



Barrow group nature reserves

draft management plan

2011



Department of
Environment and Conservation



Conservation
Commission
WESTERN AUSTRALIA

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**Department of Environment and Conservation
Conservation Commission of Western Australia**

Acknowledgments

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- the department's Contaminated Sites Unit and other specialist branches
- the department's Parks and Conservation Executive
- the Conservation Commission of Western Australia.

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Front cover images:

Main photo: Southerly perspective of the western coastline of
Barrow Island Nature Reserve – Photo Fran Stanley (DEC).

Other photos: Barrow Island euro (*Macropus robustus*) – Photo Kevin Crane (DEC).
A nesting flatback turtle (*Natator depressus*) – Photo Kevin Crane (DEC).

Invitation to comment

The *Barrow group nature reserves draft management plan 2011* provides an opportunity for information exchange, to express your opinion, suggest alternatives and have your say on how the area covered by the plan (Barrow, Boodie, Double and Middle islands) will be managed during the next 10 years.

Make your comments count

What to consider

In making your submission, it is important to understand that legislation and policy imposes certain obligations on the department to manage lands and waters vested with the Conservation Commission and that there may be little room to manage some issues outside of these constraints and responsibilities. Nevertheless, it is important to hear from the public about the management of these issues. There are also some issues which may have a number of management options during the life of the plan, or where the department has developed a proposal and wants to gauge public opinion about management. The department and the Conservation Commission would particularly like to seek feedback on:

- key values and threats identified in the plan
- management actions and key performance indicators mentioned through various sections of the plan
- proposed annual forum to discuss ecological management
- proposed fire management strategy
- reporting requirements
- priority areas for research.

How to make effective comments

It is important to indicate those management actions and recommendations you agree with as well as those with which you disagree. Each submission is important, but those that give reasons for concerns, give support where appropriate and offer information and constructive suggestions are most useful.

If you prefer not to write your own submission, you could make a joint submission with others. To ensure your submission is as effective as possible:

- make it clear and concise
- list your points according to the subject sections and page numbers in the plan
- describe briefly each subject or issue you wish to discuss
- say whether you agree or disagree with any or all of the desired outcomes, objectives, management actions or key performance indicators within each subject or just those of specific interest to you – clearly state your reasons (particularly if you disagree) and provide supportive information where possible
- suggest alternatives to deal with issues with which you disagree.

Where to send your comments

Submissions are welcome for two months after the release date of the draft management plan and can be made online at: www.dec.wa.gov.au or by writing to:

Planning Coordinator
Barrow group nature reserves draft management plan
Department of Environment and Conservation
Locked Bag 104
BENTLEY DELIVERY CENTRE WA 6983

How your comments will be considered

All submissions will be summarised according to topics discussed. The management plan will then be reviewed in the light of submissions, according to established criteria (see below). A summary of the submissions will be prepared along with the final management plan, including an indication of how the plan was amended or not amended in response to the submissions.

1. The draft management plan will be amended if a submission:
 - (a) provides additional information of direct relevance to management
 - (b) provides additional information on affected user groups of direct relevance to management
 - (c) indicates a change in (or clarifies) government legislation, management commitment or management policy
 - (d) proposes management actions that would better achieve objectives and desired outcomes
 - (e) indicates omissions, inaccuracies or a lack of clarity.
2. The draft management plan will not be amended if a submission:
 - (a) clearly supports proposals in the plan
 - (b) makes general statements and no change is sought
 - (c) makes statements already in the plan or were considered during the plan preparation
 - (d) addresses issues beyond the scope of the plan
 - (e) is one among several widely divergent viewpoints received on the topic but the text/management actions in the plan are still considered the preferred option
 - (f) contributes options that are not feasible (generally because of conflict with existing legislation, government policy, lack of resource capacity or lack of research knowledge to make decisions)
 - (g) is based on unclear, factually incorrect information
 - (h) provides details that are not appropriate or necessary for inclusion in a document aimed at providing management direction over the long term.

