+10.1 and VT30.1+04 (Table 30). These vegetation types are generally considered to be dependent on sheet flow, with the exception of VT02 which is found on creeklines and drainage lines. Further information on sheet flow is provided in Section 9.7.3.

Floristic Groups of Conservation Significance

The floristic analysis undertaken by Trudgen and Griffin (2011) defined eight floristic groups of high conservation significance, including:

- two Mulga groups occurring on the plains (430 and 433)
- two Mulga/*E. leucophloia* groups occurring on the plains (539 outside the Survey area, and 568)
- two *E. leucophloia/C. hamersleyana* groups occurring on upper slopes (527 and 564)
- One *E. victrix/C. hamersleyana* group occurring on major creeks (575)
- One *Tecticornia* spp. group occurring on the flats of the Fortescue Marsh (490).

These eight floristic groups correspond approximately to the following VTs/Vas as defined by ENV (2013a):

- 430/433: VT1, VT2, VT3, VT10.1, VT10.2, VT30.1
- 539/568: VT10.1, VT10.2
- 527/564: VT17

- 575: VT1
- 490: VA1-VA9.

9.4.6 Ecohydrology and Groundwater Sensitive Vegetation

'Ecohydrology' refers to the interaction between ecosystems and hydrological regimes. Hydrological regimes determine the amount and quality of water available to vegetation and fauna. The amount of water present, its quality and frequency will determine the species present and the density at which these species occur. Changes in the hydrological regime, such as changes in groundwater levels or duration of inundation, can affect the distribution of species and result in changes to ecosystems. The extent and severity of these impacts depends on the ability of the species present to tolerate the change in conditions.

Changes in groundwater level and surface water regimes may affect the health of vegetation overlying the area of change. Vegetation in the region is likely to have some tolerance to changes in hydrological regimes as the region experiences highly variable rainfall and consequently significant natural fluctuations in groundwater levels and surface water flows. GDEs are natural ecosystems that are dependent on access to groundwater to meet some or all of their water requirements in order to maintain their biological composition, ecological processes and ecosystem services (ENV 2013a).

At Christmas Creek, changes in groundwater levels may cause impacts to vegetation through:

- drawdown on vegetation that may be groundwater-dependent (relevant to samphire, and River Red Gum and Coolibah vegetation)
- mounding on vegetation that may be intolerant of waterlogging (relevant to Mulga vegetation).

Other vegetation types present at Christmas Creek are not sensitive to changes in groundwater levels.

Changes to surface water flow regimes may also impact on Mulga communities that may be reliant on surface water flows. This section discusses the determination of trigger levels for groundwater level change that may impact upon the specific vegetation types. Potential impacts of changes to groundwater levels or surface water regimes on sensitive vegetation are discussed in Section 9.7.2 and Section 9.7.3 respectively.

River Red Gum and Coolibah

Vegetation dominated by River Red Gum (*Eucalyptus camaldulensis*) potentially represents a GDE as *E camaldulensis* is considered to be a vadophyte (groundwater-dependent species). Vegetation containing Coolibah (*E. victrix*) can be an indicator of a potential GDE.

Vegetation in a potential GDE may utilise groundwater opportunistically or during times of limited water supply and drought-like conditions, and are susceptible to extended periods of water stress (ENV 2013a).

In areas where the depth to groundwater is less than 5 m, vegetation is more likely to be dependent on groundwater for some of its water requirements. This is illustrated by studies that show groundwater dependent River Red Gum and Coolibah occur in areas in the Pilbara with groundwater between zero and eight metres below ground level (DoW 2010b). Areas where drawdown occurs where the original water level was less than 5 m from the surface have been highlighted in this impact assessment as areas where vegetation health may be affected. As groundwater levels in the area can vary by up to 2 m between years, 2 m drawdown has been used as the trigger for changes in groundwater levels affecting species in the areas with a natural watertable located at 5 m or less below the surface.

Within the Proposal area, vegetation type VT01 was mapped as a potential GDE, while vegetation types VT02, VT08 and VT09 were mapped as non-GDE creekline communities (ENV 2013a).

Mulga

Mulga vegetation on the plains occurs as groves or as isolated trees to low woodlands. Groved or banded areas of Mulga are considered to be dependent on sheet flow (ENV 2013a). Sheet flow occurs as a thin film of run-off that moves across the gently undulating plains (ENV 2013a). A recent study by Astron (2012) on the depth and architecture of the root systems of Mulga in the Proposal area found Mulga vegetation displayed a predominantly shallow root system. This is suggestive of a water use strategy aimed at utilising shallow soil water derived from direct rainfall and surface inflows associated with sheet flow, natural drainage lines and ponding in low-lying positions of the landscape (Astron 2012).

In addition to potential sheet flow impacts, Mulga may be sensitive to groundwater mounding. Mulga is not tolerant of salt entering its root zone, and it also intolerant of waterlogging (UWA 2010). Equinox (2013) found that within the Proposal area, the majority of Mulga roots occur predominantly in the top 1.5 m of the soil profile. Only a few fine roots (less than 2 mm diameter) occur below this depth (Equinox 2013). Areas of Mulga vegetation where mounding results in groundwater levels rising to within 2 m of the surface, where this was not previously the case, have been highlighted in this impact assessment as areas where the health of Mulga may be affected by mounding.

Samphire

The key water-related ecosystem in the Christmas Creek area is the Fortescue Marsh. Vegetation around the edge of the Fortescue Marsh predominantly consists of salt-tolerant, succulent samphire species, predominantly *Tecticornia indica* subsp. *bidens*.

Due to the perceived possibility that this species could be impacted by drawdown from the Christmas Creek mine, Fortescue commissioned work to assess how this species and other *Tecticornia* spp. utilise water.

This work has been considered in the development of the conceptual ecohydrological model, and includes:

1. Mapping of the vegetation communities of the Fortescue Marsh in the Christmas Creek area.
2. An ecophysiological study of *T. indica* subsp. *bidens* and other samphire species by University of Western Australia (UWA).
3. A physiological study of three *Tecticornia* species (*T. auriculata, T. indica* and *T. medusa*) by researchers at UWA to determine their responses to drought.
4. CSIRO trial of the use of remote sensing via satellite imagery to assess water balances and vegetation condition within the Fortescue Marsh.
5. Investigations into the root architecture of *T. indica* subsp. *bidens* within the Fortescue Marsh to assist in determining where the species obtains its water. This study was also undertaken for Mulga (*Acacia aneura*).
6. Modelling of *T. indica* subsp. *bidens* water-use based on the findings of the UWA studies and root architecture studies using the HYDRUS model. The aim of the modelling was to determine how the species survives between flood periods and how differences in soil type and rainfall conditions may affect plant survival (Equinox 2013). Once developed, this model could be used to determine the potential impacts of dewatering due to mining on this samphire species.

These reports and the conceptual ecohydrological model are summarised the report *Fortescue Marsh: Synthesis of eco-hydrological knowledge* (Equinox 2013, Appendix 5E). The following section provides a brief summary of the work presented in Equinox (2013).

Samphire Ecohydrology

Under natural conditions, *T. indica* subsp. *bidens* is likely to use groundwater as a source of water during wet periods when the soil is inundated. The ability of *T. indica* subsp. *bidens* to tolerate drought conditions (both in-situ and in laboratory conditions) suggests that the ecological water requirements of this species can be wholly or predominately met by surface inputs.

Dewatering associated with mining may potentially reduce groundwater levels during both wet and dry periods. This reduction in groundwater levels may reduce the period over which *T. indica* subsp. *bidens* can access groundwater and reduce the amount of soil water present in the soil. To determine the potential impact of reducing groundwater levels on soil water availability, Fortescue has undertaken modelling of soil water using the HYDRUS software

package. To understand this modelling, it is important to understand how water behaves in soils above the watertable; this is outlined in the following sections.

T. indica subsp. *bidens* has few roots below a depth of 0.3 m, with roots scarce below a depth of 0.5 m. Between flood events, the roots of *T. indica* subsp. *bidens* are located within the unsaturated zone.

Small rainfall events between floods may replenish soil water stores. If rainfall does not occur, the amount of plant available water in the capillary fringe will reduce over time due to plant uptake. The point at which all plant available water is removed is referred to as the 'permanent wilting point'. The permanent wilting point for samphire in the loam and clay loam soils of the Fortescue Marsh is approximately 0.112 v/v (i.e. 0.112 of the total pore volume is saturated (Fortescue 2013). Below the permanent wilting point, plants may die due to lack of water.

Soil Water Availability Modelling

To test the hypothesis that fringing samphire can meet its water requirements from the unsaturated zone and capillary fringe under most climatic regimes, numerical modelling of the unsaturated zone water balance was undertaken. The HYDRUS software package was utilised to develop the model. The HYDRUS package models water, heat and solute movement in variably saturated soils. The model can account for water uptake by plant roots and has been used to analyse problems relating to plant water use and growth, soil moisture dynamics and salinisation.

Effect of Drawdown on Samphire

In order to predict the impact of drawdown on soil water availability for samphire, the calibrated HYDRUS model was then run using four different groundwater levels and two rainfall scenarios (Fortescue 2013b). The objective of the modelling was to predict the soil water profile and assess whether soil water contents remain above the permanent wilting point during the various scenarios.

The following section relates to the results of the HYDRUS modelling report*, Modelling Analysis of the Impact of Mine Dewatering on Soil Water Availability to the Samphire Vegetation on the Fringe of the Fortescue Marsh* (Fortescue 2013b; Appendix 5F). A previous iteration of the HYDRUS modelling report was peer reviewed by Gavan McGrath UWA (2014). A copy of the peer review is provided as Appendix 5H. The majority of the recommendations of this peer review have been addressed in the current version of the HYDRUS modelling report. A summary of recommendations and comments is included below.

Recommendation 1: Consider reappraising the experimental data and presenting the data more completely within the Report, particularly the water potential / vegetation stress data, including the methodology adopted.

Response 1: Section 5 has been updated to incorporate a detailed presentation of the experimental determination of the water stress indices used in the model, including a description of experimental methods used by Marchesini et al (2014).

Recommendation 2. Increase the value of K_{cb} so peak transpiration rates are closer to observed and to calibrate the stress function, water retention curve(s), and or salinity stress to better capture transpiration rates during the dry season.

Response 2: Real time simulation from the beginning of 01/01/2009 to the end of 31/12/2011 was conducted to calibrate the basal plant coefficient, Kcb. The basal plant coefficient was adjusted in the calibration to minimise the deviation between the simulated actual daily transpiration and the daily transpiration from sap flow measurements.

Recommendation 3. Include salinity in the simulation and modelling to better account for the impact of total water potential (osmotic + matric) upon the occurrence of permanent wilting and patterns of water use.

Response 3: Because the model simulates water flow only, the effect of salinity on plant root water uptake is not modelled explicitly in this assessment. However, the effect of salinity has been indirectly accounted for as follows:

> (1) Parameters for Feddes water stress reduction coefficient module (e.g., wilting point matric potential, etc.) were derived from UWA experimental data from plants growing in high salinity soils. Soil water potential used in UWA chart was converted to matric potential (Section 5 of Fortescue 2013b), removing the osmotic effect;
>
> (2) the samphire basal plant coefficient, K_{cb}, was estimated from measured sap flows/transpirations fluxes in Fortescue Marsh samphires growing under representative saline conditions south of the Cloudbreak mine site;

Since the current HYDRUS programs do not incorporate temporal variation of the soil hydraulic properties, water flow parameters used in the simulations were invariant of soil water salinity levels. Fortescue considers that the assumptions and simplifications around salinity used in the development of the model are sufficient and scientifically sound to enable the effects of salinity to be accounted for without explicitly modelling saline transport.

Recommendation 4. Reconsider the need for 2-D simulations and instead, or as well, consider the use of 1-D simulations in order to allow better simulation of compensated root water uptake.

Response 4: The current report presents the 2-D modelling. Fortescue intends to undertake a comparison using 1-D modelling in the future, however this has not been incorporated into the current version of the HYDRUS modelling report. The 1-D assessment will be presented as an addendum to the existing modelling report.

Recommendation 5. If 2-D simulations are considered necessary then an alternative modelling approach should be considered, whereby individual plants and their root systems can be simulated.

Response 5: Fortescue intends to consider individual plants and root systems as part of the planned 1-D model comparison. It is not possible to incorporate this into the existing 2-D model within the time constrains and scope of this modelling exercise

Recommendation 6. Adjust the lower boundary condition in order to allow better assessment of the possible changes in the water table due to large rain events and prolonged drying.

Response 6: The Fortescue Marsh (about 980 km^2) is situated in a so-called terminus area of a multi-catchment drainage system receiving surface water runoffs from a watershed of about 30,000 km^2. Surface water runoff into the marsh is considered to drive the fluctuations of the groundwater levels beneath the marsh area and in the immediate vicinity of the marsh area (Equinox 2013). Analysis of the groundwater level hydrographs of the Chichester near-marsh monitoring bores reveals relatively high correlations among the observed groundwater levels in the different monitoring bores at regional scale. The localised HYDRUS models are unlikely to adequately simulate the fluctuations of the near-marsh groundwater levels.

Recommendation 7. Change the assumed impact of canopies upon potential soil evaporation rates as the current approach likely significantly underestimates its contribution to water fluxes.

Response 7: The potential soil surface evaporation rates impacted by plant canopies in the 2-D model were revised per the peer review recommendations and the relevant charts in the report were updated accordingly. No significant changes to the outcomes of the assessment were observed as a result of this update.

Recommendation 8. Improve the uncertainty analysis by considering a wider variety of soil hydraulic properties in simulations.

Response 8: The current model considers two values for soil hydraulic conductivity. Fortescue intends to incorporate further sensitivity analysis for a based on range of unsaturated soil hydraulic properties during 1-D modelling which will be undertaken in the future.

Recommendation 9. Consider simulations and experiments to assess the role of episodic flood events on the recruitment and establishment of samphire species and their spatial distribution.

Response 9: Consideration of the role of natural episodic flood events on the recruitment of samphire species is outside the scope of the HYDRUS modelling, which was primarily undertaken in order to quantify impacts to samphire species as a result of impacts associated with mining activities.

The groundwater level scenarios used for modelling were:

- groundwater at 404 m AHD (base case, representing the average groundwater level in the Fortescue Marsh near Christmas Creek)
- groundwater at 403 m AHD (representing 1 m of drawdown)
- groundwater at 402 m AHD (2 m of drawdown)
- groundwater at 401 m AHD (3 m of drawdown) (Fortescue 2013b).

For all of the wet and dry scenarios modelled, the water content in the soil remained above the permanent wilting point (refer to Figures 21 – 23 of Appendix 5F). The modelling indicates that *T. indica* subsp. *bidens* can survive drawdown of 3 m, even under periods of prolonged drought.

Samphire is known to occur only where the depth to groundwater is less than 5 m. Areas of samphire vegetation where the depth to groundwater was less than 5 m (without mining) and where a drawdown of greater than 3 m was shown as a result of the modelling were mapped to assess potential impacts of the Proposal.

9.4.7 Vegetation Health Monitoring

Fortescue has undertaken vegetation health monitoring since August 2011, in accordance with the *Vegetation Health Monitoring and Management Plan* CC-PL-EN-0004 (Fortescue 2012a, Appendix 6B. This plan specifies monitoring management triggers for the four keystone plant species and their associated habitats identified as occurring at Christmas Creek: *Acacia aneura, Eucalyptus victrix, Eucalyptus camaldulensis* and *Tecticornia* spp.

Results of the 2013 monitoring surveys indicate that Level 1 monitoring management triggers have been exceeded in all three communities (Mulga, samphire and phreatophytic vegetation). As such, Fortescue has increased the frequency of monitoring and will undertake further analysis of cause and effect. When all trends within the three communities were examined, there was no strong indication that an impact has occurred, especially for the phreatophytic and samphire communities.

At Mulga monitoring sites, Level 1 triggers have been exceeded for midday water potential, canopy cover and multivariate values for all ecophysiological parameters. Despite the exceedances, overall, the condition of Mulga in both eastern and western areas as assessed by visual health ratings was good with reference and potential impact sites comparable and trending similarly in 2013. There have also been no deaths of sample trees to date. Declining soil moisture at both the reference and potential impact sites at the end of the dry season (November 2013) indicates that if mounding is occurring, groundwater remains below 0.5 m depth and therefore, below the depth of the majority of Mulga roots.

In the phreatophytic community, monitoring management triggers were exceeded for predawn water potential at some sites. Further investigation of the exceedances is likely to indicate that groundwater drawdown was not the cause of the trends observed and that the trees are maintaining good health. If dewatering was having an effect at the monitoring sites then water potential would be expected to be significantly lower than at the reference site and displaying a negative trend.

Two of the monitoring management triggers were exceeded in monitoring of the samphire community: height of samphires was significantly greater in the potential impact area and there was a difference in the multivariate analysis of height and tip die back (health). Reporting against the monitoring management trigger in relation to community composition change was not possible due to the inability to identify species because of the absence of reproductive structures on the plants at both reference and potential impact sites. Despite the exceedances, samphire communities within both the reference and potential impact areas appear in relatively good health. Further, health of samphires is rated as higher in the potential impact site than at the reference site. Differences in height and trends in health may be due to inherent site differences such as depth of soil and soil salinity as potential impact sites are somewhat further from the centre of the Fortescue Marsh than reference sites.

In accordance with the *Vegetation Health Monitoring and Management Plan* CC-PL-EN-0004 (Fortescue 2012a). Fortescue has increased the frequency of vegetation health monitoring and is currently undertaking a review of the suitability of trigger levels outlined in the Plan. Any proposed changes to the approved monitoring or management of vegetation health would be submitted to the OEPA for approval via a revision of the Management Plan.

9.4.8 Flora

Recent and previous surveys of the Proposal area recorded a total of 541 taxa (including species, subspecies and varieties), representing 181 genera and 54 families (ENV 2013a). During the 2011-2013 surveys a total of 485 taxa (including published species, subspecies and varieties were recorded, comprising 175 genera and 53 families; the families with the highest number of taxa were Fabaceae (80 taxa), Poaceae (76 taxa), Malvaceae (44 taxa), Chenopodiaceae (44 taxa), Asteraceae (26 taxa) and Amaranthaceae (26 taxa).

The DPaW (2014) survey of the Fortescue Marsh recorded 274 taxa, 90 of which had not been recorded in previous surveys of the Proposal area. Ten species had not previously been recorded from the Fortescue Marsh and two new taxa were phrase named from specimens collected during this survey.

9.4.9 Conservation Significant Flora

Within the Proposal area, no threatened flora (threatened flora under the WC Act or flora taxa listed under the EPBC Act) have been recorded (ENV 2013a). A total of 14 priority flora have been recorded within the Study area (Figure 44), comprising five species of Priority 1, one Priority 2, six Priority 3 and two Priority 4 (ENV 2013a). Two additional Priority 3 flora species have been recorded in the Fortescue Marsh.

Flora Species of Conservation Significance Recorded within or nearby to the Proposal Area

Table 31 provides both the number of locations of populations (i.e. where more than one individual is recorded in close proximity) and the VTs and VAs in which these flora were recorded.

Locations of conservation significant flora recorded in the Proposal area are shown in Figure 44. Potential impacts on species of conservation significance as a result of the Proposal are outlined in Section 9.7.1.

Table 31: Conservation Significant Flora Recorded in the Survey Area

Species	Conservation status (Federal)	Conservation status (State)	No. of locations	VTs and VAs recorded from
Calotis squamigera	None	Priority 1	1	VT30.1
Eremophila spongiocarpa	None	Priority 1	101	VA2, VA3, VA5, VA7, VA9, VA10, VT2, VT4, VT10.1, VT30.1, VT30.1+04, VT30.1+10, VT30.2
Nicotiana heterantha	None	Priority 1	51	VA1, VA2, VA3, VA4, VA5, VA7, VA8, VA9, VA10, VT3
Tecticornia sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063)	None	Priority 1	35	VA1, VA2, VA3, VA4 VA5,VA7 VA10, VA11
Tecticornia globulifera	None	Priority 1	5	VA2, VA6, VA11
Vigna sp. central (M.E. Trudgen 1626)	None	Priority 2	90	VT2, VT4, VT10.1
Atriplex flabelliformis	None	Priority 3	3	VA7, VA11
Eleocharis papillosa	None	Priority 3	6	VA2, VA7
Rhagodia sp. Hamersley (M. Trudgen 17794)	None	Priority 3	195	VT1, VT2, VT3, VT4, VT17 VT30.1
Rostellularia adscendens var. *latifolia*	None	Priority 3	3	VT1, VT2, VT17
Tecticornia medusa	None	Priority 3	7	VA2, VA6, VA10, VA11
Themeda sp. Hamersley Station (M.E. Trudgen 11431)	None	Priority 3	4	VT2, VT4
Eremophila youngii subsp. *lepidota*	None	Priority 4	49	VA2, VA5, VA7, VT2, VT4, VT10.1, VT30.1, VT30.1+04, VT30.2
Goodenia nuda	None	Priority 4	89	VT1, VT2, VT3, VT4, VT8, VT9, VT10.1, VT17, VT30.1

According to preliminary survey results, a number of the species listed in Table 31 were also recorded during the DPaW survey of the Fortescue Marsh (DPaW 2014b):

- *Calotis squamigera* (P1)
- *Eremophila spongiocarpa* (P1)
- *Nicotiana heterantha* (P1)
- *Tecticornia* sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063) (P1)
- *Tecticornia globulifera* (P1)
- *Atriplex flabelliformis* (P3)
- *Tecticornia medusa* (P3)
- *Eremophila youngii* subsp. *Lepidota* (P4).

An additional two flora species of conservation significance, *Stackhousia clementii* (P3) and *Eragrostis crateriformis* (P3) were also recorded from the Fortescue Marsh during the DPaW survey (DPaW 2014b). As the preliminary results of this survey provide limited information, locations of the Priority species records are not available, so it is not possible to determine their proximity to the Proposal area.

<u>Priority 1 Species</u>

Calotis squamigera

This species is a procumbent annual herb which grows to 0.2 m and produces yellow flowers in July (WAH 2013). It was recorded once as a single individual in VT30.1 by ENV (2013a). It was also recorded outside the Proposal Area during DPaW's survey of the Fortescue Marsh in 2013 (DPaW 2014b).

Eremophila spongiocarpa

Eremophila spongiocarpa is a compact, succulent-leaved shrub, to 1 m with white flowers in May and September. It occurs on weakly saline alluvial plains on the margins of marsh areas. It was recorded at over 70 locations in vegetation types bordering the Marsh during the 2011-2013 surveys (ENV 2013a), and previously at two locations in VT22 (Mattiske 2007). This species was also recorded outside the Proposal Area during DPaW's survey of the Fortescue Marsh in 2013 (DPaW 2014b).

Nicotiana heterantha

Nicotiana heterantha is a decumbent short lived annual or perennial herb to 0.5 m that forms low spreading colonies. It occurs on seasonally wet flats (WAH 2013). It was recorded at 51 locations during the 2011-2013 surveys in VT2, VT3 and VT22 (ENV 2013a). It was also recorded outside the Proposal Area during DPaW's survey of the Fortescue Marsh in 2013 (DPaW 2014b).

Tecticornia sp. Christmas Creek (K.A. Shepherd & T. Colmer *et al*. KS 1063)

This species is an erect, spreading shrub to 0.6 m with red to green foliage. It occurs on Samphire flats in association with salt lakes. It was previously recorded at eight locations within VT31, VT32, VT35 and VT36, associated with the Marsh (ENV 2010a). This species was recorded during the 2012 survey at 22 locations throughout the Marsh (ENV 2013a). It was also recorded outside the Proposal Area during DPaW's survey of the Fortescue Marsh in 2013 (DPaW 2014b).

Tecticornia globulifera

Tecticornia globulifera is a shrub up to 1.5 m with leaves about 1-2 mm in diameter. During dry periods, only the upper two leaves remain on the branchlets, resembling red balls. The flowers are reduced and are green to yellow. The species favours heavy clays on the margins of salt

lakes and marshes (Shepherd & van Leeuwin 2011) and is known from 10 records at the WAH (Lake Weelarrana 80 km south of Newman and Fortescue Marsh). It was previously recorded at three locations in VT31 associated with the Marsh (ENV 2010a, 2011b), and was recorded at two locations during the 2012 survey in the lower, still wet parts of the Marsh (ENV 2013a). This species was also recorded outside the Proposal Area during DPaW's survey of the Fortescue Marsh in 2013 (DPaW 2014b).

Priority 2 Species

Vigna sp. central (M.E. Trudgen 1626)

This species is a vine with a perennial rootstock which grows short lived erect to scrambling stems after rain. It has small yellow pea flowers and a pod, 1 to 2 cm long. This species colonises loamy to clayey creek banks in the Hamersley Ranges (M. Trudgen, pers. comm.) and is known from six records at the WAH (2013), including at least three coastal locations at Onslow in the Carnarvon bioregion and the remaining records from the Pilbara bioregion. It was recorded twice in 2011 and represents a small range extension to the south-east (ENV 2013a).

Priority 3 Species

Atriplex flabelliformis

Atriplex flabelliformis is a monoecious, erect, rounded perennial herb to 0.35 m. It occurs in clay-loams and loams on saline flats and marshes. It was recorded at one location in VT34 associated with the Fortescue Marsh during a previous survey (ENV 2011b). This species was recorded again during the 2012 survey from one location in a depression of the mid – Marsh, in the western part of the Survey Area, in damp, clayey, slightly saline soil (ENV 2013a). This species was also recorded outside the Proposal Area during DPaW's survey of the Fortescue Marsh in 2013 (DPaW 2014b).

Eleocharis papillosa

Eleocharis papillosa was recorded in 2012 in six locations in the Survey Area with densities between <1% up to 80%, in the lower Marsh in saline clay soils that were still very moist. Records from the current Survey Area represent a large range extension for this priority species (ENV 2013a).

Rhagodia sp. Hamersley (M. Trudgen 17794)

This species is a perennial erect shrub to 1.4 m with red-pink flowers. It is known from 11 records from the WAH (2013) and occurs on alluvial soils, often dominated by Mulga vegetation. It was recorded at 139 locations in VTs 1, 2, 3, 4, 17 and 30 during the 2011 survey, previously from one location in VT4 (ENV 2010a) and from two locations in VT17 (Fortescue 2014d).

Rostellularia adscendens var. *latifolia*

This species is a prostrate shrub to 0.3 m with purple flowers from April to May. It occurs on ironstone soils, on rocky hills and near creeks and at the time of the survey was known from 12 records from the WAH (2013). This species was recorded at two locations in VT1 (a major creekline) during the 2011 survey (ENV 2013a) and at one location in VT17 (hill slope) during previous surveys (Fortescue 2014d).

Tecticornia medusa

Tecticornia medusa [formerly *T*. sp. Roy Hill (H. Pringle 62)] is an erect, yellow-green shrub to 1.2 m. It occurs in red, clayey sand on flat flood ways, lake beds, saline alluvial plains and drainage sumps. At the time of survey, it was known from 18 records from the WAH (2013). This species was previously recorded at five locations in VTs 31, 34, 35 and 36 associated with the Marsh (ENV 2010a). This species was recorded again during the 2012 survey at two locations in the western and central part of the lower Marsh, in wet saline clay soil (ENV 2013a). It was also recorded outside the Proposal Area during DPaW's survey of the Fortescue Marsh in 2013 (DPaW 2014b).

Themeda sp. Hamersley Station (M.E. Trudgen 11431)

This species is a tussocky perennial grass-like herb, to 1.8m. It occurs in red clay sand, clay pan and grass plain. It is easily differentiated from the common *T. triandra* by its preference for clayey soils, bluish leaves, thick, dense tussocks with curly broad leaves and its very vigorous growth. It was recorded inside the Proposal are during previous surveys (Mattiske 2005a) and at one location during the 2011-2013 surveys (ENV 2013a).

<u>Priority 4 Species</u>

Eremophila youngii subsp. *Lepidota*

This species is a dense spreading shrub to 3 m high with purple, red or pink flowers. It occurs in stony sandy red loam soils on semi-saline flats and floodplains (WAH 2013). At the time of the survey, it was known from 27 records from the WAH (2013). The taxon was recorded at four locations in VTs 1, 2, 3 and 30 near the Marsh during the 2011 survey, and at over 20 locations during subsequent surveys.

Goodenia nuda

Goodenia nuda is an erect to ascending herb to 0.5 m with yellow flowers. It is known from twenty records from the WAH (2013). *G. nuda* was recorded at eight locations in VTs 8, 10 and 17 during the 2011 survey (ENV 2013a) and from 20 locations in VT 1, 2, 3, 4 and 30 during previous surveys (Biota 2004a and 2004b; Fortescue 2014d).

Flora Species of Conservation Significance from the Pilbara Bioregion not Recorded within or nearby to the Proposal Area

An additional three taxa listed under the WC Act and/or EPBC Act are known to occur in the Pilbara bioregion (ENV 2013a). A list of these taxa including their current conservation status is presented in Table 32. None of these species have been recorded in the Proposal area, and none are expected to occur there.

Table 32: Threatened Flora of the Pilbara Bioregion

Species	Conservation status (Federal)	Conservation status (State)	Comments
Aluta quadrata	None	Declared Rare Flora (Schedule 1 – Extant)	Unlikely to occur. Found on edge of creek beds, base of cliffs, rocky crevices, near crest of ridge. No records of this species in the Fortescue or Chichester subregions, known from 23 locations in the Hamersley subregion (DPaW 2014a)
Lepidium catapycnon (Hamersley Lepidium)	Vulnerable	Declared Rare Flora (Schedule 1 – Extant)	Unlikely to occur. A disturbance opportunist found on stony hill slopes, open woodland and hummock grasslands in hilly areas and on road verges and cuttings. Recorded in both the Fortescue and Chichester subregions; closest record is 39 km away. Considered unlikely to exist in the Survey Area (ENV 2013a)
Thryptomene wittweri (Mountain Thryptomene)	Vulnerable	Declared Rare Flora (Schedule 1 – Extant)	Unlikely to occur. Known from three disjunct populations in WA between Wiluna and Karratha. Occurs on steep slopes, rock scree and breakaways near the summits of prominent hills. Preferred habitat does not occur within the Survey Area. No records of this species in the Fortescue or Chichester subregions (DPaW 2014a).

Flora Species of Potential Significance

Acacia aff. *aneura* (long, flat, recurved; FMR35.3)

Biota (2004b) and ENV (2013a) both noted an unusual Mulga, *Acacia* aff. *aneura* (long, flat, recurved; FMR35.3), mapped at 52 locations. This form of *Acacia aneura* appears to represent a distinct taxon (ENV 2013a); however, due to the taxonomic complexity of the Mulga group and the lack of a formal description, this cannot be confirmed. As noted by Maslin and Reid (2012), the Mulga group is comprised of a large number of closely related groups of species that are prone to hybridisation and contain many informal variants. *Acacia* aff. *aneura* (long, flat, recurved; FMR35.3) was considered to be common and widespread within the Survey Area and was dominant in some communities (ENV 2013a). Although there are not many records of this informal variant outside of the Survey Area, this is a reflection of the difficulty of identifying *Acacia* aff. *aneura* (long, flat, recurved; FMR35.3) rather than an indication of its distribution. Based on this information, the informal variant *Acacia* aff. *aneura* (long, flat, recurved; FMR35.3) is not considered to be conservation significant for the purposes of this assessment.

9.4.10 Introduced Flora

A total of 20 introduced flora taxa (weeds) were recorded within the Survey Area (Table 33) (Figure 45). The majority of these species are common and widespread within the Pilbara region of Western Australia (ENV 2013a). The distribution of weeds was mainly concentrated around minor creeklines and drainage lines, or in areas of more degraded vegetation. Many of the weeds present are associated with previous pastoral use of the landscape.

Two Declared Pests were recorded in the Survey Area as listed under the BAM Act as shown in Table 33:

- Mexican Poppy (**Argemone ochroleuca*)
- Mexican Poppy (**Argemone mexicana*).

**Argemone ochroleuca* is a Declared Pest and is listed as C3 Management for the whole of the state (DAF 2013). **Argemone mexicana*, a different form of Mexican Poppy, is a Prohibited Organism and listed under the C1 Exclusion category, indicating that this species is not yet established in Western Australia and measures must be taken to control any infestations. ENV (2013a) state that **Argemone mexicana* is very likely to have been misapplied to **Argemone ochroleuca*, and thus it is unlikely that **Argemone mexicana* is present within the Survey Area.

Table 33: Introduced Flora of the Survey Area

Species	BAM Act Status	Environmental Significance (ENV 2013)
**Acetosa vesicaria* (Ruby Dock)	-	Invasive disturbance specialist recorded in disturbed areas and creeks.
**Aerva javanica* (Kapok Bush)	-	Moderately invasive species recorded along degraded creeks and rivers.
**Argemone mexicana* (Mexican Poppy)	C1 Exclusion	Aggressive environmental weed of riparian zones. Feasibility of control is low. Record may have been misapplied to *A. ochroleuca.*
**Argemone ochroleuca* (Mexican Poppy)	C3 Management	Aggressive environmental weed of riparian zones. Feasibility of control is low.
**Bidens bipinnata* (Bipinnate Beggartick)	-	Typical weed of Mulga stands and occasionally creeks and rivers. Can form dense stands. Seeds transported by people and animals.
**Cenchrus ciliaris* (Buffel Grass)	-	Introduced as pastoral fodder. Highly invasive, inhibits native species growth and may impact on local fire regime. Feasibility of control is low.
**Cenchrus setiger* (Birdwood Grass)	-	Introduced as pastoral fodder. Highly invasive, inhibits native species growth and may impact on local fire regime. Feasibility of control is low.
**Chloris virgata* (Feathertop Rhodes Grass)	-	Recorded at low densities. Not considered to impact local vegetation communities.
**Citrullus colocynthis*	-	Climber that quickly covers disturbed ground. Low ecological impact.
**Cucumis melo subsp. agrestis* (Ulcardo Melon)	-	Climber that quickly covers disturbed ground. Low ecological impact.
**Echinochloa colona* (Awnless Barnyard Grass)	-	Recorded at low densities. Not considered to impact local vegetation communities.
**Eragrostis curvula* (African Lovegrass)	-	Recorded at low densities. Not considered to impact local vegetation communities.
**Flaveria trinervia* (Speedy weed)	-	Recorded at low densities. Not considered to impact local vegetation communities.
**Heliotropium europaeum* (Common Heliotrope)		Recorded at low densities. Not considered to impact local vegetation communities.
**Malvastrum americanum* (Spiked Malvastrum)	-	Associated with dense Mulga, creeks and rivers. High ecological impact, however control is not considered feasible.
**Portulaca oleracea* (Purslane)	-	Recorded at low densities. Not considered to impact local vegetation communities.
**Setaria verticillata* (Whorled Pigeon Grass)	-	Recorded at low densities. Not considered to impact local vegetation communities.
**Sonchus oleraceus* (Common Sowthistle)	-	Recorded at low densities. Not considered to impact local vegetation communities.
**Tribulus terrestris* (Caltrop)	-	Recorded at low densities. Not considered to impact local vegetation communities.
**Vachellia farnesiana* (Mimosa Bush)	-	Widespread along roadsides, creeks, rivers and disturbed floodplains. High ecological impact, but has a stable distribution.

9.4.11 Proposed Fortescue Marsh Conservation Reserve

DPaW is proposing that portions of the Mulga Downs, Hillside, Marillana and Roy Hill stations be excluded from the renewal of pastoral leases in 2015 and added to the conservation estate (or managed by conservation agreement) (Figure 46). The proposed Fortescue Marsh Conservation Reserve (FMCR) totals 213,049 ha. Parts of the proposed conservation reserve overlap some areas of the Proposal, including areas of proposed vegetation clearing.

The proposed FMCR may encompass a considerable proportion of the Fortescue Marsh. In recommending creation of other conservation reserves in the Pilbara, DPaW has recognised that a multiple-use framework of land management is required where the proposed new reserve encompasses other interests, such as areas with significant mineral interest and within the claimed boundaries of Native Title aspirants. Consultation and agreement led by DPaW under a similar framework process is expected to also apply in this case.

9.5 Potential Impacts

Activities or aspects of the Proposal that have the potential to affect flora and vegetation, not considering mitigation measures, include:

- clearing of vegetation will directly reduce the extent of vegetation communities, and may disturb conservation significant flora species or ecological communities
- groundwater abstraction will lower groundwater levels and may affect potentially groundwater-dependent vegetation
- alterations to surface water flows can affect downstream vegetation communities
- spread of weeds from vehicle movements, introduced/imported material, earthworks or surface and/or subsurface water flow have the potential to introduce and spread weed species
- dust generation due to earthworks and vehicle movements has the potential to smother vegetation
- on-site ignition sources that could result in increased fire frequency/intensity that may favour the establishment of weeds and prevent the regeneration of native vegetation.

9.6 Evaluation of Options or Alternatives to Avoid or Minimise Impact

Alternative locations to avoid or minimise impact are somewhat limited as the location of the mine is dictated by the location and extent of the resource. However, locations of linear infrastructure and waste landforms are flexible to some extent and avoidance of significant flora species or vegetation communities is part of the mine planning process.

All proposed vegetation clearing and ground disturbance activities are required to go through a procedure of internal review and approval (a GDP) prior to commencement of works. Under the permitting process, areas of vegetation that may contain high value flora and/or vegetation may require on-ground surveys to inform a risk assessment. The risk assessment includes factors such as proximity to the Fortescue Marsh, drainage lines, Mulga and areas where no previous surveys have been conducted. Areas found to have higher conservation value may be re-assessed for suitability for clearing.

The dewatering and injection system has been designed to minimise impacts to significant vegetation within the Fortescue Marsh by minimising propagation of drawdown or mounding into the Fortescue Marsh habitats (Section 7.6.2).

The Proposal is based on strip mining due to the comparatively shallow nature of the resources. Strip mining requires areas to be cleared in order to extract the ore and manage the waste rock or overburden. This style of mining may be undertaken in a number of ways, including:

- developing a large shallow open pit with large adjacent overburden stockpiles
- progressive development of the pit, where a starter pit is opened (with overburden from the starter pit placed in a smaller overburden stockpile), and the open pit is then progressively backfilled with overburden and rehabilitated as the mining face progresses.

The latter method is used where possible to reduce the size of the areas required for overburden storage and consequently the amount of vegetation clearing required. This method also allows progressive rehabilitation which aims to re-establish vegetation values on the final landform.

9.7 Assessment of Likely Direct and Indirect Impacts

9.7.1 Clearing of Vegetation

Vegetation will be progressively removed from sections of the Proposal area during construction of mining infrastructure and during mining. Up to 7,821 ha of disturbance for mine pits, waste dumps and associated mine infrastructure and facilities is proposed, incorporating clearing of up to 7,752 ha of native vegetation. The proposed disturbance will be undertaken within the Development Envelope of approximately 33,000 ha. The total disturbance area for the Christmas Creek Project (i.e. the Proposal combined with the already approved clearing) will be approximately 17,956 ha.

Clearing of vegetation will directly reduce the local extent of vegetation communities and potentially disturb some priority flora species. The majority of vegetation communities recorded in the Proposal area are well represented across the Pilbara region and clearing is considered unlikely to significantly affect regional diversity.

Assessment of Direct Impacts to Regional Vegetation

A breakdown of potential impacts to vegetation systems resulting from clearing is provided in Table 34. Of the four vegetation systems that exist in the Survey Area, three will be affected by the Proposal (vegetation systems 29, 173 and 562).

In accordance with EPA Position Statement No. 2 (EPA 2000a), a proposal should demonstrate that the loss of vegetation would not compromise any vegetation type by taking it below the "threshold level" of 30% of that pre-clearing extent of the vegetation type. All three of the vegetation systems affected by the Proposal are well represented (vegetation system 29 with 97.5%, vegetation system 173 with 97.4% and vegetation system 562 with 92.3%) with impacts from clearing not of a magnitude sufficient to take them below the 30% threshold level.

Table 34: Vegetation Systems Affected by Clearing

Vegetation System	Pre-European Extent (ha)	Current Extent (ha)	Proportion Remaining (%)	Approved Clearing (Existing Mine)		Proposed Additional Clearing		Cumulative Clearing (Christmas Creek)		Proportion Remaining after Proposal (%)
				ha	%	ha	%	ha	(%)	
29	8,096,900	7,910,775	97.7	6,813	0.1	5,421	0.1	12,234	0.2	97.6
173	1,797,009	1,750,458	97.4	1	<0.1	21	<0.1	22	<0.1	97.4
562	106,192	103,662	97.6	3,320	3.2	2,310	2.3	5,630	5.4	92.3
676	2,092,352	1,979,251	94.6	0.1	<0.1	0.0	0.0	0.1	<0.1	94.6
N/A	n/a	n/a	n/a	n/a	n/a	69	n/a		n/a	n/a
Total proposed clearing		-	-	**10,135**		**7,821**		**7,821**		

Assessment of Direct Impacts to Vegetation Types

Vegetation types of the Survey Area have been described at two different scales; vegetation systems (Beard 1975; Shepherd *et al*. 2002) and VTs/VAs (ENV 2013a) (see sections 9.4.1 and 9.4.2). The effects on each resulting from vegetation clearing are discussed in the following sections. As shown in Table 35, clearing for the Proposal will be required within 13 of the 24 VTs/VAs recorded from the Survey Area. Of the 12 VTs/VAs to be cleared, five of these are likely to be cleared above the 30% from within the Survey Area. These are:

- VT02, Mulga (not sheet flow dependent)
- VT03, Mulga (sheet flow dependent)
- VT04, Mulga (sheet flow dependent)
- VT08, no recorded significance
- VT17, no recorded significance.

These vegetation types exist outside the Survey Area for Christmas Creek, as documented by Mattiske (2007) and ENV (2011b). Additional representation of the five VTs listed above which meets the following criteria have been presented in Table 35:

- outside the Christmas Creek Survey Area (to avoid duplication with ENV (2013a) data
- outside the Cloudbreak Survey Area (to discount areas which could be impacted by proposed Mining Activities at Cloudbreak).

When this additional representation is considered, only one vegetation type; VT17, remains above the 30% loss threshold (30.6%). As VT17 occurs in ranges, hills and hillslopes, it has not been represented to its full extent in surveys undertaken by Fortescue outside the proposed mining areas at Cloudbreak and Christmas Creek. The large scale flora and vegetation survey undertaken in 2007 by Mattiske focused on the fringing vegetation of the Fortescue Marsh, and did not extend far enough north to capture large areas of VT17 in the hillslope areas (Mattiske 2007). To assess the potential for VT17 to be represented outside the surveyed areas vegetation systems, topography, land systems and the Fortescue Marsh have been considered.

The occurrence of VT17 in surveyed areas broadly follows Vegetation System 562 and the Newman land system, which occur in an east-west direction, north of the Fortescue Marsh in the footslopes of the Chichester Ranges. It follows that VT17 will very likely occur up to 2 km north of the northern extent of the Christmas Creek and Cloudbreak Survey Areas and in a similar area to the west of Cloudbreak, north of the Mattiske (2007) Survey Area. The extent of Vegetation System 652 and the Newman land system across the north of the Fortescue Marsh outside existing Survey Areas is approximately 20,000 ha. A conservative assumption is that VT17 covers 75% of this area and as such it is estimated that VT17 is present in up to 15,000 ha outside existing surveyed areas. When considering the total estimated extent of this vegetation type in the area north of the Fortescue Marsh, proposed disturbance of 5,115 ha at Christmas Creek corresponds to a loss of approximately 18%.

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Table 35: Vegetation Types Affected by Clearing

VT	Conservation Significance	Extent within Study area	Approved Clearing (existing mine)		Proposed Additional Clearing	Cumulative Clearing at Christmas Creek		Additional mapped presence[3] excluding Christmas Creek[4] and Cloudbreak[5] Survey Areas	% Loss when considering additional survey data
			ha	%		ha	%		
VT01	None recorded	1,910	142	7.5	355	497	26.0	N/A	N/A
VT02	Mulga	5,544	1,307	23.6	891	2,198	**39.7**	5,796	19.3
VT03	Mulga	6,722	1,301	19.4	941	2,242	**33.4**	12,488	11.7
VT04	Mulga	10,151	2,875	28.3	1,847	4,722	**46.5**	7,614	26.6
VT08	None recorded	571	57	10.0	142	199	**34.9**	290	23.1
VT10.1	Mulga	2,637	15	0.6	608	624	23.7	N/A	N/A
VT10.2	Mulga	50	3	5.6	0.5	3	6.6	N/A	N/A
VT30.1+04	Mulga	541	4	0.7	4	8	1.4	N/A	N/A
VT30.1+10.1	Mulga	1,064	6	0.6	2	8	0.7	N/A	N/A
VT17	None recorded	13,349	3,012	22.6	2,103	5,115	**38.3**	3,371	**30.6**
VT30.1	None recorded	8,024	301	3.8	856	1,157	14.4	N/A	N/A
VT30.3	None recorded	490	3	0.5	1	4	0.7	N/A	N/A
Historical cleared	Not available	1,109	1,109	0	69	1,178	100.0	N/A	N/A
Total: All Vegetation		**52,162**	**10,135**	**15.37**	**7,821**	**17,956**	**25.73**	**N/A**	**N/A**

[3] Based on Mattiske (2007), *Flora and Vegetation Near Fortescue Marshes*
[4] Christmas Creek Survey Area as defined in ENV (2013a)
[5] Cloudbreak Survey Area as defined in ENV (2011b)

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Assessment of Direct Impacts to Conservation Significant Vegetation Communities

Fortescue Marsh Priority Ecological Community

No direct clearing of the VAs associated with the Fortescue Marsh PEC (VA01 to VA09, Table 34) is anticipated. Therefore, there will be no direct impacts to the Fortescue Marsh Priority 1 PEC as a result of the vegetation clearing undertaken for the Proposal.

Mulga

As Mulga woodland is the most common vegetation within the local area, clearing of this vegetation type is unavoidable. As summarised in Table 36, the existing Christmas Creek mine as approved will result in clearing of up to 5,511 ha or 20.6% of the mapped Mulga vegetation (includes Mulga on flats and broad plains as well as Mulga on creeks and drainage lines) in the Survey Area. The Proposal will increase this clearing to up to 9,805 ha or 36.7% of Mulga vegetation mapped in the Survey Area.

A number of the Mulga vegetation types exist outside the Survey Area for Christmas Creek, as documented by Mattiske (2007) and ENV (2011b). Additional representation of the five VTs listed above which meets the following criteria have been assessed:

- outside the Christmas Creek Survey Area (to avoid duplication with ENV (2013a) data
- outside the Cloudbreak Survey Area (to discount areas which could be impacted by proposed Mining Activities at Cloudbreak).

Occurrences of Mulga vegetation VT2, VT3, VT4 and VT10 which meet the criteria above were recorded during Mattiske's 2007 survey of the fringing vegetation of the Fortescue Marsh. As summarised in Table 36, consideration of the known occurrences of Mulga vegetation outside the mine Survey Areas results in a loss of 15.1% of Mulga vegetation as a result of the existing and proposed disturbance associated with the Christmas Creek mine.

Table 36: Summary of Predicted Impacts to Mulga Vegetation Types at Christmas Creek

Extent within Survey Areas (ha)	Approved Clearing (existing mine)		Proposed Additional Clearing	Cumulative Clearing (Christmas Creek site)		Additional mapped presence[6] excluding Christmas Creek[7] and Cloudbreak[8] Survey Areas	% Loss when considering additional survey data
	ha	%		ha	%	ha	%
26,709	5,511	20.6	4,294	9,805	36.7	38,055	15.1%

[6] Based on Mattiske (2007), *Flora and Vegetation Near Fortescue Marshes*
[7] Christmas Creek Survey Area as defined in ENV (2013a)
[8] Cloudbreak Survey Area as defined in ENV (2011b)

Assessment of Direct Impacts to Conservation Significant Flora

As summarised in Table 37 and Figure 44, clearing associated with the Proposal may directly affect five priority flora species. For another four species, no known populations are present in the Proposal area (area of indicative disturbance). The remaining five species of priority flora and the two range extension species will not be directly affected by the Proposal in terms of clearing known populations or clearing VAs or VTs that these species are known to occur within.

Table 37: Predicted Impact to Known Populations of Priority Flora

Species	Conservation Status	Total Populations[9]	Populations inside DE	Populations inside the Proposal Area (area of indicative disturbance)
Calotis squamigera	Priority 1	1*	1	0
Eremophila spongiocarpa	Priority 1	101*	31	2
Nicotiana heterantha	Priority 1	51*	0	0
Tecticornia sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063)	Priority 1	35*	0	0
Tecticornia globulifera	Priority 1	5*	0	0
Vigna sp. central (M.E. Trudgen 1626)	Priority 2	90	40	1
Atriplex flabelliformis	Priority 3	3*	0	0
Eleocharis papillosa	Priority 3	6	0	0
Rhagodia sp. Hamersley (M. Trudgen 17794)	Priority 3	195	129	21
Rostellularia adscendens var. *latifolia*	Priority 3	7	4	0
Tecticornia medusa	Priority 3	7*	0	0
Themeda sp. Hamersley Station (M.E. Trudgen 11431)	Priority 3	4	0	0
Eremophila youngii subsp. *lepidota*	Priority 4	49*	18	1
Goodenia nuda	Priority 4	89	40	13
Maireana amoena	(Range extension)	7	0	0
Sclerolaena recurvicuspis	(Range extension)	1	0	0

[9] The population data provided in this table does not incorporate the results of the recent survey of the Fortescue Marsh (DPaW 2014b). Preliminary results of this survey are available, which list the conservation significant species which were recorded, but no population data is available to date. Species recorded as part of this survey are indicated with a * in the Total Populations column, indicating that additional populations outside the Development Envelope are likely to have been recorded by DPaW (2014b).

Impacts to priority species as a result of the Proposal can be summarised as follows:

- Direct impact:
  - *Eremophila spongiocarpa* (P1):
    - two populations occur within the Proposal area (indicative disturbance footprint), representing potential direct impact to 2% of the populations recorded in the Survey Area
    - 29 populations occur inside the Development Envelope but outside the Proposal area
    - recorded by DPaW (2014b) during the survey of the Fortescue Marsh, no population or location details are available to date.
  - *Vigna* sp. central (M.E. Trudgen 1626) (P2):
    - one population occurs inside the Proposal area, representing potential direct impact to 1% of the populations recorded in the Survey Area
    - 39 populations occur inside the Development Envelope but outside the Proposal area.
  - *Rhagodia* sp. Hamersley (M. Trudgen 17794) (P3):
    - 21 populations inside the Proposal area, representing potential direct impact to 11% of the populations recorded in the Survey Area
    - 108 populations inside the Development Envelope but outside the Proposal area.
  - *Eremophila youngii* subsp. *lepidota* (P4):
    - one population inside the Proposal area, representing potential direct impact to 2% of the populations recorded in the Survey Area
    - 17 populations inside the Development Envelope but outside the Proposal area
    - recorded by DPaW (2014b) during the survey of the Fortescue Marsh, no population or location details are available to date.
  - *Goodenia nuda* (P4):
    - 13 populations inside the Proposal area, representing potential direct impact to 15% of the populations recorded in the Survey Area
    - 27 populations inside the Development Envelope but outside the Proposal area.
- Potential impact (no populations recorded inside the Proposal area):
  - *Calotis squamigera* (P1): one population recorded inside the Development Envelope.

- *Rostellularia adscendens* var. *latifolia* (P3): four populations recorded inside the Development Envelope.
- *Nicotiana heterantha* (P1): no populations inside the Development Envelope.
- *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) (P3): no populations inside the Development Envelope.

Assessment of Direct Impacts to the Proposed Fortescue Marsh Conservation Reserve

The direct clearing of vegetation for the Proposal will include direct clearing of vegetation in the proposed Fortescue Marsh Conservation Reserve (FMCR) (Figure 46). A summary of clearing proposed for inside the proposed conservation reserve is presented in Table 38. A total of 6,333 ha of the proposed FMCR is within the Development Envelope of the Proposal. A total of 1,182 ha of this area are proposed to be cleared, which equates to 0.6% of the total area of the proposed FMCR.

Table 38: Direct Impacts to Proposed Fortescue Marsh Conservation Reserve

Description	Area (ha)	Proportion of total proposed FMCR (%)
Portion of proposed FMCR inside the Development Envelope	6,333	3.0
Area of clearing for the Proposal inside proposed FMCR	1,182	0.6

9.7.2 Groundwater Abstraction and Injection

Native vegetation may be indirectly affected by drawdown of the watertable as a result of groundwater abstraction for the Proposal. This type of impact specifically affects vegetation which is wholly or partially reliant upon groundwater, such as the GDE VT01 and potentially also the Fortescue Marsh VTs 01 to 09.

Native vegetation may also be affected by groundwater mounding, which occurs when water is injected into the groundwater system. Groundwater mounding may impact upon Mulga vegetation, such as VTs 02, 04, 10.1, 10.2 and mosaics VT 30.1+10.1 and VT 30.1+04. Numerical modelling of both drawdown and mounding was undertaken by Fortescue to investigate the likely effects of the Proposal. Drawdown and mounding contours were then mapped over significant vegetation types, to determine potential areas of indirect impact.

Assessment of Indirect Impacts to Vegetation through Groundwater Drawdown

Drawdown related stress on vegetation is likely to manifest as reduced productivity and vigour in the first instance. Scatter deaths may then progressively appear in some species, mainly during summer and autumn months when soil moisture content and groundwater levels are at their lowest. Broad scale deaths could be experienced in areas immediately adjacent to wellfield locations where vegetation with a high dependency on groundwater occurs (e.g. wetlands).

Impacts of drawdown will particularly manifest during periods of poor moisture availability (e.g. dry summers that follow low rainfall winters/extended droughts) coincidental to abstractions.

The key factors that relate to potential for groundwater dependent vegetation to be affected is the vegetation species, depth to watertable, seasonal variations in the watertable, magnitude of the drawdown, climatic conditions and the rate at which drawdown occurs. As discussed in Section 9.4.6, vegetation types and associations considered sensitive to groundwater drawdown or mounding include the potential GDE VT01, as well as the samphire communities of the Fortescue Marsh, represented by VA01 to VA09 (Table 39).

Areas where depth to groundwater is less than 5 m without mining occurring and drawdown of greater than 2 m is expected have been mapped on an annual basis and are presented in Figure 47 (2014) to Figure 61 (2028) to determine areas of indirect impact to GDE vegetation (VT01). A small area of VT01 in the southern part of the Survey Area is expected to be affected. This impact commences in 2026 and is expected to continue until 2028. Figure 62 shows the extent of indirect impact areas to VT01 for all years combined. The area of indirect impact to VT01 is 1.1 ha at its largest predicted extent.

Samphire is known to occur only where the depth to groundwater is less than 5 m. Areas where a drawdown of greater than 3 m was shown where the depth to groundwater was less than 5 m without mining have been mapped on an annual basis and are presented in Figure 47 (2014) to Figure 61 (2028) to determine potential areas of indirect impact to samphire vegetation (VA01 – VA09). No samphire occurs in the area where a drawdown of greater than 3 m is anticipated.

Table 39: Maximum Potential Impact to Samphire and GDEs as a Result of the Proposal

VT/VA	Extent within the Study area (ha)	Proposed Clearing (ha)	Maximum Impact of Groundwater Abstraction (ha)	Total Proposed Impact (ha)
VA01	15.1	0	0	0
VA02	5,549.9	0	0	0
VA03	24.9	0	0	0
VA04	65.2	0	0	0
VA05	153.2	0	0	0
VA06	517.5	0	0	0
VA07	2,177.1	0	0	0
VA08	216.7	0	0	0
VA09	177.6	0	0	0
VT01	1,873.9	355.0	1.1	356.1

Results of the numerical modelling indicate that the only sensitive vegetation anticipated to be potentially impacted by groundwater abstraction is a small area of VT01 (River Red Gum/Coolibah vegetation) in the southern part of the Survey Area (Table 39). Cumulative impacts of the Proposal (including direct impacts of clearing discussed in 9.7.1 and the indirect impacts discussed in Section 9.7.2 to 9.7.7) are summarised in Table 41.

Impact to GDE VT01 is not expected to significantly affect the regional representation of this vegetation community as it is widespread throughout the Pilbara along creek and drainage lines.

Assessment of Indirect Impacts to Vegetation through Groundwater Mounding

The majority of Mulga roots predominantly occur in the top 1.5 m of the soil profile (Equinox 2013). Only a few fine roots (less than 2 mm diameter) occur below this depth (Equinox 2013). Mulga is not tolerant of salt (electrical conductivity greater than 9,500 µS/cm) entering its root zone (UWA 2010). Areas where mounding results in groundwater levels rising to within 2 m of the surface, where this was not previously the case, have been highlighted in this impact assessment as areas where the health of Mulga (should it occur) may be affected by mounding.

As described in Section 7.6.2, limited mounding is expected to occur as a result of the Proposal. Areas where depth to groundwater without mining is greater than 2 m without mining occurring and experiences mounding that causes groundwater to rise to within 2 m of the surface were identified as part of the modelling process. As shown in Figure 47 (2014) to Figure 61 (2028), no mounding is expected to occur within these parameters, as such; no indirect impacts to Mulga vegetation as a result of groundwater mounding are expected.

9.7.3 Alteration of Surface Water Flows

Physical infrastructure such as mine pits, waste landforms and linear infrastructure can affect surface water flows by potentially diverting upstream flows and capturing rainfall within mining areas, reducing the catchment area for downstream flows. This can result in areas of shadowing that receive less flow than previously because surface flow processes have been interrupted or diverted. Shadowing can affect both channel flow and sheet flow processes.

Sheet flow is dependent upon a range of rainfall factors (such as duration, intensity, and variability) as well as soil physical and chemical properties. Interruptions to the natural surface hydrology, particularly by linear infrastructure, may result in water shadows and water starvation (ENV 2013a). These impacts can be mitigated by environmentally sensitive designs that reduce the severity and extent of impact to sheet flow dependent Mulga communities (ENV 2013a).

Construction of mine pits and associated infrastructure (in particular, linear infrastructure) has the potential to change surface water run-off patterns and can affect downstream vegetation communities that are dependent on sheet flow (particularly Mulga woodlands). Barriers to surface water flow up-gradient of Mulga woodlands can reduce the volume of water delivered to the area, while down-gradient barriers can increase flood inundation time; both conditions may potentially have detrimental impacts on the Mulga communities. Ineffective drainage management may also channel surface flow that would have otherwise been sheet flow, thereby reducing the volume of water that Mulga woodlands are able to intercept away from the channel, leading to increased erosion in and around the channel.

As outlined in Section 9.4.6, banded Mulga communities depend on sheet flow to help meet its ecological water requirements (Worley Parsons 2014). The occurrence of Mulga is linked to landscape drainage patterns, with communities commonly associated with drainage tracts and localised depressions (Worley Parsons 2014). In some areas of low relief and poorly defined drainage, banded Mulga communities occur. This distinctive vegetation pattern is comprised of bands or groves of *A. aneura* trees of about 30% canopy cover in lower areas and an intergrove area of grass or forb-land between the groves (Anderson & Hodgkinson 1997). If this sheet flow is cut off, then surface water flows to the banded Mulga communities will be reduced, potentially affecting community health.

As outlined in Section 7.6.1, of the 6,142 ha of sheet flow areas identified by Worley Parsons, 3,415 ha of Mulga vegetation will not be impacted by either sheet flow shadowing or clearing (Table 40, Figure 20). A total of 439 ha of vegetation that is not within the Proposal Area (are of indicative disturbance) will be indirectly impacted by sheet flow shadowing (Table 40, Figure 20).

Table 40: Sheet Flow Shadowing as a Result of the Proposal

Level of Impact	Area (ha)	Percentage of Sheet Flow Area (%)
Direct Impact (Clearing of Sheet Flow Area)	2,288	37
Indirect Impact (Sheet Flow Shadowing)	439	7
No Impact	3,415	56
TOTAL	**6,142**	**100**

9.7.4 Surface Discharge of Excess Groundwater

It is anticipated that any excess abstracted groundwater will be injected, as described in Section 4.9.3. Fortescue currently has approval under Part V of the EP Act to undertake surface discharge of excess groundwater in the event that reuse, injection, in-pit disposal and temporary storage are not available or have been exhausted. Surface discharge has not been required at Christmas Creek to date.

In the event that surface discharge is required, it would be undertaken only at specified locations, for a duration not exceeding a period of 21 days. As such, any potential impacts to vegetation would be short term and localised.

9.7.5 Spread of Weeds

Impacts to flora and vegetation the result of vehicular activity is likely to be associated with the spread of weeds. As discussed in Section 9.4.10, the distribution of weeds within the Proposal Area is mainly concentrated around minor creeklines and drainage lines, or in areas of more degraded vegetation.

The highest risk of weed spread is likely to be associated with the importation of unclean material by vehicles. Any establishment of weed species in areas cleared for the Proposal from neighbouring areas may result in further intrusion in surrounding vegetation, especially if that vegetation is under stress due to groundwater drawdown or is in an otherwise disturbed state (such as the early stages of rehabilitation).

Appropriate weed hygiene and control measures (Section 9.9) will be applied to ensure adequate management of weed establishment/increased weed distribution risks. Management of weed ingress and establishment is addressed in the *Weed Management Plan* 45-PL-EN-0013 (Fortescue 2011d) and the *Rehabilitation and Revegetation Management Plan* 45-PL-EN-0023 (Fortescue 2005; 2013d). Areas of particular focus are vehicle hygiene, rehabilitation activities and management of declared weeds or weeds with high environmental impact.

9.7.6 Dust Generation

Dust emissions can cause a decline in vegetation health or loss of vegetation. Dust interferes with physiological processes such as photosynthesis, transpiration and respiration. In extreme cases, dust can smother and kill vegetation and lead to increased incidence of plant pests and diseases.

Ambient dust concentrations can be naturally high in inland Pilbara due to low rainfall and high evaporation rates (causing soils to desiccate), relatively sparse vegetation, frequent high winds and frequent uncontrolled bushfires. Dust build-up may be naturally mitigated by periodic heavy rainfall.

The key activities undertaken by Fortescue that have the potential to generate dust include vegetation clearing, ground disturbance, drilling, construction and establishment of infrastructure, open pit mining (including blasting), ore processing, stockpiling, materials handling and vehicle movement.

Dust emissions will be limited through minimising vegetation clearing and ground disturbance where possible, and through implementing progressive rehabilitation. Where dust emissions may significantly affect conservation values of significant flora or vegetation, dust suppression measures will be implemented.

Various management measures will be implemented to reduce dust generation from other aspects of the mining operations. These are listed in Section 9.9 and further details can be found in the *Mine and Rail Dust Management Plan* 45-PL-EN-0030 (Fortescue 2011e).

9.7.7 Bushfire Risk

Bushfires occur all year round in the Pilbara and are further affected by cyclonic or tropical lows causing rain and lightning storms in the region. Typically, there is an increased risk of fires between October and March, depending on storm severity.

Historically, bushfires in the Pilbara result from lightning strikes; however, fires can result from human activity such as campfires, escapes from planned burning operations, industrial activity such as mining, Indigenous land management practices and deliberate arson. More recently, changed land management practices and the introduction of industrial activities into the environment has increased the risk of unwanted fire events from human interaction.

The *Emergency Management Sub-Plan: Bushfire Management* 100-PL-EM-0009 (Fortescue 2014e) provides details on the prevention of bushfires due to human influence as well as emergency response and preparedness, and minimising the risks to people and property in the event of a naturally occurring bushfire.

9.8 Cumulative Impacts

The main potential cumulative impact on vegetation and flora is the combined effect of clearing of conservation significant vegetation communities from Cloudbreak Mine, Christmas Creek Mine and Roy Hill Mine (Table 41, Table 42 and Table 43). Cumulative impacts have been calculated using the following projects:

- Roy Hill Mine – Stages 1 and 2
- Fortescue Port Hedland to Christmas Creek Rail and Duplication
- Cloudbreak – approved Project and expansion
- Christmas Creek – approved Project and this Proposal.

Table 41: Potential Cumulative Direct Impact Calculations for Mulga

Project	Mapped Area (ha)	Impact Area (ha)	Proportion of Impact per Project (%)	Proportion of Total Impact (%)
Roy Hill Mine	17,679	4,145	23.4	5.1
Port Hedland to Christmas Creek Rail and Duplication	13,218	386	2.9	0.5
Cloudbreak (originally approved Project and life of mine expansion)	24,393	14,165	58.1	17.3
Christmas Creek	26,709	9,805	36.7	12.0
TOTAL	**81,999**	**28,485**	**N/A**	**34.8**

Table 42: Potential Cumulative Direct Impact Calculations for Samphire

Project	Mapped Area (ha)	Impact Area (ha)	Proportion of Impact per Project (%)	Proportion of Total Impact (%)
Roy Hill Mine	0	0	0	0
Port Hedland to Christmas Creek Rail and Duplication	0	0	0	0
Cloudbreak (originally approved Project and life of mine expansion)	1,380	4	0.3	0.04
Christmas Creek	8,897	0	0	0
TOTAL	**10,277**	**4**	**N/A**	**0.04**

Table 43: Potential Cumulative Direct Impact Calculations for Groundwater Dependent Vegetation

Project	Mapped Area (ha)	Impact Area (ha)	Proportion of Impact per Project (%)	Proportion of Total Impact (%)
Roy Hill Mine	2,587	437	16.9	8.0
Port Hedland to Christmas Creek Rail and Duplication	N/A	0	0	0
Cloudbreak (originally approved Project and life of mine expansion)	1,008	565	56.1	10.3
Christmas Creek	1,874	355	18.9	6.5
TOTAL	**5,469**	**1,357**	**N/A**	**24.8**

Table 44 shows the cumulative impacts associated with direct disturbance to the Roy Hill and Hillside areas of the proposed FMCR.

Table 44: Cumulative Direct Impacts to Proposed Fortescue Marsh Conservation Reserve

Description	Area (ha)	Proportion of total proposed FMCR (%)
Cloudbreak indicative footprint	2,754	1.2
Christmas Creek indicative footprint	1,182	0.6
TOTAL (Indicative Disturbance Footprints)	3,936	1.8

Table 45 shows the cumulative impacts associated with indirect disturbance to the Roy Hill and Hillside areas of the proposed FMCR. This includes indirect impacts to Mulga, groundwater dependent and samphire vegetation types due to drawdown, mounding and sheetflow shadowing as relevant to each vegetation type.

Table 45: Cumulative Indirect Impacts to Proposed Fortescue Marsh Conservation Reserve

Description	Area (ha)	Proportion of total proposed FMCR (%)
Cloudbreak indirect impacts (mounding, drawdown and shadowing)	1,081	0.5
Christmas Creek indirect impacts (mounding, drawdown and shadowing)	196	0.1
TOTAL (Indirect impacts)	1,277	0.6

Cumulative impacts to flora and vegetation from Roy Hill mine have been based on information in the public domain (Roy Hill Iron Ore 2009). Calculations for the rail and Cloudbreak use the approved disturbance as outlined in the relevant approval documentation (Fortescue 2011c).

The cumulative impacts of the three mines and the rail line come to approximately 35% of the Mulga vegetation that has been mapped across the various project areas (Table 41). However, it should be noted that Mulga vegetation generally is widespread in the region and is known to extend much further than has been considered for these individual projects.

The cumulative impacts for Samphire are extremely low (0.04%) and are limited to impacts of the Cloudbreak Mine (Table 42). Roy Hill, Christmas Creek and the rail line do not have direct impacts to samphire. Note that the total area of samphire in the region is actually much higher, as these figures only show the portion of the Fortescue Marsh that has been included in mapping for the Cloudbreak and Christmas Creek Projects.

The cumulative impacts of the three mines and the rail line come to approximately 25% of the mapped extent of groundwater dependent vegetation across the various project areas (Table 43). For Christmas Creek, this is the Red Gum and Coolibah vegetation as identified by ENV (2013a); for the other projects different communities that are also considered at least partially groundwater dependent may have been identified.

9.9 Management Measures and Performance Standards

9.9.1 Management of Ground Disturbance

A procedure of internal review and approval of all proposed vegetation clearing and ground disturbance activities is required prior to the commencement of works (GDP). Under the permitting process, areas of vegetation that may comprise high value may require ground-truthing surveys to assess its value. This process is based on a risk assessment approach such that where particular risk factors are triggered (such as proximity to the Fortescue Marsh, drainage lines, Mulga and where no previous surveys have been conducted), further surveys are conducted prior to clearing where required.

9.9.2 Adaptive Management of Groundwater

Potential impacts to significant vegetation communities, such as Mulga and samphire communities, from drawdown and mounding will be managed through the adaptive management approach outlined in the *Christmas Creek Groundwater Operating Strategy* CC-PH-HY-0002 (Fortescue 2012d, Appendix 5C) and the *Groundwater Management Plan* 100-PL-EN-0029 (Fortescue 2014b, Appendix 2C). The adaptive management approach is based on responding to information provided through implementation of a monitoring program and response plan. If monitoring indicates that unexpected and significant impacts are likely, Fortescue will implement an appropriate contingency action within the adaptive management approach, in consultation with the regulatory agencies.

The proposed contingency measures are hierarchical, ordered by response to impacts of increasing severity as follows:

1. The primary contingency measures involve adjustment of dewatering wellfield configurations and dewatering rates or adjustment of the location and injection rates of the injection wellfields.
2. Localised mitigation of temporary groundwater level changes through case specific contingencies such as surface irrigation.
3. Temporary reduction in dewatering or injection rates while further investigations into potentially unacceptable and unexpected occurrence are undertaken.
4. Permanent reduction in dewatering or injection rates, where these are determined to be appropriate, in consultation with DoW.
5. Cease dewatering or injection and investigate alternatives.

The adaptive management approach is also used in the management of vegetation health, outlined in the *Vegetation Health Monitoring and Management Plan* CC-PL-EN-0004 (Fortescue 2012a; Appendix 2G). Baseline monitoring of vegetation health is undertaken biennially and looks for changes in vegetation health at dewatering and mounding impact areas. Where vegetation monitoring detects vegetation stress potentially attributable to the Proposal, management measures outlined in the *Christmas Creek Groundwater Operating Strategy* CC-PH-HY-0002 (Fortescue 2012d, Appendix 5C) will be implemented. A summary of the vegetation health monitoring results conducted to date is discussed in 9.4.7.

9.9.3 Management of Surface Water

As discussed in Section 7.6.1, surface water impacts will be managed using the existing management actions as outlined in the *Surface Water Management Plan* 100-PL-EN-1015 (Fortescue 2014i).

Key management actions specific to managing impacts to Mulga vegetation include:

1. Diverting surface water away from mine pits and WRSFs, and maintain downstream flow regimes where feasible.
2. Keeping clean and potentially contaminated surface water separate. Containing and appropriately managing contaminated stormwater prior to release to the environment.
3. Disposing of water via surface water flow paths as a contingency method only or when maintenance is required.

A summary of this plan is provided below, together with key management actions.

Surface Water Management Plan

The *Surface Water Management Plan* 100-PL-EN-1015, (Fortescue 2014i, Appendix 2B) provides consistent management objectives and actions relating to surface water at all Fortescue operations.

Management measures detailed in the *Surface Water Management Plan* which are relevant to vegetation and flora include:

1. Minimise clearing and vegetation disturbance so that flow regimes are minimally impacted.
2. Conduct a risk assessment to determine the likelihood of a change to the surface water regime, including in areas where sheet flow dependent Mulga communities have been identified, that may lead to unacceptable environmental or safety impacts.
3. Locate, design, construct and operate drainage infrastructure to design specifications which reflect risk assessment outcomes in minimising interference and disruption of natural surface water flows and quality.
4. Incorporate appropriate drainage infrastructure into the project design where sheet flow dependent Mulga communities have been identified and significant impacts from changes to sheet flow regimes are likely.
5. When culverts are used in areas with sheet flow dependent Mulga communities to be protected, install sheet flow redistribution structures downstream and immediately upstream of the culverts where sheet flow shadowing is unacceptable.
6. Where appropriate, re-establish natural stream and drainage flows to resemble original drainage patterns, including rehabilitation of major drainage channels.

9.9.4 Environmental Management Plans

Impacts to vegetation and flora will be managed using the following management plans:

- *Significant Flora and Vegetation Management Plan* 45-PL-EN-0017 (Fortescue 2012b)
- *Vegetation Health Monitoring and Management Plan* CC-PL-EN-0004 (Fortescue 2012a)

- *Rehabilitation and Revegetation Management Plan* 45-PL-EN-0023 (Fortescue 2005; 2013d).
- *Surface Water Management Plan* 100-PL-EN-1015, (Fortescue 2014i)

Key management measures include:

- record significant flora and vegetation in the internal GIS and record keeping systems, and inform DPaW of any new populations or communities discovered, as required
- avoid clearing in areas of priority flora where possible, or identify priority flora on the ground by appropriate signage and fencing/flagging prior to clearing
- manage dewatering activities and water discharge to minimise drawdown impact on GDEs such as the fringing vegetation of the Fortescue Marsh
- report and investigate unauthorised disturbance of significant flora or vegetation
- clearing to be undertaken progressively.

9.10 Predicted Environmental Outcome

After application of management and mitigation measures described in Section 9.9, the Proposal is expected to result in the following outcomes in relation to flora and vegetation:

1. Disturbance of approximately 7,821 ha, consisting of 7,752 ha of native vegetation (approximately 17,956 ha total disturbance combined with existing mine within a Development Envelope of 33,000 ha) for the mine expansion and associated infrastructure.
2. No clearing or indirect disturbance will occur to the Fortescue Marsh PEC (P1).
3. Up to 4,924 ha of Mulga vegetation will be directly affected by the Proposal and up to 439 ha of sheet flow dependent Mulga will be indirectly affected by altered surface water regime; however, Mulga communities are well represented in the region.
4. No indirect impacts will occur to Mulga vegetation as a result of groundwater drawdown or mounding.
5. Up to 355 ha of GDE vegetation (VT01) will be directly affected by the Proposal and up to 1.1 ha could potentially be indirectly affected by groundwater drawdown; however, floristic analysis demonstrates that VT01 (as floristic group 575) occurs in several locations outside the Survey Area, with 13 sites located within the Survey Area and a further 11 sites located outside the Survey Area (Appendix E of ENV 2013a).
6. No direct impacts to samphire vegetation will result from the Proposal, and no indirect impacts to samphire vegetation through groundwater drawdown are expected.
7. Clearing for the Proposal and potential indirect impacts to vegetation will not compromise any vegetation system by taking it below the “threshold level” of 30% of its pre-clearing extent.

8. No change in the conservation status of conservation significant flora species is expected.
9. Rehabilitation will restore some of the vegetation values of the pre-existing landscape.

The Proposal is not expected to result in a change in status of conservation significance flora and is not expected to represent a significant impact to VTs and VAs. Geographical distribution, productivity, and ecosystems are expected to be maintained through management and mitigation measures. Where significant residual impacts are expected to occur, offset measures will be implemented, as discussed in Section 14.

In considering the outcome as described, the Proposal is expected to meet the EPA objectives for vegetation and flora to maintain representation, diversity, viability and ecological function at the species, population and community level.

10. TERRESTRIAL FAUNA

10.1 Relevant Environmental Objectives, Legislation, Policies and Guidelines

10.1.1 EPA Objective

The EPA applies the following objective to the assessment of proposals that may affect terrestrial fauna:

> *To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.*

10.1.2 Regulatory Framework

The protection of terrestrial fauna is covered by a range of statutes as discussed in the following sections.

Wildlife Conservation Act 1950

In Western Australia, rare or endangered species are declared under the *Wildlife Conservation (Specially Protected Fauna) Notice* 2 December 2014, under the WC Act. Schedules 1 to 4 in this Notice are relevant to this assessment, providing a list of species protected by this Notice.

Fauna are also listed by DPaW as Priority Species if they are potentially threatened but for which there is insufficient evidence to properly evaluate their conservation significance. They range from Priority 1 to Priority 4 species as follows:

- Priority 1: Poorly known taxa. Taxa, which are known from one or a few (generally <5) populations, which are under threat
- Priority 2: 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
- Priority 3: Poorly known taxa. Taxa which are known form several populations, at least some of which are not believed to be under immediate threat
- Priority 4: Rare. Taxa which are considered to have been adequately surveyed and which, whilst being rare, are not currently threatened by any identifiable factors.

The Priority fauna classifications are employed by DPaW to manage and classify their database of species considered to potentially be at risk. These categories have no legislative status for protection.

Environmental Protection Act 1986

The EP Act provides for protection of fauna through assessment of proposals that may have a significant effect on the environment. The EPA assesses proposals to determine whether, if implemented, the impact(s) of the proposal could be considered environmentally acceptable. Impacts to fauna and fauna habitat are taken into account as part of the assessment process with special consideration given to any fauna listed under WC Act, as well as Priority listed fauna.

Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act provides for the protection of MNES including threatened fauna species. Species are listed under a number of different categories including:

- extinct
- extinct in the wild
- critically endangered
- endangered
- vulnerable
- conservation dependent.

Guidance and Position Statements

The following EPA position and guidance statements set the framework for identification and assessment of impacts to terrestrial fauna:

- EPA (2002) Position Statement No. 3 - *Terrestrial Biological Surveys as an Element of Biodiversity Protection* discusses the principles the EPA would apply when assessing proposals that may have an effect on biodiversity values in Western Australia
- EPA (2004c) Guidance Statement No. 56 - *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* provides guidance on standards and protocols for terrestrial fauna surveys, particularly those undertaken for the Environmental Impact Assessment of proposals
- EPA (2009) Guidance Statement No. 20 - *Sampling of Short Range Endemic Fauna for Environmental Impact Assessment in Western Australia* provides guidance on standards and protocols for surveys for Short Range Endemics (SRE) fauna, particularly those undertaken for the Environmental Impact Assessment of proposals
- EPA and DEC (2010) *Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* provides additional guidance on sampling techniques and methodologies.

International Agreements

Australia is party to the Japan-Australia (JAMBA), Republic of Korea- Australia (ROKAMBA), China-Australia (CAMBA) Migratory Bird Agreements and the Convention on the Conservation of Migratory Species of Wild Animals.

JAMBA and CAMBA require the parties to protect migratory birds by:

- limiting circumstances under which migratory birds are taken or traded
- protecting and conserving important habitats
- exchanging information
- building cooperative relationships.

The ROKAMBA agreement provides a basis for collaboration on the protection of migratory shorebirds and their habitat.

10.2 Existing Environment

Surveys in the Christmas Creek area have recorded 120 vertebrate fauna species, including four frog species, 45 reptile species, 11 mammal species and 60 bird species.

Eight species of conservation significance are known to occur within the Development Envelope, including:

- *Liasis olivaceus barroni* (Pilbara Olive Python)
- *Ardeotis australis* (Australian Bustard)
- *Merops ornatus* (Rainbow Bee-eater)
- *Neochmia ruficauda subclarescens* (Western Star-Finch)
- *Burhinus grallarius* (Bush Stone-curlew)
- *Leggadina lakedownensis* (Short-tailed Mouse)
- *Falco hypoleucos* (Grey Falcon)
- *Haliaeetus leucogaster* (White-bellied Sea-Eagle).

Two potential SRE species; a spider and a millipede, are known to occur in the Christmas Creek area.

10.3 Surveys and Investigations

Surveys and monitoring of terrestrial fauna have been conducted in the Development Envelope since 2004. Table 46 lists the surveys and investigations undertaken at Christmas Creek. Recent studies of terrestrial fauna within the Development Envelope have included a Terrestrial Fauna and Fauna Habitat Assessment (ENV 2012a, Appendix 7A) undertaken in March 2011, a Targeted Fauna Survey undertaken in July-August 2011 (ENV 2012b), and a number of Short Range Endemic (SRE) invertebrate surveys undertaken in 2011 and 2012 (Subterranean Ecology 2012, Appendix 7B).

Table 46: Terrestrial Fauna Surveys and Investigations

Title of Survey	Reference	Field Work Timing
Terrestrial Fauna		
Fauna habitats and fauna assemblage of the proposed Fortescue Stage B rail corridor and Mindy Mindy, Christmas Creek, Mt Lewin and Mt Nicholas mine areas	Biota 2005	March & June–July 2004
Fortescue Metals Croup Christmas Creek terrestrial vertebrate fauna desktop assessment	Ecologia 2010	July–August 2010
Christmas Creek terrestrial vertebrate fauna and fauna habitat assessment	ENV 2012a, Appendix 7A	March 2011 July–August 2011
Assessment of potential fauna diggings, Christmas Creek	ENV 2012c	14, 15 December 2011
Targeted fauna survey of the Christmas Creek Life of Mine area	ENV 2012b	July–August 2011
Christmas Creek Water Management Scheme Conservation Significant Fauna baseline monitoring	Ecologia 2013, Appendix 7E	27 November 2012 and 12 June 2013.
Christmas Creek Water Management Scheme Northern Quoll Annual Monitoring Report 2014	Ecologia 2014a, Appendix 7F	10-16 June 2014
Christmas Creek Water Management Scheme Pilbara Olive Python Annual Monitoring Report 2014	Ecologia 2014b, Appendix 7G	January 2014
Short-range Endemic Fauna		
Christmas Creek short-range endemic invertebrate survey report: Fortescue Marsh Samphire	Biologic 2012, Appendix 7C	May 2012
Christmas Creek Life of Mine project terrestrial SRE invertebrate survey	Subterranean Ecology 2012, Appendix 7B	March–April 2011

The results of these surveys and investigations form the basis for the description of the terrestrial fauna factor described in the following section. Additional information specific to listed threatened fauna managed under the EPBC Act, is provided in Section 12.

Targeted fauna monitoring has also been undertaken, subsequent to the main terrestrial fauna surveys of 2011. The results of this targeted monitoring (Ecologia 2013, 2014a, 2014b, Appendices 7E-7G), has influenced the likelihood of occurrence of some terrestrial fauna species.

10.4 Description of Factor

10.4.1 Terrestrial Fauna Habitats

Four main habitat types were identified in the Christmas Creek fauna Survey Area by ENV (2012a, Appendix 7A). For consistency, the habitat types described in this survey were compared to habitat types identified from a previous survey conducted at Cloudbreak mine directly adjacent to the Christmas Creek Survey Area. The resulting habitat types outlined below are directly comparable to those identified in previous surveys. These are:

- Drainage Line and Alluvial Plain
- Marsh
- Low Hill
- Stony Plain.

Cleared or degraded areas were also recorded during the survey. Table 47 briefly describes these habitat types and their extent.

Table 47: Habitat Types and Extent in Survey Area

Habitat Type	Corresponding Land System	Description	Habitat Value	Area of Habitat in Survey Area (ha)
Drainage Line and Alluvial Plain	Calcrete, Cowra, Jamindie, Marsh, Turee, Warri	Creekline with fringing acacia and eucalypt	Moderate	8,673
Marsh	Cowra, Marsh	Low halophytic shrubland/samphire	High	18,406
Low Hill	McKay, Newman	Spinifex covered hills, rocky escarpment	Low	13,976
Stony Plain	Boolgeeda, Jamindie, Turee, Warri	Snakewood and Mulga woodland	Low	25,119

Source: ENV, 2012a

These habitats occur in three main bands running in an east-west direction through the Development Envelope (Figure 63). The Marsh habitat type is located south of the Development Envelope (i.e. Fortescue Marsh), moving northward into Stony Plain followed by Low Hill. Drainage Lines and Alluvial Plains run in a north-south direction towards the Fortescue Marsh.

Drainage Line and Alluvial Plain

Drainage Line and Alluvial Plain habitats are combined because they are closely associated and provide similar fauna habitat. The drainage lines intersect the Survey Area along a north to south direction due to water flowing into the Fortescue Marsh (ENV 2012a). The vegetation identified in this habitat type is described as Woodland of *Eucalyptus victrix, Eucalyptus camaldulensis* and *Acacia aneura* over *Acacia pruinocarpa* and *Acacia tetragonophylla* over *Triodia* and *Themeda* species. A small amount of cracking clay habitat has been recorded

within this habitat type (Biota 2005), and additional areas are likely to occur since cracking clays are known to occur in the Jamindie, Cowra, Marsh and Turee land systems associated with this habitat type.

A number of microhabitats exist in this particular habitat type, which includes tree hollows, logs, leaf litter, thick vegetation and soft soil suitable for burrowing (ENV 2012a). The Drainage Line and Alluvial Plain habitat is considered to provide an important corridor for fauna movement through the area, particularly for birds, bats, large mammals and wide-ranging reptiles. The presence of large, mature Eucalyptus trees may also provide a corridor for fauna movement through the area. This habitat type is considered to be of moderate fauna value (ENV 2012a).

Marsh

The Marsh habitat type consists of areas of permanent, semi-permanent and ephemeral water bodies surrounded by low halophytic shrubland consisting of mixed Chenopod species and Samphire (Ecologia 2010). After periods of heavy rainfall, the Fortescue Marsh becomes inundated providing suitable nesting habitat for thousands of waterbirds. As a result, the Fortescue Marsh is recognised as an important ecological area in the Pilbara, being classed as an ESA and a PEC (Ecologia 2010).

This Marsh habitat type contains a limited number of microhabitats due to absence of tree hollows and logs, and sparseness of the leaf litter and vegetation. However, the soft substrate is suitable for burrowing and digging animals, and an abundance of water provides episodic foraging opportunities to migratory shorebirds and resident waterbirds (ENV 2012a). More than 250,000 waterbirds have been estimated to occasionally occupy the Fortescue Marsh, which is considered to be of high habitat value (ENV 2012a). Areas of dense chenopod vegetation may provide suitable habitat for the Night Parrot (*Pezoporus occidentalis*), while areas consisting of sandy substrate located above the watertable may provide suitable burrowing habitat for the Greater Bilby (*Macrotis lagotis*) (Ecologia 2010). The Marsh habitat value is considered to be high.

Low Hill

The Low Hill habitat type is located to the north of the Survey Area. The habitat type consists of scattered eucalypts and acacias (*Eucalyptus leucophloia* and *Acacia pyrifolia*) over Hummock grassland of *Triodia basedowii* (Ecologia 2010, ENV 2012a). The ground is typically a red loam-clay and covered with a layer of small to medium sized pebbles (Ecologia 2010).

A small number of microhabitats are identified within this habitat type, including sparse leaf litter and vegetation. No tree hollows and very few logs are present. A number of breakaways and rocky outcrops are also present within this habitat type; however, these are small in number and contain only a few substantial caves and other important fauna microhabitats. This habitat is considered to be of low fauna habitat value (ENV 2012a).

