



Report and recommendations of the Environmental Protection Authority



Environmental and water assessments relating to mining and mining-related activities in the Fortescue Marsh management area

Advice of the Environmental Protection Authority to
the Minister for Environment under Section 16(e) of the
Environmental Protection Act 1986

Report 1484

July 2013

This advice is provided to the Minister for Environment by the Environmental Protection Authority under section 16(e) of the *Environmental Protection Act 1986*. The content of the advice is not statutory in nature, but provides guidance and information to assist the Minister and other decision-making authorities so that decisions are complementary and coordinated.

The advice will be subject to periodic review by the Environmental Protection Authority.

Foreword

The Fortescue Marsh, approximately 100 kilometres (km) north-west of Newman, is the largest ephemeral wetland in the Pilbara region and is recognised as nationally important.

The Marsh itself extends over approximately 1,048 square kilometres (km²) within a management area of 5,836 km², and a broader catchment area of the upper Fortescue River of 29,791 km².

It is rich in plant and animal species of high conservation value and is part of an ancient and complex array of alluvial aquifers and groundwater systems.

It is also at the heart of an important mining province and longstanding pastoral industry, and has high cultural and heritage importance to the Indigenous peoples of the region.

Like many areas of our vast State, there is incomplete information on its ecological and hydrological function. Much of what is known about the hydrology of the Marsh has been developed through studies undertaken by mining proponents, to support the environmental assessment of individual proposals. Through continuing research efforts by State agencies, academic institutions, and by industry, a clearer picture will emerge in due course.

For its part, the Environmental Protection Authority is charged with protecting the environment and preventing, controlling and abating pollution and environmental harm. Our functions include providing strategic advice to Government, and assessing the environmental impact of significant development proposals and making recommendations to the Minister as to whether they can be implemented.

This advice, provided under section 16(e) of the *Environmental Protection Act 1986*, aims to provide clarity and consistency in relation to environmental assessment and approvals process by identifying the water and environmental values in different zones and their relative priority.

It is intended that this will help proponents and regulators avoid impacts on the important values of the Marsh. The EPA recognises that mining proponents in the area have adopted practices to protect the environmental values of the Marsh, such as reinjection of excess water to minimise the impacts to groundwater dependent ecosystems and the discharge of excess surface water to the Marsh. Similarly, proponents of new projects, expansions or upgrades should clearly outline their strategies for avoiding impacts and achieving the relevant objectives for each zone where their operations have potential to impact water or environmental values.

I emphasise that this advice is just that. It does not suspend the exercise of judgement, preclude learning from experience, or prevent consideration of new information as our understanding of the Marsh and its functions improves.

In this vein, the EPA is actively considering ways to collate and share information and data between proponents and regulatory agencies so that, over time, knowledge of the Fortescue Marsh management area will improve, and adaptive management improvements can be made to ensure that environmental values are well protected.

The broader Fortescue River catchment is very large and falls outside the scope of this advice. Proponents who undertake mining activities beyond the management area should refer to the advice where activities either directly or indirectly impact the Fortescue Marsh management area.

The EPA recognises that cultural, heritage, industry, tourism, recreational and pastoral values are important in the Fortescue Marsh management area. The EPA also recognises that other, non-mining related land uses and events may affect water and environmental values in the Fortescue Marsh management area. However, these values and activities are beyond the scope of this advice and will be addressed through other processes of Government.

This advice would not have been completed without the cooperation and significant contributions of the Office of the Environmental Protection Authority, the Department of Water, the Department of Environment and Conservation and the Department of State Development as well as the traditional owners, mining companies, industry peak bodies, academics and Government departments who were consulted in its development.

A handwritten signature in blue ink, appearing to read 'P. Vogel', with a long horizontal line extending to the right.

Dr Paul Vogel
Chairman
Environmental Protection Authority

June 2013

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Summary of Fortescue Marsh management zones: values, objectives and strategies

The table below provides a summary of the key environmental values, objectives and strategies identified by the Fortescue Marsh Strategic Advice. The Fortescue Marsh management area is zoned according to key environmental values. These zones are prioritised according to relative environmental significance: zone 1a (Northern Flank) and zone 1b (Marsh) being of highest environmental significance; zone 2a (Calcrete Flats), zone 2b (Poonda Plain) and zone 2c (Fortescue River Coolibah) being of medium environmental significance; and zone 3a (Kulbee Alluvial Flank) and zone 3b (Marillana Plain) being of lowest environmental significance. For each environmental value, management objectives are identified and strategies to achieve these objectives outlined.

	Zone	Environmental values	Objectives	Strategies
Highest environmental significance	1a Northern Flank	Natural springs and pools	<ul style="list-style-type: none"> Protect natural pools and springs. 	<ul style="list-style-type: none"> Minimise disruption to natural surface flow regimes. Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Minimise impacts to natural spring flows and water quality from groundwater mounding. Manage surface discharge of excess water in the vicinity of springs and restrict to episodic (campaign) discharges. . Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>.
		Natural water regimes	<ul style="list-style-type: none"> Minimise disruption to groundwater in aquifers supporting groundwater dependant ecosystems. Protect the hydrological and ecological integrity of major tributaries entering the Marsh. Maintain the natural flow regime at the boundary between Northern Flank and Marsh zones. 	<ul style="list-style-type: none"> Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. Avoid locating infrastructure on or in close proximity to major Marsh tributaries. Manage groundwater drawdown so that riparian vegetation along major tributaries is not significantly impacted. Minimise disruption to surface flows through the appropriate design and placement of infrastructure. Undertake research and monitoring to determine the extent of cumulative hydrological impacts on the Marsh.
		Mulga woodlands	<ul style="list-style-type: none"> Protect existing mulga vegetation. Maintain groundwater levels to protect mulga vegetation. 	<ul style="list-style-type: none"> Avoid (where possible) and minimise clearing of mulga vegetation. Minimise disruption to groundwater levels or water quality gradients in aquifers that support mulga vegetation. Minimise disruption to natural surface flow regimes. Minimise impacts to mulga vegetation from the effects of groundwater mounding. Seek acquisition and reservation of mulga-dominated woodland and shrubland vegetation types in the 2015 pastoral relinquishment conservation reserve system. Undertake an assessment of cumulative impacts to mulga vegetation communities.
		Species of conservation significance	<ul style="list-style-type: none"> Protect species of conservation significance and their habitat. Protect mulga and mixed <i>Acacia</i> woodland and shrublands. 	<ul style="list-style-type: none"> Avoid (where possible) and minimise clearing of areas of native vegetation that represents important habitat. Minimise disruption to groundwater levels or water quality gradients in aquifers that support important habitats. Minimise disruption to natural surface flow regimes. Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. Undertake surveys to identify and map distributions of conservation significant species.
		Night Parrot	<ul style="list-style-type: none"> Protect the Night Parrot and its habitat. 	<ul style="list-style-type: none"> Undertake targeted surveys and identify suitable habitat for the Night Parrot. Avoid (where possible) and minimise clearing of areas of native vegetation where critical habitat has been identified. Seek acquisition and reservation of suitable Night Parrot habitat in the 2015 pastoral relinquishment conservation reserve system. Undertake feral predator control measures.
		Northern Quoll	<ul style="list-style-type: none"> Protect the Northern Quoll and its habitat. 	<ul style="list-style-type: none"> Undertake targeted surveys and identify suitable habitat for the Northern Quoll. Avoid (where possible) and minimise clearing of areas of native vegetation where critical habitat has been identified. Seek acquisition and reservation of suitable Northern Quoll habitat in the 2015 pastoral relinquishment conservation reserve system. Undertake feral predator control measures.

Highest environmental significance		Subterranean fauna	<ul style="list-style-type: none"> Enhance knowledge of local subterranean fauna. 	<ul style="list-style-type: none"> Define habitat requirements of conservation significant subterranean fauna and ensure that hydrological regimes are maintained. Enhance survey effort to document the presence and richness of subterranean fauna. Develop a Fortescue Marsh Management Area subterranean fauna theme atlas within NatureMap.
		Land systems	<ul style="list-style-type: none"> Manage impacts to the land system. Minimise disruption to groundwater dependent ecosystems. 	<ul style="list-style-type: none"> Reinstate natural landforms following mining where possible in accordance with the EPA/DMP's <i>Guidelines for Mine Closure Plans</i>. Avoid (where possible) and minimise clearing of native vegetation. Minimise disruption to natural surface flow regimes through the appropriate placement of infrastructure. Minimise disruption to groundwater levels or water quality gradients in aquifers that support groundwater dependant ecosystems and riparian vegetation. Excess water should be reinjected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Restrict to campaign discharges and manage surface discharge of extracted water in riparian habitats. Add areas supporting Cowra and Christmas land systems to the conservation reserve system.
	1b Marsh	Pools and springs	<ul style="list-style-type: none"> Protect natural pools and springs. 	<ul style="list-style-type: none"> Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with the National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. Prevent discharge of excess water directly to the wetland or indirectly via industry-induced surface expression of saline or fresh water. If discharge is proposed it should be in accordance with an approved management and monitoring plan and ideally be of an episodic nature (campaign discharge) to coincide with natural flooding/inundation events.
		Wetland	<ul style="list-style-type: none"> Minimise disruption to aquifers supporting the Marsh. Maintain the natural flow regime at the Marsh boundary. Minimise disturbance to native vegetation. 	<ul style="list-style-type: none"> Prevent discharge of excess water directly to the wetland or indirectly via industry-induced surface expression of saline or fresh water. If discharge is proposed it should be in accordance with an approved management and monitoring plan and ideally be of an episodic nature (campaign discharge) to coincide with natural flooding/inundation events. Installation of bores that penetrate multiple aquifers will require a minimum standard of an ADIA Class 2 driller or have equivalent Water Drilling certification approved by the Department of Water. Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with the National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. Avoid (where possible) and minimise clearing of samphire vegetation or halophytic vegetation. Minimise disturbance activities with a preference to use previously disturbed areas for new disturbance footprints, e.g. existing dilapidated fence lines and corridors for vehicle movements. Any ground disturbing activity within the proposed 2015 conservation estate should be undertaken in a manner consistent with DEC conservation estate management guidelines (where available). Prior to the availability of these guidelines, consultation with the DEC is considered essential. Implement best practice impact mitigation and management techniques. Undertake research and monitoring to determine the extent of cumulative hydrological impacts on the Marsh.
		Water quality gradient	<ul style="list-style-type: none"> Maintain water quality in the Marsh. Minimise disruption to aquifers supporting the Marsh Maintain the natural surface water flow regime of the Marsh. 	<ul style="list-style-type: none"> Prevent discharge of excess water directly to the wetland or indirectly via industry-induced surface expression of saline or fresh water. If discharge is proposed it should be in accordance with an approved management and monitoring plan and ideally be of an episodic nature (campaign discharge) to coincide with natural flooding/inundation events. Installation of bores that penetrate multiple aquifers will require a minimum standard of an ADIA Class 2 driller or have equivalent Water Drilling certification approved by the Department of Water. Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with the National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>.
		Species of conservation significance	<ul style="list-style-type: none"> Protect species of conservation significance and their habitat. 	<ul style="list-style-type: none"> Avoid (where possible) and minimise clearing of samphire and halophytic vegetation. Minimise disruption to groundwater levels or water quality gradients in aquifers that support important habitats. Minimise disruption to natural surface flow regimes. Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Manage surface discharge of excess water and restrict to episodic (campaign) discharges. Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with the National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. Undertake surveys to identify and map distributions of conservation significant species.
		Samphire vegetation community	<ul style="list-style-type: none"> Protect samphire and halophytic vegetation. Enhance understanding of <i>Tecticornia</i> species. 	<ul style="list-style-type: none"> Minimise disruption to groundwater levels or water quality gradients in aquifers that support samphire vegetation communities. Minimise disruption to natural surface flow regimes. Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Manage surface discharge of excess water and restrict to episodic (campaign) discharges. Undertake surveys to delimit and define samphire vegetation communities.