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Introduction

1. Overview

This draft management plan, prepared by the Department of Environment and Conservation (the department; DEC) on behalf of the Conservation Commission of Western Australia (the Conservation Commission), covers two nature reserves (Barrow Island Nature Reserve and Boodie, Double and Middle Islands Nature Reserve) located within the Shire of Ashburton, about 1,600 kilometres north-west of Perth and 56 kilometres west of the mainland (DEC 2007) between Onslow and Dampier (see Map 1 and section *Management plan area*). Day-to-day environmental management is undertaken by the department and industry operators¹ based on Barrow Island Nature Reserve.

The reserve is particularly valued for its:

- diverse and relatively unaltered fauna assemblage
- extensive anchialine karst system and the subterranean fauna that it supports
- important nesting beaches for marine turtles (especially the green and flatback species) and migratory shorebird species.

The planning area is also important because it contains an array of conservation significant fauna species and populations. For example, there are species that are threatened, priority-listed, endemic, short-range endemic, relictual and disjunct. Some flora species and communities are also priority-listed, at or near the extent of their range and/or are restricted in distribution within the planning area. Other important ecosystems such as intertidal mudflats, rock platforms and mangroves, rock piles and cliffs, clay pans and caves also exist. The isolation of the islands and low abundance of non-indigenous species has made the planning area an important refuge for significant components of the state's fauna.

Petroleum titles (such as production licences and exploration permits) exist over the entire planning area (except for the southern part of Double Island). Industry presence is the Barrow Island Joint Venture (BWIJV), which has produced petroleum on Barrow Island Nature Reserve since 1967 and the Gorgon Joint Venture (GJV), which began construction on Barrow Island Nature Reserve in late 2009. These operations involve large numbers of contracting organisations.

The major threats to biodiversity and other key values include land clearing, altered hydrological regimes, introduction of non-indigenous species, altered fire regimes, gravel extraction, and contamination and/or pollution.

This draft management plan acknowledges that conditional environmental approval has already been granted for the current petroleum and gas processing operations in the planning area. Hence, the purpose of the plan is not to impose additional environmental requirements on these industry operators (except where it relates to licences such as works approvals issued through the department) but to maintain a key focus of fulfilling departmental legislative responsibilities to protect the key values of the planning area and to work with GJV, BWIJV (via the relevant operator) and the Barrow Island Coordination Council (BICC)² to assist them with compliance in general environmental law and their specific environmental approvals.

¹The operator on behalf of Gorgon and Barrow Island joint ventures, any future body undertaking industry operations within the planning area and the Barrow Island Coordination Council.

²A single industrial entity established in accordance with Clause 13 of the Gorgon Gas Processing and Infrastructure Project Agreement (Schedule 1 to the Barrow Island Act 2003; the State Agreement). Its primary role is to provide coordinated management of industry-related incidents. The current BICC participants are the GJV and the BWIJV.

2. Management plan area

This management plan covers 24,070 hectares of two existing nature reserves vested with the Conservation Commission and managed by the department. They are set aside for the purpose of 'conservation of flora and fauna' and include:

- Barrow Island Nature Reserve (Reserve 11648, class A) covers an area of 23,483 hectares
- Boodie, Double and Middle Islands Nature Reserve (Reserve 38728, other than class A) covers an area of 586.7 hectares (see Map 1).

Barrow Island was originally gazetted as a class C reserve in 1908 to protect its flora and fauna. It was upgraded to a class A reserve in 1910 and in 1979 it was classified as a nature reserve. Boodie, Double and Middle Islands Nature Reserve was gazetted in 1984. Both reserves extend to low water mark³. Collectively they are known as the Barrow group and are referred to in the management plan as the 'planning area' (see Map 1).

Pasco Island is a small parcel (2.6 hectares) of unallocated Crown land located about 0.53 kilometres off the eastern coast of Boodie Island (see Map 1). This management plan proposes its addition to the Boodie, Double and Middle Islands Nature Reserve. Any reserve additions, or changes in the classification of existing reserves or the category of land, will be subject to usual government consideration and determination.