Stony Plain

This habitat type consists of open to moderate Mulga (*Acacia aneura*) and other mixed Acacia species as low woodland over scattered Eremophila, Senna and mixed Acacia shrubs with an understory of Spinifex (Ecologia 2010). With the drainage lines and alluvial plains found intersecting this habitat type, a number of cracking clay habitats may occur since cracking clays are known to occur in Jamindie and Turee land systems associated with this habitat type (Biota 2005).

Within Mulga woodland, dead wood, tree stumps and peeling bark can provide microhabitats for small reptile species, while several bird species are also typically associated with Mulga woodlands (Ecologia 2010). There is limited microhabitat availability within this habitat type as the dominant Acacia species provides no tree hollows, few logs, minimal leaf litter and sparse vegetation. This habitat type is considered to be of low habitat value (ENV 2012a).

10.4.2 Vertebrate Fauna

A number of desktop studies have been undertaken to compile the overall faunal assemblage within the Survey Area. Ecologia (2010) utilised records from internal databases, DPaW Naturemap (DPaW 2014a), DPaW Threatened and Priority Fauna database, and DSEWPaC (now DoE) Protected Matters Database, as well as analysing results from previous surveys undertaken within 50 km of the Survey Area (Table 48).

Systematic sampling undertaken within the Survey Area between the 16 and 27 March 2011 (ENV 2012a) identified a total of 120 vertebrate fauna species; 11 mammals, 60 birds, 45 reptiles and four amphibians (ENV 2012a). All bird species identified had been previously listed as occurring in the vicinity of Christmas Creek. One amphibian (Douglas's Toadlet, *Pseudophyrne douglasi*), four reptiles (*Caimanops amphiboluroides, Diplodacttylus pulcher, Delma elegans* and *Lerista timida*) and one mammal (Pallid Long-eared Bat, *Nyctophilus daedalus*) were not returned by the database search and are considered to be new records for the Christmas Creek area (ENV 2012a).

Table 48: Summary of Previous Survey Results

Survey	Mammals: Native (introduced)	Birds	Reptiles	Amphibians
ENV (2012a)	11(2)	60	45	4
Ecologia internal database	24 (7)	122	77	2
Fortescue stage B rail corridor	16 (5)	101	42	2
Jimblebar to Yandi	1 (3)	52	16	0
Mining lease M270SA	1 (0)	6	3	0
NatureMap	18 (4)	98	71	0
Birdata	n/a	106	n/a	n/a
Cloudbreak	21 (8)	138	31	4
TOTAL	**34 (9)**	**165**	**99**	**6**

Source: Ecologia 2010 and ENV 2012a

Mammals

A total of 11 mammal species were identified during the survey undertaken by ENV (2012a). Two individual Planigale species were identified within the Low Hill habitat area, and a single House Mouse (*Mus musculus*) was captured within the Drainage Line and Alluvial Plain habitat type.

A total of eight bat species were identified through recordings of echolocation calls. All eight bat species were recorded within the Drainage Line and Alluvial Plain habitat type and included the Yellow-bellied Sheath-tailed Bat (*Saccolaimus flaviventrus*), Common Sheath-tailed Bat (*Taphozous georgianus*), Northern Freetailed-bat (*Chaerephon jobensis*), Lesser Long-eared Bat (*Nyctophilus geoffroii*), Pallid Long-eared Bat (*N. daedalus*), Gould's Wattled Bat (*Chalinolobus gouldii*), Finlayson's Cave Bat (*Vespadelus finlaysoni*) and Little Broad-nosed Bat (*Scotorepens greyii*). Four bat species were also recorded in the Low Hill habitat type, which included the Lesser Long-eared Bat, Little Broad-nosed Bat, Gould's Wattled Bat and Finlayson's Cave Bat.

Birds

Systematic surveys undertaken by ENV (2012a) identified total of 51 species. A further nine species of bird were recorded opportunistically in the Survey Area:

- Pacific Black-Duck (*Anas superciliosa*)
- Plumed Whistling Duck (*Dendrocygna eytoni*)
- Whistling Kite (*Haliastur sphenurus*)
- Black Kite (*Milvus migrans*)
- Eurasian Coot (*Fulica atra*)

- Black-fronted Dotterel (*Elseyornis melanops*)
- Banded Lapwing (*Vanella tricolor*)
- Variegated Fairy Wren (*Malurus lamberti*)
- Western Star Finch (*Neochmia ruficauda subclarescens*).

Results from this survey indicated bird species richness is greatest in the Drainage Line and Alluvial Plain, and Stony Plain habitat type. The survey results recorded 90% of the bird species expected, based on the species richness curve (ENV 2012a).

The most common birds located within the Survey Area are the Zebra Finch (*Taeniopygia guttata*) and the Budgerigar (*Melopsittacus undulatus*), accounting for 36% of the 972 individuals recorded in the Survey Area at Christmas Creek (ENV 2012a).

Reptiles

The survey undertaken by ENV (2012a) recorded a total of 43 species of reptile during the 2012 survey, consistent with the results from the Biota survey undertaken in 2005. The ENV (2012a) survey identified an additional two species opportunistically; *Ctenotus uber* and Pilbara Olive Python (*Liasis olivaceus barroni*). Species richness was greatest in the Low Hill habitat type.

Amphibians

Four species of frogs have been identified as occurring in the Survey Area (ENV 2012a):

- Main’s Frog (*Cyclorana mainii*)
- Red Tree Frog (*Litoria rubella*)
- Douglas’s Toadlet (*Pseudophryne douglasi*)
- Water-holding Frog (*Cyclorana platycephala*).

Amphibian species richness was greatest in the Drainage Line and Alluvial Plain habitat type, but fewer species occurred in the Low Hill and Stony Plain habitat types.

Vertebrate Species of Conservation Significance

Based on searches of databases and literature from within 50 km of the Survey Area, results from previous surveys and findings of current surveys have indicated there is a potential for 23 species of conservation significant vertebrate fauna to occur within the area (Table 49). Of the species with potential to occur, seven have been recorded (Figure 64).

Table 49: Presence of Conservation Significant Species

Species Name	Status		Habitat	Distribution	Ecology	Likelihood of Occurrence
	EPBC Act	State				
Northern Quoll (*Dasyurus hallucatus*)	Endangered	Schedule 1	This species occurs mainly in areas of open eucalypt woodland within 200 km of the coast. It favours rocky area, and utilises gullies and drainage lines. Potential shelter and denning habitat is restricted to high relief gorge terrain in the north-east of the Survey Area, located outside the Development Envelope.	The Northern Quoll occurs in five regional populations across Queensland, the Northern Territory and Western Australia both on the mainland and on offshore islands (DoE 2014).	Northern Quoll have a short life span (1 – 3 years). Breeding habits make this species highly vulnerable to extinction. Juveniles suffer high mortality once leaving the pouch. The species is an opportunistic omnivore, with a varied diet. Females occupy home ranges, with males appearing to a roving strategy to enable them to monitor the onset of oestrus (DoE 2014).	Drainage Line and Alluvial Plain habitat type may provide suitable foraging habitat for this species. Northern Quoll scats were recorded from Mt Nicholas, 65 km to the west of Christmas Creek (Biota 2005); individuals have not been recorded in the area since 1980. Likelihood of occurrence: **Unlikely**
Night Parrot (*Pezoporus occidentalis*)	Endangered	Schedule 1	Prefer hummock grasslands with Spinifex, from areas dominated by samphire. They have also been recorded in low chenopod scrublands with saltbush and bluebush. Potentially suitable habitat is located throughout Fortescue Marsh situated in the south of the Survey Area.	The distribution of the Night Parrot is very poorly understood, with a small number of confirmed records from arid and semi-arid regions of Queensland, South Australia, Western Australia and the Northern Territory (DoE 2014). There have also been a number of unverified reports from across Australia, including on recent unconfirmed sighting in Queensland.	The expected generation length of this species is 10 years. Loose nests are constructed at the end of a tunnel within Triodia tussock or small bush; or within a cave. Diet is expected to contain green herbage, grass seeds, roots and tubers (DoE 2014).	This species may be found near Spinifex hummocks and samphire in proximity to water. The only recent record of the Night Parrot in the area occurred in 2005 at Minga Well, approximately 60 km west of Christmas Creek. Likelihood of occurrence: **Possible**
Australian Painted Snipe (*Rostratula australis*)	Endangered, Migratory	Schedule 1	The Australian Painted Snipe generally inhabits shallow terrestrial freshwater or occasionally brackish wetlands, including ephemeral and permanent lakes, swamps and claypans. It is also known to use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains. Nesting generally occurs amongst tall vegetation.	The species has been recorded in freshwater (and less commonly in brackish) wetlands across Australia, although it is more common in the Eastern States.	Occasional records from remote places indicate that the species can move long distances and may be dispersive or migratory. It is generally thought to be crepuscular (active at dawn and dusk), but may be nocturnal. This species is usually observed singly or in pairs, or less often in small flocks, and feeds on vegetation, seeds, insects, worms, molluscs, crustaceans and other invertebrates.	This species is a wading bird, known from wetland areas around Australia. The nearest record of this species was recorded in 2012, from Coondiner Pool (30 km south of the Development Envelope). This species could potentially occur within the Fortescue Marsh. Likelihood of occurrence: **Possible**
Greater Bilby (*Macrotis lagotis*)	Vulnerable	Schedule 1	This species prefers sandy substrates for burrowing. Potentially suitable habitat occurs throughout the area (Drainage Line and Alluvial Plain, and Marsh habitat types).	Bilby populations are restricted predominantly to the Tanami Desert, Northern Territory, the Great Sandy and Gibson Deserts, Western Australia, and an outlying population between Boulia and Birdsville in south-west Queensland (DoE 2014).	The species is in general a solitary animal, nocturnal and can breed throughout the year. Females can commence breeding at six months, and life span in captivity is greater than five years. The Greater Bilby is an opportunistic omnivore with a diverse diet. The species is highly mobile, with large foraging ranges (DoE 2014).	There have been no recordings of this species occurring within the Christmas Creek and Fortescue Stage B rail corridor Survey Areas. Potentially suitable habitat is located throughout the Survey Area but results of targeted monitoring surveys indicate that the species is unlikely to occur. Likelihood of occurrence: **Unlikely**
Pilbara Olive Python (*Liasis olivaceus barroni*)	Vulnerable	Schedule 1	The Pilbara Olive Python prefers rocky habitats near water, particularly rock pools. Microhabitat preferences are often under rock piles, on top of rock or under Spinifex. Suitable habitat occurs throughout the area (Drainage Line and Alluvial Plain).	The species is restricted to ranges within the Pilbara Region, including the Hamersley Ranges and the islands of the Dampier Archipelago (DoE 2014).	The breeding season for this species occurs from June to August, with males roving long distances in search of females. Sheltered areas such as caves are utilised for breeding. The species are adept at swimming and utilising water holes to hunt (DoE 2014).	This species has been opportunistically recorded within the Survey Area, adjacent to a drainage line (ENV 2012a). Likelihood of occurrence: **Recorded**
Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* [Pilbara form])	Vulnerable	Schedule 1	Requires deep caves or abandoned mine shafts in which to roost. Foraging occurs in areas of open woodland.	The Pilbara form of the species is restricted to the Pilbara region and has been recorded from three discrete subpopulations: eastern Pilbara mines and granite, Hamersley Range, Upper Gascoyne (DoE 2014).	Females mature after about seven months, and males at about 16 months. Life expectancy is approximately 10 years. Feeding is expected to favour moths and beetles, with some utilisation of insects such as termites. Colony size and location appears to be linked to availability of water, and environmental conditions with some recorded permanent colonies (DoE 2014).	No records of this species occurring within the Survey Area. Suitable roosting habitat is not present within the Survey Area; and lack of evidence of the species during monitoring surveys indicates that it is unlikely to occur. Likelihood of occurrence: **Unlikely**
Fork-tailed Swift (*Apus pacificus*)	Migratory	Schedule 3	This species forages high above the tree canopy and is independent of terrestrial habitats.	The Fork-tailed Swift is found across all states and territories of Australia, and globally in Asia, New Zealand, the UK and North America.	The Fork-tailed Swift does not breed in Australia. The species has been recorded eating small bees, wasps, termites and moths. This species is an aerial eater, which feeds in flocks of 10 – 1000 birds (DoE 2014).	This species is expected to be found within the area at the start of the wet season. There are no previous records of this species occurring in the vicinity of the Development Envelope. Likelihood of occurrence: **Possible**
Cattle Egret (*Ardea ibis*, formerly known as *Bubulcus Ibis*)	Migratory	Schedule 3	The species inhabits short grass in damp pastures and wetlands, and is an infrequent visitor to Western Australia.	The Cattle Egret is found across all states and territories of Australia, and globally in Africa, Europe, Asia and North and South America.	Cattle Egret breeds in colonies, utilising artificial situations and urban areas as well as wooded swamps. The species requires the availability of food for nestlings at nest sites. Colonial breeding has been noted as a factor which inherently makes this species vulnerable, due to the relatively small number of satisfactory sites available (DoE 2014).	This species has not been recorded as occurring in the Survey Area; however, the Drainage Line and Alluvial Plain habitat type provides suitable habitat. Likelihood of occurrence: **Likely**

Species Name	Status		Habitat	Distribution	Ecology	Likelihood of Occurrence
	EPBC Act	State				
Eastern Great Egret (*Ardea modesta*)	Migratory	Schedule 3	Inhabits mostly shallow fresh lakes, pools in rivers, lagoons, lignum swamps, clay pans and samphire flats, large dams and sewage ponds. The Drainage Line and Alluvial Plain habitat type, as well as the Marsh habitat type, provide suitable habitat for this species within the Survey Area.	The Eastern Great Egret is found across all states and territories of Australia, and globally in Asia and New Zealand.	The breeding season for this species is variable (November – April), depending to some extent on rainfall. Nesting occurs in colonies. Diet and foraging behaviours are diverse. Pairs will defend a small nest territory within the colony. Threats to the species include loss or degradation of foraging and breeding habitat (DoE 2014).	Drainage Line and Alluvial Plain, including Marsh, habitat types provides suitable foraging and breeding habitat, only when surface water is present. Fortescue Marsh located to the south of the project area also provides suitable habitat for this species. This species was not recorded during ground-surveys but has been recorded in the Fortescue Marsh during aerial surveys (Bamford 2012a). Likelihood of occurrence: **Recorded**
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	Migratory	Schedule 3	Distributed along the coast. Nesting occurs on high ground such as rock pinnacles, rigid shrubs or tall trees.	The species is found along the coastline of mainland Australia and Tasmania, and globally across Asia.	This species first breeds at approximately six years. Life span is up to 30 years, with pairs breeding in solitary and monogamous pairs that mate for life. The species is an opportunistic feeder. Breeding adult birds are generally sedentary, with territories located close to bodies of water. Home ranges may be up to 100 km^2 (DoE 2014).	Drainage Line and Alluvial Plain, including Marsh habitat type, can contain surface water suitable for this species to forage. Recorded as occurring within the Fortescue Marsh area at Roy Hill Station (Bamford 2012a). Likelihood of occurrence: **Likely**
Oriental Plover (*Charadrius veredus*)	Migratory	Schedule 3	Found on sparsely vegetated plain including Spinifex and Samphire plains, as well as beaches and flats.	The species occurs across Australia, in coastal and inland areas, mostly in northern Australia, and globally across Asia.	The Oriental Plover does not breed in Australia, however the entire population is thought to winter in Australia from mid-September to March. The species diet is not well known, but includes insects such as termites, beetles, grasshoppers, crickets and bugs (DoE 2014).	There are no records of this species occurring in the area or adjacent areas. The Stony Plain and Low Hill habitat types contain large amounts of Spinifex that may provide suitable foraging habitat. Likelihood of occurrence: **Possible**
Wood Sandpiper (*Tringa glareola*)	Migratory	Schedule 3	This species primarily inhabits freshwater wetlands and inter-tidal mudflats that occur along the coast and inland regions of Western Australia.	The species occurs in scattered coastal areas around the mainland of Australia. Globally, it has been recorded in Asia, Europe and America.	The Wood Sandpiper does not breed in Australia. They are regular visitors at many sites, but also apparently dispersive and appear erratically in summer at storm pools inland (DoE 2014).	Both the Marsh and Drainage Line and Alluvial Plain habitat types contain freshwater wetlands, which are suitable habitat for this species. This species has been previously recorded in the Marsh habitat type within the area (Bamford 2012a). Likelihood of occurrence: **Likely**
Common Greenshank (*Tringa nebularia*)	Migratory	Schedule 3	Common along the coast of Western Australia, this species inhabits intertidal mudflats, as well as fresh and saltwater wetlands of the coast or inland.	The species occurs across Australia, mainly in coastal areas, and globally across Asia, Europe and Africa, as far north as the Arctic circle.	Birds overwinter in Australia (August – April), returning to the northern hemisphere to breed. The species utilise only a few sites. During non-breeding season, most birds within Australia do not seem to move long distances, although dispersive movements may sometimes occur (DoE 2014).	Both the Marsh and Drainage Line and Alluvial Plain habitat types contain freshwater wetlands, which are suitable habitat for this species. This species has been previously recorded in the Marsh habitat type within the area (Bamford 2012a). Likelihood of occurrence: **Likely**
Rainbow Bee-eater (*Merops ornatus*)	Migratory	Schedule 3	Occurs in lightly wooded, often sandy country, preferring areas near water. Nests in burrows excavated in sandy ground or banks. All habitat types within the Survey Area provide suitable foraging habitat. The drainage line and alluvial plain habitat type has soft substrates which are suitable for nesting sites	The species is found throughout mainland Australia, and globally across Asia.	The breeding season extends from August to January. The species feeds on insects, and occasionally other animals such as earthworms and tadpoles. Cane Toads are a known threat to this species, due to nests being located on the ground (DoE 2014).	This species was recorded in the Stony Plain habitat type, as well as the Drainage Line and Alluvial Plain habitat type, during the ENV survey (2012a) and during previous surveys. Likelihood of occurrence: **Recorded**
Peregrine Falcon (*Falco peregrinus*)	N/A	Schedule 4	The peregrine falcon prefers coastal cliffs, rivers and ranges, as well as wooded watercourses and lakes. Potentially suitable habitat is located throughout the Survey Area (Drainage Line and Alluvial Plain habitat type).	The Peregrine Falcon is found across Australia, though less frequently in desert regions. It is found worldwide, with the exception of New Zealand.	Feeding is almost entirely on other bird species, but includes rabbits, moderate sized mammals, bats and reptiles. The species is territorial during breeding (DoE 2014).	Individuals were recorded along the Fortescue Stage B rail corridor and at Christmas Creek during the 2004 Biota survey (Biota 2005). The survey undertaken by ENV (2012a) within the Survey Area did not record any individuals of this species. Likelihood of occurrence: **Recorded**
Blind snake (*Ramphotyphlops ganei*)	N/A	Priority 1	This species is likely to inhabit topsoil and ants nests. One member of this species was recorded in Hummock grassland on a scree slope in 2004.	This species is found in the Pilbara Region of WA.	Ecological information on this species is limited.	Not recorded during current surveys; potentially suitable habitat is found within the Low Hill habitat type located to the north of the Survey Area. Likelihood of occurrence: **Possible**

Species Name	Status		Habitat	Distribution	Ecology	Likelihood of Occurrence
	EPBC Act	State				
Bush Stonecurlew (*Burhinus grallarius*)	N/A	Priority 4	This species inhabits dry open woodlands with groundcover of small, sparse shrubs, grass or litter of twigs. The species also occurs within proximity to watercourses or swamps. Alluvial and Stony Plain habitat types, specifically those adjacent to drainage lines, are located throughout the Survey Area and are the preferred habitat for this species.	The Bush Stonecurlew is found across Australia, with the exception of Tasmania.	Avoids dense forest, and closed canopy habitats. The nest is a scrape on the ground, with camouflaged eggs lying on bare ground (Morcombe 2004).	This species was not recorded during the Biota survey (2005), nor was it recorded during ENV survey (2012a). This species has, however, been previously recorded within 40 km of the area (ENV 2012a). Potentially suitable habitat for this species occurs throughout the Survey Area. Likelihood of occurrence: **Likely**
Australia Bustard (*Ardeotis australis*)	N/A	Priority 4	This species prefers tussock grassland, arid scrub and dry, open woodland. The Stony Plain habitat type, located throughout the majority of the Survey Area, is ideal habitat for this species.	The Australian Bustard is found in the inland and tropical north of mainland Australia and in southern New Guinea.	This species is nomadic. The nest is a slight hollow on the ground, often on a slightly elevated site (Morcombe 2004).	There were 16 individuals recorded in the Fortescue Stage B rail corridor Survey Area during Biota survey (2005), while nine individuals were identified within the Survey Area during ENV survey (2012a). This species has also been recorded within 40 km of the area. Likelihood of occurrence: **Recorded**
Western Star Finch (*Neochmia ruficauda subclarescens*)	N/A	Priority 4	This species prefers grassland with sparse vegetation, and is likely to occur within proximity to permanent water bodies during the dry season. The Marsh habitat type, as well as the drainage lines and alluvial plain habitat type, provide suitable habitat for this species.	The species is found across northern parts of WA, Northern Territory and Queensland.	This species occurs in pairs or small flocks up to 20 or more birds (Morcombe 2004).	Individuals of this species have been recorded opportunistically within the Survey Area. Likelihood of occurrence: **Recorded**
Brush-tailed Mulgara (*Dasycercus blythi*) Note: *D. blythi* is now accepted as distinct from *D. cristicauda* (Vulnerable, Schedule 1), following a molecular study of the genus *Dasycercus* (Woolley 2005).	N/A	Priority 4	The Brush-tailed Mulgara appears to prefer Hummock grassland on sandplain, living in burrows in flats between sand dunes.	The Brush-tailed Mulgara is endemic to Australia, where it is widely distributed in arid regions of the central and western parts of the country. Records of Mulgara in Western Australia are generally accepted to be associated with *D. blythi*. As the separation of *D. blythi* and *D. cristicauda* has occurred relatively recently, the identity of museum specimens must be re-checked before the true range limits of both species can be determined (Woolley 2005; 2008).	It is generally a solitary species that hunts at night, although it is not strictly nocturnal (Woolley 2008). The species maintains complicated, extensive burrows with multiple entrances. Burrows are predominantly located on the eastern side of dunes, with latrines located near the entrance. Life span in the wild is likely to be 2- 3 years, with litters of up to eight recorded in August and September. The species is an opportunistic carnivore. It is thought that the species is probably sedentary (DoE 2014).	Evidence of the Mulgara was recorded as occurring towards the eastern end of the Fortescue Stage B rail corridor from the Biota survey (2005). No evidence of the Mulgara occurring within the Survey Area; however this species was recorded within 40 km of the Development Envelope. Likelihood of occurrence: **Possible**
Northern Short-tailed mouse (*Leggadina lakedownensis*)	N/A	Priority 4	This species occurs in a range of habitat types on seasonally inundated sandy-clay soils. In the Pilbara, the Short tailed Mouse prefers stony hummock grassland. The Stony Plain habitat type located throughout the Survey Area provides suitable habitat for this species.	This species is endemic to northern Australia, and is found from Cape York in the east to the Pilbara in WA.	The Northern Short-tailed Mouse is nocturnal, with a gestation of approximately 30 days. Populations apparently fluctuate dramatically (Strahan 1995).	Species recorded within the Survey Area (Biota 2005), and along the Fortescue Stage B rail corridor. Likelihood of occurrence: **Recorded**
Western Pebble-mound Mouse (*Pseudomys chapmani*)	N/A	Priority 4	Prefers gentle slope and spurs, where suitably sized pebbles are readily available. The Low Hill habitat type provides suitable habitat for this species.	This species is endemic to the non-coastal, central and eastern parts of the Pilbara.	Mounds of the Western Pebble-mound mouse cover areas of 0.5 – 9.0 m^2 and are lasting structures which may contain more than one nest (Strahan 1995).	A large number of potential mounds (both active and inactive) were recorded in the Survey Area during the ENV targeted survey (ENV 2012b). Likelihood of occurrence: **Likely**
Ghost Bat (*Macroderma gigas*)	N/A	Priority 4	This species prefers rock piles and abandoned mines and caves that are used as roosting sites.	This species is endemic to Australia, being found in WA, the Northern Territory and Queensland in separate colonies distributed across northern tropical and subtropical coastal and inland regions	The Ghost Bat is Australia's only carnivorous bat, with diet including large insects, frogs, lizards, birds, small mammals and other bats. Prey is often captured on the ground, and consumed at an established feeding site (rock overhang or small cave) (Strahan 1995).	The Ghost bat has not been recorded within the Survey Area. A potential roost cave was identified in 2009, but no individuals were recorded and that area has since been cleared for the development of the existing Eyre Pit. It is considered likely that part of the Stage B Railway corridor may be suitable foraging habitat for this species. Likelihood of occurrence: **Possible**
Grey Falcon (*Falco hypoleucos*)	N/A	Priority 4	The Grey Falcon nests in River Gum and Coolibah trees, and prefers lightly wooded coastal and riverine plains. Possible nesting habitat occurs along Drainage Line and Alluvial Plain habitat type.	This species is found over much of mainland Australia, generally across northern tropical and subtropical coastal and inland regions.	Grey Falcons use standing dead trees as lookout posts. Stick nests of other species are utilised. The species occurs solitary, in pairs, or in family groups of parents and offspring.	Has been previously recorded within the Survey Area, and within 40 km of the Development Envelope. Drainage Line and Alluvial Plain habitat type may provide suitable hunting habitat. Likelihood of occurrence: **Likely**

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10.4.3 Short Range Endemic Invertebrate Species

SRE species are invertebrate species with highly restricted distribution ranges, and are consequently endemic to relatively small or localised areas (Subterranean Ecology 2012, Appendix 7B).

A total of 26 species from six taxonomic groups (spiders, pseudoscorpions, scorpions, myriapods, isopods and snails) occur at Christmas Creek. These species were identified during the end of wet season survey of the Development Envelope in 2011 (Subterranean Ecology 2012).

DNA sequencing revealed the occurrence of two potential SRE species, the millipede *Antichiropus* sp. 'christmas' (Paradoxosomatidae), and the spider *Karaops* sp. 'christmas' (Selenopidae). The remaining taxa were not considered to be SRE species (Table 50). Figure 13 of Appendix 7B presents the locations of potential SRE species located within the Survey Area.

Table 50: Potential SRE Species Recorded Within and Adjacent to the Project Area

Species	Number Recorded	SRE Status	Habitat
Polydesmida: Paradoxosomatidae (*Antichiropus* sp. 'christmas')	8	Likely	Individuals were collected from the Drainage Line and Alluvial Plain habitat type, as well as along vegetation groves and rocky hills/gullies and gorges
Aranaeomorphae: Selenopidae (*Karaops* sp. 'christmas')	1	Potential	Found within the Drainage Line and Alluvial Plain habitat type, including vegetation groves.

No SRE species of conservation significance have been recorded from within the Development Envelope (Subterranean Ecology 2012). A search of the DPaW Threatened Fauna list found no listed terrestrial invertebrate species from within the Survey Area. A previous terrestrial fauna survey (Ecologia 2010) observed habitat for the following Priority 2 SRE invertebrate fauna species which may occur in the Development Envelope and the Fortescue Marsh:

- *Antipodogomphus hodgkini* (dragonfly)
- *Nososticta* Pilbara (dragonfly)
- *Dupucharopa millestriata* (snail).

The two dragonfly species, while potentially occurring in the Fortescue Marsh, are not expected to be restricted to the Survey Area (Subterranean Ecology 2012). The type locality for the snail (*D. millestriata*) is Depuch Island, and has not been recorded as occurring within the Fortescue Marsh (Subterranean Ecology 2012).

An additional survey was undertaken in May 2012 (Biologic 2012, Appendix 7C) which targeted samphire habitats within the Development Envelope and Fortescue Marsh. Six taxa were recorded in the Survey Area, none of which were considered to be SRE species. Four were

aquatic snails, which are not likely to be restricted to the Survey Area, and the other two species (land snail *Pupoides beltianus and* the isopod *Buddelundia* sp. Nov. 14) are both found outside both the Survey Area and Samphire habitat area.

10.5 Potential Impacts

Activities or aspects of the Proposal that have the potential to affect terrestrial fauna, not considering mitigation measures, include:

- clearing of habitat may reduce the capacity of the habitat to support fauna
- groundwater abstraction and injection will affect groundwater levels, which may indirectly affect groundwater-dependent vegetation (potential fauna habitats)
- alteration to surface water flows can affect downstream fauna habitats
- vehicle movements can cause mortality of fauna during construction and ongoing operations
- presence of artificial water bodies may attract native and non-native fauna resulting in drowning or reliance on artificial water sources.

10.6 Evaluation of Options or Alternatives to Avoid or Minimise Impact

Alternative locations to avoid or minimise impact are limited as the location of the mine is dictated by the location and extent of the resource. However, locations of linear infrastructure and waste landforms are flexible to some extent and avoidance of important fauna habitat is part of the mine planning process.

All proposed vegetation clearing and ground disturbance activities are required to undergo an internal review and approval (GDP) process prior to commencement of works. Under the permitting process, areas of vegetation that may contain areas of important fauna habitat may require on-ground surveys to inform a risk assessment.

The Proposal is based on an open-cut, strip mining methodology selected to reduce the size of the areas required for overburden storage, and consequently the extent of fauna habitat clearing required (see Section 4.4). This method also allows progressive rehabilitation, which aims to re-establish vegetation values (such as fauna habitat) on the final landform.

10.7 Assessment of Likely Direct and Indirect Impacts

10.7.1 Clearing of Habitat

Almost all native fauna species rely on native vegetation to provide food, shelter and breeding sites. Loss or degradation of native vegetation may reduce the capacity of the habitat to support

the range of species it could support in an undisturbed state. The fauna habitat types identified by previous surveys support a range of fauna species, including conservation significant species (ENV 2012a).

Vegetation will be progressively removed from sections of the Development Envelope during construction of mining infrastructure and during mining. Up to 7,752 ha of native vegetation (fauna habitat) will be disturbed within a Development Envelope of approximately 33,000 ha.

Table 51 outlines the extent of clearing or disturbance to each habitat type identified within the Development Envelope.

Table 51: Fauna Habitats Affected by Clearing

Habitat Type	Extent Within the Survey area (ha)	Cleared (existing mine)		Proposed Additional Clearing (ha)	Cumulative Impact (Christmas Creek)	
		ha	%		ha	%
Marsh	18,406	24	0.1	14	38	0.2
Drainage Line and Alluvial Plain	8,673	1,455	16.8	1,117	2,572	29.7
Stony Plain	26,119	5,039	19.3	4,366	9,405	36.0
Low Hill	13,976	3,507	25.1	2,255	5,763	41.2
Historical Cleared	110	110	100.0	0	110	100.0
TOTAL	**637,174**	**10,135**	**15.1**	**7,752**	**17,887**	**26.6**

The majority of disturbance of the Proposal will occur in the Stony Plain habitat type (4,366 ha), followed by the Low Hill habitat type (2,255 ha) and the Drainage Line and Alluvial Plain habitat type (1,117 ha). These habitat types occur extensively throughout the Pilbara region.

Mortality of small and sedentary fauna, such as the Pebble-mound Mouse and Northern Short-tailed Mouse may occur when the animal is unable to move out of the area prior to clearing. This could result in a local loss of individuals due to their limited ability to relocate to neighbouring areas of similar habitat. Clearing during the breeding season also has the potential to destroy nests, burrows and chicks of any species breeding within the Development Envelope. Conservation significant species likely to breed within the Development Envelope include Rainbow Bee-eater, Bush Stone-curlew, Australian Bustard and Peregrine Falcon.

Clearing of vegetation has the potential to result in fragmentation of habitats and lead to the inability of individuals to move between areas of habitat, as well as increase predation events as individuals move across cleared areas. Clearing within the mine footprint, including that already undertaken for the existing operations, has the potential to create a barrier for some species that typically move north-south through this area to access the food, water and habitat resources of the Fortescue Marsh. Fragmentation of habitat will be minimised through progressive rehabilitation, including re-establishment of major creek lines that may act as fauna corridors through the Development Envelope.

Conservation Significant Vertebrate Species

Table 52 summarises the assessment of impacts of the Proposal on vertebrate species of conservation significance. Of the 23 vertebrate species of conservation significance potentially occurring within the Development Envelope, none are considered likely to be significantly affected by clearing undertaken for the Proposal. No change to conservation status or regional distribution is expected to occur to any conservation significant vertebrate taxa as a result of the Proposal.

Table 52: Assessment of Impacts to Conservation Significant Species

Species	Likelihood of Occurrence	Habitat Use within the Development Envelope	Description of Impact	Outcome
Northern Quoll (*Dasyurus hallucatus*) [Endangered/ Schedule 1]	Unlikely	Approximately 74 ha of the Survey Area were considered to be potential habitat for Northern Quoll. Due to the limited availability of habitat, it is not expected that many, if any, Northern Quolls are resident within the Development Envelope. However, individuals, especially males, may occasionally move through the Development Envelope due to the presence of potential foraging habitat. Suitable denning habitat is characterised by rocky escarpments.	No critical breeding/denning habitat will be impacted by the Proposal. A total of 2,255 ha of potential foraging habitat may be impacted by the Proposal out of approximately 13,976 ha of Low Hill habitat type identified in the Survey Area (Figure 63). Fortescue commits to avoiding any clearing within the rocky escarpment habitat to avoid direct disturbance of denning habitat.	• 16% of foraging habitat within Low Hills disturbed in Survey Area • no impact to breeding/ denning habitat.
Night Parrot (*Pezoporus occidentalis*) [Endangered/ Schedule 1]	Possible	Based on the predicted preferred habitat of this species within the Development Envelope, the hummock grasslands with Spinifex from areas dominated by Samphire located in the Fortescue Marsh provide potentially suitable habitat for this species. Spinifex communities are widely distributed throughout the Pilbara, and Samphire shrublands are also represented extensively in the area within and on the fringe of the Fortescue Marsh.	Consequently, if the Night Parrot is present in the area, it will not be directly affected by the small amount of habitat clearing. This level of habitat clearing is not expected to cause fragmentation or significant edge effects.	• 16% of foraging habitat within Low Hills disturbed in Survey Area • <0.1% of potential Marsh foraging habitat in the Survey Area disturbed.
Australian Painted Snipe (*Rostratula australis*) [Endangered/ Migratory/ Schedule 1]	Possible	The nearest record of this species was recorded in 2012, from Coondiner Pool (30 km south of the Development Envelope). This species could potentially occur within the Fortescue Marsh.	Most of the potentially suitable habitat in the local area is located outside the area proposed to be disturbed. Similar habitat is well represented outside of the Development Envelope. No regional impacts are anticipated.	• <0.1% of potential Marsh habitat in the Survey Area disturbed.
Greater Bilby (*Macrotis lagotis*) [Vulnerable/ Schedule 1]	Unlikely	The Survey Area contains approximately 18,406 ha of potential habitat for the Greater Bilby. Suitable habitat of the Development Envelope is not generally considered to be ideal.	Most of the suitable habitat is located outside the area proposed to be disturbed, and only less favourable habitat will be disturbed. Similar habitat is well represented outside of the Development Envelope. No regional impacts are anticipated.	• <0.1% of potential Marsh habitat in the Survey Area disturbed.

Species	Likelihood of Occurrence	Habitat Use within the Development Envelope	Description of Impact	Outcome
Pilbara Olive Python (*Liasis olivaceus barroni*) [Vulnerable/ Schedule 1]	**Recorded**	One individual was recorded as occurring within the Development Envelope adjacent to the Drainage Line and Alluvial Plain habitat type; however, it was noted that this is not the typical rocky habitat preferred by this species, and it was thought to be observed dispersing or travelling through the area (ENV 2012a). This species may traverse the area to gain access to habitat sites that are known to occur outside the Development Envelope.	The probability of this species occurring in the Development Envelope is low due to the lack of preferred habitat. This species is not expected to be significantly affected by the Proposal.	• 13% of potential foraging habitat within Drainage Line and Alluvial Plains in the Survey Area disturbed.
Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) [Vulnerable/ Schedule 1]	**Unlikely**	The Pilbara Leaf-nosed Bat was not recorded during any of the surveys undertaken within the Development Envelope. This species is considered unlikely to roost within the area due to a lack of suitable habitat such as warm and humid caves. This species may use drainage lines and alluvial plains habitat for foraging. Roosting habitat is the key limiting resource for this species.	As suitable roosting habitat has not been identified in the Survey Area, it is unlikely that the clearing associated with the Proposal will significantly impact this species.	• 13% of potential foraging habitat within Drainage Line and Alluvial Plains in the Survey Area disturbed.
Fork-tailed Swift (*Apus pacificus*) [Migratory/ Schedule 3]	**Possible**	The Fork-tailed Swift is a non-breeding visitor to Australia that breeds exclusively in Mongolia (DoE 2013c). Although this species was not recorded during surveys of the Development Envelope, it was abundant during surveys of the Fortescue Stage B Rail Corridor that services Christmas Creek and Cloudbreak mine (Biota 2005).	The species is almost entirely aerial and will not be affected by the activities of the Proposal.	• No expected impact to this species.
Cattle Egret (*Ardea ibis*) [Migratory/ Schedule 3]	**Likely**	The Cattle Egret is widespread and common in Australia and its breeding sites in Australia are known to occur predominantly on the east coast (DoE 2014). While no records exist of the Cattle Egret occurring in the Development Envelope, it is possible that the species occurs in the vicinity.	Similar habitat is well represented outside of the Development Envelope. No regional impacts are anticipated.	• No expected impact to this species.
Eastern Great Egret (*Ardea modesta*)	**Likely**	The Eastern Great Egret may breed in the Fortescue Marsh. However, it is considered that the area is likely to be minor breeding sites with the largest breeding colonies, and greatest concentration of breeding	A total of 8,673 ha of Drainage Line and Alluvial Plain habitat type is located within the Survey Area. Of this, approximately 1,117 ha are likely to be directly disturbed as a result of the Proposal.	• 13% of potential foraging habitat within Drainage Line and Alluvial Plains in the Survey Area disturbed.

Species	Likelihood of Occurrence	Habitat Use within the Development Envelope	Description of Impact	Outcome
[Migratory/ Schedule 3]		colonies located in near coastal regions of the Northern Territory (DoE 2014). This species may also use the creek line habitat, although the creek lines only provide habitat when inundated.	Given the ephemeral nature of the creeks and the lack of clearing impacts to the Fortescue Marsh habitat, this species is unlikely to be affected by the Proposal.	• <0.1% of potential Marsh habitat in the Survey Area disturbed.
Oriental Plover (*Charadrius veredus*) [Migratory/ Schedule 3]	Possible	The Oriental Plover is a non-breeding visitor to Australia that commonly occurs in coastal and inland areas in northern Australia. Most records of the species are from the northwest coast of Western Australia (DoE 2014). While no records exist of this species occurring at the Development Envelope, it is possible that it occurs in the area.	Given that this species does not breed in Australia and noting its widespread distribution, it is unlikely to be affected by the Proposal.	• No expected impact to this species.
White-bellied Sea-Eagle (*Haliaeetus leucogaster*) [Migratory/ Schedule 3]	Likely	Suitable habitat (containing freshwater wetlands) includes both the Marsh and Drainage Line and Alluvial Plain habitat types. The Marsh is likely to be more important habitat than the creek lines. Broad scale Fortescue Marsh flooding may persist for three to six months (DoE 2014), but creek lines are unlikely to hold water for extended periods.	Similar habitat is well represented outside of the Development Envelope. No regional impacts are anticipated.	• <0.1% of potential Marsh habitat in the Survey Area disturbed.
Rainbow Bee-eater (*Merops ornatus*) [Migratory/ Schedule 3]	Recorded	The Rainbow Bee-eater is represented in a wide range of habitats across Australia (DoE 2014), including the Development Envelope. This species breeds throughout most of its range and is thought to adapt well to disturbance (DoE 2014). Recorded within both the Stony Plain and Drainage Line and Alluvial Plain habitat types during the ENV (2012a) survey.	Similar habitat is well represented outside of the Development Envelope. No regional impacts are anticipated. Clearing during the breeding season has the potential to destroy nests and chicks of this species.	• 17% of potential habitat within Stony Plains in the Survey Area disturbed. • 13% of potential foraging habitat within Drainage Line and Alluvial Plains in the Survey Area disturbed.
Wood Sandpiper (*Tringa glareola*) [Migratory/ Schedule 3]	Likely	Suitable habitat (containing freshwater wetlands) includes both the Marsh and Drainage Line and Alluvial Plain habitat types. The Marsh is likely to be more important habitat than the creek lines. Broad scale Fortescue Marsh flooding may persist for three to six months (DoE 2014), but creek lines are unlikely to hold water for extended periods.	Similar habitat is well represented outside of the Development Envelope. No regional impacts are anticipated.	• <0.1% of potential Marsh habitat in the Survey Area disturbed. • 13% of potential foraging habitat within Drainage Line and

Species	Likelihood of Occurrence	Habitat Use within the Development Envelope	Description of Impact	Outcome
				Alluvial Plains in the Survey Area disturbed.
Common Greenshank (*Tringa nebularia*) [Migratory/ Schedule 3]	Likely	Suitable habitat (containing freshwater wetlands) includes both the Marsh and Drainage Line and Alluvial Plain habitat types. The Marsh is likely to be more important habitat than the creek lines. Broad scale Fortescue Marsh flooding may persist for three to six months (DoE 2014), but creek lines are unlikely to hold water for extended periods.	Similar habitat is well represented outside of the Development Envelope. No regional impacts are anticipated.	• <0.1% of potential Marsh habitat in the Survey Area disturbed. • 13% of potential foraging habitat within Drainage Line and Alluvial Plains in the Survey Area disturbed.
Peregrine Falcon (*Falco peregrinus*) [Schedule 4]	Likely	The Peregrine Falcon is a wide ranging, nomadic bird that has high dispersal abilities, and is unlikely to rely on particular habitats within the Survey Area (ENV 2012a).	No impact to critical habitat.	• No expected impact to this species.
Blind Snake (*Ramphotyphlops ganei*) [Priority 1]	Possible	The ecology and habitat requirements of this species are poorly known, but it is considered endemic to the Pilbara. There have been no records of this species occurring within the Development Envelope (ENV 2012a). It is considered that potentially suitable habitat for this species is located in the Low Hill habitat type.	Approximately 2,255 ha of the Low Hill habitat type will be directly disturbed as a result of the Proposal out of approximately 13,976 identified in the Survey Area. This is not expected to cause significant impacts on populations of this species.	• 16% of foraging habitat within Low Hills disturbed in Survey Area
Bush Stone Curlew (*Burhinus grallarius*) [Priority 4]	Likely	The Bush Stone Curlew was identified at Minga Well by Bamford (2010). It has not been recorded as occurring within the Survey Area. The Drainage Line and Alluvial Plain habitat type is considered to be the preferred habitat for this species within the Survey Area.	The Bush Stone Curlew is a wide ranging, nomadic bird that has high dispersal abilities, and is unlikely to rely on particular habitats within the Survey Area (ENV 2012a).	• 13% of potential foraging habitat within Drainage Line and Alluvial Plains in the Survey Area disturbed.
Australian Bustard (*Ardeotis australis*) [Priority 4]	Recorded	Nine individuals of this species were recorded as occurring within the Survey Area, particularly in the Drainage Line and Alluvial Plain habitat type and Stony Plain habitat type (ENV 2012a). The Australian Bustard is a highly mobile species, utilising very large home ranges of up to 10,000 km^2.	Any disturbance to potentially suitable habitat in the Survey Area is unlikely to impact on this species significantly in the local or regional setting (ENV 2012a).	• 17% of potential habitat within Stony Plains in the Survey Area disturbed. • 13% of potential foraging habitat within Drainage Line and

Species	Likelihood of Occurrence	Habitat Use within the Development Envelope	Description of Impact	Outcome
				Alluvial Plains in the Survey Area disturbed.
Western Star Finch (*Neochmia ruficauda subclarescens*) [Priority 4]	Recorded	The Western Star Finch is confined to the Pilbara region and typically inhabits areas of permanent water, such as the Fortescue Marsh, which it uses for drinking and breeding (ENV 2012a). This species was recorded as occurring in the Drainage Line and Alluvial Plain habitat type during the ENV (2012a) survey.	The Western Star Finch is a highly mobile species and, as such, it is considered that any disturbance to potentially suitable habitat within the Development Envelope is unlikely to significantly affect this species on a regional scale.	• 13% of potential foraging habitat within Drainage Line and Alluvial Plains in the Survey Area disturbed.
Mulgara (*Dasycercus blythi*) [Priority 4]	Possible	It is considered that this species may occur within the Survey Area, though the lack of confirmed records makes it difficult to judge the likelihood of occurrence.	The potential habitat areas for Mulgara are predominantly outside the Development Envelope, with only approximately 14 ha likely to be affected. Marsh habitat may be potential foraging habitat. Fragmentation and edge effects will be small, as the clearing will not be extensive nor will it divide significant areas of habitat. As such, habitat loss, fragmentation and edge effects are unlikely to be a factor for this species.	• <0.1% of potential Marsh habitat in the Survey Area disturbed.
Northern Short-tailed Mouse (*Leggadina lakedownensis*) [Priority 4]	Recorded	The Northern Short-tailed Mouse occupies spinifex and tussock grasslands, samphire, acacia shrublands and stony ranges, and most habitats that are seasonally inundated (Ecologia 2010). Several individuals were captured during the Fortescue Stage B rail corridor fauna survey (Biota 2005) from tussock grasslands on cracking clay, along drainage lines and within Mulga groves, consistent with the Stony Plain and Drainage Line and Alluvial Plain habitat types. Subsequent surveys have not recorded this species as occurring within the Survey Area.	It is expected that there will be localised impacts to the Northern Short-tailed Mouse from the Proposal as they are a resident species with small home ranges and have poor dispersal abilities (ENV 2012a). However, this species is found broadly across the Pilbara and, therefore, it is considered that loss of local habitat is unlikely to impact their overall conservation status.	• 17% of potential habitat within Stony Plains in the Survey Area disturbed. • 13% of potential foraging habitat within Drainage Line and Alluvial Plains in the Survey Area disturbed.
Western Pebble Mouse (*Pseudomys chapmani*) [Priority 4]	Likely	Potential suitable habitat for this species can be found throughout the Low Hill habitat type. Western Pebble Mouse active and inactive mounds have been identified in proximity to the Survey Area during the Biota (2005) survey, while a number of active and inactive mounds were identified as occurring	Given the widespread distribution of this species in the Pilbara, and that disturbance associated with mining is mostly restricted to the Stony Plain habitat type, it is expected that clearing of habitat as a result of mining will not impact on the species locally or regionally (ENV 2012a).	• 16% of foraging habitat within Low Hills disturbed in Survey Area.

Species	Likelihood of Occurrence	Habitat Use within the Development Envelope	Description of Impact	Outcome
		within the Survey Area (ENV 2012c). No individuals have been recorded within the Survey Area.		
Ghost Bat (*Macroderma gigas*) [Priority 4]	**Likely**	The Ghost Bat has a widespread distribution across northern Australia. A single individual was trapped in November 2007 near the Fortescue Marsh, outside the Survey Area (Bamford 2007b). No other individuals have been recorded as occurring in the Survey Area. It is unlikely that any roosting sites occur within the Development Envelope.	Disturbance to potential foraging habitat may occur through vegetation clearing; however, it is anticipated that individuals will be able to locate new foraging grounds in the surrounding areas. No regional impacts to this species are expected.	• 13% of potential foraging habitat within Drainage Line and Alluvial Plains in the Survey Area disturbed.
Grey Falcon (*Falco hypoleucos*) [Priority 4]	**Likely**	The Grey Falcon has been recorded as occurring in the Cloudbreak area, adjacent to Christmas Creek (Bamford 2010). This species is generally regarded as a rare bird in Australia, being strongly transient in nature. The Grey Falcon nests in River Gum and Coolibah trees and feeds mostly on birds (ENV 2012a). Potential nesting habitat occurs in large trees located within the Drainage Line and Alluvial Plain habitat type.	Similar habitat is well represented outside of the Development Envelope. No regional impacts are anticipated. Clearing during the breeding season has the potential to destroy nests and chicks of this species.	• 13% of potential nesting habitat within Drainage Line and Alluvial Plains in the Survey Area disturbed.

Short Range Endemic Invertebrate Species

None of the key habitat types surveyed and in which potential SRE species were observed are unique or restricted to the Survey Area. All habitats described in the Development Envelope are very well distributed in the surrounding area, reducing the likelihood of SRE species being confined to the Development Envelope.

The potential SRE spider *Karaops* sp. 'Christmas' is generally considered to be specialist inhabitants of cracks and crevices in rocky outcrops, or under the bark of trees (Subterranean Ecology 2012). The specimen was collected from an isolated patch from the Boolgeeda land system from within the Survey Area, consistent with the Stony Plain habitat type. This particular species is also known to occur at Bonney Downs Station, outside the Survey Area (Subterranean Ecology 2012). Approximately 4,366 ha of Stony Plain habitat type will be disturbed as a result of the Proposal, which makes up approximately 16% of the mapped extent within the Survey Area. The abundance and distribution of this species is not expected to be affected by the Proposal as a result.

The potential SRE millipede *Antichiropus* sp. 'Christmas' was collected from a number of differing habitat types, including Drainage Lines and Alluvial Plains and Stony Plains (Subterranean Ecology 2012). The frequency at which this species was detected during the survey was high, possibly as a result of suitable environmental conditions including high rainfall before and during the survey. This species has not been recorded outside the Survey Area to date; however, this species could occur in similar habitats in the wider local area (Subterranean Ecology 2012). Given that this species has been identified across two different habitat types, and approximately 14 ha of Drainage Line and Alluvial Plain habitat type and 16% of Stony Plain habitat type will be directly disturbed as a result of the Proposal, impacts to this species are not likely to be significant.

10.7.2 Groundwater Abstraction and Injection

Dewatering and injection activities can result in groundwater drawdown and mounding across the Development Envelope. This can affect native fauna through the resultant effects on vegetation. Groundwater drawdown can lead to impacts on phreatophytic vegetation that relies on constant access to groundwater to survive, as well as to carry out processes such as flowering and setting seed. In contrast, groundwater mounding may result in bringing the watertable into the root zone of intolerant plants, such as Mulga, with consequent effects on vegetation health. Impacts to vegetation from groundwater drawdown and mounding are discussed in detail in Section 9.7.2.

Results of the numerical modelling indicate that the only sensitive vegetation anticipated to be impacted by groundwater abstraction is a small portion of the Drainage Line and Alluvial Plain habitat type in the south-eastern part of the Survey Area (Section 7.6.2 and 9.7.2). The value of this habitat type is considered to be Moderate (ENV 2012a) and the area to be indirectly impacted totals approximately 1.1 ha and corresponds to creekline GDE vegetation (VT01).

This area occurs just outside the southern boundary of the Development Envelope (refer Figure 60 and Figure 62). As such, groundwater abstraction is not expected to have a significant impact on SRE fauna or fauna habitat.

Injection of water will be managed in order to assist in mitigating impacts from groundwater drawdown, with the result that no significant mounding is expected as a result of injection.

10.7.3 Alteration of Surface Water Flows

As discussed in Section 7.6.1, physical infrastructure such as mine pits, waste landforms and linear infrastructure can affect surface water flows by potentially diverting upstream flows and capturing rainfall within mining areas, reducing the catchment area for downstream flows. This can result in areas of shadowing that receive less flow than previously because surface flow processes have been interrupted or diverted. Shadowing can affect both channel flow and sheet flow processes.

The Stony Plain habitat type is the only habitat type likely to be directly and indirectly affected by altered surface water regimes, as the Mulga communities within this habitat type rely on sheet flow (ENV 2013a).

10.7.4 Vehicle Movements

Preparation of the site and the passage of vehicles on haul roads and access tracks have the potential to result in the fatality or injury of individuals.

Speed limits and restrictions on driving off-road will continue to be implemented on site, which minimises the likelihood of fauna strikes. Signage is in place across the site to warn drivers of the potential for fauna to occur on roads. Isolated deaths of individuals are not expected to affect the conservation status and distribution of any fauna species. Any incidents involving conservation significant fauna will be reported to the appropriate State or Federal Regulator in accordance with the legislative requirement.

10.7.5 Presence of Artificial Water Bodies

Artificial water bodies form part of the current operations for the Christmas Creek mine, and additional water bodies may be required for the Proposal. The types of artificial water bodies likely to be included in the Proposal comprise:

- storage, transfer and settling ponds associated with the water management scheme (includes saline and brackish ponds)
- smaller ponds and containment structures such as bunded areas and sumps, used for managing surface water and/or treating runoff from areas which may be subject to contamination (i.e. workshops, fuel facilities)

- temporary water bodies formed by supernatant water ponding on active TSFs
- turkeys nest ponds for storage of process water.

Artificial water bodies may attract native fauna, creating risks of altering fauna behaviour, entrapment, or poisoning of animals if water quality is not suitable for consumption. They may also attract and increase introduced fauna numbers, which in turn can increase predation of native fauna species.

Additional artificial water bodies can have a number of impacts upon fauna:

1. They can support additional livestock and introduced fauna that rely on the artificial water bodies for drinking.
2. They can support additional native fauna that rely on the artificial water bodies for drinking. For example, kangaroos can increase in abundance and this can increase grazing pressure in surrounding areas. Artificial water bodies can also support many bird species that would otherwise be uncommon or absent during dry periods. When in flood, the Fortescue Marsh attracts large numbers of waterbirds that are unlikely to be attracted to small artificial water bodies. However, as the Fortescue Marsh dries out, waterbirds may be attracted to small water bodies rather than dispersing. The artificial water bodies can also be viewed as providing a refuge for waterbirds as the natural wetland dries out. Such interference with natural dispersal is not expected to be significant given the usually small numbers of waterbirds involved, but could be a consideration if large areas of habitat were created.
3. They can attract waterbirds and other wildlife that subsequently die. Artificial water bodies may be perceived as habitat by waterbirds, with the waterbirds being poisoned if the water is toxic. As all larger artificial water bodies associated with the Proposal are related to groundwater storage, they are likely to be saline and non-toxic. Smaller ponds are related to surface water management and may contain low levels of hydrocarbons; however, they are unlikely to be used by waterbirds because of their small size.

As there are already artificial water bodies in the area, some of these impacts may already be occurring. The provision of additional artificial water bodies could be expected to increase these impacts. The nature of those impacts depends very much on the nature of the artificial water bodies. Tailings storage is proposed to be undertaken in completed mine pits which have no surrounding habitat value while in use and, therefore, have limited access to most fauna. The water storage ponds are contained without surrounding wetland vegetation.

To minimise the potential impacts of artificial water bodies on fauna, Fortescue will undertake management measures, as follows:

- use of fencing to exclude livestock and larger introduced and native mammals from all artificial water bodies created by Fortescue
- inclusion of egress points in the water storage facilities to ensure that any fauna that do enter the water body can escape

- use of high level switches or other mechanisms to prevent overflow of artificial water bodies in dry conditions
- removal of artificial water bodies once no longer required.

In most cases, the aim of the listed measures is to reduce accessibility or attractiveness of the artificial water body to fauna, with a focus on fauna where there is likely to be a conservation issue. With the above management measures in place, the presence of additional artificial water bodies in the Development Envelope is not expected to have a significant impact on fauna.

10.8 Cumulative Impacts

The main potential cumulative impact is the combined effect of clearing of Stony Plain (Mulga) habitat from Cloudbreak, Christmas Creek Mine and Roy Hill Mine. Cumulative impacts to Mulga are discussed in more detail in Section 9.8. Cumulative impacts to Drainage Line and Alluvial Plain habitat (which may include groundwater-dependent vegetation) and Marsh habitat (Samphire) are also discussed in Section 9.8. Generally, all habitat types that will be affected by the Proposal occur in other project areas and will have some cumulative impact to the local representation of these habitat types. However, all of these habitats occur in the wider region and cumulative impacts are not expected to have significant impacts on the distribution and abundance of fauna species.

10.9 Management Measures and Performance Standards

10.9.1 Management of Ground Disturbance

A procedure of internal review and approval of all proposed vegetation clearing and ground disturbance activities is required prior to the commencement of works (a GDP). Areas of higher conservation value will be avoided where possible.

10.9.2 Adaptive Management of Groundwater

Impacts to significant fauna habitat such as Mulga and the Fortescue Marsh from groundwater drawdown will be managed using the CCWMS; an adaptive management framework. This approach is discussed in more detail in Section 7.8.

10.9.3 Environmental Management Plans

Impacts to terrestrial fauna will be managed using the *Conservation Significant Fauna Management Plan* (100-PL-EN-0022) (Fortescue 2013c; Appendix 2H).

Key management objectives include the following:

- undertaking clearing in stages and along one front to allow fauna to vacate the area, and large mature habitat trees will be retained, where possible
- undertaking progressive rehabilitation
- providing opportunity for native animals encountered on site to move on if there is no threat to safety of personnel
- restricting vehicles, machinery and personnel to designated areas and tracks
- disposing of food scraps and other waste in covered waste facilities to ensure introduced or other animals are not attracted to the site
- recording all incidents involving fauna and reporting to site environmental staff
- capping all exploration drill holes on completion of drilling program
- inducting all staff on fauna management procedures prior to mobilising to site, and training appropriate site representatives in snake handling techniques and providing equipment to safely handle snakes
- providing updated information regarding fauna management to personnel during operations by way of toolbox meetings, site HSE meetings, training and awareness sessions and visual displays in prominent on-site locations.

10.10 Predicted Environmental Outcomes

After application of mitigation measures as described, the Proposal is expected to result in the following outcomes in relation to terrestrial fauna:

1. Approximately 7,752 ha of fauna habitat will be disturbed by the Proposal with the majority of this occurring in the Low Hill habitat type.
2. There will be some loss of Stony Plain, Low Hill, Drainage Line and Alluvial Plain habitat but very little disturbance within the Marsh habitat.
3. There will likely be some localised impacts to fauna species due to clearing activities. However, the Proposal is not expected to significantly affect regional abundance or range of any conservation significant taxa.
4. Significant regional impact to fauna is not expected as all the habitats that occur within the Development Envelope also occur extensively outside the Development Envelope.
5. The Proposal itself will not conflict with the WC Act, as no fauna species will cease to exist or have its conservation status affected as a result of the implementation of the Proposal.
6. Significant regional impact to SRE species is not expected to occur as a result of the Proposal:
    - three Priority 2 SRE species may occur in the Fortescue Marsh, but this habitat is unlikely to be impacted by the Proposal

- three potential SRE species recorded within the Development Envelope are likely to occur in the wider region, based on the wide distribution of the preferred habitat types (Drainage Line and Alluvial Plain).

7. The Proposal is not expected to result in significant impacts to species listed as Endangered or Vulnerable under either the WC Act or EPBC Act (Section 12).
8. Annual surveys will continue to determine the presence/absence of the Night Parrot in the vicinity of the Proposal, potentially adding to the body of knowledge available on this rare species.

As demonstrated, the Proposal will not result in a change in the status of fauna of conservation significance; will not represent a significant clearing of habitat types; and will not significantly affect the regional distribution of fauna species. Geographical distribution, productivity, and ecosystems will be maintained through management and mitigation measures. Where residual impacts are expected to occur, offset measures will be implemented as discussed in Section 14.

In considering the outcome as described, the Proposal is expected to meet the EPA objectives for terrestrial fauna.

11. SUBTERRANEAN FAUNA

11.1 Relevant Environmental Objectives, Legislation, Policies and Guidelines

11.1.1 EPA Objective

The EPA applies the following objectives to the assessment of proposals that may affect subterranean fauna:

> *To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.*

11.1.2 Regulatory Framework

As described in detail in Section 10.1.2, the protection of fauna, including subterranean fauna, is covered by the following statutes:

- WC Act
- EP Act
- EPBC Act.

Guidance and Position Statements

The following EPA position and guidance statements set the framework for identification and assessment of impacts to subterranean fauna:

- EPA Environmental Assessment Guideline No. 12 *Consideration of subterranean fauna in environmental impact assessment in WA* (EPA 2013b) provides guidance on consideration of subterranean fauna in environmental impact assessment in Western Australia.
- EPA Guidance Statement 54a *Sampling methods and survey considerations for subterranean fauna in Western Australia* (EPA 2007) provides detailed guidance on sampling methods and survey considerations for subterranean fauna.

11.2 Existing Environment

Subterranean fauna are fauna that inhabit underground environments. They are predominantly invertebrates and are divided into two broad categories; stygofauna and troglofauna.

11.2.1 Stygofauna

Stygofauna are obligate (constrained) groundwater dwellers that spend their entire life cycle below ground, sometimes occurring very close to the surface. Typical groundwater habitats include large caves, mesocaverns in karst and basalts, and the interstitial spaces of alluvial aquifers. Some species of stygofauna have extremely localised patterns of distribution, and this has been linked to a lack of connectivity between aquifers (Watts & Humphreys 2006). The most common stygofauna are crustaceans.

Surveying for stygofauna began in the Pilbara in the 1990s (Humphreys 1999) and has rapidly increased over the last decade following the systematic stygofauna sampling during the Pilbara Biodiversity Survey (Eberhard *et. al*. 2009, Halse *et. al*. 2014).

11.2.2 Troglofauna

Troglofauna are obligate underground terrestrial fauna historically known from cave systems and karst environments; however, they may occur in other fractured and cavernous geology types. Some troglofauna species have restricted distribution ranges due to long periods of isolation and a lack of connectivity between populations. As a result, short-range endemism is common in this type of fauna. Common examples of troglofauna include spiders, scorpions and millipedes.

At the time of initial assessments conducted for Christmas Creek and Cloudbreak, troglofauna were relatively unknown in Western Australia outside of caves, and they were not expected to occur within Fortescue Valley. However, troglofauna have since been found to be widespread in vuggy and fractured rock habitats of the Pilbara, especially pisolite and banded iron, as well as in calcrete and alluvium. Consequently, there has recently been more emphasis on consideration of troglofauna in environmental impact assessment in the Pilbara (Bennelongia 2014).

11.3 Surveys and Investigations

Many subterranean fauna species are considered to be short range endemics as they have naturally small distributions of less than 10 000 km^2 (EPA 2009).

Several surveys (including desktop assessments, reconnaissance surveys and detailed sampling surveys) have been conducted within the Survey Area to identify existing subterranean fauna values relevant to the Proposal (Table 53).

Table 53: Subterranean Fauna Surveys Completed within the Survey Area

Title and Scope of Survey	Reference	Field Work Timing
Christmas Creek expansion project, subterranean fauna assessment • Document the subterranean fauna communities occurring, or likely to occur, within the Christmas Creek mining area based on a review of current and historic monitoring. • Document the subterranean fauna communities occurring, or likely to occur, within the Proposal. • Characterise the subterranean fauna habitat within and around the Proposal. • Identify the potential threats to subterranean fauna species arising from the Proposal. • Assess the risk to subterranean fauna species as a result of the Proposal.	Bennelongia 2014, Appendix 7D	March–May 2011 April–June 2012 May–August 2012
Christmas Creek project expansion: troglofauna assessment • Desktop investigation of potential impacts of increased groundwater abstraction at Christmas Creek on troglofauna.	Bennelongia 2010b	Desktop assessment
Christmas Creek project expansion: stygofauna assessment • Desktop investigation of potential impacts of increased groundwater abstraction at Christmas Creek on stygofauna.	Bennelongia 2010a	Desktop assessment
Assessment of stygofauna values at the Christmas Creek project • Undertake sampling to determine the presence of stygofauna at Christmas Creek	Bennelongia 2008	October 2007 June–July & October 2008
Report for Fortescue Metals Group, Pilbara Iron Ore Mine Sites • Identify any potential stygofauna habitat sites. • Undertake stygofauna sampling in conjunction with drilling for groundwater resources and hydrogeological investigations. • Assess the potential effect on stygofauna from dewatering operations.	(Knott and Goater, undated)	September 2004

The results of these surveys and investigations form the basis for the description of the subterranean fauna factor described in the following section. Bennelongia (2014) assessed the results of previous surveys from 2005 to 2012 and identified species as occurring in the area to be affected by mining and changes in groundwater level (the ‘impact area’) or in the ‘reference area’ outside the impact area. The following text represents the findings of Bennelongia (2014) except where otherwise noted.

A copy of the Bennelongia (2014) report can be found in Appendix 7D. Sites surveyed for stygofauna in the most recent study are shown in Figure 65, and for troglofauna in Figure 66.

11.3.1 Stygofauna Sampling

Stygofauna sampling yielded 2,486 specimens representing 69 species from 13 higher level taxonomic groups. This included 22 species of Copepoda, 12 species of Amphipoda, 12 species of Ostracoda, three species of Rotifera, nine species of Oligochaeta, three species of Syncarida, two species of Isopoda; and one species each of Gastropoda, Polychaeta, Aphanoneura, Acarifomres, Spelaeogriphacea and Nematoda. This is considered to represent a rich stygofauna community for the Pilbara region.

Of the 69 species collected within the Survey Area, 39 are known from beyond the northern Fortescue Valley. The remaining 30 species comprise 26 species that are known only from the northern Fortescue Valley, and four that could not be identified to species level and have uncertain distributions.

Five stygofauna species have only been recorded from the likely impact areas associated with the Proposal. Four of these species have only been recorded within the drawdown impact area (Table 54, Figure 67), and three are considered to be possibly restricted in range.

11.3.2 Troglofauna Sampling

Troglofauna sampling yielded 249 specimens representing 29 species from 13 Orders. This included eight species from four Orders of arachnids, three species of Isopoda (crustaceans), two species of Scolopendromorpha (centipedes), one species of Polyxenida (millipedes), two species of Cephalostigmata (pseudocentipedes), one pauropod, and 12 species from four Orders of hexpods. This is considered to represent a moderately rich troglofauna community for the Pilbara region.

Of the 29 species of troglofauna recorded within the Survey Area, three are known to occur throughout the Survey Area, another four are also known to exist at Cloudbreak, two species are of uncertain range due to low taxonomic resolution, while the remaining 20 species are currently known only from the Survey Area.

Of the 20 species currently known only from the Survey Area, 12 were restricted to the proposed impact area: nine were recorded only within the proposed mine pits and three were recorded only within the area of groundwater mounding associated with injection (Table 55, Figure 68). Four species are considered to be possibly restricted in range. Pilbara troglofauna species are often localised within an area such as the northern flank of the Fortescue Valley.

Table 54: Stygofauna Species Currently Known Only From the Christmas Creek Survey Area

<table>
<tr><th>Species</th><th>Number of Specimens</th><th>Type of Area Recorded</th><th>Comment</th></tr>
<tr><td>Hydrobiidae sp. B04</td><td>6</td><td rowspan="13">Reference sites</td><td rowspan="16">Exists outside the impact area</td></tr>
<tr><td>nr Areacandona sp. BOS315</td><td>8</td></tr>
<tr><td>Cyprididae sp. A</td><td>4</td></tr>
<tr><td>Harpacticoida sp. B03</td><td>2</td></tr>
<tr><td>Bogidiella sp. B03</td><td>3</td></tr>
<tr><td>Bogidiella sp. B04</td><td>5</td></tr>
<tr><td>Melitidae sp. B01 (sp. 1 group)</td><td>1</td></tr>
<tr><td>Chydaekata sp. B03</td><td>11</td></tr>
<tr><td>Paramelitidae (nr Pilbarus) sp. B06</td><td>3</td></tr>
<tr><td>Paramelitidae Genus 2 sp. B10</td><td>3</td></tr>
<tr><td>Paramelitidae Genus 2 sp. B11</td><td>104</td></tr>
<tr><td>Paramelitidae sp. B29</td><td>17</td></tr>
<tr><td>Pygolabis sp. B08</td><td>3</td></tr>
<tr><td>Chydaekata sp. B02</td><td>17</td><td rowspan="3">Main impact area and reference sites</td></tr>
<tr><td>Paramelitidae sp. B12</td><td>75</td></tr>
<tr><td>Microcerberidae sp. B01</td><td>18</td></tr>
<tr><td>Australocamptus sp. B07</td><td>16</td><td>Main impact area</td><td>Likely to extend beyond impact area</td></tr>
<tr><td>Bathynella sp. B02</td><td>40</td><td>Main and minor impact areas</td><td rowspan="3">Possibly restricted to impact area</td></tr>
<tr><td>Canthocamptidae sp. B02</td><td>1</td><td rowspan="2">Main impact area</td></tr>
<tr><td>Goniocyclops sp. B02</td><td>3</td></tr>
</table>

Table 55: Troglofauna Species Currently Known Only From the Christmas Creek Survey Area

Species	Number of Specimens	Type of Area Recorded	Comment
Atemnidae sp. B03	1	Reference sites	Recorded outside the impact area
Hyidae sp. B02	9		
nr *Encoptarthria* sp. B07	5		
Troglarmadillo sp. B31	17	Impact and reference areas	
Hanseniella sp. B16	29		
Trinemura sp. B15	10		
nr *Encoptarthria* sp. B05	3		
Nocticola sp. B20	23		
Palpigradi sp. B12	2	Impact area: proposed mine pits	Considered likely to extend beyond impact area
Draculoides sp. B31	4		
Draculoides sp. B33	1		
nr *Cryptops* sp. B15	1		
Cryptops sp. B32	1		
Japygidae sp. B29	1		
Trinemura sp. B19	1		
Trinemura sp. B18	1	Impact area: potential groundwater mounding area	
Anajapygidae sp. B02	3	Impact area: proposed mine pits	Possibly restricted to impact area
Projapygidae sp. B12	1		
Parajapygidae sp. B24	1	Impact area: potential groundwater mounding area	Possibly restricted to impact area
***Troglarmadillo* sp. B30**	**3**		

11.3.3 Fauna Habitat

Stygofauna

Stygofauna habitat consists of suitably sized voids and fissures below the watertable. Lateral connectivity of these spaces is important to allow animal movement. Vertical connectivity is important to allow supply of carbon and nutrients from the surface. Stygofauna generally occur in fresh to brackish waters but may occur in salinities up to 50,000 mg/L TDS.

Potential stygofauna habitat at Christmas Creek includes the following:

- pebbly formations in the alluvium/colluvium with fresh to brackish groundwater within the saturated portion of the Tertiary Detrital layers
- cemented and loose gravel within the semi-confined detrital deposits of the upper portion of the Tertiary Detrital layers with fresh to brackish groundwater (saline near the Fortescue Marsh)

- banded iron formations in the upper portion of the MMF where vugs and pisolitic structures occur and groundwater is brackish to hypersaline
- vuggy portions of the Oakover Formation where water is brackish to hypersaline.

Troglofauna

Habitats of troglofauna are defined by the availability of suitable voids and fissures above the watertable in which these species can live. In the Pilbara, troglofauna can live within pisolite (sedimentary rocks with grain size 2–10 mm) and banded iron formations, but may also occur in calcrete (porous limestone) and alluvium.

Troglofauna at Christmas Creek are considered likely to occur in the following environments:

- hardcap at the top of the Nammuldi Member of the MMF, which is vuggy and porous with solution cavities (Fortescue 2013)
- mineralised MMF, based on the porosity of the rock based on previous records in this formation within the Pilbara.

A description of the geology of the Christmas Creek area can be found in Section 2.2.

The overlying sediments are considered to be less likely to be troglofauna habitat due to grain size, although troglofauna have been found in alluvium in the Pilbara.

11.4 Potential Impacts

Activities or aspects of the Proposal that have the potential to affect subterranean fauna, not considering mitigation measures, include:

- abstraction of ore and waste rock may result in physical loss of habitat
- groundwater abstraction and associated drawdown may result in loss of habitat
- injection may cause mounding of groundwater and changes in salinity which may result in loss of habitat.

11.5 Evaluation of Options or Alternatives to Avoid or Minimise Impact

Options to avoid or minimise impact to stygofauna and troglofauna include:

- minimising the extent of groundwater drawdown and mounding
- minimising changes in groundwater salinity.

The extent of groundwater drawdown will be minimised by limiting the duration of abstraction to that required for mining. Strategic location of injection will also be used to mitigate against drawdown in areas close to the Fortescue Marsh. Changes in groundwater salinity will be

minimised by injecting saline groundwater into the deeper aquifers, where stygofauna are less likely to occur. Further discussion of these mitigation measures can be found in Section 7.6.2.

11.6 Assessment of Likely Direct and Indirect Impacts

11.6.1 Removal of Ore and Waste Rock

As troglofauna are found within underground air filled cavities and caves, impacts related to these species are largely associated with those activities that require excavation of rocky material, such as development of the open pit. Impacts may also arise from placement of infrastructure, particularly those items with a large footprint such as the TSF and WRD. Where infrastructure impedes movement of water, nutrients and detritus from the surface into subsurface cavities, voids and caves, subterranean fauna habitat will be degraded.

Pit excavation below the watertable will also result in the loss of stygofauna habitat; however, as this lies within the area of groundwater drawdown it is considered as part of groundwater abstraction described in the following section.

11.6.2 Groundwater Abstraction

Groundwater abstraction to draw the watertable below the level of mining may cause significant risk to restricted stygofauna species. If drawdown occurs through the full thickness of the aquifer, any stygofauna species restricted to the drawdown area will be affected. For troglofauna species with ranges coinciding with the area of drawdown, there may also be as risk of habitat loss resulting from groundwater drawdown.

The following criteria were used to differentiate the possible impacts of different amounts of drawdown within the Proposal area:

1. Drawdown of >5 m is considered to be potentially significant as it represents localised de-watering of all or most of at least one of the four stratified aquifers within the Proposal area.
2. Drawdown of 2–5 m is considered to be a minor impact as this is likely to represent <50% of the vertical extent of the upper component of the stratified alluvial aquifer in the southern portion of the Proposal area. In the northern portion of the Proposal area, the aquifers are not stratified and drawdown of up to 5 m will remove less of the vertical extent of the upper aquifers.
3. Drawdown of <2 m is not considered to be an impact as it is within the range of natural variation and is a small proportion of the habitat thicknesses.

11.6.3 Groundwater Injection

Injection of groundwater has the potential to change groundwater chemistry (particularly salinity) if water is not returned to the source aquifer, potentially affecting stygofauna and stygofauna habitat. More commonly, groundwater mounding is likely to reduce the amount of troglofauna habitat. This could present a threat to troglofauna species where the depth to groundwater is small and there is only a small thickness of troglofauna habitat.

The impacts of injection of hypersaline water are difficult to predict and largely depend on the resultant salinity profile in the area of injection. There is some evidence that fresh and brackish water stygofauna species occur in groundwater above the hypersaline halocline around Fortescue Marsh. Hypersaline and brackish groundwater will be injected into aquifers of similar natural qualities, reducing the potential for significant changes in salinity.

Hypersaline groundwater will be injected into the Oakover Formation via bores located to the south of the Proposal pits. Injected hypersaline groundwater is considered unlikely to cause regional groundwater mounding, and modelling has indicated that hypersaline water will not affect the salinity of the overlying aquifer (Section 8.6.2).

Modelling also indicates that injection of brackish groundwater will not affect the quality of the overlying aquifer, although groundwater mounding is expected to occur (Section 8.6.2). The area of groundwater mounding has been designed to coincide with the area of >5 m drawdown resulting from the Proposal, in order to mitigate the overall effect on groundwater levels.

11.6.4 Summary of Impact

Stygofauna

A total of 26 stygofauna species have been recorded only in the Christmas Creek Survey Area. Four of these were found only within the Proposal drawdown impact area.

One apparently restricted species (*Australocamptus* sp. B07) was recorded only in areas of minor drawdown (2–5 m) and the threat to this species is considered to be low because of its occurrence near the boundary of the modelled drawdown area and the limited drawdown it will experience. The ranges of the other three apparently restricted species are unknown or considered to be possibly restricted to the Proposal impact area. Canthocamptidae sp. B02 has an uncertain range and the level of threat to the species is unclear because there is no information about the biology of the species. The threat to the remaining two species (*Bathynella* sp. B02 and *Goniocyclops* sp. B02) is considered to be low based on knowledge of the biology and habitat preferences of these species.

Canthocamptidae sp. B02

Canthocamptidae sp. B02 may belong to an undescribed genus. A single male animal was collected within the impact footprint in an area with >5 m drawdown. At least 14 species of the family Canthocamptidae have been identified from bores/drill-holes in the Pilbara. The known ranges of these species based on current data vary from single localities to Pilbara-wide. Given the very limited survey data available for this species, the potential impact is best assessed by examining the ranges of other copepods collected in the area. Fifteen of the 19 species are widespread and this suggests that Canthocamptidae sp. B02 could be expected to have a range extending beyond the Proposal impact area.

However, the assessment is not underpinned by any knowledge of the species-specific biology of Canthocamptidae sp. B02, because it has been collected as a single animal.

Troglofauna

Eight of the 12 troglofauna species found only within the impact areas of the Proposal are considered likely to extend to beyond these areas, either in the near vicinity of the mine pits, or to the north of the Proposal in the MMF within the Chichester Range. The apparent restriction of these species is probably an artefact of sampling techniques and occurrence at low abundance. The remaining four species found only within the proposed impact area comprise two species likely to experience minor habitat loss as a result of groundwater mounding (Parajapygidae sp. B24 and *Troglarmadillo* sp. B30), and two species that are likely to experience more significant habitat loss resulting from pit excavation (Anajapygidae sp. B02 and Projapygidae sp. B12).

Anajapygidae sp. B02, Parajapygidae sp. B24 and Projapygidae sp. B12

The limited information about the ranges of troglofaunal Parajapygidae, Anajapygidae, and Projapygidae suggests that species of these families tend to occur in valley sediments rather than across ranges and may sometimes have tightly restricted ranges (Bennelongia unpublished data). Anajapygidae sp. B02, Parajapygidae sp. B24 and Projapygidae sp. B12 may potentially be restricted to the impact footprint despite the related Parajapygidae 'DPL031' being known from both Christmas Creek and Cloudbreak with a linear range of 35 km. Impacts to Parajapygidae sp. B24, which occurs in the expected area of groundwater mounding, are expected to be short term and localised (Section 7.6.2 and Figure 21 to Figure 25).

Troglarmadillo sp. B30

This species is represented by three specimens from one bore. *Troglarmadillo* is the most common troglofaunal isopod genus in the Pilbara and Bennelongia has records of 12 species. They have, at most, moderate ranges up to about 20 km (Bennelongia unpublished data). One species of *Troglarmadillo* (sp. B15) was previously collected on the northern flank of the Fortescue Valley. This species is known to have a range of 16 km. It is considered likely that *Troglarmadillo* sp. B30 has a similar range to its sister species and probably a preference for valley habitat. This range suggests that *Troglarmadillo* sp. B30 may be restricted to the impact

area, but when the expected mine pit layout (Figure 11) is considered, it is likely that this species will occur in undisturbed areas between mine pits.

Habitat Connectivity

Habitat connectivity is important for subterranean fauna in terms of the geographic range of subterranean fauna. Potential boundaries such as geological intrusions and impermeable formations can prevent the movement of subterranean fauna. The geology of the northern flank of the Fortescue Marsh within the 120 km between Nullagine-Newman Road and the BHP Billiton Railway Line is considered to be broadly similar, although there is some variability on a scale of tens to hundreds of metres. This variability is considered unlikely to affect the distribution of troglofauna and stygofauna along the northern flank.

Stygofauna recorded in the Survey Area contain both widespread species that probably mostly consist of stygophiles (inhabit both surface and subterranean aquatic environments) and more restricted species that may be considered stygobitic (strictly groundwater-adapted species). Many stygobitic species in the Pilbara have ranges aligned with tributaries of major catchments. Hydrological information for the northern Fortescue Valley suggests that these stygofauna habitats should be well connected; however, survey results are variable and do not always reflect this connectivity. Identifying the finer hydrological units or patches that the more restricted species are associated with is likely to be challenging.

Troglofauna were collected from all three of the major troglofauna habitats within the Survey Area; the Hardcap zone, mineralised MMF and colluviums or alluvium. Based on the scale at which geological information is available, all troglofauna habitats within the Proposal area are likely to be well connected with the surrounding habitats. In contrast, sampling results seem to indicate that a series of ‘barriers’ occur along the northern side of the Fortescue Valley that restrict the ranges of several species. From this information, the habitat characterisation has limited capacity to predict the extent of occurrence of troglofauna species in the northern Fortescue Valley.

11.7 Cumulative Impacts

Cumulative impacts were considered by Bennelongia in terms of the additional threat to conservation of subterranean fauna species resulting from the Proposal, when the impact of the Proposal is considered in relation to the impact of previously approved mines in nearby areas. There are two other approved mines within the northern Fortescue Valley: Cloudbreak and the Roy Hill Mine. Both these approved mines have substantial groundwater impacts and pit excavations.

While using the extent of suitable habitat for subterranean fauna as a surrogate for species distributions can sometimes provide a method of calculating cumulative impacts, this has not been undertaken for the Proposal. The fine scale complexities of geology and hydrogeology, in addition to the relative paucity of information on the biology and habitat requirements of

stygofauna and troglofauna species recorded in the Survey Area, prevented identification of predictive relationships between habitat units and species occurrence.

Cumulative impact of mining on troglofauna within the northern Fortescue Valley is considered unlikely as a result of the Proposal. No troglofauna species identified from other sub-regions of the Pilbara is reliant on the occurrence of species within the Proposal footprint to ensure its preservation. This is a reflection of the small ranges of nearly all troglofauna species. No species collected at Cloudbreak is dependent on the occurrence of specimens from the Proposal area for its preservation. No troglofauna species were identified from Roy Hill, and potential cumulative impacts on species at Roy Hill Mine could not be evaluated because of incomplete data for that site.

Cumulative impact of mining on stygofauna within the northern Fortescue Valley is considered unlikely as a result of the Proposal. No stygofauna species recorded at Cloudbreak is reliant on the occurrence of species within the Proposal area. While sampling results suggest that there will be no threat to species conservation from the cumulative impacts of dewatering, Bennelongia noted that one species previously known only from the impact footprint at Cloudbreak; namely *Goniocyclops* sp. B02 (collected from one bore only) will experience additional impacts as a result of the Proposal (see Section 7.6.2 for details). Cumulative impact assessment was not possible for species occurring at Roy Hill, as surveys for this Proposal lacked species level identifications, making it impossible to conduct comparisons.

11.8 Management Measures and Performance Standards

Potential impacts to subterranean fauna in the Proposal area will be minimised through implementation of the following management measures:

- management and monitoring of groundwater will be undertaken through implementation of the DoW approved *Christmas Creek Groundwater Operating Strategy* CC-PH-HY-0002 (Fortescue 2012d, Appendix 5C)
- ongoing implementation of the *Subterranean Fauna Survey Plan* (45-PL-EN-0010) (Fortescue 2011f)
- GDPs will be required prior to commencement of activities
- hydrocarbons and chemicals will be appropriately stored and bunded to minimise the potential for spillage
- spill kits will be provided and maintained in all areas where hydrocarbons and chemicals are stored or used
- drainage from areas likely to be contaminated with hydrocarbons or chemicals (such as workshops) will be captured and treated (for example through oil-water separators).

11.9 Predicted Environmental Outcomes

After application of management and mitigation measures described in Section 11.8, the Proposal is expected to result in the following outcomes in relation to subterranean fauna:

1. Four species of stygofauna recorded only within the Proposal drawdown impact area, and one species which has been recorded within the Cloudbreak and Proposal drawdown areas.

    (a) The threat to four of the stygofauna species recorded only within the predicted impact areas associated with the Proposal and Cloudbreak is considered to be low.

    (b) The threat to the stygofauna species Canthocamptidae sp. B02 is uncertain because of limited information on the biology of the species, however the range of other copepods in the area suggests that this species is likely to have a range extending beyond the Proposal impact area.

    Overall, the Proposal is not expected to represent a significant impact to stygofauna.

2. There were 12 species of troglofauna with restricted distributions recorded within the Proposal area.

    (a) Eight of these are considered likely to extend beyond the impact areas

    (b) Two species may be exposed to minor habitat loss as a result of groundwater mounding,

    (c) Two species that will be affected by habitat loss resulting from pit excavation.

    Overall, the Proposal is not expected to represent a significant impact to troglofauna.

3. No subterranean fauna species recorded at the approved Cloudbreak or Roy Hill mine is reliant on the occurrence of species within the Proposal footprint to ensure conservation of that species.

The Proposal is not expected to represent a significant impact to subterranean fauna habitat from pit excavations and groundwater drawdown and mounding.

In considering the outcome as described, the Proposal is expected to meet the EPA objectives for subterranean fauna to maintain representation, diversity, viability and ecological function at the species, population and assemblage level.

12. MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

The nine matters of national environmental significance (MNES) protected under the EPBC Act are:

- world heritage properties
- national heritage places
- wetlands of international importance (listed under the Ramsar Convention)
- listed threatened species and ecological communities
- migratory species protected under international agreements
- Commonwealth marine areas
- the Great Barrier Reef Marine Park
- nuclear actions (including uranium mines)
- a water resource, in relation to coal seam gas development and large coal mining development

The Proposal has the potential to affect the following MNES:

- threatened species (fauna only)
- migratory species.

As a consequence, DoE has determined the Proposal to be a 'controlled action' under the EPBC Act. For the purpose of consistency with the other chapters in this PER, the 'controlled action' is also referred to as the Proposal within this chapter.

The EPBC Act objectives are to:

- provide for the protection of the environment, especially MNES species
- conserve Australian biodiversity
- provide a streamlined national environmental assessment and approvals process
- enhance the protection and management of important natural and cultural places
- control the international movement of plants and animals (wildlife), wildlife specimens and products made or derived from wildlife
- promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources.

12.1 Relevant Environmental Objectives, Legislation, Policies and Guidelines

12.1.1 Australian Government Protection

The EPBC Act protects species listed under Schedule 1 of the Act. In 1974, Australia became a signatory to the *Convention on International Trade in Endangered Species of Wild Fauna and Flora*. As a result, an official list of endangered species was prepared and is regularly updated. This listing is administered through the EPBC Act. The current list differs from the various State lists; however, some species are common to both.

The EPBC Act aims to prevent significant impacts occurring to MNES, including threatened species through assessment of proposed actions against the *Matters of National Environmental Significance: Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (DEWHA 2009).