		Aquatic Invertebrates	<ul style="list-style-type: none"> Enhance knowledge of local invertebrates. 	<ul style="list-style-type: none"> Minimise disruption to groundwater levels or water quality gradients in aquifers that support significant aquatic invertebrate populations. Minimise disruption to natural surface flow regimes. Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Manage surface discharge of excess water and restrict to episodic (campaign) discharges.
		Waterbirds	<ul style="list-style-type: none"> Protect waterbird habitat and foraging habitat. Maintain water quality and natural flow regimes in the Marsh. 	<ul style="list-style-type: none"> Minimise disruption to groundwater levels or water quality gradients in aquifers that support waterbird habitat. Maintain the natural surface water flow regime. Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Manage surface discharge of excess water and restrict to episodic (campaign) discharges. Undertake unmanaged livestock and feral predator control measures.
Medium environmental significance	2a Calcrete Flats	Natural water regimes	<ul style="list-style-type: none"> Maintain the natural flow regimes, especially at the Marsh boundary. Maintain natural cycles of wetting for claypan habitats. Minimise disruption to aquifers from activities in neighbouring zones. 	<ul style="list-style-type: none"> Prevent discharge of excess surface water where possible. Limit disturbance to claypan habitats where possible. Excess water should be managed in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with the National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. Undertake research and monitoring to determine the extent of cumulative hydrological impacts on the Marsh.
		Subterranean fauna	<ul style="list-style-type: none"> Enhance understanding of local subterranean fauna. 	<ul style="list-style-type: none"> Undertake targeted surveys to confirm presence and species richness/endemism of subterranean fauna. Develop a Fortescue Marsh Management Area subterranean fauna theme within NatureMap.
		Aquatic invertebrates	<ul style="list-style-type: none"> Enhance understanding of aquatic invertebrates. 	<ul style="list-style-type: none"> Undertake targeted surveys to identify macroinvertebrates within claypans. Limit surface discharge of excess water, especially in vicinity of claypan habitats.
		Vegetation communities	<ul style="list-style-type: none"> Minimise impact to native vegetation communities. Rehabilitate native vegetation where possible. 	<ul style="list-style-type: none"> Minimise clearing of native vegetation. Limit the surface discharge of excess water, especially in vicinity of claypan habitats.
		Species of conservation significance	<ul style="list-style-type: none"> Protect species of conservation significance and their habitat. 	<ul style="list-style-type: none"> Prevent the surface discharge of excess water. Minimise disturbance to claypan habitats. Excess water should be managed in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with the National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. Undertake surveys to identify and map distributions of conservation significant species.
	2b Poonda Plain	Natural water regimes	<ul style="list-style-type: none"> Maintain the natural flow regime at the boundary between Northern Flank and Marsh zones. Maintain the natural flow regime of tributaries entering the Marsh. Protect the hydrological and ecological integrity of major tributaries entering the Marsh. 	<ul style="list-style-type: none"> Excess water should be managed in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with the National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. Ensure that any change to the rate and timing of seasonal discharges to the tributaries do not significantly alter their hydrological and ecological integrity. Avoid locating infrastructure on or in close proximity to major Marsh tributaries. Ensure that groundwater drawdown does not lead to the loss of riparian vegetation (such as Coolibah) along major tributaries. Undertake research and monitoring to determine the extent of cumulative hydrological impacts on the Marsh.
		Sand dune communities	<ul style="list-style-type: none"> Protect Priority Ecological Community. 	<ul style="list-style-type: none"> Undertake surveys to document and map the extent of the species composition of this community. Minimise ground disturbance activities to limit opportunities for weed invasion. Minimise clearing of native vegetation and abstraction of basic raw material (sand) for construction purposes. Minimise the discharge of surface water to the Poonda Plain that supports sand dune communities.
		Species of conservation significance	<ul style="list-style-type: none"> Protect species of conservation significance and their habitat. 	<ul style="list-style-type: none"> Manage surface discharge of excess water to riparian communities and restrict to episodic (campaign) discharges. Minimise clearing of native vegetation. Minimise disturbance to habitats supporting conservation significant species. Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with the National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. Undertake surveys to identify and map distributions of conservation significant species.

Medium environmental significance		Northern Quoll	<ul style="list-style-type: none"> Protect the Northern Quoll and its habitat. 	<ul style="list-style-type: none"> Minimise disturbance to Northern Quoll habitat. Avoid (where possible) and minimise clearing of areas of native vegetation where critical habitat has been identified. Undertake targeted surveys to identify and map distributions of the Northern Quoll. Undertake feral predator control measures.
		Bilby	<ul style="list-style-type: none"> Protect the Bilby and its habitat. 	<ul style="list-style-type: none"> Minimise disturbance to Bilby habitats. Avoid (where possible) disturbance to extant Bilby burrows and minimise clearing of native vegetation where critical habitat has been identified. Undertake targeted surveys to determine persistence, extent and habitat preference of Bilbies. Undertake feral predator control measures.
		Subterranean fauna	<ul style="list-style-type: none"> Enhance understanding of local subterranean species. 	<ul style="list-style-type: none"> Enhance survey effort to document presence and richness of subterranean fauna. Develop a Fortescue Marsh Management Area subterranean fauna theme within NatureMap.
		Aquatic invertebrates	<ul style="list-style-type: none"> Enhance understanding of aquatic invertebrates. 	<ul style="list-style-type: none"> Undertake targeted surveys to document macroinvertebrates within claypans. Limit surface discharge of excess water, especially in vicinity of claypan habitats.
	2c Fortescue River Coolibah	Natural water regimes	<ul style="list-style-type: none"> Maintain natural water balances and function of the aquifer. Maintain the natural flow regime at the Marsh boundary 	<ul style="list-style-type: none"> Excess water should be managed in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with the National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. Undertake research and monitoring to determine the extent of cumulative hydrological impacts on the Marsh.
		Riparian vegetation	<ul style="list-style-type: none"> Minimise impacts to riparian native vegetation. Maintain the natural surface water flows and flooding regime of the alluvial and gilgai plains. Minimise disruption to aquifers supporting groundwater dependent ecosystems and riparian vegetation. 	<ul style="list-style-type: none"> Infrastructure (roads, rail, levees) should be designed and constructed to maintain the natural flooding regime. Map the condition of riparian vegetation and undertake revegetation activities where appropriate.
		Bilby	<ul style="list-style-type: none"> Protect the Bilby and its habitat. 	<ul style="list-style-type: none"> Undertake targeted surveys to determine persistence, extent and preferred habitat of Bilbies. Avoid (where possible) disturbance to extant Bilby burrows and minimise clearing of native vegetation where critical habitat has been identified. Undertake feral predator control measures.
		Subterranean fauna	<ul style="list-style-type: none"> Enhance understanding of local subterranean fauna. 	<ul style="list-style-type: none"> Enhance survey effort to document presence and richness of subterranean fauna. Develop a Fortescue Marsh Management Area subterranean fauna theme within NatureMap.
Lowest environmental significance	3a Kulbee Alluvial Flank	Natural water regimes	<ul style="list-style-type: none"> Maintain the natural flow regime at the Marsh boundary. Protect the hydrological and ecological integrity of major tributaries entering the Marsh. 	<ul style="list-style-type: none"> Excess water should be managed in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with the National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. Ensure that changes to the rate and timing of seasonal discharges to the tributaries do not significantly alter their hydrological and ecological integrity. Avoid locating infrastructure on or in close proximity to major Marsh tributaries. Ensure that groundwater drawdown does not lead to the loss of keystone species within riparian communities (such as Coolibah) along major tributaries. Undertake research and monitoring to determine the extent of cumulative hydrological impacts on the Marsh.
		Natural springs and pools	<ul style="list-style-type: none"> Protect the natural pools and springs. 	<ul style="list-style-type: none"> Minimise disruption to natural surface flow regimes. Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Minimise impacts to natural spring flows and water quality from groundwater mounding. Manage surface discharge of excess water in the vicinity of springs and restrict to episodic (campaign) discharges. Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with the National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>.
		Mulga woodlands	<ul style="list-style-type: none"> Manage impacts to mulga vegetation. Manage overland surface water flows. 	<ul style="list-style-type: none"> Avoid (where possible) and minimise clearing of mulga vegetation. Minimise disruption to surface flows through the appropriate design and placement of infrastructure.

Lowest environmental significance		Species of conservation significance	<ul style="list-style-type: none"> Protect species of conservation significance and their habitat. 	<ul style="list-style-type: none"> Limit extent of native vegetation clearing. Undertake surveys to identify and map distributions of conservation significant species.
		Subterranean fauna	<ul style="list-style-type: none"> Enhance understanding of local subterranean fauna. 	<ul style="list-style-type: none"> Enhance survey effort to document presence and richness of subterranean fauna. Develop a Fortescue Marsh Management Area subterranean fauna theme within NatureMap.
	3b Marillana Plain	Natural water regimes	<ul style="list-style-type: none"> Maintain the natural flow regime at the Marsh boundary. 	<ul style="list-style-type: none"> Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with the National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. Undertake research and monitoring to determine the extent of cumulative hydrological impacts on the Marsh.
		Land systems	<ul style="list-style-type: none"> Manage impacts to the land system. 	<ul style="list-style-type: none"> Minimise the clearing of native vegetation. Minimise disruption to natural surface flow regimes through the appropriate design and placement of infrastructure.
		Mulga woodlands	<ul style="list-style-type: none"> Manage impacts to mulga vegetation. Maintain the natural overland surface water flow regime. 	<ul style="list-style-type: none"> Avoid (where possible) and minimise clearing of mulga vegetation. Minimise disruption to natural surface flow regimes through the appropriate design and placement of infrastructure.
		Species of conservation significance	<ul style="list-style-type: none"> Protect species of conservation significance and their habitat. 	<ul style="list-style-type: none"> Minimise native vegetation clearing. Undertake surveys to identify and map distributions of conservation significant species.
		Subterranean fauna	<ul style="list-style-type: none"> Enhance understanding of local subterranean fauna. 	<ul style="list-style-type: none"> Enhance survey effort to document the presence and richness of subterranean fauna. Develop a Fortescue Marsh Management Area subterranean fauna theme within NatureMap.
		Aquatic invertebrates	<ul style="list-style-type: none"> Enhance understanding of local aquatic invertebrates. 	<ul style="list-style-type: none"> Enhance survey effort to document aquatic fauna within claypans. Minimise surface discharge of excess water, especially in vicinity of claypan habitats.

Introduction

The Environmental Protection Authority (EPA) presents to the Minister for Environment its Strategic Advice on environmental and water assessments relating to mining and mining related activities in the Fortescue Marsh Area (the Advice). The EPA is providing the Advice to the Minister in accordance with section 16(e) of the *Environmental Protection Act 1986*.

The EPA recognises the importance of mining activities in the Fortescue Marsh management area. There are extensive mineral deposits and mining activity in the area surrounding the Fortescue Marsh, and there are several new proposals identified for further development.

To ensure that the Advice represents agreed guidance, the EPA has extensively involved the Office of the Environmental Protection Authority, the Department of Water, the Department of Environment and Conservation, and the Department of State Development, during its development. The Advice provides consistent guidance for agencies and proponents to help streamline project assessment and approval processes to deliver positive environmental outcomes for the Fortescue Marsh. In addition, coordinated direction in the Fortescue Marsh management area will provide:

- more effective and efficient management;
- a better collective understanding of the Marsh and knowledge gaps; and
- a better understanding of cumulative impacts on the Marsh.

It is recognised that cultural, industry, tourism, recreational and pastoral values are important in the Fortescue Marsh management area. However, these values are beyond the scope of the Advice and will be addressed through other processes.

Purpose

The purpose of the Advice is to:

- identify the water regime and environmental values of the Fortescue Marsh and its immediate surrounds;
- provide agreed guidance for the Department of Water, Department of Environment and Conservation and the Office of the Environmental Protection Authority 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; and
- provide guidance to proponents of mining and mining activities on the values and objectives of the Fortescue Marsh.