The planning area is entirely located within the 'Cape Range subregion', of the Carnarvon Interim Biogeographic Regionalisation for Australia (or IBRA) bioregion. Kendrick and Mau (2003) provide a general description of this subregion. Currently, about 17.5 per cent of the land in the subregion is managed by the department and the planning area comprises about 31 per cent of the existing conservation reserves.

Desired outcome

The planning area is protected by providing the most appropriate tenure, class and purpose available.

Management actions

1. Incorporate Pasco Island into Boodie, Double and Middle Islands Nature Reserve, subject to usual government consideration and determination.
2. Manage Pasco Island in accordance with this management plan once it becomes vested with the Conservation Commission.

³Low water mark in the planning area varies over different parts of the islands and throughout the year, causing confusion as to where the exact boundary lies. Maps in this plan show the intertidal habitat layer used in DEC 2007 to assist with management of this zone. At some point in the future, clarification of this boundary will be required to assess the level of impact upon key values resulting from petroleum and gas processing operations.

3. Other tenure and land arrangements

The department's *Management plan for the Montebello/Barrow islands marine conservation reserves 2007–2017* (DEC 2007) provided for the establishment of the adjoining Barrow Island Marine Park and the Barrow Island Marine Management Area (including the specific management zone: Bandicoot Bay Conservation Area [Benthic Fauna/Seabird Protection]⁴). This plan complements the management of these marine reserves. The Barrow Island Port Area also borders the planning area (see Map 1).

Industrial activities have the potential to impact on the ecological integrity of Barrow Island Nature Reserve. From 1967 until 2009, the BWIJV was the only permanent industry presence in the planning area. The operator is Chevron Australia Pty Ltd, and at the time of writing, its joint venture participants were Chevron (TAPL) Pty Ltd, Mobil Australia Resources Company Pty Limited and Santos Offshore Pty Ltd. The lease (L 1H R2) was renewed for a further 21 years in early 2009. The environmental management plan that is directly linked to the lease is due for review in 2011. At that time, consistency with this management plan should be considered.



Bandicoot Bay Conservation Area – Photo Kevin Crane (DEC)

⁴This area has been gazetted under the Fish Resources Management Act 1994 to high water mark as part of an order to establish fishing restrictions. Management of this area under the department's Management plan for the Montebello/Barrow islands marine conservation reserves 2007–2017 only applies seaward from low water mark. The area between low and high water mark is part of the planning area and its management is therefore addressed in section Native animals and habitats.

The BWIJV has also been issued with an *Environmental Protection Act 1986* (Environmental Protection Act) licence for oil and gas production from wells and a waste water treatment facility. This licence is renewed by the department each year subject to an audit for compliance.

The *Barrow Island Act 2003* (Barrow Island Act) primarily allows for the establishment of gas processing projects on Barrow Island, while minimising environmental disturbance. The GJV has been granted approval under the Gorgon Gas Processing and Infrastructure Agreement (the State Agreement), which is Schedule 1 to the Barrow Island Act, to establish a gas processing project that produces 15 megapascals of liquefied natural gas and 300 terra joules per day of domestic gas on Barrow Island. The gas is extracted from the Greater Gorgon Area. The GJV is to establish the project in accordance with environmental approvals granted under the state and federal government environmental legislation.

Government granted conditional environmental approval⁵ for this project to proceed in 2009. The operator for this project is Chevron Australia Pty Ltd, on behalf of GJV participants, who at the time of writing were, Shell Development (Australia) Proprietary Limited, Mobil Australia Resources Company Pty Ltd, Chevron (TAPL) Pty Ltd, Osaka Gas Gorgon Pty Ltd, Chubu Electric Power Gorgon Pty Ltd and Tokyo Gas Gorgon Pty Ltd.

In accordance with the Barrow Island Act, the GJV is required to seek appropriate *Land Administration Act 1997* (Land Administration Act) titles (that is, leases, licences or easements) for their operations. The first long term lease will be valid for a period of up to 60 years and total land tenure at any time cannot cover more than 300 hectares of previously uncleared land. Parts of L 1H R2 have been surrendered to enable the grant of Land Administration Act leases to the GJV for certain infrastructure requirements. Construction has now commenced and the first liquefied natural gas export is expected to be produced in 2014, with domestic gas by the end of 2015.