12.1.2 International Agreements

Australia is party to the JAMBA, CAMBA and ROKAMBA Agreements. Most of the birds listed in these agreements are associated with saline wetlands of coastal shorelines and have little relevance to the Proposal area; however, some migratory birds not associated with water are also listed on these international treaties.

12.2 Surveys and Investigations

The Proponent has utilised the results from the surveys and investigations in Table 56 to support the assessment of potential impacts of the Proposal on MNES.

Table 56: MNES Surveys and Investigations

Description of Survey and Reference	Field Work Timing
Christmas Creek Water Management Scheme Northern Quoll Annual Monitoring Report 2014 (Ecologia 2014a, Appendix 7F)	10-16 June 2014
Christmas Creek Water Management Scheme Pilbara Olive Python Annual Monitoring Report 2014 (Ecologia 2014b, Appendix 7G)	January 2014
Christmas Creek Water Management Scheme Conservation Significant Fauna baseline monitoring (Ecologia 2013, Appendix 7E)	27 November 2012 and 12 June 2013.
Surveys for the Night parrot *Pezoporus occidentalis* in the Cloudbreak Project Area – annual surveys undertaken from 2005 to 2010 (Bamford): • May 2005: survey undertaken following sighting of the Night parrot, focussing on Minga Well (Bamford 2005) • March 2006: survey undertaken in wet season conditions (Bamford 2006) • November 2006: survey undertaken in dry season/early wet season conditions (Bamford & Burbidge 2007a) • December 2006: Brief survey to further investigate observations made in November 2006 (Bamford & Burbidge 2007) • November 2007: survey undertaken in late dry season/early wet season conditions (Bamford 2007b) • September 2008: surveys undertaken on locations farther afield than previous surveys (Bamford & Raines 2009) • December 2009: survey focussed in the use of motion sensor cameras set up at water holes (Bamford 2010) • September-November 2010: survey focussed in the use of motion sensor cameras set up at water holes and along the ecotone between Spinifex and Samphire communities. (Bamford 2011) • July 2011 – January 2012: long term survey using motion-sensitive cameras (Bamford & Turpin 2012)	2005 - 2012
Christmas Creek Terrestrial Vertebrate Fauna and Fauna Habitat Assessment (ENV 2012a, Appendix 7A)	16–27 March 2011, 29 July–4 August 2011
Assessment of potential fauna diggings which had been formerly identified as Greater Bilby diggings, Christmas Creek (ENV 2012c)	14 and 15 December 2011
Targeted fauna survey of the Christmas Creek Survey Area (ENV 2012b)	28 July–5 August 2011
Cloudbreak Level 2 Terrestrial Vertebrate Fauna Assessment (Ecologia 2011)	18-29–October 2010

The results of these surveys and investigations form the basis for the description of the MNES factor described in the following section. Additional targeted surveys for the Night Parrot are ongoing annually at the Cloudbreak Survey Area, adjacent to Christmas Creek.

12.3 Description of MNES Species

Based on previous surveys, database and literature searches, seven Threatened fauna species and six Migratory bird species listed under the EPBC Act have the potential to occur within the Proposal area (Table 57). Several of these species have been recorded within or adjacent to the Proposal area during previous fauna surveys.

Table 57: Likelihood of Occurrence of MNES species within the Proposal Area

Species	Status	Description	Likelihood of Occurrence
Night Parrot (*Pezoporus occidentalis*)	Endangered	Species may be found near Spinifex hummocks within proximity to water. There have been no records of this species occurring within the Christmas Creek Development Envelope, however, potentially suitable habitat occurs within the Development Envelope.	Possible
Northern Quoll (*Dasyurus hallucatus*)	Endangered	Drainage Line and Alluvial Plain may provide suitable foraging habitat for this species, while a small area of potentially suitable denning habitat is located to the north-east of the Survey Area (74 ha). Although it has been previously considered possible that this species could occur within the Development Envelope (ENV 2013), results of targeted monitoring surveys (Ecologia 2014a) indicate that the species is unlikely to occur.	Unlikely
Australian Painted Snipe (*Rostratula australis*)	Endangered/ Migratory	This species is a wading bird, known from wetland areas around Australia. The nearest record of this species was recorded in 2012, from Coondiner Pool (30 km south of the Development Envelope). This species could potentially occur within the Fortescue Marsh.	Possible
Greater Bilby (*Macrotis lagotis*)	Vulnerable	There have been no recordings of this species occurring within the Christmas Creek Survey Area. Potentially suitable habitat is located throughout the Christmas Creek Survey Area. Although it has been previously considered possible that this species could occur within the Development Envelope (ENV 2013), results of targeted monitoring surveys (Ecologia 2013) indicate that the species is unlikely to occur.	Unlikely
Olive Python, Pilbara subspecies (*Liasis olivaceus barroni*)	Vulnerable	Opportunistically recorded within the Christmas Creek Survey Area, adjacent to a drainage line, during the ENV survey (2012a). Considered to be a dispersing individual due to lack of suitable habitat within the Survey Area.	Recorded
Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* [Pilbara form])	Vulnerable	No records of this species occurring within the Christmas Creek Survey Area. Suitable roosting habitat is not present within the Survey Area; however it may be likely that this species will forage over all present habitat types. Although it has been previously considered possible that this species could occur within the Development Envelope (ENV 2013), results of targeted monitoring surveys (Ecologia 2013) indicate that the species is unlikely to occur.	Unlikely
Northern Marsupial Mole (*Notoryctes caurinus*)	Endangered	Species prefers to live underground in sand dunes and sandy soils along river flats. There have been no records of this species occurring within the Christmas Creek Survey Area. This species has not been recorded from within the Pilbara bioregion.	Highly Unlikely
Fork-tailed Swift (*Apus pacificus*)	Migratory	This species is expected to be found within the Christmas Creek Survey Area at the start of the wet season. There are no previous records of this species occurring in the vicinity of the Proposal area.	Possible
Cattle Egret (*Ardea ibis*)	Migratory	This species has not been recorded as occurring in the Christmas Creek Survey Area; however, the Drainage Line and Alluvial Plain habitat type provides suitable habitat.	Likely
Eastern Great Egret (*Ardea alba*)	Migratory	Drainage Line and Alluvial Plain and Marsh habitat types provide suitable foraging and breeding habitat, only when surface water is present. Fortescue Marsh located to the south of the Proposal area also provides suitable habitat for this species. This species has been previously recorded as occurring within the Development Envelope.	Recorded

Species	Status	Description	Likelihood of Occurrence
Oriental Plover (*Charadrius veredus*)	Migratory	There are no records of this species occurring in the Christmas Creek Survey Area or adjacent areas. The Stony Plains and Low Hill habitat types contain large amounts of Spinifex that may provide suitable foraging habitat.	Possible
Rainbow Bee-eater (*Merops ornatus*)	Migratory	This species was recorded in the Stony Plain habitat type, as well as the Drainage Line and Alluvial Plain habitat type, during the ENV survey (2012a).	Recorded

The migratory species listed in Table 58 were not identified during database surveys or literature searches; however, they have been recorded as occurring near the Christmas Creek Proposal area during previous fauna surveys.

Table 58: Likelihood of Occurrence of MNES species near the Proposal Area

Species	Status	Description	Likelihood of Occurrence
Wood Sandpiper (*Tringa glareola*)	Migratory	Both the Marsh and Drainage Line and Alluvial Plain habitat types contain freshwater wetlands, which are suitable habitat for this species. This species has been previously recorded in the marsh habitat type within the area	Likely
Common Greenshank (*Tringa nebularia*)	Migratory	Both the Marsh and Drainage Line and Alluvial Plain habitat types contain freshwater wetlands, which are suitable habitat for this species. This species has been previously recorded in the Marsh habitat type within the area	Likely
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	Migratory	Drainage Line and Alluvial Plain and Marsh habitat types, can contain surface water suitable for this species to forage. This species is recorded as occurring within the Fortescue Marsh area at Roy Hill Station.	Likely

12.3.1 Northern Quoll (*Dasyurus hallucatus*) – Endangered

The Northern Quoll is the smallest of the four Australian Quoll species, weighing up to 1.2 kg, with the males being larger than the females. The Northern Quoll has a pointed snout and reddish brown fur with a cream underside. It has white spots on its back and rump, and a long, sparsely-furred and unspotted tail (DoE 2014).

The Northern Quoll was historically common across northern Australia, occurring from the Pilbara to Brisbane. The Northern Quoll now occurs in five regional populations across Queensland, the Northern Territory and Western Australia, both on the mainland and on offshore islands (DoE 2014).

Records of Northern Quoll occurrence in the Pilbara bioregion are scattered across the Hamersley, Fortescue Plains, Chichester and Roebourne Plains subregions, with records extending as far west as the Little Sandy Desert and as far south as Karijini National Park (DoE 2014).

The Northern Quoll tends to prefer the Rocklea, Macroy and Robe land systems, which comprise basalt hills, mesas, high and low plateaux, lower slopes and stony plains supporting either hard or soft Spinifex grasslands (DoE 2014).

Radio tracking and live trapping undertaken in Kakadu National Park indicates that female Northern Quoll individuals occupy an average home range of 35 ha. Alternatively, male Northern Quolls adopt a roving strategy during mating season and can occupy a total range of >100 ha to overlap several female, and male, home ranges. Before mating season, the male Northern Quoll home range is of a similar size to that of the female (DoE 2014).

Habitat Preference

Across their entire range (i.e. northern Australia) Northern Quolls live in a wide variety of habitats including rocky hills and escarpments, eucalypt forests and woodlands, rainforests and areas of human settlement. Northern Quolls are both terrestrial and arboreal, and use a variety of den sites including rock crevices, tree hollows, logs, termite mounds, house roofs and goanna burrows (DoE 2014). The *National Recovery Plan for the Northern Quoll* (prepared by the Northern Territory, Western Australian, Queensland and Commonwealth environment departments) reiterates that rocky areas provide prime habitat for Northern Quolls (Hill & Ward 2010).

Within the Pilbara, areas that have the highest potential to contain resident Northern Quolls are along gullies and creek lines and around rocky or stony scree slopes, rocky boulder fields and rocky ranges. The association of the Northern Quoll with rocky habitats in the Pilbara is likely to be driven by this species' need for suitable den sites, as woodlands containing tree hollows of suitable size are limited in the region. Rocky habitat types are widespread and common across the Pilbara, but represent a small portion of the landscape in terms of area (DoE 2014)

The Christmas Creek Survey Area contains approximately 74 ha of suitable denning habitat for Northern Quoll, located to the north-east of the Proposal area (Figure 69). This location contains gorge and breakaway habitat types, suitable for shelter. This is approximately equivalent to the home range of two Northern Quoll individuals in the non-breeding season (ENV 2012a). Any Northern Quolls present would occupy home ranges in these small areas of suitable habitat identified in the north of the Proposal area. Females are likely to stay within the immediate vicinity of those areas, foraging each night along rocky breakaways and escarpments. Males may move about between widely separated areas of suitable foraging habitat, especially between May and July, as they visit females during the breeding season. No other suitable habitat has been identified within the Christmas Creek Survey Area.

Results of Targeted Fauna Surveys and Monitoring Programs

Several fauna surveys and monitoring programs have been undertaken at Christmas Creek and in adjacent areas. The majority of surveys did not identify Northern Quolls or their signs; however, ATA Environmental (2006) recorded unconfirmed scats at two locations during an assessment of the proposed Cloudbreak airstrip, camp and access road, approximately 8 km

from the north-western edge of the Christmas Creek lease boundary (ENV 2012b). Potential shelter habitat for this species is extremely limited in the Christmas Creek Survey Area (ENV 2012b). Given the presence of the scats, and taking the relatively large home-range of the Northern Quoll into consideration, it was previously considered that this species may occur on the Christmas Creek lease (ENV 2012b). Given the lack of records from subsequent surveys and monitoring undertaken for the Northern Quoll; Northern Quolls are considered unlikely to occur within the Proposal area (Ecologia 2013).

Targeted fauna surveys of the Christmas Creek Proposal area were undertaken in 2011 and 2012, and involved installation of cage and Elliot traps, and motion sensitive cameras (ENV 2012a). Transects through potentially suitable foraging habitat were also walked by personnel. The most recent monitoring survey (Ecologia 2014a) also utilised motion detection cameras in areas of different habitat within the Christmas Creek Proposal area. Personnel also completed nocturnal and diurnal monitoring regimes. No Northern Quolls were either recorded on the motion cameras or captured in traps, and no other evidence of their presence was identified in either survey in and near the Christmas Creek Survey Area (Table 59).

Table 59: Survey Effort for the Northern Quoll

Survey	Elliott/ Cage Trap Nights	Camera Trap Nights	Personnel Survey Hours	Observations
Biota (2005)	400	-	-	No Northern Quolls recorded
ENV Christmas Creek Terrestrial Fauna and Fauna Habitat Assessment (2012a)	112	-	9	No Northern Quolls recorded
ENV Targeted Fauna Survey of the Christmas Creek Survey Area (2012b)	1,273	8	39	No Northern Quolls recorded
Ecologia Christmas Creek Water Management Scheme Conservation Significant Fauna Baseline Monitoring (2013)	-	505 (cumulative)	12	No Northern Quolls recorded
Christmas Creek Water Management Scheme Northern Quoll Annual Monitoring Report 2014 (Ecologia 2014a)	-	2,880	52.5	No Northern Quolls or evidence recorded
Total	**1,385**	**3,885**	**112.5**	**No records**

Threats

The major threats to the Northern Quoll outlined in the *National Recovery Plan for the Northern Quoll* (Hill & Ward 2010) that are relevant to the Pilbara include, but are not limited to the following:

- removal, degradation and fragmentation of habitat
- inappropriate fire regimes
- feral predators.

The Pilbara population is considered important because it is the only large area of the species' range that is free of Cane Toads and not threatened by their imminent arrival. Toads have severely decreased the abundance and distribution of the Northern Quoll through poisoning.

Conservation Programs in the Pilbara

The main conservation effort for Northern Quolls in Western Australia involves the preparation and implementation of Cane Toad management measures by DPaW. *The Cane Toad Strategy for Western Australia: 2009-2019* (DEC 2009c) includes:

- strengthening toad quarantine and abatement measures
- identifying potential refuge areas for native fauna potentially affected by cane toads
- identifying high value biodiversity assets and potential locations for targeted conservation programs.

State government funding has also been provided to the Kimberley Toad Busters, to prevent the spread of toads through the Kimberley and into the Pilbara.

The *National Recovery Plan for the Northern Quoll* aims to minimise the rate of decline of the Northern Quoll in Australia, such that viable populations remain in each of the major regions of distribution in the future. The nine main objectives of the Plan include:

- protect Northern Quoll populations on offshore islands from invasion and establishment of Cane Toads, cats and other potentially invasive species
- foster the recovery of the Northern Quoll sub-populations in areas where the species has survived alongside the Cane Toad
- halt declines in areas not yet colonised by the Cane Toad
- halt declines in areas recently colonised by Cane Toads
- maintain secure populations and source animals for future reintroductions/ introductions, if they become appropriate
- reduce the risk of Northern Quoll populations being impacted by disease
- reduce the impact of pastoral land management practices on the Northern Quoll
- raise public awareness of the plight of the Northern Quoll and the need for biosecurity of islands and Western Australia.

12.3.2 Night Parrot (*Pezoporus occidentalis*) – Endangered

The Night Parrot (*Pezoporus occidentalis*) is a medium sized parrot, growing to between 22 and 25 cm in length, with a wingspan between 44 and 66 cm. Adults are bright green in colour with black and yellow bars and spots and streaks over most of their bodies; bright yellow colouring

on the belly and vent, and black colouring on the upper surfaces of the periphery of their wings (DoE 2014).

The Night Parrot is secretive and is usually assumed to be nocturnal. Movement patterns are unknown but some authors presume that the Night Parrot is nomadic (DoE 2014). This reclusive species may be ground-dwelling and have the ability to live away from water sources; possibly returning to water sources during hot, dry conditions (Bamford 2010).

Distribution of the species is poorly understood; however, historical evidence indicates that Night Parrots were distributed over much of semi-arid and arid Australia (Garnett & Crowley 2000). The Night Parrot is known from only 23 museum specimens and a small number of confirmed sightings since the late 1800s (DoE 2014). The most recent confirmed sighting was made in 2005 on Mulga Downs Station in close proximity to the Fortescue Marsh (DoE 2014).

Over the past 15 to 20 years, a number of dedicated searches have failed to identify a single extant population of the species (DoE 2014). The age at sexual maturity and life expectancy of the Night Parrot are not known. The diet and foraging ecology is also largely unknown, although limited available information suggests a preference is to feed on the seeds of grasses, herbs and soft grasses (DoE 2014).

The small number of confirmed and verifiable records in Australia and the Pilbara makes it difficult to determine population trends with any accuracy (DoE 2014). The Night Parrot population is currently listed as “unknown” on the IUCN Red List of Threatened Species (BirdLife International 2014), as there is a lack of data currently available on the species. Given the decline in reporting rates, accounts of local and regional extinctions, and the failure of a number of recent targeted surveys, the total population size of the Night Parrot is believed to have declined since the late 1800s (DoE 2014). The species is likely to now be extinct in some parts of its former range and speculation indicates that it now only occurs in five subpopulations in Australia, the largest of which is estimated to consist of 20 breeding birds (DoE 2014) – the actual locations of these speculative subpopulations has not been determined (i.e. there are no known subpopulations within, or near, the Proposal area).

Habitat Preference

Distribution and habitat requirements of the Night Parrot are very poorly understood and, based on accepted records, the habitat of the Night Parrot is thought to consist of *Triodia* grasslands in stony or sandy environments, and Samphire and chenopod shrublands on floodplains, claypans, and on the margins of salt lakes, creeks or other sources of water, set within a landscape otherwise dominated by Spinifex (DoE 2014, Bamford 2005). Other reports state the Night Parrot is associated mainly with *Triodia* (Spinifex) and/or chenopod-dominated systems (Murphy 2012). The last recording of the species was at the permanent water source of Minga Well which is within Mulga habitat. This species may utilise this particular habitat, while not being preferred habitat.

At least six surveys, totalling more than 280 person-days of effort, have failed to record the Night Parrot in about the vicinity of Minga Well since the initial record (ENV 2012a).

The Marsh habitat type identified in the ENV survey (2012a) is considered to be the preferred habitat for the Night Parrot due to the presence of halophytic shrubland on the margin of the Fortescue Marsh. Low Hill habitat type is considered to also be potential habitat due to the presence of Spinifex, which this species may use as foraging habitat during the wet season (Bamford & Turpin 2012). Figure 71 outlines the extent of potentially suitable habitat within the Christmas Creek Survey Area.

Pilbara wide regional mapping of potential habitat for this species has not been undertaken as there is limited information on Night Parrot habitat. Recent regional sightings of the Parrot are limited to the single sighting at Minga well in 2005 (Figure 72).

The most likely movement of individuals will be within the dense Spinifex and Samphire in the vicinity of the Fortescue Marsh as individuals move to areas with a food source (e.g. seeding Spinifex). During drought conditions, some movements may occur between their typical habitat within and surrounding the Fortescue Marsh, and any nearby water sources.

The small number of confirmed or verifiable records makes it difficult to determine whether any Night Parrot populations occur within reserves (DoE 2014).

Results of Targeted Fauna Surveys and Monitoring Programs

After a series of unconfirmed sightings over several decades suggested the Night Parrot still survived in areas in the vicinity of the Fortescue Marsh, the Night Parrot was sighted at Minga Well on Mulga Downs Station in April 2005 during surveys commissioned by Fortescue for the Environmental Impact Assessment of the approved Cloudbreak Mine. Nine Night Parrot surveys have since been conducted using a range of techniques and, despite a high survey effort with numerous targeted surveys conducted within the Cloudbreak Survey Area, no further individuals have been recorded. The survey conducted in December 2009 (Bamford 2010) recorded a call and sighting of an unidentified bird near Cooke’s Pool on the Fortescue Marsh. The bird had the potential to be a Night Parrot given the characteristics of the call and size of the bird; however, the sighting was made at dusk in low light conditions making it impossible to determine colour or markings of the bird. The 2010 Night Parrot survey did not observe any known or possible Night Parrots (Bamford 2011). The 2011-2012 motion-sensitive camera survey did not record any known or possible Night Parrots (Bamford & Turpin 2012). Ongoing Night Parrot surveys will be undertaken to research the potential occurrence of Night Parrots within the Fortescue Marsh area.

A targeted baseline survey was conducted in 2012 and 2013 (Ecologia 2013), which involved installation of 10 motion cameras along the border of the Fortescue Marsh; six cameras were installed at drift fence sites, and four cameras at feeding stations within the Christmas Creek Survey Area. These cameras were left recording for six months. Additionally, three acoustic recording sites were monitored for Night Parrot calls over a total of 192 hours (Table 60). No

Night Parrots were recorded on either the motion cameras or through acoustic recordings, and no other evidence of their presence was identified.

Targeted pre-clearance surveys for the Night Parrot were undertaken at the neighbouring Cloudbreak Mine in 2013, incorporating the use of SM2 Automated Recording Units. No Night Parrots or attributable signs were recorded (Outback Ecology 2013a).

As a condition of EPBC 2010/5696 (the Cloudbreak Life of Mine Project), Fortescue is undertaking a Night Parrot Research Program to better understand the biology and habitat requirements of the species, along with developing methodologies for its detection. The results of this program will be available in 2016.

Table 60: Survey Effort for the Night Parrot

Survey	Person days in field	Person hours	Camera trap nights	Acoustic recording hours	Observations
2005-2007 (Bamford 2009)	250	-	-	-	No night Parrot detected. Two calls of interest noted.
2008 (Bamford & Raines 2009)	30	99	-	-	No Night Parrot detected
2009 (Bamford 2010)	-	125	127	-	No Night Parrot detected.
2010 (Bamford 2011)	-	5	686	-	No Night Parrot detected
2011 (Bamford & Turpin 2012)	-	-	3,380	-	No Night Parrot detected
Pre-clearance Night Parrot Survey (Outback Ecology 2013a)		96	33	36	No Night Parrot detected
2012-2013 (Ecologia 2013)	-	-	1,654 (cumulative)	192	No Night Parrot detected
Total	**280**	**325**	**5,880**	**228**	**No records**

Threats

The lack of information available regarding Night Parrot biology, ecology and habitat preferences makes it difficult to determine the cause or causes of the apparent decline in population size. There is no direct evidence to link any threatening process to the apparent decline.

An interim recovery plan for the Night Parrot in Western Australia identified threatening processes including:

- predation by cats and foxes
- altered fire regimes
- grazing by stock and rabbits
- reduced availability of water due to over-use by camels

- competition from introduced herbivores for, and degrading effects upon, critical areas of above-average nutrients and moisture in the arid zone, especially during times of drought
- the degrading effect by hard hoofed animals around watering points.

Conservation Programs in the Pilbara

A brief recovery outline for this species appears in *The Action Plan for Australian Birds* (Garnett & Crowley 2000).

The *Night Parrot (Pezoporus occidentalis) Research Plan* was developed by Fortescue to meet the requirements of EPBC 2010/5696 (Cloudbreak Life of Mine). The Plan has been finalised, and incorporates the following:

- funding of a suitably qualified expert/s to (undertake) research which contributes to understanding the field ecology/biology of the Night Parrot
- conduct or fund comprehensive targeted surveys for the Night Parrot in at least three sites in areas where confirmed sightings or specimens of Night Parrot have been recorded.

Implementation of the Plan will take place between 2014 and 2016.

12.3.3 Australian Painted Snipe (*Rostratula australis*) – Endangered

The Australian Painted Snipe is a wading bird which has been recorded in freshwater wetlands across Australia, although it is more common in the Eastern States. It is a medium-sized bird, with a length between 22 to 25 cm and a wingspan of 50 to 54 cm (DoE 2014)

Occasional records from remote places indicate that the species can move long distances and may be dispersive or migratory. It is generally thought to be crepuscular (active at dawn and dusk), but may be nocturnal. This species is usually observed singly or in pairs, or less often in small flocks, and feeds on vegetation, seeds, insects, worms, molluscs, crustaceans and other invertebrates (Birdlife International 2014).

It is estimated that the total population of this species numbers between 1,500 and 2,000 (Birdlife International 2014). There is one record of this species occurring in the Pilbara Region, where a single bird was identified at Coondiner Pool, 30 km south of the Development Envelope in 2012 (DPaW 2014a). This record has recently been added to the EPBC Protected Matters database, where it is noted that “species or species habitat may occur” within the Christmas Creek area.

There are no other records of this species occurring in the Pilbara Region, although there are several other records around Western Australia, as far south as Dumbleyung in the southern wheatbelt region, to the northern Kimberley, near Kununurra (DPaW 2014a).

Habitat Preference

The Australian Painted Snipe generally inhabits shallow terrestrial freshwater or occasionally brackish wetlands, including ephemeral and permanent lakes, swamps and claypans. It is also known to use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains (DoE 2014). Nesting generally occurs amongst tall vegetation (Birdlife International 2014).

Of the fauna habitat types present across the Development Envelope, this species could potentially utilise Marsh Habitat for foraging (Figure 73). Suitable habitat for this species on a regional scale is presented in Figure 74.

Results of Targeted Fauna Surveys and Monitoring Programs

As this species had not been recorded in the Pilbara until 2012, it has not been subject to targeted fauna survey or monitoring programs. However, Fortescue has undertaken a number of surveys, including an aerial survey of birds on the Fortescue Marsh (Bamford 2012) which would have likely recorded the species if it was present in significant numbers on the Fortescue Marsh.

Threats

The primary threatening process linked to the apparent decline of this species is the loss of wetland habitat areas (DoE 2014). Infestation of potential wetland habitat areas by invasive weed species, grazing of cattle and predation by feral animals are also considered to be potential threats to this species.

Conservation Programs in the Pilbara

As the Australian Painted Snipe was not recorded in the Pilbara until recently (2012), there are no species-specific local conservation programs in place in the region. On a national scale, the Threatened Bird Network and the Australasian Wader Studies Group initiated a project in 2011 to improve knowledge of the species (Rogers *et al.* 2005). As part of this project, recovery actions included the development of a database of records and an assessment of habitat preferences (Rogers *et al.* 2005). Birds Australia has been conducting annual surveys of the species since 2001.

12.3.4 Greater Bilby (*Macrotis lagotis*) – Vulnerable

The Greater Bilby (*Macrotis lagotis*) is listed as Vulnerable under the EPBC Act. It is an omnivorous, medium sized ground mammal, ranging in weight from 1.0 to 2.5 kilograms (kg). The species is nocturnal and constructs a substantial deep burrow system up to 3 m in length (Biota 2005). The Greater Bilby is generally a solitary animal and can breed throughout the year (DoE 2014).

The Greater Bilby forages at night, excavating prey including termites, ants, beetles, insect larvae and spiders from the soil and creating holes up to 25 cm in depth. The species has been documented as showing temporary home ranges and relatively rapid changes in distribution in response to variation in habitat resources. Males, females and juveniles may occupy overlapping home ranges and in optimal habitat can have a density of 12 to 16 individuals per km^2. The species is highly mobile and can have large foraging ranges. Adult females have been known to move up to 1.5 km between burrows on consecutive days, and adult males regularly move 2 to 3 km and up to 5 km between burrows on consecutive days (DoE 2014).

Habitat Preference

The Greater Bilby occurs in a wide variety of habitat, including Mitchell Grass and stony downs country of cracking clays, the desert sandplains and dune fields sometimes containing laterite, with hummock grassland and massive red earths with Acacia scrubland (ENV 2012c). These Spinifex hummocks provide runways, enabling easier movement and foraging (DoE 2014). Free surface water is not typically available in the Bilby's range; as a result, they derive most of their water from food. They are omnivorous and have a diet that consists of insects and their larvae, seeds, fruit and fungi (ENV 2012a).

In limited parts of the Greater Bilby's range, fire may be an important factor in improving the habitat value for the species. Occurrence of the Greater Bilby is associated with close proximity to recently burnt (i.e. <1 year) habitat (DoE 2014). The presence of the Greater Bilby is strongly associated with substrate type (sandy or sandy-loam), mean annual rainfall and the presence of dingoes in the area as they suppress the abundance of foxes and possibly feral cats (Southgate *et al* 2007).

The suitability and quality of potential habitat within the Christmas Creek Survey Area is considered to be in very poor condition due to high levels of degradation by cattle, as well as being unsuitable for the Greater Bilby as the majority of soil types and vegetation are not generally favoured by this species (Ecologia 2013). Potential foraging habitat is presented in Figure 75 and suitable habitat on a regional scale is presented in Figure 76.

Results of Targeted Fauna Surveys and Monitoring Programs

A targeted survey was undertaken in 2011 by ENV and Richard Southgate (ENV 2012c) to assess a number of fauna diggings at the Proposal area which had been formerly identified as Greater Bilby diggings. The diggings occurred in habitat generally considered unsuitable for the species. Upon completion of the survey, all of the diggings were considered to have been made by goannas (ENV 2012c).

Previous surveys undertaken by Biota (2005) did not record any sightings of this species, and this species is considered unlikely to occur in the Proposal area. Table 61 summarises the recent survey efforts for the Greater Bilby in and near the Christmas Creek Survey Area.

Table 61: Survey Effort for the Greater Bilby

Survey	Trap Nights	Survey Hours	Motion Camera Hours (total)	Observations
Biota (2005)	400	-	-	No Greater Bilbies were recorded
ENV Christmas Creek Terrestrial Fauna and Fauna habitat assessment (2012a)	112	-	9 hours	No Greater Bilbies were recorded
Ecologia (2013) conservation significant fauna baseline monitoring	-	70,776	312	No Greater Bilbies were recorded
Outback Ecology (2013b) Cloudbreak Preclearance Greater Bilby and Mulgara Surveys		38	354	No Greater Bilbies were recorded
ENV Assessment of potential fauna diggings, Christmas Creek (ENV 2012c)	-	-	2 days	No Greater Bilbies were recorded
Total	**512**	**70,818**	**691**	**No records**

Threats

Predation by feral animals and clearing of habitat for grazing are considered to be the greatest threats to Greater Bilby populations (DoE 2014). The historic decline and the current distribution of the Greater Bilby correlate with the spread and distribution of the fox, while feral cats have been known to take the Greater Bilby as prey; however there is doubt over their role in the decline of Greater Bilby numbers. The Greater Bilby and the Dingo occur in similar environments, and the presence of Dingoes may improve habitat favourability for the Greater Bilby as they are an important predator of cats and may help displace populations of the fox (DoE 2014).

Other threats to the Greater Bilby in the Pilbara include competing for resources by rabbits and habitat disruption by cattle. Changed fire regimes are considered to play a role in the decline of the Greater Bilby, as seed from fire-promoted plants is a significant part of their diet (DoE 2014).

Conservation Programs in the Pilbara

A National Recovery Plan has been developed to achieve an accurate assessment of distribution, outline trends in occurrence of the Greater Bilby, and successfully reduce the impacts of key threatening processes (DoE 2014).

There are no known specific conservation programs in the Pilbara. The closest such program to the Pilbara is located at Francois Peron National Park (Gascoyne) managed by the DEC (now DPaW), where the Greater Bilby has successfully been re-introduced to the Peron Peninsula.

12.3.5 Pilbara Olive Python (*Liasis olivaceus barroni*) – Vulnerable

The Pilbara Olive Python is a dull olive-brown to rich brown python with a white underbelly and pale lips. The Pilbara Olive Python can grow up to 4 m in length but has an average size of 2.5 m, with females slightly larger than the males (DoE 2014).

The Pilbara subspecies is restricted to ranges within the Pilbara region, such as the Hamersley Range, and some islands of the Dampier Archipelago. This species prefers rocky escarpments, gorges and waterholes, with radio-telemetry indicating that individuals are usually in proximity to water and rock outcrops that attract suitably sized prey. Microhabitat preferences of the Pilbara Olive Python are under rock piles, on top of rocks or under Spinifex. Some individuals have been known to utilise man-made water sources such as sewage treatment ponds and recreational lakes (DoE 2014).

The Pilbara Olive Python is a strong swimmer, and often utilises waterholes to hunt for prey. This species is also known to wait in ambush along worn tracks (DoE 2014). The diet of the Pilbara Olive Python consists of Rock Wallabies, Euros, Fruit Bats, Ducks, Corellas and Spinifex Pigeons (Pearson 2006).

Males have been recorded travelling up to 4 km during breeding season (June to August) in search of females. Males and females often utilise caves for shelter and will remain together for approximately 3 weeks. Eggs are laid in October and hatch around January. Little is known about incubation or the average number of young; however, the young are known to disperse from place of birth in search of food (DoE 2014).

Habitat Preference

The Pilbara Olive Python is known to occur at 21 locations within the Pilbara, including populations at Pannawonica, Millstream, Tom Price and Burrup Peninsula (DoE 2014). Estimating population size for this subspecies is difficult due to the cryptic nature of the python, lack of any reliable trapping or census data and the narrow range of reliable surveys. One report considers that populations of this species are sizeable in pockets, with some remote populations removed from threatening influences (Pearson 2006).

The Pilbara Olive Python prefers deep gorges and waterholes in the range of the Pilbara region. Radio-telemetry has indicated that individuals spend the cooler winter months sheltering in caves and rocky crevices away from water sources before emerging in the warmer summer months. The Pilbara Olive Python is known to range widely, usually in proximity to waterbodies and rocky outcrops (DoE 2014). Potential suitable foraging habitat may occur within the Christmas Creek Proposal area, specifically in the Drainage Lines and Alluvial Plain habitat type when water is present.

Part of this species habitat is conserved within Karijini National Park.

Potentially suitable foraging habitat for the Pilbara Olive Python is presented in Figure 77 and suitable habitat for this species on a regional scale is presented in Figure 78.

Results of Targeted Fauna Surveys and Monitoring Programs

A number of surveys have been undertaken within the Christmas Creek Proposal area and surrounds, with only one individual recorded (ENV 2012a). This individual was identified on a haul road adjacent to the Drainage Line and Alluvial Plain habitat type; however, this was not the preferred habitat type for this species (rocky habitat) and, as such, this individual was considered to be dispersing or travelling through the area (ENV 2012a). ENV (2012a) considers that due to lack of suitable habitat within the Christmas Creek Proposal area, populations of the Pilbara Olive Python are unlikely to be affected by further development in the area. A targeted fauna survey was undertaken by ENV (2012b) with the primary objective to verify the presence of the Northern Quoll (as per Section 9.3 and 12.2), while the secondary objective was to search for the Pilbara Olive Python within the Proposal area. No signs of either species were detected.

This species was not identified in the Biota survey (2005); however, a sloughed skin was found in a cave above a water body near HDD05 in the Chichester Range during the Hope Downs rail surveys (Biota 2005). Surveys undertaken by Ecologia (2013) also did not record any Pilbara Olive Python individuals or secondary evidence of occurrence in potential habitat within the Christmas Creek Proposal area. Ecologia undertook a targeted monitoring survey in January 2014 for this species, and none were recorded (Ecologia 2014b).Table 62 outlines survey efforts and results of surveys undertaken in and near the Christmas Creek Survey Area to date.

Table 62: Survey Effort for the Pilbara Olive Python

Survey	Survey Hours	Motion Camera Hours (total)	Observations
Biota (2005)	-	-	No Pilbara Olive Python recorded
ENV Christmas Creek Terrestrial Fauna and Fauna Habitat Assessment (2012a)	53.5	-	No Pilbara Olive Python recorded
ENV Targeted Fauna Survey of the Christmas Creek Survey Area (2012b)	39	8	No Pilbara Olive Python recorded
Ecologia Christmas Creek Water Management Scheme Conservation Significant Fauna Baseline Monitoring (2013)	240	12,120	No Pilbara Olive Python recorded
Ecologia Christmas Creek Water Management Scheme Pilbara Olive Python Annual Monitoring Report 2014 (Ecologia 2014b)	14	-	No Pilbara Olive Python recorded
Total	**307.5**	**12,128**	**No records**

Threats

Predation by feral cats and foxes, especially on juveniles is considered to be the single greatest threat to the Olive Python, followed by predation of food sources (quolls and rock wallabies) by

foxes, major fires and destruction of habitat by gas and mining developments (DoE 2014). Given the species limited range and restricted habitat, the Olive Python may also be vulnerable to disturbance through increasing numbers of tourists using water holes, and some individuals have been deliberately killed when mistaken for venomous snakes.

Mining developments have the potential to affect habitat, alter prey availability and increase deaths through vehicle collisions. Additional water bodies such as dams and sewage ponds associated with mining or development; however, appear to benefit the snake and provide extra habitat where none previously existed (DoE 2014).

Conservation Programs in the Pilbara

There is no targeted conservation program for the Pilbara Olive Python in the Pilbara known to date. There are; however, many projects that assist Pilbara Olive Python populations both directly and indirectly. The Pilbara Corridors Project has been undertaken in partnership between Greening Australia and Rangelands NRM, and aims to address key environmental land issues within the Fortescue River catchment by:

- protecting and enhancing existing native vegetation
- managing threats to biodiversity through the coordinated control of threatening processes such as fire and feral fauna species
- contributing and assisting land managers to increase their uptake of sustainable grazing and land management practices.

The Threatened Species Scientific Committee (TSSC 2008) compiled conservation advice for the Pilbara Olive Python, which outlined priority research and actions to assist in the protection of this species. The extent of implementation of the recommended actions described in the advice is not known.

12.3.6 Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* [Pilbara form]) – Vulnerable

The Pilbara Leaf-nosed Bat is a moderate sized bat with short orange fur, small ears and a fleshy noseleaf structure surrounding the nostrils. This noseleaf is distinctively diamond shaped and differs from the squarer and rounder shapes of the noseleaf in other leaf-nosed bats. This species weighs between 8.7–9.3 g and has a forearm length of between 45.2–47.8 mm (Armstrong 2001).

The species is limited to the Pilbara and Gascoyne regions. Colonies of the Pilbara Leaf-nosed Bat are found in three distinct areas: in the mines of the eastern Pilbara; scattered throughout the Hamersley Range in smaller colonies; and in sandstone formations south of the Hamersley Range in a small number of significant colonies (Armstrong 2001). This includes the six confirmed roosts of Bamboo Creek Mine, Copper Hills Mine, Klondyke Queen Mine, Lalla

Rookh Mine and one cave in Barlee Range; and eight other likely permanent occurrences (DoE 2014).

A major component of the Pilbara Leaf-nosed Bat population, from both a demographic and genetic perspective, occurs in Barlee Range Nature Reserve, Western Australia. No roost has been confirmed in any other reserve system in the region (DoE 2014). The remainder of known roosts and observations of bats in flight or specimens collected occur on mining and pastoral leases. Other than being protected in the Barlee Range Nature Reserve, there is no active management of the species (DoE 2014).

Habitat Preference

As with all cave-roosting bats, the Pilbara Leaf-nosed Bat has separate diurnal and nocturnal habitats: the roost and foraging sites. Dry season roosting sites for the Pilbara Leaf-nosed Bat are restricted to caves and mine adits (horizontal shafts) with stable, warm and humid microclimates because of its poor ability to thermoregulate and retain water (DoE 2014). The roost is usually over pools of water, or deep in an area that maintains elevated temperature and humidity. The roosting site is often at depth in mines; in small crevices within caves, usually those ascending between sedimentary rock layers; and with associated groundwater seeps (DoE 2014). In the Pilbara, few roost clusters have been observed, perhaps the only one being that in the Comet mine (in Marble Bar) prior to 1992 (Armstrong 2001). Simple vertical shafts are not used by Pilbara Leaf-nosed Bats and shallow caves beneath mesa bluffs are also unlikely roost sites (Armstrong 2001).

Roosting habitat for Pilbara Leaf-nosed Bat is limited to areas likely to contain suitable caves. These may occur in hills and ranges, plateaux, mesa, breakaways, tor fields or along river gorges. Potential foraging habitat for the Pilbara Leaf-nosed Bat is presented in Figure 79 and suitable habitat on a regional scale for this species is presented in Figure 80.

Foraging habitat is diverse owing to the wide distribution of the Pilbara Leaf-nosed Bat; however, it has been observed in the following habitats in the Pilbara (DoE 2014):

- *Triodia* hummock grasslands covering low rolling hills and shallow gullies with scattered *Eucalyptus camaldulensis* along the creeks
- over small watercourses amongst granite boulder terrain and around nearby koppies (small hills rising up from the Spinifex grasslands)
- over pools and low shrubs in ironstone gorges
- over low shrubs and around pools in gravelly watercourses with *Melaleuca leucadendron*, such as in Barlee Range Nature Reserve.

The limiting factor for Pilbara Leaf-nosed bat numbers is considered to be roosting habitat.

Results of Targeted Fauna Surveys and Monitoring Programs

Surveys within and in proximity to the Christmas Creek Proposal area all failed to record any evidence of the Pilbara Leaf-nosed Bat. ENV (2012a) has stated that there is potential foraging habitat available throughout all habitat types identified within the Proposal area. However, maternal or day roost caves (critical habitat for the species) are not located within the Proposal area.

A Level 2 targeted survey was undertaken for the Northern Quoll in 2011 by ENV (ENV 2012b). An additional bat survey was conducted during this targeted survey where no evidence of the Pilbara Leaf-nosed Bat was recorded. Due to the lack of suitable roost caves and lack of any evidence of this species being recorded at Christmas Creek, it is considered unlikely to occur within the Proposal area. Table 63 outlines survey efforts and results of surveys undertaken in and near the Christmas Creek Survey Area to date.

Table 63: Survey Effort for the Pilbara Leaf-nosed Bat

Survey	Bat Acoustic Monitoring Hours	Survey Hours	Observations
Biota (2005)	12 sequences	-	No Pilbara Leaf-nosed Bat recorded
ENV Christmas Creek Terrestrial Fauna and Fauna Habitat Assessment (2012a)	3 nights	31	No Pilbara Leaf-nosed Bat recorded
ENV Targeted Fauna Survey of the Christmas Creek Survey Area (2012b)	7 nights		No Pilbara Leaf-nosed Bat recorded
Ecologia Christmas Creek Water Management Scheme Conservation Significant Fauna Baseline Monitoring (2013)	1 248	240	No Pilbara Leaf-nosed Bat recorded
Total	**>1,248 hours**	**271**	**No records**

Threats

A number of threats to populations of the Pilbara Leaf-nosed Bat are described below:

1. Heat and water loss: the Pilbara Leaf-nosed Bat has a poor ability to maintain heat and water balance in unsuitable roost microclimates.
2. Habitat disturbance: disturbance to critical habitat (suitable roosting habitat) due to collapse of old mine structures, flooding, backfill of old mine shafts during rehabilitation and human entry to roost sites.
3. Road kills: this species tends to fly relatively low, and displays a curiosity for light sources, resulting in collisions with vehicles

The Pilbara Leaf-nosed Bat is also particularly sensitive to human intrusion (DSEWPaC 2013), and so may be forced to migrate from an area if noise and vibration disturbances are significant

Conservation Programs in the Pilbara

At present, there is no specific conservation program for the Pilbara Leaf-nosed Bat in Western Australia. The Action Plan for Australian Bats details specific recovery and research actions for the Pilbara Leaf-nosed Bat, which includes requirements for replacing supports in old mines, further surveys of natural breeding roosts and the development of a Code of Practice for the mining industry.

12.3.7 Northern Marsupial Mole (*Notoryctes caurinus*) – Endangered

The Northern Marsupial Mole, also known as the Karkarratul, is a blind marsupial that has adapted to living underground. Its body is covered in long, silky, golden-brown fur and has a horny shield on the snout (DoE 2014). It has not been recorded from within the Pilbara bioregion.

The preferred habitat for this species is sand dune habitat and sandy soils along river flats. Underground signs of marsupial moles are usually found on well-vegetated dunes. The vegetation in Northern Marsupial Mole habitat is generally Acacia spp., small shrubs and Desert Oak and often associated with spinifex (*Triodia* spp.).

This species only recently appears on EPBC Act Protected Matters searches in this area. As such, previous fauna surveys at Christmas Creek have not targeted this species. The Northern Marsupial Mole has not been recorded in the Development Envelope in surveys undertaken by Fortescue. The proposed action will not disturb preferred habitat and the species has not been recorded in the Pilbara, therefore there is limited risk that the proposed action will affect this species.

12.3.8 Migratory Birds

The following section contains information on the remainder of the Migratory birds identified in the EPBC Protected Matters Search and the terrestrial vertebrate fauna desktop assessment conducted for the Proposal area in 2010 (Ecologia 2010).

Rainbow Bee-eater (*Merops ornatus*) – Migratory

The Rainbow Bee-eater is scarce to common throughout much of Western Australia, except for the arid interior. While habitat mapping is not available for this species at a regional scale, locations of sightings of this species in the Pilbara can be found in Figure 81.

The Rainbow Bee-eater occupies open country, most vegetation types and dunes, banks. It has been recorded from the Stony Plain, as well as Drainage Line and Alluvial Plane habitat types within the Christmas Creek Survey Area.

Eastern Great Egret (*Ardea alba*) – Migratory

The Eastern Great Egret occurs in the Kimberley, Pilbara, and on the west coast from the Murchison River south, throughout the south-west, and east to Cape Arid. It inhabits mostly shallow fresh lakes, pools in rivers, lagoons, lignum swamps, clay pans and Samphire flats, large dams and sewage ponds (ENV 2012a). The Eastern Great Egret also inhabits shallow saltwater habitats, and breeds colonially at wooded swamps and river pools, nesting in riparian trees (ENV 2012a).

The Drainage Line and Alluvial Plain habitat type, as well as the Marsh habitat type, provide suitable foraging habitat for this species, but only when water is present.

One individual was recorded within the Christmas Creek Survey Area during a previous survey in 2005 (Biota 2005), and the species was recorded during the Bamford (2012) aerial survey of the Fortescue Marsh.

Cattle Egret (*Ardea ibis*) – Migratory

The Cattle Egret is widespread and common in Australia and its breeding sites in Australia are known to occur predominantly on the east coast. The species was originally native to Africa, south-west Europe and Asia but has undergone a significant range expansion and is now found throughout South and Central America and the United States of America (DoE 2014). Locations of sightings of this species in the Pilbara can be found in Figure 82.

The Cattle Egret occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands. It has occasionally been seen in arid and semi-arid regions however this is extremely rare (DoE 2014).

The Cattle Egret has not been recorded within the Christmas Creek Survey Area; however, the Drainage Line and Alluvial Plain habitat type provides suitable habitat for this species.

Oriental Plover (*Charadrius veredus*) – Migratory

The Oriental Plover is a non-breeding visitor to Australia which commonly occurs in coastal and inland areas in northern Australia. Most records of the species are from the north-west coast of Western Australia (DoE 2014). While habitat mapping is not available for this species at a regional scale, locations of sightings of this species in the Pilbara can be found in Figure 83.

Oriental Plovers utilise coastal habitats such as estuarine mudflats and sandbanks, on sandy or rocky ocean beaches or nearby reefs, or in near-coastal grasslands, before dispersing further inland. Thereafter they usually inhabit flat, open, semi-arid or arid grasslands, where the grass is short and sparse and interspersed with hard, bare ground (DoE 2014).

The Oriental Plover has not been recorded as occurring within the Christmas Creek Survey Area or adjacent areas. The Stony Plains and Low Hill habitat types contain large amounts of Spinifex that may provide suitable foraging habitat.

Fork-tailed Swift (*Apus pacificus*) - Migratory

The Fork-tailed Swift is a relatively common trans-equatorial migrant from October to April throughout mainland Australia. Fork-tailed Swifts are a highly nomadic aerial species and can travel large distances.

The species is almost entirely aerial, particularly associated with storm fronts. As a result, Fork-tailed Swifts are likely to occasionally forage in the sky above the Survey Area at the start of the wet season.

White-bellied Sea-eagle (*Haliaeetus leucogaster*) - Migratory

The White-bellied Sea-eagle occurs in coastal and near coastal areas across Australia, inhabiting most types of habitats except closed forest. Locations of sightings can be found in Figure 84.

The White-bellied Sea-eagle has been recorded near the Proposal area at Roy Hill Station. The Marsh, and Drainage Line and Alluvial Plain, habitat types can contain surface water suitable for hunting. This species is not generally found as far inland as the Fortescue Marsh.

Wood Sandpiper (*Tringa glareola*) - Migratory

The Wood Sandpiper is a trans-equatorial migrant, spending the non-breeding months in Africa, south Asia and Australia.

Both the Marsh and Drainage Line and Alluvial Plain habitat types contain freshwater wetland which is suitable habitat for this species. The Wood Sandpiper has been previously recorded in the Marsh habitat type within the Christmas Creek Survey Area.

Common Greenshank (*Tringa nebularia*) - Migratory

The Common Greenshank is a non-breeding visitor to well-watered regions of Australia that can be observed in all months.

Similar to the Wood Sandpiper, both the Marsh and Drainage Line and Alluvial Plain habitat types contain freshwater wetland which is suitable habitat for this species. The Common Greenshank has been previously recorded in the Marsh habitat type within the Christmas Creek Survey Area.

12.4 Potential Impacts

Activities or aspects of the Proposal that have the potential to affect MNES species, not considering mitigation measures, include:

- clearing of habitat may reduce the capacity of the habitat to support fauna
- inappropriate fire regimes may indirectly impact on some MNES species through a reduction of foraging habitat or a reduction in cover resulting in increased predation
- groundwater abstraction and injection will affect groundwater levels, which may indirectly affect groundwater-dependent vegetation (potential fauna habitats)
- alteration to surface water flows can affect downstream fauna habitats
- trenching has the potential to provide temporary barriers for fauna movement as well as risk of stress, injury or fatality during construction where trenches are required
- establishment or increase in number of feral predators
- vehicle movements can cause mortality of small and sedentary fauna.

12.5 Assessment of Likely Direct and Indirect Impacts

12.5.1 Northern Quoll

Clearing of Habitat

Due to limited availability of habitat, Northern Quolls are not expected to be resident within the Development Envelope. However, individuals, especially males, may occasionally move through the Development Envelope due to the presence of potential foraging habitat located to the north-east.

Habitat availability, associated with the rocky escarpments in the Chichester Range foothills in the Survey Area, is limited. An area of 74 ha of the Christmas Creek Survey Area was considered to be potentially suitable denning habitat for Northern Quoll, but is located outside the Development Envelope. As such, Fortescue commits to avoiding clearing within the identified rocky escarpment habitat type and thereby avoiding any direct disturbance of preferred habitat for this species.

Inappropriate Fire Regimes

The Proposal does have the potential to increase the frequency of fires in proximity to the mine area. This can lead to a reduction of foraging habitat or a reduction in cover resulting in increased predation of Northern Quolls. Fires may be caused by:

- sparks from grinding or welding
- inappropriate disposal of cigarette butts
- ignition of flammable vegetation through sparks or radiated heat from vehicle exhausts.

Appropriate controls will be implemented as per the *Bushfire Management Plan* 100-PL-EM-0009 (Fortescue 2014e) to ensure indirect impacts to the Northern Quoll are eliminated. With these controls implemented on site, the risk of fire resulting from Proposal related activities will be minimised.

Groundwater Abstraction and Injection

Dewatering and injection activities will result in groundwater drawdown and mounding across the Proposal area. This can affect native fauna through the resultant effects on vegetation. Groundwater drawdown can lead to impacts on phreatophytic vegetation that relies on constant access to groundwater to survive, and for processes such as flowering and setting seed. In contrast, groundwater mounding may result in bringing the watertable into the root zone of intolerant plants, such as Mulga, with consequent effects on vegetation health. Impacts to vegetation from groundwater drawdown and mounding are discussed in detail in Section 7.6.2.

Some creekline vegetation dominated by Coolibah (*Eucalyptus victrix*) and River Red Gum (*Eucalyptus camaldulensis*) is potentially a GDE that can be found within the Drainage Line and Alluvial Plain habitat type. As these locations do not contain preferred habitat for the Northern Quoll, direct and indirect impacts of groundwater abstraction and injection are expected to be insignificant.

Alteration to Surface Water Flows

As discussed in Section 7.6.1, physical infrastructure such as mine pits, waste landforms and linear infrastructure can affect surface water flows by potentially diverting upstream flows and capturing rainfall within mining areas, reducing the catchment area for downstream flows. This can result in areas of shadowing that receive less flow than previously because surface flow processes have been interrupted or diverted. Shadowing can affect both channel flow and sheet flow processes.

The Stony Plain habitat type is the only habitat type likely to be directly and indirectly affected by altered surface water regimes as the Mulga communities within this habitat type rely on sheet flow (ENV 2013a). The Stony Plain habitat type is not a preferred habitat type for the Northern Quoll, and so impact to altered surface water regimes on this species will be insignificant.

Trenching

Trenching has the potential to provide temporary barriers for fauna movement as well as risk of stress, injury or fatality during construction where trenches are required.

Northern Quoll preferred habitat is located outside the Development Envelope, and will not be affected by trenching activities.

Feral Predators

Establishment or increase in the number of feral predators can be considered as a potential impact to this species. Existing management strategies including trapping and baiting programs to control feral animals are established at Christmas Creek, and will continue in order to control feral animal populations. General housekeeping practices including effective storage and handling of putrescible waste is also undertaken to reduce attraction of feral animals to the operations. As a result of the existing management strategies in place to control feral animals, the risk to this species associated with the establishment or increase in number of feral predators is considered to be low.

Vehicle Movements

There is a low risk of vehicle mortality for the Northern Quoll as preferred habitat for this species is located outside the Development Envelope.

12.5.2 Night Parrot

Clearing of Habitat

Based on the predicted preferred habitat of this species within the Proposal area, hummock grasslands with Spinifex from areas dominated by Samphire located in the Marsh habitat type provide potentially suitable habitat for this species. Approximately 14 ha of Marsh habitat type will be directly disturbed as a result of the Proposal, which makes up <0.1% of the 18,406 ha of this habitat type identified in the Survey Area. Spinifex communities are widely distributed throughout the Pilbara, and Samphire shrublands are also represented extensively in the area within and on the fringe of the Fortescue Marsh.

Potentially suitable foraging habitat is situated in the northern portion of the Survey Area as Low Hill habitat type. Approximately 2,255 ha will be disturbed as a result of the Proposal out of a total of approximately 13,976 ha of this habitat type identified within the Survey Area. The Night Parrot may forage within this habitat type only in the wet season due to the presence of Spinifex. Spinifex communities are well represented on a regional scale and, as such, it is expected that disturbance to this habitat type will not have a significant impact on this species. This level of habitat disturbance is not expected to cause fragmentation or significant edge effects.

Inappropriate Fire Regimes

Fire on site may indirectly impact on the Night Parrot through destruction of Low Hill habitat type, which provides potential foraging areas, located within the Development Envelope. Ongoing fire management will minimise the risk of uncontrolled fires within the Development Envelope, and so will minimise any indirect impact on the Night Parrot.

Groundwater Abstraction and Injection

Some creekline vegetation dominated by Coolibah (*Eucalyptus victrix*) and River Red Gum (*Eucalyptus camaldulensis*) is potentially a GDE that can be found within the Drainage Line and Alluvial Plain habitat type. As these locations do not contain preferred habitat for the Night Parrot, direct and indirect impacts of groundwater abstraction and injection are expected to be insignificant.

Alteration to Surface Water Flows

The Stony Plain habitat type is the only habitat type likely to be directly and indirectly affect by altered surface water regimes as the Mulga communities within this habitat type rely on sheet flow (ENV 2013a). The Stony Plain habitat type is not a preferred habitat type for the Night Parrot, and so impact to altered surface water regimes on this species will be insignificant.

Trenching

Trenching will not have a significant impact on this species as it is capable of flight and able to escape from holes or trenches.

Feral Predators

As a result of the existing management strategies in place to control feral animals, the risk to this species associated with the establishment or increase in number of feral predators is considered to be low.

Vehicle Movement

There is a low risk of vehicle mortality for the Night Parrot as preferred habitat of this species is located outside the Proposal area.

12.5.3 Greater Bilby

Clearing of Habitat

Greater Bilbies occur in a variety of habitats, including Spinifex grassland, Acacia shrubland, open woodland, and cracking clays where soil types are suitable for burrowing and foraging (Maxwell *et al*. 1996). Potential habitat for this species occurs in the Marsh habitat type within

the Survey Area. Approximately 14 ha of Marsh habitat type will be directly disturbed as a result of the Proposal, which makes up <0.1% of the 18,406 ha of this habitat type identified in the Survey Area. Based on the proposed clearing amounts and the broad availability of suitable habitat outside of the Proposal area, the Proposal is not expected to result in significant impacts to the Greater Bilby. Most of the preferred habitat is located outside the area proposed to be disturbed, and only less favourable habitat will be disturbed. The clearing associated with the Proposal is unlikely to result in edge effects and fragmentation of an important population, as the area is not considered to be ideal habitat when compared regionally.

Inappropriate Fire Regimes

Inappropriate fire regimes will not have a significant impact as habitat within the Survey Area that may be affected by uncontrolled fire is not considered favourable to this species. In limited parts of the Greater Bilby's range, fire may be an important factor in improving the habitat value for the species (DoE 2014).

Groundwater Abstraction and Injection

Some creekline vegetation dominated by Coolibah (*Eucalyptus victrix*) and River Red Gum (*Eucalyptus camaldulensis*) is potentially a GDE that can be found within the Drainage Line and Alluvial Plain habitat type. As these locations do not contain preferred habitat for the Greater Bilby, direct and indirect impacts of groundwater abstraction and injection are expected to be insignificant.

Alteration to Surface Water Flows

The Stony Plain habitat type is the only habitat type that is likely to be directly and indirectly affect by altered surface water regimes as the Mulga communities within this habitat type rely on sheet flow (ENV 2013a). The Greater Bilby also derives most of its water from food and so does not rely on free surface water to remain hydrated. Alteration to surface water regimes will not have a significant impact on this species.

Trenching

Trenching will not have a significant impact on this species as the majority of preferred habitat of this species is located outside the Development Envelope.

Feral Predators

As a result of the existing management strategies in place to control feral animals, the risk to this species associated with the establishment or increase in number of feral predators is considered to be low.

Vehicle movement

There is a low risk of vehicle mortality for the Greater Bilby as the majority of preferred habitat of this species is located outside the Development Envelope.

12.5.4 Australian Painted Snipe

Clearing of Habitat

Based on the predicted preferred habitat of this species within the Proposal area, the Marsh habitat type may provide potentially suitable foraging habitat for this species. Approximately 14 ha of Marsh habitat type will be directly disturbed as a result of the Proposal, which makes up <0.1% of the 18,406 ha of this habitat type identified in the Survey Area. The Fortescue Marsh provides suitable wetland habitat for this species outside the Development Envelope.

Inappropriate Fire Regimes

Ongoing fire management will minimise the risk of uncontrolled fires within the Development Envelope, and so will minimise any indirect impact on the Australian Painted Snipe.

Groundwater Abstraction and Injection

No significant indirect impacts to Samphire vegetation within the Marsh habitat which could potentially support this species are expected as a result of dewatering or injection of groundwater.

Alteration to Surface Water Flows

No significant alteration of surface water regimes is expected in the Marsh habitat.

Trenching

Trenching will not have a significant impact on a wading bird species.

Feral Predators

As a result of the existing management strategies in place to control feral animals, the risk to this species associated with the establishment or increase in number of feral predators is considered to be low.

Vehicle movement

Limited vehicle access will take place in the Marsh habitat, and as such, impacts to the species due to vehicle movement are not expected to be significant.

12.5.5 Pilbara Leaf-nosed Bat

Clearing of Habitat

The Pilbara Leaf-nosed Bat was not recorded during any surveys undertaken within the Christmas Creek Proposal area. This species is considered unlikely to roost within the area due to a lack of suitable habitat such as warm and humid caves. This species may; however, use Drainage Lines and Alluvial Plains for foraging. Approximately 1,117 ha of Drainage Line and Alluvial Plain habitat type will be directly disturbed as a result of the Proposal from a total of approximately 8,673 ha identified within the Survey Area. As roosting habitat is the key limiting resource for this species, and suitable roosting habitat has not been found in the Survey Area, clearing associated with the Proposal is not expected to significantly affect this species.

Inappropriate Fire Regimes

Uncontrolled fires are not expected to affect the Pilbara Leaf-nosed Bat as preferred habitat is not located within the Development Envelope.

Groundwater Abstraction and Injection

Dewatering and injection activities will result in groundwater drawdown and mounding across the Proposal area. This can affect native fauna through the resultant effects on vegetation. Groundwater drawdown can lead to impacts on phreatophytic vegetation that relies on constant access to groundwater to survive, and to support processes such as flowering and setting seed. In contrast, groundwater mounding may result in bringing the water table into the root zone of intolerant plants, such as Mulga, with consequent effects on vegetation health. Impacts to vegetation from groundwater drawdown and mounding are discussed in detail in Section 7.6.2.

Some creekline vegetation dominated by Coolibah (*Eucalyptus victrix*) and River Red Gum (*Eucalyptus camaldulensis*) is potentially a GDE that can be found within the Drainage Line and Alluvial Plain habitat type. This habitat type can provide foraging areas for the Pilbara Leaf-nosed Bat; however, this habitat type is not considered key preferred habitat and groundwater abstraction and injection will have an insignificant impact on this species.

Alteration to Surface Water Flows

Alteration to surface water flows is not going to have a significant impact as key roosting habitat for this species is located outside the Development Envelope. Potential foraging habitat (drainage lines and alluvial plains) will not be impacted by alterations to surface water flow and so impact on this species will be insignificant.

Trenching

Trenching will not have a significant impact on this species as the Pilbara Leaf-nosed Bat spends most of its time in flight or roosting in caves outside the Development Envelope.

Vehicle Movement

Pilbara Leaf-nosed Bats are known to forage close to the ground and, as such, may be more susceptible to vehicle strikes.

12.5.6 Pilbara Olive Python

Clearing of Habitat

The Pilbara Olive Python has a preference for rocky habitats including ranges and gorges with access to water (Bamford 2005). One individual was recorded as occurring within the Proposal area adjacent to the Drainage Line habitat type; however, this is not the typical rocky habitat preferred by this species, and the individual was considered to be dispersing or travelling through the area (ENV 2012a). Survey area does not represent ideal habitat for the Pilbara Olive Python; however, this species may traverse the area to gain access to habitat sites known to occur outside the Development Envelope.

Potential foraging habitat for this species is located within the Drainage Line and Alluvial Plain habitat type when water is present. Approximately 1,117 ha of Drainage Line and Alluvial Plain habitat type will be directly disturbed as a result of the Proposal from a total of approximately 8,673 ha identified within the Survey Area. Due to the lack of preferred habitat within the Development Envelope, the probability of this species to occur in proximity to the Proposal area is low. Disturbance to Drainage Line and Alluvial Plain habitat is not expected to have a significant impact on this species.

Inappropriate Fire Regimes

Uncontrolled fires have the potential to modify vegetation structure and result in reduced cover for the Pilbara Olive Python. This may result in an increased risk to predation. There is also the potential for the number of prey species to reduce. The Proposal area does not contain preferred habitat for the Pilbara Olive Python, and this species is only expected to traverse across the area to gain access to habitat sites known to occur outside the Proposal area. As a result, uncontrolled fires are not expected to have a significant impact on this species.

Groundwater Abstraction and Injection

Some creekline vegetation dominated by Coolibah (*Eucalyptus victrix*) and River Red Gum (*Eucalyptus camaldulensis*) is potentially a GDE that can be found within the Drainage Line and Alluvial Plain habitat type. The preferred habitat of the Pilbara Olive Python contains rocky outcrops in proximity to gorges and waterholes, which will not be affected by groundwater abstraction and injection.

Alteration of Surface Water Flows

The Stony Plain habitat type is the only habitat type likely to be directly and indirectly affect by altered surface water regimes as the Mulga communities within this habitat type rely on sheet flow (ENV 2013a). The Stony Plain habitat type is not a preferred habitat type for the Pilbara Olive Python, and impact to altered surface water regimes on this species will consequently be insignificant

Trenching

Trenching is not expected to impact on this species as the preferred habitat of the Pilbara Olive Python is located outside the Development Envelope.

Vehicle movements

There is a low risk of vehicle mortality for the Pilbara Olive Python as the majority of preferred habitat of this species is located outside the Development Envelope.

12.5.7 Migratory Birds

Eight migratory bird species have the potential to either fly over or forage within and around the Proposal area. Of these species, four have been recorded in or within proximity to the Proposal area. Impacts to migratory waders as a result of the Proposal are considered unlikely to occur due to the distribution of the species and the limited impact expected on the Fortescue Marsh. The area only provides habitat for migratory birds when the area is wet, which may only be a few days per year for the creek lines, but is likely to persist for longer periods in the Fortescue Marsh. Assessment of the potential impacts to each species is discussed further below.

Rainbow Bee-eater

The Rainbow Bee-eater was recorded within both the Stony Plain and Drainage Line and Alluvial Plain habitat types during the ENV survey (2012a). The Rainbow Bee-eater breeds throughout most of its range and is thought to adapt well to disturbance. Clearing during the breeding season has the potential to destroy nests and chicks of this species. The Rainbow Bee-eater is represented in a wide range of habitats (DoE 2014). Given the widespread occurrence of the species in the region and Australia and the range of habitat available, the species is not expected to be significantly affected by the Proposal.

Eastern Great Egret

The Eastern Great Egret may breed in the Fortescue Marsh. However, the area is considered likely to contain minor breeding sites with the largest breeding colonies, and greatest concentration of breeding colonies, located in near-coastal regions of the Northern Territory (DoE 2014). Approximately 14 ha of Marsh and approximately 1,117 ha of Drainage Line and Alluvial Plain habitat types will be directly disturbed as a result of the Proposal which makes up

approximately 1.7% of the habitat identified within the Survey Area. Creek lines associated with the Fortescue Marsh only provides habitat when infrequently inundated. Given this and the limited clearing and fragmentation that will occur within the Marsh habitat, the Proposal is unlikely to have a significant effect on this species.

Cattle Egret

The Cattle Egret is widespread and common in Australia and its breeding sites in Australia are known to occur predominantly on the east coast (DoE 2014). While no records exist of the Cattle Egret occurring in the Proposal area, the species may occur in the vicinity. Given the species is common and widespread nature, it is unlikely to be affected by the Proposal.

Oriental Plover

The Oriental Plover is a non-breeding visitor to Australia which commonly occurs in coastal and inland areas in northern Australia. Most records of the species are from the northwest coast of Western Australia (DoE 2014). While no records exist of this species occurring at the Proposal area, it may occur in the area. However, given that the species does not breed in Australia and noting its widespread distribution, it is unlikely to be affected by the Proposal.

Fork-tailed Swift

The Fork-tailed Swift is a non-breeding visitor to Australia which breeds exclusively in Mongolia (DoE 2014). Although this species was not recorded during surveys of the Proposal area, it was abundant during surveys of the Fortescue Stage B Rail Corridor that services Christmas Creek and Cloudbreak mine (Biota 2005). The species is almost entirely aerial and will not be affected by the activities of the Proposal.

White-bellied Sea Eagle, Wood Sandpiper and Common Greenshank

These species have all been recorded as occurring within the Proposal area or as being in proximity to the Proposal area. Both the Marsh and Drainage Line and Alluvial Plain habitat types contain freshwater wetland, when water is present, which is suitable habitat for these species. The Marsh is likely to be more important habitat than the Drainage Line and Alluvial Plain. Broad scale flooding of the Fortescue Marsh may persist for three to six months (DoE 2014), but creek lines are unlikely to hold water for extended periods.

12.6 Cumulative Impacts

The main potential cumulative impact is the combined effect of clearing of habitat potentially utilised by MNES species from Cloudbreak, Christmas Creek Mine and Roy Hill Mine. Generally, all habitat types that will be affected by the Proposal occur in other Project areas and will have some cumulative impact to the local representation of these habitat types. However, all

these habitats occur in the wider region and cumulative impacts are not expected to have significant impacts on the distribution and abundance of fauna species.

12.7 Management Measures and Performance Standards

12.7.1 Ground Disturbance

A procedure of internal review and approval of all proposed vegetation clearing and ground disturbance activities is required prior to the commencement of works (a GDP). Under the permitting process areas of vegetation which may comprise high value flora and vegetation, including of habitat value such as Mulga and 'habitat' trees, may require surveys to assess its value. This process is based on a risk assessment approach such that where particular risk factors are triggered, such as proximity to the Fortescue Marsh, drainage lines, Mulga and where no previous surveys have been conducted, further surveys are conducted prior to clearing where required. Areas confirmed as having higher values may then be reassessed for suitability for clearing in consultation with DPaW.

12.7.2 Environmental Management Plan

Management of potential impacts on fauna from this Proposal are also addressed in the *Conservation Significant Fauna Management Plan,* 100-PL-EN-0022 (Fortescue 2013c, Appendix 2H) and includes the following key management actions:

- clearing will not be undertaken outside authorised areas as defined under the GDP process (as described above)
- significant fauna habitat will be spatially identified and where appropriate, demarcated on site
- surface water storage facilities will have management measures such as fauna egress
- vehicles speeds will be restricted across the Proposal area
- off road driving or driving on restricted access routes will be prohibited other than for emergency situations
- rehabilitation of disturbed areas within the pipeline corridors not required to remain open post-construction will be implemented
- low noise equipment will be used where practicable and all activities will be carried out in accordance with statutory requirements and appropriate standards
- lighting will be directed onto construction or operational areas.

12.7.3 Offset Plan

Fortescue is currently in the process of developing an approach to offsetting the areas of preferred habitat for MNES threatened fauna species that will potentially be affected by Fortescue's Chichester Projects. Fortescue will develop a *Threatened Fauna Offset Plan* in

consultation with DoE and DPaW. Potential preferred habitat of threatened fauna affected by the Proposal includes:

- 14 ha of Marsh habitat for the Greater Bilby
- 2,269 ha of Marsh (14 ha) and Low Hill (2,255 ha) habitats; potential breeding and foraging habitat for Night Parrot
- 1,117 ha of Drainage Line and Alluvial Plains habitat; potential foraging habitat for the Pilbara Leaf-nosed Bat and Pilbara Olive Python
- 14 ha Marsh habitat for Migratory birds.

12.8 Predicted Environmental Outcomes

After mitigation measures have been applied, the Proposal is expected to result in the following outcomes in relation to MNES species:

1. Approximately 7,752 ha of potential MNES habitat will be directly disturbed by the Proposal with the majority of this occurring in the Stony Plain habitat type.
2. Clearing will not be undertaken in the rocky escarpment habitat which is potentially critical denning habitat for the Northern Quoll.
3. Approximately 14 ha (<0.1%) of the Marsh habitat type (potentially suitable habitat for the Night Parrot, Australian Painted Snipe and Greater Bilby) will be directly disturbed as a result of the Proposal.
4. Approximately 2,255 ha (16%) of Low Hill habitat (potential foraging habitat for the Night Parrot and Northern Quoll) will be directly disturbed as a result of the Proposal.
5. Approximately 1,117 ha (13%) of Drainage Line and Alluvial Plain habitat (potentially suitable foraging habitat for the Pilbara Olive Python and Pilbara Leaf-nosed Bat) will be directly disturbed as a result of the Proposal.
6. Surveys will continue annually as required to determine the presence/absence of the Night Parrot in the vicinity of the Proposal.

The Proposal is not expected to result in significant impacts to:

- species listed as Endangered or Vulnerable under the EPBC Act
- Migratory bird species listed under the EPBC Act.

With the management and mitigation measures in place, the Proposal will not significantly affect MNES.

13. REHABILITATION AND MINE CLOSURE

Closure planning is an ongoing process which requires regular review and development throughout the life of the Christmas Creek Mine. Regular review of mine closure planning documentation will capture changes in legal obligations, community expectations, corporate requirements, industry practice, improvements in technical knowledge, and changes to the Christmas Creek Mine.

13.1 Relevant Environmental Objectives, Legislation, Policies and Guidelines

13.1.1 EPA Objective

The EPA applies the following objective to the assessment of mine closure and rehabilitation:

> *To ensure that premises can be closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed outcomes and land uses, and without unacceptable liability to the State.*

13.1.2 Regulatory Framework

Mine closure is jointly regulated in Western Australia by the EPA under the EP Act and the Department of Mines and Petroleum under the *Mining Act 1978*. As the Christmas Creek Mine is operated under the *Iron Ore (FMG Chichester Pty Ltd) Agreement Act 2006,* the applicability of the *Mining Act 1978* is limited and rehabilitation and mine closure for this Proposal will be primarily regulated by the EPA under Part IV of the EP Act.

13.1.3 Guidance

The following regulatory position and guidance statements set the framework for the management of rehabilitation and mine closure:

- EPA and DMP (2011) *Guidelines for Preparing Mine Closure Plans*.
- DMP (2014) *Draft Guidelines for Preparing Mine Closure Plans* (October 2014).
- EPA (2006b) *Guidance Statement No 6: Rehabilitation of Terrestrial Ecosystems*.
- EPA (2013c) *Environmental and water assessments relating to mining and mining-related activities in the Fortescue Marsh management area*.

The EPA/DMP *Guidelines for Preparing Mine Closure Plans* (EPA & DMP 2011) are currently undergoing a formal review. The Guidelines were open for stakeholder review and comment in early 2014. DMP has since released a final draft version of the Guidelines (DMP 2014), and the revised version is due to be published for use in early 2015.

13.2 Surveys and Investigations

13.2.1 Conceptual Closure Plan

A *Conceptual Closure Plan* was developed for the Stage B Project, which incorporated the development of the Christmas Creek Mine. Since the development of the *Conceptual Closure Plan*, a large number of studies have been undertaken at Christmas Creek, which has increased the understanding around environmental factors relevant to the closure and rehabilitation of the Mine.

13.2.2 Mine Closure Plan

A Mine Closure Plan (MCP) has been prepared for Christmas Creek, incorporating the existing operations and the Proposal in accordance with the draft DMP *Guidelines for Preparing Mine Closure Plans* (DMP 2014). This MCP is included as Appendix 8E.

This MCP incorporates the following:

- consolidation and documentation of all previous work undertaken pertinent to closure planning and rehabilitation
- a framework of closure domains
- identification of the studies, trials, research, assessment and monitoring that are recommended/ required post approval
- objectives, criteria, post-mining land use(s) and closure issues
- identification of risks that could influence successful closure and tenure relinquishment
- identification and prioritisation of tasks using a risk management approach to guide future closure planning works
- framework for calculating indicative closure costs for financial provisioning and the timeframes for implementation
- pathway to relinquish the site.

13.2.3 Desktop Assessment of Rehabilitation

Fortescue has undertaken a desktop assessment of rehabilitation strategies in the Pilbara (Fortescue 2014h, Appendix 8A). This assessment provides a summary of rehabilitation practices at Fortescue, along with providing strategies and case studies of rehabilitation covering the following aspects:

- characterisation of soil profiles and waste material

- vegetation, topsoil and growth medium management
- reconstruction of soil profile
- selecting appropriate species and seed management
- vegetation establishment
- completion criteria
- rehabilitation and revegetation monitoring
- potential rehabilitation strategies for Christmas Creek closure domains.

13.2.4 Waste Characterisation

A summary of the Waste Characterisation undertaken to date at Christmas Creek is provided in Section 2.2.1 and an assessment of potential impacts of AMD to water quality is provided in Section 8.6.3.

Based on the characterisation work completed, the AMD risk posed by the Proposal is considered to be low. Waste rock and tailing material subjected to acid-base analysis has been classified as barren (very low in sulphur) and NAF or NAF-uncertain (URS 2014). As such, specific strategies for the management of PAF material during mining have not been required.

Christmas Creek has an ongoing AMD characterisation programme for waste, tailings and pit wall material, which is presented in detail in Section 8.6.3. In the unlikely event that PAF material is identified in areas which will be disturbed as part of future mining activities, specific management strategies will be developed to ensure that potential impacts to soil quality and water quality are minimised.

13.2.5 Ongoing Investigations

Investigations will be carried out over the life of mine to assist the ongoing life of mine planning for the Proposal. Investigations include, but are not limited to, rehabilitation design and layout, geochemical characterisation and ongoing monitoring of pit and waste rock dump stability. The outcomes of these investigations will be used to refine closure criteria and rehabilitation strategies.

13.2.6 Rehabilitation and Revegetation Activities undertaken to Date

Fortescue has undertaken rehabilitation activities at a number of sites, including mine and rail areas. The sections below provide a brief summary of the rehabilitation activities undertaken and the monitoring data available.

Christmas Creek Mine

Fortescue has conducted 5.7 ha of rehabilitation at Christmas Creek to date. A laydown area and access track totalling 3.58 ha was rehabilitated in 2014, and a borrow pit of 2.12 ha was rehabilitated in 2011.

The borrow pit was rehabilitated as per Fortescue's *Borrow Pit Management Plan* (45-PL-EN-0018). Following contouring, the borrow pit was deep ripped but topsoil spreading and seeding was not undertaken. The borrow pit was monitored for the first time in 2014 as part of Fortescue's rehabilitation monitoring program in accordance with Fortescue's *Rehabilitation and Revegetation Monitoring Procedure* (45-PR-EN-0027), with parameters recorded for:

- vegetation
    - species richness
    - diversity
    - composition
    - perennial species percentage cover
    - density
- landscape function analysis
    - stability
    - nutrient cycling
    - infiltration.

No measurements for erosion were taken as no recordable rills and gullies were present.

Monitoring results show that the rehabilitation is performing well when compared to analogue sites. Species richness, diversity and composition are all similar to the analogue sites. The overall cover of native perennials is lower than the analogue sites; due mostly to a lack of spinifex in the ground cover, but the cover of middle-storey and the density of upper storey species is comparable to remnant vegetation. The landscape function analysis data shows both the infiltration and nutrient cycling indices of the rehabilitation site are comparable with the analogues, but that the stability index is below that of remnant vegetation. This is expected to improve following further development of perennial ground cover.

The Airport Topsoil Storage and Laydown Area (2.65 ha) was rehabilitated in July 2014. The area was contoured and reshaped by a grader in order to encourage natural drainage and prevent the establishment of ponded water. Topsoil from the existing stockpiles was applied over the entire disturbance area and spread to a depth of 100 cm. The entire surface was deep ripped to a depth of 100 cm. Additional grub and log mulch was obtained from an existing

topsoil stockpile within the area and spread over the surface and a pile of rocks previously present when the area was cleared was retained as habitat.

The area was monitored in late 2014. All landscape function analysis parameters at the rehabilitation area were lower than the analogue sites, as to be expected for a recently disturbed area, although the nutrient cycling index was similar to one of the analogues. With favourable conditions and adequate rainfall, it is anticipated that some vegetation will establish from the seedbank in the topsoil. It is also expected that some vegetation may establish from surrounding undisturbed areas with existing native vegetation, such as *Acacia ancistrocarpa, A. maitlandii, Corchorus parviflorus, Tephrosia rosea* var. Fortescue Creeks and *Triodia basedowii*.

The Airport Access Track area (0.93 ha) was also rehabilitated in July, 2014. The area was contoured and reshaped by a 980 Loader in order to encourage natural drainage and prevent the establishment of ponded water. Topsoil/vegetation from a nearby stockpile were delivered to the area and spread to a depth of 100 cm. The area was deep ripped and some areas of previously existing native vegetation growth were left in place when rehabilitation earthworks were undertaken.

Photographic monitoring from two photo points was undertaken at this site in 2014. Fourteen native species were recorded at this area including *Acacia* and *Senna* spp. Minor amounts of erosion were recorded in the area as well as the presence of kapok bush (**Aerva javanica*) and buffel grass (**Cenchrus ciliaris*). Monitoring will take place annually for the first three years according to the procedure then every two years, and monitoring data will be used to set completion criteria for Christmas Creek. Remedial actions will be undertaken if the levels of erosion and weeds compromise the success of the rehabilitation works

Future rehabilitation earthworks are planned for 2015/2016, including Flinders Waste Rock Dump, and the ANFO clearance area adjacent to the explosives magazine. A revegetation trial to investigate optimum seeding rates is planned for this area, with a seed mix selected as per Fortescue's *Seed Collection and Management Guidelines* (45-GU-EN-0007).

Cloudbreak Mine

Extensive planning for Cloudbreak's rehabilitation programme took place between 2011 and 2013, with targeted geotechnical and geochemical research undertaken for closure landforms to address safety, stability, appropriate hydrology and visual amenity objectives. Bulk rehabilitation earthworks and initial profiling commenced in 2013 for three waste dumps (Cocos 2, Green and Brampton 3) and continued throughout 2014, with final slope profiling, surface water management structures including drains and growth medium application taking place in 2014. Physical and chemical characterisation of stockpiled topsoil materials from all three dumps was undertaken in 2014 to determine the suitability of the material as a rehabilitation resource.

All three waste dumps were rehabilitated with a batter bench structure, with batter slopes ranging from 14 to 20 degrees and 5 degree backsloping berms. The eastern face of Cocos

Waste Rock Dump (12.3 ha), the entire Green Waste Rock Dump (37.28 ha) and the eastern face of Brampton 3 Waste Rock Dump (26.26 ha) have been rehabilitated.

The rehabilitation monitoring program at Cloudbreak commenced for the first time in 2014, with monitoring conducted as per Fortescue's *Rehabilitation and Revegetation Monitoring Procedure* (45-PR-EN-0027), with additional bioindicator monitoring of ants at selected Mulga analogue sites to address the specific requirements of the *Cloudbreak Revegetation Management Plan* (CB-PL-EN-0026). Other parameters recorded included: vegetation (species richness, diversity, composition, perennial species percentage cover, density) and landscape function analysis (stability, nutrient cycling, and infiltration) and erosion.

Landscape function indices for all sites were low in comparison to the control sites and reflected the soft topsoil and absence of a surface crust, as expected due to the recent disturbance and young age of the rehabilitation area. The sites have not been seeded and as expected due to the lack of rainfall, no vegetation was present at the time of monitoring. In terms of landscape organisation, there was a high proportion of troughs at each rehabilitation transect, formed by ripping of the soil surface, and these will provide areas for retention and accumulation of resources, such as water and organic material. Monitoring will take place annually for the first three years according to the procedure then every two years, and monitoring data will be used to set completion criteria for Cloudbreak.

Future earthworks are planned for Cocos 3 and Long Waste Rock Dumps, in 2015-2017, with revegetation planned using a seed mix to be applied mechanically whilst ripping takes place. The seed mix has been selected specifically for the Ranges, Hills and Hillslopes broad vegetation community which is the target community for waste dump rehabilitation at Cloudbreak.

Solomon Mine

Fortescue has undertaken 56.7 hectares of rehabilitation at Solomon to date, with the majority of works estimated to have taken place in 2012 and some small areas of reworking done in 2013-2014. The 24 rehabilitated areas include rehabilitated airstrips, the old Fly Camp; borrow pits for mining areas and linear disturbance such as access tracks.

Works have included contouring and deep ripping as per Fortescue's *Borrow Pit Management Plan* (45-PL-EN-0018). Specific recommendations provided for the airstrip rehabilitation included contouring to a <5% relief, respreading of topsoil stockpiles, deep ripping and seeding.

The rehabilitation monitoring program at Solomon commenced for the first time in 2014, with monitoring conducted as per Fortescue's *Rehabilitation and Revegetation Monitoring Procedure* (45-PR-EN-0027). Photographic monitoring was undertaken at the smaller rehabilitation areas and linear infrastructure. Parameters recorded included: vegetation (species richness, diversity, composition, perennial species percentage cover, density) and landscape function analysis (stability, nutrient cycling, and infiltration) and erosion.

Overall, compared to control sites, rehabilitation sites had a higher percentage of interpatches, lower infiltration and stability indices, higher nutrient cycling index, higher species richness and species evenness with a higher proportion of annuals and lower perennial vegetation cover. The perennial cover of rehabilitation sites tended to be dominated by shrubs (*Acacia* spp.), whereas control sites were generally dominated by hummock grasses (*Triodia* spp.). Monitoring will take place annually for the first three years according to the procedure then every two years, and monitoring data will be used to set completion criteria for Solomon.

Proposed future rehabilitation works and revegetation trials include earthworks at a section of haul road in Valley of the Kings, to trial a closure profile of 15 degrees and incorporating a bench berm structure. Part of the slope may also be used as a site for revegetation trials. There are other laydown/cleared areas throughout the mine which may be available for rehabilitation in the next 12-18 months.

Rail

Fortescue's rail network includes the Hamersley Line (Solomon), Mainline and East-West Spur. Approximately 2,489 hectares of rehabilitation have been undertaken, comprising mostly of borrow pits, with the majority of earthworks done in 2008 and 2012.

Borrow pits were rehabilitated as per Fortescue's *Borrow Pit Management Plan* (45-PL-EN-0018) and *Railway Corridor Rehabilitation Management Plan* (R-PL-EN-0008), which stipulates that rehabilitation works must stabilise the land surface such that it is safe, stable, erosion resistant over the long term and where practicable, visually similar to the surrounding landscape, re-establish self-sustaining vegetation that is compatible with planned end land uses and minimise adverse effects on the environmental values of the surrounding area.

Rehabilitation monitoring has been conducted previously at the Hamersley Line and Mainline, consisting of landscape function analysis, photographic monitoring and carbon dioxide flux monitoring, and was conducted in 2009 and 2013. As part of Fortescue's newly established, whole of operations rehabilitation monitoring program, monitoring took place at the Hamersley Line, Mainline and East-West spur in 2014 as per Fortescue's *Rehabilitation and Revegetation Monitoring Procedure* (45-PR-EN-0027).

Transects were installed on a variety of rehabilitation areas (borrow pits, overburden stockpiles, laydown areas) and topographies ranging from flats to steep slopes and photographic monitoring was also undertaken as part of the assessment in 2014.

Given the high volume of sites, and in order to evaluate the progression of rehabilitation, sites were compared to each other and to their respective control sites, using the maximum and minimum values of the control sites to set a 'control range'. Given the early stage of rehabilitation for all rehabilitation sites, values below the control range were not considered to specifically indicate poor rehabilitation. Instead, the control range was used to provide a reference or benchmark for rehabilitation values. Landscape function indices were typically lower for rehabilitation than those of the control sites, especially the stability index. Landscape

function indices are likely to improve over time with the growth of vegetation. Patch proportions (areas which capture vital resources such as water and nutrients) were typically higher on the control sites were they were formed naturally by vegetation and litter. Patches on rehabilitation sites were primarily comprised of troughs, formed by ripping of the soil surface. Over time it is expected that the proportion of troughs on rehabilitation will diminish, and the proportion of vegetation and litter will increase if vegetation is developing along a desired trajectory.