Background

The Fortescue Marsh is a unique wetland formed at the terminus of the Upper Fortescue River as a result of the low permeability of the Goodiadarrie Hills. The Marsh extends east from the Goodiadarrie Hills for over 100 km and may be 30 km wide when in flood. The Marsh is flanked to the north by the Chichester Ranges and to the south by the Hamersley Ranges. The catchment area of the wetland, recognised as the Upper Fortescue River catchment, is approximately 30,000 km².

Land use in the immediate vicinity of Fortescue Marsh consists of mining and mining related activities (such as mine site infrastructure, rail and road infrastructure, waste dumps, bore fields, etc) and pastoral activities over four separate leases (Mulga Downs, Marillana, Hillside and Roy Hill stations) (Appendix A).

The water regime of Fortescue Marsh is dominated by surface water run-off from the catchment and subsequent evaporative loss (Figure 1). The Marsh is episodically inundated, predominately as a result of rainfall associated with tropical low pressure cyclonic weather systems that generally occur between December and April. Although cyclonic activity is largely restricted to summer/autumn in the tropical arid Pilbara region, there is high inter-annual variability and subsequent inundation of the Marsh is irregular and infrequent.

Following rainfall events, surface water from the catchment enters the Marsh via the surrounding hills and plains and several major surface tributaries and accumulates in the Marsh. With restricted outflow from the system, evaporation processes dominate causing loss of water and the accumulation of salts. This process results in wetland water quality alternating between fresh, saline and hypersaline conditions.

Vertical leaching of the salts into the underlying groundwater has resulted in the formation of a hypersaline groundwater mound below the Marsh, with a distinct gradient from hypersaline to fresh water observed (which varies in both a vertical and lateral sense). Figure 1 shows this in a simplified general cross-section of the Marsh.

Several significant groundwater aquifer systems (eg. Weeli Wolli Creek and Fortescue River alluvial aquifers) contribute to the complex groundwater regime, which can dramatically change in a short time after reasonable rainfall. The permeable, saturated sediments and bedrock of the Fortescue Marsh catchment contain significant groundwater storage, particularly in the Weeli Wolli Creek alluvial fan. A number of paleochannels exist which act as preferential flow paths into the Fortescue Marsh, including some channel iron deposits on the southern side (eg. the Weeli Wolli Creek channel iron deposit).

Groundwater levels at or near the Marsh are very shallow resulting in localised discharge to the Marsh, development of surface expressions of groundwater in the areas immediately up gradient of the Marsh (ie. springs), and a potential brackish groundwater source for vegetation.

Recent detailed investigations¹ accompanying mining project assessments provide the best current knowledge of the hydrogeology of the Marsh. In particular, detailed descriptions are found in the *Cloudbreak Life of Mine Public Environmental Review 2011* (in particular, the groundwater assessment report) for the northern side of the Marsh (Figure 1), and the *Brockman Resources Public Environmental Review 2010* for the southern side of the Marsh. Recent research and monitoring being undertaken by Government and industry is gradually building a better understanding of the Marsh's hydrology.

The Fortescue Marsh is the largest ephemeral wetland in the Pilbara and the water regime supports a variety of environmental values. Plant and animal species and communities of high conservation value occur in the Marsh and in surrounding areas. The Fortescue Marsh is listed in the *Directory of Important Wetlands in Australia* (2001) as meeting 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 Department of Environment and Conservation also lists the wetland as a Priority 1 Priority Ecological Community (PEC).

¹ Hydroconcept (2011). *Groundwater issues associated with mining around the Fortescue Marsh*, draft report prepared for Department of Sustainability, Environment, Water, Population and Communities, Sept. 2011.

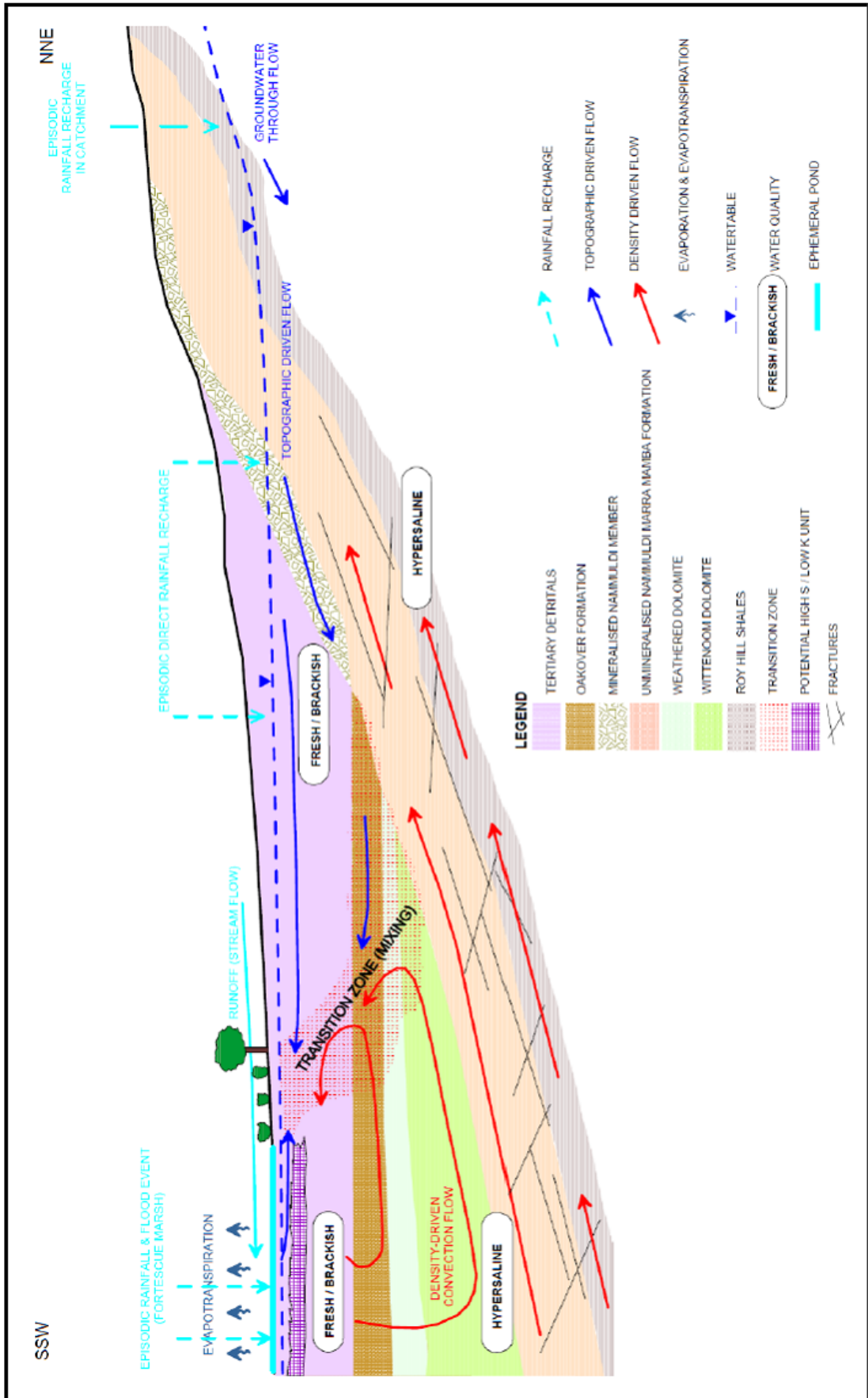


Figure 1: Conceptual understanding of the hydrogeology of the Fortescue Marsh (courtesy of Fortescue Metals Group)

Legislative/policy context

Several laws and policies relate to the protection and management of Fortescue Marsh. Water and catchment management in this area is important for maintaining the environmental values of the Marsh. The *Rights in Water Irrigation Act 1914* protects and promotes sustainable allocation of water resources through issuing permits and licences to water users.

The *Environmental Protection Act 1986* has a number of powers including requirements to approve clearing of native vegetation and environmental impact assessment for new proposed projects that are likely to have a significant impact on the environment. It also has the capacity to apply operating and licensing conditions where waste emissions are discharged to the environment.

The *Conservation and Land Management Act 1984* relates to land reserved for protection through the conservation reserve system. Although there are currently no conservation reserves inside the Fortescue Marsh management area, there are a number of pastoral leases from which significant portions are intended for inclusion in the conservation estate in 2015, subject to decision-making processes by relevant State agencies and negotiation with native title claimants (Appendix A).

Most of the land in the management area consists of pastoral leases which are administered under the *Land Administration Act 1997*. Mining operations around Fortescue Marsh are held under tenure granted under the *Mining Act 1978* and some operations are managed under various Agreement Acts.

There are a number of species of conservation significance within the management area which are afforded special protection under the *Wildlife Conservation Act 1950* and the Federal *Environment Protection and Biodiversity Conservation Act 1999* which protects listed threatened species, listed ecological communities, and matters of national significance, which includes habitat of any listed migratory bird species covered under international agreements such as:

- the China-Australia Migratory Bird Agreement (CAMBA)
- the Japan-Australia Migratory Bird Agreement (JAMBA)
- the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA)
- the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

The *Wetlands Conservation Policy for Western Australia* (1997) outlines strategies to conserve, protect and manage wetlands, to increase community awareness of wetlands, and to encourage development to be consistent with the policy objectives.

In January 2012, the Department of Planning released the *Pilbara Planning and Infrastructure Framework*, which provides Government's position on the Pilbara's planning direction for the next 25 years. The framework sets regional planning principles, goals, objectives and actions in relation to infrastructure,

economic development, the natural environment and cultural heritage. The framework includes objectives to minimise development near waterways and wetlands, and to improve the responsible consumption of water by industry.

Important sites and places of importance to Aboriginal people are found in the vicinity of Fortescue Marsh. These sites are protected under the *Aboriginal Heritage Act 1972*. Native title claims in the area have been made under the *Native Title Act 1993* for Aboriginal people to hold land rights and protect places of cultural, spiritual or heritage significance.

Adaptive management approach

Adaptive management refers to the systematic and iterative process of decision making, where some uncertainty exists, with the intention of 'learning through doing' to achieve the desired outcomes. The concept originated in the 1970s as a way to implement resource management policies as on-ground experiments^{2, 3}.

In an environmental context, adaptive management is aligned with the 'precautionary principle'⁴ in that it does not advocate the delay of management action until there is adequate knowledge available to effectively manage the environmental asset – this is especially relevant for urgent issues and important assets⁵. Results of on-ground experiments and management experiences will help to develop knowledge about the environmental asset, so better management decisions can be made in the future.

Although various adaptive management approaches exist, many utilise key aspects of the ISO 14004 Environmental Management Systems model (AS/NZS ISO 14004, 1996) and more recently the National Water Quality Management Strategy Water Quality and Monitoring Guidelines⁶.

In this context, key aspects for ensuring the effective long term protection and management of Fortescue Marsh generally include:

- establishing agreed environmental values and related objectives;
- developing an implementation program or strategies to achieve the objectives;
- developing monitoring, reporting and evaluation components relating to the implementation program or strategies and their outcomes;
- developing a means to measure implementation progress of outcomes against the objectives, reviewing learnings, and to generally make improvements to the current management approach.

² Holling, C.S. ed. (1978). *Adaptive environmental assessment and management*. John Wiley & Sons, New York.

³ Walters, C. (1986). *Adaptive management of renewable resources*. Macmillan, New York.

⁴ A core principle of the *Environmental Protection Act 1986* (s.4A).

⁵ Lee, K.N. (1999). Appraising adaptive management, *Conservation Ecology*, 3(2): 3.

⁶ ANZECC and ARMCANZ (2000) *National Water Quality Management Strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Canberra, Australian Capital Territory.

This Advice focuses on identifying the environmental values and corresponding management objectives and strategies for Fortescue Marsh in the context of mining-related approvals. It should be noted that this Advice is not intended to be a management plan that outlines a budget and responsibilities for implementing the strategies, nor does it outline monitoring, reporting and evaluation mechanisms. Nonetheless, it does provide a foundation for enabling an adaptive management approach in the Fortescue Marsh management area.