All remaining parts of the planning area (except for the southern part of Double Island) are covered by petroleum exploration permits: EP 62 R6 and EP 61 R6. Although not technically part of the planning area, activities undertaken in some offshore petroleum production licence areas (L 10 and TL/3), may also have adverse impacts on the intertidal habitat within the planning area. All existing permits relevant to the planning area are held by the same group of companies (Chevron Australia Pty Ltd, Chevron (TAPL) Pty Ltd, Mobil Australia Resources Company Pty Limited and Santos Offshore Pty Ltd).

⁵ State ministerial implementation statements (no. 748, no. 769 and no. 800) and the federal ministerial implementation statements (reference 2003/1294 and reference 2008/4178), stipulate environmental conditions with which the Gorgon Joint Venture must conform prior to, during and upon completion of its project. This includes the development of project-specific management plans, reports, systems and programs that primarily address the necessary management/mitigation actions for any ecological impacts that may be caused through its operations. It also includes the establishment of expert panels to provide specialist advice on dredging, marine turtles and quarantine.

4. Key values and threats

4.1 Key threats

The planning area:

- includes the second biggest island off the Western Australian (WA) coast
- is an important site of biological refuge because of its isolation from the mainland and some threatening processes (for example, low levels of non-indigenous species, including no vertebrates)
- contains flora species that are restricted in the planning area and/or are at the limits of their range, as well as priority-listed flora species and communities
- has a significant number of fauna species with high conservation value (for example, species that are threatened, priority-listed, endemic, disjunct, relictual, locally restricted, at the limits of their range and/or significant according to regional, national or international criteria). Some of these species include the marine turtles identified in the planning area, a variety of subterranean species such as the blind subterranean fish, eel and snake, the black-footed rock-wallaby and the Barrow Island populations of the boodie, the spectacled hare-wallaby, the euro, the golden bandicoot and the black and white fairy wren
- has an extensive hydrological karst system with a subsurface (anchialine) connection to the sea, which supports the subterranean fauna community of high conservation significance
- includes regionally and nationally significant rookeries for the threatened green and flatback turtle species
- has important habitat for migratory shorebirds and is also used by these species as a migration terminus
- contains other significant habitat values such as intertidal mudflats, rock platforms, mangroves, rock piles and cliffs, clay pans and caves
- has a fossil record that indicates local historical biodiversity and evolution
- has a history of Aboriginal and non-Indigenous use including 13 registered Aboriginal cultural heritage sites, potential for stratified heritage deposits dating back to the Pleistocene, and early non-Indigenous heritage sites probably associated with pearling
- has considerable baseline data established from long-term ecological research since the early 1900s, and particularly since the mid 1960s.



Barrow Island spectacled hare-wallaby (*Lagorchestes conspicillatus*) – Photo Dorian Moro (Chevron Australia Pty Ltd)

4.2 Key threats

Land clearing on Barrow Island Nature Reserve will result in direct and indirect loss of some vegetation and habitat. Other potential adverse impacts in the planning area include:

- altered hydrological regimes
- introduction of non-indigenous species
- large intense bushfires
- contamination and/or pollution (especially artificial lighting)
- physical barriers to fauna from infrastructure
- direct harm to fauna from operating machinery/vehicles.

Management purpose

5. Management directions

The vision for the planning area is:

By 2021, and in partnership with key stakeholders and the wider community, the department will have protected and/or enhanced the key values of the Barrow group nature reserves, while petroleum activities continue to be carried out.

6. Legislative framework

The department is responsible for administering the following key Acts:

- The *Conservation and Land Management Act 1984* (CALM Act), which provides for the management of lands and waters vested with the Conservation Commission and the Marine Parks and Reserves Authority, respectively.
- The *Wildlife Conservation Act 1950*, which provides for specific protection of native flora and fauna on all state lands and waters.
- The *Contaminated Sites Act 2003* (Contaminated Sites Act), which provides specifically for prevention, identification, registration and remediation of contaminated sites.