Vegetation results for rehabilitation areas were varied, with only 20 sites displaying total perennial cover within the control range, yet 41 sites had total perennial density within the control range. This indicates that the size of plants was generally smaller on the rehabilitation sites, but there was a large number of plants and therefore potential for increased cover in the future. Given that *Triodia* was the dominant genus on 85% of the control sites, its presence on rehabilitation sites was considered very important. The majority of rehabilitation sites had some *Triodia* present, and 28 transects had *Triodia* cover within the control site range. Two possible impediments to successful rehabilitation were recorded in 2014. These included the introduced grass species *Cenchrus ciliaris* (buffel grass), and erosion features, comprised of rills (<30 cm deep) and gullies (≥ 30 cm deep). Four rehabilitation transects were considered to be performing extremely well, and had eight out of eight measured parameters, including landscape function analysis and vegetation parameters, within or above the range of the control sites. Monitoring will take place annually for the first three years according to the procedure then every two years and monitoring data will be used to set completion criteria where relevant for Rail.

13.3 Potential Impacts

Should there be poor rehabilitation and mine closure planning and management practices there could be a number of undesirable impacts to the receiving environment, such as:

- unauthorised vegetation disturbance
- depletion of topsoil resources
- compacted soil layers with poor infiltration rates
- the formation of pit lakes which may attract and harm wildlife, birds or stock
- the introduction of weeds to rehabilitated areas
- landscape modification, altered hydrology and other ecosystem impacts
- unstable landforms and adverse dust impacts
- poor return of native vegetation and flora species
- contamination.

13.4 Rehabilitation and Mine Closure Planning – Operational Aspects

The following sections present information related to the closure of specific operational aspects of the Christmas Creek mine, including:

- backfill strategies
- pit lakes
- WRSF
- TSF
- surface water management across pit voids.

13.4.1 Backfill Options

Fortescue considers numerous options for backfilling of pits during the development of each iteration of the Christmas Creek mine plan. Considerations regarding backfilling of pits are subject to change over time, and backfilling strategy can be influenced by factors such as:

- current product strategy: cut-off levels between ore and waste, which influences the ratio of ore: waste and thus the volume of waste material that is available to be used as backfill
- potential sterilisation: inability to access material which could be classified as ore in the future, either in temporary stockpiles or beneath currently mined pits
- mine layout: haul distances from temporary waste stockpiles to potential backfill areas
- rehandling costs: dependent on fuel and labour costs
- alternative uses for waste material: waste material with suitable geotechnical and geochemical characteristics can be used in the construction of tailings facilities and as construction fill material in mine infrastructure areas.

Pit voids can be backfilled with the following materials, either in isolation, or as a combination of materials:

- waste material (incorporating overburden and internal waste)
- tailings
- imported clean fill material.

General options for backfilling include:

1. **No Backfill**: pit voids left completely unfilled, all waste and/or tailings materials stored in permanent external WRSFs and TSFs

2. **Partial Backfill, Some Waste**: pit voids partially filled, some waste and/or tailings materials stored in permanent external WRSFs and TSFs
3. **Partial Backfill, All Waste**: pit voids partially filled with all available waste material and tailings, no waste and/or tailings materials stored in permanent external WRSFs and TSFs
4. **Complete Backfill**: backfill of all pit voids to pre-mining ground surface level.

The existing, approved strategy for backfilling at Christmas Creek is Option 2: Partial Backfill, Some Waste with all pit voids backfilled to a minimum of the pre-mining groundwater level.

An assessment of backfill options for the Proposal has been undertaken and is summarised below.

Option 1: No Backfill

In order to implement this option for the Proposal, external WRSFs and TSFs would be used for the permanent storage of all waste rock and tailings. This option involves no rehandling of waste materials and costs for waste handling are borne progressively throughout the operational life of the mine.

External storage of all waste and tailings would require a significantly larger disturbance footprint. Above ground WRSFs and TSFs carry inherently higher environmental risks

The levels of the pit floors at Christmas Creek are generally below the level of the natural groundwater table. Following the cessation of dewatering activities, pit voids will partially fill with groundwater, resulting in a permanent pit lakes developing over time. Environmental impacts associated with permanent pit lakes have not been assessed in detail at Christmas Creek, but impacts could include:

- decreased surface water quality (including salinity, water chemistry and dissolved metals)
- decreased groundwater quality
- alteration of behaviour of migratory bird species using the Fortescue Marsh for foraging or breeding
- alteration of surface water flows downstream of pit voids.

Option 1 is not a preferred option for the Proposal.

Option 2: Partial Backfill, Some Waste

This Option is currently being implemented at Christmas Creek, as described in Section 4.9. Sequential backfilling of pits with mine waste is undertaken where practicable, and tailings are stored in the Windich in-pit TSF and the Vasse in-pit below and above ground TSF.

Option 2 allows for backfilling of some pit voids with waste material or tailings. Backfill is undertaken to above the pre-mining groundwater table level in all pit voids. Some waste material will be stored in permanent external WRSFs. Tailings are stored preferentially in mined-out pits, but some external TSFs may be developed as required. Some rehandling of waste material may occur, but the majority of material can be placed in its final location during operations. The footprint associated with the Proposal is reduced, as there are less external WRSFs or TSFs required. This option does not result in the creation of permanent pit lakes.

Option 2 is the preferred backfill option for the Proposal.

Option 3: Partial Backfill, All Waste

Option 3 allows for backfilling of pit voids with waste material or tailings. Backfill is undertaken to above the pre-mining groundwater table level in all pit voids. All waste material is used for backfill purposes and none will be stored in permanent external WRSFs. All tailings are stored in mined-out pits and no external TSFs will be developed. Significant rehandling of waste material will occur. The footprint associated with the Proposal may be reduced, as no permanent external WRSFs or TSFs required. However, temporary WRSFs and TSFs would likely be required to store waste material sourced from the initial strips in new pits, and for tailings material in the instance that there is no available capacity to store tailings in mined-out pits. Implementation of this option involves a loading of waste handling costs to the end of the operations, when any temporary WRSFs and TSFs would be removed and placed into mined-out pits as backfill material. Materials balance undertaken in the current life-of-mine plan indicates that based on current strip ration's, ore classifications and ore prices, insufficient material will be available to completely fill all pit voids to pre-mining ground surface level, even when all waste and tailings are returned to the pit voids. This option does not result in the creation of permanent pit lakes.

Option 3 is not a preferred option for the Proposal.

Option 4: Complete Backfill

Complete backfill of all mine voids is not a practical or cost effective option at Christmas Creek. Quantities scheduling based on current ore classifications and projected iron ore prices indicates that insufficient volumes of waste and tailing will be produced to fill all pit voids to pre-mining ground surface. As such, fill material from offsite would need to be imported to allow for complete backfill.

Option 4 is not a preferred option for the Proposal.

13.4.2 Pit Lakes

Fortescue will backfill all pits to at least pre-mining groundwater level prior to closure. As such, permanent pit lakes are not anticipated to occur as part of the Proposal. During the operational

phase of the Proposal, temporary pit lakes may occur following periods of heavy rain or when dewatering pumps are switched off in a particular area of dewatering. As such, the potential for long term contamination of surface water or groundwater resulting from permanent pit lakes is not considered further as part of this Proposal.

13.4.3 Waste Rock Storage Facilities

Fortescue designs external WRSFs in accordance with the internal guidance document *Planning for Closure – Design of Mineral Waste Rock Landforms* (100-PR-EN-1017, Appendix 8B). This document outlines design considerations and guidance, including:

- risk assessment
- site selection
- surface drainage
- topsoil recovery and management
- deposition
- geometry of waste landforms
- surface water management
- armouring/capping
- closure criteria
- revegetation
- closure costing.

As described in the guidance document, a number of site specific studies are required in order to undertake detailed design of each specific landform. These studies include:

- geochemical assessment of mineral waste rock and soil (in accordance with the *Characteristics of Mineral Waste Rock and Soils Guideline* (100-GU-EN-0018))
- geotechnical assessment;
- vegetation survey outcomes;
- soil characterisation programs;
- available plant (topsoil, seed and plants) and soil substrate (plant growth medium and parent material).

Ongoing waste rock characterisation at Fortescue's Chichester operations allowed for the representative physical properties of waste rock to be identified (Table 64).

Table 64: Physical Properties for Representative Chichester Waste Rock

Property	Parameter	Unit	Results
Soil Classification	USCS	-	GP-GW Poorly to well graded GRAVEL
Particle Size Distribution	>2 mm (Gravel sized)	% Retained	–50 - 75%
	2 mm to 75 µm (Sand sized)	% Retained	–20 - 30%
	<75 µm (Silt and clay sized)	% Passing	5 - 20
Atterberg Limits	Liquid Limit (LL)	%	25 – 30
	Plastic Limit (PL)	%	12 - 21
	Plasticity Index (PI)	%	Non plastic to 9
	Linear Shrinkage (LS)	%	3.0 – 4.5
Standard Compaction	SMDD	t/m^3	2.30 - 2.45
	OMC	%	10 - 12

Key design considerations for WRSFs include:

- Wherever possible, outer embankment faces should be constructed to their final slopes and geometry (including any inter-berm benches) and progressively rehabilitated to reduce long term closure costs.
- Rock and material types that show a high resistance to erosion should be identified and stored adjacent to the WRSF for future use as armouring material.
- The geotechnical properties of all material types must be identified and assessed.
- Materials that have been identified during the assessment process with a high clay, sand or kaolin content (i.e. potentially erodible materials), are not suitable for final slopes and will have to be placed within the WRSF or used as backfill elsewhere.
- The planning process must include the characterisation and source of mineral waste rock and soils to be placed within and on the surface of the WRSF.

Flood modelling will assess the performance of the adopted risk based closure design of WRSFs and will include assessment of impact under a range of hydrological conditions up to and including the Probable Maximum Flood.

13.4.4 Tailings Storage Facilities

TSFs are designed to meet the requirements of the *Guidelines on the Safe Design and Operating Standards for Tailings Storage* (DME 1999) and the *Guidelines on Tailings Dams; Planning, Design, Construction, Operation and Closure* (ANCOLD 2012).

Each TSF design takes into consideration the following factors:

- risk assessment

- geotechnical assessment of construction materials, including soil classification, particle size distribution, Atterberg limits, standard compaction, falling head permeability and internal angle of friction
- geochemical assessment of construction materials including aba, nag testing, pH, electrical conductivity, SPLP, total elemental analysis and mineralogical analysis
- geotechnical and geochemical assessment of tailing material
- hydrological assessment of the pit floor and pit walls, for an in-pit TSF
- embankment stability assessment, typically using software such as SLOPE/W
- freeboard assessment and water balance over the life of the facility
- rehabilitation and closure assessment.

Flood modelling will assess the performance of the adopted risk based closure design of TSFs (in accordance with ANCOLD guidance) and will include assessment of impact under a range of hydrological conditions up to and including the Probable Maximum Flood.

13.4.5 Surface Water Management across Pit Voids at Closure

Fortescue has undertaken extensive investigation into the management of significant creeklines for closure. An internal guideline has been developed (Appendix 8C), along with a case study (Appendix 8D). These documents are available for confidential regulator review, and will not be included as appendices to the PER which is released for public review.

The *Guideline for Re-Establishing Major Watercourses across Backfilled Pits* CH-GU-EN-0002 (Appendix 8C) was developed specifically for Fortescues Chichester operations and outlines the processes to be followed when backfilling pits that have disturbed major watercourses, which require the backfilled surface to be stable and self-sustaining under drainage patterns similar to those that existed before mining commenced.

The channel design process is based upon the following concept:

- The broader active channel design for major watercourses includes a pilot channel.
- The longitudinal gradient of the active channel bed should match the existing channel gradients at the upstream and downstream ends of the backfilled pit, as being similar to the original channel gradients along its length.
- Pilot and active channel cross sectional area are based on upstream and downstream channel dimensions. Any transitions zones need to be checked for potential for excessive erosion.
- The transition between the active channel zone and the higher overbanks should be limited to a batter slope of approximately 10% (1V:10H or 5.7 degrees) or less, to minimise initial bank erosion.

- The surface of the overbanks should be contoured to create micro-topography perpendicular to the down-fan slope to retain fines and moisture to promote vegetative growth.
- Post construction monitoring will determine the need for and location of lateral restraints. On meandering channels the designer should consider placing coarser waste rock, if available, on the thalweg (main channel flow) side where velocity is likely to be highest. Lateral restraints may be required for retention until vegetation is established. Lateral restraint construction options include:
  - Use of excavated channel material to replace eroded material.
  - Lateral restraints may be constructed by using locally available materials including deeper cemented/indurated fan materials that are unsuited for riprap, gabions, fabric-encapsulated trench fills or soil-cement, all of which would be temporary.
  - The spacing of the lateral restraints to be based upon post construction monitoring. For estimating purposes, these are expected to be at spacings approximately 3-5 times the pilot channel width, and the lengths of the individual structures would be approximately the same as the pilot channel width.

13.5 Rehabilitation and Mine Closure Planning – Closure Aspects

13.5.1 Post Closure Land Use

The Proposal is located primarily on Pastoral Leases. Closure activities will aim to return the land to its pre-mining land use. Areas within Pastoral Lease boundaries will be returned to a pastoral land use, namely low intensity livestock grazing. Fortescue will take into consideration the proposed FMCR and if a conservation reserve is instated prior to the cessation of mining, the post closure land use will be reviewed in consultation with DPaW.

13.5.2 Closure Domains

Planning for mine closure has identified a number of domains to enable clear and specific objectives and strategies to be identified. The domains have been developed such that areas where similar rehabilitation works and strategies are required are combined into one domain. This provides a structured and consistent approach to closure of the site. The domains identified for mine closure planning are:

- TSF
- WRSF
- mine pit void
- processing area and support infrastructure

- CCWMS infrastructure (pipelines and ponds).

The MCP (Appendix 8E) addresses closure for the three major closure domains including mine voids, WRSFs and TSFs. Due to the long project life, these three landform features will comprise the majority of ongoing environmental work (e.g. rehabilitation and monitoring) during operations, and therefore provide the focus for the current MCP. All other domains on site, which primarily consist of infrastructure which cannot be progressively rehabilitated, will be addressed in a decommissioning plan to be developed within five years of the planned completion of operations.

13.5.3 Closure Objectives

Closure management will assist in ensuring that disturbed areas are safe and suitably rehabilitated for the long term end land use as determined in consultation with relevant stakeholders and the community. Fortescue's environmental objectives in relation to rehabilitation and closure are to:

- establish a safe and stable post-mining land surface which supports vegetation growth and is erosion resistant over the long-term
- re-establish a self-generating ecosystem comprising local native vegetation and fauna species which resembles the surrounding environment
- leave site in a safe, stable, non-polluting and tidy condition with no remaining plant or infrastructure that is not required for post-operational use
- minimise downstream impacts on vegetation due to interruption of drainage
- identify any potential long-term soil, surface water or groundwater pollution associated with the operations and formulate an action plan to address this
- develop a stakeholder consultation group prior to closure, to facilitate discussion of closure planning
- continue to monitor environmental performance during decommissioning, rehabilitation and post-closure stages of the project and take appropriate action until the approved completion criteria have been met.

Indicative completion criteria and measurement tools used to assess closure success of each domain are also summarised in Table 65.

Table 65: Closure Objectives, Completion Criteria and Measurement Tools

Subject	Objective	Domain	Criteria	Verification Tools	MCP Section
1. Safety					
1.1 Safety	Site is safe for use under the agreed post mine land use	All	Hazards which may endanger safety of humans or animals are identified and eliminated where possible. Residual safety hazards have been identified and appropriate management controls developed and implemented.	Relevant regulator guidelines have been met. Mine safety inspection audit.	Sections 8 and 10
1.2 Landform safety	Final landforms are safe	All	Landforms have been constructed as per management and operation guidelines for each domain: • *Guideline for the Integrated Planning and Design of Waste Rock Landforms* (CH-GU-EN-0002) • *Tailings Storage Facility Closure Management Guideline* (CH-GU-OP-0001) • *Design Specification for Mine Pit Backfill and Associated Surface Water Management Structures* (100-SW-EN-0046).	Rehabilitation monitoring confirms landforms constructed to management guidelines. Monitoring results display landform safety in relation to design criteria and relevant guidelines.	Sections 9 and 10
2. Stability					
2.1 Landform Stability	Final landforms are stable	All	Landforms have been constructed as per management and operation guidelines for each domain: • *Guideline for the Integrated Planning and Design of Waste Rock Landforms* (CH-GU-EN-0002) • *Tailings Storage Facility Closure Management Guideline* (CH-GU-OP-0001) • *Guideline for Re-Establishing Major Watercourses across Backfilled Pits* CH-GU-EN-0002 (Appendix 8C).	Rehabilitation monitoring confirms landforms constructed to management guidelines. Environmental reports available for review.	Sections 9 and 10
2.2 Surface Stability	Constructed surface is stable and does not display significant erosion	All (excluding mine voids)	Surface of landforms have been constructed in accordance with guideline specifications for each domain: • *Guideline for the Integrated Planning and Design of Waste Rock Landforms* (CH-GU-EN-0002) • *Tailings Storage Facility Closure Management Guideline* (CH-GU-OP-0001)	Rehabilitation monitoring confirms landform surfaces constructed to management guidelines. Rehabilitation monitoring results indicate surface is stable.	Sections 9 and 10

Subject	Objective	Domain	Criteria	Verification Tools	MCP Section
			• *Guideline for Re-Establishing Major Watercourses across Backfilled Pits* CH-GU-EN-0002 (Appendix 8C).		
3. Pollution					
3.1 Sedimentation	Landform surfaces not prone to sediment transport beyond natural geomorphic processes	All (excluding mine voids)	Surface of landforms have been constructed in accordance with guideline specifications for each domain: • *Guideline for the Integrated Planning and Design of Waste Rock Landforms* (CH-GU-EN-0002) • *Tailings Storage Facility Closure Management Guideline* (CH-GU-OP-0001) • *Guideline for Re-Establishing Major Watercourses across Backfilled Pits* CH-GU-EN-0002 (Appendix 8C).	Rehabilitation monitoring confirms landform surfaces constructed to management guidelines. Backfill monitoring confirms geomorphological stability of reconstructed channels is consistent with natural systems. Monitoring completed as per the *Fortescue Marsh Hydrology and Vegetation Monitoring and Management Plan* (100-PL-EN-1013).	Sections 9 and 10
3.2 Acid and/or Metalliferous Drainage	Acid and/or metalliferous drainage is appropriately managed	All	Waste material used in landform construction is characterised through Fortescue's Guideline *Planning for Closure – Characterisation of Mineral Waste Rock and Soils* (100-GU-EN-0018).	Monitoring reports generated through Fortescue's *Acid and/or Metalliferous Drainage Plan* (100-PL-EN-1016) indicate material is appropriately managed.	Sections 8 and 10
4. Sustainability					
4.1 Sustainability	Rehabilitation is sustainable and suitable for the agreed post mine land use	All where relevant	Rehabilitation activities are carried out in accordance with Fortescue's *Rehabilitation and Revegetation Management Plan* (100-PL-EN-0023).	Monitoring reports generated through Fortescue's *Rehabilitation and Revegetation Monitoring Procedure* (45-PR-EN-0027).	Sections 8 and 10
4.2 Growth medium	Suitable growth medium is in place to facilitate rehabilitation and agreed post mine land use	All (except voids)	Surface of landforms have been constructed in accordance with guideline specifications for each domain: • *Guideline for the Integrated Planning and Design of Waste Rock Landforms* (CH-GU-EN-0002) • *Tailings Storage Facility Closure Management Guideline* (CH-GU-OP-0001) • *Guideline for Re-Establishing Major Watercourses across Backfilled Pits* CH-GU-EN-0002 (Appendix 8C)	Rehabilitation monitoring confirms landform surfaces constructed to management guidelines.	Sections 9 and 10

Subject	Objective	Domain	Criteria	Verification Tools	MCP Section
4.3 Vegetation development	Vegetation is suited to the agreed post mine land use	All (except voids)	Rehabilitation activities are carried out in accordance with Fortescue's *Rehabilitation and Revegetation Management Plan* (100-PL-EN-0023).	Monitoring reports generated through Fortescue's *Rehabilitation and Revegetation Monitoring Procedure* (45-PR-EN-0027).	Sections 8 and 10
4.4 Provenance	Vegetation is of local provenance	All	Rehabilitation activities are carried out in accordance with Fortescue's *Rehabilitation and Revegetation Management Plan* (100-PL-EN-0023).	Monitoring reports generated through Fortescue's *Rehabilitation and Revegetation Monitoring Procedure* (45-PR-EN-0027).	Sections 8 and 10
4.5 Weeds	Presence of weeds does not limit the sustainability of rehabilitation or its potential to sustain agreed post mine land use	All	Rehabilitation activities are carried out in accordance with Fortescue's *Rehabilitation and Revegetation Management Plan* (100-PL-EN-0023). Weed management is carried out in accordance with Fortescue's *Weed Management Plan* (45-PL-EN-0013).	Monitoring reports generated through Fortescue's *Rehabilitation and Revegetation Monitoring Procedure* (45-PR-EN-0027).	Sections 8 and 10
5. Hydrology					
5.1 Surface Hydrology	Mining related impacts on natural surface water flows is minimised	All	Landforms have been constructed as per management and operation guidelines for each domain: • *Guideline for the Integrated Planning and Design of Waste Rock Landforms* (CH-GU-EN-0002) • *Tailings Storage Facility Closure Management Guideline* (CH-GU-OP-0001) • *Guideline for Re-Establishing Major Watercourses across Backfilled Pits* CH-GU-EN-0002 *(Appendix 8C).*	Rehabilitation monitoring confirms landforms constructed to management guidelines. Backfill monitoring confirms geomorphological stability of reconstructed channels is consistent with natural systems Surface water monitoring confirms that pit lake water quality does not negatively impact on downstream surface water quality.	Sections 9 and 10
5.2 Groundwater Hydrology	Mining related impacts on groundwater quality have been minimised	All	Landforms have been constructed as per management and operation guidelines for each domain: • *Guideline for the Integrated Planning and Design of Waste Rock Landforms* (CH-GU-EN-0002) • *Tailings Storage Facility Closure Management Guideline* (CH-GU-OP-0001)	Rehabilitation monitoring confirms landforms constructed to management guidelines. Groundwater monitoring confirms that pit lakes and backfilled pits do not	Sections 9 and 10

Subject	Objective	Domain	Criteria	Verification Tools	MCP Section
			• *Guideline for Re-Establishing Major Watercourses across Backfilled Pits* CH-GU-EN-0002 (Appendix 8C).	negatively impact on downstream groundwater quality.	
6. Miscellaneous					
6.1 Visual Amenity	Visual amenity of constructed landforms is compatible with local landforms	All (except voids)	Landforms have been constructed as per management and operation guidelines for each domain: • *Guideline for the Integrated Planning and Design of Waste Rock Landforms* (CH-GU-EN-0002) • *Tailings Storage Facility Closure Management Guideline* (CH-GU-OP-0001) • *Guideline for Re-Establishing Major Watercourses across Backfilled Pits* CH-GU-EN-0002 (Appendix 8C).	Rehabilitation monitoring confirms landforms constructed to management guidelines. Environmental reports available for review.	Sections 9 and 10
6.2 Heritage	No disturbance of heritage sites during rehabilitation and access to sites of significance preserved	All	Landforms have been constructed as per management and operation guidelines for each domain: • *Guideline for the Integrated Planning and Design of Waste Rock Landforms* (CH-GU-EN-0002) • *Tailings Storage Facility Closure Management Guideline* (CH-GU-OP-0001) • *Guideline for Re-Establishing Major Watercourses across Backfilled Pits* CH-GU-EN-0002 *(Appendix 8C).* Rehabilitation activities are carried out in accordance with Fortescue's *Rehabilitation and Revegetation Management Plan* (100-PL-EN-0023). Fortescue's *Stakeholder Consultation Strategy* (100-PH-EN-0003) has been adhered to.	Rehabilitation monitoring confirms landforms constructed to management guidelines. Stakeholder register has been completed Site heritage register has been maintained.	Sections 9 and 10

13.5.4 Closure Strategies

Construction of Vehicular Access Barriers

Vehicular access to areas such as the TSFs, WRSFs and mine pit voids will be prevented by closing, ripping and revegetating access roads and tracks. Physical barriers, such as boulders, logs or bunds, will be placed to discourage use of these roads where required.

Access to some areas may be required for closure monitoring and maintenance. These will be maintained to a level of safety required for operational access roads. Once access is no longer required, these roads will be closed as described above.

QA Construction Audits

After completion of closure earthworks, the final levels will be confirmed and signed off by a Registered Surveyor. Where levels or grades deviate significantly from designs, the work will be remediated to the satisfaction of a suitably qualified and experienced engineer. Where compaction of surfaces is specified in design, the degree of compaction will be checked by a suitably qualified contractor.

Health and Safety Audits

Upon completion of all landform earthworks including capping, the landform(s) will be subject to a risk-based Health and Safety audit by a suitably experienced and qualified Health and Safety Professional. Audit actions will be implemented as directed by the authorised auditor.

Construction of Passive Surface Water Infrastructure

Where surface water infrastructure is required (such as spillways and diversion drains), infrastructure that is robust for long-term closure and does not rely on active management (such as pumping) will be constructed. Drainage structures (such as culverts and channels) will be designed in accordance with Fortescue's Drainage Standard. Fortescue will re-instate major watercourses across backfilled pit voids preferentially as described in Section 13.4.5.

Progressive Rehabilitation

Progressive rehabilitation will be considered in life of mine planning, to investigate how rehabilitation can be practically and progressively implemented across Christmas Creek.

Mine planning will consider where tailings deposition and waste rock placement can be completed to the final height and thereby allow rehabilitation trials and activities to be undertaken whilst tailings deposition is ongoing in other areas. Rehabilitation trials are currently underway at two locations at Christmas Creek, and the large scale rehabilitation and revegetation of Flinders WRSF is scheduled to commence within the next two years.

Target Ecosystem and Vegetation Selection

Further investigation will be conducted by a qualified professional into vegetation selection for re-vegetation of the landforms. Seeds will be collected locally and/or commercially sourced. Further investigations and the results of ongoing trials will be undertaken to confirm:

- target species for re-vegetation
- proposed cap design and specification of optimal topsoil and subsoil mix for revegetation, along with the requirements for any soil conditioning
- nutrient cycling for sustainability of vegetation.

Revegetation Strategy

Disturbed areas will be re-profiled (made stable) and revegetated. The revegetation strategy will incorporate:

- selection and sourcing of appropriate flora species for the re-vegetation of the area
- design for erosion resistant surfaces
- rehabilitation trials
- anticipated monitoring and maintenance includes:
  - assessment of rehabilitation progress using EFA
  - physical site inspections to identify problem areas
  - a weed prevention and control programme to prevent establishment and spread of weeds
  - a feral animal control programme to prevent rehabilitation being destroyed by feral herbivores.

A summary of the closure strategies specific to each domain is provided in Table 66. Detailed information on these strategies is provided in the MCP.

Table 66: Domain Specific Closure Strategies

Domain	Category	Strategy
TSF	Health and Safety	Removal of redundant infrastructure
	Water	Flood mitigation investigation
	Landform Stability	Geotechnical investigations of TSF foundation
		Detailed cap designs
		Detailed spillway designs
WRSF	Water	PAF material deposition strategy
		AMD leachate management
	Landform Stability	Geotechnical investigations of WRSF foundation

Domain	Category	Strategy
		Detailed materials scheduling model
		Detailed cap designs
Mine Pit Voids	Health and Safety	Construction of abandonment bunding
	Water	Water balance model to predict closure outcomes
	Pit Stability	Pit geotechnical design
	Environment	Geochemical characterisation of pit wall materials

13.5.5 Financial Provisioning

As part of mine closure planning, a cost estimate to implement the closure strategies and rehabilitation requirements will be prepared. The cost estimate will include decommissioning and removal of infrastructure, required earthworks and revegetation. Where sufficient information exists, costs will be calculated based on quantities identified from current site layouts and estimated contractor rates. Where detailed costing cannot be made, a provisional sum will be allocated. Closure cost estimates will be reviewed on a regular basis so that they remain valid and reflect the true cost of undertaking the works required. These costs can be developed by using the *Material Movement Cost Calculator* (M-TE-EN-0001).

13.5.6 Monitoring, Maintenance and Reporting

As individual sites are rehabilitated and closure works completed, there will be a period of monitoring and maintenance to make sure the site has been made safe and to demonstrate to the regulatory bodies and key stakeholders that the post-mining operation is approaching a safe and sustainable state. The monitoring and maintenance programme will include monitoring of surface and groundwater levels and quality, rehabilitation performance, erosion and geotechnical stability and general maintenance.

Monitoring results must demonstrate that closure objectives and closure criteria have been met and that there are no ongoing impacts from the site, in order to successfully relinquish tenements post-closure. It is envisaged that monitoring and maintenance will continue for a minimum period of five years following closure, but may be extended depending on the outcomes of the monitoring and maintenance programme.

13.6 Management Measures and Performance Standards

Fortescue undertakes rehabilitation activities and planning for mine closure in accordance with the following management plans, procedures and guidelines:

- *Planning for Closure – Design of Mineral Waste Rock Landforms* (100-PR-EN-1017)
- *Planning for Closure – Design Approval for Mineral Waste Rock Landforms* (100-PR-EN-1018)

- *Christmas Creek Mine Planning Dump Design Parameters* (CC-GU-GE-0001)
- *Tailings Storage Facility Closure Management Guideline* (CH-GU-OP-0001)
- *Planning for Closure-Characterisation of Mineral Waste Rock and Soils* (100-GU-EN-0018)
- *Overburden Management Re-Growth and Waste Procedure* (45-PR-EN-0012)
- *Vegetation Clearing and Topsoil Management Procedure* (45-PR-EN-0013)
- *Rehabilitation and Revegetation Monitoring Procedure* (45-PR-EN-0027).

13.7 Predicted Environmental Outcome

The Proposal is not likely to result in significant environmental impact following closure when management measures are considered. Ongoing investigations and monitoring undertaken during the life of mine will refine the management measures required to achieve the long term objectives of mine closure and in accordance with EPA's closure objective. This will include implementation of the MCP to achieve documented objectives and monitoring to check implementation and measure outcomes.

The key likely long-term outcomes for closure are:

1. Final landforms will have stabilised slopes of appropriate gradient and covered by vegetation re-established from respread topsoil and/or seed of local provenance.
2. The groundwater table will recover to a level and quality to that of pre-mining.
3. Altered surface water regimes will be stable and re-vegetated with stable self-sustaining ecosystems.
4. All areas disturbed for mining and infrastructure are rehabilitated following decommissioning and meet specified final land use criteria.

The management measures to appropriately decommission, decontaminate and rehabilitate disturbed areas are in place to mitigate the potential risks to final mine closure. During life of mine operations, investigations and the adaptive management approach will ensure that risks to closure are detected early and are addressed so as to meet the EPA's closure objective.

14. OFFSETS

14.1 Relevant Environmental Objectives, Legislation, Policies and Guidelines

14.1.1 EPA Objective

The EPA applies the following objective to the assessment of proposals that may require environmental offsets:

> *To counterbalance any significant residual environmental impacts and/or uncertainty through the application of offsets.*

Guidance and Positions Statements

The following EPA position and guidance statements set the framework for offsets:

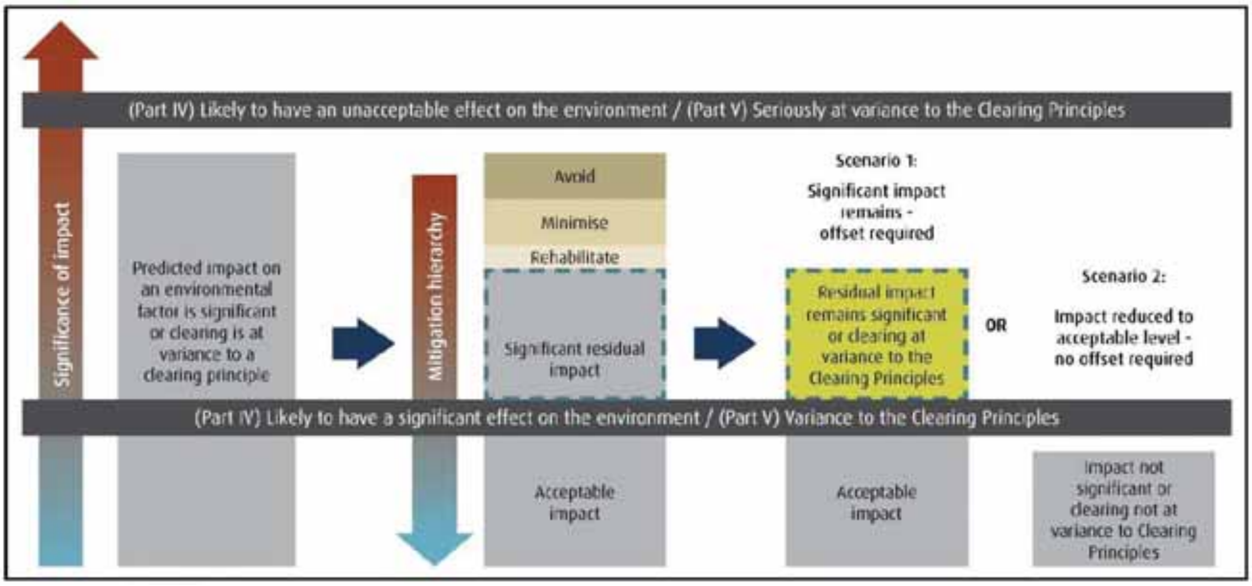
- *WA Environmental Offsets Policy* (Government of Western Australia 2011).
- Environmental Protection Bulletin Number 1: *Environmental Offsets*, revised August 2014 (EPA 2014)
- *WA Environmental Offsets Guidelines, August 2014* (Government of Western Australia 2014).

The following EPBC Act policy sets the framework for offsets that relate to MNES:

- Department of Sustainability, Environment, Water, Populations and Communities (2012) *EPBC Act Environmental Offsets Policy*.

Environmental Protection Bulletin Number 1 (EPA 2014) states that environmental offsets may only be considered once all other reasonable attempts to mitigate adverse impacts have been exhausted. The hierarchy of impact mitigation (Plate 4) is described in the *WA Environmental Offsets Guidelines* (Government of Western Australia 2014). The management and mitigation measures for potential environmental impacts of the Proposal have been designed to take this hierarchy into consideration.

Plate 4: Impact Mitigation Hierarchy



Source: Government of Western Australia 2014.

The *EPBC Act 1999 Environmental Offsets Policy* (DSEWPaC 2012) outlines the Commonwealth government's approach to the use of offsets under the EPBC Act. The Policy defines offsets as 'measures that compensate the residual adverse impacts of an action on the environment'.

The policy states that avoidance and mitigation measures must be the primary strategy to manage significant impacts and that offsets do not reduce likely impacts but rather compensate for residual significant impacts.

14.2 Existing Offset Requirements

Fortescue is currently implementing a number offset programs required by existing approvals under Part IV or the EP Act for the Christmas Creek Mine and the CCWMS (Table 67).

Table 67: Existing Offset Requirements and Implementation Status

Reference	Requirement	Implementation Status
MS 707 P14.1	Fund detailed research programs into Mulga or other poorly known taxa including: • Three PhD research projects or equivalent to be run consecutively for a period of nine years; Three Honours projects or equivalent to be run consecutively for a period of three to six years.	Memorandum of Understanding dated 6 August 2012 confirms that the 'Fortescue Marsh Floristics and Vegetation Mapping Project', fulfils the three PhD requirement for research into Mulga or other poorly known taxa. Two Honours Projects have been completed to date: • Pigment concentrations and spectral signals of samphires (UWA and CSIRO), CH-RP-EN-0001; and • Hydrological Processes in Sheetflow Dependent Mulga Groves (UWA).

Reference	Requirement	Implementation Status
MS 707 P14.2	Fund detailed research programs into a relevant Threatened Fauna Species: • One PhD research project or equivalent to be run for a period of three years.	Fortescue has funded two research projects through the Centre of Evolutionary Biology at UWA. Both project focus on the reproductive biology of small Pilbara ground mammals. The current project (Captive breeding and assisted reproductive technologies in the Western Pebble-Mound Mouse) is of particular nature conservation interest.
MS 707 P14.3	Fund research into Mulga – Water Relationships for a period of five years.	Four years completed out of five year commitment. Project title: *Assessment of vegetation water use of upland and lowland communities associated with the Fortescue Marsh using isotopic tracers*. University of Western Australia.
MS 707 P14.4	Fund a position within CALM to manage project implementation and operations over the life of the project.	'Conservation Officer – Fortescue Marsh' – position at the DPaW in Karratha is funded by Fortescue.
MS 707 P14.5	Weed Management Extension Program to improve the existing environment outside the project area.	Fortescue contributes $100,000 per annum to the DPaW in Karratha to implement the Weed Management Extension Program, as outlined in the Draft Collaborative Agreement with the DPaW.
MS 707 P14.6	Fund the development of a statutory Fortescue Marsh Management Plan.	The Statutory Fortescue Marsh Management Plan will not be developed until the proposed Conservation Estate has been excised from the current Pastoral Leases. Fortescue and DPaW have agreed that $100,000 or equivalent of in-kind will be provided in the 2014/ 2015 financial year for the development of this plan.
MS 707 P14.7	A Memorandum of Understanding to be developed between CALM and the proponent to develop and maintain good working relationships between both organisations.	A draft MOU (The Collaborative Agreement) between Fortescue and DPaW has been drafted and remains under negotiation.
MS 871	No offset conditions	N/A

Fortescue is also implementing a number offset programs required under the existing Commonwealth approvals:

- EPBC 2010/5513
- EPBC 2010/5567
- EPBC 2010/5696
- EPBC 2010/5706.

Fortescue will continue to implement the offset requirements of the CCWMS approval (EPBC 2010/5706) until it expires on 1 September 2016.

The offset requirements of EPBC 2010/5706 include the implementation of the *Fortescue Marsh Baiting Plan* CC-PL-EN-0007 (Fortescue 2011g) and the development of an Offsets Plan. This

offset requirement is also a condition of approval under EPBC 2010/5513, EPBC 2010/5567 and EPBC 2010/5696 and states:

> *To offset the residual impacts of the action on the **EPBC Act** listed threatened fauna species, the person taking the action must prepare and submit for the **Minister's** approval an Offsets Plan for an area of no less than 20,000 ha in the Pilbara bioregion by 30 June 2015. The Offsets Plan must be prepared in consultation with **relevant stakeholders** and be reviewed and endorsed by a **suitably qualified listed species expert** and a **suitably qualified land management expert**. The Offsets Plan must:*
>
> *a. contain management actions for the benefit of **EPBC Act** listed threatened fauna species. Management actions must include but are not limited to the management of:*
>
> *i. fire*
>
> *ii. feral herbivores*
>
> *iii. feral predators*
>
> *iv. weeds.*
>
> *b. contain details of:*
>
> *i. the timing, frequency, duration and responsibility for actions for each management action*
>
> *ii. the relationship to other relevant strategic land management programs being undertaken in the Pilbara bioregion.*
>
> *c. contain a **monitoring and evaluation strategy**.*
>
> *The approved Offsets Plan must be implemented.*
>
> *Alternatively, in lieu of preparing, submitting and implementing the Offsets Plan, the approval holder may seek the written agreement of the **Minister** to incorporate commitments commensurate with the Offsets Plan into an existing or new land management plan or program within the Pilbara bioregion. The approval holder must provide written agreement from the person or persons responsible for implementing the plan or program and / or receiving funds, to receive funds and undertake the specified land management actions within the specified timeframes.*

14.2.1 Offset Management Plan

Fortescue is currently preparing the Offsets Plan in consultation with key stakeholders including DPaW, DAFWA, Pilbara Corridors, Pilbara Mesquite Management Committee, pastoralists, Rangelands NRM, Greening Australia and other resources Proponents. The Plan will be submitted (for approval) to the Commonwealth Minister by 30 June 2015.

The Offsets Plan will outline landscape scale management actions to address threats to the following EPBC Act threatened fauna species:

- Greater Bilby
- Northern Quoll

- Pilbara Leaf-nosed Bat
- Night Parrot
- Mulgara.

The landscape scale management activities will be designed to ensure the better protection and long-term conservation of the listed species. The Offsets Plan will outline landscape scale management strategies for an area of 450,000 ha. Key management actions of the plan include:

- feral herbivore control
- feral predator control
- weed management
- fire management.

The key benefits of a landscape scale management approach include:

- a focus on managing and/or controlling specific threats to EPBC listed fauna species in the Pilbara, fire, feral animals and invasive weeds, on a large scale
- implementation across a large area rather than just individual patches or populations of EPBC Act listed fauna species
- a consistent and coordinated approach to the implementation of offset programs rather than the management of small parcels of fragmented land in isolation, by teams that may not have specific expertise in conservation management
- the large land size and scale of the management actions will limit any impact to the conservation outcomes from mining and/or other alternative land uses
- DPaW, the key conservation management body in WA will be involved in the development and implementation of the plan
- pastoral lease holders, managers and other stakeholders including those included in the ‘Care for our Country’ and Natural Resource Managers will be consulted and encouraged to participate in the coordinated program
- implementation will include consideration of social benefits such as indigenous training and employment opportunities
- Traditional Owners will be consulted to ensure cultural values are also considered and knowledge is incorporated into implementation.

The Offsets Plan will also contain details of timing, frequency duration and responsibility for each management activity and will also outline a monitoring and evaluation program.

The Offsets Plan will be implemented in consultation with the key stakeholders to support the implementation of consistent management approaches in an efficient and targeted manner.

Under existing EPBC approval conditions, Fortescue is required to undertake offset activities within an area of up to 450,000 ha[10].

14.3 Residual Impact Assessment to Determine Offset Requirements

The Proposal has the potential to affect vegetation, flora, habitat and fauna species of State and National environmental significance. An assessment of the impact of the proposal to these environmental assets, the measures to avoid, mitigate and rectify these impacts and any significant residual impact are discussed in Table 68.

The environmental assets potentially impacted by the Proposal were assessed against the residual impact significance model provided within the *WA Environmental Offsets Guidelines* (Government of Western Australia 2014). Generally, the Environmental Factors considered to represent a significant impact requiring offsetting include:

- Vegetation and Flora
- Subterranean Fauna
- Terrestrial Fauna

In regards to the Proposal, the following aspects are considered to represent a significant impact to one of the assets described under the Environmental Factors above:

- Vegetation and Flora
    - Rare flora: no declared rare flora has been recorded or is expected to occur within the Proposal area (Section 9.4.9).
    - TECs: no TECs protected under the EPBC Act or the EP Act have been recorded within a 50 km radius of the Proposal area (Section 9.4.5).
    - Remnant vegetation: clearing of vegetation does not result in the clearing of greater than 10% of the pre-European extent of any vegetation complex, or more than 18% of the surveyed regional extent of any VT/VA (Section 9.7.1).
    - Wetlands and waterways: the Proposal avoids impacts to the Fortescue Marsh. Impacts to fauna habitat associated with wetlands and waterways are addressed under Terrestrial Fauna.
    - Conservation areas: no areas reserved under statute or managed for the purpose of conservation will be impacted by the Proposal (Section 3.1.2).
    - High biological diversity: the Proposal avoids impacts to the Fortescue Marsh. Impacts to migratory fauna habitat are addressed under Terrestrial Fauna.

[10] This area includes offsets for the Crest-tailed Mulgara (*Dasycercus cristicauda*) which is not present in the Pilbara. This area may therefore be reduced.

- Subterranean Fauna
  - High biological diversity: no significant impacts to areas recognised as having high biological value in relation to subterranean fauna are expected (Section 11.9).
  - Habitat for fauna: no significant impacts to subterranean fauna protected under the WC Act or EPBC Act are expected (Section 11.9)
- Terrestrial Fauna
  - Wetlands and waterways: implementation of the Proposal results in direct disturbance of 1,131 ha of vegetation associated with wetlands and waterways, defined as Drainage Line and Alluvial Plain habitat type (1,117 ha) and Marsh Habitat type (14 ha) (Section 10.7.1).
  - Conservation areas: no areas reserved under statute or managed for the purpose of conservation will be impacted by the Proposal (Section 3.1.2).
  - High biological diversity: the Proposal will impact 14 ha of the Fortescue Marsh (Marsh Habitat Area), considered as habitat which supports Migratory birds.
  - Habitat for fauna: the proposal will impact habitat for a number of fauna species protected under the EPBC Act and WC Act. Impacts to significant habitat for these species are limited to the Drainage Line and Alluvial Plain (1,117 ha) and Marsh (14 ha) habitat types (Section 10.4.2).
- Overall Environment
  - Approximately 7,468 ha of vegetation in good to excellent condition will be disturbed as a result of the Proposal. Impacts to Vegetation in good – excellent condition is not listed as an example of a significant residual impact which will or may require an offset in the Residual Impact Significance Model (Government of Western Australia 2014), however, it has been highlighted as requiring offsets by the EPA in a number of publications including the Strategic Advice on Cumulative environmental impacts of development in the Pilbara region and EPA Report 1533. Inclusion of this aspect in offset calculations for this Proposal will be the subject of further negotiation with the Policy Branch of the OEPA.

Table 68 provides a summary of the assessment of residual impact significance in accordance with the *WA Environmental Offsets Guidelines* (Government of Western Australia 2014). The offsets listed here are draft in nature, and have been provided to the OEPA and DoE for initial review and consultation.

The offset calculation methodology provided in the *WA Environmental Offsets Guidelines* (Government of Western Australia 2014) has not been undertaken as the Proposal will likely be subject to an offset rate per hectare. The current rates (subject to change) for the Fortescue subregion are $1,500 per hectare of vegetation in good – excellent condition and $3,000 per hectare for additional state significant values.

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Table 68: EPA Environmental Offsets Reporting Form

Existing environment/ impact	Mitigation			Significant Residual Impact
	Avoid and Minimise	Rehabilitation Type	Likely Rehab Success	
Vegetation and Flora				
Rare Flora No declared rare flora has been recorded or is expected to occur within the Proposal area (Section 9.4.9)	N/A	N/A	N/A	N/A
Threatened Ecological Communities No TECs protected under the EPBC Act or the EP Act have been recorded within a 50 km radius of the Proposal area (Section 9.4.5).	N/A	N/A	N/A	N/A
Remnant Vegetation Clearing of vegetation does not result in the clearing of greater than 10% of the pre-European extent of any vegetation complex, or more than 18% of the surveyed regional extent of any VT/VA (Section 9.7.1).	N/A	N/A	N/A	N/A
Wetlands and Waterways The proposal does not directly impact the Fortescue Marsh. Clearing is concentrated around areas of mineralisation and has not been extended south towards the Fortescue Marsh. Impacts to fauna habitat associated with wetlands and waterways are included in the Wetlands and Waterways assessment under the Terrestrial Fauna Environmental Factor.	N/A	N/A	N/A	N/A

Existing environment/ impact	**Mitigation**			**Significant Residual Impact**
	Avoid and Minimise	**Rehabilitation Type**	**Likely Rehab Success**	
<u>Conservation Areas</u> No areas reserved under statute or managed for the purpose of conservation will be impacted by the Proposal (Section 3.1.2).	N/A	N/A	N/A	N/A
<u>High Biological Diversity</u> The Fortescue Marsh is a nationally significant wetland. Impacts to the Fortescue Marsh have been specifically avoided the design of the Proposal.	N/A	N/A	N/A	N/A
<u>Vegetation in Good to Excellent Condition</u> Approximately 7,468 ha of vegetation in good to excellent condition will be disturbed as a result of the Proposal. Impacts to Vegetation in good – excellent condition is not listed as an example of a significant residual impact which will or may require an offset in the Residual Impact Significance Model (Government of Western Australia 2014), however, it has been highlighted as requiring offsets by the EPA in a number of publications including the Strategic Advice on Cumulative environmental impacts of development in the Pilbara region and EPA Report 1533. Inclusion of this aspect in offset calculations for this Proposal will be the subject of further negotiation with the Policy Branch of the OEPA.				
Subterranean Fauna				
<u>High Biological Diversity</u> No significant impacts to areas recognised as having high biological value in relation to subterranean fauna are expected (Section 11.9).	N/A	N/A	N/A	N/A
<u>Habitat for Fauna</u> No significant impacts to subterranean fauna protected under the WC Act or EPBC Act are expected (Section 11.9).	N/A	N/A	N/A	N/A
Terrestrial Fauna				
<u>Wetlands and Waterways</u> Implementation of the Proposal results in the direct disturbance of 1,131 ha of vegetation associated with wetlands and waterways defined as Drainage	Impacts to the Marsh habitat type have been specifically avoided and minimised in the design of the Proposal. Impacts to Drainage Line and Alluvial Plain and Stony Hill habitat types is unavoidable if the	Rehabilitation will be undertaken progressively where possible, and will aim to ensure that areas	<u>Can the environmental values be rehabilitated/evidence?</u> Landscape function analysis and vegetation monitoring indicates that rehabilitation can achieve	<u>Extent</u> 1,131 ha of clearing of vegetation associated

Existing environment/ impact	Mitigation			Significant Residual Impact
	Avoid and Minimise	Rehabilitation Type	Likely Rehab Success	
Line and Alluvial Plain habitat type (1,117 ha) and Marsh habitat type (14 ha) (Section 10.7.1).	Proposal is to proceed. Overall, disturbance has been minimised by concentrating the location of supporting infrastructure as close to the proposed pit areas as possible. Impacts to wetlands and waterways and their associated vegetation will be minimised through the application of the following measures: • surface water will be diverted away from mine pits and WRSFs, and downstream flow regimes maintained where feasible • buildings and process infrastructure will be located outside the 1 in 100-year floodway to minimise the potential for surface water contamination • pipelines will be either buried or raised at channel crossings and at appropriate intervals in sheet flow areas containing Mulga vegetation to allow surface water flow and prevent ponding • water will only be disposed of via surface water flow paths as a contingency measure or during maintenance • project infrastructure has been located away from known areas of conservation significant flora and/or vegetation as far as practicable • clearing will not be undertaken outside authorised areas as defined under the GDP process • off road driving or driving on restricted access routes will be prohibited other than for emergency situations • significant flora and vegetation will be recorded in GIS and record keeping systems, and DPaW will be informed of any new populations or communities discovered, as required	are consistent with the agreed post-closure land use, low intensity livestock grazing.	acceptable environmental values, however it cannot recreate the exact same landform, landscape function, biodiversity and suitability as fauna habitat as the undisturbed land. Significant watercourses will be rehabilitated as per the *Guideline for Re-establishing Major Watercourses across Backfilled Pits* CH-GU-EN-0002 (Appendix 8C), which results in backfilled surfaces which are stable and self-sustaining under drainage patterns similar to those that existed before mining commenced. <u>Operator experience in undertaking rehabilitation?</u> Section 13.2.6 details the rehabilitation activities undertaken by Fortescue to date. Fortescue has completed more than 2,500 ha of rehabilitation across its sites, including Rail, Christmas Creek, Cloudbreak and Solomon. <u>What is the type of vegetation being rehabilitated?</u> Vegetation types and associations are described in detail in Section 9.4.2 and Table 30.Vegetation of the Fortescue Marsh is primarily halophytic shrubland of mixed Chenopod species and Samphire and vegetation associated with Drainage Lines and Alluvial Plains	with wetlands and waterways <u>Quality</u> Vegetation is primarily in good – excellent condition (Section 9.4.4) <u>Conservation Significance</u> This area is not currently reserved under statute for conservation. <u>Land Tenure</u> Mining tenure overlying pastoral leases. <u>Time Scale</u> The Proposal will be implemented over a life of mine of 14 years (to 2028).

Existing environment/ impact	Mitigation			Significant Residual Impact
	Avoid and Minimise	Rehabilitation Type	Likely Rehab Success	
	• dewatering activities and water discharge will be managed to minimise drawdown impacts on potential GDEs such as the fringing vegetation of the Fortescue Marsh • the unauthorised disturbance of significant flora or vegetation will be reported and investigated • clearing and rehabilitation will be undertaken progressively where possible • all activities will be carried out in accordance with statutory requirements and appropriate standards.		is a mixture of open Eucalyptus woodland and Acacia scrubland. <u>Time lag?</u> Some rehabilitation will be able to be undertaken progressively, while rehabilitation of active pits and fixed infrastructure may have a time lag of up to 14 years (the life of the Proposal). <u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u> Section 13.2.6 details the rehabilitation activities undertaken by Fortescue to date, including a summary of the successes experienced and opportunities for continued improvement.	
<u>Conservation Areas</u> No areas reserved under statute or managed for the purpose of conservation will be impacted by the Proposal (Section 3.1.2).	N/A	N/A	N/A	N/A
<u>High Biological Diversity</u> The Proposal may also impact habitat which is significant or potentially significant to Migratory birds. The following Migratory bird species have either been recorded, or are considered possible or likely to occur in the Proposal area: • **Fork-tailed Swift**: this species is almost entirely aerial and is not directly associated with any of the	Impacts to the Marsh habitat type have been specifically avoided and minimised in the design of the Proposal. Impacts to Drainage Line and Alluvial Plain and Stony Hill habitat types is unavoidable if the Proposal is to proceed. Overall, disturbance has been minimised by concentrating the location of supporting infrastructure as close to the proposed pit areas as possible. Impacts to Migratory birds and their associated habitat will be minimised through the application of the following measures:	Rehabilitation will be undertaken progressively where possible, and will aim to ensure that areas are consistent with the agreed post-closure land use, low intensity livestock grazing.	<u>Can the environmental values be rehabilitated/evidence?</u> Landscape function analysis and vegetation monitoring indicates that rehabilitation can achieve acceptable environmental values, however it cannot recreate the exact same landform, landscape function, biodiversity and suitability as fauna habitat as the undisturbed land.	<u>Extent</u> 1,131 ha of clearing of significant or potentially significant fauna habitat <u>Quality</u> Vegetation is primarily in good – excellent condition (Section 9.4.4) <u>Conservation Significance</u>

<table>
<tr><th rowspan="2">Existing environment/ impact</th><th colspan="3">Mitigation</th><th rowspan="2">Significant Residual Impact</th></tr>
<tr><th>Avoid and Minimise</th><th>Rehabilitation Type</th><th>Likely Rehab Success</th></tr>
<tr><td>habitat types which will be impacted by the Proposal.
• Cattle Egret: this species has widespread occurrence in the region and a large range of suitable habitat, the Proposal does not affect significant habitat.
• Eastern Great Egret: Marsh habitat type may provide minor breeding habitat.
• White-bellied Sea-eagle: Marsh and Drainage Line and Alluvial Plain is suitable habitat when water is present.
• Oriental Plover: this species has widespread distribution across Australia and does not breed in Australia, as such the Proposal does not affect significant habitat.
• Wood Sandpiper: Marsh and Drainage Line and Alluvial Plain is suitable habitat when water is present.
• Common Greenshank: Marsh and Drainage Line and Alluvial Plain is suitable habitat when water is present.
• Rainbow Bee-eater: this species has widespread occurrence in the region and a large range of suitable habitat, proposal does not affect significant habitat.
Impacts to significant (or potentially significant) habitat for these Migratory species are limited to the Drainage Line and Alluvial Plain (1,117 ha) and Marsh (14 ha) habitat types (Section 10.4.2).</td><td>• project infrastructure has been located away from known areas of conservation significant flora and/or vegetation as far as practicable
• clearing will not be undertaken outside authorised areas as defined under the GDP process
• off road driving or driving on restricted access routes will be prohibited other than for emergency situations
• significant flora and vegetation will be recorded in GIS and record keeping systems, and DPaW will be informed of any new populations or communities discovered, as required
• dewatering activities and water discharge will be managed to minimise drawdown impacts on potential GDEs such as the fringing vegetation of the Fortescue Marsh
• the unauthorised disturbance of significant flora or vegetation will be reported and investigated
• clearing and rehabilitation will be undertaken progressively where possible
• all activities will be carried out in accordance with statutory requirements and appropriate standards
• significant fauna habitat will be spatially identified and where appropriate, demarcated on site
• clearing will be undertaken in stages and along one front to allow fauna to vacate an area, and large mature habitat trees will be retained, where possible
• low noise equipment will be used where practicable</td><td></td><td><u>Operator experience in undertaking rehabilitation?</u>
Section 13.2.6 details the rehabilitation activities undertaken by Fortescue to date. Fortescue has completed more than 2,500 ha of rehabilitation across its sites, including Rail, Christmas Creek, Cloudbreak and Solomon.
<u>What is the type of vegetation being rehabilitated?</u>
Vegetation types and associations are described in detail in Section 9.4.2 and Table 30.Vegetation of the Fortescue Marsh is primarily halophytic shrubland of mixed Chenopod species and Samphire and vegetation associated with Drainage Lines and Alluvial Plains is a mixture of open Eucalyptus woodland and Acacia scrubland.
<u>Time lag?</u>
Some rehabilitation will be able to be undertaken progressively, while rehabilitation of active pits and fixed infrastructure may have a time lag of up to 14 years (the life of the Proposal).
<u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u>
Section 13.2.6 details the rehabilitation activities undertaken by Fortescue to date, including a summary of the successes</td><td>This area is not currently reserved under statute for conservation.
<u>Land Tenure</u>
Mining tenure overlying pastoral leases.
<u>Time Scale</u>
The Proposal will be implemented over a life of mine of 14 years (to 2028).</td></tr>
</table>

Existing environment/ impact	Mitigation			Significant Residual Impact
	Avoid and Minimise	Rehabilitation Type	Likely Rehab Success	
	• lighting will be directed onto construction or operational areas.		experienced and opportunities for continued improvement.	
Habitat for Fauna The proposal will impact habitat for a number of fauna species protected under the EPBC Act and WC Act. Protected species are listed in Table 49. Impacts to significant habitat for species have been limited to those species which have been recorded or are considered likely or possible to occur within the Proposal Area. • **Night Parrot**: Marsh habitat type is potentially suitable habitat and Low Hill habitat type is potentially suitable foraging habitat. • **Australian Painted Snipe**: Marsh habitat type is potentially suitable foraging habitat • **Pilbara Olive Python**: Drainage Line and Alluvial Plain is potential foraging habitat • **Fork-tailed Swift**: this species is almost entirely aerial and is not directly associated with any of the habitat types which will be impacted by the Proposal. • **Cattle Egret**: this species has widespread occurrence in the region and a large range of suitable habitat, the Proposal does not affect significant habitat. • **Eastern Great Egret**: Marsh habitat type may provide minor breeding habitat. • **White-bellied Sea-eagle**: Marsh and Drainage Line and Alluvial	Impacts to the Marsh habitat type have been specifically avoided and minimised in the design of the Proposal. Clearing is concentrated around areas of mineralisation and has not been extended south towards the Fortescue Marsh. Impacts to Drainage Line and Alluvial Plain and Stony Hill habitat types is unavoidable if the Proposal is to proceed. Overall, disturbance has been minimised by concentrating the location of supporting infrastructure as close to the proposed pit areas as possible. Impacts to fauna and fauna habitat will be minimised through the application of the following measures: • project infrastructure has been located away from known areas of conservation significant flora and/or vegetation as far as practicable • clearing will not be undertaken outside authorised areas as defined under the GDP process • off road driving or driving on restricted access routes will be prohibited other than for emergency situations • significant flora and vegetation will be recorded in GIS and record keeping systems, and DPaW will be informed of any new populations or communities discovered, as required • dewatering activities and water discharge will be managed to minimise drawdown impacts on potential GDEs such as the fringing vegetation of the Fortescue Marsh	Rehabilitation will be undertaken progressively where possible, and will aim to ensure that areas are consistent with the agreed post-closure land use, low intensity livestock grazing.	Can the environmental values be rehabilitated/evidence? Landscape function analysis and vegetation monitoring indicates that rehabilitation can achieve acceptable environmental values, however it cannot recreate the exact same landform, landscape function, biodiversity and suitability as fauna habitat as the undisturbed land. Operator experience in undertaking rehabilitation? Section 13.2.6 details the rehabilitation activities undertaken by Fortescue to date. Fortescue has completed more than 2,500 ha of rehabilitation across its sites, including Rail, Christmas Creek, Cloudbreak and Solomon. What is the type of vegetation being rehabilitated? Vegetation types and associations are described in detail in Section 9.4.2 and Table 30.Vegetation of the Fortescue Marsh is primarily halophytic shrubland of mixed Chenopod species and Samphire, vegetation associated with Drainage Lines and Alluvial Plains is a mixture of open Eucalyptus woodland and Acacia scrubland and vegetation associated with the Low Hill habitat type is	Extent 3,386 ha of clearing of significant or potentially significant fauna habitat Quality Vegetation is primarily in good – excellent condition (Section 9.4.4) Conservation Significance This area is not currently reserved under statute for conservation. Land Tenure Mining tenure overlying pastoral leases. Time Scale The Proposal will be implemented over a life of mine of 14 years (to 2028).

Existing environment/ impact	Mitigation			Significant Residual Impact
	Avoid and Minimise	Rehabilitation Type	Likely Rehab Success	
Plain is suitable habitat when water is present. • **Oriental Plover**: this species has widespread distribution across Australia and does not breed in Australia, as such the Proposal does not affect significant habitat. • **Wood Sandpiper**: Marsh and Drainage Line and Alluvial Plain is suitable habitat when water is present. • **Common Greenshank**: Marsh and Drainage Line and Alluvial Plain is suitable habitat when water is present. • **Rainbow Bee-eater**: this species has widespread occurrence in the region and a large range of suitable habitat, proposal does not affect significant habitat. • **Peregrine Falcon**: Drainage Line and Alluvial Plain is suitable habitat when water is present. Impacts to significant (or potentially significant) habitat for these protected species are limited to the Drainage Line and Alluvial Plain (1,117 ha), Low Hill (2,255 ha) and Marsh (14 ha) habitat types (Section 10.4.2).	• the unauthorised disturbance of significant flora or vegetation will be reported and investigated • clearing and rehabilitation will be undertaken progressively where possible • all activities will be carried out in accordance with statutory requirements and appropriate standards • significant fauna habitat will be spatially identified and where appropriate, demarcated on site • clearing will be undertaken in stages and along one front to allow fauna to vacate an area, and large mature habitat trees will be retained, where possible • native animals encountered on site will be given the opportunity to move on if there is no threat to safety of personnel • staff will be inducted on fauna management procedures prior to mobilising to site • fauna management information, news and updates will be provided via toolbox meetings, site HSE meetings, training and awareness sessions and visual displays in prominent on-site locations.		primarily .scattered Eucalypts and Acacias over hummock grasslands. <u>Time lag?</u> Some rehabilitation will be able to be undertaken progressively, while rehabilitation of active pits and fixed infrastructure may have a time lag of up to 14 years (the life of the Proposal). <u>Credibility of the rehabilitation proposed (evidence of demonstrated success)</u> Section 13.2.6 details the rehabilitation activities undertaken by Fortescue to date, including a summary of the successes experienced and opportunities for continued improvement.	

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14.4 Predicted Environmental Outcomes

14.4.1 State Offsets

The assessment using the residual impact significance model applied in Western Australia (Table 68), results in the outcome that the Proposal has the potential to result in the following significant residual impacts:

- direct disturbance of 14 ha of Marsh habitat type, which is significant as a watercourse/wetland, habitat/potential habitat for Migratory birds and habitat/potential habitat for fauna protected under the EPBC Act and/or WC Act
- direct disturbance of 1,117 ha of Drainage Line and Alluvial Plain habitat type, which is significant as a watercourse/wetland, habitat/potential habitat for Migratory birds and habitat/potential habitat for fauna protected under the EPBC Act and/or WC Act
- direct disturbance of 2,255 ha of Low Hill habitat type, which is significant as habitat/potential habitat for fauna protected under the EPBC Act and/or WC Act.

These areas are shown in Figure 85. An offset for disturbance of Vegetation in Good – Excellent condition has not been included in the assessment following the residual impact significance model (Table 68), and its inclusion as a required offset for this Proposal will continue to be negotiated with the OEPA.

Fortescue understands that the State Government is considering the appropriateness of a strategic conservation fund for the Pilbara (Government of Western Australia 2014). As an alternative to proponent managed offset programs, contributions would be paid by the proponent into a fund for the purpose of undertaking agreed offset actions.

14.4.2 Commonwealth Offsets

Significant impacts associated with threatened or migratory species listed under the EPBC Act include:

- direct disturbance of potential habitat (14 ha of Marsh habitat type) and potential foraging habitat (2,255 ha of Low Hill habitat type) for the Night Parrot.
- direct disturbance of potential foraging habitat (1,117 ha of Drainage Line and Alluvial Plain habitat type) for the Pilbara Olive Python.
- direct disturbance of potential habitat (14 ha of Marsh habitat type and 1,117 ha of Drainage Line and Alluvial Plain habitat type) for Migratory bird species.

The Stony Plain habitat type which also exists within the Development Envelope is not considered to be significant habitat for any EPBC listed threatened or migratory species.

To offset the potential residual impacts of the Proposal on MNES, Fortescue proposes to expand the offsets program required by existing approvals issued under the EPBC Act. This would involve expansion of (or contribution of funding to) the Offsets Plan described in Section 14.2.1.

The residual impacts to MNES are consistent with the residual impacts determined using the State Government residual impact significance model (Section 14.4.1) and occur over the same three habitat types. This duplication of residual impacts which require offsetting under both State and Commonwealth policies will need to be considered in the final offset package to be agreed with both the State and Commonwealth regulators.

15. ENVIRONMENTAL MANAGEMENT

15.1 Environmental Management System

The mitigation and management measures detailed in this document will be implemented through the life of the Proposal to ensure potential environmental impacts are minimised. These measures will be implemented via Fortescue's Environmental Management System (EMS) which is guided by Fortescue's environmental policy.

Fortescue's Environment Policy communicates the following:

- Fortescue respects the need to protect the environment in which it operates, demonstrating a proud history of environmental engagement to minimise, mitigate and remediate the impacts of its operations.
- Fortescue strives to achieve effective and sustainable environmental outcomes through disciplined environmental management. This includes the consideration of innovative environmental management techniques in project development, operations and rehabilitation.
- Compliance with all relevant environmental laws and obligations is the minimum standard to which Fortescue operates and the minimum requirement against which environmental performance is measured.
- The protection of the environment is a cornerstone of Fortescue's success and sustainability. This success benefits not just Fortescue but its families, communities and future generations.

Fortescue's EMS is broadly based on *ISO 14001: 2004 – Environmental Management Systems – Requirements for guidance and use.* Under Fortescue's EMS:

- Environmental risks are identified, analysed and evaluated, and controls established.
- Responsibility for meeting environmental objectives, targets and obligations, and the implementation of controls are clearly communicated.
- Regular checks are undertaken to determine whether environmental objectives, targets, obligations and controls are being met.
- Environmental performance is monitored and reviewed to ensure continuous improvement.

15.2 Environmental Management Plans

Management plans are a critical component of Fortescue's EMS. Their hierarchy within Fortescue EMS is depicted in Plate 5.

Plate 5: EMS Document Hierarchy

The potential impacts of the Proposal and the proposed management measures and performance standards are detailed in Sections 7 – 14 of this document. Management measures are primarily based on the implementation existing management plans and procedures. Management plans that will be implemented to mitigate and manage the potential impacts are discussed in Sections 7 – 14 and include the following:

- *Chemical and Hydrocarbon Management Plan*, 100-PL-EN-0011 (Fortescue 2014f).
- *Chichester Operations Noise and Vibration Management Plan* CB-PL-EN-0007
- *Christmas Creek Mine Site Water Usage Management Plan* CC-PL-EN-0001
- *Christmas Creek Vegetation Health Monitoring and Management Plan* CC-PL-EN-0004 (Fortescue 2012a)
- *Christmas Creek Water Management Scheme Stakeholder Consultation Reinjection Management Plan*, CC-PL-EN-0006 (Fortescue 2011a)
- *Conservation Significant Fauna Management Plan* 100-PL-EN-0022 (Fortescue 2013c)

- *Emergency Management Sub-Plan: Bushfire Management* 100-PL-EM-0009 (Fortescue 2014e)
- *Fortescue Marsh Baiting Plan* CC-PL-EN-0007 (Fortescue 2011g)
- *Fortescue Marsh Hydrology and Vegetation Monitoring and Management Plan*, 100-PL-EN-1013 (Fortescue 2014g)
- *Groundwater Management Plan* 45-PL-EN-0029 (Fortescue 2014b)
- *Mine and Rail Dust Management Plan*, 45-PL-EN-0030 (Fortescue 2001f)
- *Rehabilitation and Revegetation Management Plan* 45-PL-EN-0023 [Revision 2 – issued for EPA review] (Fortescue 2013d)
- *Significant Flora and Vegetation Management Plan* CC-PL-EN-0017 (Fortescue 2012b)
- *Subterranean Fauna Survey Plan* 45-PL-EN-0010 (Fortescue 2011f)
- *Surface Water Management Plan*, 100-PL-EN-1015 (Fortescue 2014i)
- *Weed Management Plan,* 45-PL-EN-0013 (Fortescue 2011d)
- *Waste Management Plan*, 45-PL-EN-0014.

Key management plans are included in Appendix 2. These management plans may be amended to incorporate conditions of the approval, if approval for the Proposal is granted.

Management strategies as described within this document and within Fortescue's management plans can be adapted in response to external factors such as the outcomes of ongoing stakeholder consultation, changes in Government policy or developments to regional management strategies.

15.3 Environmental Monitoring

Environmental monitoring will be undertaken during the implementation of this Proposal as required by Fortescue's management plans and approvals. Fortescue's environmental guidelines and site specific procedures will provide the specific details of monitoring requirements including the following:

- parameters to be monitored
- frequency and timing
- review and evaluation.

15.4 Consistency with Environmental Principles

The EP Act includes a set of core Principles that are applied by the EPA in assessing proposals. These environmental protection principles are listed in Table 69 together with a summary of these have been applied to the Proposal.

Table 69: Consistency of the Proposal with the Principles of Environmental Protection

Environmental Protection Principle	Consideration given in the Proposal
1. The precautionary principle Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In application of this precautionary principle, decisions should be guided by – • careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and • assessment of the risk-weighted consequences of various options.	Fortescue maintains an environmental management system (EMS) that addresses activities with a potential to affect the environment. A key element of the EMS includes assessing risk to identify potential impacts early in the process to enable planning for avoidance and/or mitigation. Detailed site investigations and specialist studies have been undertaken to identify and address potential impacts. These investigations and studies have allowed the Proposal to be designed to minimise potential impacts to the key environmental values of the local flora, vegetation, fauna and Fortescue Marsh. The environmental risks associated with the Proposal have been assessed.
2. The principle of intergenerational equity The present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations.	Fortescue believes the Proposal can be implemented without adverse impacts to the health, diversity and productivity of the environment for future generations. Where practicable areas of high environmental and/or heritage value have been avoided. Fortescue's proposed offsets and closure planning aims to enhance the environment for the benefit of future generations.
3. The principle of conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	The conservation of biological diversity and ecological integrity is fundamental to Fortescue's approach to environmental management and has been a major consideration for the Proposal. Biological investigations have been undertaken early in the project planning process to identify areas of high conservation value and areas where disturbance should be avoided. The Proposal has been designed to minimise potential impacts to these areas including the Fortescue Marsh. The Proponent has committed to restoring disturbed environments upon decommissioning, as well as the ongoing rehabilitation of vegetation around Christmas Creek. The aim of all rehabilitation is to establish sustainable endemic vegetation units consistent with reconstructed landforms and surrounding vegetation. The Proponent is also undertaking monitoring of groundwater and surface water in the area to determine impacts, as well as funding ongoing studies into the Fortescue Marsh.

Environmental Protection Principle	Consideration given in the Proposal
4. The principles relating to improved valuation, pricing and incentive mechanisms Environmental factors should be included in the valuation of assets and services. The polluter pays principles – those who generate pollution and waste should bear the cost of containment, avoidance and abatement. The user of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste. Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structure, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solution and responses to environmental problem	Fortescue acknowledges the need for improved valuation, pricing and incentive mechanisms and endeavours to pursue these principles when practicable. For example: • environmental factors have played a role in determining infrastructure locations. • procedures are in place to ensure that emissions and discharges are minimised as far as practicable. • the cost of rehabilitation and closure has been incorporated into the costs of the product from the commencement of operation.
5. The principle of waste minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment	Fortescue's approach to waste management, in order of priority is: • avoid and reduce at source • reuse and recycle • treat and/or dispose. Fortescue operates an appropriately licensed landfill for the disposal of general domestic solid wastes and has a comprehensive recycling program on site which includes the recycling of aluminium cans, scrap steel, plastic, batteries, light globes, fluorescent tubes, polyethylene pipe, office paper and cardboard.

The findings of this PER demonstrate that the Proposal is environmentally acceptable if implemented in accordance with proposed management measures and offsets.

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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Description
ABA	Acid Base Accounting
ASS	Acid Sulphate Soils
AH Act	*Aboriginal Heritage Act 1972*
AHD	Australian Height Datum
AMD	Acid and/or Metalliferous Drainage
ANC	Acid Neutralising Capacity
ANCOLD	Australian National Committee on Large Dams
ANZECC	Australian and New Zealand Environment and Conservation Council
API	Assessment on Proponent Information
ARC	Australian Research Council
ARD	Acid Rock Drainage
ARI	Average Return Interval
ARMCANZ	Agricultural and Resource Management Council of Australia and New Zealand
ASLP	Australian Standard Leachate Procedure
BAM Act	*Biosecurity and Agriculture Management Act 2007*
BIF	Banded Iron Formation
CALM Act	*Conservation and Land Management Act 1984*
CAMBA	China-Australia Migratory Bird Agreement
CCY1	Central Contractors Yard 1
CCY2	Central Contractors Yard 2
CCWMS	Christmas Creek Water Management Scheme
DEC	Department of Environment and Conservation (now DPaW and DER)
DER	Department of Environment Regulation
DMP	Department of Mines and Petroleum
DoE	Department of the Environment
DoW	Department of Water
DPaW	Department of Parks and Wildlife
DSEWPaC	Department of Sustainability, Environment, Water Population and Communities (now DoE)
EC	Electrical Conductivity
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ESA	Environmentally Sensitive Area
ESD	Environmental Scoping Document
FaHCSIA	Department of Families, Housing, Community Services and Indigenous Affairs
Fortescue	Fortescue Metals Group Ltd

Abbreviation	Description
Fortescue Marsh Guidance	Environmental and Water Assessments Relating to Mining and Mining-related Activities in the Fortescue Marsh Management Area
FMCR	Fortescue Marsh Conservation Reserve (proposed)
GAI	Geochemical Abundance Index
GDE	Groundwater Dependent Ecosystem
GDP	Ground Disturbance Permit
GL/a	Gigalitres per Annum
Golder	Golder Associates Pty Ltd
ha	Hectares
HSE	Health, Safety and Environment
IBRA	Interim Biogeographic Regionalisation of Australia
ISQG	Interim Sediment Quality Guideline
JAMBA	Japan-Australia Migratory Bird Agreement
K_h	Horizontal Hydraulic Conductivity
kL	Kilolitres
km	Kilometres
LAA	Land Access Agreement
LIDAR	Light detection and ranging
m AHD	Metres, Australian Height Datum
ML	Megalitres
MMF	Marra Mamba Formation
MNES	Matters of National Environmental Significance
MPA	Maximum Potential Acidity
m/s	Metres per Second
Mtpa	Million tonnes per Annum
MW	Megawatt
NAF	Non-Acid Forming
NAG	Net Acid Generating
NAPP	Net Acid Producing Potential
NHMRC	National Health and Medical Research Council (NHMRC
NRMMC	Natural Resource Management Ministerial Council (NRMMC)
NWQMS	National Water Quality Management Strategy
OEPA	Office of the Environmental Protection Authority
OPF	Ore Processing Facility
PAF	Potentially Acid Forming
PEC	Priority Ecological Community
PER	Public Environmental Review
RCH	Remote Crushing Hub
RIWI Act	*Rights in Water and Irrigation Act 1914*

Abbreviation	Description
ROKAMBA	Republic of Korea- Australia Migratory Bird Agreement
ROM	Run of Mine
SRE	Short Range Endemic
SRK	SRK Consulting (Australasia) Pty Ltd
SPLP	Synthetic Precipitation Leaching Procedure
t/a	Tonnes per Annum
TDS	Total Dissolved Solids
TEC	Threatened Ecological Community
t/m^3	Tonnes per Cubic Metre
TSF	Tailings Storage Facility
TSSC	Threatened Species Scientific Committee
URS	URS Australia Pty Ltd
VA	Vegetation Association
VT	Vegetation Type
VTEC	Vocational Training and Employment Centre
WC Act	*Wildlife Conservation Act 1950*
WRSF	Waste Rock Storage Facility
XRD	X-ray Diffraction
XRF	X-ray Fluorescence
µS/cm	Micro Sieverts per Centimetre

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Figure 1: Regional Location of the Proposal

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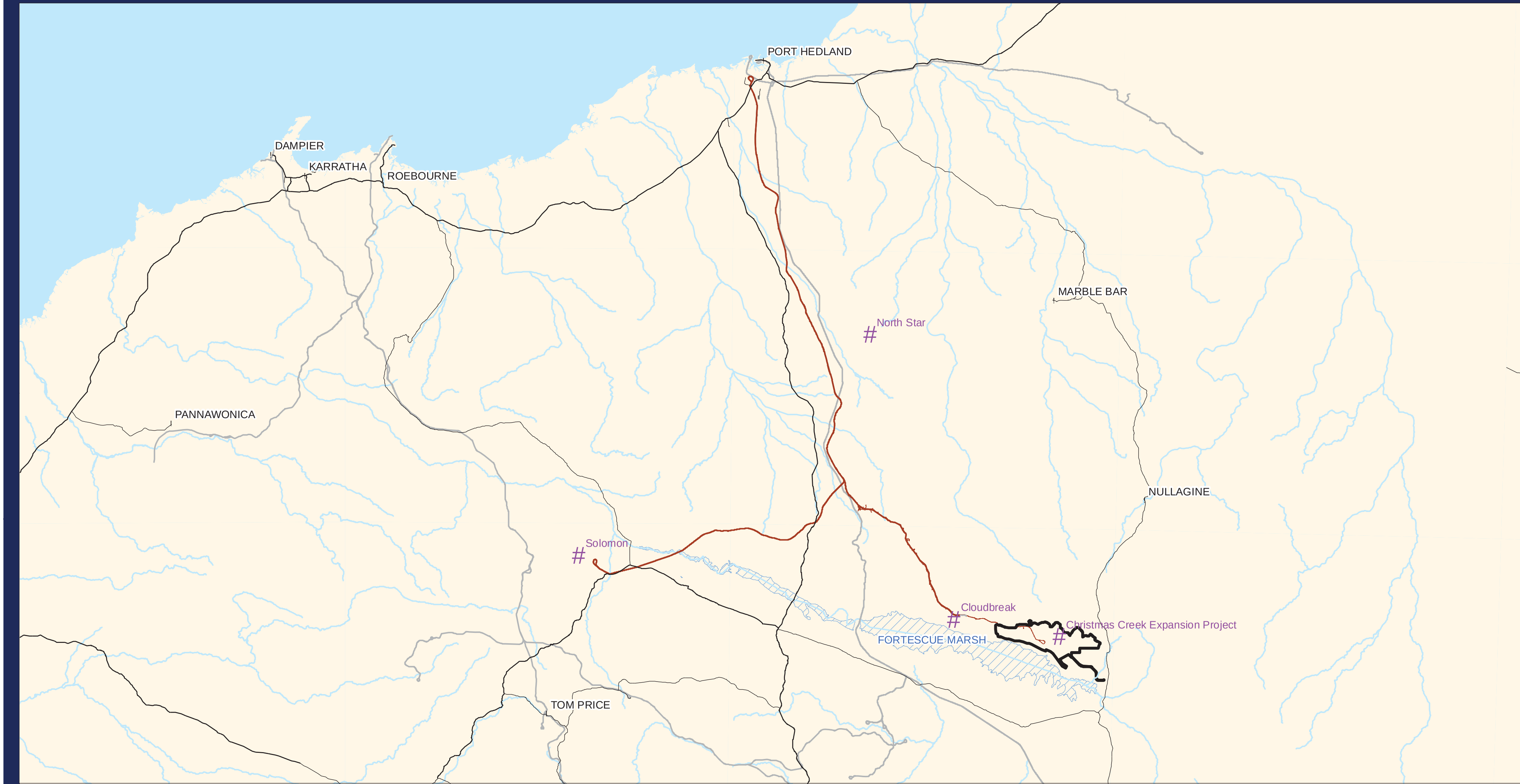

LEGEND

- # FMG Mines
- Major Towns
- Major Roads
- FMG Railways
- Other Railways
- Gov 250K Drainage
- Development Envelope
- Fortescue Marsh

Data Source(s):
Marsh data sourced from GOV

0 10 20 30 40 50
Kilometres

Regional Location

Requested By: Rachael Sharp — Date: 12/06/2014
Drawn By: S.Finning — Size: A3L
Revised By: jcrute — Revision: 0
Approved By: — Confidentiality: 1
Scale: 1:1,540,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F001_RegionalLocation

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 2: Proposal Locality and General Layout

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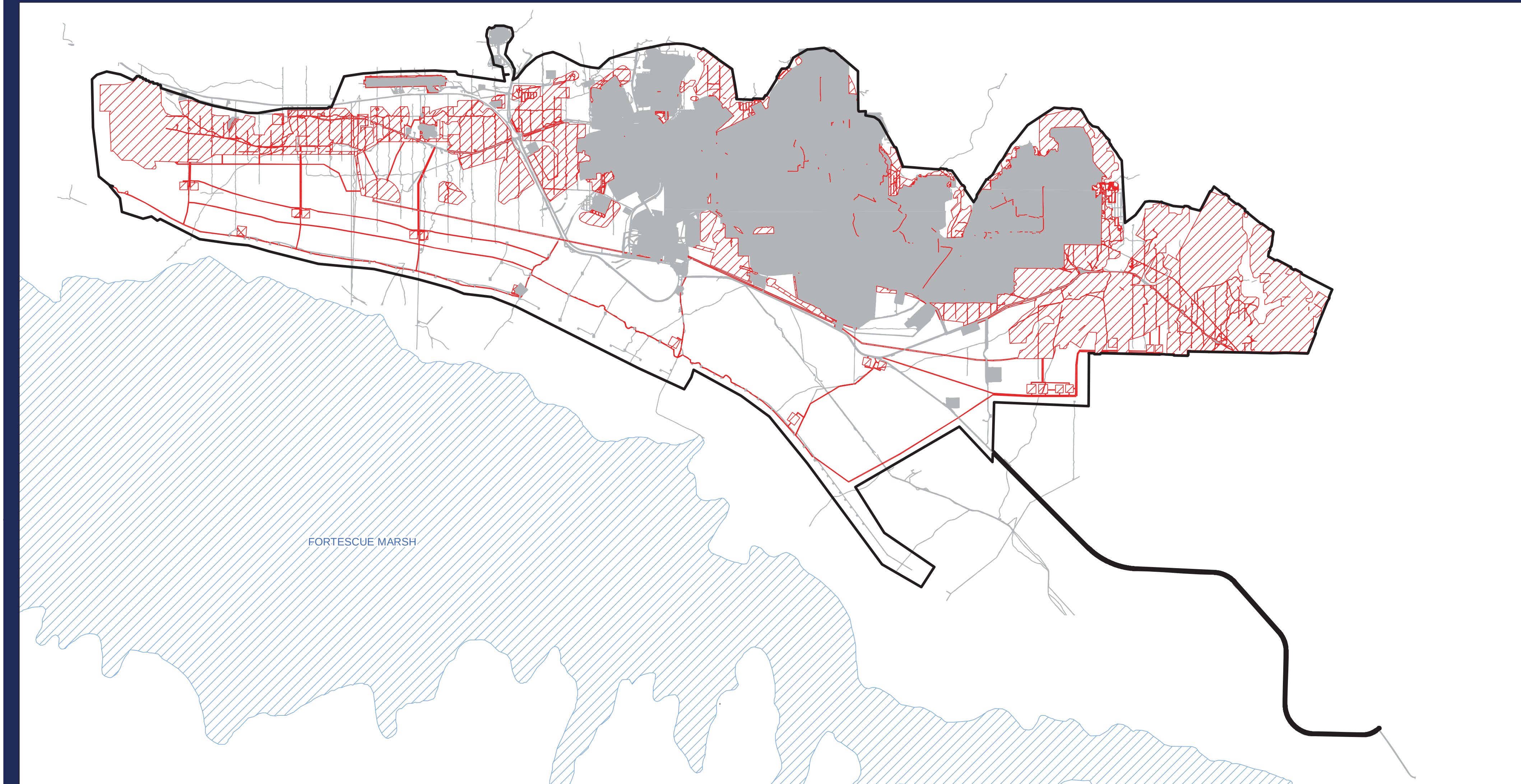

LEGEND

- Development Envelope
- Existing Approved Footprint
- Proposal Area (Indicative Disturbance Footprint)
- Fortescue Marsh

0 1 2 3 4 5
Kilometres

Data Source(s):
Marsh data sourced from GOV

Layout

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: sfinning
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F002_Layout

Date: 6/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 3: Existing Christmas Creek Operations

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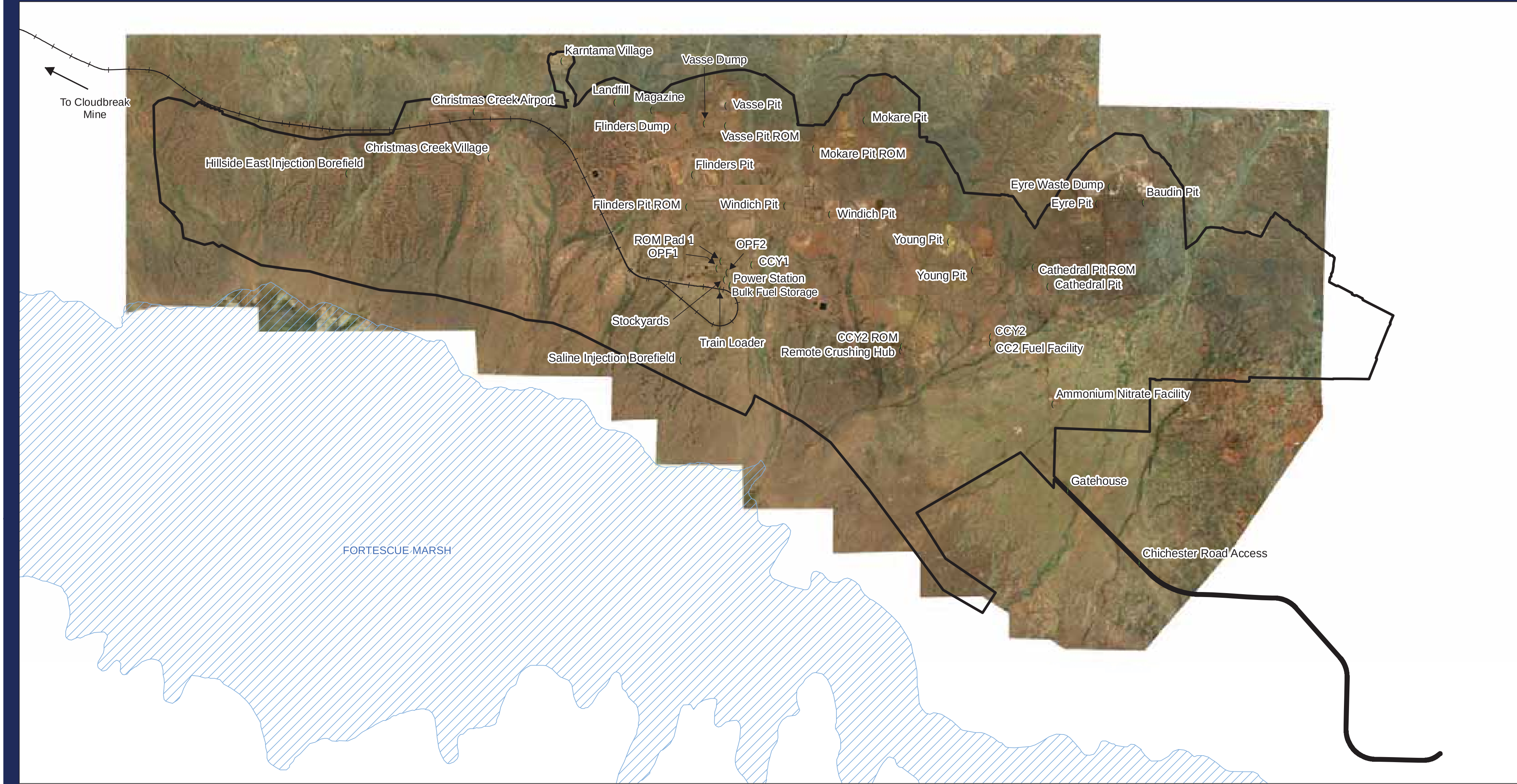

LEGEND

Rail Alignment

Development Envelope

Data Source(s):
Marsh data sourced from GOV

Existing Christmas Creek Operations

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: sfinning
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F003_ExistChristCreekOps

Date: 12/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

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The New Force in Iron Ore

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Figure 4: Proposal Tenure

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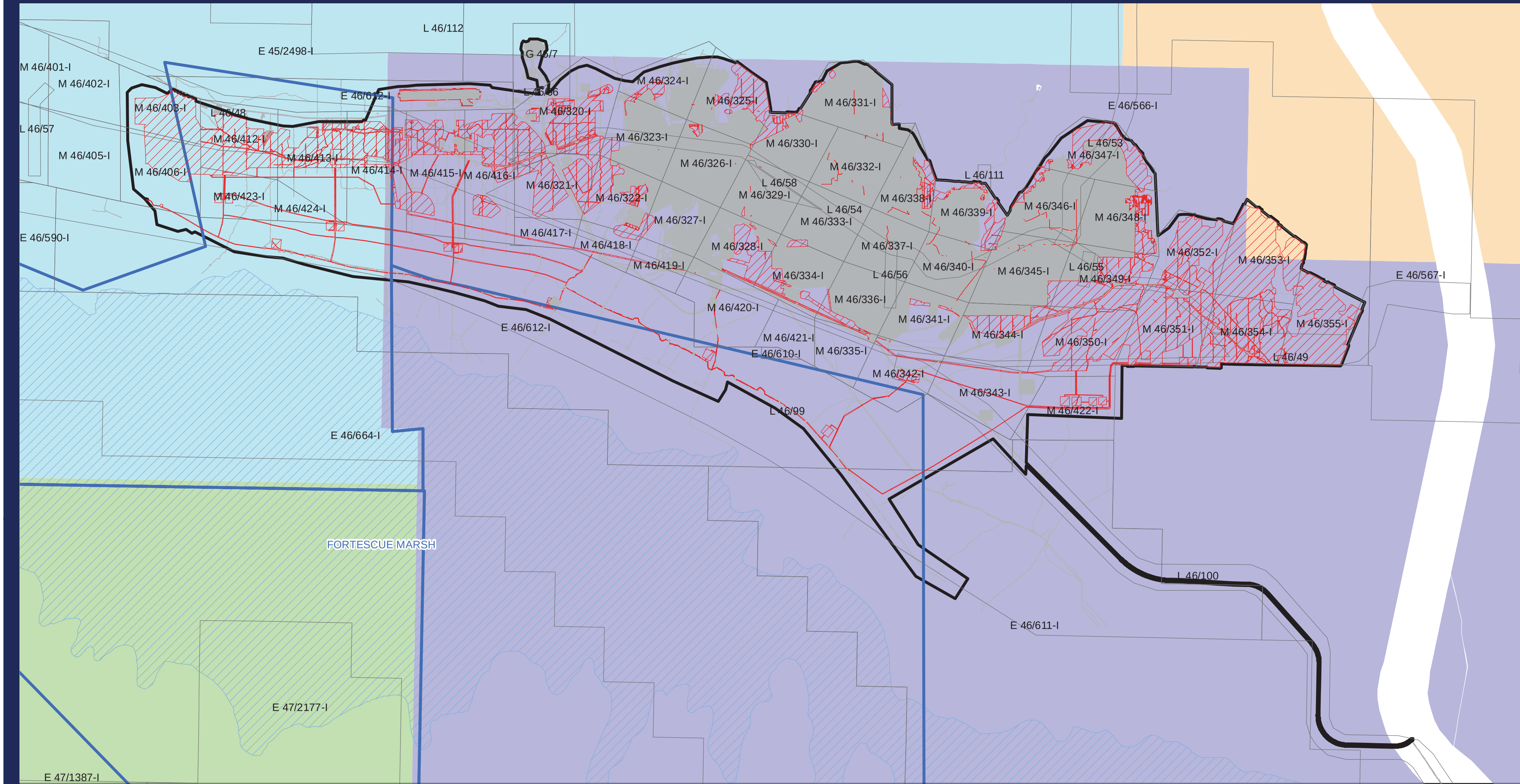

LEGEND

- Development Envelope
- Proposal Area (Indicative Disturbance Footprint)
- Existing Approved Footprint
- Fortescue Tenements
- Fortescue Marsh
- Proposed Fortescue Marsh Conservation Reserve

Pastoral Leases

- Bonney Downs
- Hillside
- Marillana
- Roy Hill

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Tenure

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F004_Tenure

Date: 16/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 5: Geology of the Proposal Area

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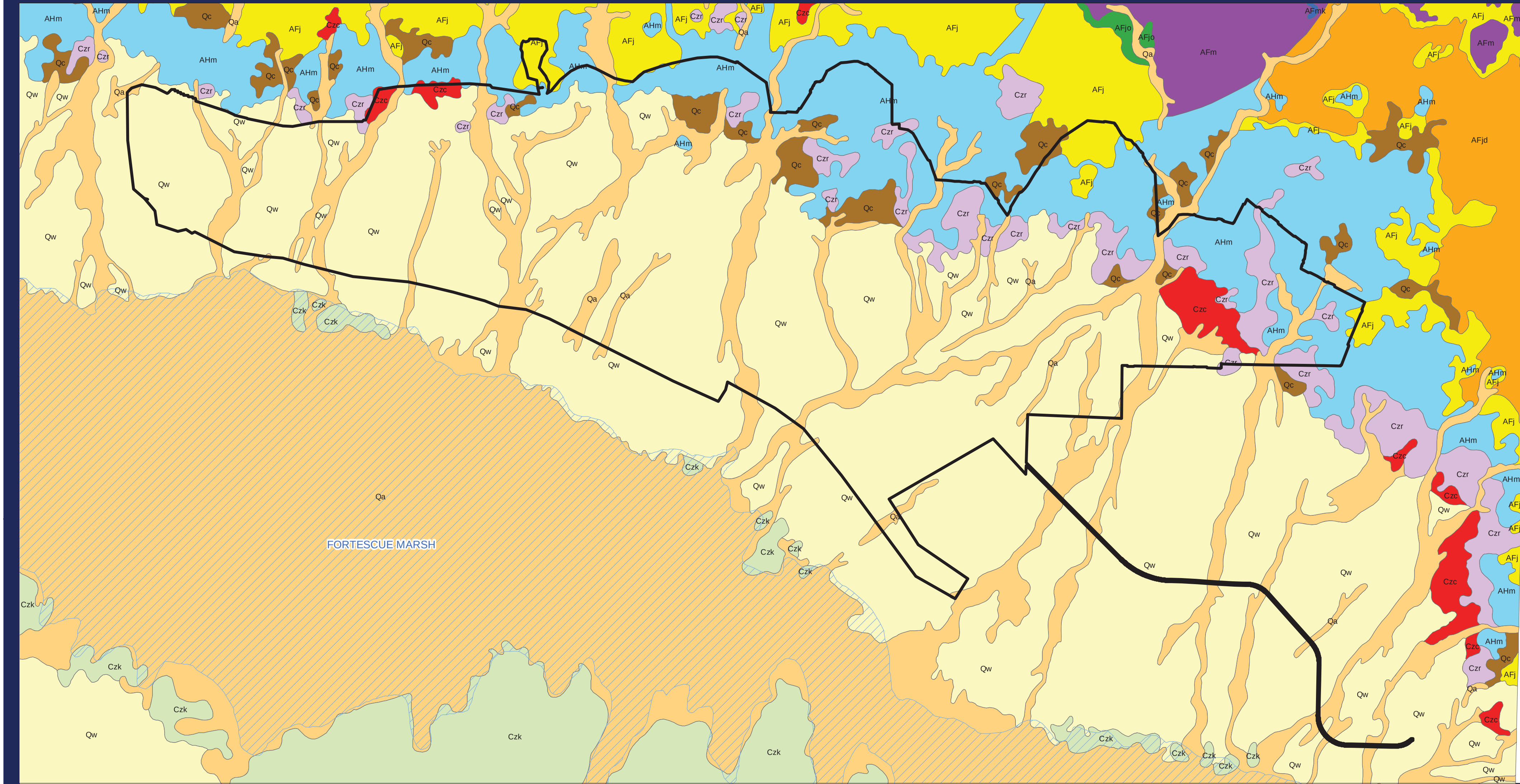

LEGEND

Development Envelope

Surface Geology

- AFj: JEERINAH FORMATION: pelite, chert, and thin-bedded metasandstone; intruded by metadolerite sills in the Hamersley Range
- AFjd: Pelite and thin-bedded metadolomite
- AFjo: Woodiana Member: metamorphosed quartzitic sandstone, pelite, and chert (locally stromatolitic)
- AFm: MADDINA BASALT: amygdaloidal metabasaltic flows and breccia
- AFmk: Kuruna Member: metamorphosed volcanic sandstone, pelite, chert, and metadolomite; local accretionary lapilli and stromatolites
- AHm: MARRA MAMBA IRON FORMATION: chert, banded iron-formation, and pelite
- Czc: Colluvium-partly consolidated quartz and rock fragments in silt and sand matrix; old valley-fill deposits
- Czk: Calcrete-sheet carbonate; found along major drainage lines
- Czr: Hematite-goethite deposits on banded iron-formation and adjacent scree deposits
- Qa: Alluvium_unconsolidated silt, sand, and gravel; in drainage channels and on adjacent floodplains
- Qc: Colluvium-unconsolidated quartz and rock fragments in soil; locally derived soil, and scree, and talus deposits
- Qw: Alluvium and colluvium-red-brown sandy and clayey soil; on low slopes and sheetwash areas

Data Source(s):
Marsh data sourced from GOV.
Geology 250K sourced from DMP.