Fortescue Marsh management zones

This Advice focuses on mining and mining-related activities that may have the potential to impact water and environmental values within the Fortescue Marsh management area (Figure 2). This area is of primary importance to the direct management of the Marsh, particularly in relation to the natural water regime and ecological perspectives. The broader Fortescue River catchment is extremely large and has not been included due to a focus on the area in close proximity to the wetland where significant mining and related activities occur. Mining occurring beyond the management area should still refer to this Advice where impacts may affect the Fortescue Marsh management area either directly or indirectly (e.g. groundwater mounding or drawdown, discharge of excess water, or the damming or diverting of watercourses).

Zones within the management area were assigned in relation to key environmental values and management / decision-making priorities (Figure 2; Table 1). These zones are prioritised according to highest environmental significance (zone 1), medium environmental significance (zone 2), and lowest environmental significance (zone 3). While it should be recognised that the entire Fortescue Marsh wetland is an important wetland, the level of environmental significance for each zone is generally indicative of the level of sensitivity when regulatory agencies assess development proposals.

A two-step process was used to identify the zones / sub-zones:

1. The environmental values, as well as landscape, geological and hydrological features of the management area were spatially mapped using information obtained from stakeholder input⁷ and from Government agencies. This process drew extensively on data sourced from Government agencies and mining companies.
2. Areas having common water and environmental values were identified by technical experts to help define the zones and subzones. Adjustments were made to the zone boundaries based on existing environmental condition, industry activities and alignment with existing land features for ease of reference.

The boundaries of management zones may require further refinement and adjustment as new information becomes available over time.

⁷ A workshop was held on 19 March 2010 at the Perth Convention Centre with over 40 stakeholders represented. General environmental and hydrological values were identified at this workshop.

Table 1: Management zones in the Fortescue Marsh management area.

Zone	Zone name	Relative priority
1a	Northern Flank	Highest environmental significance
1b	Marsh	
2a	Calcrete Flats	Medium environmental significance
2b	Poonda Plain	
2c	Fortescue River Coolibah	
3a	Kulbee Alluvial Flank	Lowest environmental significance
3b	Marillana Plain	

Fortescue Marsh environmental values

The Fortescue Marsh has been identified as an important wetland having both State and national significance. Many environmental values relating to the Marsh and its surrounds contribute to the Marsh's environmental importance.

The *Environmental Protection Act 1986* recognises 'environmental values' as any aspect of the environment that requires protection from the effects of pollution, environmental harm, waste discharges and deposits. Water values are considered a subset of environmental values relating specifically to natural water features.

There are widespread mining and mining-related activities in the Fortescue Marsh management area and in the broader catchment, with several new proposals and expansions being planned (Figure 3). Cumulative impacts from these mines, in addition to associated pressures and threats, need to be actively managed to protect the water and environmental values. Examples of relevant impacts, pressures and threats to Fortescue Marsh from mining and mining-related activities may include:

- clearing of native vegetation and habitat;
- altered hydrology, caused by damming or diverting of watercourses, dewatering, over-abstraction of groundwater, and unmanaged discharge of excess water;
- introduced pests, including feral animals and weeds;
- discharge of altered water quality, particularly from sedimentation, nutrient and acid discharge; and
- altered fire regimes.

The EPA recognises that other land uses (eg. pastoral activities) and events (eg. wildfires) may also impact water and environmental values; however, these are considered beyond the scope of this Advice.

A key purpose of this Advice is to identify all the water and environmental values of the Fortescue Marsh management area. These values will be used by Government agencies in relation to regulatory and management processes (such as developing the DEC Fortescue Marsh management plan, environmental impact assessment of proposals, water allocation planning, issuing vegetation clearing permits, water licensing, and pastoral management planning). The Advice will also enable a consistent approach by land users, mining stakeholders and Government regulators in recognising a common suite of environmental values to help improve the long term protection and management of the Marsh.

Water and environmental values in the Fortescue Marsh management area (Table 2) were determined using information obtained from stakeholder input⁸ and technical specialists from the DEC, the Department of Water and the Office of the Environmental Protection Authority. This process drew extensively on data sourced from Government agencies and mining companies.

It should be noted that some water and environmental values were established for specific species where they are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (ie. Bilby, Night Parrot, Northern Quoll) and the *Wildlife Conservation Act 1950*, while other values were established more broadly (eg. species of conservation significance, vegetation communities). Both types of values were considered appropriate to reflect the need for both specific and broad management objectives.

Table 2 Key water and environmental values of the Fortescue Marsh management area.

Zone	Key environmental values
1a Northern Flank	<ul style="list-style-type: none"> • Natural springs and pools • Natural water regimes • Mulga woodlands • Species of conservation significance • Night Parrot • Northern Quoll • Subterranean fauna • Land systems

⁸ A workshop was held on 19 March 2010 at the Perth Convention Centre with over 40 stakeholders represented. General environmental and hydrological values were identified at this workshop.

Zone	Key environmental values
1b Marsh	<ul style="list-style-type: none"> • Pools and springs • Wetland • Water quality gradient • Species of conservation significance • Samphire vegetation community • Aquatic invertebrates • Waterbirds
2a Calcrete Flat	<ul style="list-style-type: none"> • Natural water regimes • Subterranean fauna • Aquatic invertebrates • Vegetation communities • Species of conservation significance
2b Poonda Plain	<ul style="list-style-type: none"> • Natural water regimes • Sand dune communities • Species of conservation significance • Northern Quoll • Bilby • Subterranean fauna • Aquatic invertebrates
2c Fortescue River Coolibah	<ul style="list-style-type: none"> • Natural water regimes • Riparian vegetation • Bilby • Subterranean fauna
3a Kulbee Alluvial Flank	<ul style="list-style-type: none"> • Natural water regimes • Natural springs and pools • Mulga woodlands • Species of conservation significance • Subterranean fauna
3b Marillana Plain	<ul style="list-style-type: none"> • Natural water regimes • Land systems • Mulga woodlands • Species of conservation significance • Subterranean fauna • Aquatic invertebrates