The Office of the Environmental Protection Authority and the department are jointly responsible for the administration of the Environmental Protection Act, which provides for environmental protection and management as well as the prevention, control and abatement of pollution or other environmental harm. More specifically, the Office of the Environmental Protection Authority is responsible for policy development, environmental impact assessments⁶ and compliance monitoring of ministerial conditions outlined in any relevant Environmental Protection Act statements of approval. The department will be responsible for matters such as clearing of native vegetation, natural resource management, pollution, licensing and works approvals. The department will also ensure proper quarantine, ecological monitoring, research and management, and ongoing development of the ecological knowledge base in accordance with its legislative responsibilities.

⁶A special arrangement has been made for assessment and approval of industry management plans required under the current ministerial conditions associated with the Gorgon gas project to be the responsibility of the department. If there are future proposed changes to the Gorgon gas project (for example, project expansion), they will be assessed via the normal process undertaken by the Office of the Environmental Protection Authority, unless otherwise determined by the Minister.

Other state and federal government legislation can:

- affect some of the department's activities
- confer specific powers on the department
- involve other authorities or agencies in activities in the planning area.

In particular, section 4 of the CALM Act stipulates that it does not derogate from any of the powers of petroleum legislation. Petroleum legislation allows industry unrestricted access to their lease/licence/permit area in order to carry out any activities necessary for the purposes of exploring for, recovering and processing petroleum resources. However, these activities are regulated by the Department of Mines and Petroleum to ensure good oilfield practice, especially with respect to any environment, safety and resource issues. State and federal ministerial conditions may also place certain management obligations upon the relevant industry body.

Key legislation relevant to the petroleum and gas processing operations on Barrow Island Nature Reserve includes:

- the *Petroleum Act 1936* (governs only the BWIJV operations)
- the *Petroleum Pipelines Act 1969* (governs construction, operation and maintenance of pipelines used during petroleum operations)
- the Barrow Island Act (ratifies and authorises implementation of the State Agreement; makes provisions for Land Administration Act tenure to be granted for gas processing project purposes and makes provisions for the disposal of carbon dioxide by injection beneath Barrow Island).

The federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides environmental protection of some (nationally and internationally significant) key values in the planning area. At the time of writing, Barrow Island Nature Reserve was listed on the Register of the National Estate for its natural heritage values. However, amendments to the EPBC Act in February 2007 will see the register phased out by 2012. Barrow, Boodie and Middle islands, with their surrounding waters and the Montebello islands and their surrounding waters, was previously nominated for listing on the National Heritage List for natural values but the nomination has recently lapsed. These lists, which are managed by the Australian Heritage Council, provide registered sites with statutory protection.

Most of the abovementioned Acts have subsidiary legislation (mainly regulations) that the management plan must conform to. The management plan is consistent or complementary to other relevant statutory documents, departmental policies, international and national conservation agreements to which Australia is a signatory (for example, international migratory bird agreements⁷) and other relevant state documents. In particular, this plan is guided by the department's *Policy statement no. 52: Management of north-west islands for conservation* (CALM 1994).

⁷CAMBA = China-Australia Migratory Bird Agreement, JAMBA = Japan-Australia Migratory Bird Agreement, ROKAMBA = Republic of Korea-Australia Migratory Bird Agreement.

6.1 Management agreements

Industry-related Memorandums of Understanding associated with the planning area are currently being prepared and they include:

- a Memorandum of Understanding between the department and Chevron Australia Pty Ltd (on behalf of the GJV) that sets out the arrangements for provision of services and facilities to enable the department to undertake its role with respect to GJV (best summarised in Clause 12 of the State Agreement)
- a Memorandum of Understanding developed between the participants of the BICC and the department that sets out the working arrangements with respect to management of emergency incidents such as introductions of non-indigenous species and escaped hydrocarbons or other pollutants.

There is also an opportunity to clarify the broader working relationships between all key stakeholders (for example, the department and Chevron [on behalf of GJV, BWIJV and BICC]), especially where legislative responsibilities potentially overlap. It is anticipated that this will assist integrated and successful management across Barrow Island Nature Reserve.