0 1 2 3 4 5
Kilometres

Geology

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F005_Geology

Date: 12/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 6: IBRA Subregions

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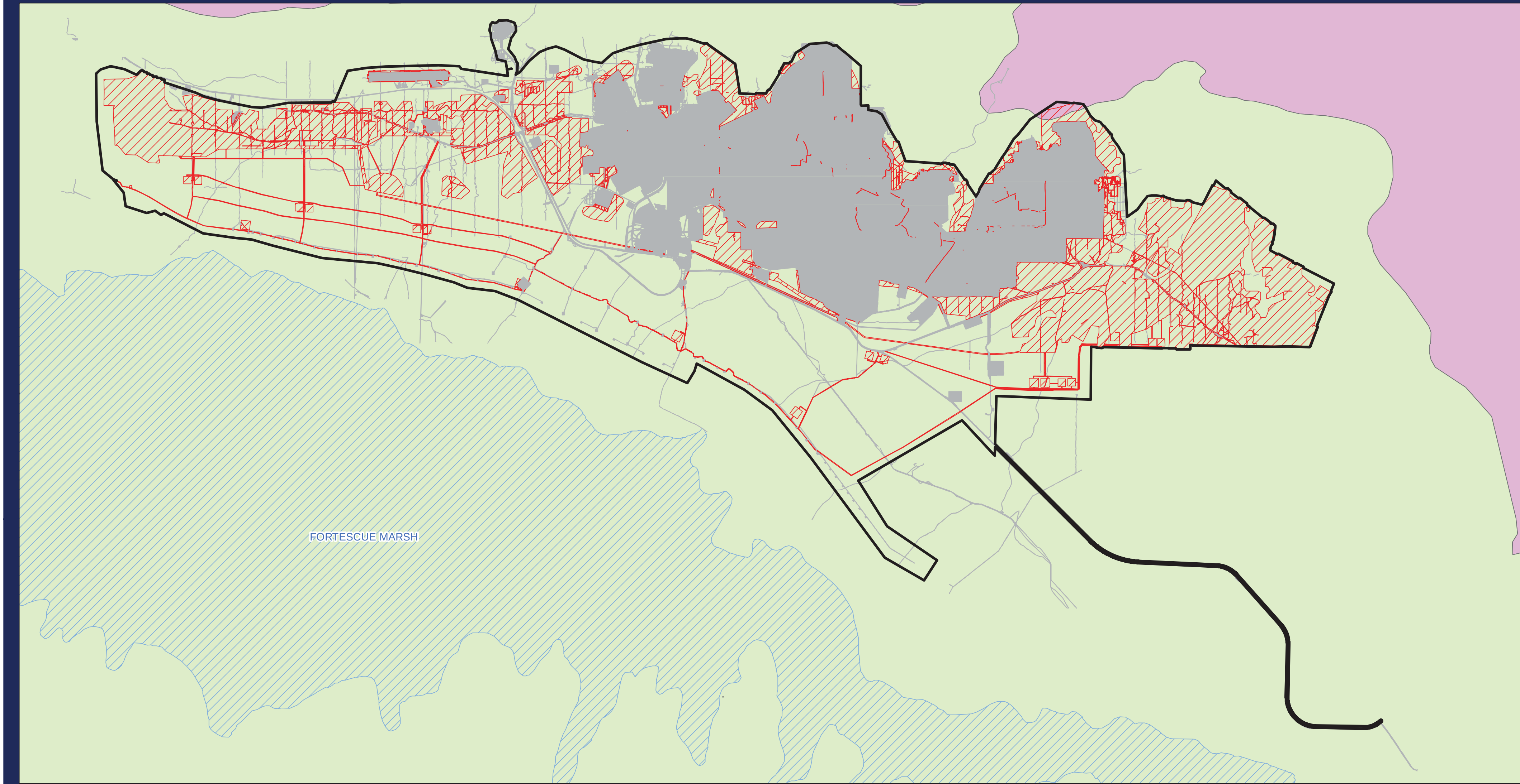

LEGEND

- Development Envelope
- Proposal Area (Indicative Disturbance Footprint)
- Existing Approved Footprint
- Fortescue Marsh

IBRA Subregion

- Chichester
- Fortescue

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

IBRA Subregions

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: sfinning
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F006_IBRASubregions

Date: 6/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 7: Land Systems of the Proposal Area

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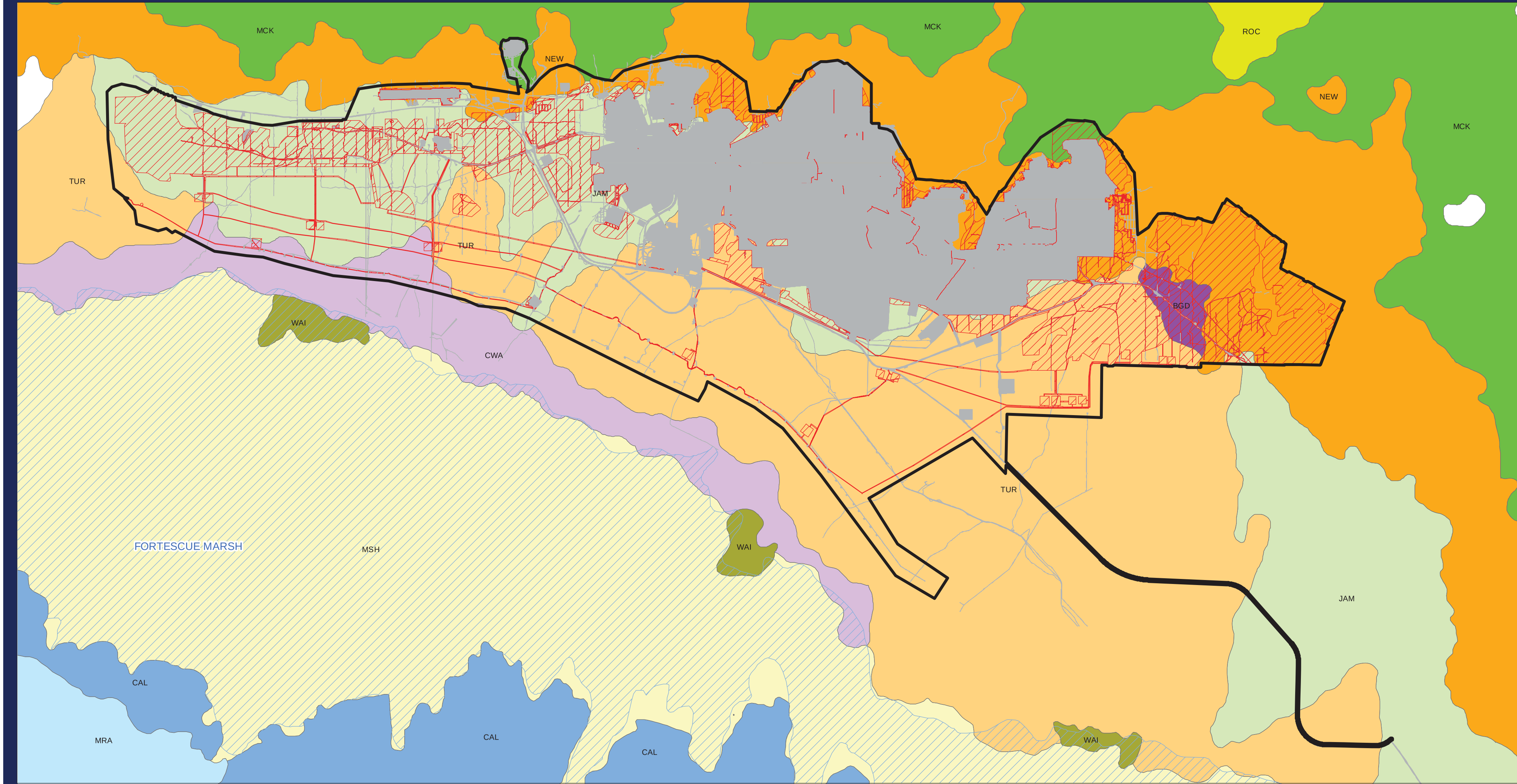

LEGEND

- Development Envelope
- Proposal Area (Indicative Disturbance Footprint)
- Existing Approved Footprint
- Fortescue Marsh

Land System

- Boolgeeda (BGD)
- Calcrete (CAL)
- Cowra (CWA)
- Jamindie (JAM)
- McKay (MCK)
- Marillana (MRA)
- Marsh (MSH)
- Newman (NEW)
- Rocklea (ROC)
- Turee (TUR)
- Warri (WAI)
- Wona (WON)

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Land Systems

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F007_LandSystems

Date: 12/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 8: Pastoral Leases and Proposed 2015 Pastoral Relinquishment Areas

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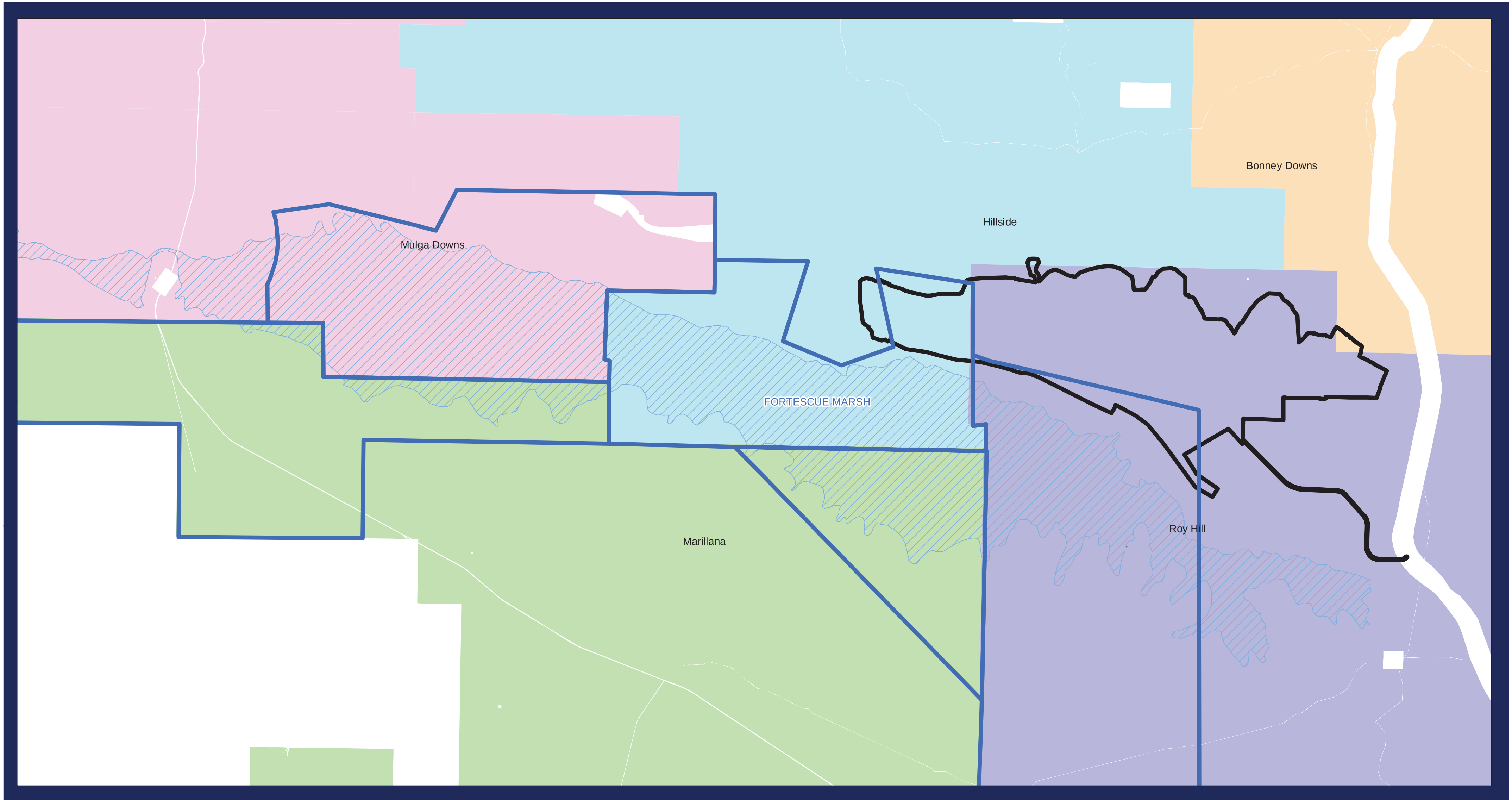

LEGEND

- Proposed Fortescue Marsh Conservation Reserve
- Development Envelope
- Proposal Area (Indicative Disturbance Footprint)
- Existing Approved Footprint
- Fortescue Marsh

Pastoral leases

- Bonney Downs
- Hillside
- Marillana
- Mulga Downs
- Roy Hill

Data Source(s):
Marsh data sourced from GOV

0 2 4 6 8 10
Kilometres

Pastoral Leases and 2015 Relinquishment

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: sfinning
Approved By:
Scale: 1:300,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F008_PL2015Rel

Date: 5/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 9: Development Envelope, Disturbance Footprint and Mine Infrastructure Zones

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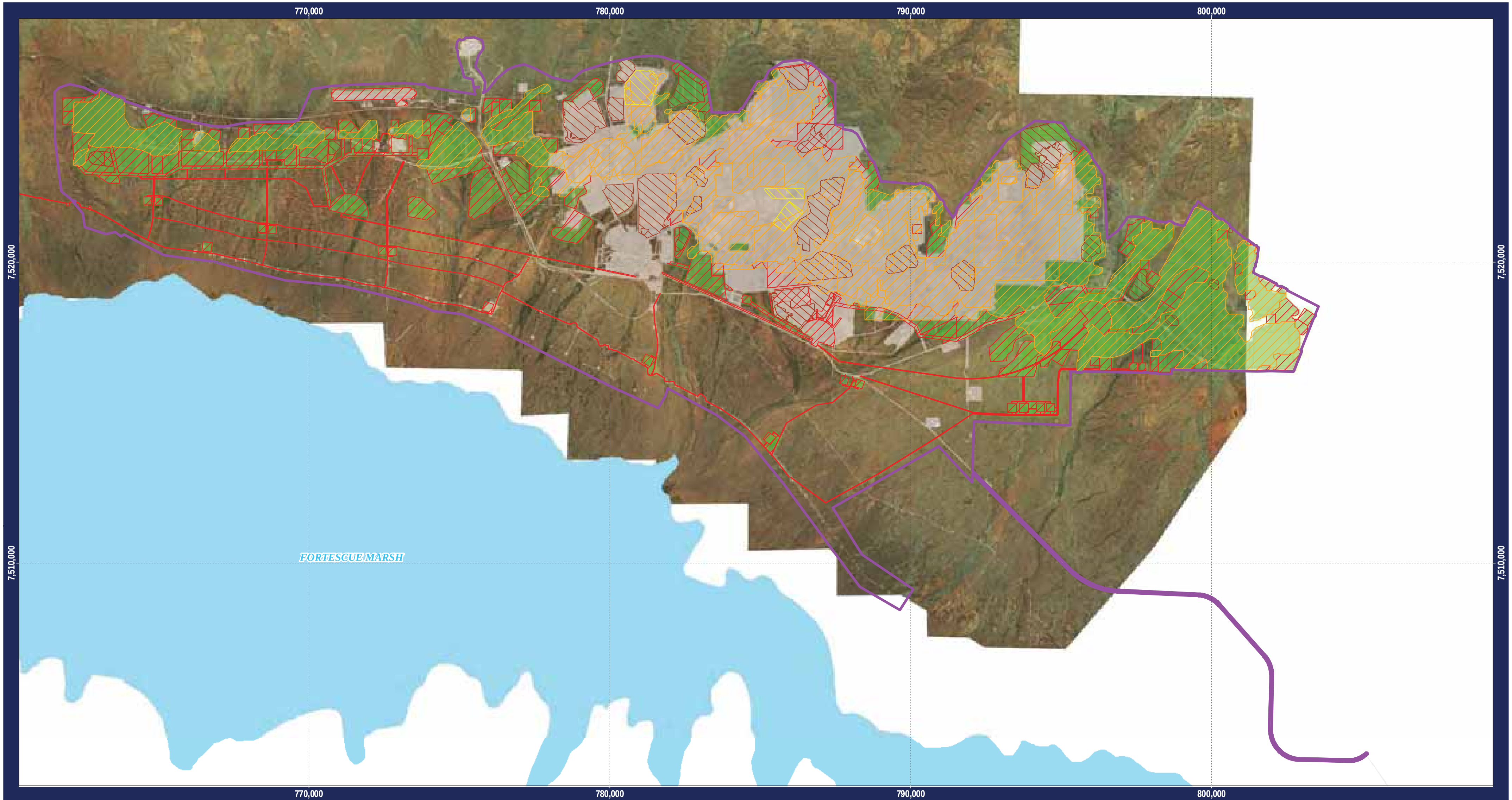

LEGEND

- Mine Development Envelope
- Indicative Proposed Disturbance Footprint
- Indicative Mine Pit Zone
- Indicative Waste Rock Storage Zone
- Indicative Tailings Storage Zone
- Indicative Miscellaneous Infrastructure Zone
- Indicative Approved Area (Ministerial Statement 707)
- Fortescue Marsh

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Mine Development Envelope, Disturbance Footprint and Mine Infrastructure Zones

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:125,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_EN_0218.001_r0

Date: 28/01/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 10: Dewatering and Injection Zones

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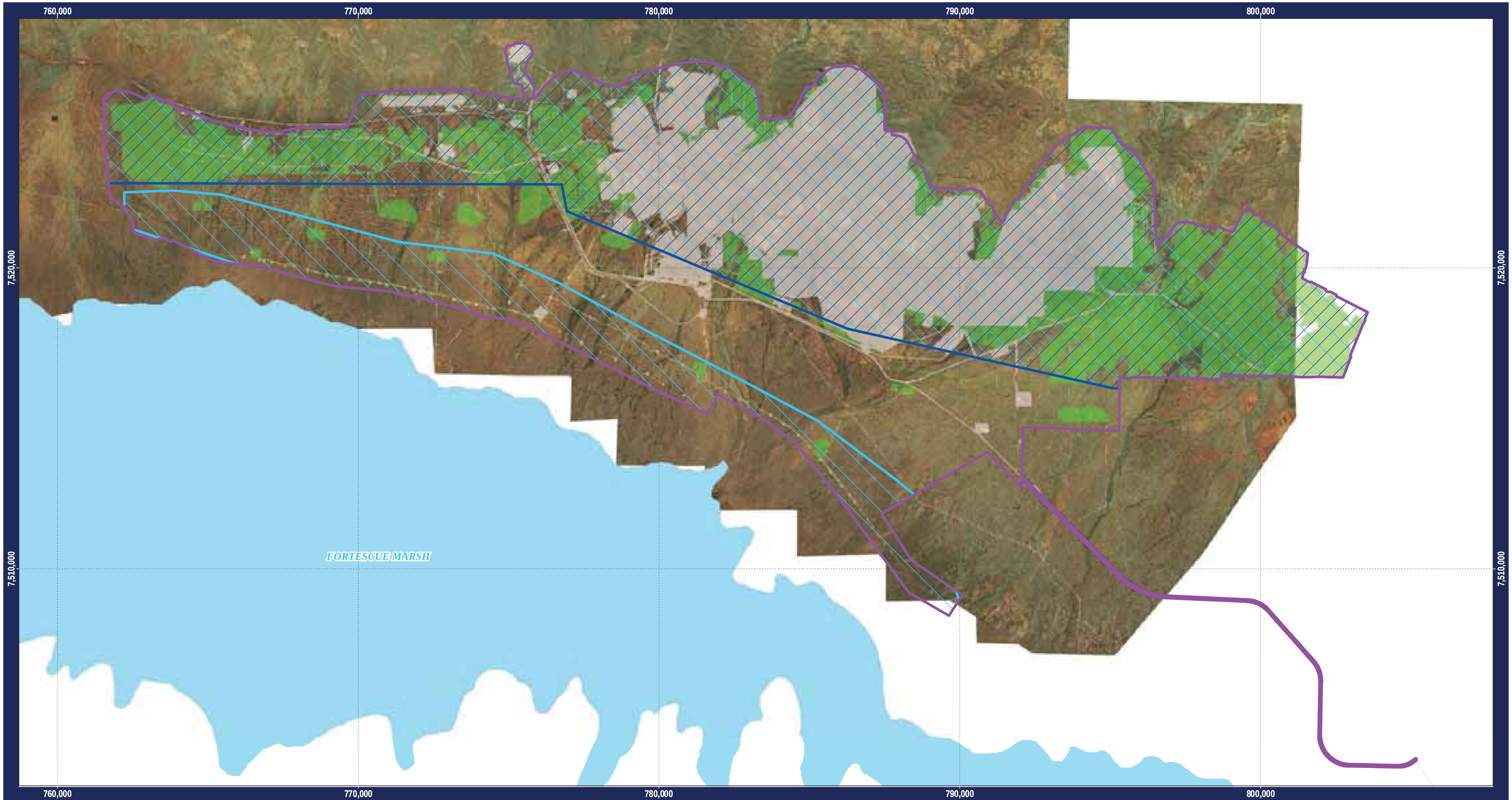

LEGEND

- Mine Development Envelope
- Dewatering Zone
- Injection Zone
- Indicative Proposed Disturbance Footprint
- Indicative Approved Area (Ministerial Statement 707)
- Fortescue Marsh

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Injection and Dewatering Zones

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:125,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_EN_0218.002_r0

Date: 29/01/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 11: Indicative Mine Sequence

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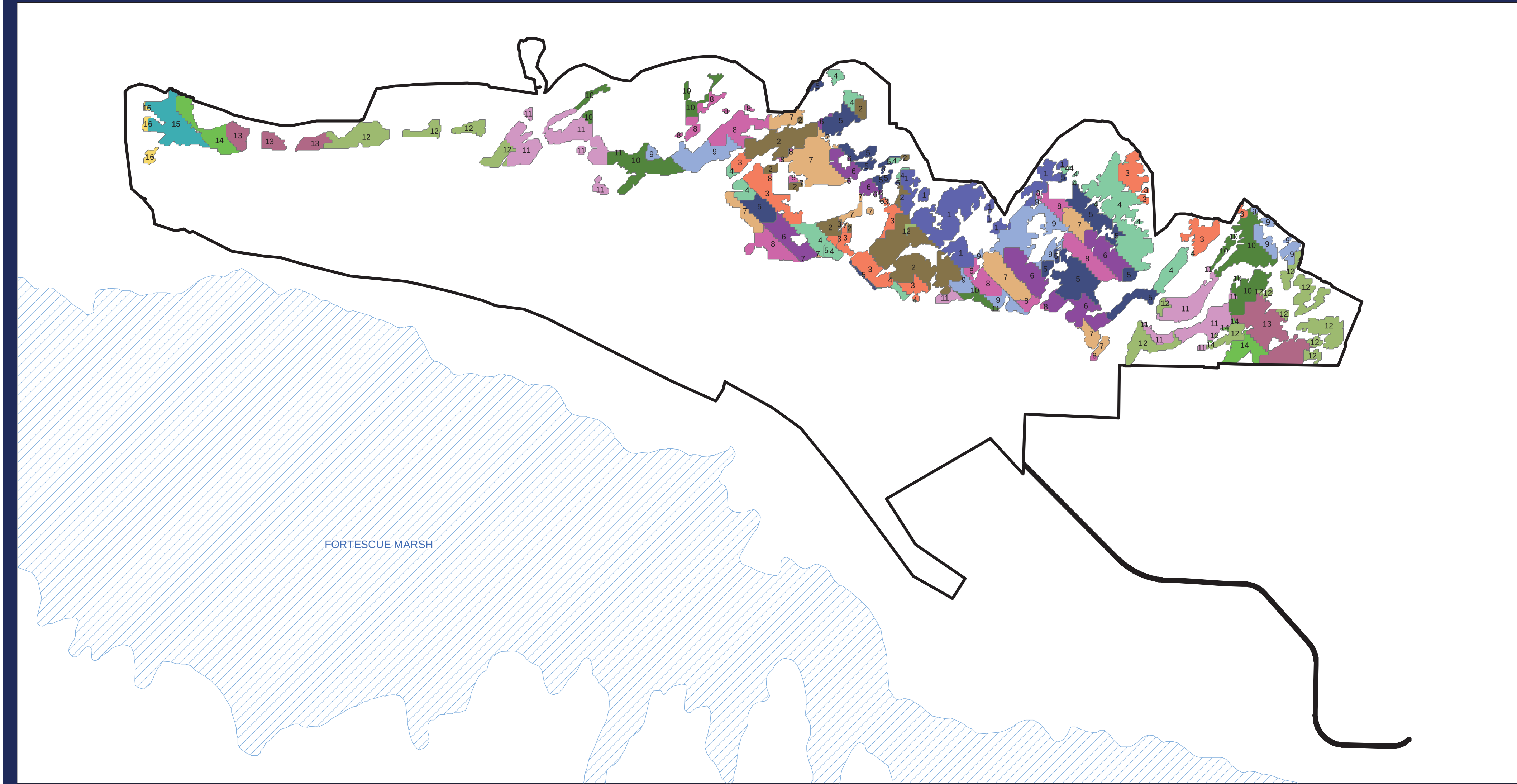

Indicative Mine Pit Sequence

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F012_IndicativeMinePitSeq

Date: 6/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 12: Fortescue Marsh Conceptual Hydrology

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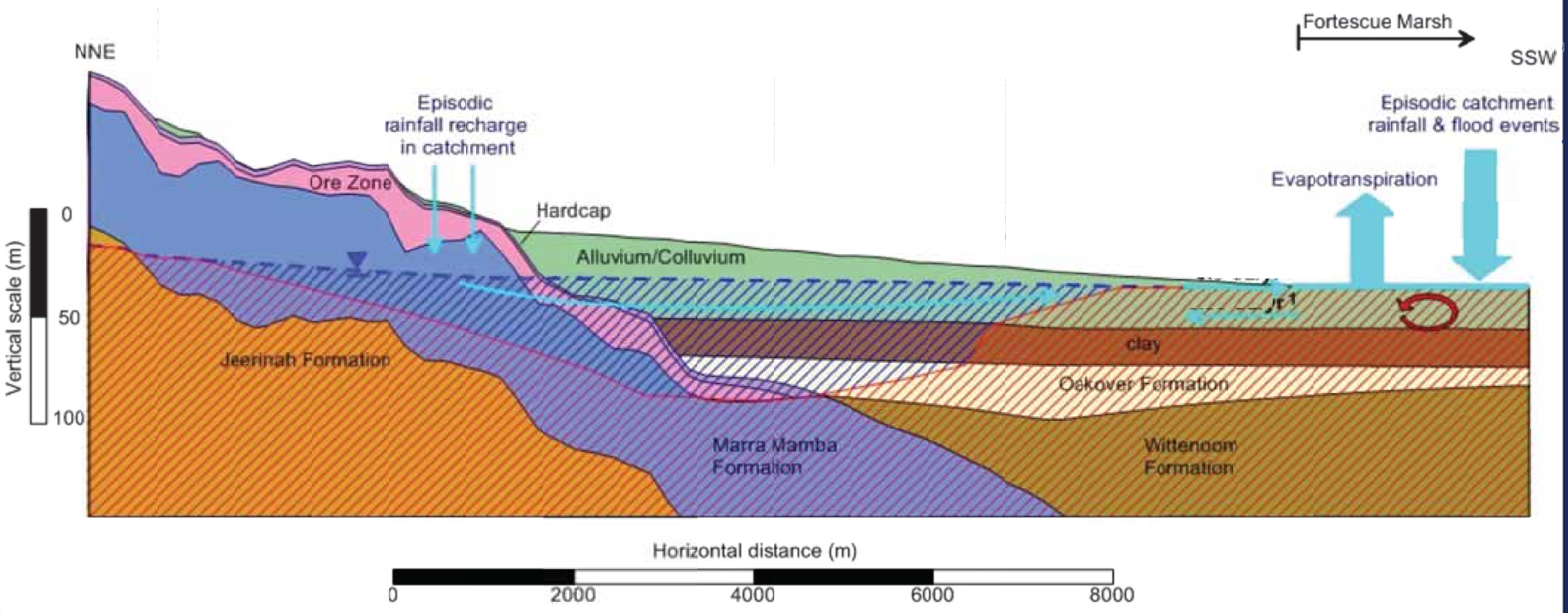

LEGEND

- Brackish Groundwater
- Saline Groundwater
- Flux Estimate
- Groundwater Table
- Evaporative concentration and salinsation of groundwater due to the upper Fortescue Marsh catchments' internal drainage

Christmas Creek Mine Conceptual Hydrogeology

Requested By: Rachael Sharp

Date: 15/06/2014

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 13: Christmas Creek Mine Catchments

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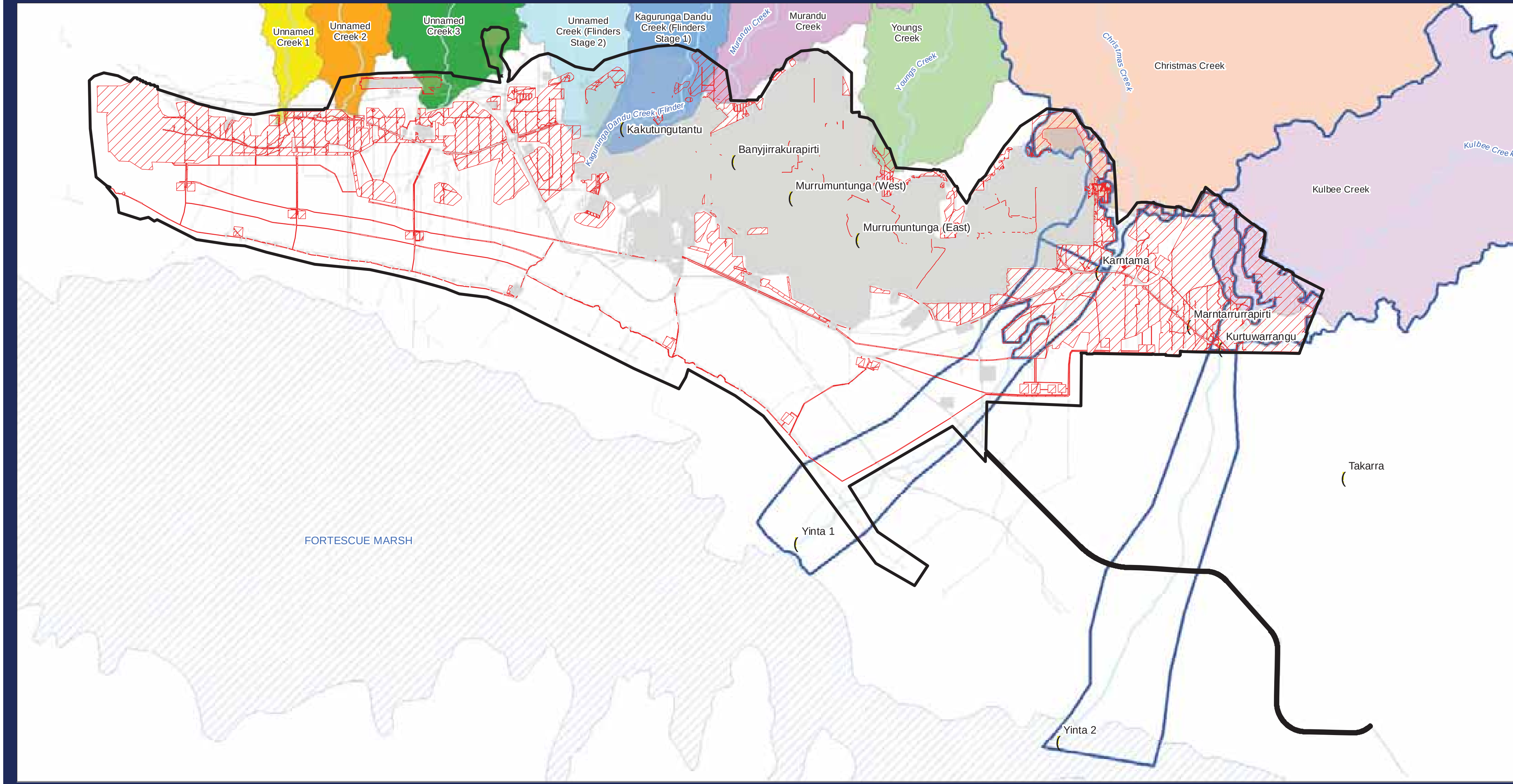

LEGEND

- Yintas
- Main Streams
- Development Envelope
- Proposal Area (Indicative Disturbance Footprint)
- Existing Approved Footprint
- Fortescue Marsh
- Catchment Yintas

Catchment Name

- Christmas Creek
- Kulbee Creek
- Murandu Creek
- Unnamed Creek (Flinders Stage 1)
- Unnamed Creek (Flinders Stage 2)
- Unnamed Creek 1
- Unnamed Creek 2
- Unnamed Creek 3
- Youngs Creek

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Christmas Creek Mine Catchments

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F014_ChristmasCkMineCatch

Date: 15/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 14: CCWMS Dewatering Bores

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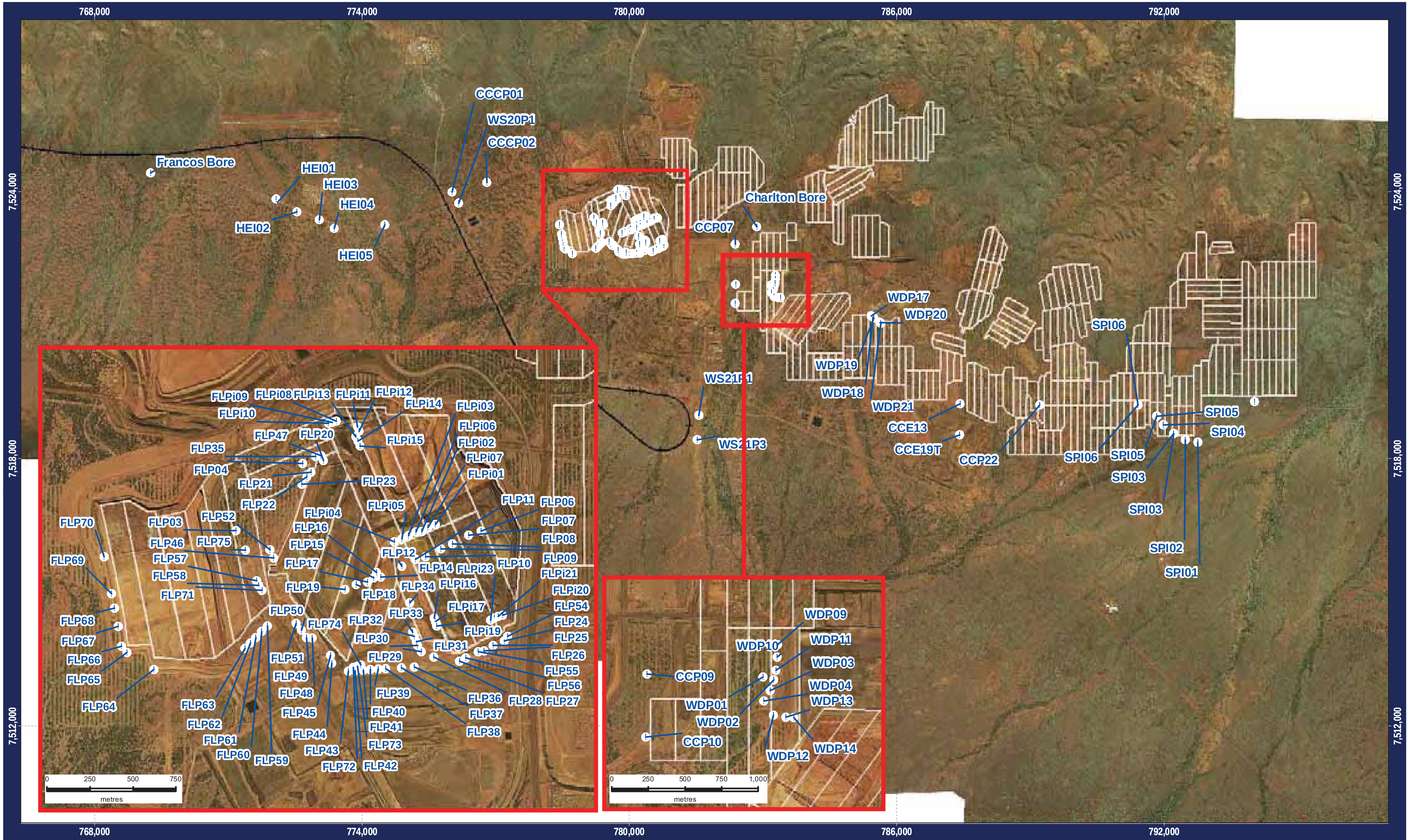

Legend

Active Production Bores

0 1 2 3
Kilometres

Requested By: Timothy Wilkinson
Drawn By: C Whyte

Approved By:
Scale: 1:110,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0172.003_r0

Date: 2/10/2013
Size: A4L
Revision: 0
Confidentiality: 1

Production Bores

Christmas Creek

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 15: CCWMS Injection Bores

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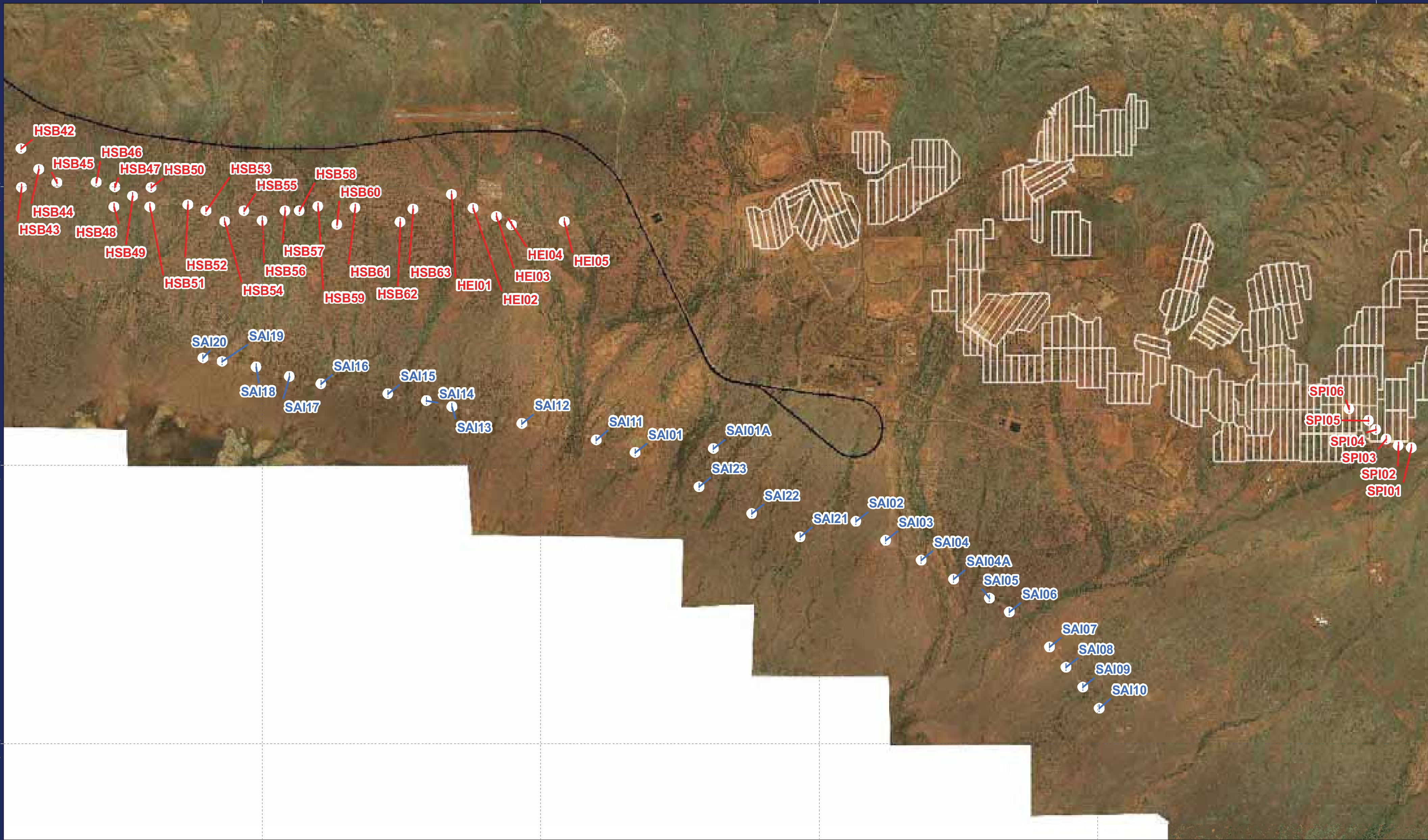

Active Injection Bores

Type

Brackish Injection

Saline Injection

0 1 2 3

Kilometres

Requested By: Timothy Wilkinson
Drawn By: C Whyte

Date: 2/10/2013
Size: A4L
Revision: 0
Confidentiality: 1

Approved By:
Scale: 1:110,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0172.001_r0

Injection Bores

Christmas Creek

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 16: CCWMS Monitoring Bores

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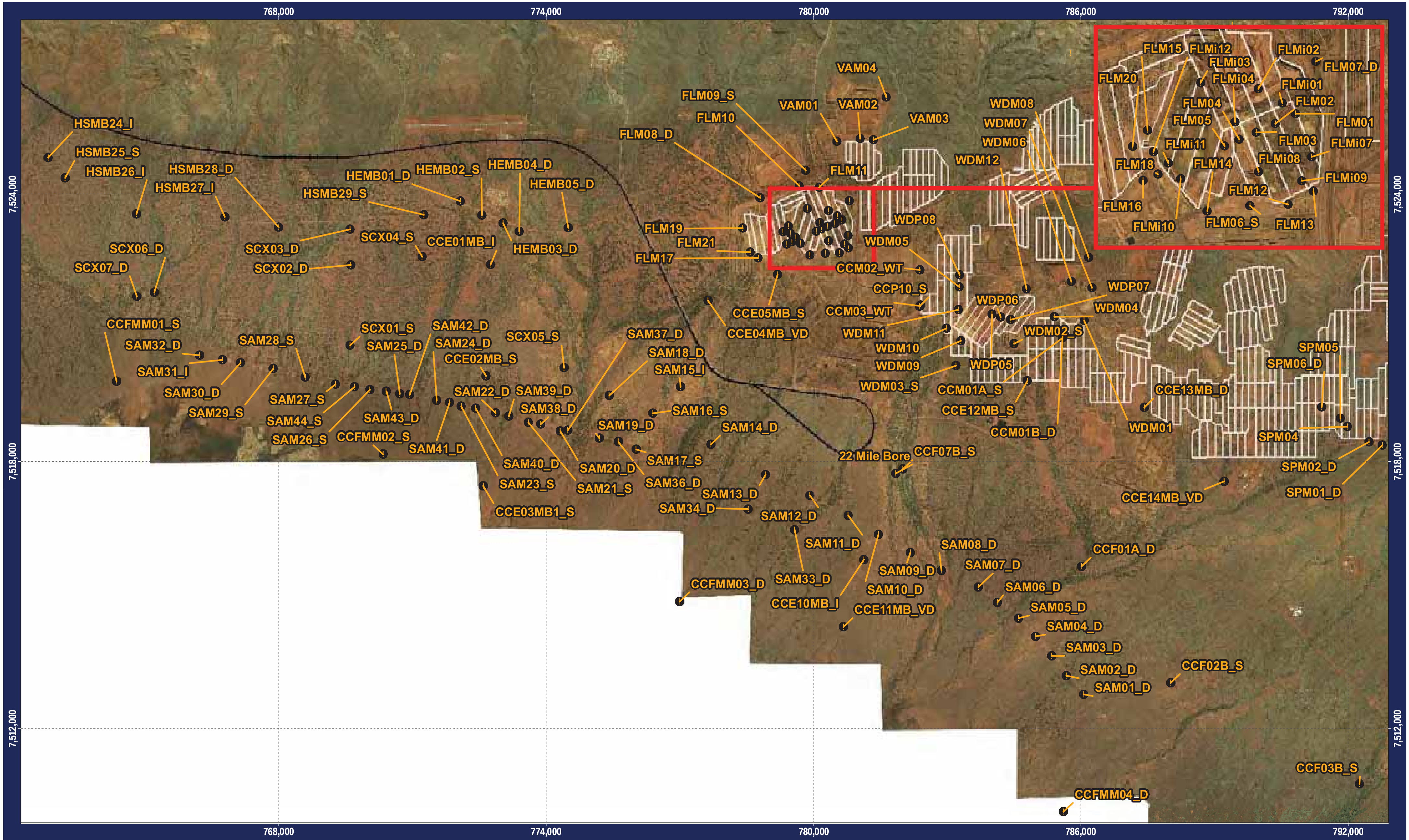

Legend

- Active Monitoring Bores

Requested By: Timothy Wilkinson
Drawn By: C Whyte

Approved By:
Scale: 1:110,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0172.002_r0

Date: 2/10/2013
Size: A4L
Revision: 0
Confidentiality: 1

Monitoring Bores

Christmas Creek

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 17: Flood Level Differences for 1 in 5 year ARI event in 2017

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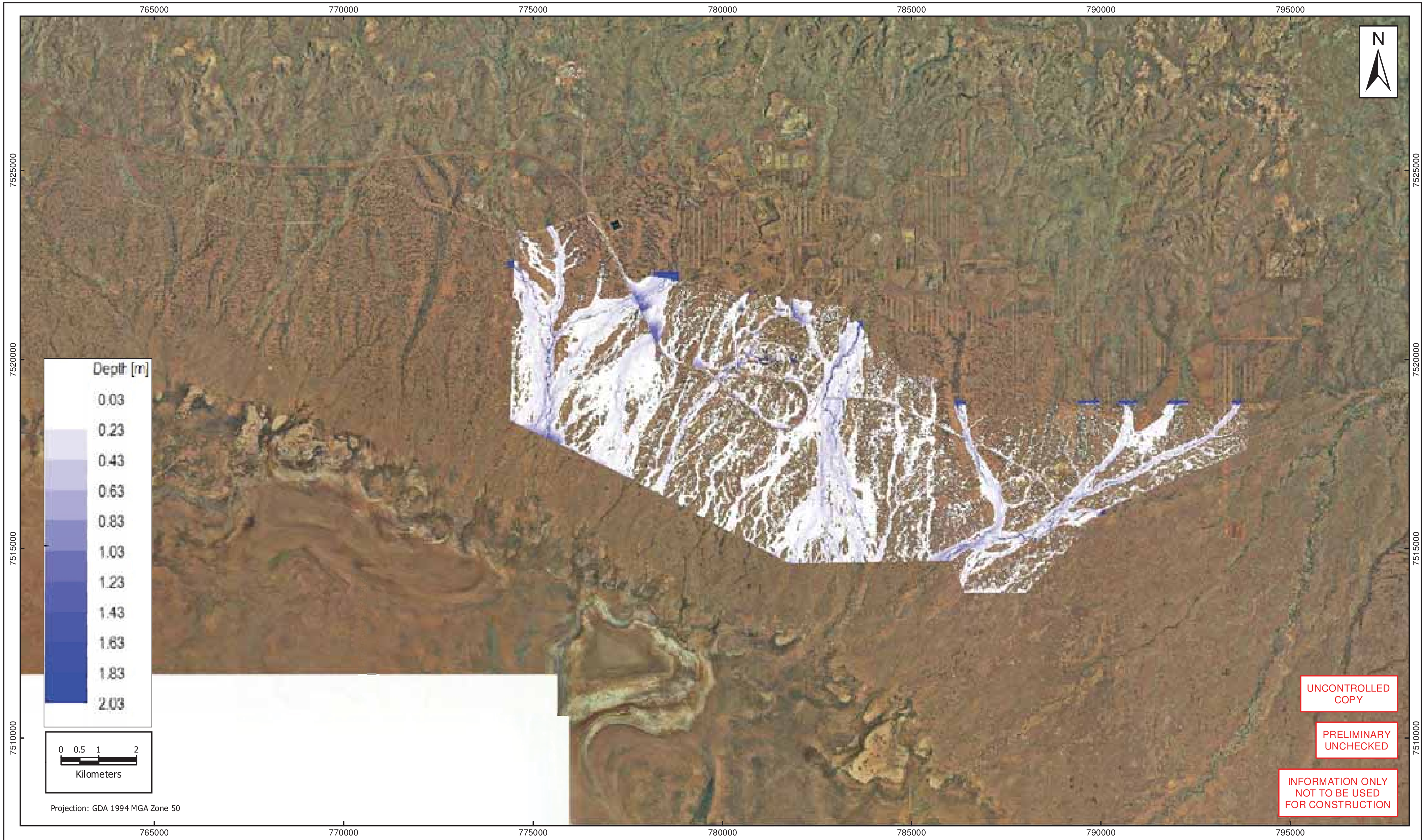

SAVE DATE & TIME : 11 FEB 2014, 1:27:04 PM

PLOT DATE & TIME : 11 FEB 2014, 1:27:05 PM

REV	DATE	REVISION DESCRIPTION	DRN	CHKD	DES	ENG CHK	APPRD	CUST
1	11/02/14	Information Only	MH					

A3 SHEET | SCALE 1:95,000

OneWay to zero harm

WORLEYPARSONS PROJECT No 301012-01527

LOCATION PLAN

CUSTOMER

FMG

WorleyParsons Consulting

CHRISTMAS CREEK
LIFE OF MINE
FLOOD DEPTHS AND EXTENTS
FY 2017 5 Year ARI

DRG No 301012-01527-GIS-DSK-107

REV 1

LOCATION: I:\PROJECTS\301012-01527 FMG CHRISTMAS CREEK PER\4_ENGINEERING\HY-HYDROLOGY\WATER RIDE\ARCGIS_PM\DEPTH MAPS.MXD

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Figure 18: Flood Level Differences for 1 in 20 year ARI event in 2017

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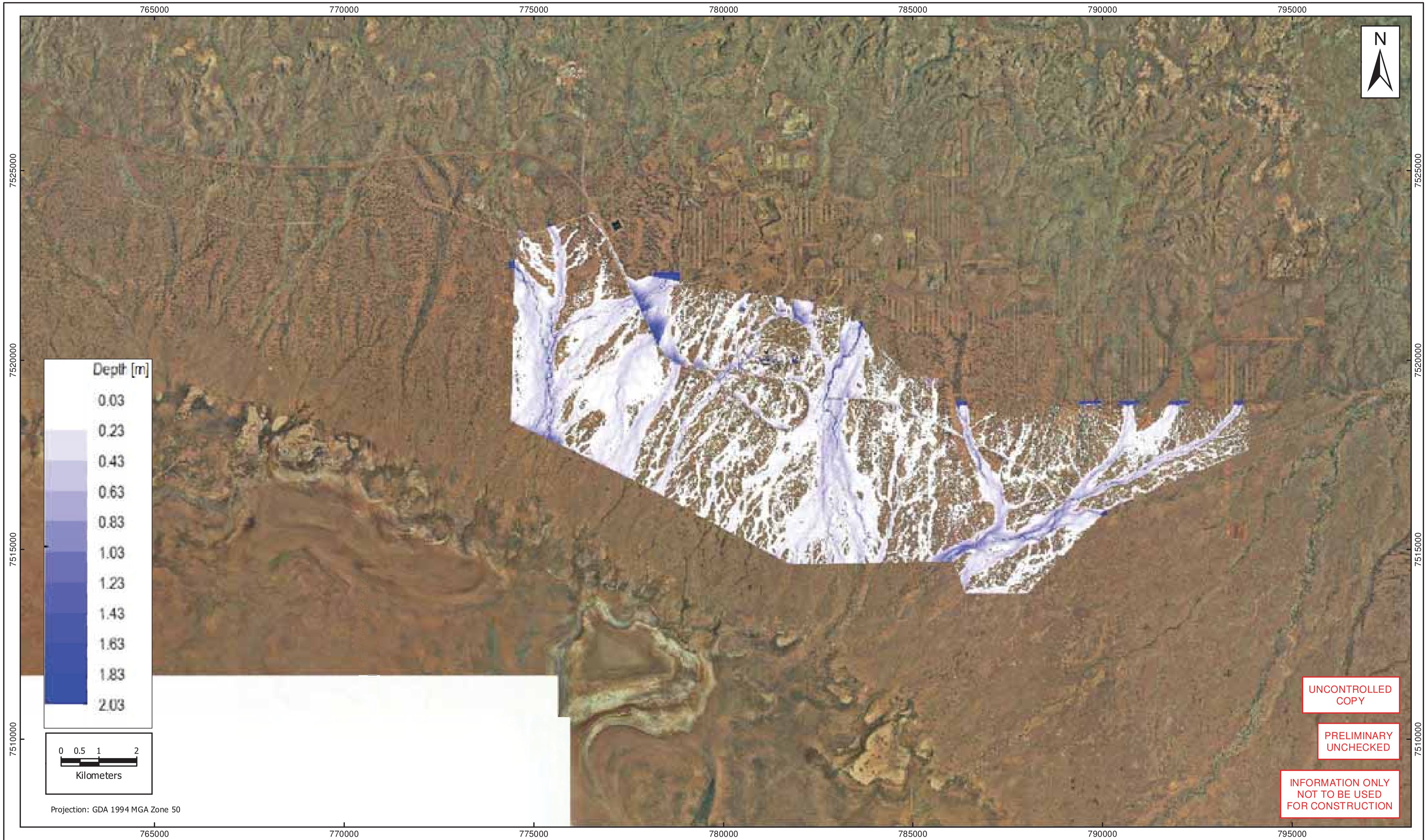

SAVE DATE & TIME : 11 FEB 2014, 1:27:45 PM

REV	DATE	REVISION DESCRIPTION	DRN	CHKD	DES	ENG CHK	APPRD	CUST
1	11/02/14	Information Only	MH					

A3 SHEET | SCALE 1:95,000

OneWay to zero harm

WORLEYPARSONS PROJECT No 301012-01527

LOCATION PLAN

CUSTOMER

FMG

WorleyParsons Consulting

CHRISTMAS CREEK
LIFE OF MINE
FLOOD DEPTHS AND EXTENTS
FY 2017 20 Year ARI

DRG No 301012-01527-GIS-DSK-108 | REV 1

PLOT DATE & TIME : 11 FEB 2014, 1:27:46 PM

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Figure 19: Flood Level Differences for 1 in 100 year ARI event in 2017

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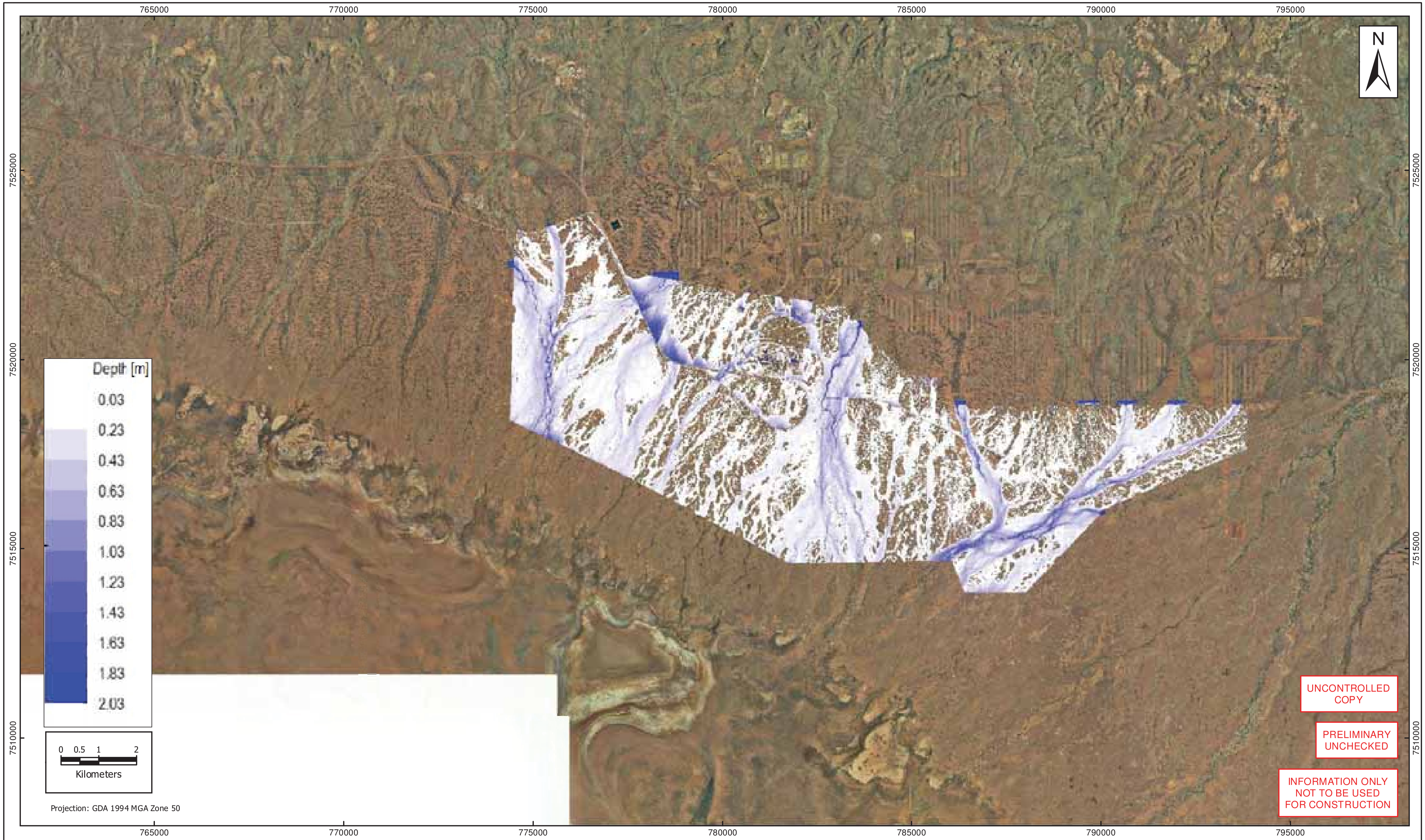

SAVE DATE & TIME : 11 FEB 2014, 1:29:29 PM

REV	DATE	REVISION DESCRIPTION	DRN	CHKD	DES	ENG CHK	APPRD	CUST
1	11/02/14	Information Only	MH					

A3 SHEET SCALE 1:95,000

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd ABN 61 001 279 812

WORLEYPARSONS PROJECT No 301012-01527

LOCATION PLAN

CUSTOMER

FMG

WorleyParsons Consulting

CHRISTMAS CREEK
LIFE OF MINE
FLOOD DEPTHS AND EXTENTS
FY 2017 100 Year ARI

DRG No 301012-01527-GIS-DSK-109 REV 1

PLOT DATE & TIME : 11 FEB 2014, 1:29:30 PM

LOCATION: I:\PROJECTS\301012-01527 FMG CHRISTMAS CREEK PER\4_ENGINEERING\HY-HYDROLOGY\WATER RIDE\ARCGIS_PM\DEPTH MAPS.MXD

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Figure 20: Areas of Potential Sheetflow Impact

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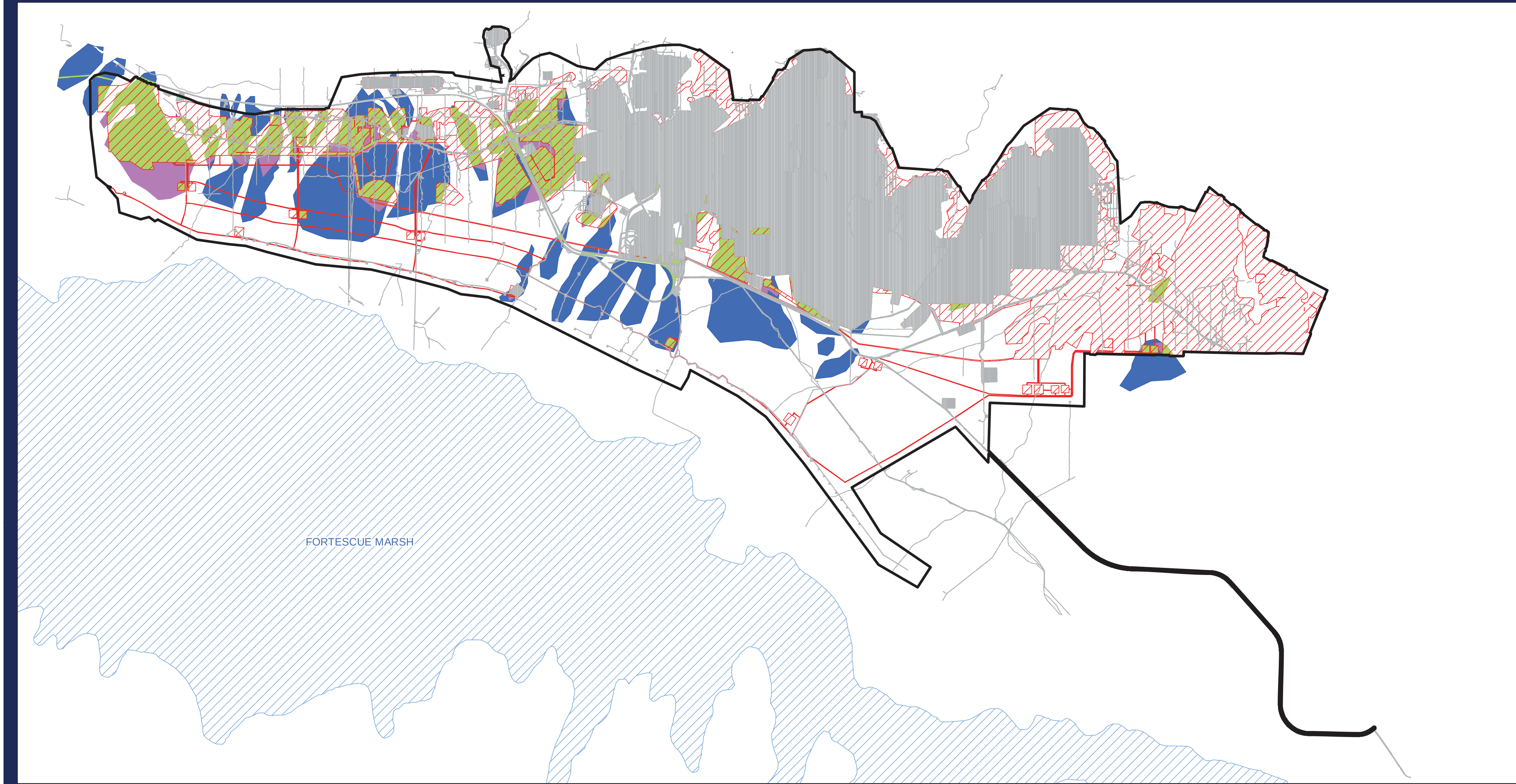

LEGEND

- Development Envelope
- Proposal Area (Indicative Disturbance Footprint)
- Existing Approved Footprint
- Fortescue Marsh
- Sheetflow Zone Direct Impacts
- Sheetflow Zone Indirect Impacts
- Sheetflow Areas

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Areas of Potential Sheetflow Impact

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: sfinning
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F033_AreasPotSheetFlowImp

Date: 6/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 21: 2014 Modelled Drawdown and Mounding

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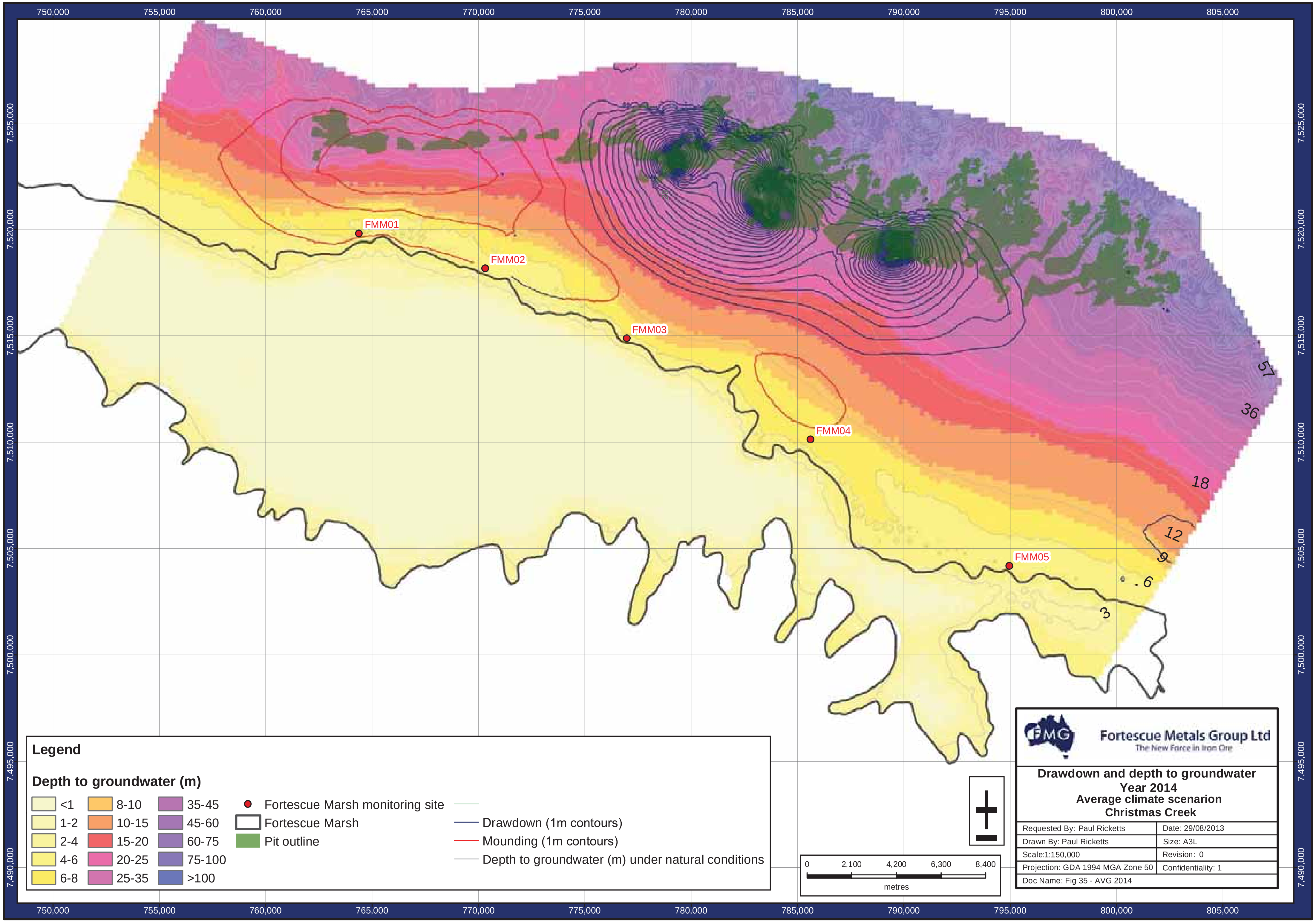

750,000
755,000
760,000
765,000
770,000
775,000
780,000
785,000
790,000
795,000
800,000
805,000
7,525,000
7,520,000
7,515,000
7,510,000
7,505,000
7,500,000
7,495,000
7,490,000
FMM01
FMM02
FMM03
FMM04
FMM05
57
36
18
12
9
6
3
Legend
Depth to groundwater (m)
<1
1-2
2-4
4-6
6-8
8-10
10-15
15-20
20-25
25-35
35-45
45-60
60-75
75-100
>100
Fortescue Marsh monitoring site
Fortescue Marsh
Pit outline
Drawdown (1m contours)
Mounding (1m contours)
Depth to groundwater (m) under natural conditions
0
2,100
4,200
6,300
8,400
metres
Fortescue Metals Group Ltd
The New Force in Iron Ore
Drawdown and depth to groundwater
Year 2014
Average climate scenario
Christmas Creek
Requested By: Paul Ricketts
Date: 29/08/2013
Drawn By: Paul Ricketts
Size: A3L
Scale:1:150,000
Revision: 0
Projection: GDA 1994 MGA Zone 50
Confidentiality: 1
Doc Name: Fig 35 - AVG 2014

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Figure 22: 2017 Modelled Drawdown and Mounding

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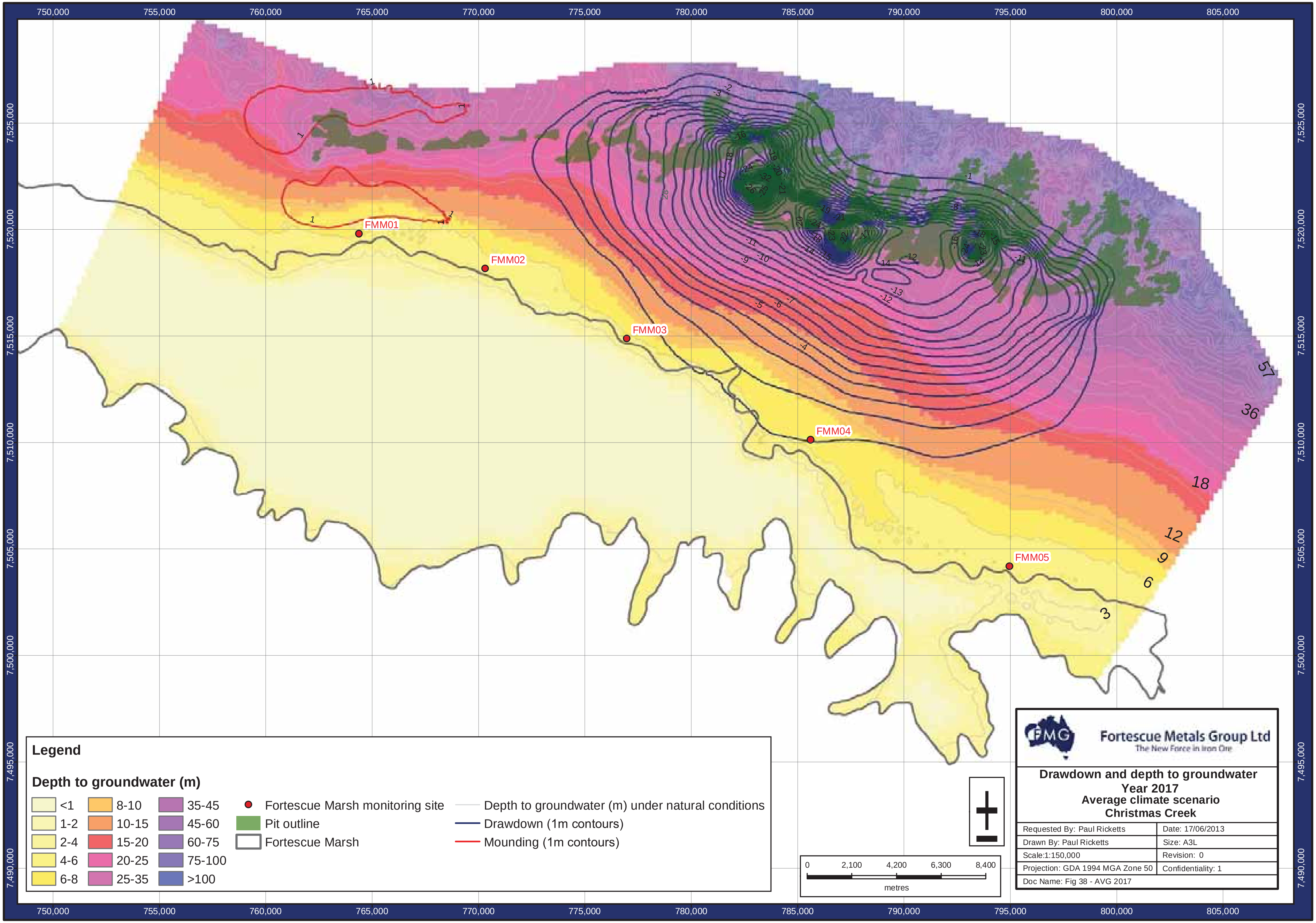

FMM01
FMM02
FMM03
FMM04
FMM05
57
36
18
12
9
6
3
Legend
Depth to groundwater (m)
<1
1-2
2-4
4-6
6-8
8-10
10-15
15-20
20-25
25-35
35-45
45-60
60-75
75-100
>100
Fortescue Marsh monitoring site
Pit outline
Fortescue Marsh
Depth to groundwater (m) under natural conditions
Drawdown (1m contours)
Mounding (1m contours)
0
2,100
4,200
6,300
8,400
metres
Fortescue Metals Group Ltd
The New Force in Iron Ore
Drawdown and depth to groundwater
Year 2017
Average climate scenario
Christmas Creek
Requested By: Paul Ricketts
Date: 17/06/2013
Drawn By: Paul Ricketts
Size: A3L
Scale:1:150,000
Revision: 0
Projection: GDA 1994 MGA Zone 50
Confidentiality: 1
Doc Name: Fig 38 - AVG 2017

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Figure 23: 2020 Modelled Drawdown and Mounding