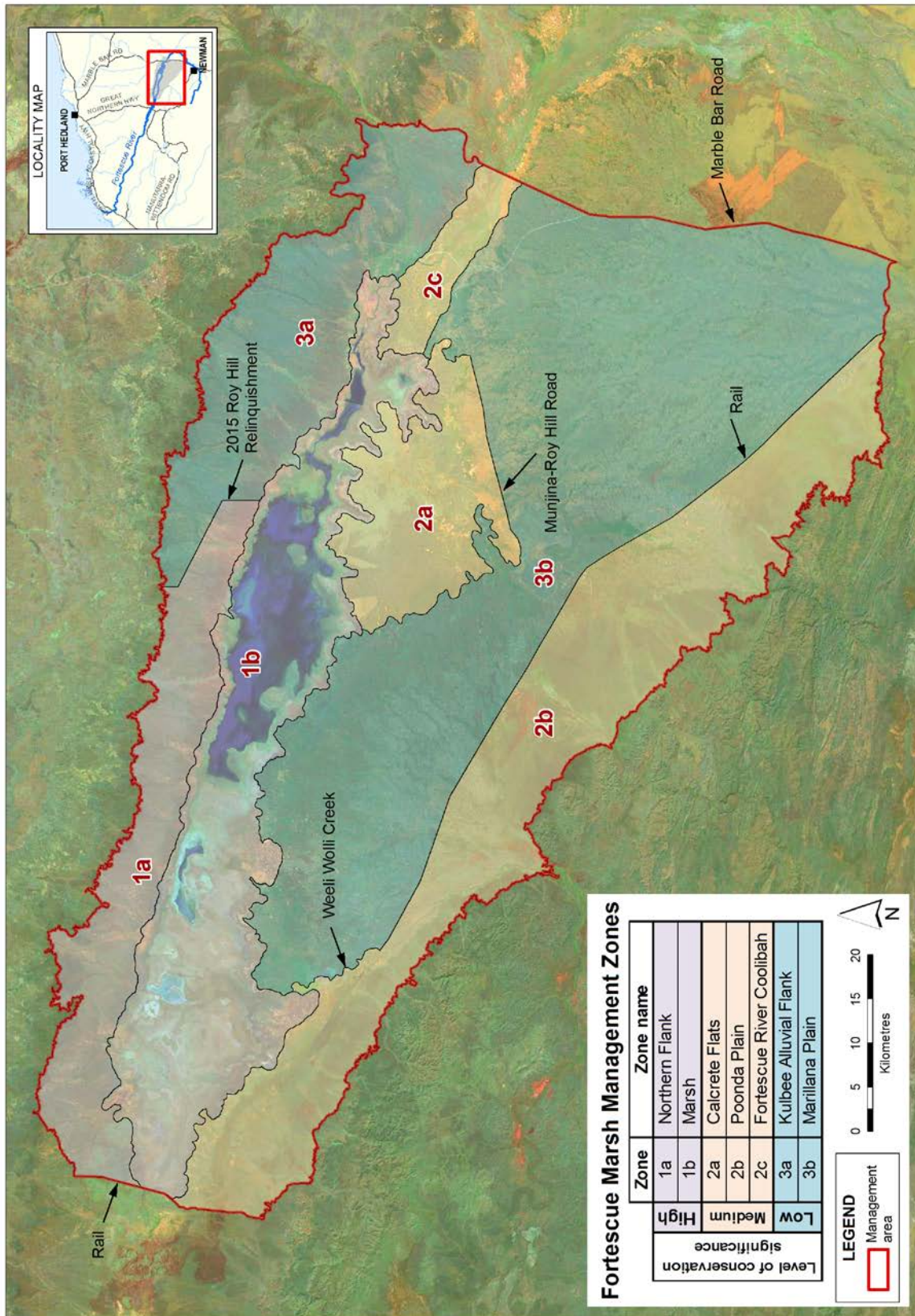


Figure 2: Fortescue Marsh management area and zones

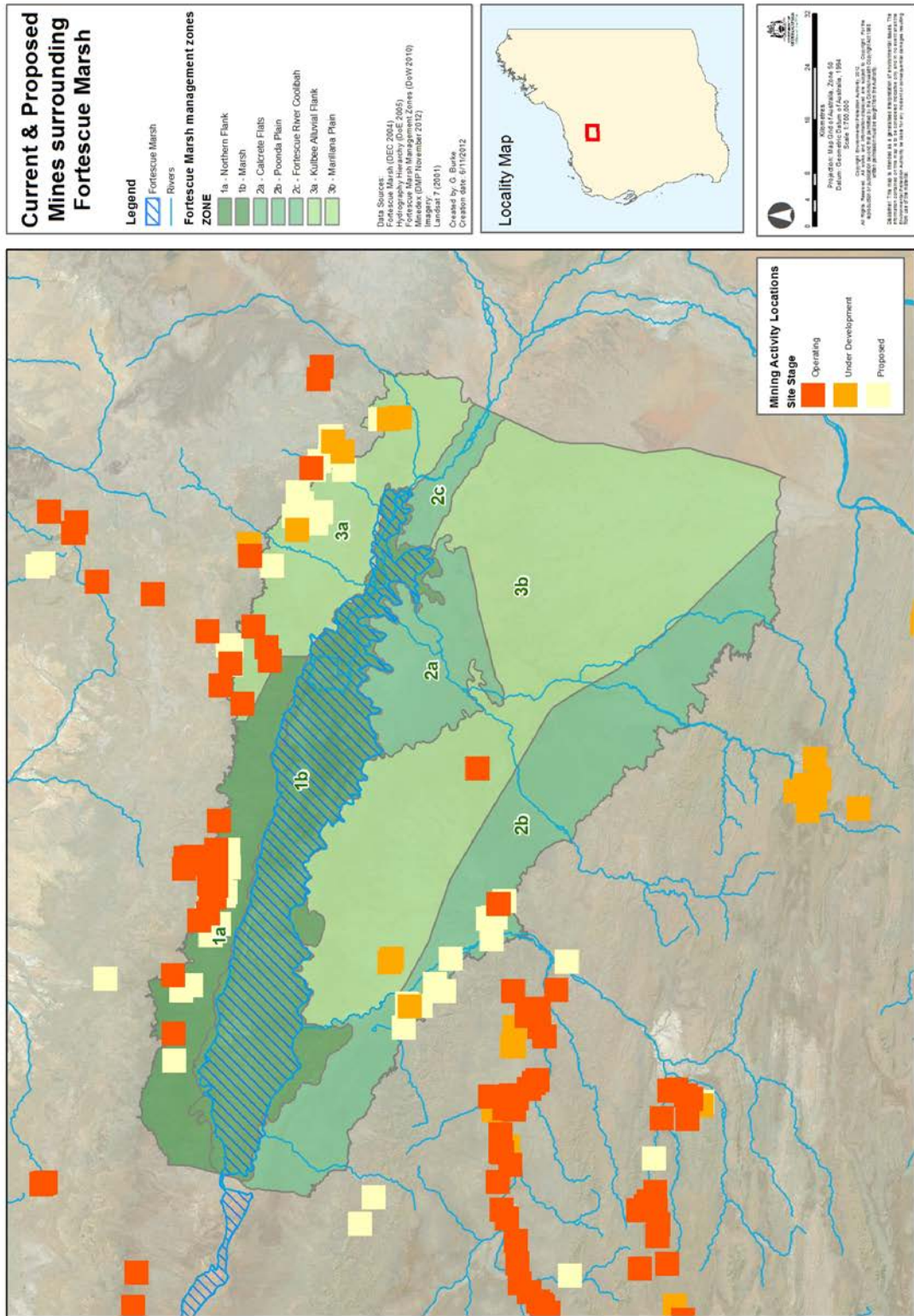


Figure 3: Representation of current and future proposed mine sites in proximity to Fortescue Marsh (current November 2012)

Fortescue Marsh objectives

Determination of environmental values allows the development of management objectives to provide a desired end result or outcome. This process follows the initial steps of the adaptive management framework. Many factors influence the development of objectives including the:

- level of existing knowledge and data;
- level of existing impact;
- conservation priority;
- management priority and capacity;
- potential threats and risks; and
- cumulative impacts.

Objectives may also vary depending on the condition or status of the environmental value. For example, mulga woodland has been identified as an environmental value in both zone 1a and zone 3b in the Fortescue Marsh management area. In each of these zones, the objectives are quite different for the mulga woodland.

In zone 1a the mulga is floristically unique, is in relatively good condition, is mostly weed free and has experienced reduced impacts from fire and pastoral grazing. The objective for zone 1a focuses on a high level of protection and has a higher conservation priority. Consequently, the objective is to “maintain condition and distribution of mulga vegetation”.

In contrast, mulga in zone 3b is comparatively more extensive and in a degraded state through the impacts of grazing, fire and significant weed invasion. In zone 3b the priority for protecting this value is not as high (as in zone 1a) due to the land being comparatively degraded and used for pastoral activities. Consequently, the objective seeks to “maintain or enhance the mulga vegetation values *where possible*”.

When determining objectives it is important to recognise that the condition or status of environmental values may change over time in response to natural events (e.g. floods, droughts), activities that may cause direct impacts or degradation, or in response to rehabilitation efforts. These changes may, in turn, require updating of objectives and strategies over time.

The need to update objectives may also occur when knowledge or technology improvements occur and management approaches need to be adapted. This is particularly relevant to the Fortescue Marsh management area where hydrogeological and ecological knowledge is still evolving.

Fortescue Marsh management strategies

Management strategies are developed to achieve the objectives and usually consist of management actions or activities. It should be noted that the management strategies presented in this Advice do not preclude proponents from developing new or alternative approaches that may better achieve the

objectives. This approach is consistent with the intent of adaptive management.

In the assessment or approvals process for new projects, expansions or upgrades, proponents should clearly outline their strategies for achieving the relevant objectives where their operations have potential to impact or threaten water and/or environmental values. Where possible, this should be accompanied by relevant processes to:

- identify key indicators of changes to the water regime or environmental condition that are directly related to each value;
- monitor those indicators using appropriate and reliable methods;
- assess results against pre-determined criteria or threshold limits; and
- undertake adaptive management if required.

The indicators and criteria should be developed along 'cause – effect' pathways that link threatening processes, impacts or risks to the condition or status of the environmental values.

It is acknowledged that there are currently significant gaps in the collective knowledge of the hydrogeology and ecology of the Fortescue Marsh. Setting appropriate key indicators and criteria relies on having good information and data available and an understanding of how the Marsh functions.

If current available information does not allow appropriate indicators to be identified and/or performance criteria/thresholds for those indicators to be established, then proponents should undertake staged developments, surveys, research projects, or monitoring programs, or establish and apply interim management standards or triggers to allow for adaptive management in the first instance.

Improved sharing of data and information for the Fortescue Marsh management area will be important across Government and industry in order to:

- enhance the collective understanding of the Marsh;
- prevent duplication of monitoring and research activities;
- develop an understanding of knowledge gaps;
- develop more specific standards and thresholds to minimise environmental and hydrological impacts; and
- progress a collective understanding of cumulative impacts.

Management zone overview: values, objectives and strategies

Zone 1a – Northern Flank

Zone Description	
The stony hardpan alluvial plains on the northern side of the Fortescue Marsh between the Marsh flat and the Chichester Range.	
Boundary Definition	
The southern boundary of this zone is defined as the Marsh land system. The mapped boundary should be used as a guide, with the transition from samphire dominated vegetation to mulga shrubland and woodland vegetation the preferred boundary. A buffer is added to this boundary to allow for edge effects. The northern boundary of this zone is the break of slope at the foot of the Chichester Range and is defined by merging the 430-450 m topographical contour. The eastern boundary is the negotiated 2015 pastoral lease relinquishment boundary as agreed with the Roy Hill lessee. The western boundary is the BHPBIO Port Hedland – Newman railway line.	
Relative importance	
High priority for protection and conservation.	
Environmental Value – Natural springs and pools	
Background	<ul style="list-style-type: none"> Fresh/brackish springs and seepages have been identified along the southern edge of the zone.
Management objective/s	<ul style="list-style-type: none"> Protect natural pools and springs.
Strategies	<ul style="list-style-type: none"> Minimise disruption to natural surface flow regimes. Excess water should be re-injected in accordance with the Department of Water's Pilbara Water in Mining Guideline (2009). Minimise impacts to natural spring flows and water quality from groundwater mounding. Manage surface discharge of excess water in the vicinity of springs and restrict to episodic (campaign) discharges. Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's Australian Groundwater Modelling Guidelines (2012).⁹
Environmental Value – Natural water regimes	
Background	<ul style="list-style-type: none"> Area of active recharge and runoff from the Chichester Ranges entering the groundwater system. Groundwater from the alluvium moves vertically into the underlying Marra Mamba Formation.

⁹ A nationally recognised standard for groundwater modeling.

	<ul style="list-style-type: none"> Integrity and physical function of the aquifer is important for maintaining natural water balances of the Marsh. Groundwater is fresh to brackish and is moving towards the Fortescue Marsh.
Management objective/s	<ul style="list-style-type: none"> Minimise disruption to groundwater in aquifers supporting groundwater dependant ecosystems. Protect the hydrological and ecological integrity of major tributaries entering the Marsh. Maintain the natural flow regime at the boundary between Northern Flank and Marsh zones.
Strategies	<ul style="list-style-type: none"> Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. Avoid locating infrastructure on, or in close proximity to, major Marsh tributaries. Manage groundwater drawdown so that riparian vegetation along major tributaries is not significantly impacted. Minimise disruption to surface flows through the appropriate design and placement of infrastructure. Undertake research and monitoring to determine the extent of cumulative hydrological impacts on the Marsh.
Environmental Value - Mulga Woodlands	
Background	<ul style="list-style-type: none"> Floristically unique mulga woodlands and shrublands including mosaics of <i>Acacia aneura</i>, <i>A. distans</i>, <i>A. xiphophylla</i>, <i>A. catenulata</i> subsp. <i>occidentalis</i> and <i>A. citrinoviridis</i>. Intact mulga communities that are relatively weed free, have experienced low fire frequencies and low total grazing pressure. Northern limits of continental distributional range of mulga woodland community type.
Management objective/s	<ul style="list-style-type: none"> Protect existing mulga vegetation. Maintain groundwater levels to protect mulga vegetation communities.
Strategies	<ul style="list-style-type: none"> Avoid (where possible) and minimise clearing of mulga vegetation. Minimise disruption to groundwater levels or water quality gradients in aquifers that support mulga vegetation communities. Minimise disruption to natural surface flow regimes.

	<ul style="list-style-type: none"> • Minimise impacts to mulga vegetation from the effects of groundwater mounding. • Seek acquisition and reservation of mulga-dominated woodland and shrubland vegetation types in the 2015 pastoral relinquishment conservation reserve system. • Undertake an assessment of cumulative impacts to mulga vegetation communities.
Environmental Value – Species of Conservation Significance	
Background	<ul style="list-style-type: none"> • The following species of conservation significance have been recorded in this zone: <ul style="list-style-type: none"> ○ Night Parrot (<i>Pezoporus occidentalis</i>) ○ Northern Quoll (<i>Dasyurus hallucatus</i>) ○ Bilby, Dalgyte, Ninu (<i>Macrotis lagotis</i>) ○ Peregrine Falcon (<i>Falco peregrinus</i>) ○ Australian Bustard (<i>Ardeotis australis</i>) ○ Bush Stone curlew (<i>Burhinus grallarius</i>) ○ <i>Goodenia nuda</i> ○ <i>Eremophila youngii</i> subsp. <i>lepidota</i>
Management objective/s	<ul style="list-style-type: none"> • Protect species of conservation significance and their habitat. • Protect mulga and mixed <i>Acacia</i> woodland and shrublands.
Strategies	<ul style="list-style-type: none"> • Avoid (where possible) and minimise clearing of areas of native vegetation that represents important habitat. • Minimise disruption to groundwater levels or water quality gradients in aquifers that support important habitats. • Minimise disruption to natural surface flow regimes. • Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. • Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. • Undertake surveys to identify and map distributions of conservation significant species.
Environmental Value – Night Parrot	
Background	<ul style="list-style-type: none"> • Contemporary observation of the Night Parrot (<i>Pezoporus occidentalis</i>) in this zone. Represents potential foraging - watering habitat. • Night Parrot listed as Endangered under <i>Environment Protection and Biodiversity Conservation Act 1999</i>. • Night Parrot listed on the IUCN Red List as Critically Endangered.

	<ul style="list-style-type: none"> Night Parrot listed as being 'rare' or 'likely to become extinct' under the <i>Wildlife Conservation Act 1950</i>.
Management objective/s	<ul style="list-style-type: none"> Protect the Night Parrot and its habitat.
Strategies	<ul style="list-style-type: none"> Undertake targeted surveys and identify suitable habitat for the Night Parrot. Undertake feral predator control measures. Avoid (where possible) and minimise clearing of areas of native vegetation where critical habitat has been identified. Seek acquisition and reservation of suitable Night Parrot habitat in the 2015 pastoral relinquishment conservation reserve system.
Environmental Value – Northern Quoll	
Background	<ul style="list-style-type: none"> Contemporary records and habitat for Northern Quoll (<i>Dasyurus hallucatus</i>) in this zone. Northern Quoll listed as Endangered under <i>Environment Protection and Biodiversity Conservation Act 1999</i>. Northern Quoll listed as being 'Rare' or 'Likely to become Extinct' under the <i>Wildlife Conservation Act 1950</i>.
Management objective/s	<ul style="list-style-type: none"> Protect the Northern Quoll and its habitat.
Strategies	<ul style="list-style-type: none"> Undertake targeted surveys and identify suitable habitat for the Northern Quoll. Undertake feral predator control measures. Avoid (where possible) and minimise clearing of areas of native vegetation where critical habitat has been identified. Seek acquisition and reservation of suitable Northern Quoll habitat in the 2015 pastoral relinquishment conservation reserve system.
Environmental Value – Subterranean fauna	
Background	<ul style="list-style-type: none"> Stygofauna and troglafauna present, with potential for restricted species but limited data.
Management objective/s	<ul style="list-style-type: none"> Enhance knowledge of local subterranean fauna.
Strategies	<ul style="list-style-type: none"> Define habitat requirements of conservation significant subterranean fauna and ensure that hydrological regimes are maintained. Enhance survey effort to document the presence and richness of subterranean fauna. Develop a Fortescue Marsh Management Area subterranean fauna theme atlas within NatureMap.