A Memorandum of Understanding also exists between the department and the Department for Regional Development and Lands in relation to the management of non-townsite unallocated Crown land and unmanaged reserves. This Memorandum of Understanding therefore applies to management of Pasco Island, until it is incorporated into Boodie, Double and Middle Islands Nature Reserve.

Desired outcome

Key values will be protected and conserved through the support and implementation of statutory and non-statutory documents.

Management actions

1. Implement this management plan in accordance with relevant statutory documents (that is, legislation) and where possible, relevant non-statutory documents such as policies, agreements and other departmental guidelines.
2. Where required, liaise with the Office of the Environmental Protection Authority to assist it with its legislative role in environmental impact assessments and compliance monitoring of ministerial conditions relevant to the planning area.
3. Promote close liaison combined with clear, integrated, well coordinated and cooperative management arrangements between all key stakeholders with legislative management responsibilities within the planning area.

7. Performance assessment

The Conservation Commission will measure the success of this plan in accordance with section 19(1)(g) (iii) of the CALM Act by using selected key performance indicators that target key components of the plan, and other mechanisms as appropriate⁸.

Some of the key performance indicators measure changes in populations. Any sustained change (that is, a continuous decrease or increase) will trigger the need for further investigation to determine the cause of that change. Some changes are naturally occurring and human intervention may not be desirable for various reasons. Other changes may be human-induced and every effort should be made to mitigate the impact. These types of key performance indicators may also require reporting on an annual (or other) basis but determining any reliable trends or outcomes may not be possible until several years of annual reporting has been undertaken. The analysis can be based on models such as control charts, where a change should be no more than one standard deviation of variation in baseline levels.

Providing suitable evidence of implementation of this management plan is essential. Data may be provided to the department by industry operators if it is available through their approved reporting, research and/or monitoring requirements to assist with trend analysis. Other information may be obtained from work carried out by the department to cover gaps in baseline data. The following are examples of evidence that could be used for this purpose:

- regular imagery photographs, mapping or figures such as graphs to show spatial and temporal changes
- checklists
- on-ground surveys
- incident investigation reports or records
- licence audit reports
- written correspondence notifying industry operators where compliance (for example with respect to quarantine management and Environmental Protection Act, Part V licences) has been achieved or where improvements in management may be required
- other written documents or forms.

Desired outcome

The department has developed systems and processes to provide evidence of plan implementation.

Management action

1. Establish and maintain a portfolio of evidence throughout the life of the plan to prove this management plan has been successfully implemented.

⁸ The key performance indicators in this plan reflect common goals of key stakeholders with management responsibilities in the planning area. Hence, achievement of these key performance indicators is largely dependent on others fulfilling their environmental management requirements. The management actions in this plan guide the department's contribution in achieving these key performance indicators. The key performance indicators do not apply where the impacts are otherwise permitted through appropriate environmental approval processes (for example, within defined disturbance footprints approved by government as part of the BWIJV and GJV operations on Barrow Island Nature Reserve). Levels at the time of plan approval provide the baseline for the performance measure, unless previous baseline information is available.

8. Administration

The day-to-day implementation of this management plan will be undertaken by departmental staff under the direction of the regional manager. Figure 1 depicts the basic process that authorises the preparation and on-ground implementation of this management plan (subject to section 4 of the CALM Act) as well as its relationship with other petroleum and gas processing arrangements.