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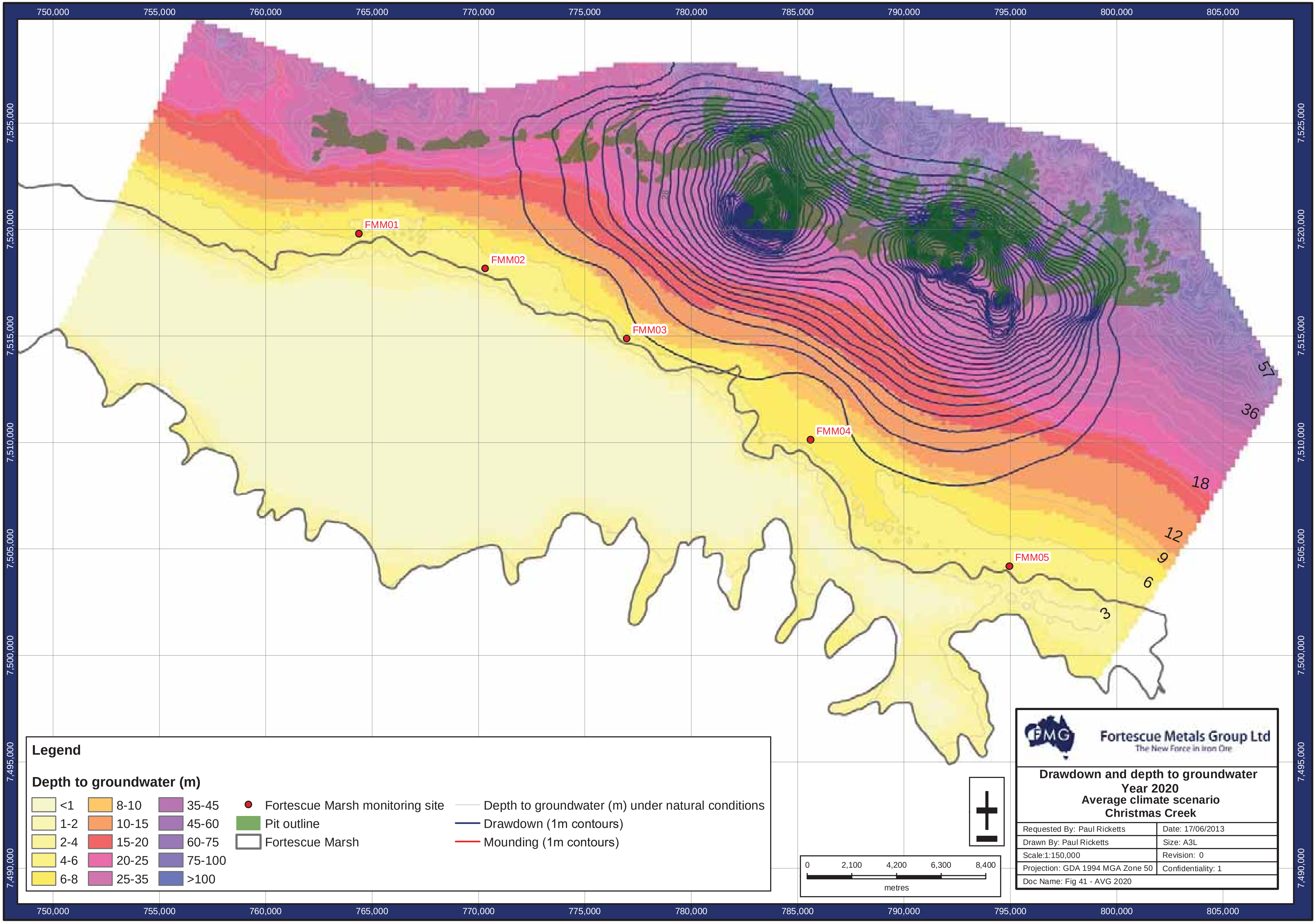

Fortescue Metals Group Ltd
The New Force in Iron Ore
Drawdown and depth to groundwater
Year 2020
Average climate scenario
Christmas Creek
Requested By: Paul Ricketts
Date: 17/06/2013
Drawn By: Paul Ricketts
Size: A3L
Scale:1:150,000
Revision: 0
Projection: GDA 1994 MGA Zone 50
Confidentiality: 1
Doc Name: Fig 41 - AVG 2020
Legend
Depth to groundwater (m)
<1
1-2
2-4
4-6
6-8
8-10
10-15
15-20
20-25
25-35
35-45
45-60
60-75
75-100
>100
Fortescue Marsh monitoring site
Pit outline
Fortescue Marsh
Depth to groundwater (m) under natural conditions
Drawdown (1m contours)
Mounding (1m contours)
0
2,100
4,200
6,300
8,400
metres
FMM01
FMM02
FMM03
FMM04
FMM05
57
36
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9
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765,000
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780,000
785,000
790,000
795,000
800,000
805,000
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7,520,000
7,515,000
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7,490,000

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Figure 24: 2024 Modelled Drawdown and Mounding

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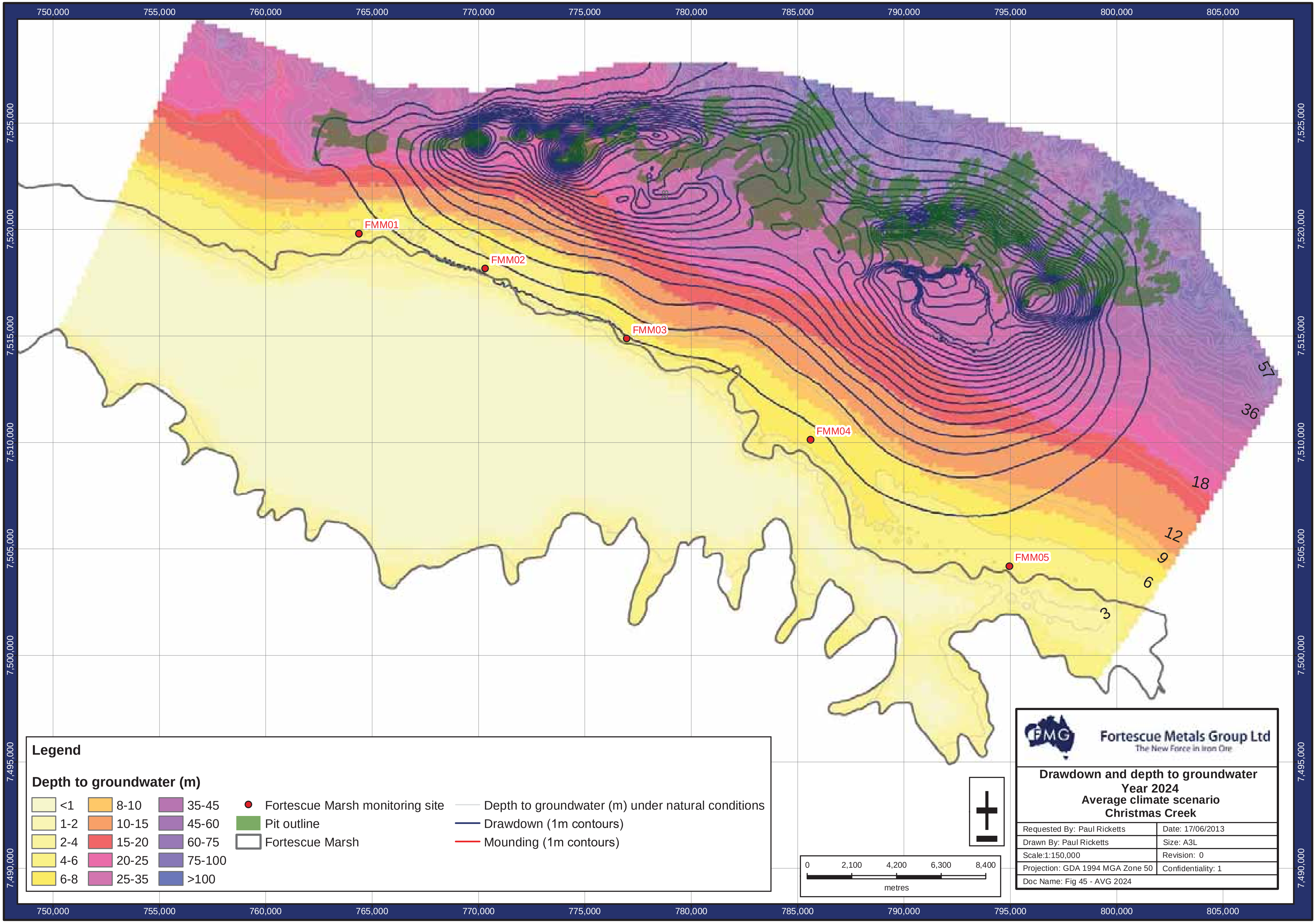

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765,000
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775,000
780,000
785,000
790,000
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805,000
7,525,000
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7,515,000
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7,505,000
7,500,000
7,495,000
7,490,000
FMM01
FMM02
FMM03
FMM04
FMM05
57
36
18
12
9
6
3
Legend
Depth to groundwater (m)
<1
1-2
2-4
4-6
6-8
8-10
10-15
15-20
20-25
25-35
35-45
45-60
60-75
75-100
>100
Fortescue Marsh monitoring site
Pit outline
Fortescue Marsh
Depth to groundwater (m) under natural conditions
Drawdown (1m contours)
Mounding (1m contours)
0
2,100
4,200
6,300
8,400
metres
FMG
Fortescue Metals Group Ltd
The New Force in Iron Ore
Drawdown and depth to groundwater
Year 2024
Average climate scenario
Christmas Creek
Requested By: Paul Ricketts
Date: 17/06/2013
Drawn By: Paul Ricketts
Size: A3L
Scale:1:150,000
Revision: 0
Projection: GDA 1994 MGA Zone 50
Confidentiality: 1
Doc Name: Fig 45 - AVG 2024

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Figure 25: 2028 Modelled Drawdown and Mounding

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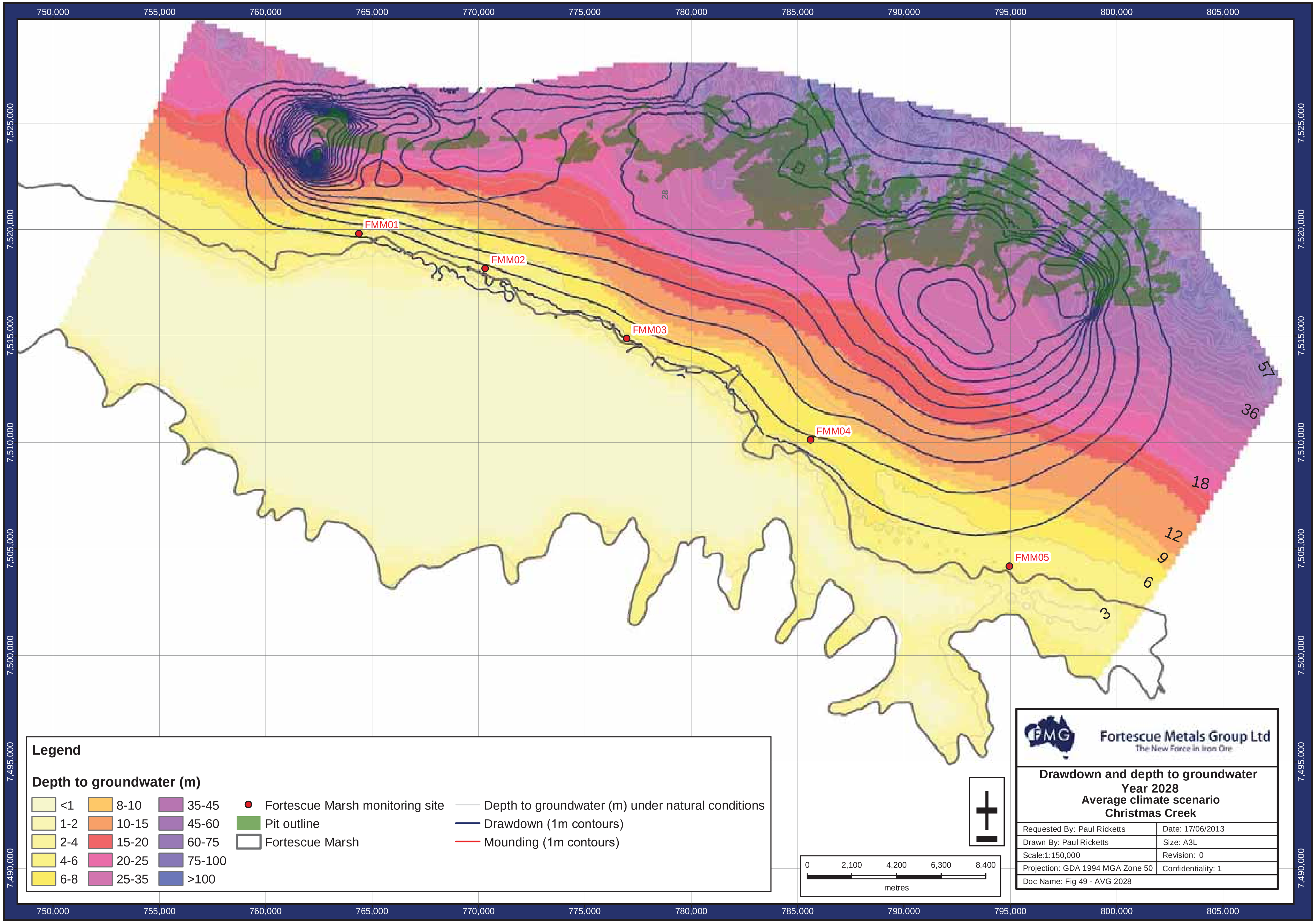

Fortescue Metals Group Ltd
The New Force in Iron Ore
Drawdown and depth to groundwater
Year 2028
Average climate scenario
Christmas Creek
Requested By: Paul Ricketts
Date: 17/06/2013
Drawn By: Paul Ricketts
Size: A3L
Scale:1:150,000
Revision: 0
Projection: GDA 1994 MGA Zone 50
Confidentiality: 1
Doc Name: Fig 49 - AVG 2028
Legend
Depth to groundwater (m)
<1
1-2
2-4
4-6
6-8
8-10
10-15
15-20
20-25
25-35
35-45
45-60
60-75
75-100
>100
Fortescue Marsh monitoring site
Pit outline
Fortescue Marsh
Depth to groundwater (m) under natural conditions
Drawdown (1m contours)
Mounding (1m contours)
0
2,100
4,200
6,300
8,400
metres
FMM01
FMM02
FMM03
FMM04
FMM05
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7,520,000
7,515,000
7,510,000
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7,500,000
7,495,000
7,490,000

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Figure 26: Monitoring and Station Bore Locations

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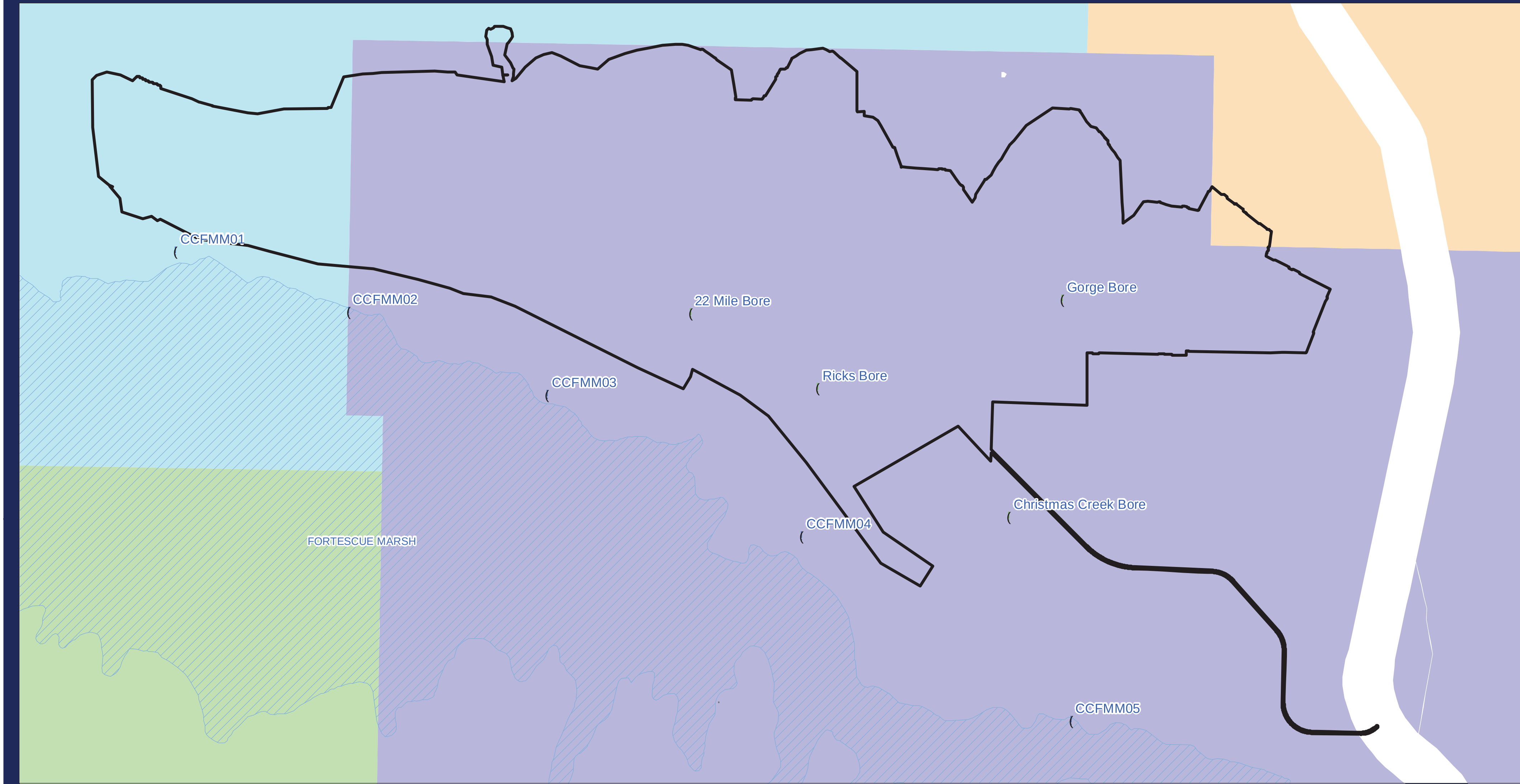

LEGEND

- Monitoring Bores
- Pastoral/Station Bores
- Development Envelope
- Existing Approved Footprint
- Fortescue Marsh

Pastoral Leases

- Bonney Downs
- Hillside
- Marillana
- Roy Hill

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Pastoral/Station Bores and Monitoring Bores

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F0XX GW Monitoring Bores

Date: 25/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 27: Modelled Groundwater Levels at CCFMM01

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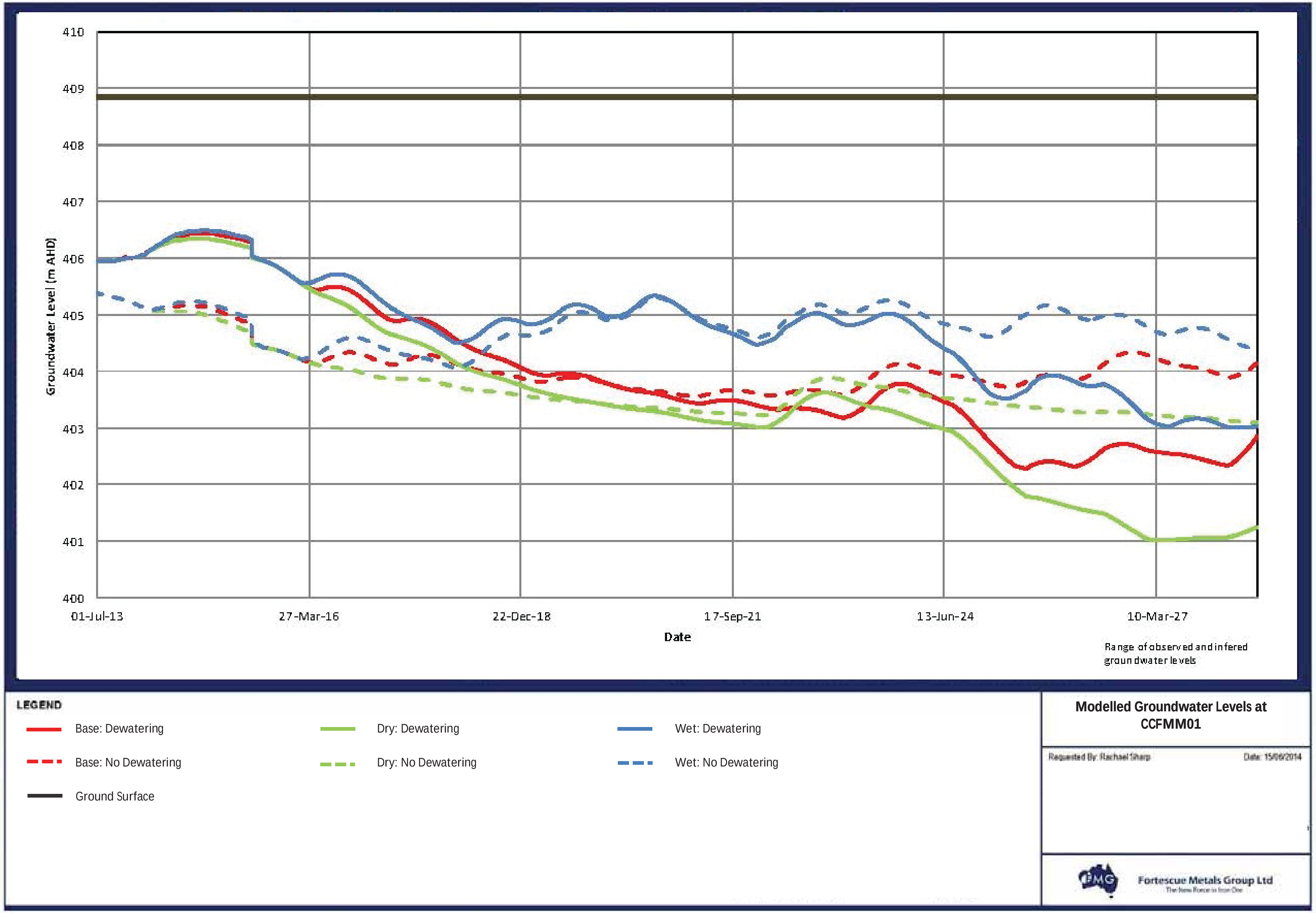

Modelled Groundwater Levels at CCFMM01

Requested By: Rachael Sharp

Date: 15/06/2014

Fortescue Metals Group Ltd

The New Force in Iron Ore

Document Path: G:\Consult\2013\FMG\FMG13132\ArcMap_documents\R001\Rev0\FMG13132_01_R001_Rev0_F014_ChristmasCkMineCatch.mxd

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Figure 28: Modelled Groundwater Levels at CCFMM02

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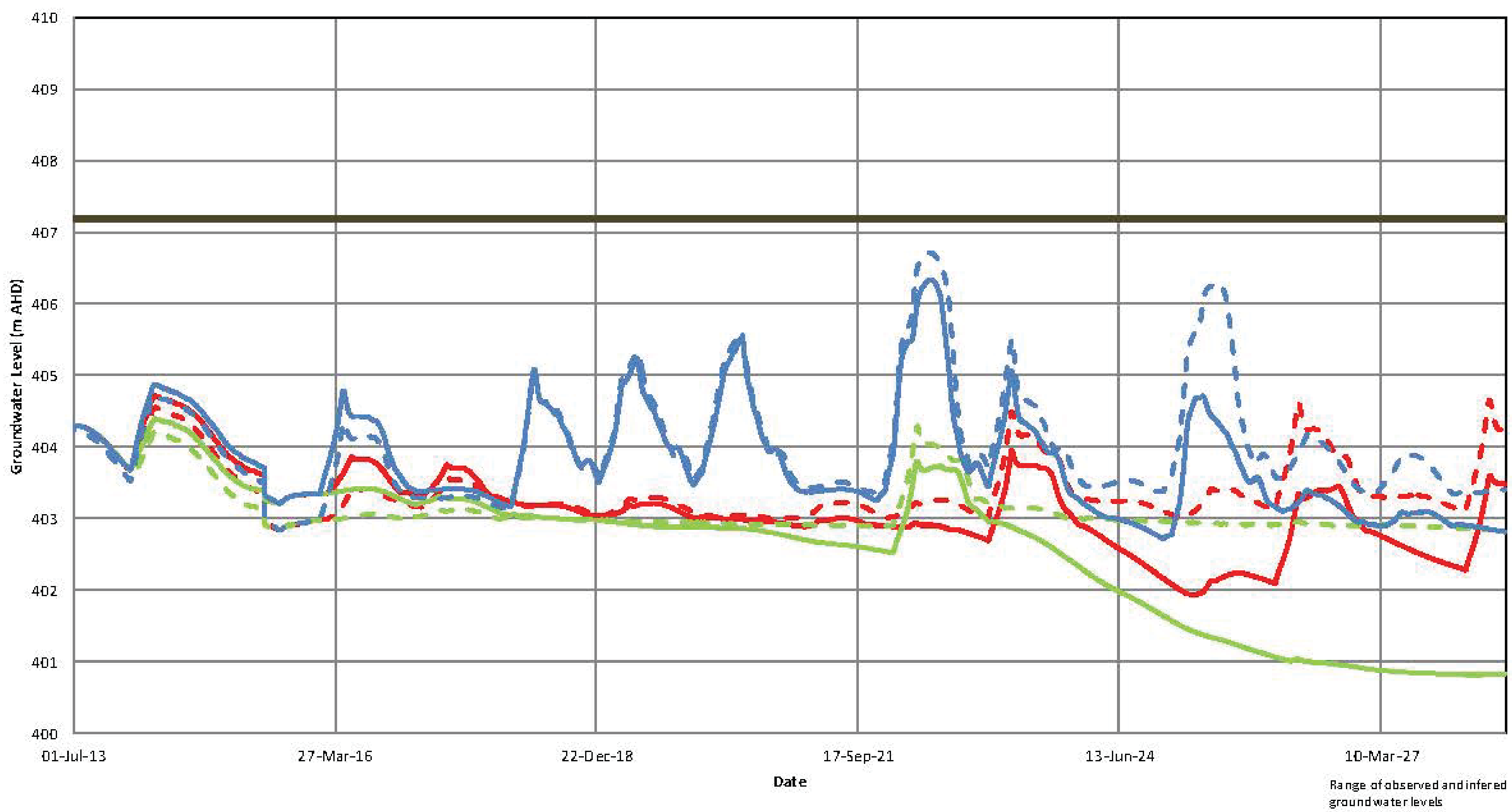

LEGEND

- Base: Dewatering
- Base: No Dewatering
- Ground Surface
- Dry: Dewatering
- Dry: No Dewatering
- Wet: Dewatering
- Wet: No Dewatering

Modelled Groundwater Levels at CCFMM02

Requested By: Rachael Sharp

Date: 15/06/2014

Fortescue Metals Group Ltd
The New Force in Iron Ore

Document Path: G:\Consult\2013\FMG\FMG13132\ArcMap_documents\R001\Rev0\FMG13132_01_R001_Rev0_F014_ChristmasCkMineCatch.mxd

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Figure 29: Modelled Groundwater Levels at CCFMM03

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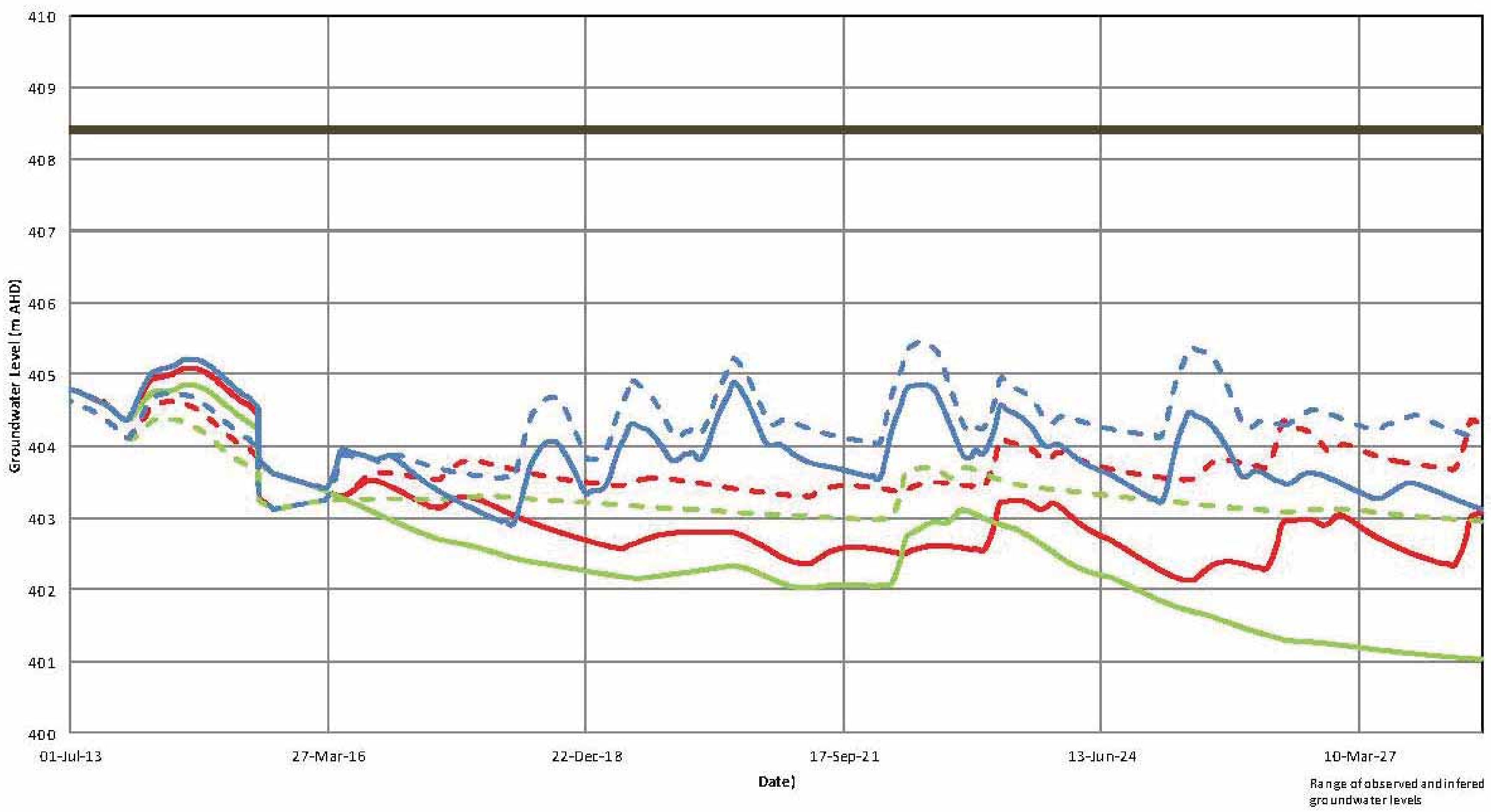

LEGEND

Base: Dewatering

Base: No Dewatering

Ground Surface

Dry: Dewatering

Dry: No Dewatering

Wet: Dewatering

Wet: No Dewatering

Modelled Groundwater Levels at CCFMM03

Requested By: Rachael Sharp

Date: 15/09/2014

Fortescue Metals Group Ltd

The New Force in Iron Ore

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Figure 30: Modelled Groundwater Levels at CCFMM04

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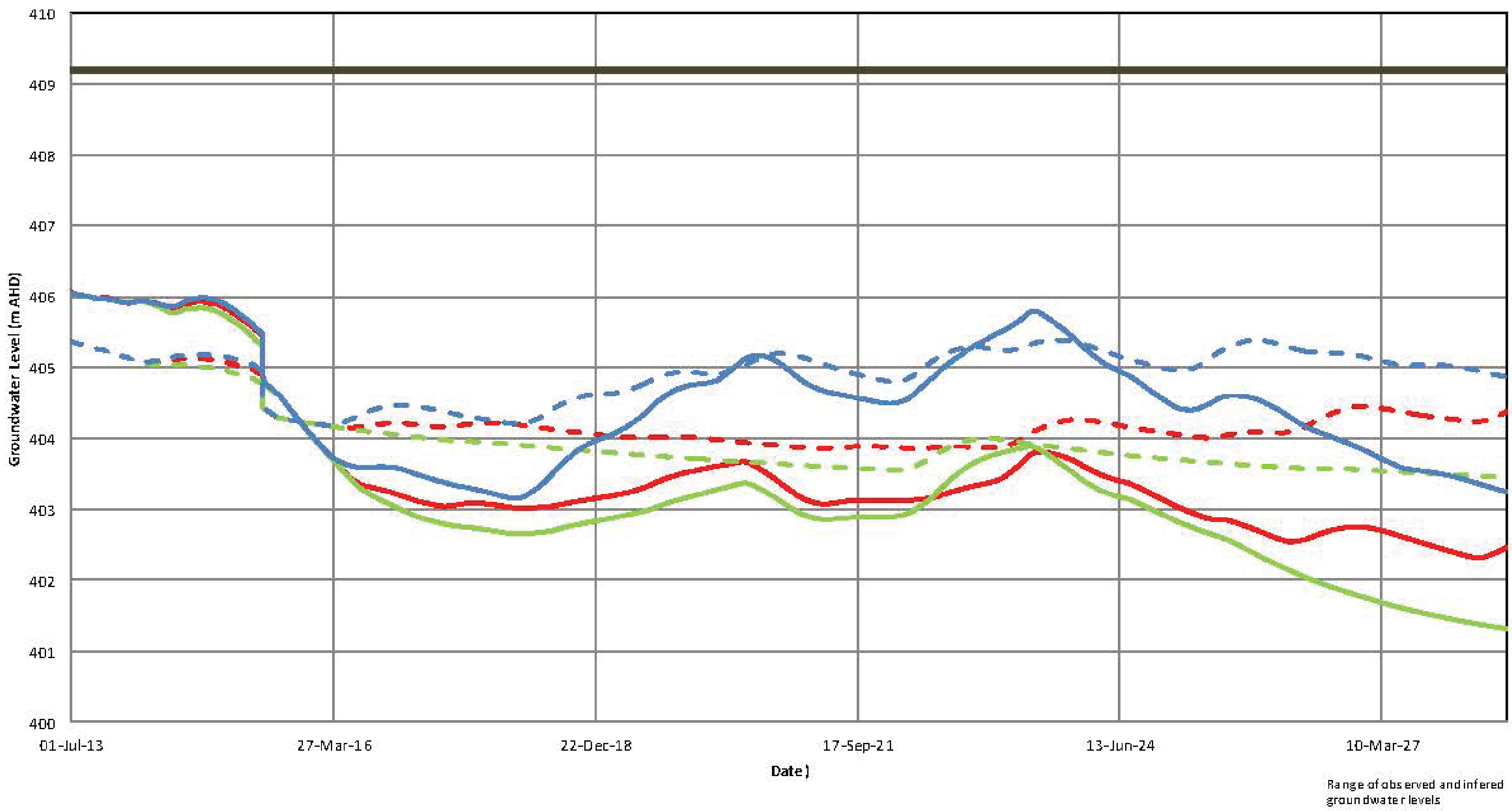

LEGEND

- Base: Dewatering
- Base: No Dewatering
- Ground Surface
- Dry: Dewatering
- Dry: No Dewatering
- Wet: Dewatering
- Wet: No Dewatering

Modelled Groundwater Levels at CCFMM04

Requested By: Rachael Sharp — Date: 15/06/2014

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 31: Modelled Groundwater Levels at CCFMM05

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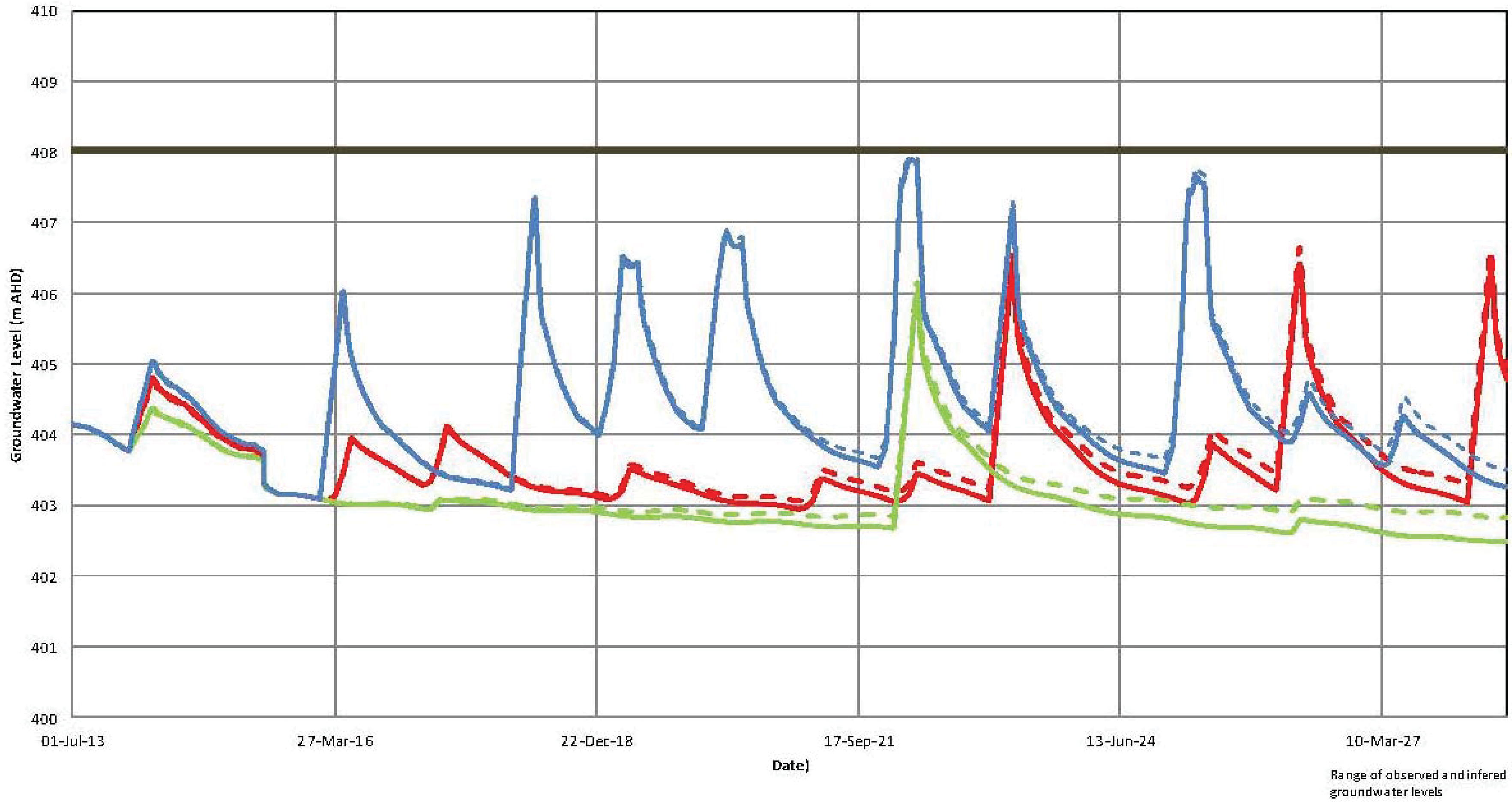

LEGEND

Base: Dewatering
Base: No Dewatering
Ground Surface
Dry: Dewatering
Dry: No Dewatering
Wet: Dewatering
Wet: No Dewatering

Modelled Groundwater Levels at CCFMM05

Requested By: Rachael Sharp

Date: 15/06/2014

Fortescue Metals Group Ltd
The New Force in Iron Ore

Document Path: G:\Consult\2013\FMG\FMG13132\ArcMap_documents\R001\Rev0\FMG13132_01_R001_Rev0_F014_ChristmasCkMineCatch.mxd

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Figure 32: Groundwater Levels, 1 Year Post Closure

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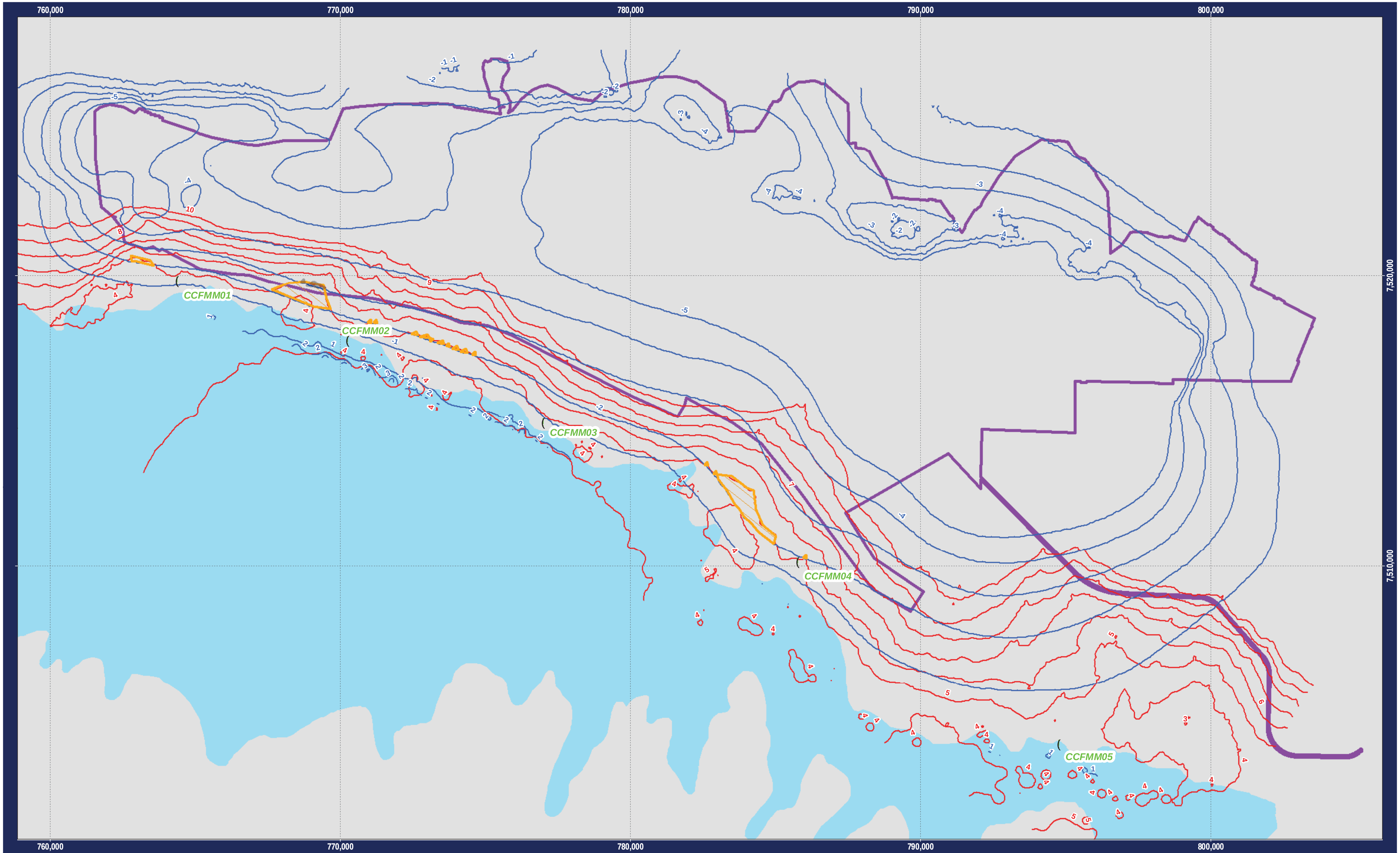

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Drawdown (negative) and Mounding (positive) resulting from the Project (m)
Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation
Mulga Vegetation
Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001). Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.017_r0

Date: 5/12/2013
Size: A3L
Revision: 0
Confidentiality: 1

Year 1 : Post Closure

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 33: Groundwater Levels, 5 Years Post Closure

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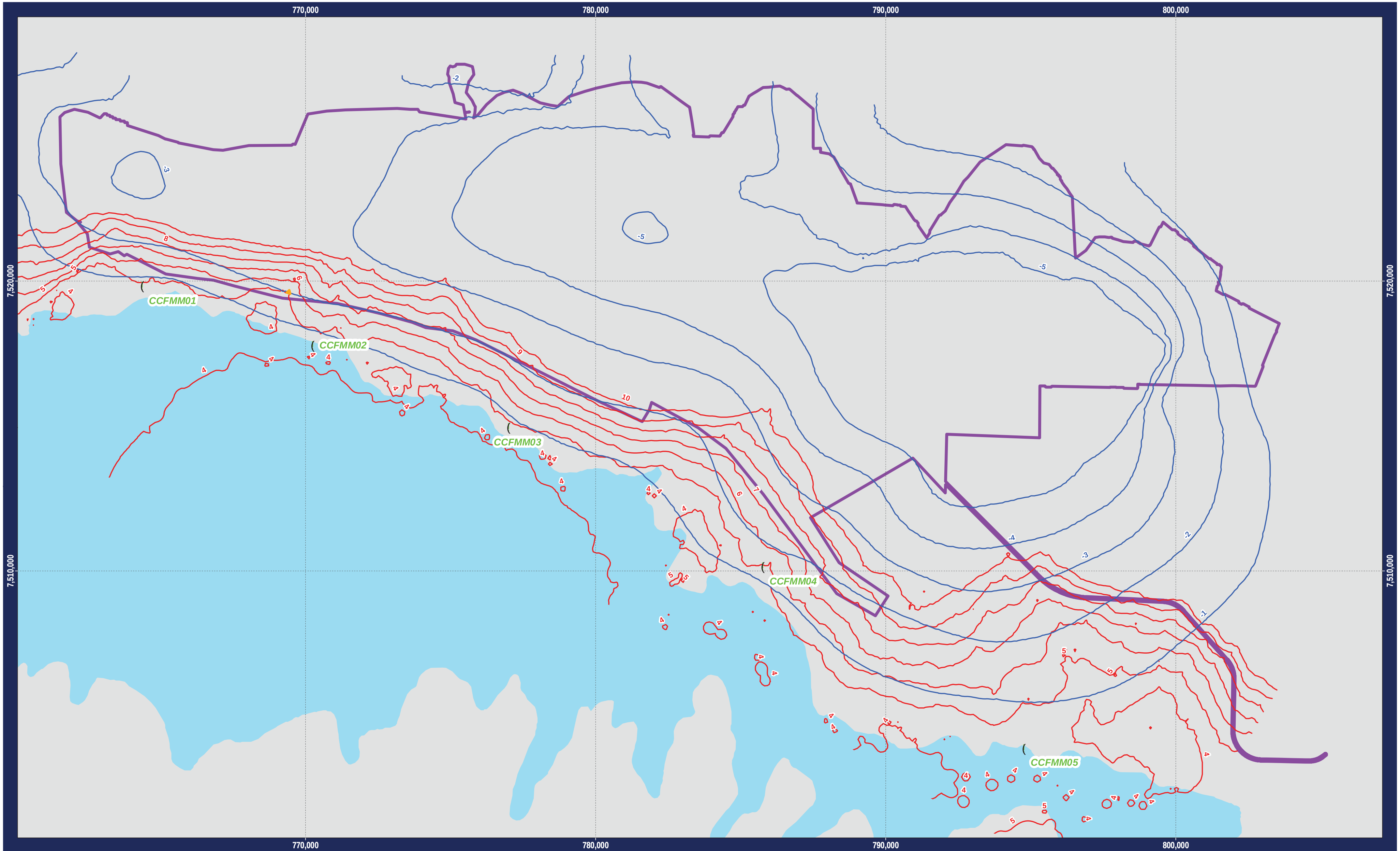

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Drawdown (negative) and Mounding (positive) resulting from the Project (m)
Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation
Mulga Vegetation
Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001). Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.021_r0

Date: 6/12/2013
Size: A3L
Revision: 0
Confidentiality: 1

Year 5 : Post Closure

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 34: Groundwater Levels, 10 Years Post Closure

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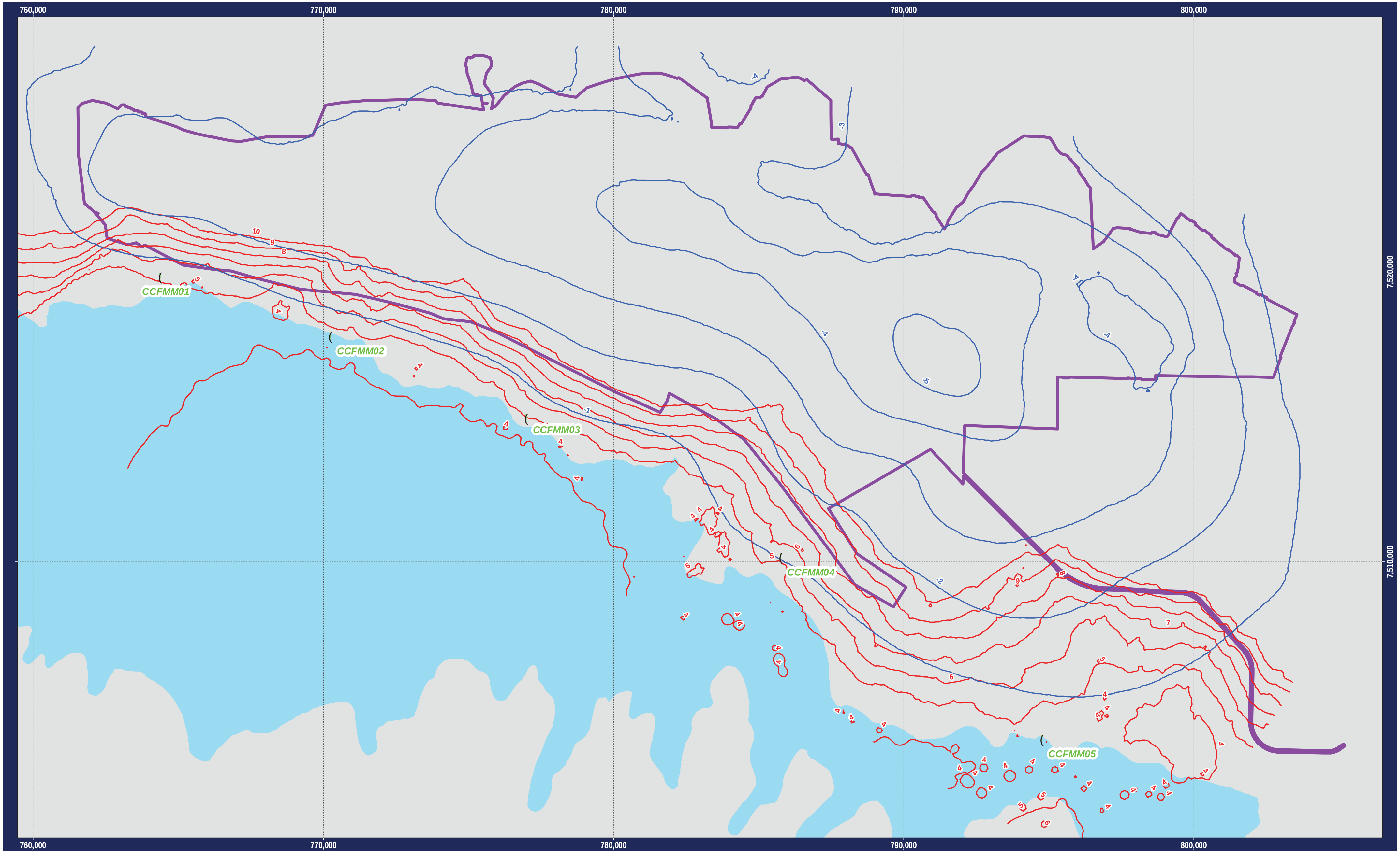

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Drawdown (negative) and Mounding (positive) resulting from the Project (m)
Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation
Mulga Vegetation
Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001).
Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.022_r0

Date: 6/12/2013
Size: A3L
Revision: 0
Confidentiality: 1

Year 10 : Post Closure

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 35: Groundwater Levels, 20 Years Post Closure

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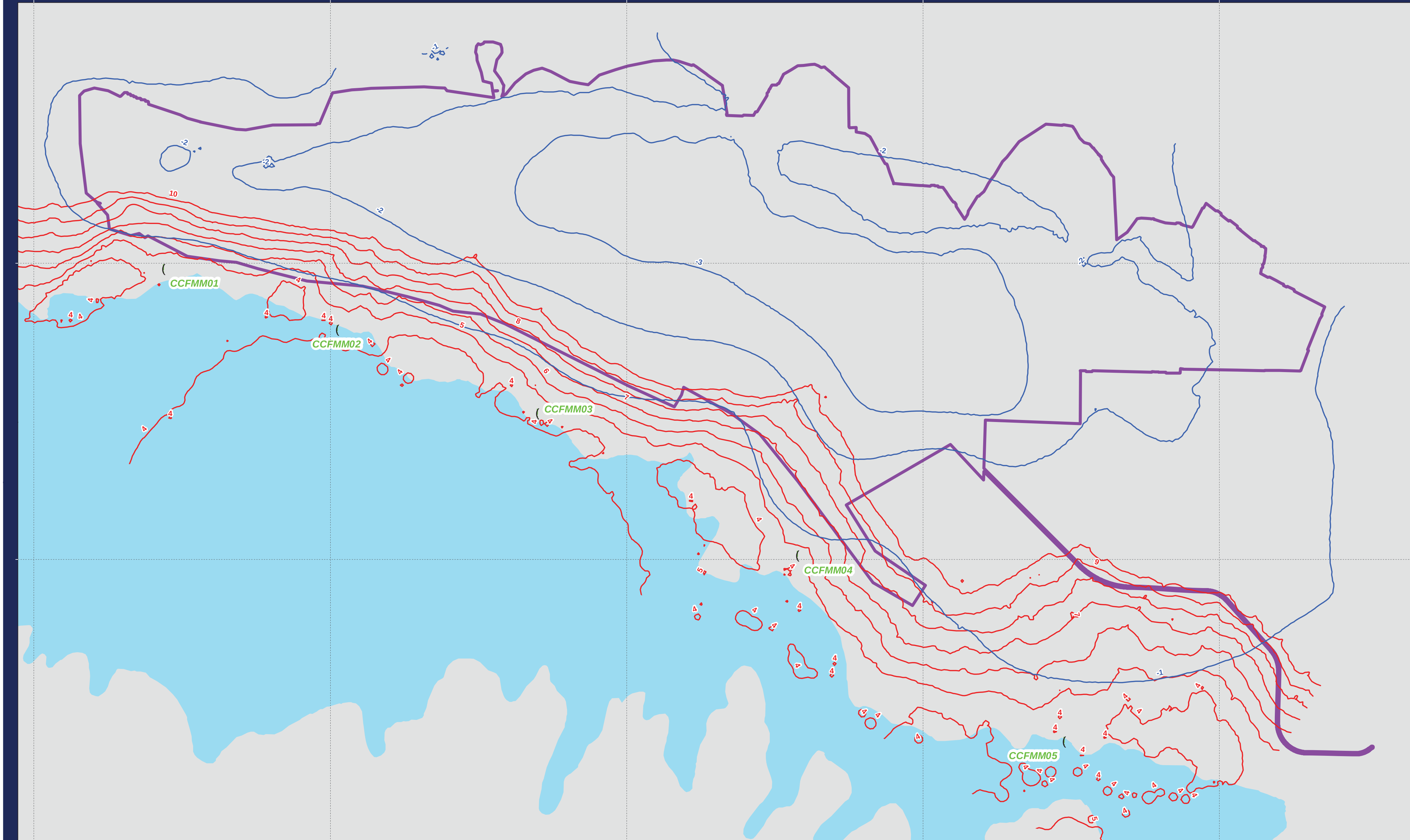

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Drawdown (negative) and Mounding (positive) resulting from the Project (m)
Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation
Mulga Vegetation
Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001).
Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.023_r0

Date: 6/12/2013
Size: A3L
Revision: 0
Confidentiality: 1

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Year 20 : Post Closure

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 36: Groundwater Levels, 50 Years Post Closure

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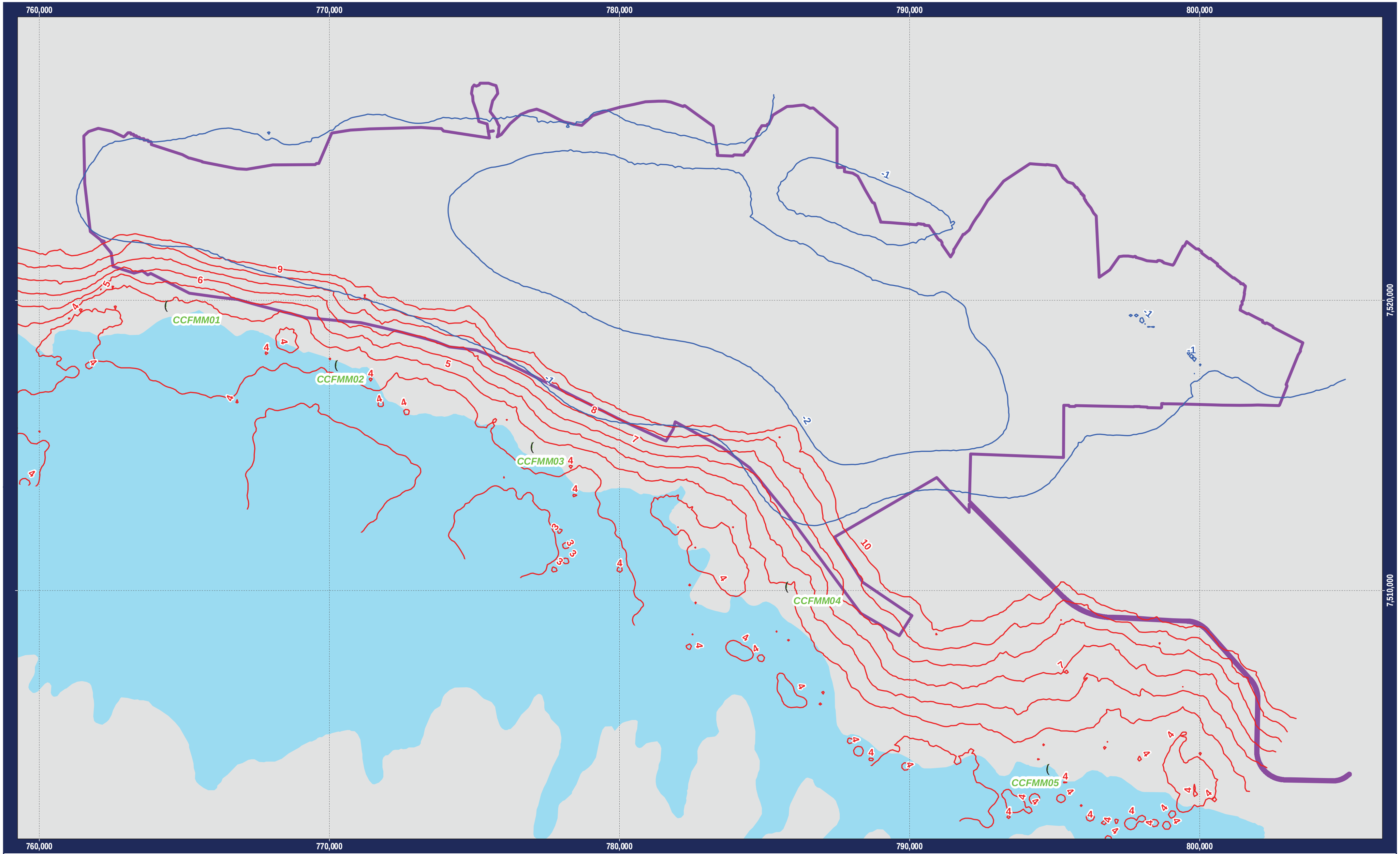

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Drawdown (negative) and Mounding (positive) resulting from the Project (m)
Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation
Mulga Vegetation
Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001).
Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.026_r0

Date: 9/12/2013
Size: A3L
Revision: 0
Confidentiality: 1

Year 50 : Post Closure

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The New Force in Iron Ore

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Figure 37: Cumulative Impact of Christmas Creek and Surrounding Mines on Groundwater Levels

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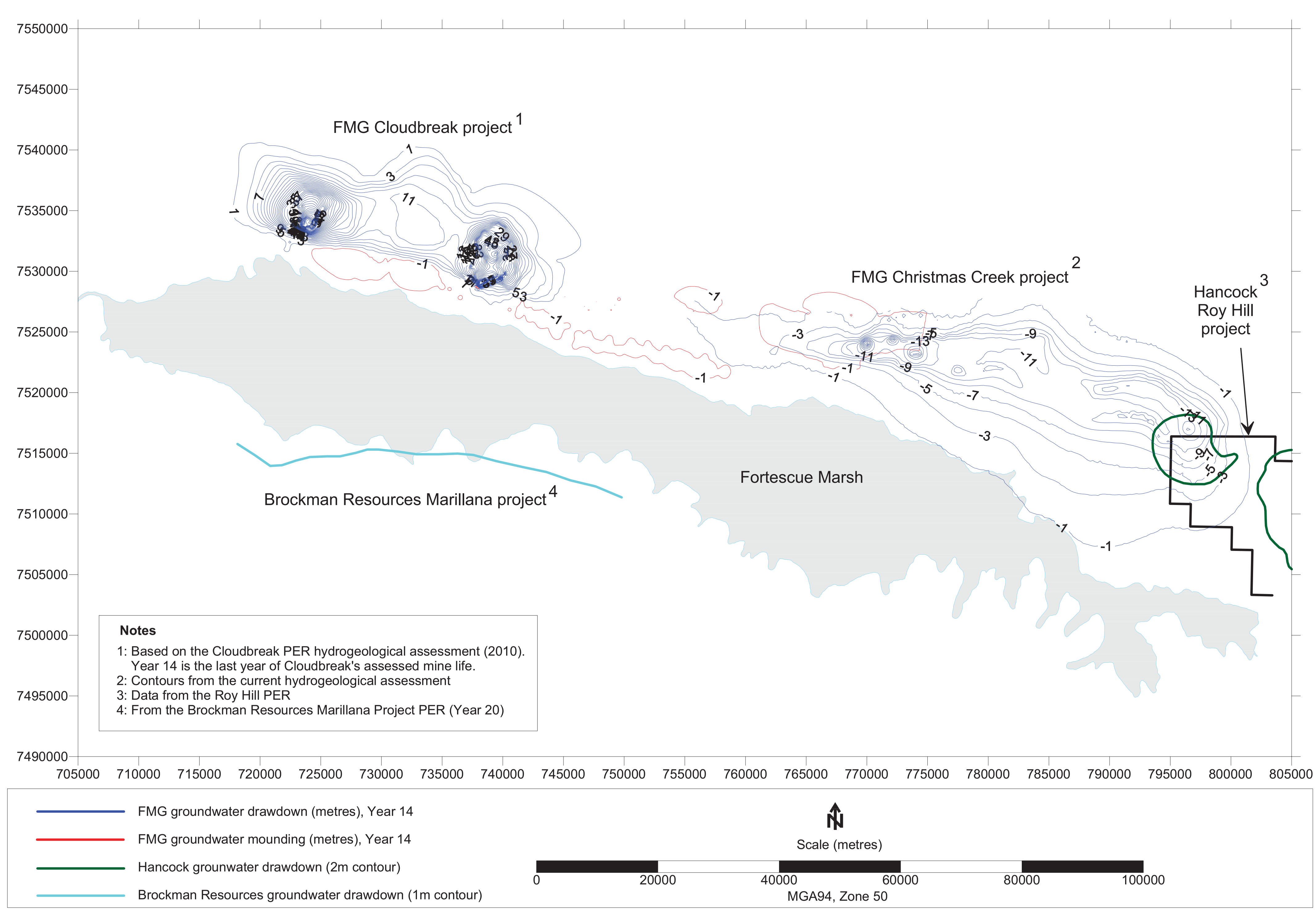
FMG Cloudbreak project 1
FMG Christmas Creek project 2
Hancock
Roy Hill
project 3
Brockman Resources Marillana project 4
Fortescue Marsh
Notes
1: Based on the Cloudbreak PER hydrogeological assessment (2010).
Year 14 is the last year of Cloudbreak's assessed mine life.
2: Contours from the current hydrogeological assessment
3: Data from the Roy Hill PER
4: From the Brockman Resources Marillana Project PER (Year 20)
FMG groundwater drawdown (metres), Year 14
FMG groundwater mounding (metres), Year 14
Hancock grounwater drawdown (2m contour)
Brockman Resources groundwater drawdown (1m contour)
Scale (metres)
0
20000
40000
60000
80000
100000
MGA94, Zone 50
7550000
7545000
7540000
7535000
7530000
7525000
7520000
7515000
7510000
7505000
7500000
7495000
7490000
705000
710000
715000
720000
725000
730000
735000
740000
745000
750000
755000
760000
765000
770000
775000
780000
785000
790000
795000
800000
805000

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Figure 38: Flow Velocity Differences for the 1 in 5 Year Event

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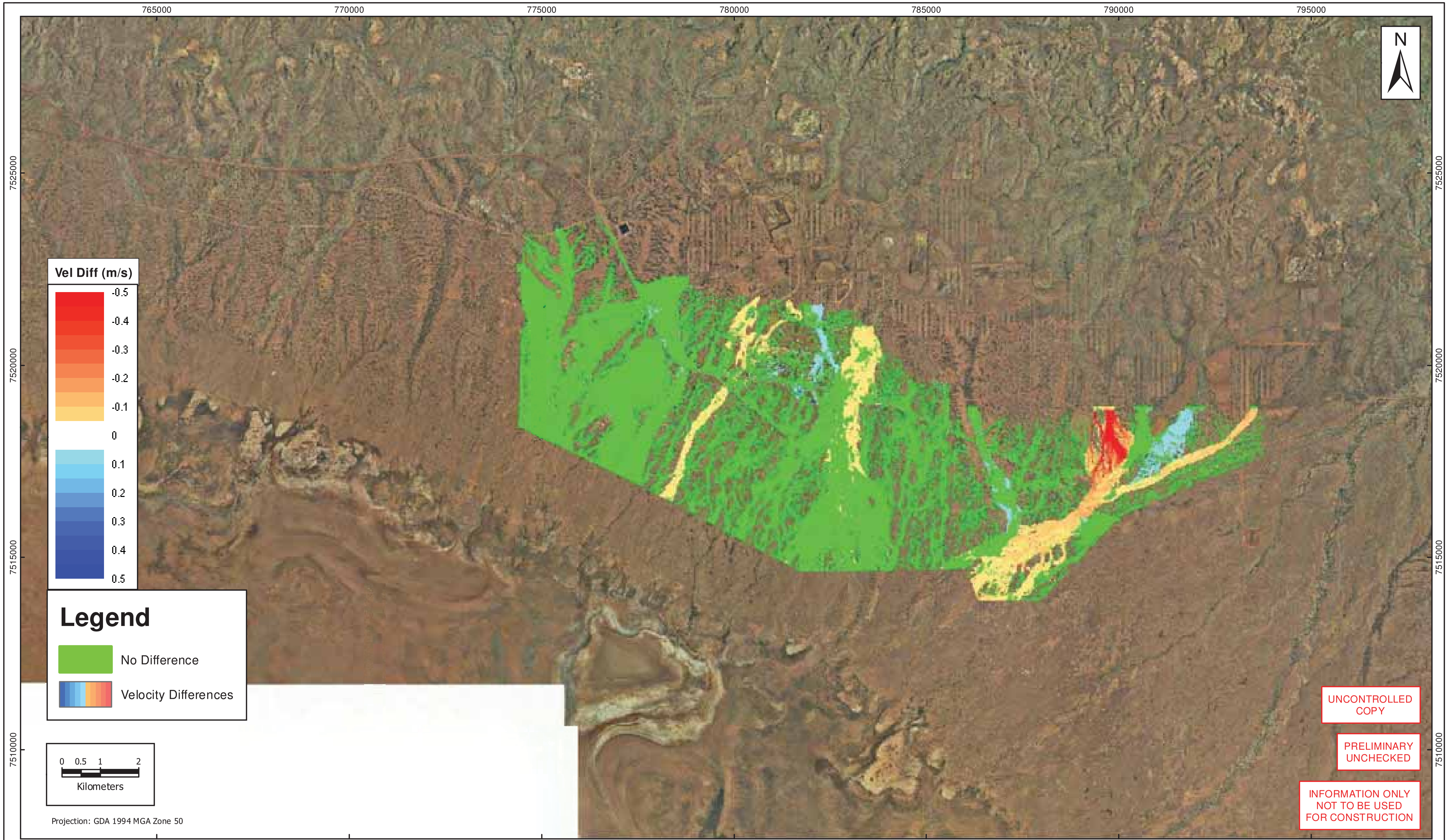

SAVE DATE & TIME : 11 FEB 2014, 4:53:13 PM

1	11/02/14	Information Only	MH					
REV	DATE	REVISION DESCRIPTION	DRN	CHKD	DES	ENG CHK	APPRD	CUST

A3 SHEET | SCALE 1:95,000

OneWay to zero harm

WORLEYPARSONS PROJECT No 301012-01527

LOCATION PLAN

CUSTOMER

FMG

WorleyParsons Consulting

CHRISTMAS CREEK LIFE OF MINE FLOOD VELOCITY DIFFERENCES
20 year ARI
FY 2017 - FY 2013

DRG No 301012-01527-GIS-DSK-120 | REV 1

PLOT DATE & TIME : 11 FEB 2014, 4:53:14 PM

LOCATION: I:\PROJECTS\301012-01527 FMG CHRISTMAS CREEK PER\4_ENGINEERING\HY-HYDROLOGY\WATER RIDE\ARCGIS_PM\DIFFERENCE MAPS_VELOCITY_2.MXD

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Figure 39: Flow Velocity Differences for the 1 in 100 Year Event

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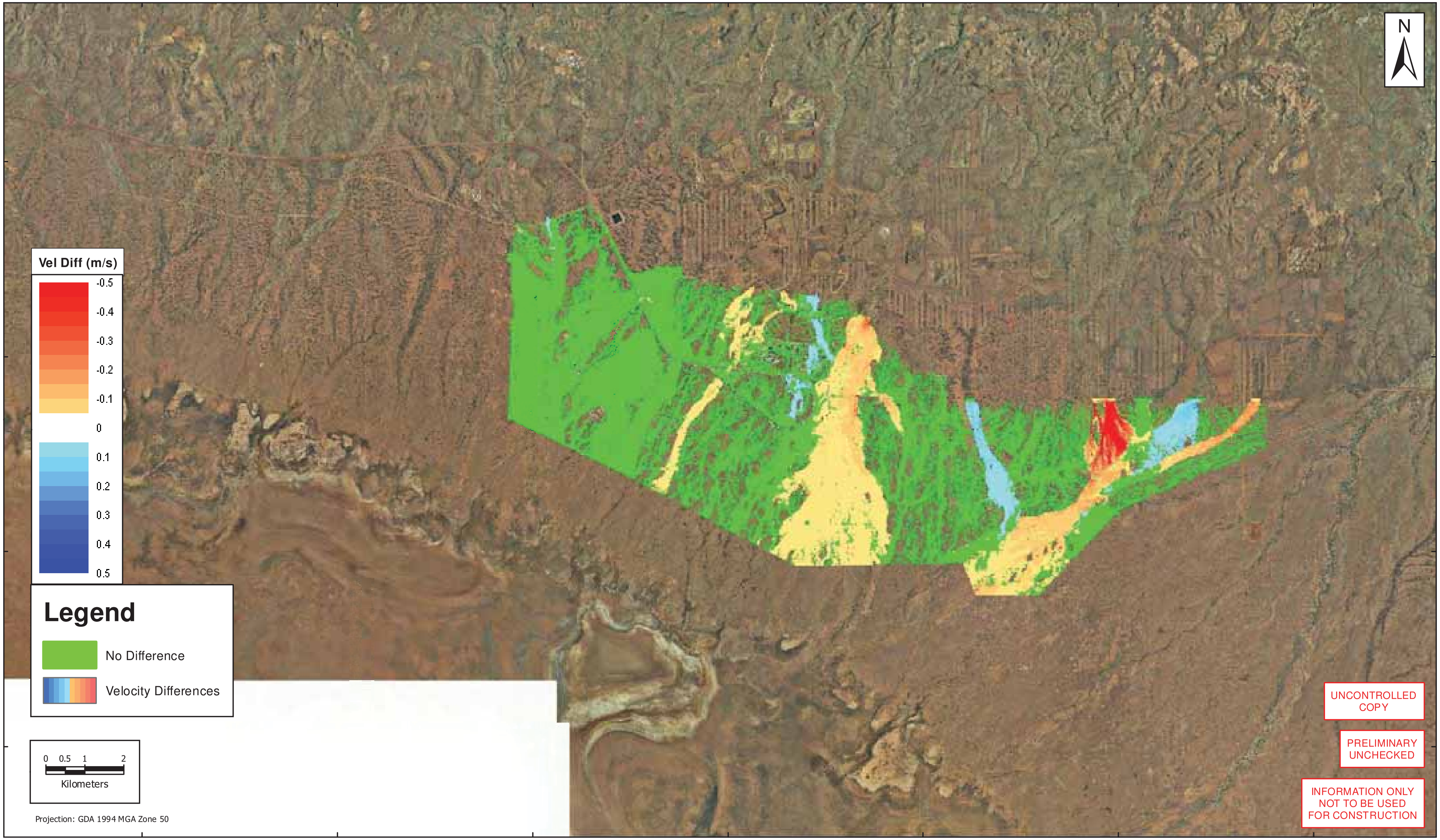

REV	DATE	REVISION DESCRIPTION	DRN	CHKD	DES	ENG CHK	APPRD	CUST
1	11/02/14	Information Only	MH					

A3 SHEET | SCALE 1:95,000

OneWay to zero harm

WORLEYPARSONS PROJECT No
301012-01527

LOCATION PLAN

CUSTOMER

FMG

WorleyParsons Consulting

CHRISTMAS CREEK
LIFE OF MINE
FLOOD VELOCITY DIFFERENCES
100 year ARI
FY 2017 - FY 2013

DRG No: 301012-01527-GIS-DSK-121
REV: 1

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Figure 40: Extent of Flora and Vegetation Surveys within Proposal Area

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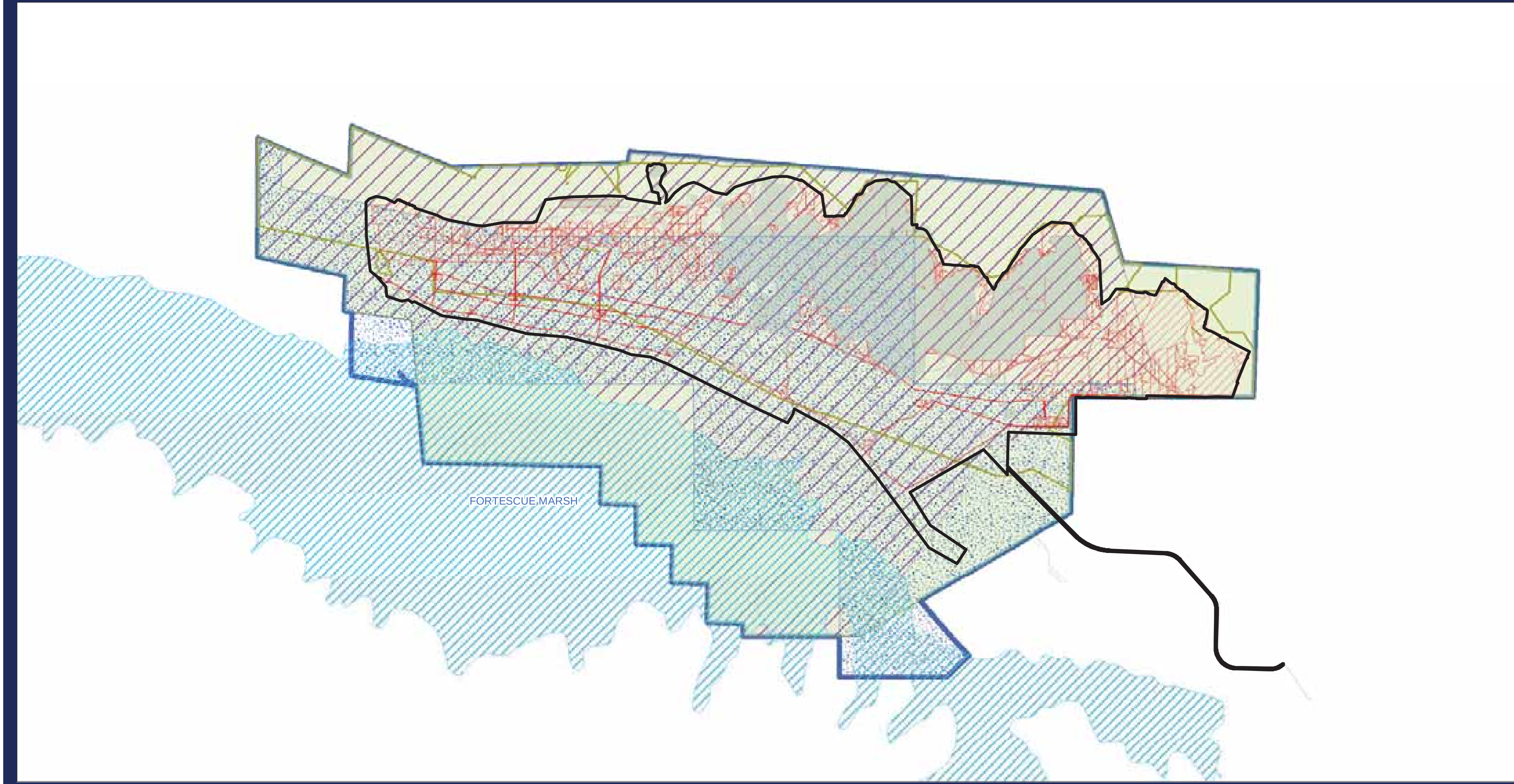

LEGEND
- Proposal Area (Indicative Disturbance Footprint)
- Existing Approved Footprint
- Development Envelope
- Fortescue Marsh
- Vegetation Survey Biota 2004
- Vegetation Survey Mattiske 2007
- Vegetation Survey ENV 2010
- Vegetation Survey ENV 2011
- Vegetation Survey ENV 2013

Data Source(s):
Marsh data sourced from GOV

Extent of Flora and Vegetation Surveys within Proposal Area

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:182,088
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F037_ExtFloraVegSurveyinPA

Date: 10/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

Document Path: Q:\Consult\2013\FMG\FMG13132\ArcMap_documents\R001\Rev0\FMG13132_01_R001_Rev0_F037_ExtFloraVegSurveyinPA.mxd

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Figure 41: Vegetation Systems of the Proposal Area

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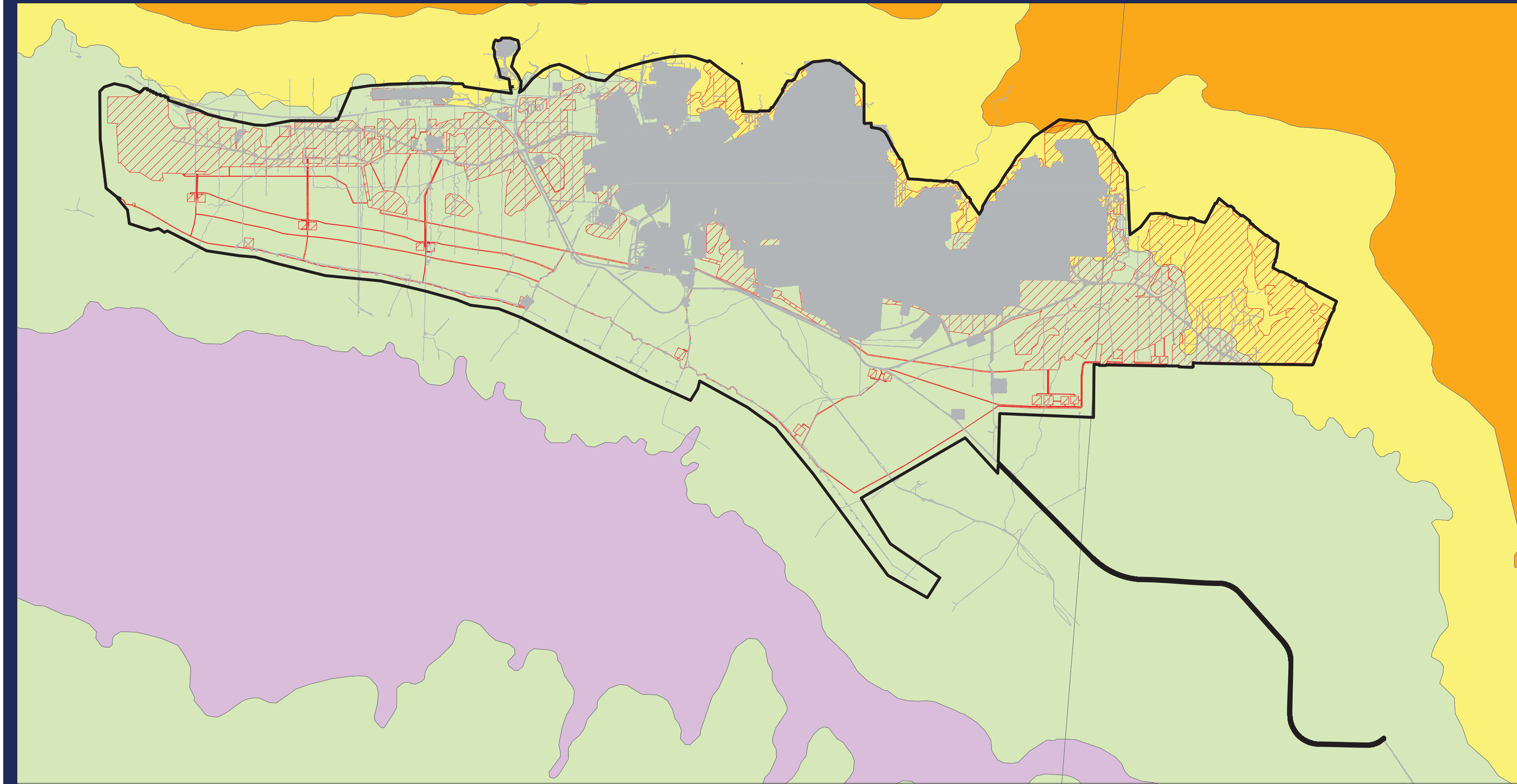

LEGEND

Development Envelope

Existing Approved Footprint

Proposal Area (Indicative Disturbance Footprint)

Vegetation Association

29 - Sparse low woodland; mulga, discontinuous in scattered groups

173 - Hummock grasslands, shrub steppe; kanji over soft spinifex and *Triodia wiseana* on basalt

562 - Mosaic: Low woodland; mulga in valleys / Hummock grasslands, open low tree-steppe; snappy gum over *Triodia wiseana*

676 - Succulent steppe; samphire

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Vegetation Systems of the Proposal Area

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F038_VegSystemsinPA

Date: 10/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 42: Vegetation Types and Associations of the Proposal Area

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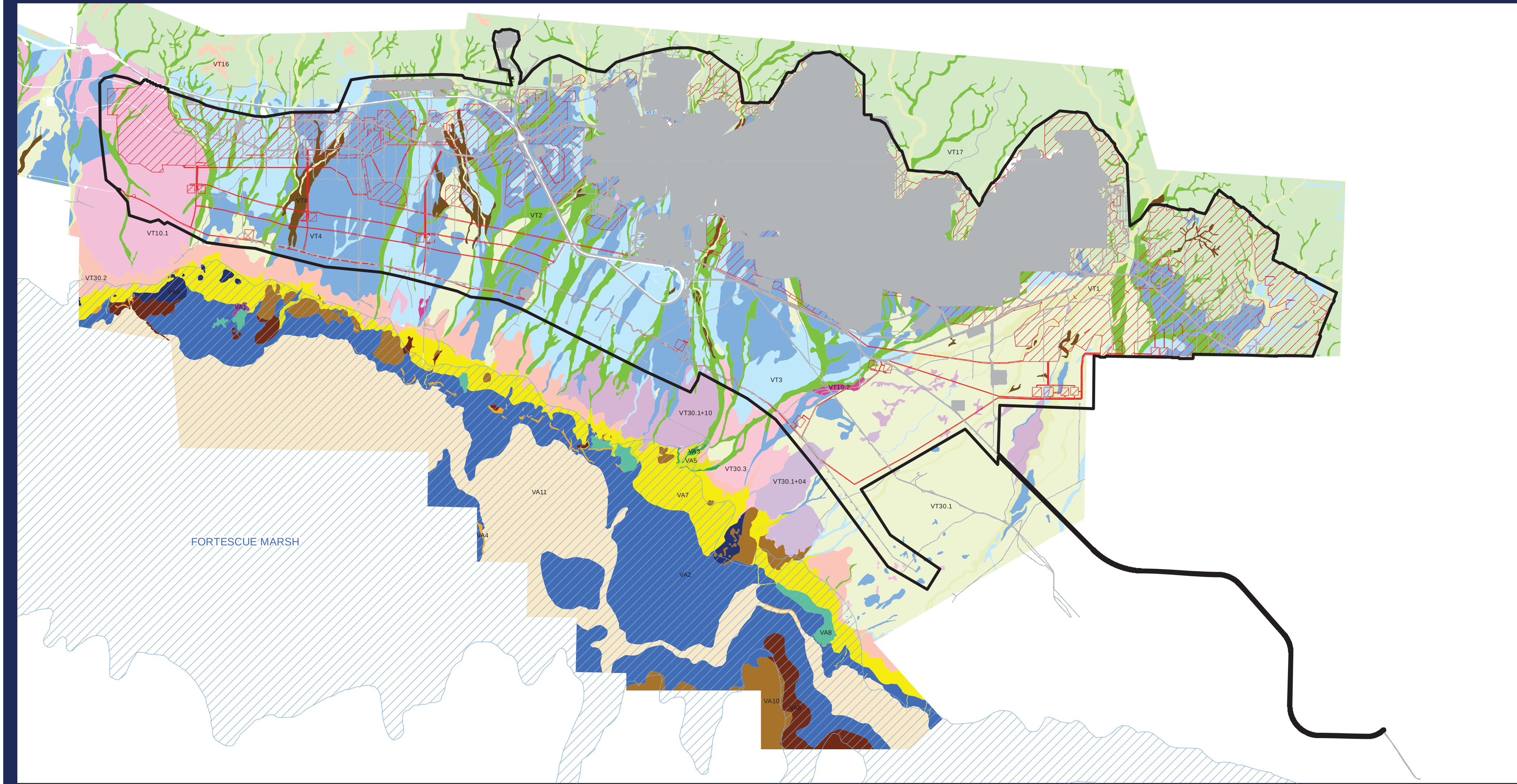

LEGEND

- Development Envelope
- Existing Approved Footprint
- Proposal Area (Indicative Disturbance Footprint)
- Fortescue Marsh

Vegetation Type

VA1	VA6	VT8
VA2	VA7	VT9
VA3	VA8	VA11
VA4	VA9	VT16
VA5	VA10	VT17
	VT1	VT30.1
	VT2	VT30.1+04
	VT3	VT30.1+10
	VT4	VT30.2
	VT10.1	VT30.3
	VT10.2	

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Vegetation Types and Associations of the Proposal Area

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F039_VegTypeandAssoc

Date: 10/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

Document Path: Q:\Consult\2013\FMG\FMG13132\ArcMap_documents\R001\Rev0\FMG13132_01_R001_Rev0_F039_VegTypeandAssoc.mxd