Environmental Value – Land systems	
Background	<ul style="list-style-type: none"> • Cowra land system is restricted to Fortescue Valley and is of conservation significance. • Christmas land system is restricted to Fortescue Valley and is of conservation significance.
Management objective/s	<ul style="list-style-type: none"> • Manage impacts to the land system. • Minimise disruption to groundwater dependent ecosystems.
Strategies	<ul style="list-style-type: none"> • Reinstate natural landforms following mining where possible in accordance with the EPA's <i>Guidelines for Mine Closure Plans</i>. • Avoid (where possible) and minimise clearing of native vegetation. • Minimise disruption to natural surface flow regimes through the appropriate placement of infrastructure. • Minimise disruption to groundwater levels or water quality gradients in aquifers that support groundwater dependant ecosystems and riparian vegetation. • Excess water should be reinjected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. • Restrict to campaign discharges and manage surface discharge of extracted water in riparian habitats. • Add areas supporting Cowra and Christmas land systems to the conservation reserve system.

Zone 1b – Marsh

Zone Description	
<p>An extensive, episodically inundated samphire marsh, approximately 100 km long and may be 30 km wide when in flood. The system is constricted at the western end by the Goodiadarrie Hills and the Marsh represents the termination basin for the upper Fortescue. Following significant rainfall events, runoff from the approximately 31,000 km² upper Fortescue River catchment drains to the Marsh. Surface water accumulates in the Marsh but, with limited discharge from the system, evaporation processes are dominant which causes loss of water and accumulation of salts. This process results in the transformation of the lake system from a fresh water ecosystem (when water levels are high) through to a saline lake to a hypersaline playa lake/groundwater system as it dries.</p>	
Boundary Definition	
<p>The boundary of this zone should be used as a guide to the boundary of the area subject to regular inundation. The mapped wetland boundary coincides with the transition from samphire dominated halophytic shrubland to mixed <i>Acacia</i> dominated vegetation. An additional 50 m buffer (in accordance with the DEC wetland buffer policy) is added to this boundary to allow for edge effects.</p>	
Relative importance	
<p>High priority for protection and conservation.</p>	
Environmental Value – Pools and springs	
Background	<ul style="list-style-type: none"> • Pools present for prolonged periods following flow events. • Fresh/brackish springs.
Management objective/s	<ul style="list-style-type: none"> • Protect natural pools and springs.
Strategies	<ul style="list-style-type: none"> • Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. • Prevent discharge of excess water directly to the wetland or indirectly via industry induced surface expression of saline or fresh water. If discharge is proposed it should be in accordance with an approved management and monitoring plan and ideally be of an episodic nature (campaign discharge) to coincide with natural flooding/inundation events.
Environmental Value – Wetland	
Background	<ul style="list-style-type: none"> • The Fortescue Marsh is a floodplain (<i>Directory of Important Wetlands in Australia</i> (DIWA) type B4) with lakes (DIWA type B6), marshes and pools. • Priority 1 Priority Ecological Community (PEC). • Designated as a wetland of national importance under

	<p>criteria 1, 2, 3 and 6 of the DIWA.</p> <ul style="list-style-type: none"> • Largest ephemeral wetland in the Pilbara and the only feature of this type in the Pilbara bioregion.
Management objective/s	<ul style="list-style-type: none"> • Minimise disruption to aquifers supporting the Marsh. • Maintain the natural flow regime at the Marsh boundary. • Minimise disturbance to native vegetation.
Strategies	<ul style="list-style-type: none"> • Prevent discharge of excess water directly to the wetland or indirectly via industry induced surface expression of saline or fresh water. If discharge is proposed it should be in accordance with an approved management and monitoring plan and ideally be of an episodic nature (campaign discharge) to coincide with natural flooding/inundation events. • Installation of bores that penetrate multiple aquifers will require a minimum standard of an Australian Drilling Industry Association (ADIA) Class 2 driller or have equivalent Water Drilling certification approved by the Department of Water. • Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. • Avoid (where possible) and minimise clearing of samphire vegetation or halophytic vegetation. • Minimise disturbance activities with a preference to use previously disturbed areas for new disturbance footprints, e.g. existing dilapidated fence lines and corridors for vehicle movements. • Any ground-disturbing activity within the proposed 2015 pastoral lease relinquishment boundaries (Appendix A) should be undertaken in a manner consistent with DEC conservation estate management guidelines (where available). Prior to the availability of these guidelines, consultation with the DEC is considered essential. • Implement best practice impact mitigation and management techniques. • Undertake research and monitoring to determine the extent of cumulative hydrological impacts on the Marsh.
Environmental Value – Water quality gradient	
Background	<ul style="list-style-type: none"> • Brackish groundwater very close to the surface (within 5 m), with thin brackish water lens overlaying denser saline and hypersaline groundwater. • Significant proportion of the area is a playa lake with active salt crust. • Major hydrological process is surface water flow and evaporation. Capillary action draws groundwater up to

	<p>the surface where it evaporates and leaves salts behind.</p> <ul style="list-style-type: none"> • Underlying the Marsh is a significant saline to hypersaline groundwater system with density driven flow. • Stratification driven by both surface water and groundwater discharge. • Spring flow is highly dependent on groundwater flow through alluvium from elevated ranges. • Pools present for prolonged periods following flow events. • Fresh/brackish springs.
Management objective/s	<ul style="list-style-type: none"> • Maintain water quality in the Marsh. • Minimise disruption to aquifers supporting the Marsh. • Maintain the natural surface water flow regime of the Marsh.
Strategies	<ul style="list-style-type: none"> • Prevent discharge of excess water directly to the wetland or indirectly via industry-induced surface expression of saline or fresh water. If discharge is proposed it should be in accordance with an approved management and monitoring plan and ideally be of an episodic nature (campaign discharge) to coincide with natural flooding/inundation events. • Installation of bores that penetrate multiple aquifers will require a minimum standard of an ADIA Class 2 driller or have equivalent Water Drilling certification approved by the Department of Water. • Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>.
Environmental Value – Species of Conservation Significance	
Background	<ul style="list-style-type: none"> • The following flora species of conservation significance have been recorded in this area: <ul style="list-style-type: none"> ○ <i>Atriplex flabelliformis</i> ○ <i>Eleocharis papillosa</i> ○ <i>Eremophila spongiorcarpa</i> ○ <i>Eremophila youngii</i> subsp. <i>lepidota</i> ○ <i>Nicotiana heterantha</i> ○ <i>Peplidium</i> sp. Fortescue Marsh (S. van Leeuwen 4865) ○ <i>Tecticornia</i> sp. Christmas Creek (K.A. Shepherd et al. KS 1063) ○ <i>Tecticornia globulifera</i> ○ <i>Tecticornia medusa</i>

	<ul style="list-style-type: none"> Records of the following fauna species of conservation significance have been recorded in this area: <ul style="list-style-type: none"> Bilby, Dalgyte, Ninu (<i>Macrotis lagotis</i>) Common Greenshank (<i>Tringa nebularia</i>) Eastern Great Egret (<i>Ardea modesta</i>) Wood sandpiper (<i>Tringa glareola</i>) The samphire and halophytic shrublands of the Marsh also appear to be ideal foraging and roosting habitat for the Night Parrot (<i>Pezoporus occidentalis</i>). A credible and scientifically accepted sighting has been documented for the Night Parrot within 1 km of the Marsh.
Management objective/s	<ul style="list-style-type: none"> Protect species of conservation significance and their habitat.
Strategies	<ul style="list-style-type: none"> Avoid (where possible) and minimise clearing of samphire and halophytic vegetation. Minimise disruption to groundwater levels or water quality gradients in aquifers that support important habitats. Minimise disruption to natural surface flow regimes. Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Manage surface discharge of excess water and restrict to episodic (campaign) discharges. Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. Undertake surveys to identify and map distributions of conservation significant species.
Environmental Value – Samphire vegetation community	
Background	<ul style="list-style-type: none"> Marshes dominated by samphire and halophytic shrublands. <i>Eremophila spongiocharpa</i> (Priority 1) endemic to the Marsh. <i>Tecticornia globulifera</i> and <i>T. medusa</i> near endemics (known from only one other locality). Possibly another three undescribed <i>Tecticornia</i> species known from the Marsh. Halophytic vegetation in mostly in good condition. Some yintas (water hole in Nyiyaparli language) support groundwater dependant ecosystems (e.g. <i>Eucalyptus victrix</i>, <i>E. camaldulensis</i>).

Management objective/s	<ul style="list-style-type: none"> • Protect samphire and halophytic vegetation. • Enhance understanding of <i>Tecticornia</i> species.
Strategies	<ul style="list-style-type: none"> • Minimise disruption to groundwater levels or water quality gradients in aquifers that support samphire vegetation communities. • Minimise disruption to natural surface flow regimes. • Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. • Manage surface discharge of excess water and restrict to episodic (campaign) discharges. • Undertake surveys to delimit and define samphire vegetation communities.
Environmental Value – Aquatic invertebrates	
Background	<ul style="list-style-type: none"> • Endemic macroinvertebrates including: a <i>Coxiella</i> snail, several undescribed ostracods (<i>Mytilocypris</i> n. sp., <i>Heterocypris</i> n. sp. - these are also known from Weelarrana Lake south of Newman), an enchytraeid oligochaete, a cladoceran (<i>Alona</i> n. sp.) and a <i>Tanytarsus</i> chironomid. • The Marsh is the richest claypan in the Pilbara region, a region with a high diversity of aquatic invertebrates but low turnover between wetland habitats compared to some other regions. • Diversity of invertebrates thought to be underestimated due to limited sampling to date. • The population for two species of macroinvertebrates (caldocerans <i>Dadaya macrocops</i> and <i>Celsinotum parooensis</i>) are the only known records for the species in Western Australia. Both species also occur in eastern Australia.
Management objective/s	<ul style="list-style-type: none"> • Enhance knowledge of local invertebrates.
Strategies	<ul style="list-style-type: none"> • Minimise disruption to groundwater levels or water quality gradients in aquifers that support significant aquatic invertebrate populations. • Minimise disruption to natural surface flow regimes. • Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. • Manage surface discharge of excess water and restrict to episodic (campaign) discharges.
Environmental Value – Waterbirds	
Background	<ul style="list-style-type: none"> • 47 species of waterbird counted during three surveys of the Fortescue Marsh after flooding events between 1999-2003 (van Leeuwen, 2004). Very high numbers of waterbirds recorded with the highest waterbird counts

	<p>in the State (up to 77,000 on a single date). Very few other wetlands in WA have ever had greater than 10,000 individuals.</p> <ul style="list-style-type: none"> • Marsh is a major breeding area for Australian Pelican (<i>Pelecanus conspicillatus</i>) and Black Swan (<i>Cygnus atratus</i>). One of only two inland breeding colonies of pelicans in WA. • Breeding records for Great Egret (<i>Ardea alba</i>), Straw-necked Ibis (<i>Threskiornis spinicollis</i>) and Yellow-billed Spoonbill (<i>Platalea flavipes</i>). This is one of only two known breeding localities for Great Egret in north-western Australia (Jaensch, 1993). • Important wetland for migratory waterbird species protected under various international agreements. • Invertebrate populations and phytoplankton are food sources for waterbirds.
Management objective/s	<ul style="list-style-type: none"> • Protect waterbird habitat and foraging habitat. • Maintain water quality and natural flow regimes in the Marsh.
Strategies	<ul style="list-style-type: none"> • Minimise disruption to groundwater levels or water quality gradients in aquifers that support waterbird habitat. • Maintain the natural surface water flow regime. • Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. • Manage surface discharge of excess water and restrict to episodic (campaign) discharges. • Undertake unmanaged livestock and feral predator control measures.