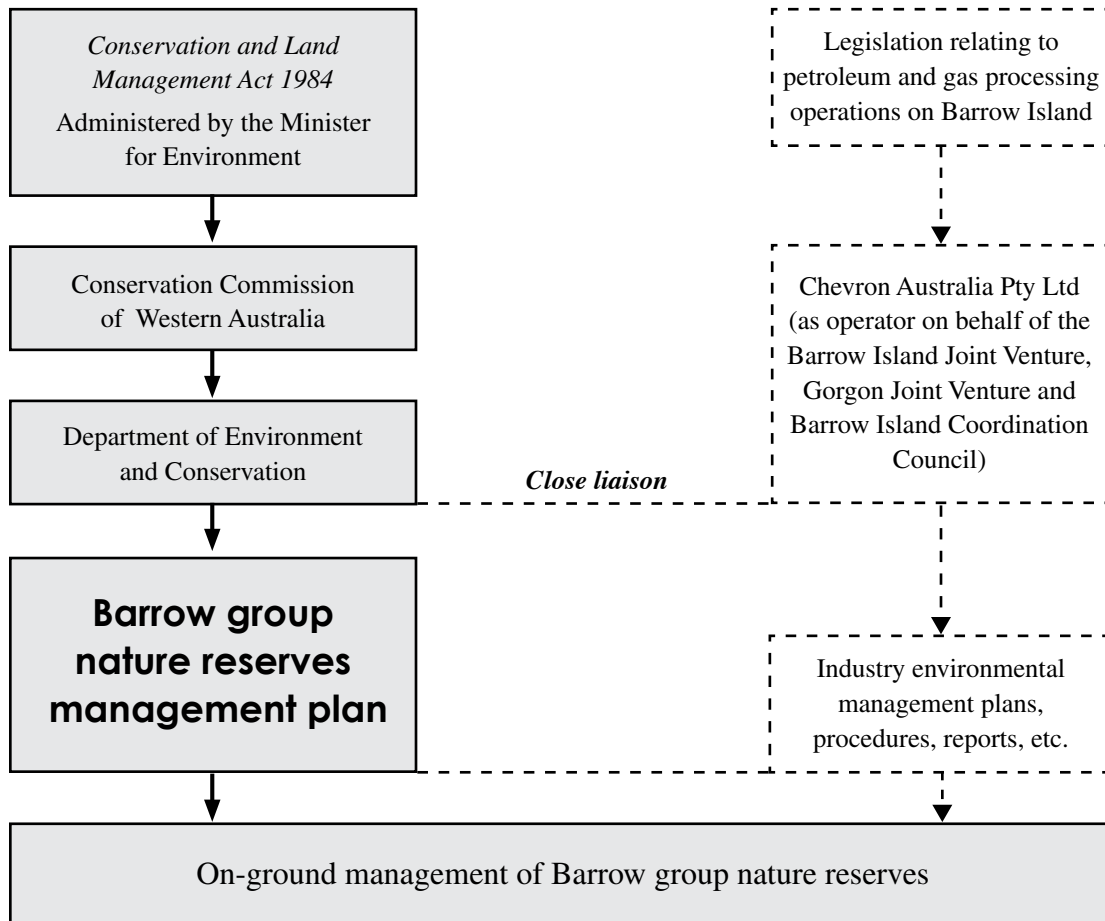


Figure 1: Hierarchical process relating to the preparation and implementation of the Barrow group nature reserves management plan.

The department also has a responsibility to undertake liaison with BICC in relation to the terms and implementation of this management plan, where it relates to the activities of the BICC participants (Clause 13 (e)(ii) of the State Agreement).

Implementation of this management plan (and other industry-related plans) may lead to:

- new knowledge and subsequently the need to apply adaptive management
- identification of gaps in knowledge that require more research.

It is proposed that an annual forum is undertaken to discuss opportunities for adaptive management and further research as well as any other issues relating to the management of key values in the planning area. Findings from this forum should be distributed to all participants in a timely manner.

In the event that GJV, BWIJV and/or BICC cease to operate, and as far as practicable, the department will continue to monitor the state of the environment over that area and respond to any high priority management issues.

Desired outcome

Successful implementation of this management plan.

Management actions

1. Incorporate best practice and adaptive management into existing management actions and key performance indicators where new knowledge and/or management techniques become available.
2. Prepare and implement (with support from GJV, BWIJV and BICC, including their willingness to actively participate⁹) an annual forum to discuss current issues in all key areas of management outlined in this plan.
3. Manage key values as outlined in this section, where petroleum and/or gas processing activities cease to operate.
4. Undertake liaison with specific bodies or individual officers (for example, the Chevron/DEC interface coordinator, BICC manager, integrated emergency response and quarantine operator, island and mainland BICC representatives, and established expert panels [marine turtle, quarantine and dredging]), where matters covered in this plan are relevant to them.