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Figure 43: Indicative Mine Infrastructure Zones and Vegetation Units

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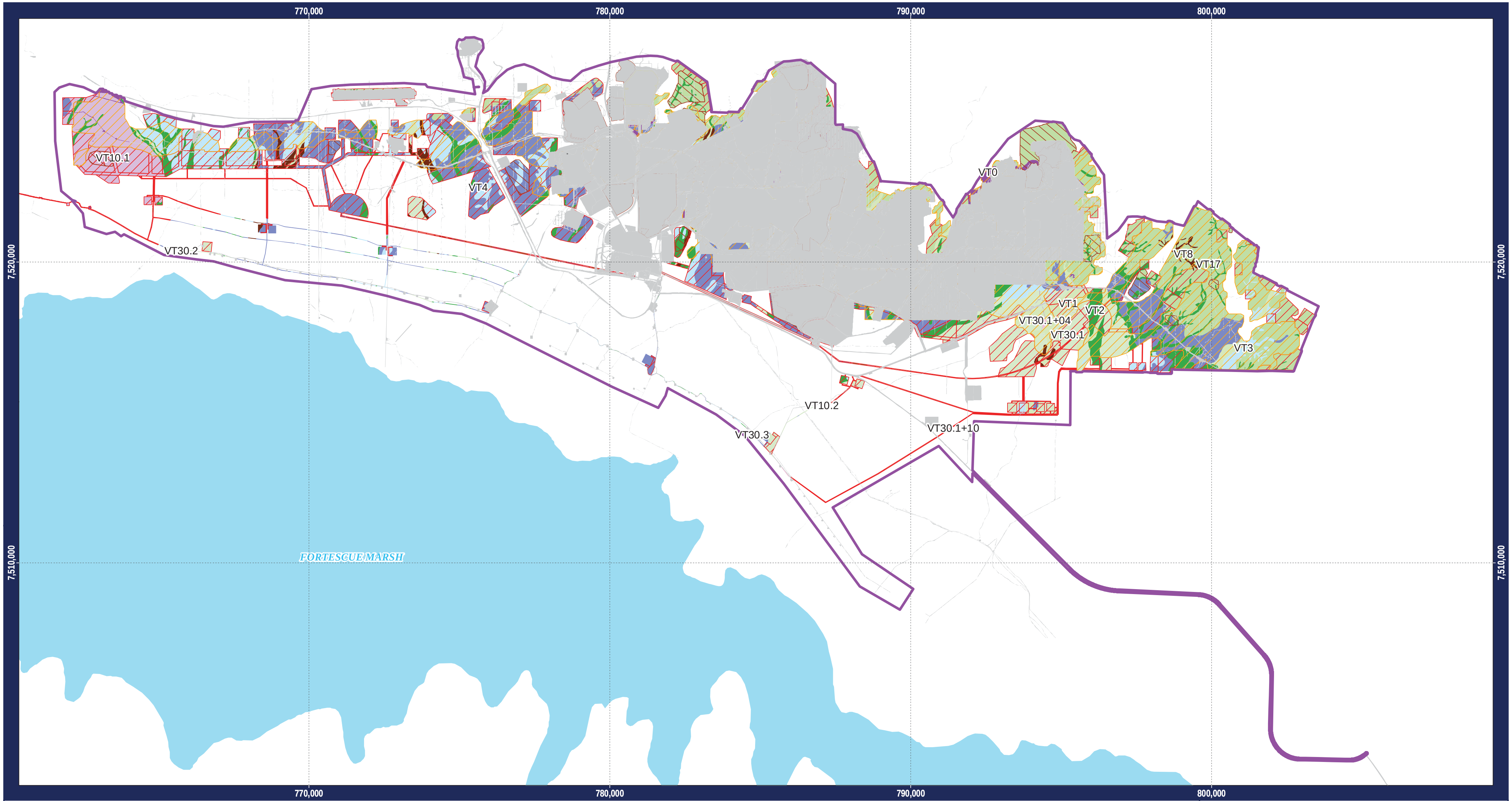

LEGEND

- Mine Development Envelope
- Indicative Mine Pit Zone
- Indicative Waste Rock Storage Zone
- Indicative Tailings Storage Zone
- Indicative Miscellaneous Infrastructure Zone
- Indicative Approved Area (Ministerial Statement 707)
- Fortescue Marsh

Vegetation Type

- cleared
- VT1
- VT10.1
- VT10.2
- VT17
- VT2
- VT3
- VT30.1
- VT30.1+04
- VT30.1+10
- VT30.2
- VT30.3
- VT4
- VT8

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Indicative Mine Infrastructure Zones and Vegetation Units

Requested By: Rachael Sharp
Drawn By: B.Ralebala
Revised By: bralebala
Approved By: Undraa George
Scale: 1:125,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_EN_0246_r0

Date: 6/11/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 44: Conservation Significant Flora and Communities

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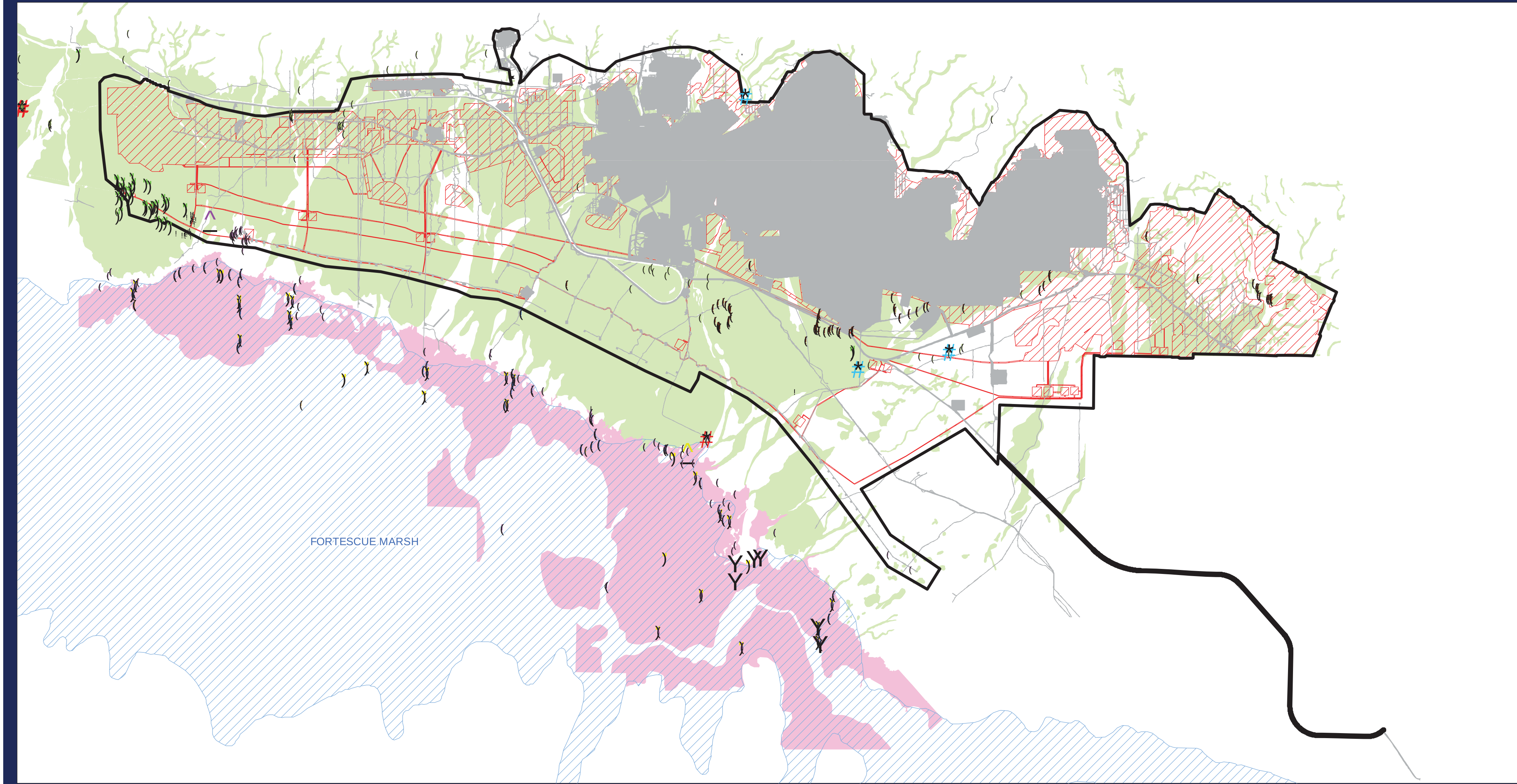

LEGEND

- Development Envelope
- Existing Approved Footprint
- Proposal Area (Indicative Disturbance Footprint)
- Fortescue Marsh

Vegetation communities

- Mulga
- Samphire

Taxa

- *Atriplex flabelliformis*
- *Calotis squamigera*
- *Eleocharis papillosa*
- *Eremophila spongiocarpa*
- *Eremophila youngii* subsp. *lepidota*
- *Goodenia nuda*
- *Maireana amoena*
- *Nicotiana heterantha*
- *Rhagodia* sp. *Hamersley Station*
- *Rostellularia adscendens* var. *latifolia*
- *Sclerolaena recurvicuspis*
- *Tecticornia globulifera*
- *Tecticornia medusa*
- *Tecticornia* sp. *Christmas Creek* (K.A. Shepherd and T. Colmer et al. KS 1063)
- *Themeda* sp. *Hamersley Station* (M.E. Trudgen 11431)
- *Vigna* sp. *central* (M.E. Trudgen 1626) PN

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Conservation Significant Flora and Communities

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F040_ConSigFloraandComm

Date: 10/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 45: Introduced Flora of the Proposal Area

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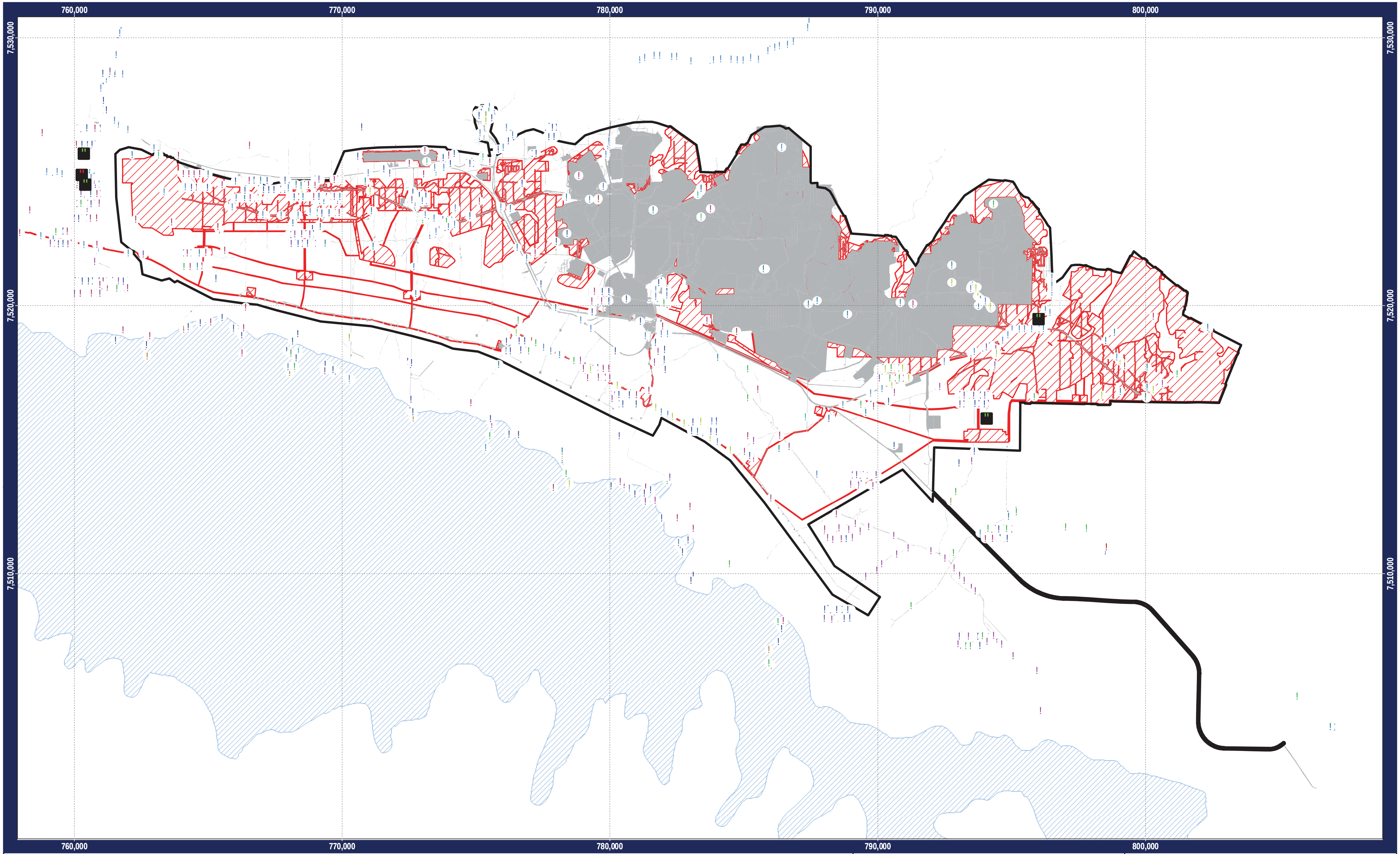

Species

- Argemone mexicana
- Argemone ochroleuca
- Acetosa vesicaria
- Aerva javanica
- Bidens bipinnata
- Cenchrus ciliaris
- Cenchrus setiger
- Chloris barbata
- Chloris virgata
- Citrullus colocynthis
- Citrullus lanatus
- Conyza bonariensis
- Cucumis melo
- Cucumis melo subsp. agrestis
- Digitaria ciliaris
- Echinochloa colona
- Eragrostis curvula
- Euphorbia hirta
- Flaveria trinervia
- Heliotropium europaeum
- Malvastrum americanum
- Portulaca oleracea
- Setaria verticillata
- Sonchus oleraceus
- Tribulus terrestris
- Vachellia farnesiana

- Development Envelope
- Indicative Approved Footprint
- Indicative Disturbance Footprint
- Fortescue_Marsh

Data Source(s):
Fortescue Marsh: DIWA

0 1 2 3 4 5
Kilometres

Requested By: Rachel Sharp
Drawn By: C Whyte
Revised By: cwhyte
Approved By: Bridget Ralebala
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_EN_0240.001_r0

Date: 4/08/2014
Size: A3L
Revision: 0
Confidentiality: 1

Introduced Flora Recorded at Christmas Creek

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 46: Proposed Fortescue Marsh Conservation Reserve

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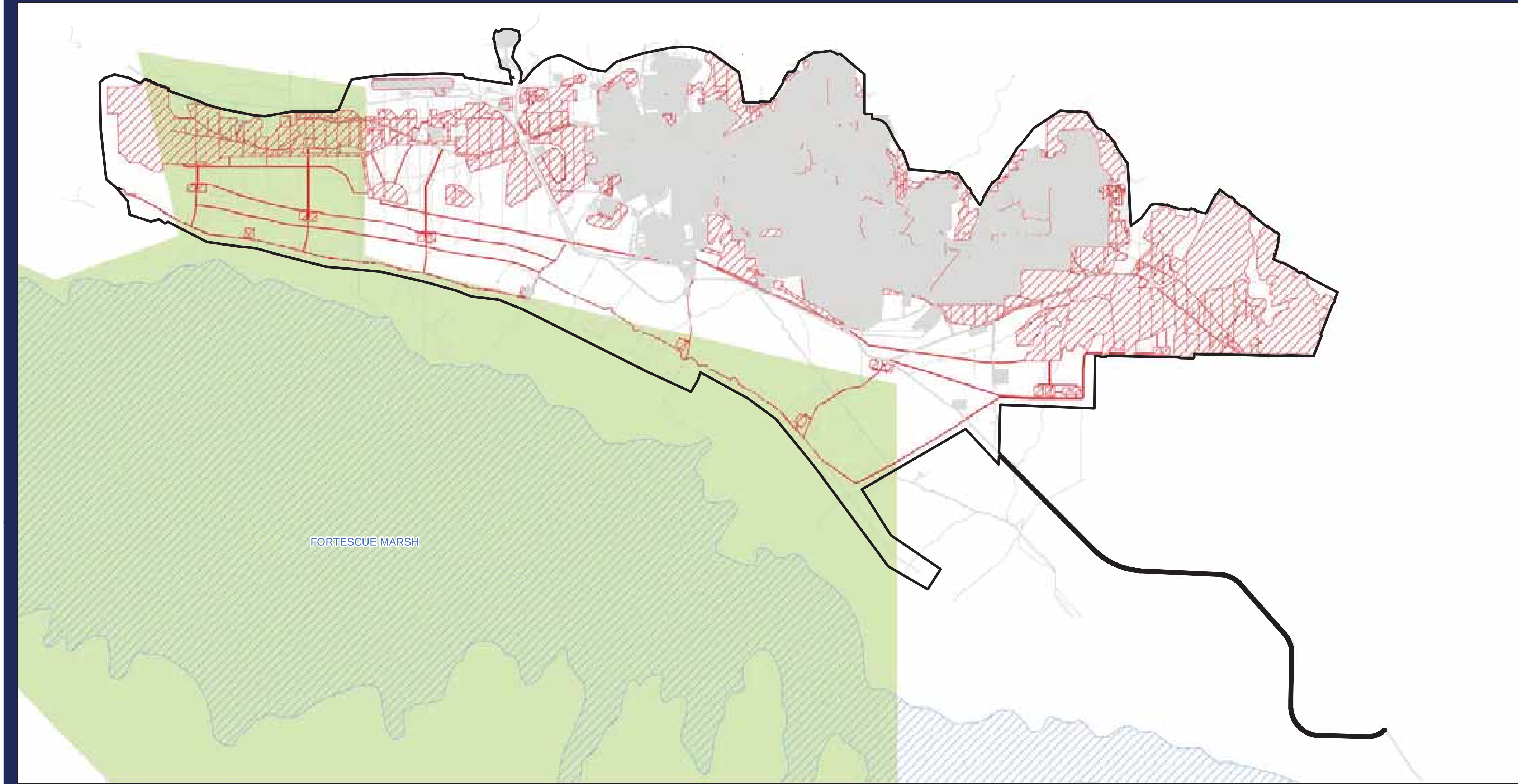

LEGEND

- Development Envelope
- Existing Approved Footprint
- Proposal Area (Indicative Disturbance Footprint)
- Fortescue Marsh
- Proposed Fortescue Marsh Conservation Reserve

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Proposed Fortescue Marsh Conservation Reserve

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: sfinning
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F041_PropFortMarchConsRes

Date: 6/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 47: Indirect Impact Areas: 2014

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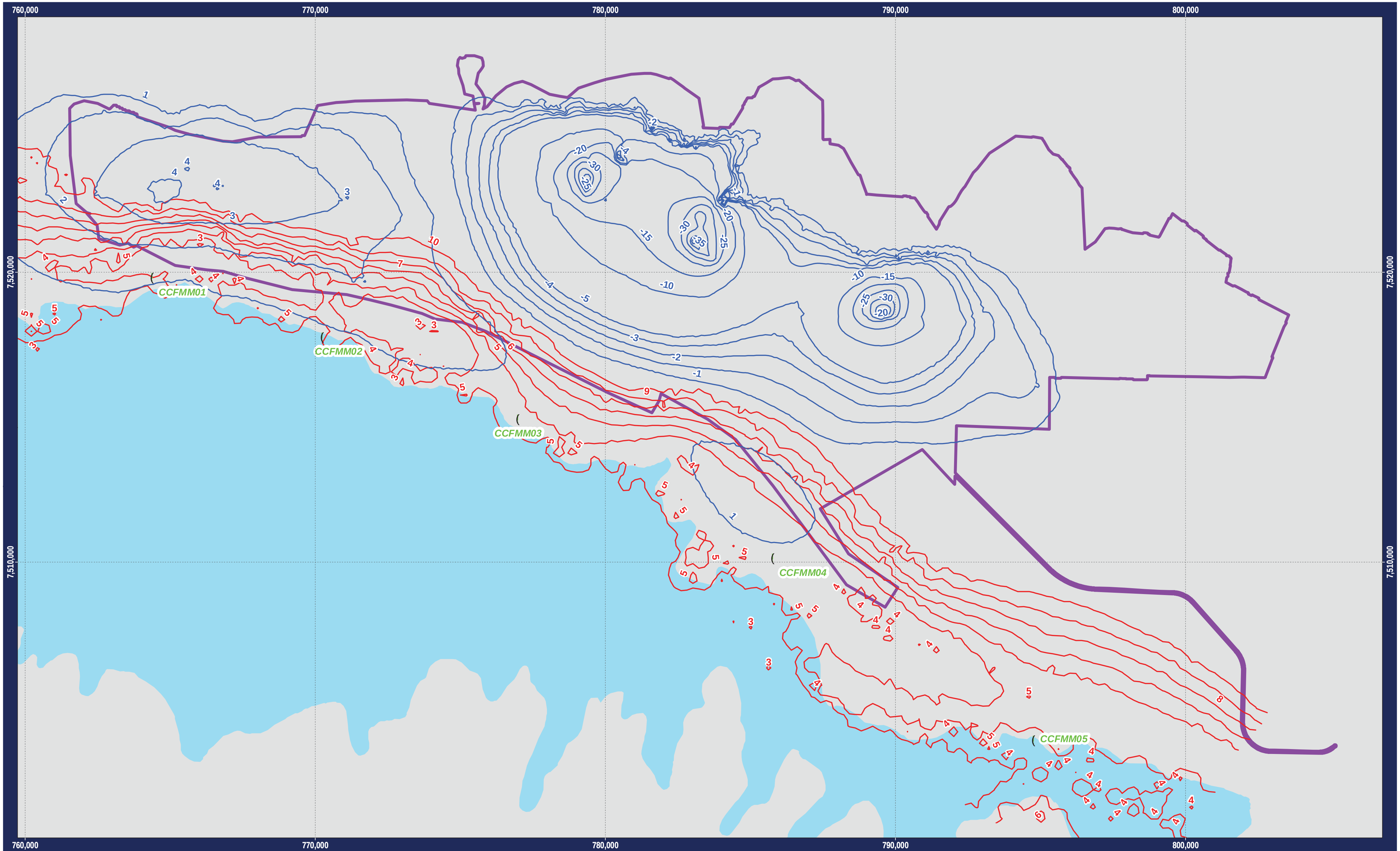

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Drawdown (negative) and Mounding (positive) resulting from the Project (m)
Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation
Mulga Vegetation
Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001).
Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced
from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.001_r0

Date: 22/11/2013
Size: A3L
Revision: 0
Confidentiality: 1

2014

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 48: Indirect Impact Areas: 2015

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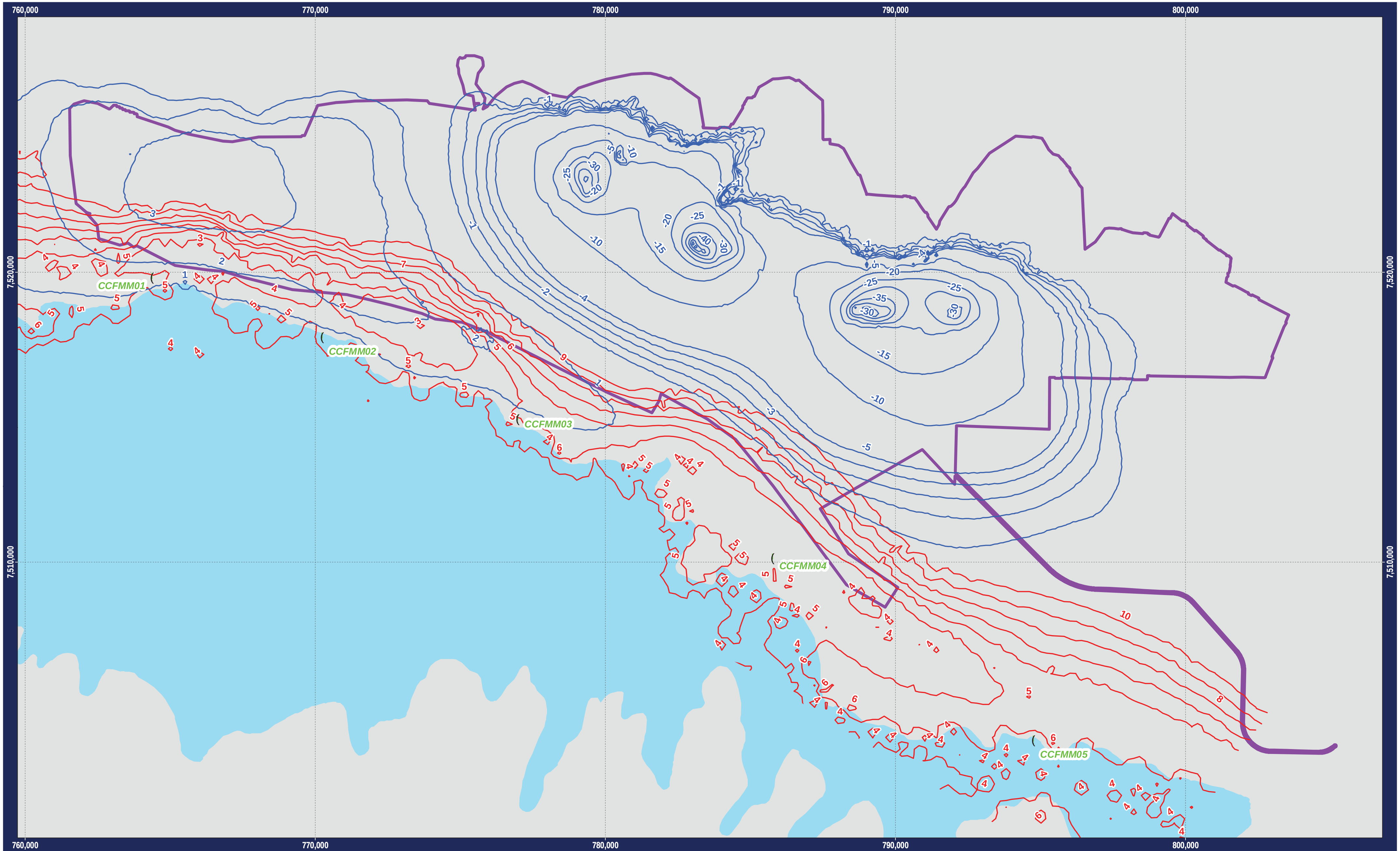

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Drawdown (negative) and Mounding (positive) resulting from the Project (m)
Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation
Mulga Vegetation
Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001). Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.002_r0

Date: 22/11/2013
Size: A3L
Revision: 0
Confidentiality: 1

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2015

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Figure 49: Indirect Impact Areas: 2016

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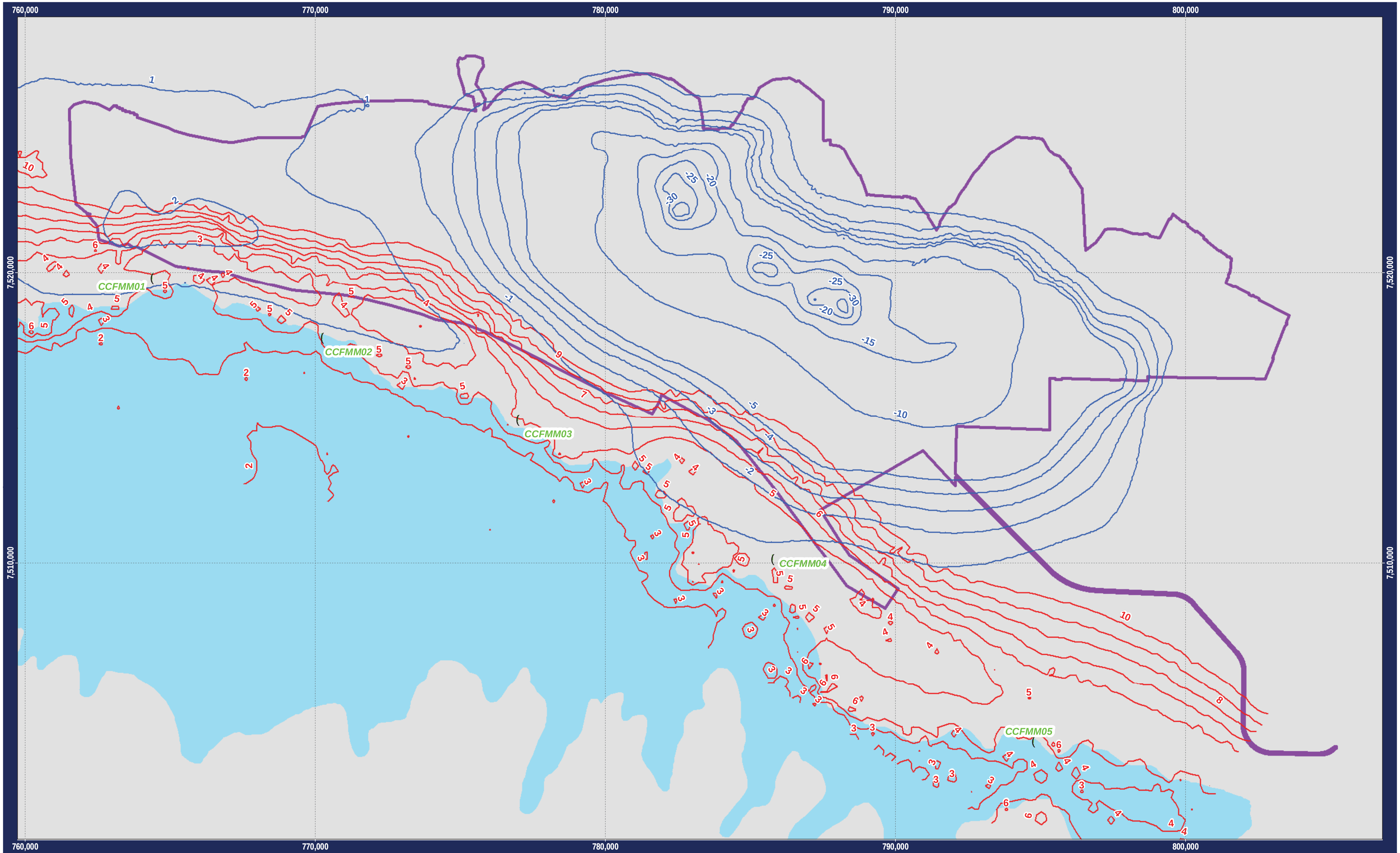

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Drawdown (negative) and Mounding (positive) resulting from the Project (m)
Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation
Mulga Vegetation
Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001). Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.003_r0

Date: 22/11/2013
Size: A3L
Revision: 0
Confidentiality: 1

2016

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 50: Indirect Impact Areas: 2017

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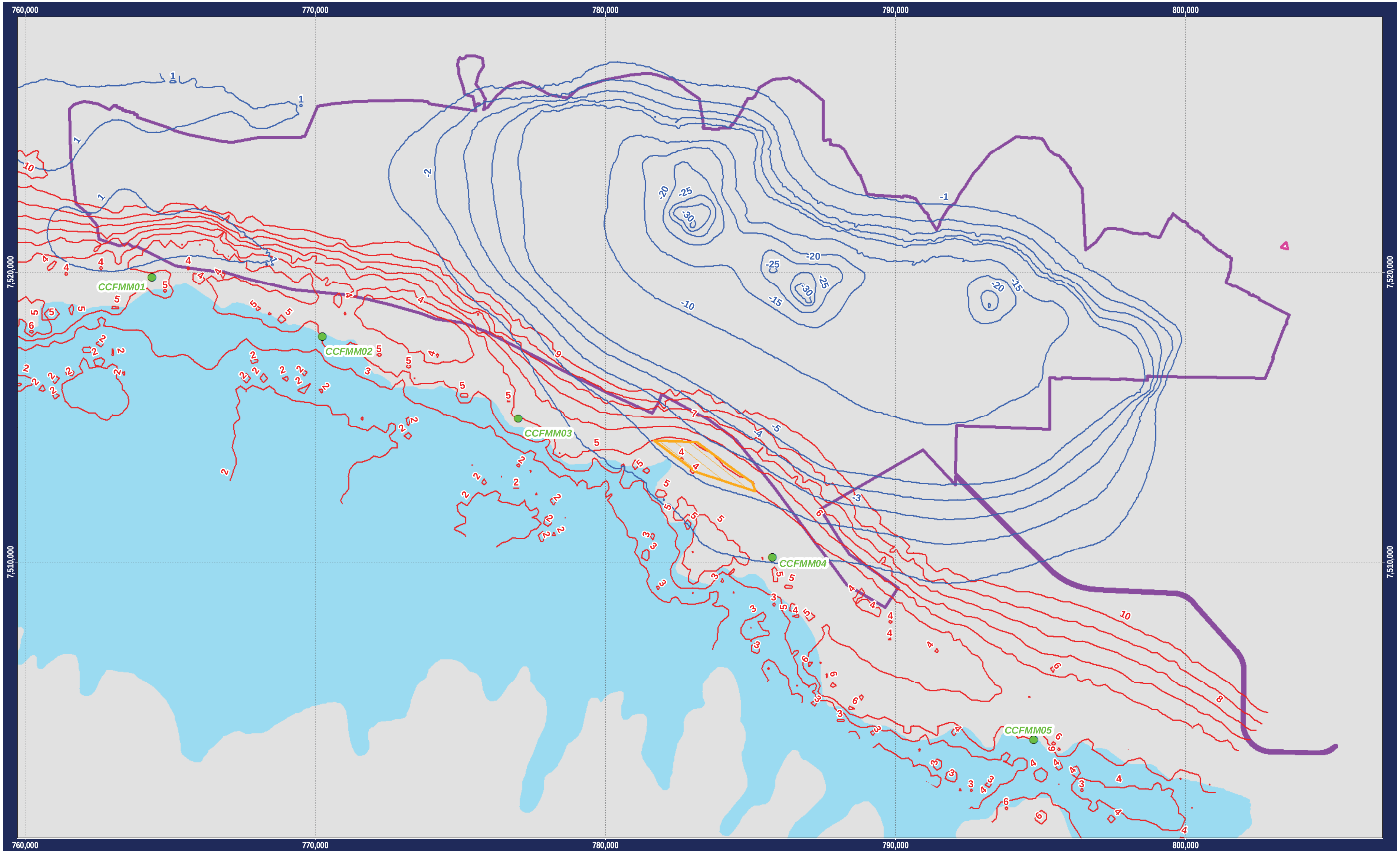

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Drawdown (negative) and Mounding (positive) resulting from the Project (m)
Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation
Mulga Vegetation
Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001).
Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.004_r0

Date: 22/11/2013
Size: A3L
Revision: 0
Confidentiality: 1

2017

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 51: Indirect Impact Areas: 2018

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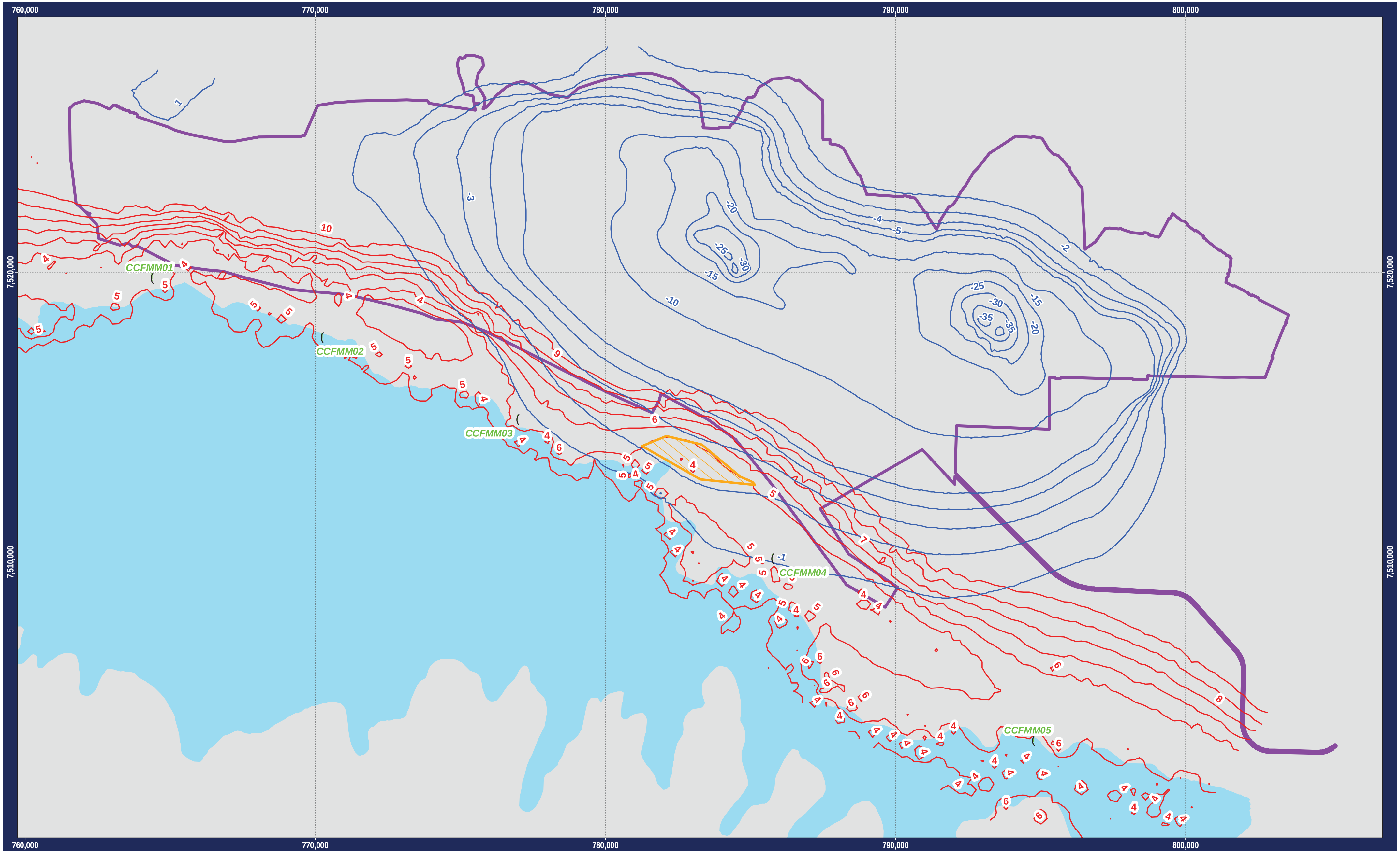

- Fortescue Marsh
- Monitoring Bore Locations
- Disturbance Envelope
- Drawdown (negative) and Mounding (positive) resulting from the Project (m)
- Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

- *Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl*
- *Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl*
- *Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl*

Significant Vegetation Indirect Impact Areas

- *Coolabah/Redgum Vegetation*
- *Mulga Vegetation*
- *Samphire Vegetation*

Data Source(s):
Marsh data sourced from Enviro Australia (2001).
Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced
from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.005_r0

Date: 22/11/2013
Size: A3L
Revision: 0
Confidentiality: 1

2018

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 52: Indirect Impact Areas: 2019

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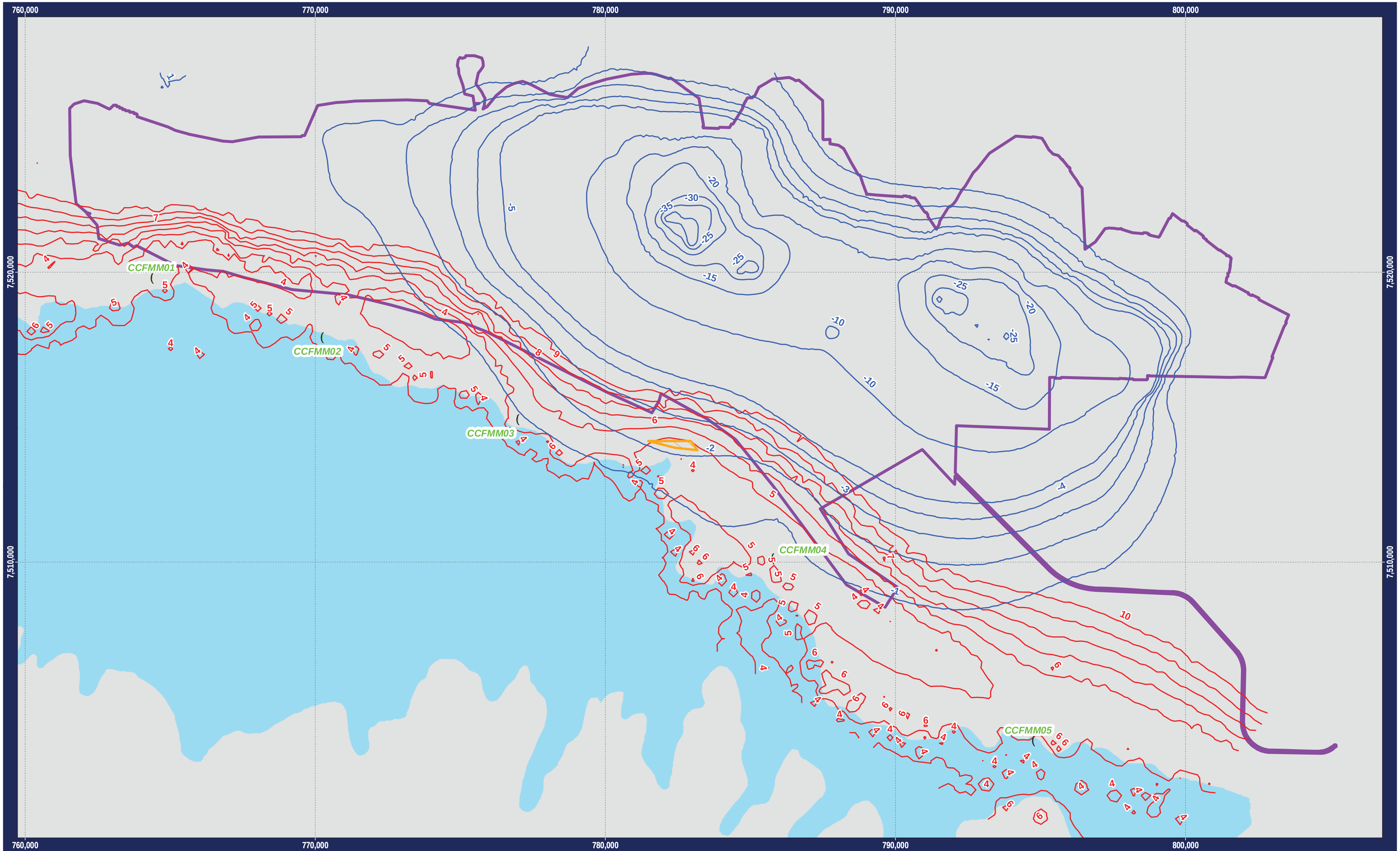

Fortescue Marsh

Monitoring Bore Locations

Disturbance Envelope

Drawdown (negative) and Mounding (positive) resulting from the Project (m)

Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl

Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl

Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation

Mulga Vegetation

Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001). Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.006_r0

Date: 22/11/2013
Size: A3L
Revision: 0
Confidentiality: 1

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2019

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 53: Indirect Impact Areas: 2020

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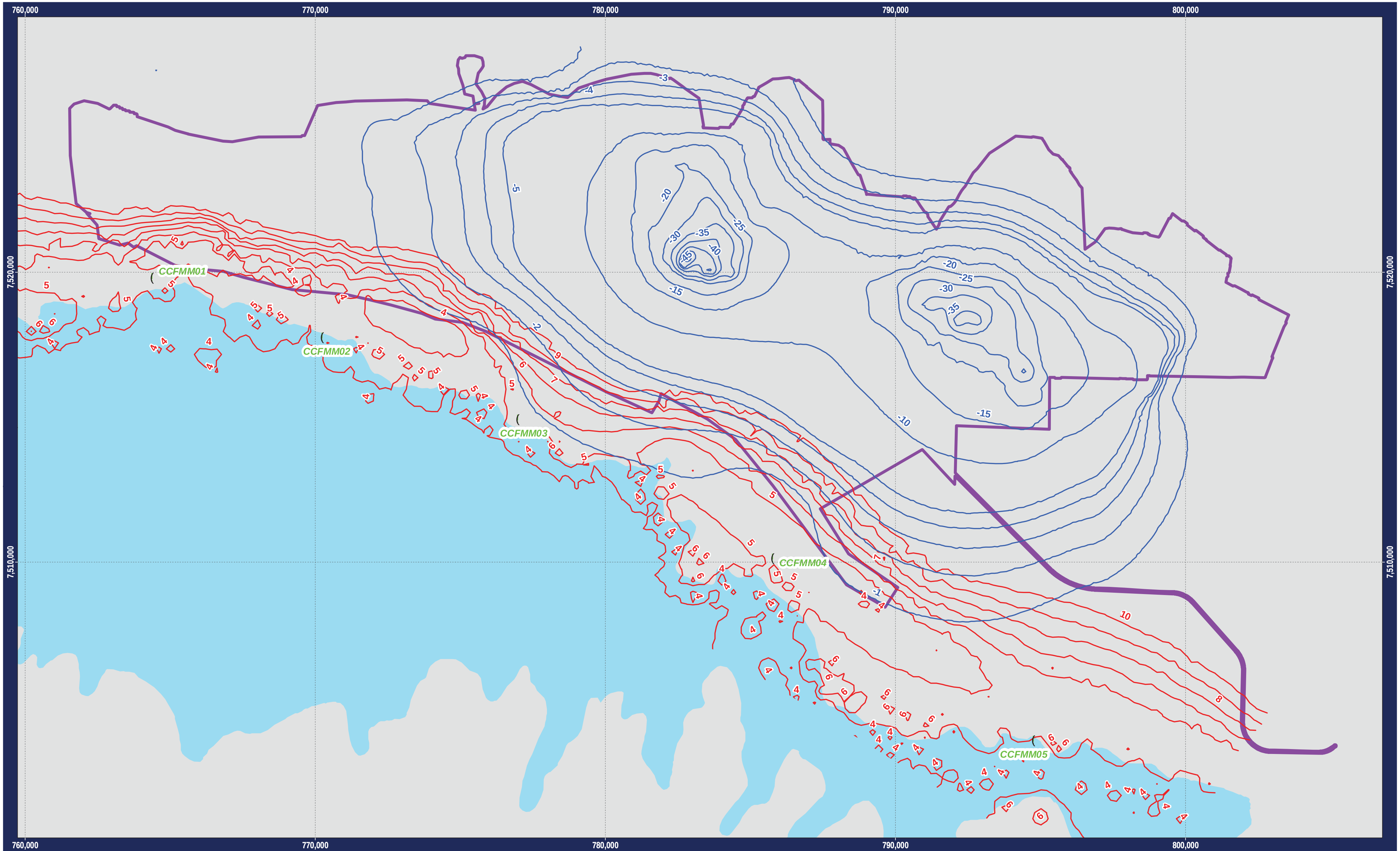

Fortescue Marsh

Monitoring Bore Locations

Disturbance Envelope

Drawdown (negative) and Mounding (positive) resulting from the Project (m)

Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl

Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl

Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation

Mulga Vegetation

Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001). Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.007_r0

Date: 22/11/2013
Size: A3L
Revision: 0
Confidentiality: 1

2020

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 54: Indirect Impact Areas: 2021

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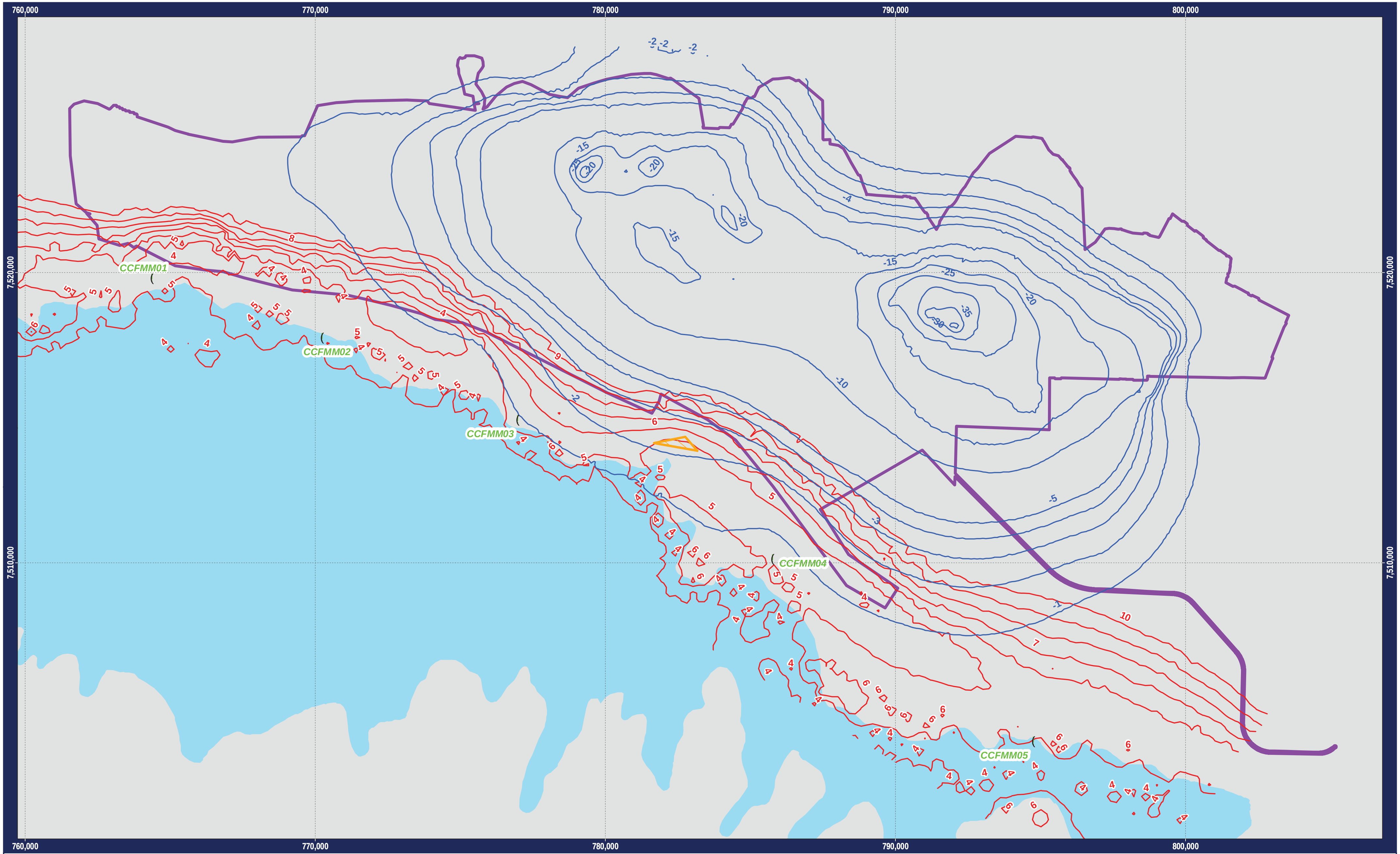

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Drawdown (negative) and Mounding (positive) resulting from the Project (m)
Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation
Mulga Vegetation
Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001).
Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.008_r0

Date: 22/11/2013
Size: A3L
Revision: 0
Confidentiality: 1

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2021

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 55: Indirect Impact Areas: 2022

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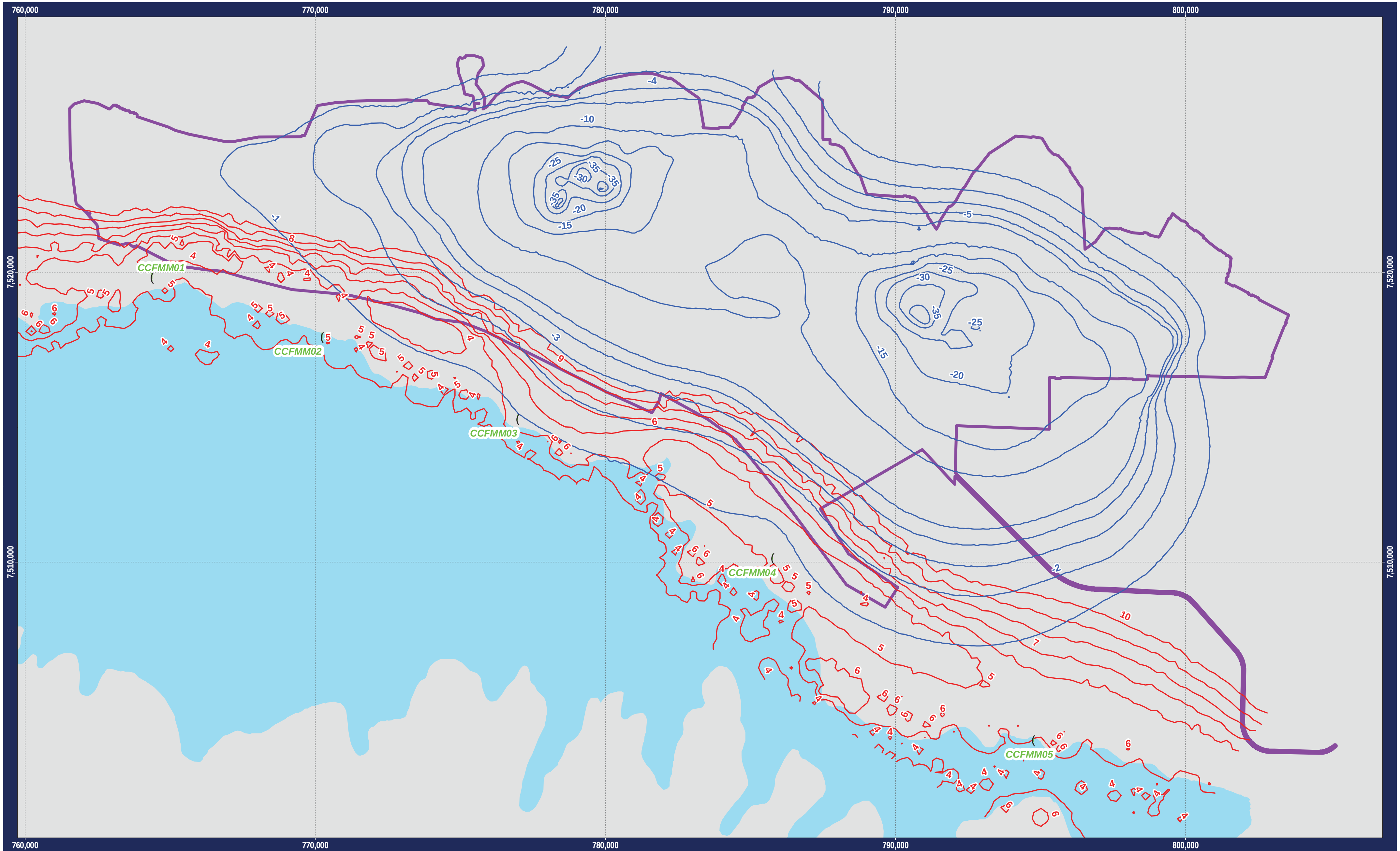

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Drawdown (negative) and Mounding (positive) resulting from the Project (m)
Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation
Mulga Vegetation
Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001). Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.009_r0

Date: 21/11/2013
Size: A3L
Revision: 0
Confidentiality: 1

2022

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 56: Indirect Impact Areas: 2023

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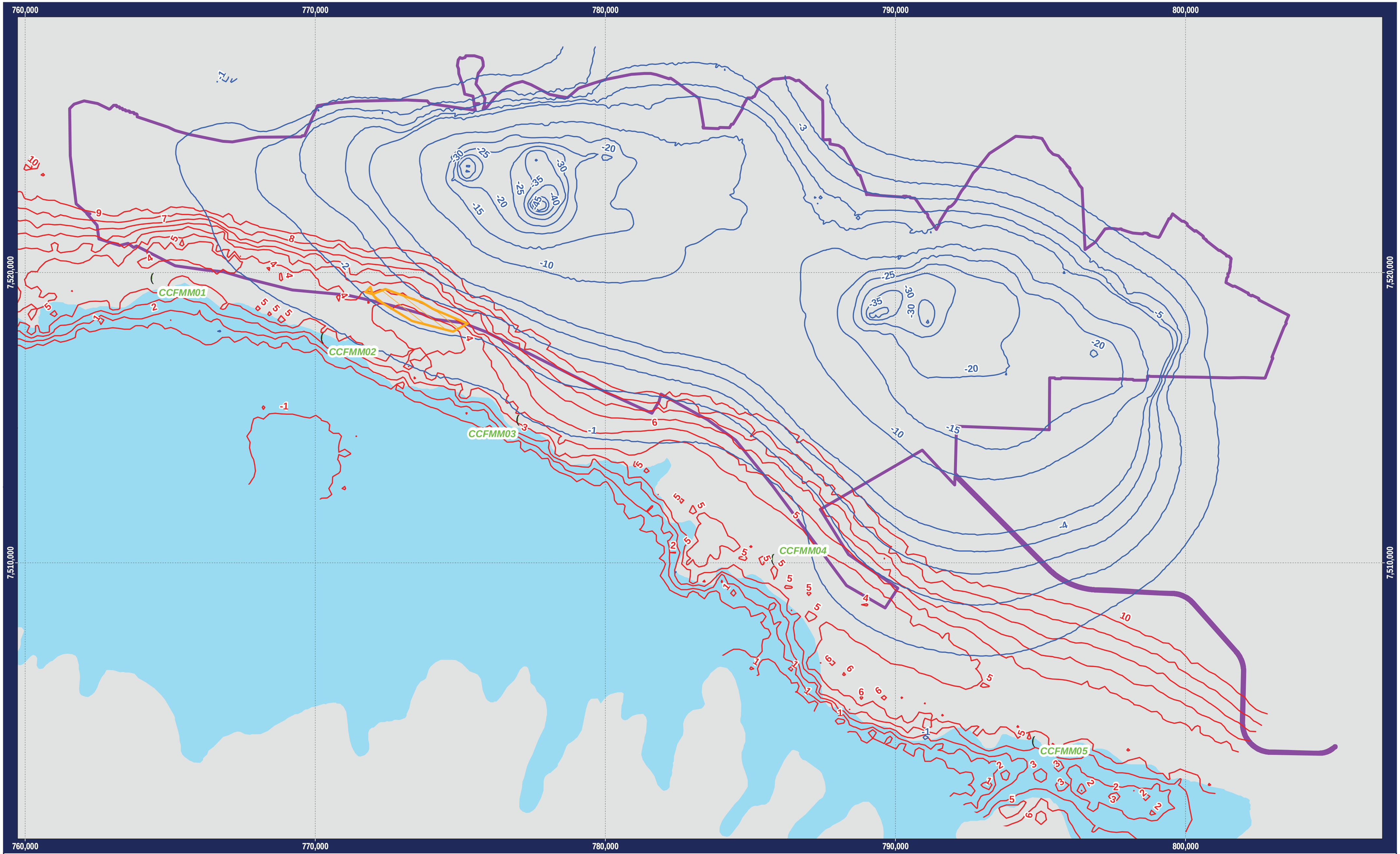

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Drawdown (negative) and Mounding (positive) resulting from the Project (m)
Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation
Mulga Vegetation
Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001). Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.010_r0

Date: 21/11/2013
Size: A3L
Revision: 0
Confidentiality: 1

2023

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 57: Indirect Impact Areas: 2024

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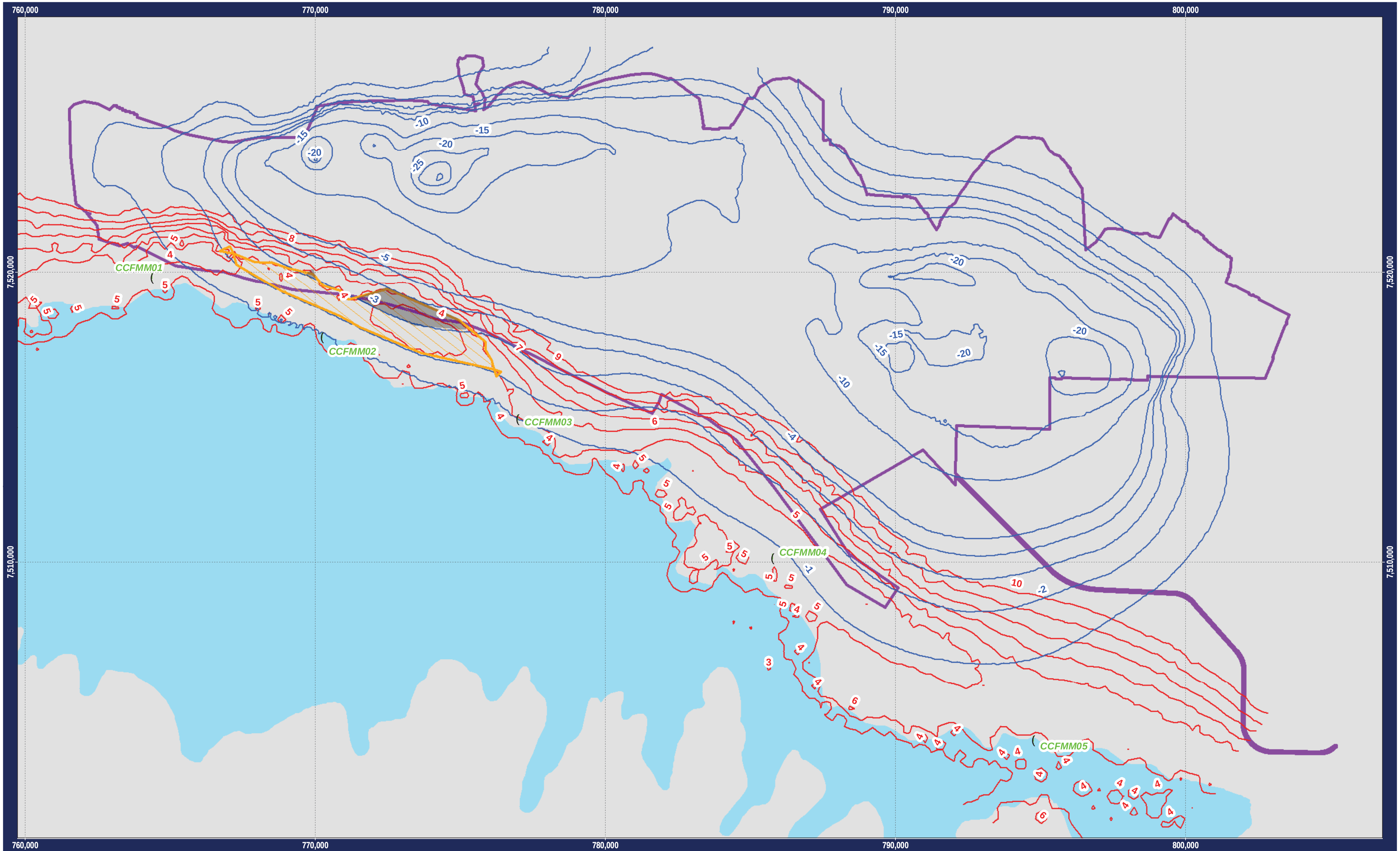

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Drawdown (negative) and Mounding (positive) resulting from the Project (m)
Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones
Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas
Coolabah/Redgum Vegetation
Mulga Vegetation
Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001).
Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.011_r0

Date: 21/11/2013
Size: A3L
Revision: 0
Confidentiality: 1

2024

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 58: Indirect Impact Areas: 2025

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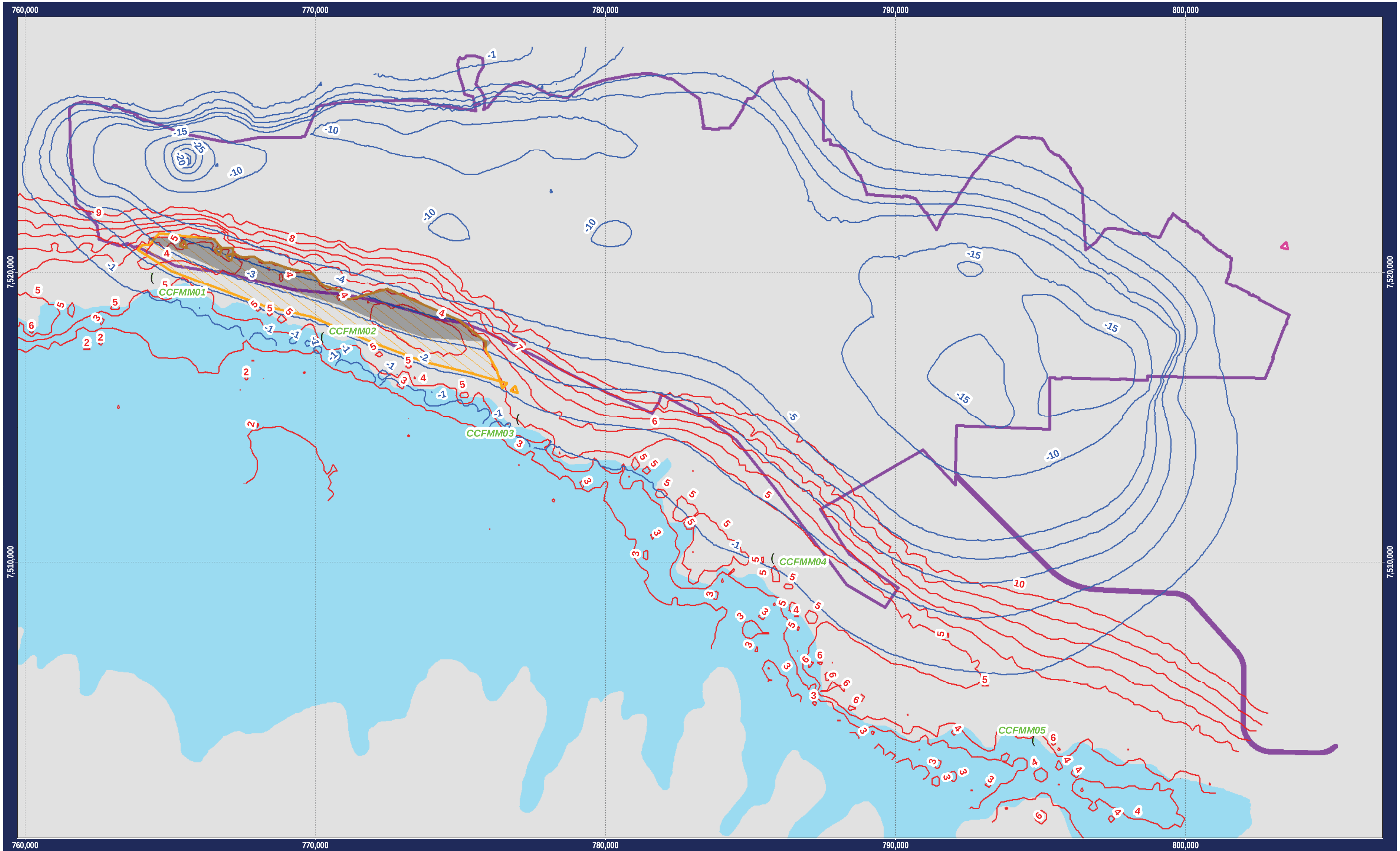

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Drawdown (negative) and Mounding (positive) resulting from the Project (m)
Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation
Mulga Vegetation
Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001).
Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.012_r0

Date: 21/11/2013
Size: A3L
Revision: 0
Confidentiality: 1

2025

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 59: Indirect Impact Areas: 2026

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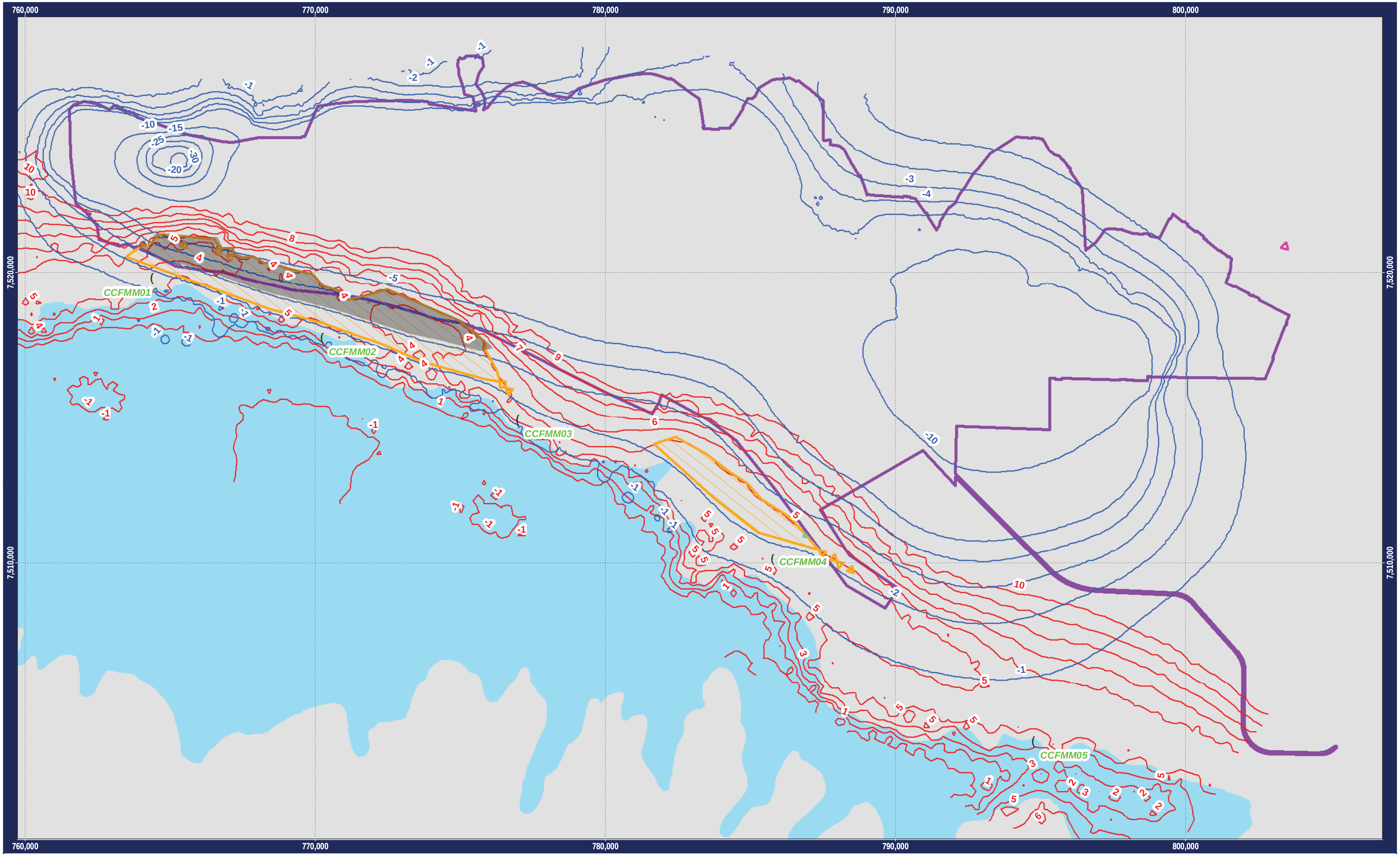

- Fortescue Marsh
- Monitoring Bore Locations
- Disturbance Envelope
- Drawdown (negative) and Mounding (positive) resulting from the Project (m)
- Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

- Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
- Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
- Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

- Coolabah/Redgum Vegetation
- Mulga Vegetation
- Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001).
Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.013_r0

Date: 21/11/2013
Size: A3L
Revision: 0
Confidentiality: 1

2026

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 60: Indirect Impact Areas: 2027

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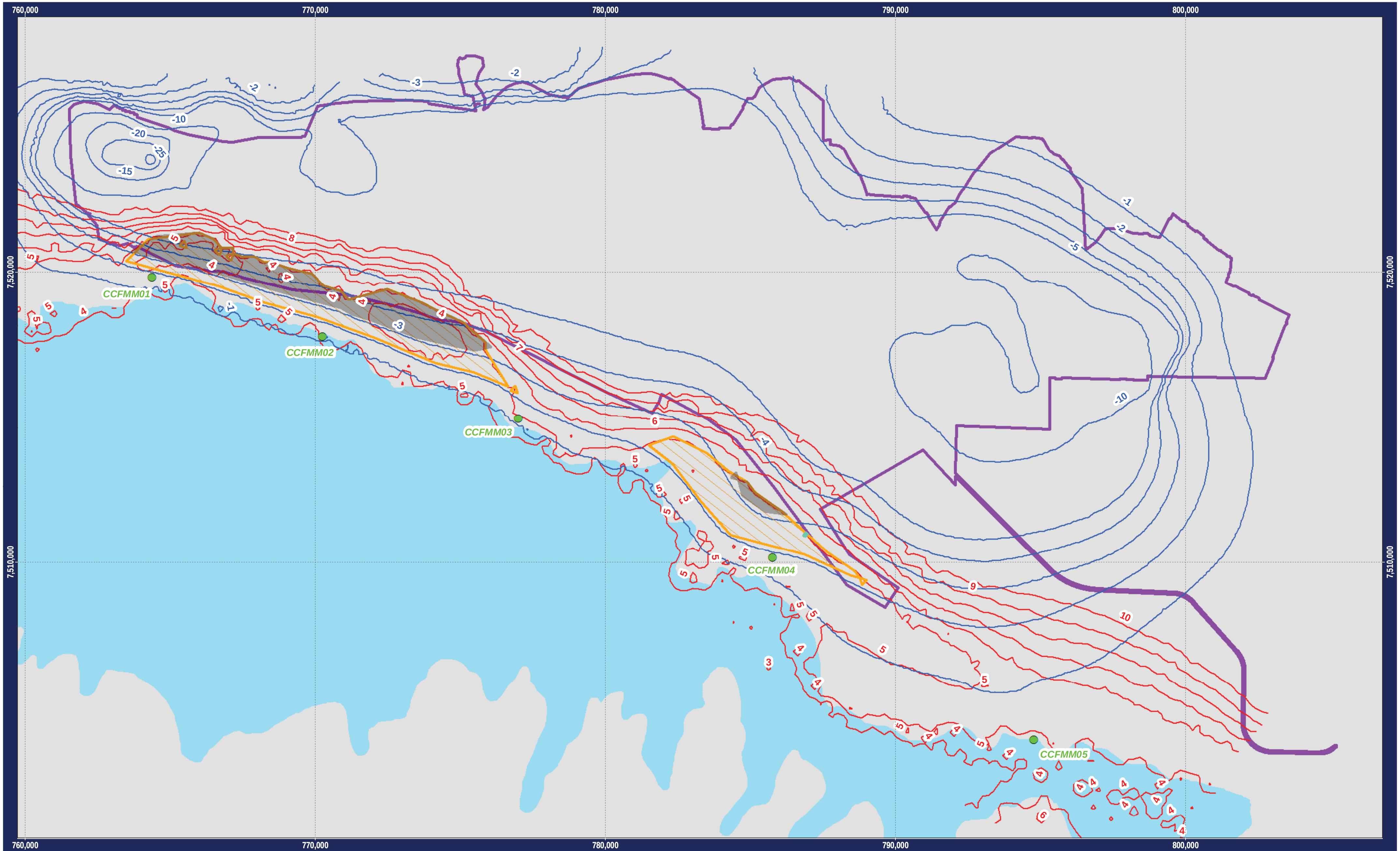

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Drawdown (negative) and Mounding (positive) resulting from the Project (m)
Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation
Mulga Vegetation
Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001). Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.014_r0

Date: 21/11/2013
Size: A3L
Revision: 0
Confidentiality: 1

2027

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 61: Indirect Impact Areas: 2028

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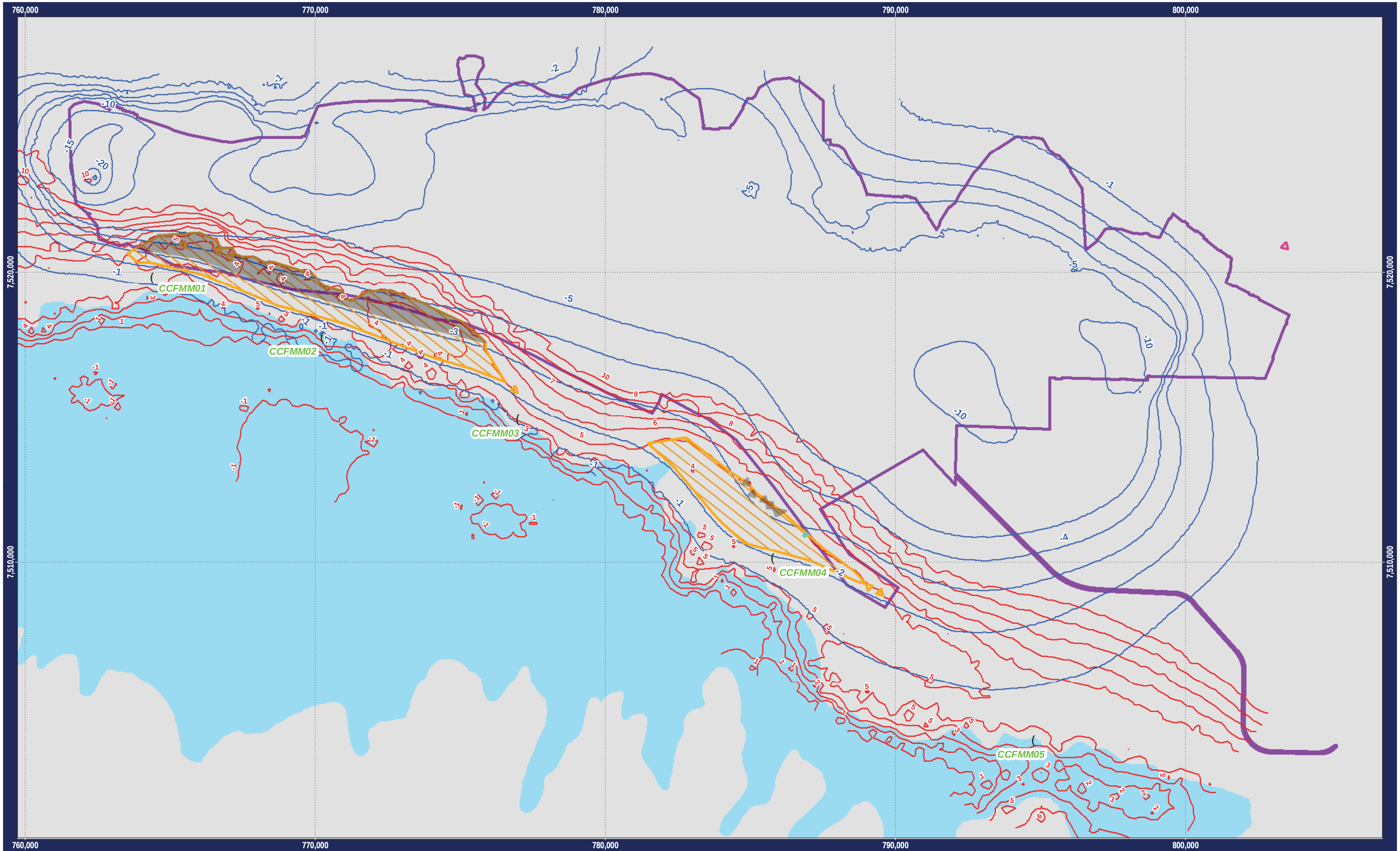

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Drawdown (negative) and Mounding (positive) resulting from the Project (m)
Depth to groundwater table under natural conditions (mbgl)

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Significant Vegetation Indirect Impact Areas

Coolabah/Redgum Vegetation
Mulga Vegetation
Samphire Vegetation

Data Source(s):
Marsh data sourced from Enviro Australia (2001).
Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

0 1 2 3 4 5
Kilometres

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.015_r0

Date: 21/11/2013
Size: A3L
Revision: 0
Confidentiality: 1

2028

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 62: Indirect Impact Areas: All Years Combined

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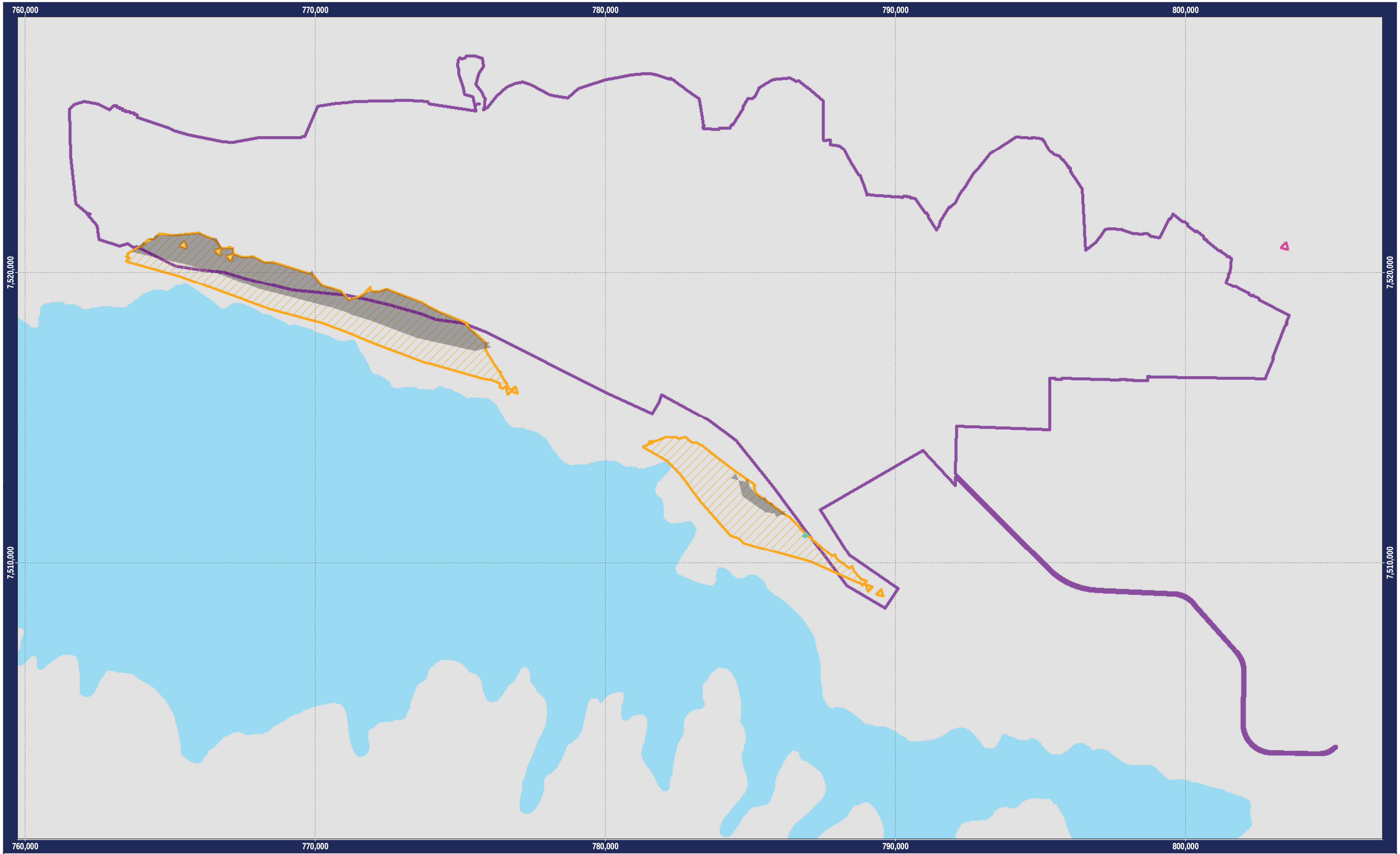

Fortescue Marsh
Monitoring Bore Locations
Disturbance Envelope
Total Veg Impact

Groundwater Zones

Zone 1: Drawdown greater than 2m where natural groundwater is <5 mbgl
Zone 2: Drawdown greater than 3m where natural groundwater is <5 mbgl
Zone 3 : Mounding of 2m or more where natural groundwater is >2mbgl

Data Source(s):
Marsh data sourced from Enviro Australia (2001). Directory of Important Wetlands in Australia
Observation wells, mine plan data sourced from FMG (2013)

Requested By: Rachael Sharp
Drawn By: A.Moore
Revised By: admoore
Approved By:
Scale: 1:120,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_HY_0174.016_r0

Date: 22/11/2013
Size: A3L
Revision: 0
Confidentiality: 1

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All Years Combined

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 63: Habitat Types

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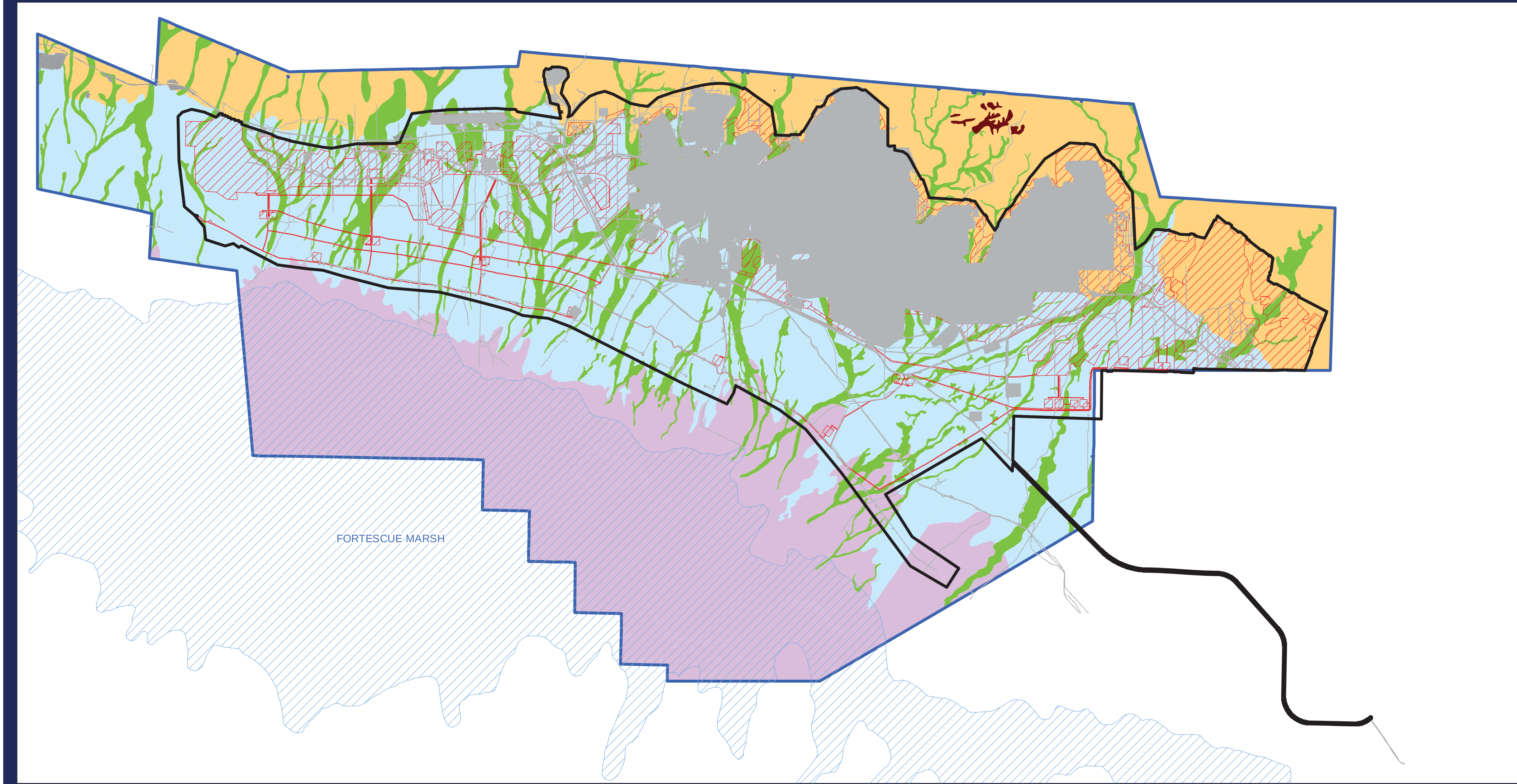