Zone 2a – Calcrete Flats

Zone Description	
<p>This zone is dominated by the calcrete land system and small adjoining areas which have some conservation significance. The zone is mostly comprised of low calcrete platforms and alluvial floodplain/sandplains and scattered claypans and drainage foci. The zone is considered to be in moderate to good condition.</p>	
Boundary Definition	
<p>The boundary for this zone is defined by the Calcrete land system to the west, the Marsh wetland boundary to the north and extended south and east to the Munjina-Roy Hill Road.</p>	
Relative importance	
<p>Important to protect and rehabilitate where possible.</p>	
Environmental Value – Natural water regimes	
Background	<ul style="list-style-type: none"> • Groundwater system has shallow thin brackish water overlying saline groundwater. • High potential for fresh water recharge to groundwater system. • Calcrete aquifer is distinct from surrounding aquifer types.
Management objective/s	<ul style="list-style-type: none"> • Maintain the natural flow regimes, especially at the Marsh boundary. • Maintain natural cycles of wetting for clay pan habitats. • Minimise disruption to aquifers from activities in neighbouring zones.
Strategies	<ul style="list-style-type: none"> • Prevent discharge of excess surface water where possible. • Limit disturbance to claypan habitats where possible. • Excess water should be managed in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. • Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. • Undertake research and monitoring to determine the extent of cumulative hydrological impacts on the Marsh.
Environmental Value – Subterranean fauna	
Background	<ul style="list-style-type: none"> • High probability of cavernous and vuggy habitat suitable for subterranean fauna. • Stygofauna communities probably low in diversity given salinity; likelihood that some unique and endemic species exist. For example, 15 km upstream in same

	calcrete system is a record for <i>Mangkurtu kutjarr</i> . <i>Mangkurtu kutjarr</i> has only been recorded from two locations, both on Roy Hill Station.
Management objective/s	<ul style="list-style-type: none"> • Enhance understanding of local subterranean fauna.
Strategies	<ul style="list-style-type: none"> • Undertake targeted surveys to confirm presence and species richness / endemism of subterranean fauna. • Develop a Fortescue Marsh Management Area subterranean fauna theme within NatureMap.
Environmental Value – Aquatic invertebrates	
Background	<p>Freshwater claypan supports unique communities of macroinvertebrates but limited data available.</p> <p>Some aquatic invertebrates known only from the claypans north (e.g. Howard's Dam) of the Munjina-Roy Hill Road: an ostracod <i>Strandesia n. sp.</i> and the only Pilbara record of the northern Australian cladoceran <i>Dadaya macrops</i>.</p> <p>Only one of these claypans (Howard's Dam - which extends into Coondiner Pool) has been surveyed.</p>
Management objective/s	Enhance understanding of aquatic invertebrates.
Strategies	<p>Undertake targeted surveys to identify macroinvertebrates within claypans.</p> <p>Limit surface discharge of excess water, especially in vicinity of claypan habitats.</p>
Environmental Value – Vegetation communities	
Background	<ul style="list-style-type: none"> • Riparian vegetation in moderate to good condition, particularly some stands of Coolibah (<i>Eucalyptus victrix</i>) woodland and sandplains dominated by snakewood. • Vegetation generally not as degraded as surrounding areas
Management objective/s	<ul style="list-style-type: none"> • Minimise impact to native vegetation communities. • Rehabilitate native vegetation where possible.
Strategies	<ul style="list-style-type: none"> • Minimise clearing of native vegetation. • Limit the surface discharge of excess water, especially in vicinity of claypan habitats.
Environmental Value – Species of conservation significance	
Background	<ul style="list-style-type: none"> • The following flora species of conservation significance have been recorded in this area: <ul style="list-style-type: none"> ○ <i>Eremophila spongiocharpa</i> ○ <i>Goodenia nuda</i> ○ <i>Myriocephalus scalpellus</i>
Management objective/s	<ul style="list-style-type: none"> • Protect species of conservation significance and their habitat.

Strategies	<ul style="list-style-type: none">• Prevent the surface discharge of excess water.• Minimise disturbance to claypan habitats.• Excess water should be managed in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>.• Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>.• Undertake surveys to identify and map distributions of conservation significant species.
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Zone 2b – Poonda Plain

Zone Description	
<p>This zone sits below the Hamersley Range escarpment and supports an undulating alluvial, stony and/or sandy plain intersected by numerous drainage tracts and some drainage foci. The vegetation is dominated by riparian woodlands along drainage tracts, extensive mulga woodland and mixed <i>Acacia</i> shrublands on heavy alluvial soils and <i>Acacia</i> shrubland and spinifex grasslands on sandy plains. Dominant features include Weeli Wolli and Coondiner creeks and the Fortescue Valley Sand Dunes Priority Ecological Community.</p>	
Boundary Definition	
<p>The northern boundary of this zone is principally defined by the BHPBIO rail line. At the point where the railway crosses Weeli Wolli Creek the boundary becomes the western bank of the creek until the Marsh zone is reached. The southern boundary of this zone is defined by the merging of 460-500 m topographical contour lines (representing the break of slope and change in land units from 'Hills and Ranges' to 'Plains' in this area).</p>	
Relative importance	
<p>Important to protect, manage natural resources sustainably, and rehabilitate where possible.</p>	
Environmental Value – Natural water regimes	
Background	<ul style="list-style-type: none"> Alluvial fans are an active recharge area for run-off entering the groundwater system from the Hamersley Range. Groundwater from the alluvium moves vertically into the underlying Wittenoom Formation bedrock. Landform integrity is significant in maintaining natural hydrological processes - represents part of the Weeli Wolli, Coondiner and Kalgan alluvium fans that emanate from the outcropping Hamersley Range. Integrity and physical function of aquifer maintains natural water balances. Groundwater is fresh to brackish. Major surface tributaries such as Weeli Wolli Creek and their associated riparian vegetation provide hydrological buffering and ecological connectivity between the Marsh and upstream aquatic systems.
Management objective/s	<ul style="list-style-type: none"> Maintain the natural flow regime at the boundary between Northern Flank and Marsh zones. Maintain the natural flow regime of tributaries entering the Marsh. Protect the hydrological and ecological integrity of major tributaries entering the Marsh.
Strategies	<ul style="list-style-type: none"> Excess water should be managed in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. Apply an independent peer review of hydrological

	<p>models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>.</p> <ul style="list-style-type: none"> • Ensure that any change to the rate and timing of seasonal discharges to the tributaries do not significantly alter their hydrological and ecological integrity. • Avoid locating infrastructure on or in close proximity to major Marsh tributaries. • Ensure that groundwater drawdown does not lead to the loss of riparian vegetation (such as Coolibah) along major tributaries. • Undertake research to determine the extent of cumulative hydrological impacts on the Marsh.
Environmental Value – Sand dune communities	
Background	<ul style="list-style-type: none"> • Sand dunes are rare in the Pilbara and support an unusual floristic community • Sand dunes in the Fortescue Valley immediately south of the Marsh are listed as a Priority 3 Priority Ecological Community (PEC). • This community is fragile and highly susceptible to threatening processes, especially weed invasion.
Management objective/s	<ul style="list-style-type: none"> • Protect Priority Ecological Communities.
Strategies	<ul style="list-style-type: none"> • Undertake surveys to document and map the extent of the species composition of this community. • Minimise ground disturbance activities to limit opportunities for weed invasion. • Minimise clearing of native vegetation and abstraction of basic raw material (sand) for construction purposes. • Minimise the discharge of surface water to the Poonda Plain and its associated sand dune communities.
Environmental Value – Species of conservation significance	
Background	<ul style="list-style-type: none"> • The following species of conservation significance have been recorded in this area: <ul style="list-style-type: none"> ○ Australian Bustard (<i>Ardeotis australis</i>) ○ Bush Stone curlew (<i>Burhinus grallarius</i>) ○ Ghost Bat (<i>Macroderma gigas</i>) ○ Western Pebble-mound Mouse, Ngadji (<i>Pseudomys chapmani</i>) ○ Mulgara (<i>Dasyercus cristicauda</i>) - EPBC ○ <i>Themeda</i> sp. Hamersley Station (M.E. Trudgen 11431)
Management objective/s	<ul style="list-style-type: none"> • Protect species of conservation significance and their habitat.

Strategies	<ul style="list-style-type: none"> • Manage surface discharge of excess water to riparian communities and restrict to episodic (campaign) discharges. • Minimise clearing of native vegetation. • Minimise disturbance to habitats supporting conservation significant species. • Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. • Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. • Undertake surveys to identify and map distributions of conservation significant species.
Environmental Value – Northern Quoll	
Background	<ul style="list-style-type: none"> • Northern Quoll (<i>Dasyurus hallucatus</i>) habitat. • Listed as Endangered under <i>Environment Protection and Conservation Biodiversity Act 1999</i>. • Listed as being 'rare' or 'likely to become extinct' under the <i>Wildlife Conservation Act 1950</i>.
Management objective/s	<ul style="list-style-type: none"> • Protect the Northern Quoll and its habitat.
Strategies	<ul style="list-style-type: none"> • Minimise disturbance to Northern Quoll habitat. • Avoid (where possible) and minimise clearing of areas of native vegetation where critical habitat has been identified. • Undertake targeted surveys to identify and map distributions of the Northern Quoll. • Undertake feral predator control measures.
Environmental Value – Bilby	
Background	<ul style="list-style-type: none"> • Known Bilby (<i>Macrotis lagotis</i>) habitat. • Listed as Vulnerable under <i>Environment Protection and Biodiversity Conservation Act 1999</i>. • Listed as being 'rare' or 'likely to become extinct' under the <i>Wildlife Conservation Act 1950</i>.
Management objective/s	<ul style="list-style-type: none"> • Protect the Bilby and its habitat.
Strategies	<ul style="list-style-type: none"> • Minimise disturbance to Bilby habitats. • Avoid (where possible) disturbance to extant Bilby burrows and minimise clearing of native vegetation where critical habitat has been identified. • Undertake targeted surveys to determine persistence, extent and habitat preference of Bilbies. • Undertake feral predator control measures.

Environmental Value – Subterranean fauna	
Background	<ul style="list-style-type: none"> • Some species of troglofauna appear to be restricted to detrital ore bodies. • Stygofauna present although significance has not been adequately assessed.
Management objective/s	<ul style="list-style-type: none"> • Enhance understanding of local subterranean species.
Strategies	<ul style="list-style-type: none"> • Enhance survey effort to document presence and richness of subterranean fauna. • Develop a Fortescue Marsh Management Area subterranean fauna theme within NatureMap.
Environmental Value – Aquatic invertebrates	
Background	<ul style="list-style-type: none"> • Freshwater claypan communities support unique species, but limited data available. • Some aquatic invertebrates known only from the claypans in the Marillana Plains zone (3b): an ostracod <i>Strandesia</i> n. sp. and the only Pilbara record of the northern Australian cladoceran <i>Dadaya macrops</i>. Only one of these claypans, Howard's Dam (which extends into Coondiner Pool) has been surveyed. This claypan extends into zone 3b.
Management objective/s	<ul style="list-style-type: none"> • Enhance understanding of aquatic invertebrates.
Strategies	<ul style="list-style-type: none"> • Undertake targeted surveys to document macroinvertebrates within claypans. • Limit surface discharge of excess water, especially in vicinity of claypan habitats.

Zone 2c – Fortescue River Coolibah

Zone Description	
<p>This zone comprises flood plains representing the major surface water inflow to the Marsh - the Fortescue River. The zone is characterised by a meandering river channel, banks and associated terraces, surrounded by alluvial and gilgai flood plains which support extensive Coolibah woodlands with a tussock grass understory. The zone has been subjected to extensive pastoral grazing.</p>	
Boundary Definition	
<p>This zone conforms mostly to the Coolibah land systems and part of the Warri land system. The eastern boundary is the Marble Bar Road in the south and the water shed of Koolkinbah Creek in the north, although the landscape feature and values extend further east for many kilometres.</p>	
Relative importance	
<p>Important to protect and manage natural resources sustainably and rehabilitate where practicable.</p>	
Environmental Value – Natural water regimes	
Background	<ul style="list-style-type: none"> • Significant area for fresh water inflow during high rainfall events from the Fortescue River. • River alluvium aquifer charges groundwater system during surface water flow events. • Integrity and physical function of aquifer to be maintained to maintain natural water balances.
Management objective/s	<ul style="list-style-type: none"> • Maintain natural water balances and function of the aquifer. • Maintain the natural flow regime at the Marsh boundary.
Strategies	<ul style="list-style-type: none"> • Excess water should be managed in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. • Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. • Undertake research and monitoring to determine the extent of cumulative hydrological impacts on the Marsh.
Environmental Value – Riparian vegetation	
Background	<ul style="list-style-type: none"> • Riparian vegetation including extensive stands of Coolibah (<i>Eucalyptus victrix</i>) although understory is somewhat degraded through total grazing pressure.
Management objective/s	<ul style="list-style-type: none"> • Minimise impacts to riparian native vegetation. • Maintain the natural surface water flows and flooding regime of the alluvial and gilgai plains.

	<ul style="list-style-type: none"> Minimise disruption to aquifers supporting groundwater dependent ecosystems and riparian vegetation.
Strategies	<ul style="list-style-type: none"> Infrastructure (roads, rail, levees) should be designed and constructed to maintain the natural flooding regime. Map the condition of riparian vegetation and undertake revegetation activities where appropriate.
Environmental Value – Bilby	
Background	<ul style="list-style-type: none"> Known Bilby (<i>Macrotis lagotis</i>) habitat. Listed as Vulnerable under <i>Environment Protection and Biodiversity Conservation Act 1999</i>. Listed as being 'rare' or 'likely to become extinct' under the <i>Wildlife Conservation Act 1950</i>.
Management objective/s	<ul style="list-style-type: none"> Protect the Bilby and its critical habitat.
Strategies	<ul style="list-style-type: none"> Undertake targeted surveys to determine persistence, extent and preferred habitat of Bilbies. Avoid (where possible) disturbance to extant Bilby burrows and minimise clearing of native vegetation where critical habitat has been identified. Undertake feral predator control measures.
Environmental Value – Subterranean fauna	
Background	<ul style="list-style-type: none"> Stygofauna and troglafauna communities may be present but there is inadequate data.
Management objective/s	<ul style="list-style-type: none"> Enhance understanding of local subterranean fauna.
Strategies	<ul style="list-style-type: none"> Enhance survey effort to document presence and richness of subterranean fauna. Develop a Fortescue Marsh Management Area subterranean fauna theme within NatureMap.

Zone 3a – Kulbee Alluvial Flank

Zone Description	
<p>This zone comprises the alluvial flanks on the north-eastern edge of the Marsh, which has an important hydrological contribution to supporting the values in management zone 2c and 1b. The zone incorporates Koolkinbah Creek alluvial fan to recognize the surface water flows from this system into the Marsh.</p>	
Boundary Definition	
<p>The western boundary for this zone is defined by the negotiated 2015 Roy Hill pastoral lease boundary. The northern boundary represents the edge of the alluvial flanks of the Chichester Range and is defined by merging the 430-450 m topographical contour to match the break of slope and change in land system. The southern boundary is defined by zone 2C which is the edge of the Coolibah land system. The eastern boundary is defined by the water shed of Koolkinbah Creek.</p>	
Relative importance	
<p>Manage natural resources sustainably.</p>	
Environmental Value – Natural water regimes	
Background	<ul style="list-style-type: none"> • Major surface tributaries such as Christmas Creek and associated riparian vegetation provide hydrological buffering and ecological connectivity between the Marsh and upstream aquatic systems. • Significant area for fresh water flow on Marsh flanks during high rainfall events. • Throughflow of brackish water from the Chichester Range to the (more saline) Marsh aquifer. • A shallow water table with saline groundwater at depth. • Significant area for fresh water recharge to groundwater system. • Integrity and physical function of aquifer maintains natural water balances.
Management objective/s	<ul style="list-style-type: none"> • Maintain the natural flow regime at the Marsh boundary. • Protect the hydrological and ecological integrity of major tributaries entering the Marsh.
Strategies	<ul style="list-style-type: none"> • Excess water should be managed in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. • Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. • Ensure that changes to the rate and timing of seasonal discharges to the tributaries do not significantly alter their hydrological and ecological integrity.

	<ul style="list-style-type: none"> • Avoid locating infrastructure on or in close proximity to major Marsh tributaries. • Ensure that groundwater drawdown does not lead to the loss of keystone species within riparian communities (such as Coolibah) along major tributaries. • Undertake research and monitoring to determine the extent of cumulative hydrological impacts on the Marsh.
Environmental Value – Natural springs and pools	
Background	<ul style="list-style-type: none"> • Fresh/brackish springs and seepages have been identified along the southern edge of the zone.
Management objective/s	<ul style="list-style-type: none"> • Protect the natural pools and springs.
Strategies	<ul style="list-style-type: none"> • Minimise disruption to natural surface flow regimes. • Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. • Minimise impacts to natural spring flows and water quality from groundwater mounding. • Manage surface discharge of excess water in the vicinity of springs and restrict to episodic (campaign) discharges. • Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>.
Environmental Value - Mulga woodlands	
Background	<ul style="list-style-type: none"> • Extensive mulga woodlands and shrublands are present on the stony hardpan plains below the Chichester Range.
Management objective/s	<ul style="list-style-type: none"> • Manage impacts to mulga vegetation. • Manage overland surface water flows.
Strategies	<ul style="list-style-type: none"> • Avoid (where possible) and minimise clearing of mulga vegetation. • Minimise disruption to surface flows through the appropriate design and placement of infrastructure.
Environmental Value – Species of conservation significance	
Background	<ul style="list-style-type: none"> • The following species of conservation significance have been recorded in this area: <ul style="list-style-type: none"> ○ Australian Bustard (<i>Ardeotis australis</i>) ○ Bush Stone curlew (<i>Burhinus grallarius</i>) ○ Ghost Bat (<i>Macroderma gigas</i>) ○ <i>Eremophila youngii</i> subsp. <i>lepidota</i> ○ <i>Goodenia nuda</i>

	<ul style="list-style-type: none"> ○ <i>Rhagodia</i> sp. Hamersley (M. Trudgen 17794)
Management objective/s	<ul style="list-style-type: none"> • Protect species of conservation significance and their habitat.
Strategies	<ul style="list-style-type: none"> • Limit extent of native vegetation clearing. • Undertake surveys to identify and map distributions of conservation significant species.
Environmental Value – Subterranean fauna	
Background	<ul style="list-style-type: none"> • Distinct and restricted stygofauna communities would be present.
Management objective/s	<ul style="list-style-type: none"> • Enhance understanding of local subterranean fauna.
Strategies	<ul style="list-style-type: none"> • Enhance survey effort to document presence and richness of subterranean fauna. • Develop a Fortescue Marsh Management Area subterranean fauna theme within NatureMap.

Zone 3b – Marillana Plain

Zone Description	
<p>This zone includes the extensive alluvial fans of Weeli Wolli, Coondiner and Kalgan creeks and the Fortescue River and is dominated by mulga woodlands and mixed <i>Acacia</i> shrublands. The zone comprises gravelly, sandy and gilgai surfaces principally of the Marillana, Fan and Divide land systems. The zone is subject to degradation as a result of grazing, high fire frequency and weed invasion (buffel grass).</p>	
Boundary Definition	
<p>This zone is bounded on the south by the BHPBIO railway line. The western boundary is Weeli Wolli Creek, and to the north the Marsh and Calcrete Flats zones provide boundaries. To the east the boundary is the Marble Bar Road. The mapped northern boundary should be used as a guide, with the transition from spinifex dominated grassland to Mulga woodland the preferred boundary.</p>	
Relative importance	
<p>Manage natural resources sustainably</p>	
Environmental Value – Natural water regimes	
Background	<ul style="list-style-type: none"> • Significant area for freshwater recharge to groundwater system. • Discharge of Weeli Wolli and Marillana Creek groundwater systems. • Integrity and physical function of aquifer maintains natural water balances. • Significant alluvial thickness and storage capacity within alluvial delta systems.
Management objective/s	<ul style="list-style-type: none"> • Maintain the natural flow regime at the Marsh boundary.
Strategies	<ul style="list-style-type: none"> • Excess water should be re-injected in accordance with the Department of Water's <i>Pilbara Water in Mining Guideline (2009)</i>. • Apply an independent peer review of hydrological models to support water and environmental assessments. The review should be consistent with National Water Commission's <i>Australian Groundwater Modelling Guidelines (2012)</i>. • Undertake research and monitoring to determine the extent of cumulative hydrological impacts on the Marsh.
Environmental Value – Land systems	
Background	<ul style="list-style-type: none"> • Marillana land system is restricted to the Fortescue Valley and is of conservation significance.
Management objective/s	<ul style="list-style-type: none"> • Manage impacts to the land system.
Strategies	<ul style="list-style-type: none"> • Minimise the clearing of native vegetation. • Minimise disruption to natural surface flow regimes

	through the appropriate design and placement of infrastructure.
Environmental Value – Mulga woodlands	
Background	<ul style="list-style-type: none"> • Extensive mulga woodlands, however large tracts have been subject to degradation as a result of total grazing pressure, altered fire regimes and invasion by environmental weed (buffel grass).
Management objective/s	<ul style="list-style-type: none"> • Manage impacts to mulga vegetation. • Maintain the natural overland surface water flow regime.
Strategies	<ul style="list-style-type: none"> • Avoid (where possible) and minimise clearing of mulga vegetation. • Minimise disruption to natural surface flow regimes through the appropriate design and placement of infrastructure.
Environmental Value – Species of conservation significance	
Background	<ul style="list-style-type: none"> • The following species of conservation significance have been recorded in this area: <ul style="list-style-type: none"> ○ Australian Bustard (<i>Ardeotis australis</i>) ○ <i>Atriplex flabelliformis</i> ○ <i>Calocephalus beardii</i> ○ <i>Goodenia nuda</i>
Management objective/s	<ul style="list-style-type: none"> • Protect species of conservation significance and their habitat.
Strategies	<ul style="list-style-type: none"> • Minimise native vegetation clearing. • Undertake surveys to identify and map distributions of conservation significant species.
Environmental Value – Subterranean fauna	
Background	<ul style="list-style-type: none"> • Limited data available. Possibly diverse and restricted stygofauna communities present.
Management objective/s	<ul style="list-style-type: none"> • Enhance understanding of local subterranean fauna.
Strategies	<ul style="list-style-type: none"> • Enhance survey effort to document the presence and richness of subterranean fauna. • Develop a Fortescue Marsh Management Area subterranean fauna theme within NatureMap.
Environmental Value – Aquatic invertebrates	
Background	<ul style="list-style-type: none"> • Freshwater claypan communities providing unique species support but limited data available. • Some aquatic invertebrates known only from claypans within this zone: an ostracod <i>Strandesia</i> n. sp. and the only Pilbara record of the northern Australian cladoceran <i>Dadaya macrops</i>. Only one of these claypans has been surveyed.

Management objective/s	<ul style="list-style-type: none">• Enhance understanding of local aquatic invertebrates.
Strategies	<ul style="list-style-type: none">• Enhance survey effort to document aquatic fauna within claypans.• Minimise surface discharge of excess water, especially in vicinity of claypan habitats.

Appendix A – Proposed 2015 pastoral lease relinquishment boundaries in vicinity of Fortescue Marsh