LEGEND

- Development Envelope
- Existing Approved Footprint
- Proposal Area (Indicative Disturbance Footprint)
- Fortescue Marsh
- Habitat Survey Boundary
- Potential Critical Northern Quoll Habitat

Habitat Type

- Cleared and Developed
- Drainage Line and Surrounding Alluvial Plain
- Low Hill
- Marsh
- Stoney Plain

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Habitat Types

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:140,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F043_HabitatTypes

Date: 12/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 64: Conservation Significant Fauna Recorded at Christmas Creek

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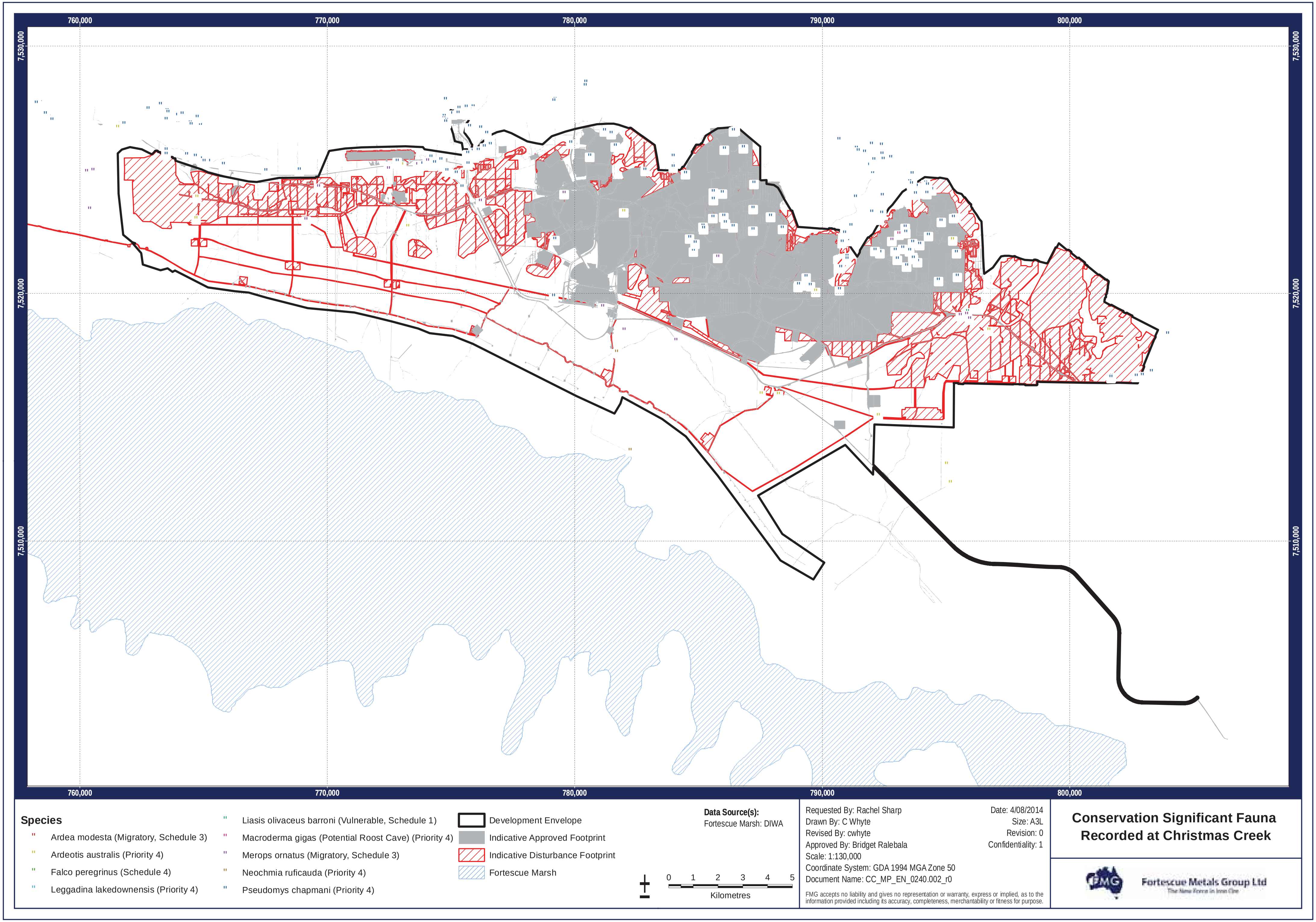
760,000
770,000
780,000
790,000
800,000
7,530,000
7,520,000
7,510,000
Species
Ardea modesta (Migratory, Schedule 3)
Ardeotis australis (Priority 4)
Falco peregrinus (Schedule 4)
Leggadina lakedownensis (Priority 4)
Liasis olivaceus barroni (Vulnerable, Schedule 1)
Macroderma gigas (Potential Roost Cave) (Priority 4)
Merops ornatus (Migratory, Schedule 3)
Neochmia ruficauda (Priority 4)
Pseudomys chapmani (Priority 4)
Development Envelope
Indicative Approved Footprint
Indicative Disturbance Footprint
Fortescue Marsh
Data Source(s):
Fortescue Marsh: DIWA
0 1 2 3 4 5
Kilometres
Requested By: Rachel Sharp
Drawn By: C Whyte
Revised By: cwhyte
Approved By: Bridget Ralebala
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_EN_0240.002_r0
Date: 4/08/2014
Size: A3L
Revision: 0
Confidentiality: 1
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Conservation Significant Fauna
Recorded at Christmas Creek
Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 65: Bores Sampled for Stygofauna in the Survey Area

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LEGEND

- Development Envelope
- Existing Approved Footprint
- Proposal Area (Indicative Disturbance Footprint)
- Fortescue Marsh

Stygofauna Bores Sampled

- Stygofauna Reference Site
- Stygofauna Impact Site
- Stygofauna Impact Site (minor)

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Bores Sampled for Stygofauna in the Survey Area

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: sfinning
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F045_BoresSampStygoinSA

Date: 6/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

Document Path: Q:\Consult\2013\FMG\FMG13132\ArcMap_documents\R001\Rev0\FMG13132_01_R001_Rev0_F045_BoresSampStygoinSA.mxd

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Figure 66: Drill Holes Sampled for Troglofauna in the Survey Area

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LEGEND

- Development Envelope
- Existing Approved Footprint
- Proposal Area (Indicative Disturbance Footprint)
- Fortescue Marsh

Troglofauna Drill Holes Sampled

- Troglofauna Reference Site
- Troglofauna Impact Site
- Troglofauna Impact Site (minor)

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Drill Holes Sampled for Troglofauna in the Survey Area

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: sfinning
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F046_DrillSampTrogoinSA

Date: 6/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 67: Stygofauna Species Known Only From Proposed Impact Areas

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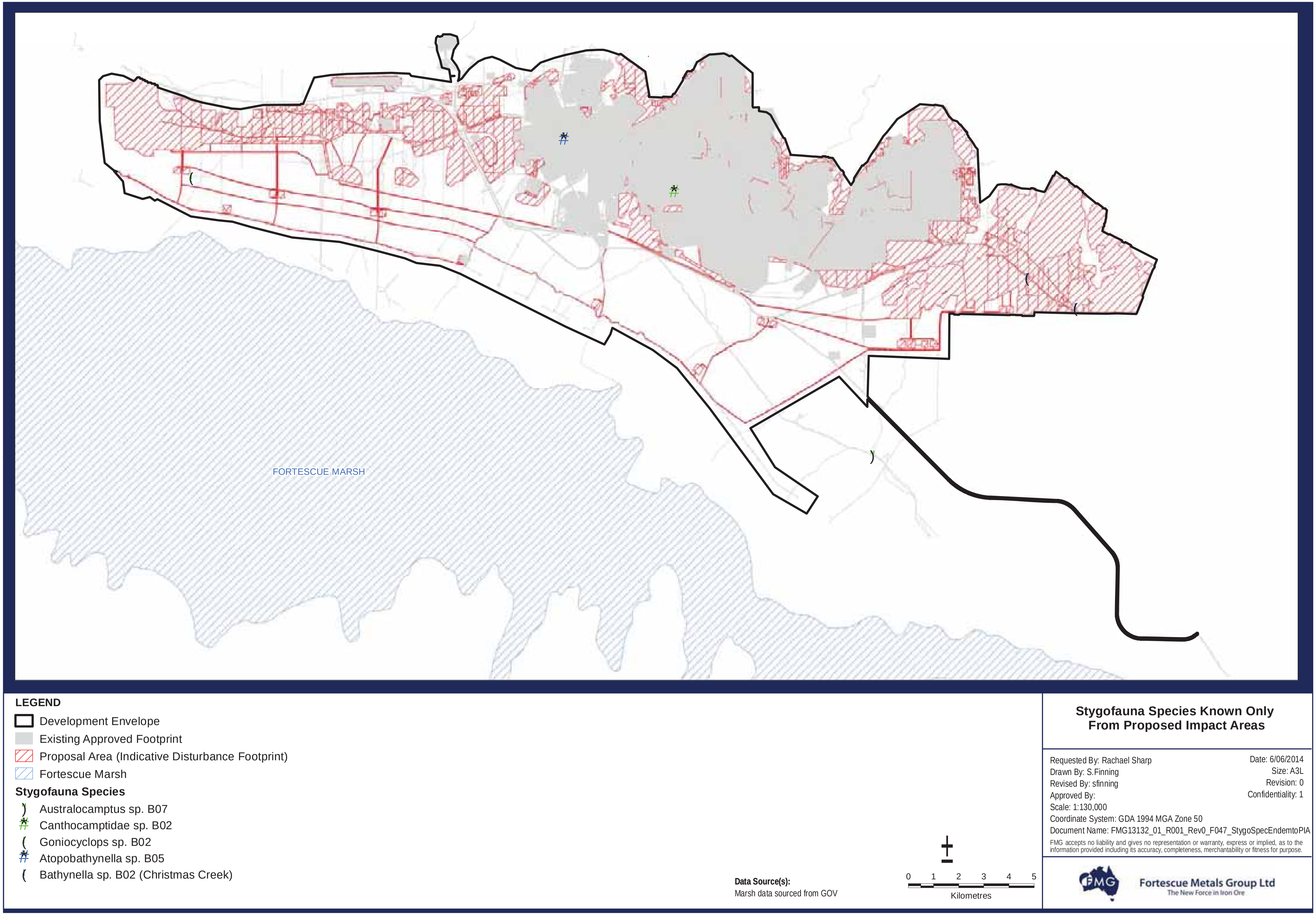

Stygofauna Species Known Only From Proposed Impact Areas

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: sfinning
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F047_StygoSpecEndemtoPIA

Date: 6/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

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Figure 68: Troglofauna Species Known Only From Proposed Impact Areas

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LEGEND

- Development Envelope
- Existing Approved Footprint
- Proposal Area (Indicative Disturbance Footprint)
- Fortescue Marsh

Troglofauna Species

- Anajapygidae sp. B02
- Japygidae sp. B29
- Parajapygidae sp. B24
- Projapygidae sp. B12
- nr Cryptops sp. B15
- Cryptops sp. B32
- Trinemura sp. B18
- Trinemura sp. B19
- Troglarmadillo sp. B30
- Palpigradi sp. B12
- Draculoides sp. B31
- Draculoides sp. B33

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Troglofauna Species Known Only From Proposed Impact Areas

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: sfinning
Approved By:
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F048_TrogoSpecEndemtoPIA

Date: 6/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 69: Potentially Suitable Habitat for Northern Quoll

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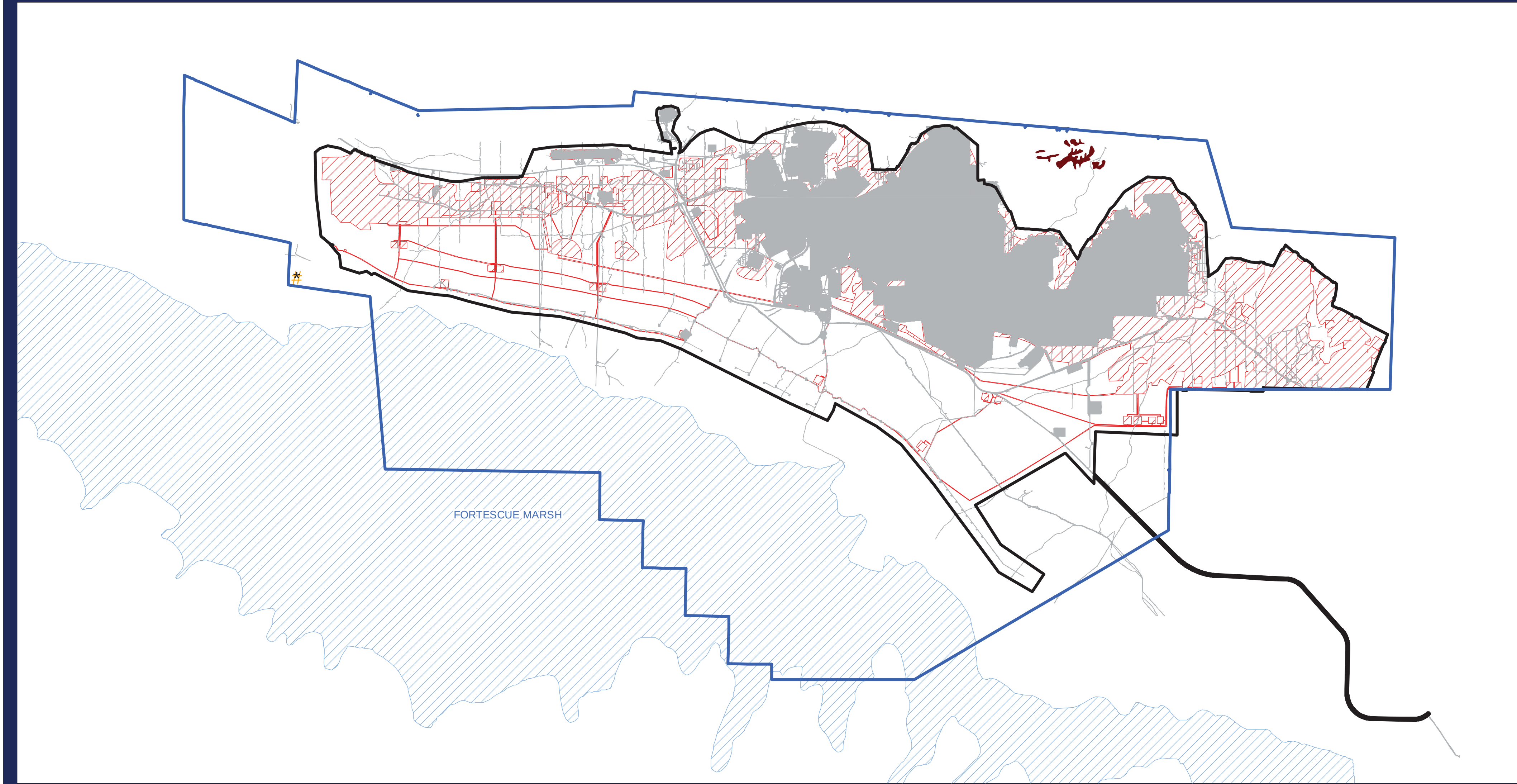

LEGEND

- Development Envelope
- Existing Approved Footprint
- Proposal Area (Indicative Disturbance Footprint)
- Fortescue Marsh
- Rocky Outcrop Habitat
- Habitat Survey Boundary

Recorded locations

- Northern Quoll

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Potentially Suitable Habitat for Northern Quoll

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:150,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F051_HabitatNQuoll

Date: 10/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

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The New Force in Iron Ore

Document Path: Q:\Consult\2013\FMG\FMG13132\ArcMap_documents\R001\Rev0\FMG13132_01_R001_Rev0_F051_HabitatNQuoll.mxd

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Figure 70: Regional Locations: Northern Quoll

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LEGEND

- Recorded Locations
- Towns
- Pilbara Region (based on Land System Mapping)
- Suitable Habitat

Data Source(s):
Marsh data sourced from GOV

0 20 40 60 80 100
Kilometres

Regional Locations: Northern Quoll

Requested By: Rachael Sharp	Date: 8/06/2014
Drawn By: S.Finning	Size: A3L
Revised By: jcrute	Revision: 0
Approved By:	Confidentiality: 1

Scale: 1:2,800,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F052_RegLocNQuoll

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 71: Potentially Suitable Foraging Habitat for Night Parrot

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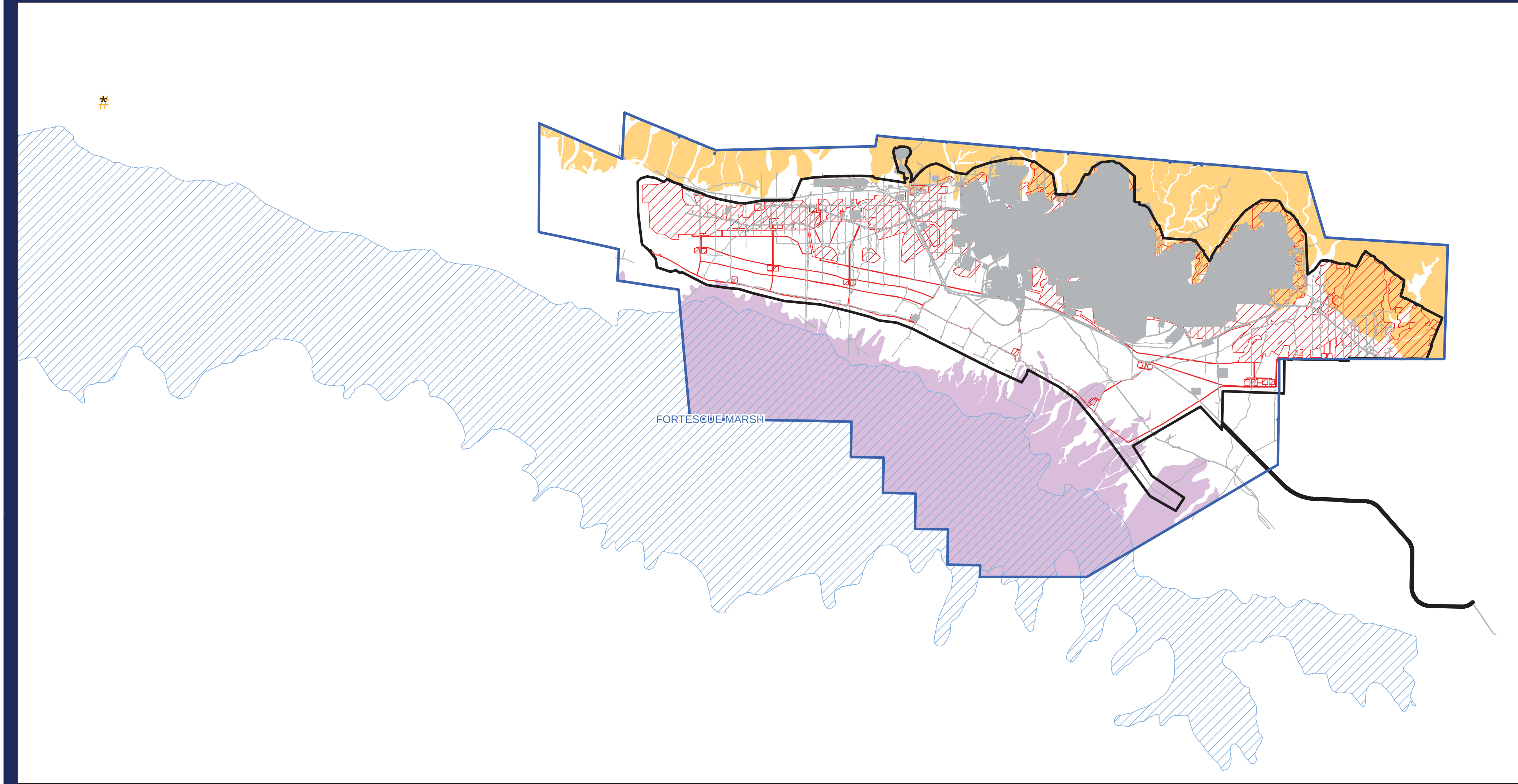

LEGEND

- Development Envelope
- Existing Approved Footprint
- Proposal Area (Indicative Disturbance Footprint)
- Fortescue Marsh
- Low Hill Habitat
- Marsh Habitat
- Habitat Survey Boundary

Recorded Locations

- Night Parrot

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Potentially Suitable Habitat for Night Parrot

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: sfinning
Approved By:
Scale: 1:200,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F049_HabitatNightParrot

Date: 9/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 72: Regional Locations: Night Parrot

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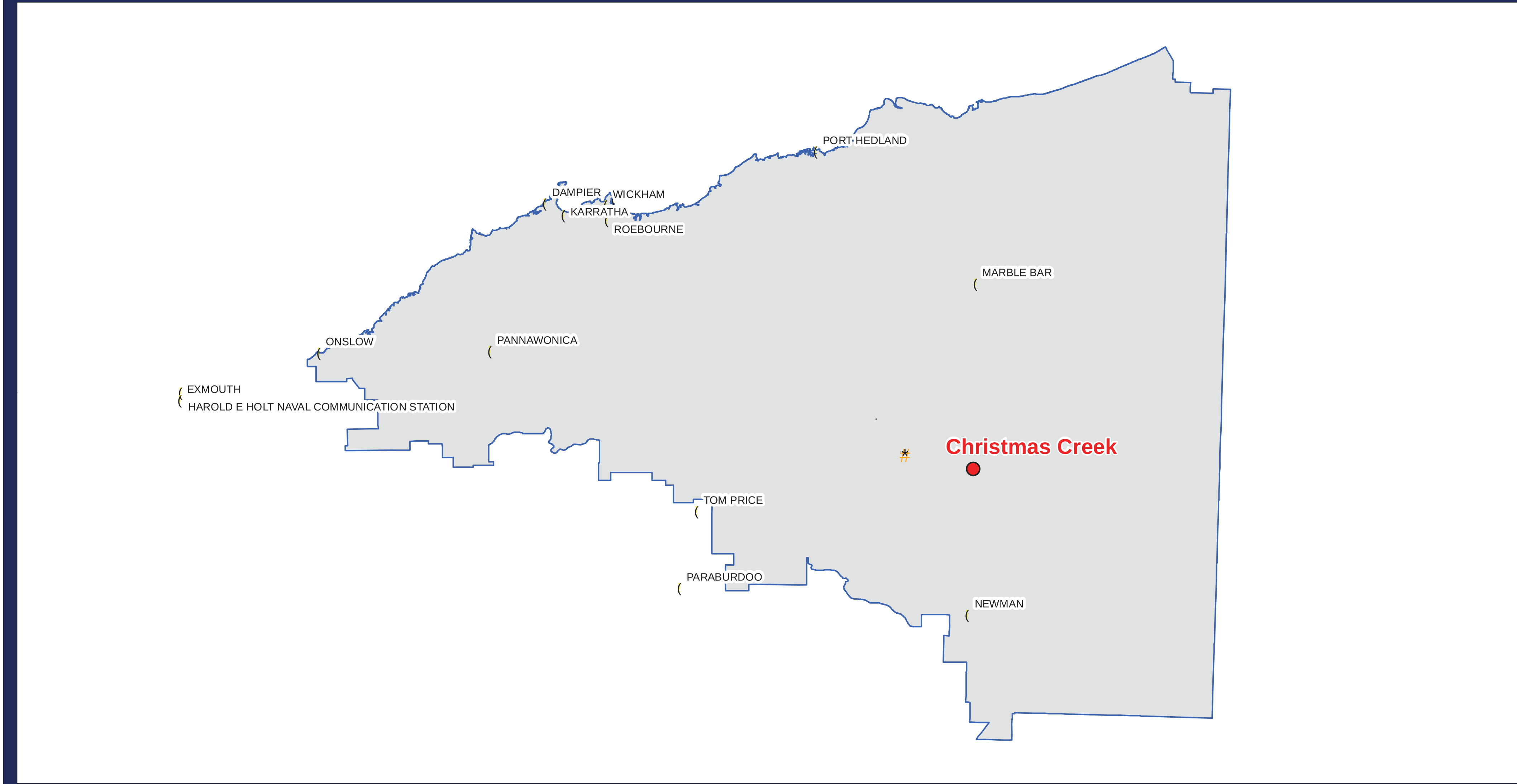

LEGEND

- Recorded Locations
- Towns
- Pilbara Region (based on Land System Mapping)

Data Source(s):
Marsh data sourced from GOV

0 20 40 60 80 100
Kilometres

Regional Locations: Night Parrot

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:2,800,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F050_RegLocNightParrot

Date: 8/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 73: Potentially Suitable Habitat for Australian Painted Snipe

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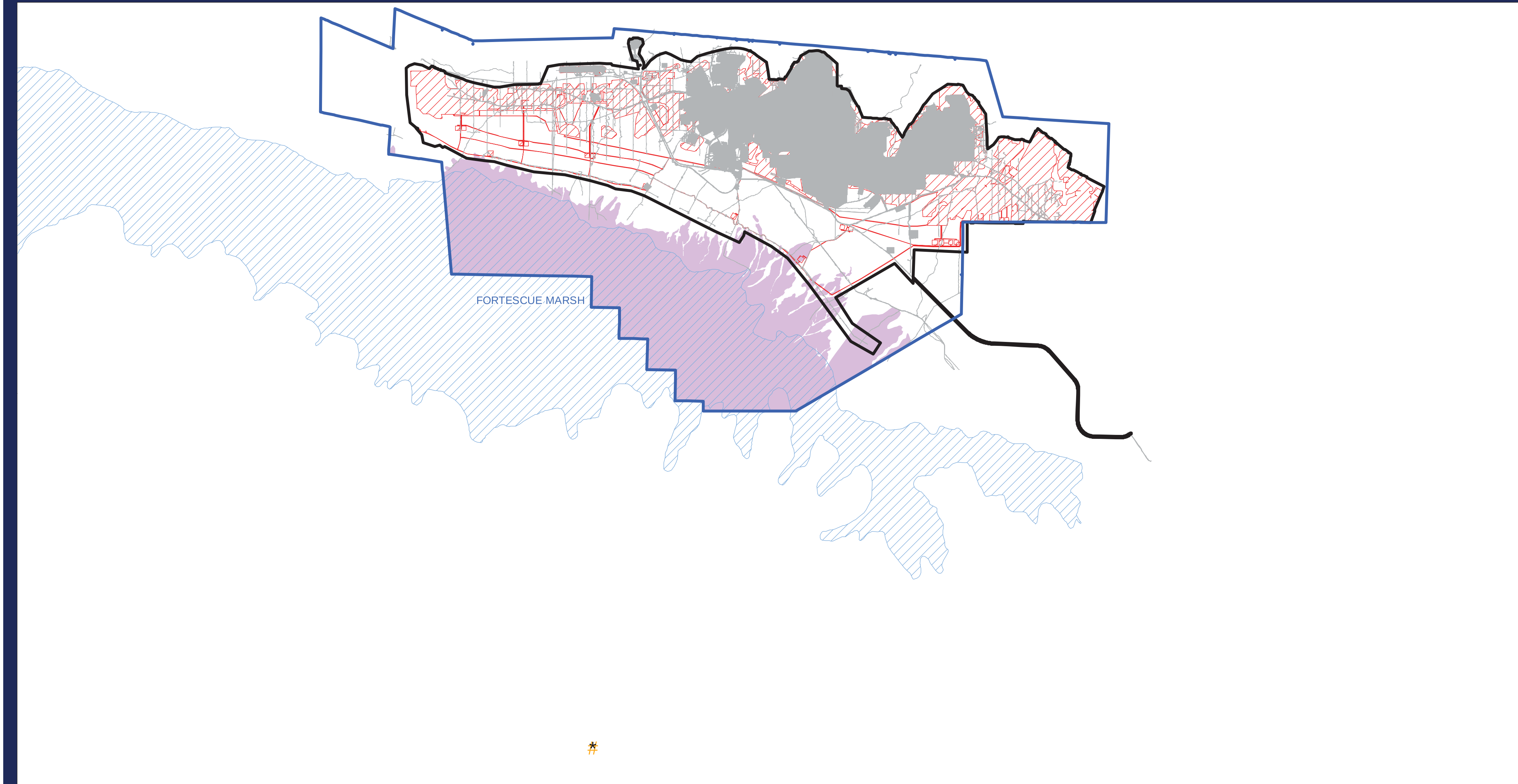

LEGEND

Recorded Locations

- Australian Painted Snipe
- Development Envelope
- Existing Approved Footprint
- Proposal Area (Indicative Disturbance Footprint)
- Fortescue Marsh
- Habitat Survey Boundary
- Marsh Habitat

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Potentially Suitable Foraging Habitat for Australian Painted Snipe

Requested By: Rachael Sharp — Date: 1/07/2014
Drawn By: S.Finning — Size: A3L
Revised By: jcrute — Revision: 0
Approved By: — Confidentiality: 1
Scale: 1:230,453
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F0XX_HabitatPaintedSnipe

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 74: Regional Locations: Australian Painted Snipe

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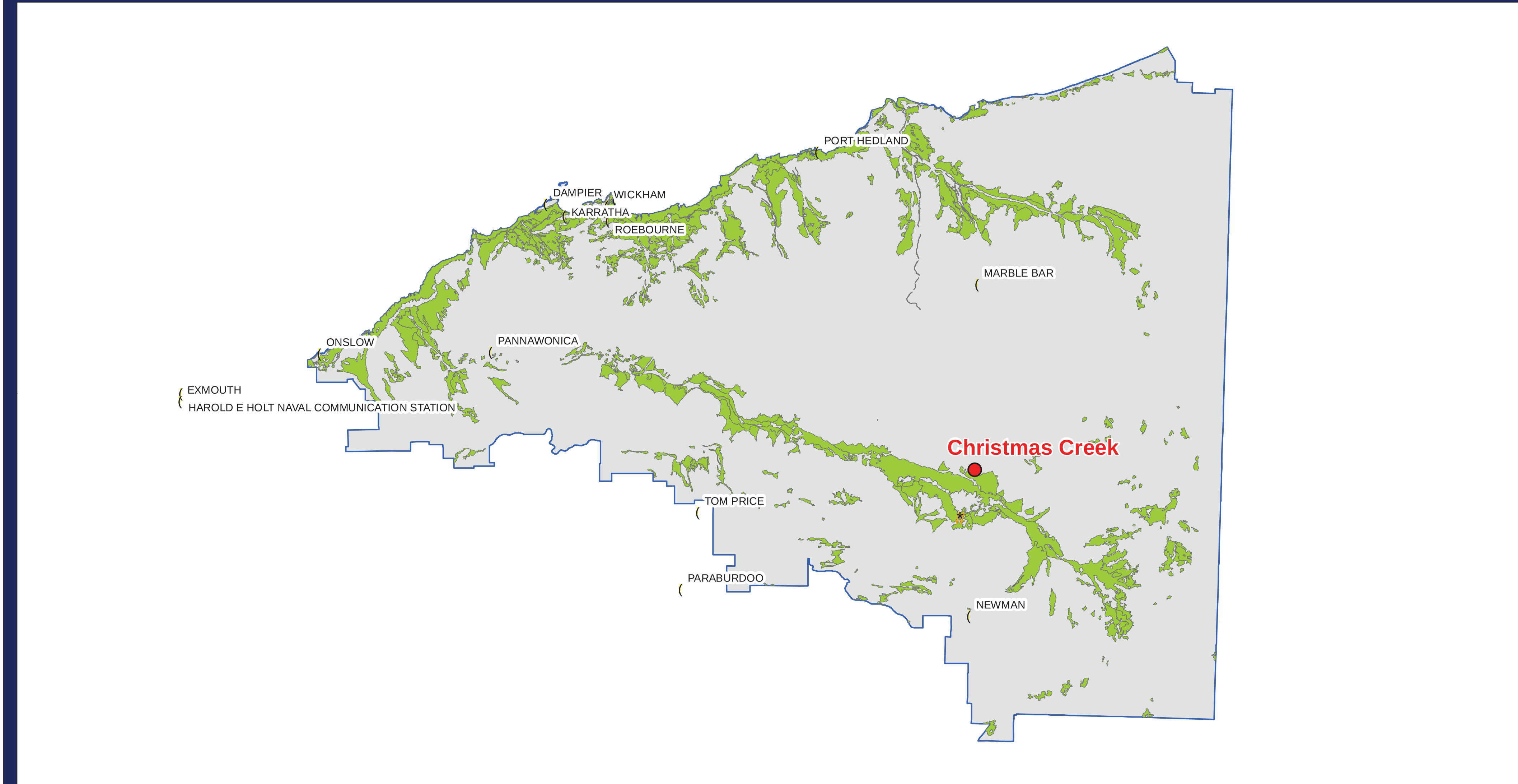

LEGEND

Towns

Recorded Locations

Australian Painted Snipe

Suitable Habitat

Pilbara Region (based on Land System Mapping)

Data Source(s):
Marsh data sourced from GOV

0 20 40 60 80 100
Kilometres

Regional Locations:
Australian Painted Snipe

Requested By: Rachael Sharp — Date: 2/07/2014
Drawn By: S.Finning — Size: A3L
Revised By: jcrute — Revision: 0
Approved By: — Confidentiality: 1
Scale: 1:2,800,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F0XX_RegLocPaintedSnipe

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 75: Potentially Suitable Foraging Habitat for Greater Bilby

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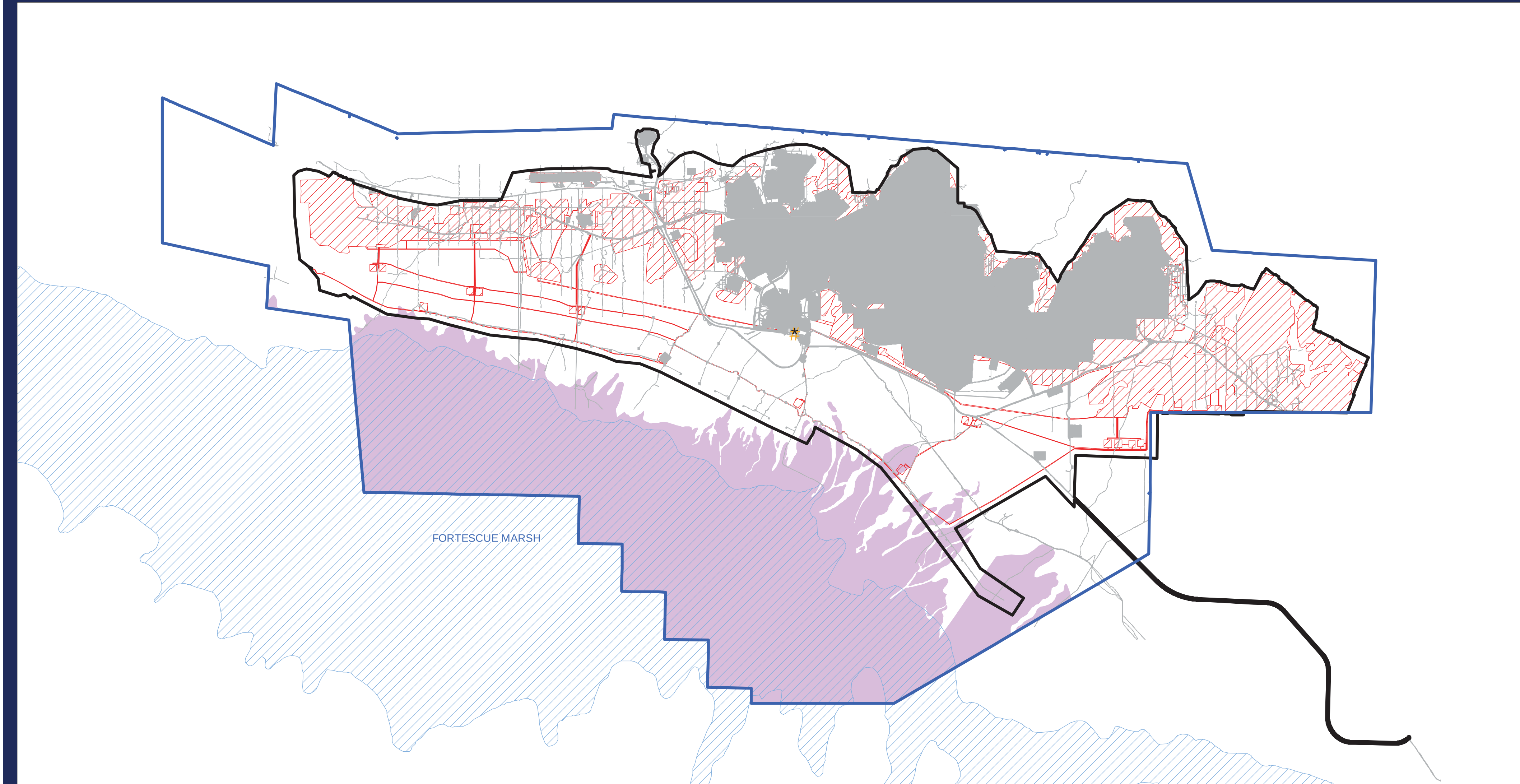

LEGEND

- Development Envelope
- Existing Approved Footprint
- Proposal Area (Indicative Disturbance Footprint)
- Fortescue Marsh
- Habitat Survey Boundary
- Marsh Habitat

Recorded Locations

- Greater Bilby

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Potentially Suitable Foraging Habitat for Greater Bilby

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:150,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F055_HabitatGBilby

Date: 10/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

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The New Force in Iron Ore

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Figure 76: Regional Locations: Greater Bilby

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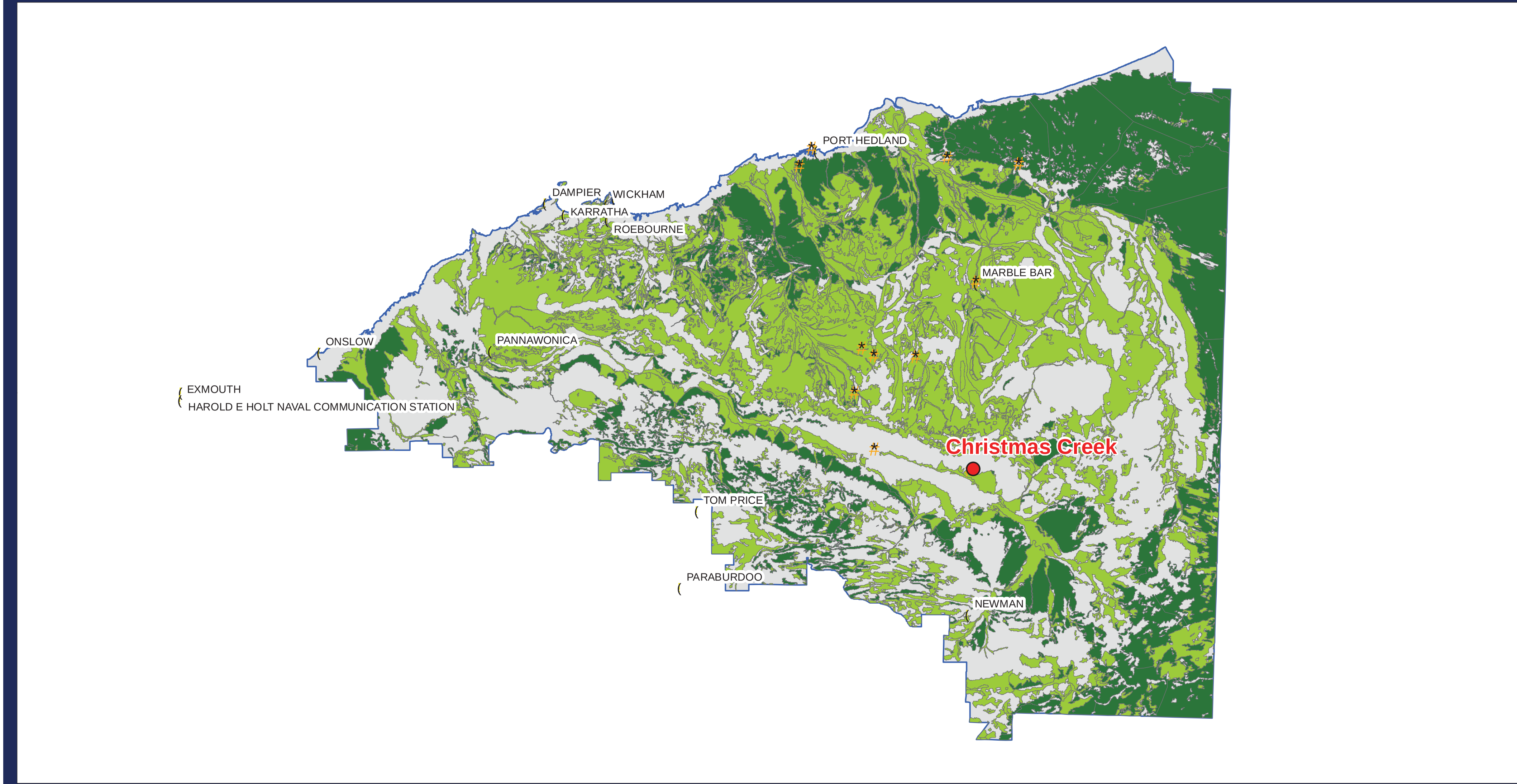

LEGEND

- Recorded Locations
- Towns
- Pilbara Region (based on Land System Mapping)
- Moderately Suitable Habitat
- Very Suitable Habitat

Data Source(s):
Marsh data sourced from GOV

0 20 40 60 80 100
Kilometres

Regional Locations: Greater Bilby

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:2,800,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F056_RegLocGBilby

Date: 8/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

Document Path: Q:\Consult\2013\FMG\FMG13132\ArcMap_documents\R001\Rev0\FMG13132_01_R001_Rev0_F056_RegLocGBilby.mxd

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Figure 77: Potentially Suitable Foraging Habitat for Pilbara Olive Python

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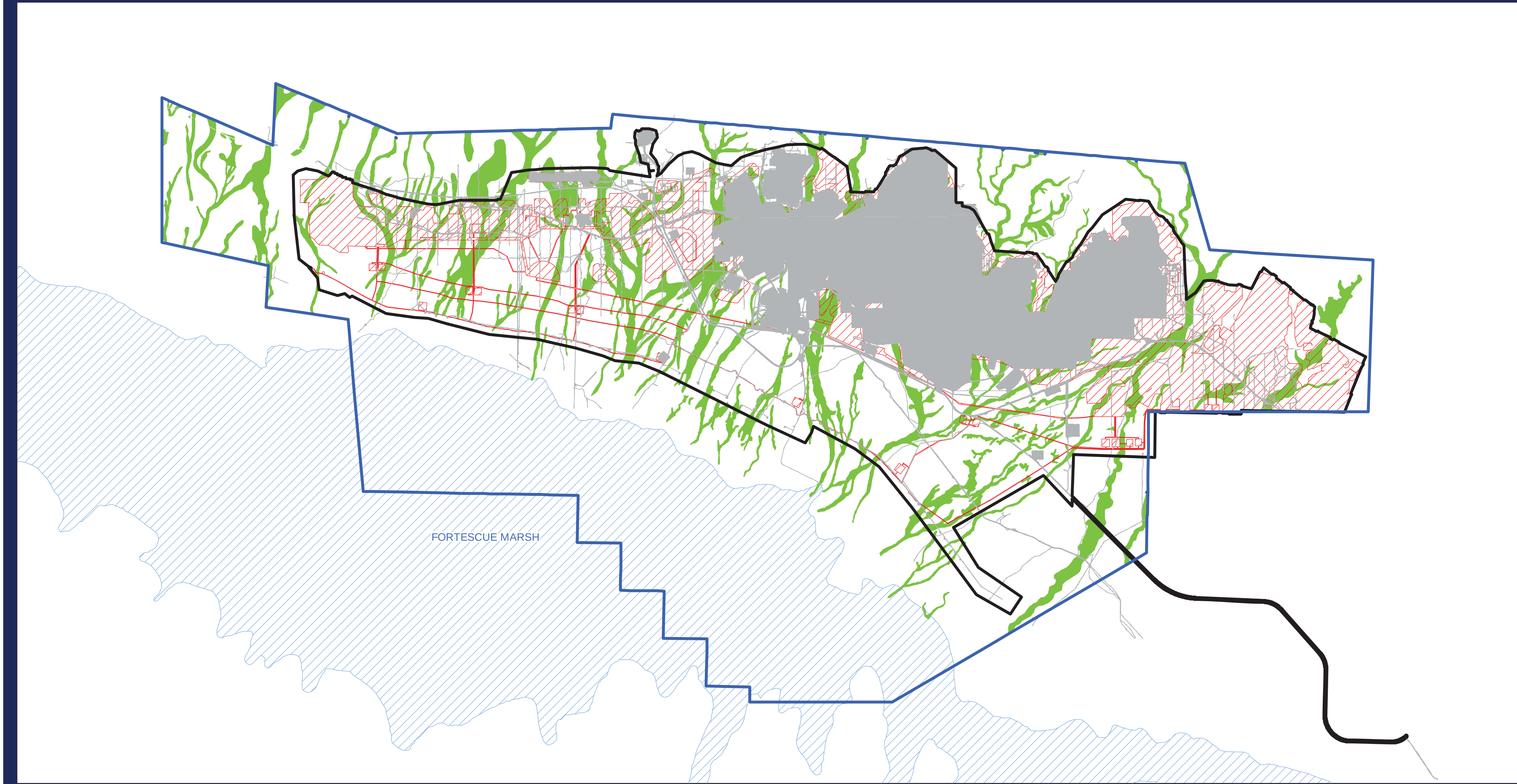

LEGEND

- Development Envelope
- Existing Approved Footprint
- Proposal Area (Indicative Disturbance Footprint)
- Fortescue Marsh
- Habitat Survey Boundary
- Drainage Line and Surrounding Alluvial Plain Habitat

Data Source(s):
Marsh data sourced from GOV

Potentially Suitable Foraging Habitat for Pilbara Olive Python

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:150,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F057_HabitatOPython

Date: 10/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

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The New Force in Iron Ore

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Figure 78: Regional Locations: Pilbara Olive Python

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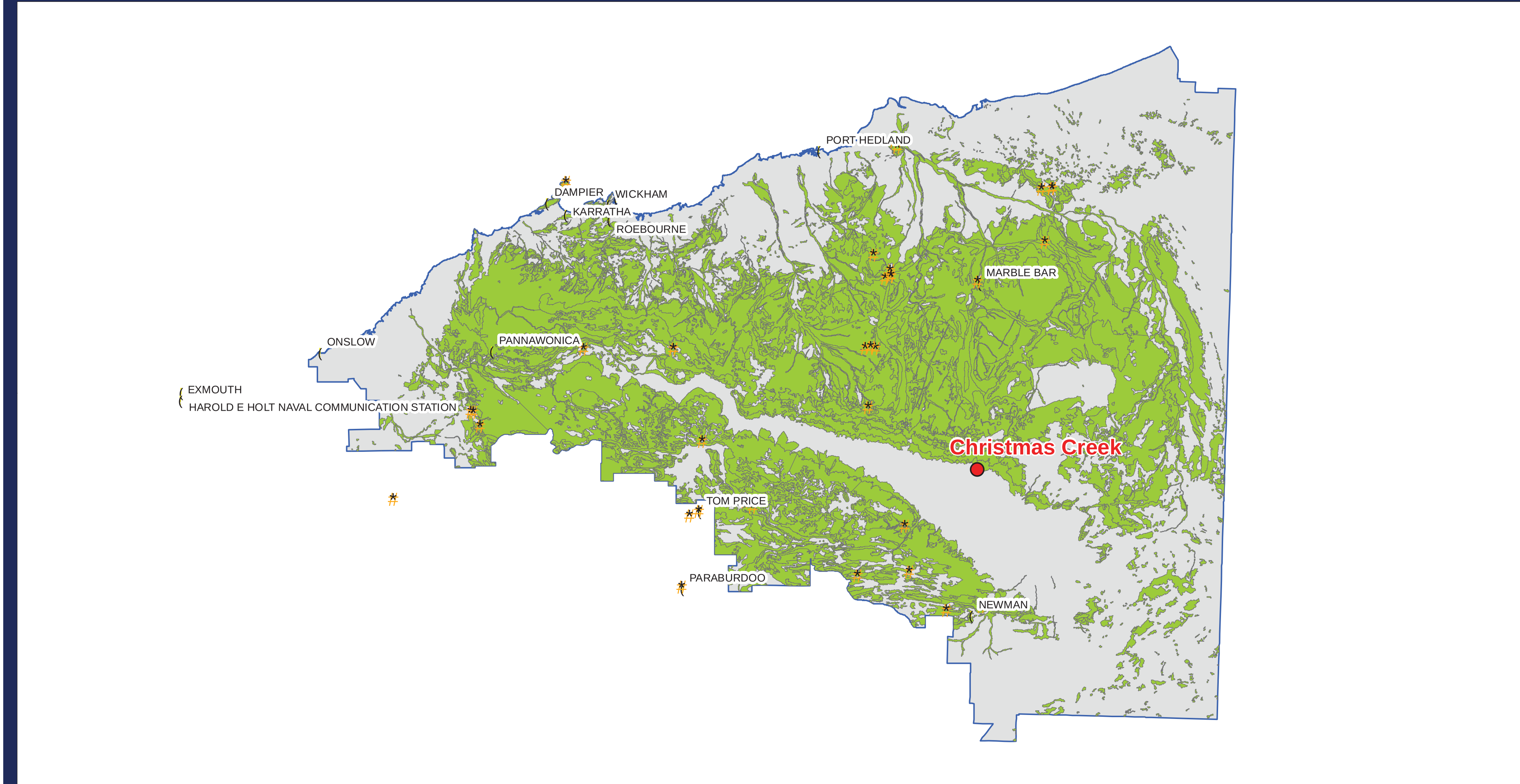

LEGEND

- Recorded Locations
- Towns
- Pilbara Region (based on Land System Mapping)
- Suitable Habitat

Data Source(s):
Marsh data sourced from GOV

0 20 40 60 80 100
Kilometres

Regional Locations: Pilbara Olive Python

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:2,800,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F058_RegLocOPython

Date: 8/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 79: Potentially Suitable Foraging Habitat for Pilbara Leaf-nosed Bat

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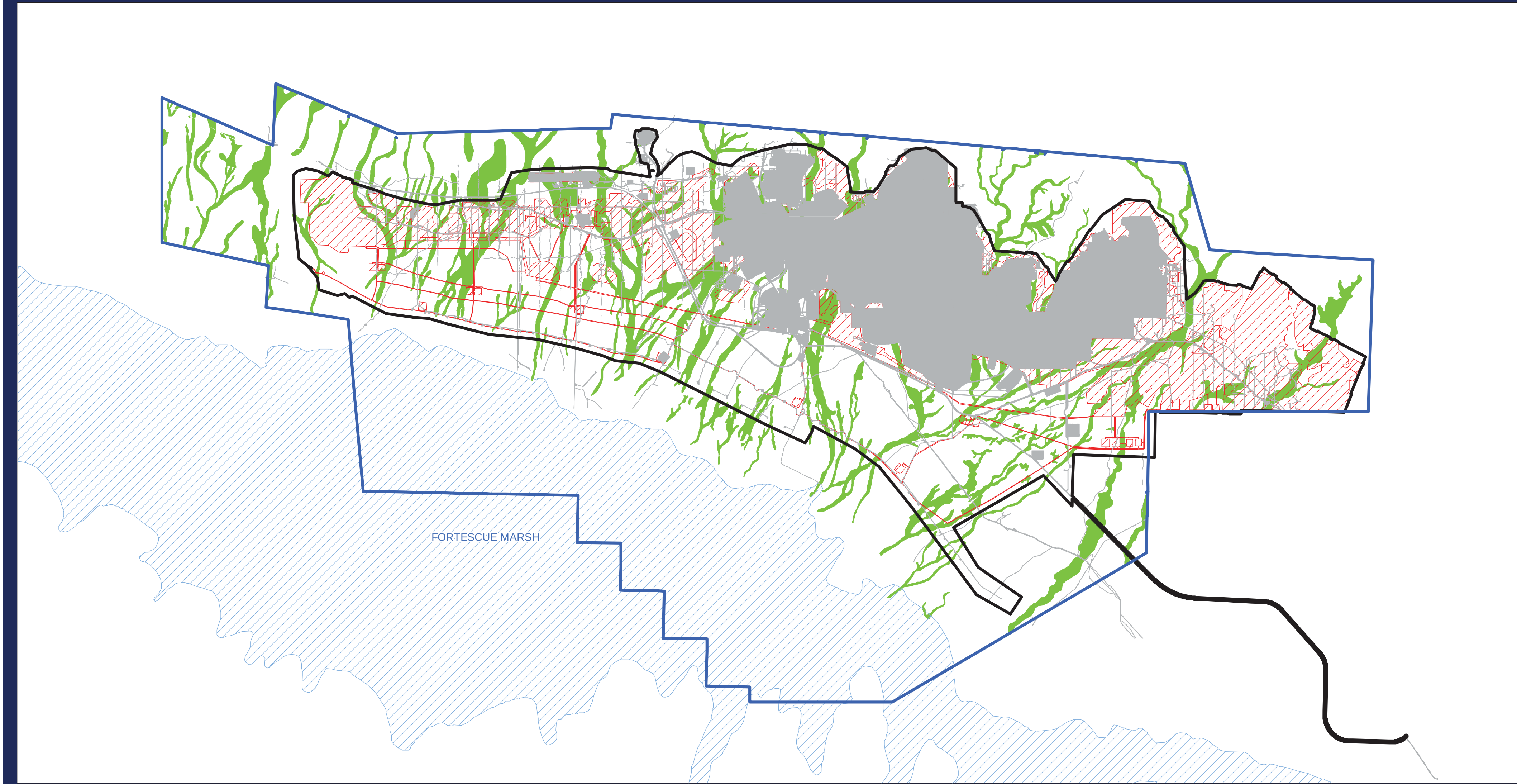

LEGEND

- Development Envelope
- Existing Approved Footprint
- Proposal Area (Indicative Disturbance Footprint)
- Fortescue Marsh
- Habitat Survey Boundary
- Drainage Line and Surrounding Alluvial Plain Habitat

Data Source(s):
Marsh data sourced from GOV

0 1 2 3 4 5
Kilometres

Potentially Suitable Foraging Habitat for Pilbara Leaf-nosed Bat

Requested By: Rachael Sharp — Date: 10/06/2014
Drawn By: S.Finning — Size: A3L
Revised By: jcrute — Revision: 0
Approved By: — Confidentiality: 1
Scale: 1:150,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F059_HabitatBat

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Figure 80: Regional Locations: Pilbara Leaf-nosed Bat

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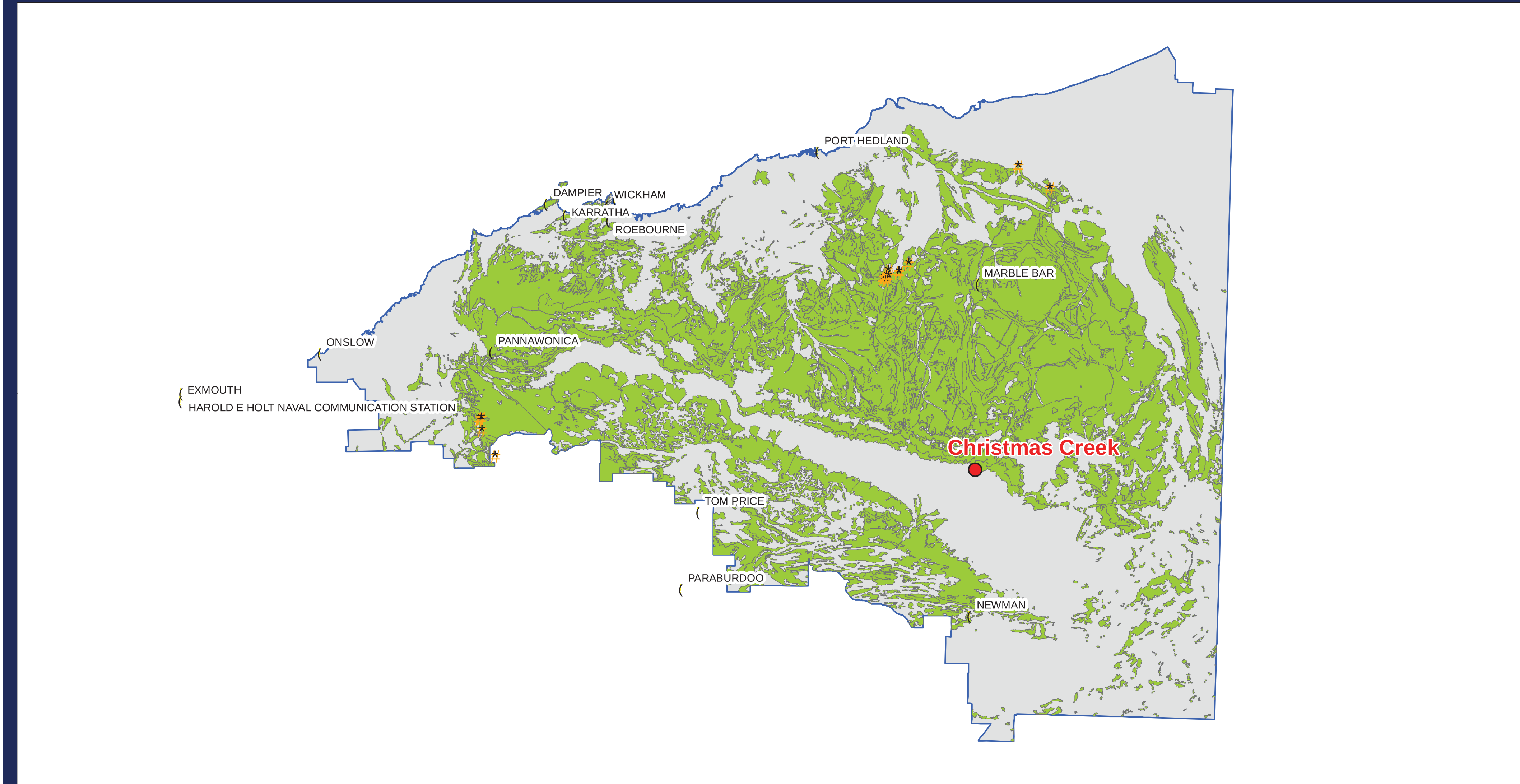

LEGEND

- Recorded Locations
- Towns
- Pilbara Region (based on Land System Mapping)
- Suitable Habitat

Data Source(s):
Marsh data sourced from GOV

0 20 40 60 80 100
Kilometres

Regional Locations: Pilbara Leaf-nosed Bat

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:2,800,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F060_RegLocBat

Date: 8/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

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The New Force in Iron Ore

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Figure 81: Recordings in the Pilbara: Rainbow Bee-eater

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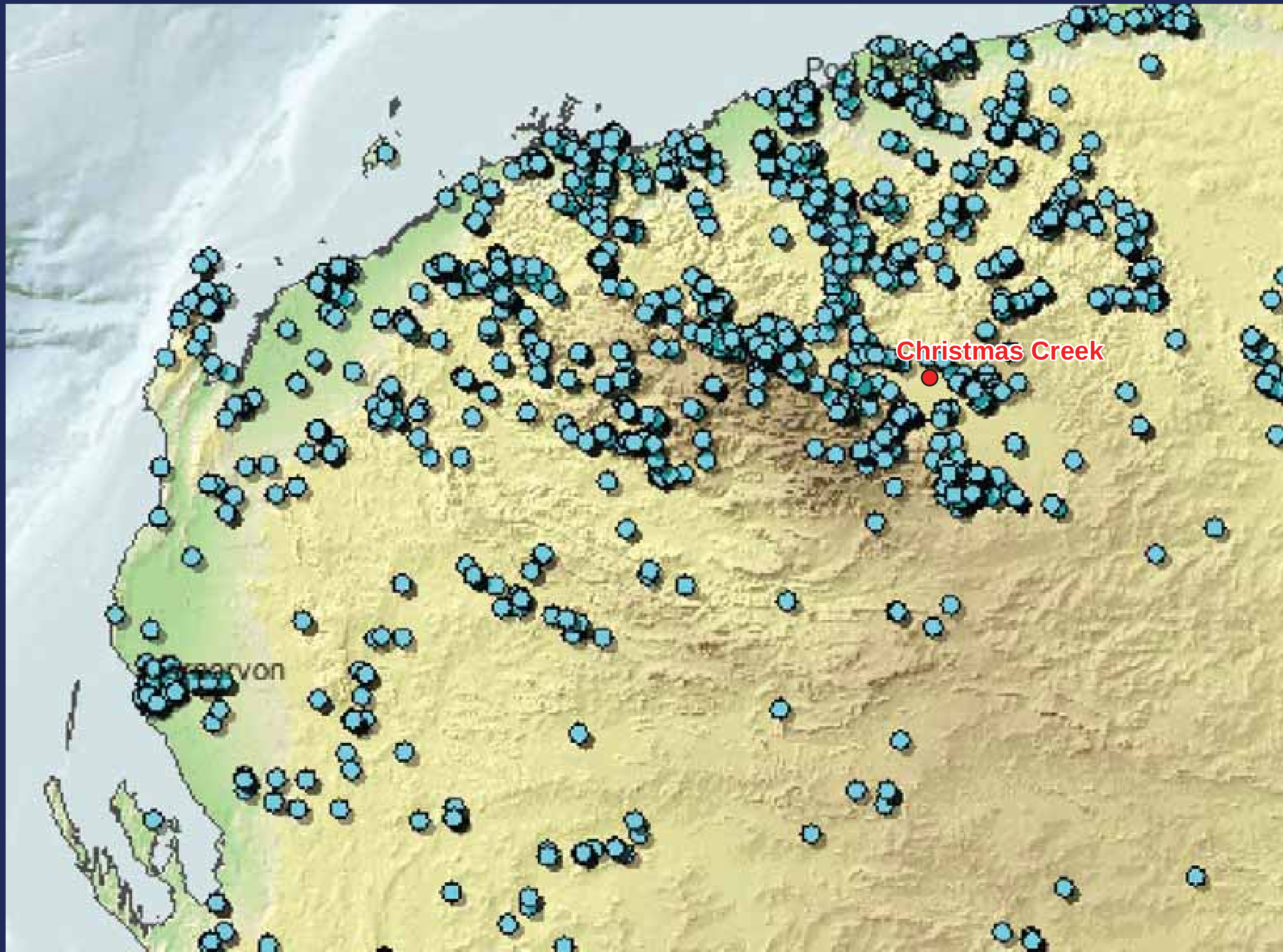

LEGEND

Recordings of Rainbow Bee-eater

Data Source(s):
Nature Map 2014.

0 20 40 60 80 100
Kilometres

Recordings in the Pilbara: Rainbow Bee-eater

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:2,800,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F061_RainbowBeaEater

Date: 8/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

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The New Force in Iron Ore

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Figure 82: Recordings in the Pilbara: Cattle Egret

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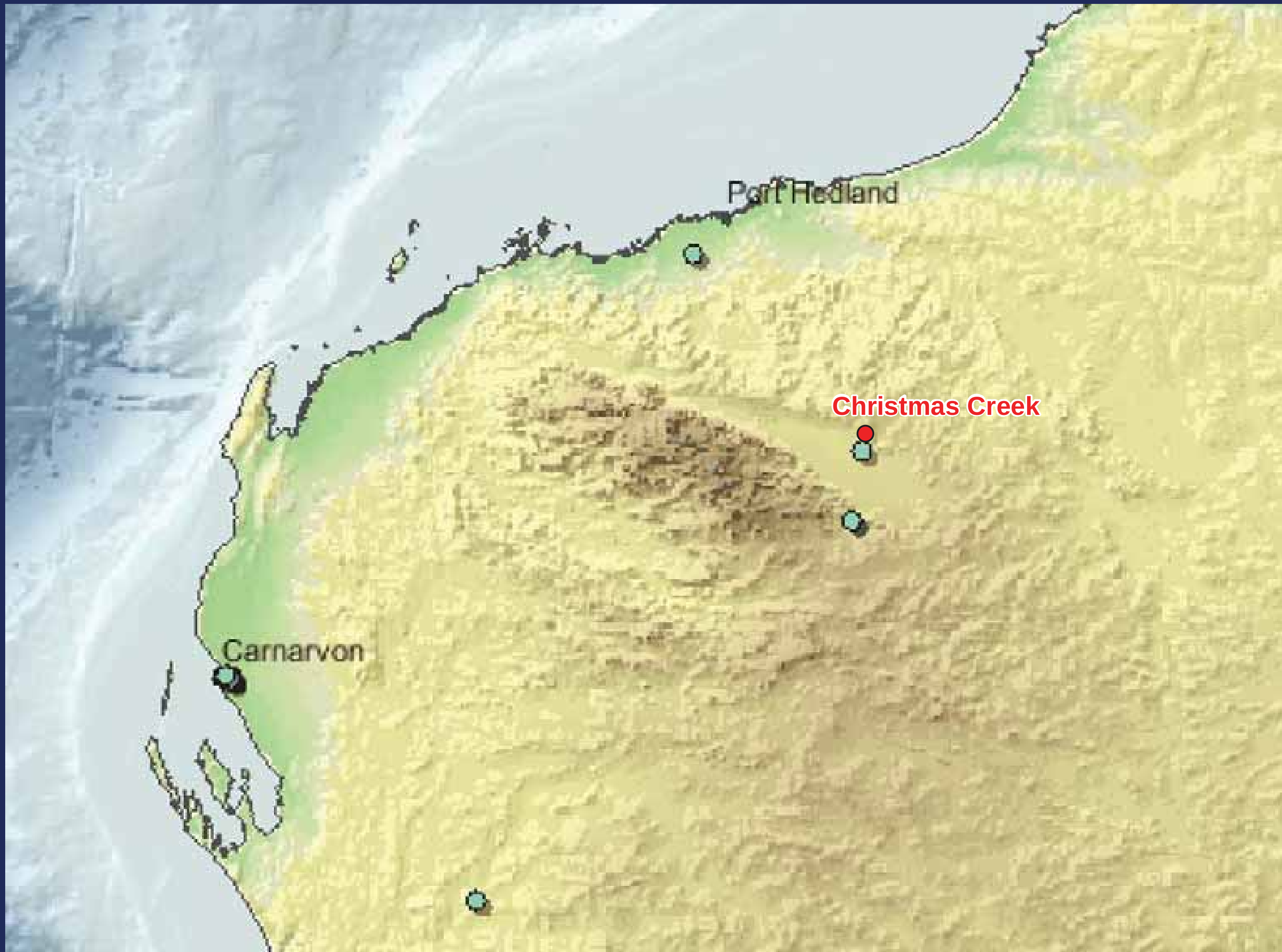

LEGEND

Recordings of Cattle Egret

Data Source(s):
Nature Map 2014.

0 20 40 60 80 100
Kilometres

Recordings in the Pilbara: Cattle Egret

Requested By: Rachael Sharp
Date: 8/06/2014
Drawn By: S.Finning
Size: A3L
Revised By: jcrute
Revision: 0
Approved By:
Confidentiality: 1
Scale: 1:2,800,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F062_CattleEgret

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Figure 83: Recordings in the Pilbara: Oriental Plover

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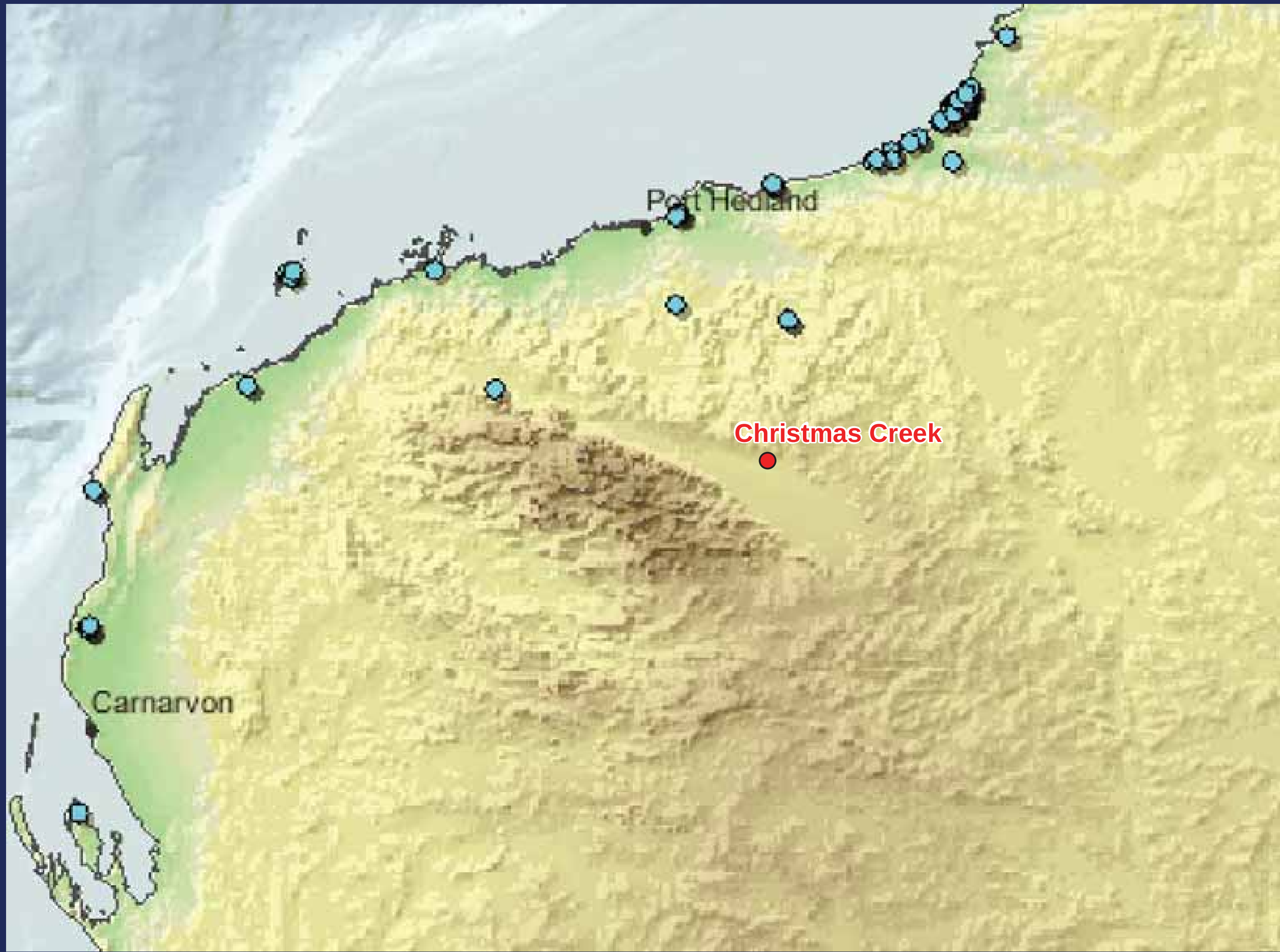

LEGEND

Recordings of Oriental Plover

Data Source(s):
Nature Map 2014.

0 20 40 60 80 100
Kilometres

Recordings in the Pilbara: Oriental Plover

Requested By: Rachael Sharp — Date: 8/06/2014
Drawn By: S.Finning — Size: A3L
Revised By: jcrute — Revision: 0
Approved By: — Confidentiality: 1
Scale: 1:2,800,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F063_Plover

Fortescue Metals Group Ltd
The New Force in Iron Ore

Document Path: Q:\Consult\2013\FMG\FMG13132\ArcMap_documents\R001\Rev0\FMG13132_01_R001_Rev0_F063_Plover.mxd

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Figure 84: Recordings in the Pilbara: White-bellied Sea Eagle

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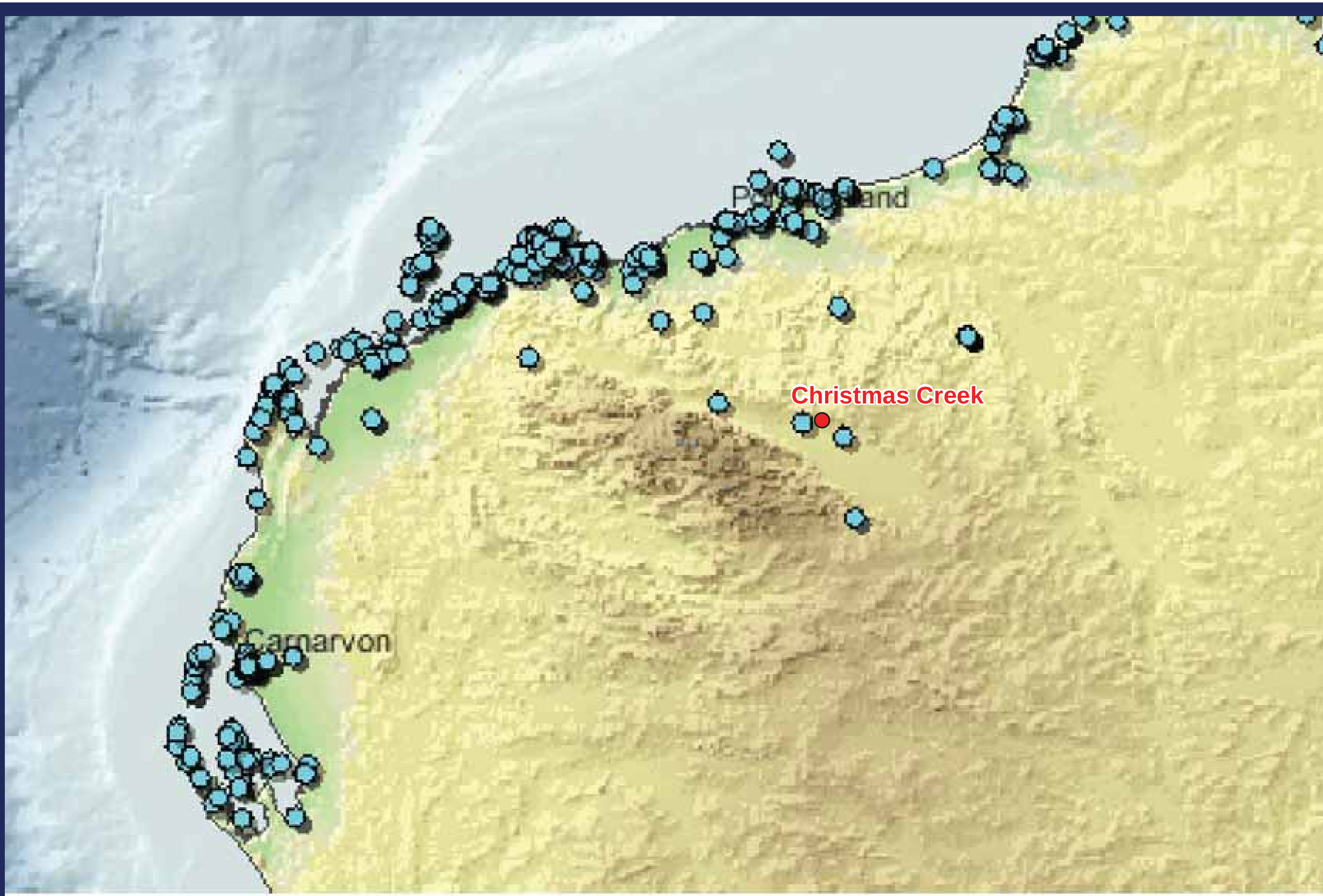

LEGEND

Recordings of White-bellied Sea Eagle

Data Source(s):
Nature Map 2014.

0 20 40 60 80 100
Kilometres

Recordings in the Pilbara: White-bellied Sea Eagle

Requested By: Rachael Sharp
Drawn By: S.Finning
Revised By: jcrute
Approved By:
Scale: 1:2,800,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: FMG13132_01_R001_Rev0_F064_WhiteBelliedEagle

Date: 8/06/2014
Size: A3L
Revision: 0
Confidentiality: 1

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Figure 85: Environmental Offsets

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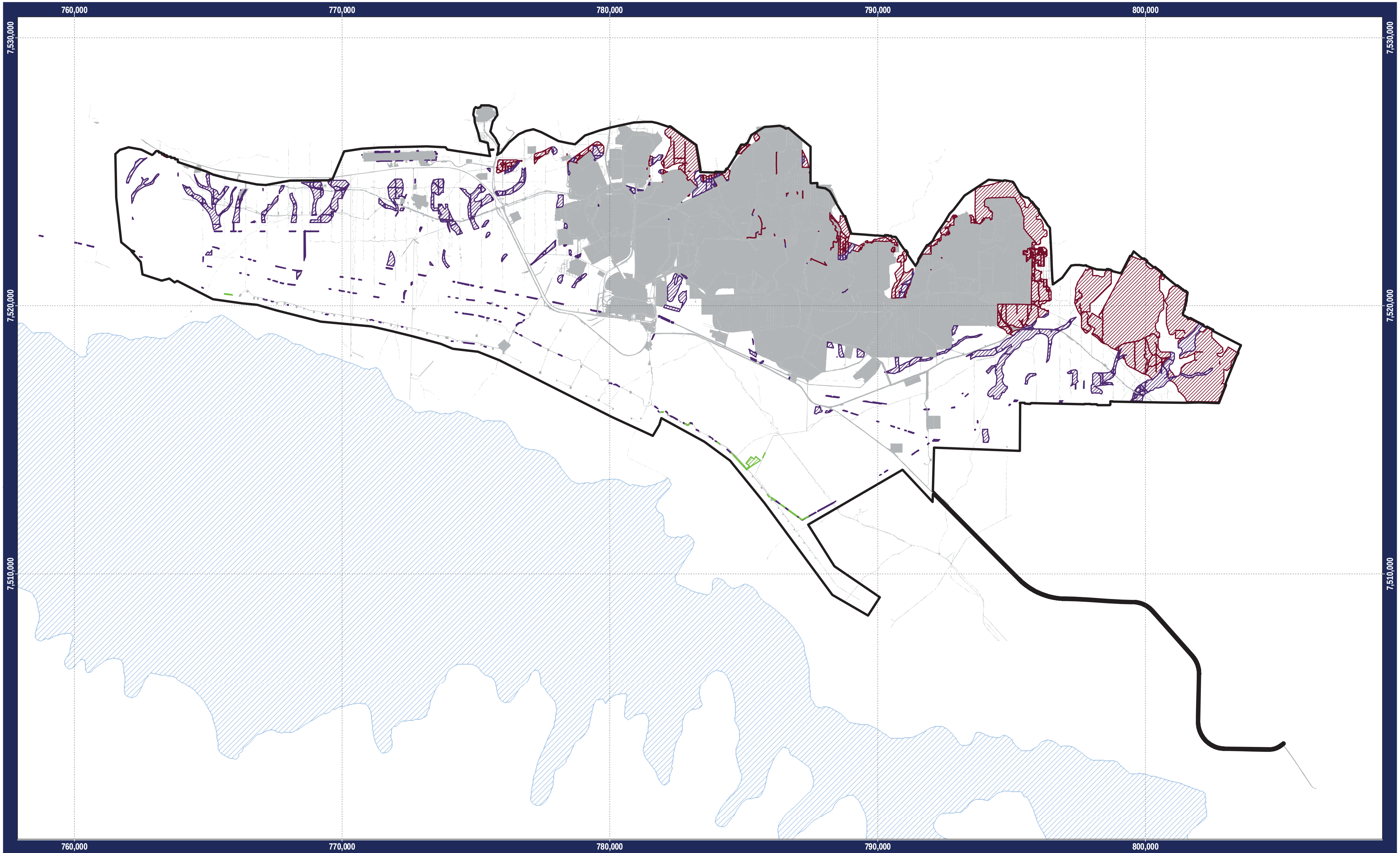

Marsh Habitat
Drainage Line and Surroundin Alluvial Plan
Low Hill Habitat
Development Envelope
Indicative Approved Footprint
Fortescue Marsh

0 1 2 3 4 5
Kilometres

Data Source(s):
Fortescue Marsh: DIWA

Requested By: Rachel Sharp
Drawn By: C Whyte
Revised By: rmaconachie
Approved By: Bridget Ralebala
Scale: 1:130,000
Coordinate System: GDA 1994 MGA Zone 50
Document Name: CC_MP_EN_0240.003_r1

Date: 13/02/2015
Size: A3L
Revision: 1
Confidentiality: 1

Environmental Offsets

Fortescue Metals Group Ltd
The New Force in Iron Ore

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Appendices

Provided on CD

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Appendix 1: Christmas Creek Iron Ore Mine Expansion Proposal: Environmental Scoping Document

Appendix 2: Environmental Management Plans

Appendix 2A: Stakeholder Consultation Reinjection Management Plan CC-PL-EN-0006

Appendix 2B: Surface Water Management Plan 100-PL-EN-1015

Appendix 2C: Groundwater Management Plan 100-PL-EN-0029

Appendix 2D: Chemical and Hydrocarbon Management Plan 100-PL-EN-0011

Appendix 2E: Fortescue Marsh Hydrology and Vegetation Monitoring and Management Plan 100-PL-EN-1013

Appendix 2F: Draft Acid and/or Metalliferous Drainage Management Plan 100-PL-EN-1016

Appendix 2G: Christmas Creek Vegetation Health Monitoring and Management Plan CC-PL-EN-0004

Appendix 2H: Conservation Significant Fauna Management Plan 100-PL-EN-0022

Appendix 3: Geochemical Assessments

Appendix 3A: Preliminary Report: Geochemical Assessment of Waste Material – Christmas Creek Mine URS 2014

Appendix 3B: Christmas Creek Preliminary Waste Rock Characterisation of Vasse WRD and Eyre Pit Tetra Tech 2013

Appendix 3C: Christmas Creek Windich Waste Rock and Tailings Assessment Golder 2013

Appendix 4: Flinders in Pit TSF Groundwater Impact Assessment SRK 2014

Appendix 5: Hydrological Assessments

Appendix 5A: Hydrogeological Assessment of the Christmas Creek Life of Mine Water Management Scheme CC-RP-HY-0017

Appendix 5B: Comments from Peer Review – Christmas Creek LOM HydroConcept 2014

Appendix 5C: Christmas Creek Groundwater Operating Strategy CC-PH-HY-0002

Appendix 5D: Christmas Creek Triennial Aquifer Review: August 2013 to July 2013 CC-RP-HY-0039

Appendix 5E: Fortescue Marsh: Synthesis of Eco-hydrological Knowledge Equinox 2013

Appendix 5F: Modelling Analysis of the Impact of Mine Dewatering on Soil Water Availability to the Samphire Vegetation on the Fringe of the Fortescue Marsh

Appendix 5G: Christmas Creek Life of Mine Expansion Surface Water Investigation and Impact Assessment Worley Parsons 2014

Appendix 5H: Peer Review of Samphire Water Use Modelling (UWA 2014)

Appendix 6: Vegetation and Flora Assessments

Appendix 6A: Christmas Creek Life of Mine Flora and Vegetation Assessment ENV 2013a

Appendix 6B: Vegetation Health Monitoring and Management Plan – Annual Report, December 2013 CC-RP-EN-0058

Appendix 7: Fauna Assessments

Appendix 7A: Christmas Creek Terrestrial Vertebrate Fauna and Fauna Habitat Assessment ENV 2012a

Appendix 7B: Christmas Creek Life of Mine project terrestrial SRE invertebrate survey Subterranean Ecology 2012

Appendix 7C: Christmas Creek Short-range Endemic invertebrate survey report: Fortescue Marsh Samphire Biologic 2012

Appendix 7D: Christmas Creek Expansion Project, subterranean Fauna Assessment Bennelongia 2014

Appendix 7E: Christmas Creek Water Management Scheme Conservation Significant Fauna baseline monitoring Ecologia 2013

Appendix 7F: Christmas Creek Water Management Scheme Northern Quoll Annual Monitoring Report 2014 Ecologia 2014a

Appendix 7G: Christmas Creek Water Management Scheme Pilbara Olive Python Annual Monitoring Report 2014 Ecologia 2014b

Appendix 8: Mine Closure and Rehabilitation Assessments

Appendix 8A: Desktop Assessment of Rehabilitation Strategies in the Pilbara

Appendix 8B: Planning for Closure: Design of Mineral Waste Rock Landforms 100-PR-EN-1017 (CONFIDENTIAL)

Appendix 8C: Re-establishing Major Watercourses over Backfilled Pits CH-GU-EN-0002 (CONFIDENTIAL)

Appendix 8D: Case Study: Re-establishing Major Watercourses over Backfilled Pits CH-GU-EN-0003 (CONFIDENTIAL)

Appendix 8E: Mine Closure Plan

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