9. Term of the plan

This management plan is for a period not exceeding 10 years and comes into operation from the date that a notice is published in the Gazette. However, the plan shall remain in force until it is revoked and a new plan is approved and substituted for it. At any time, the plan may be amended in accordance with section 61 of the CALM Act.

⁹By way of the relevant joint venture operator.

Managing the natural environment

Emphasis in management of natural values in the planning area will include:

- protecting and conserving significant flora and fauna, particularly marine turtles, subterranean fauna, short-range endemic species and migratory shorebirds
- improving baseline information on biodiversity, particularly the ecology of species of high conservation significance and lesser known species, as well as the condition of currently undisturbed but vulnerable environments such as subterranean habitats
- preventing the establishment, and undertaking eradication or control, of non-indigenous species
- managing fire to protect and promote biodiversity, and to protect life
- preventing and/or remediating contamination and/or pollution
- undertaking rehabilitation of any disturbed and unused sites.

10. Physical environment

10.1 Climate change

Climate change is considered to be a factor that is likely to affect biodiversity in the long term. With little opportunity for species to migrate to more suitable habitat, the impacts of climate change upon biodiversity are expected to be more severe on WA islands compared with the mainland (Conservation Commission 2009). In particular, it is predicted that sea levels will rise, storms will be more frequent and severe and changes will occur in sea currents, temperature, rainfall, humidity and risk of large uncontrolled bushfire (Conservation Commission 2009). Being able to accurately determine that a key value has been adversely and directly affected by climate change is very difficult and unlikely during the life of this plan. Climate change will be taken into consideration when assessing key performance indicators developed for this plan (see section *Performance assessment*). If during the life of the plan, monitoring indicates that climate change could be influencing key values, the department will consider further management options.

10.2 Geology, landforms and soils

The planning area falls within the Barrow sub-basin of the Northern Carnarvon Basin. The geology, landforms and soils of Barrow Island Nature Reserve are described in detail by various authors such as Campbell et al. (1984); Crank (1973); Lewis and Grierson (1990); McNamara and Kendrick (1994); Parry (1967); Smith (1962). Only a brief description is available for Boodie (Buckley 1980; Morris 1990), Middle and Pasco islands (Buckley 1980). Information on Double Island is not well documented.

The geology, landforms and soils of Barrow Island Nature Reserve provide or support a range of ecologically important habitats including an extensive underground karst system that probably extends to a depth of more than 100 metres below sea level (Humphreys 1995), surface caves, nesting beaches, intertidal mudflats, rock platforms, cliffs, rock piles, burrows and termite mounds (see also section *Native animals and habitats*). Clay pans are an uncommon landform, with potential for undiscovered human artefacts (see section *Aboriginal heritage*). They provide episodic fresh water for native fauna and vegetation types that are geographically restricted. Limestone formations contain fossils which provide information on the area's historical biodiversity and evolution. McNamara and Kendrick (1983, 1994) present a comprehensive discussion on this key value. Deep alluvial soils within the drainage lines on

Barrow Island Nature Reserve support a variety of locally significant vegetation communities (see section *Native plants and plant communities*). Aside from such direct relationships with vegetation (including its function as a natural seed store), soils also provide habitat for mycorrhizal fungi and other soil biota. Appropriate topsoil management following clearing is essential in preparing for future ecosystem rehabilitation.

A number of activities have the potential to adversely affect the ecological values associated with the geology, landforms and soils. Contamination or pollution (see section *Waste disposal, contamination and pollution*) of the karst and soil, and direct disturbance caused through earthworks and infrastructure development, may be difficult, if not impossible to remediate. Other potential impacts include:

- loss of topsoil
- soil erosion
- compaction and/or inversion
- alteration of natural geomorphological dynamics and processes (for example, changes in beach profiles including accretion and erosion of sediment).



Barrow Island Nature Reserve has a range of ecologically important habitats including this cave at Biggada Creek which provides shelter for a group of euros during the hottest part of the day – Photo Kevin Crane (DEC)

10.3 Hydrology

The planning area has little free surface water. Pools of fresh water form on Boodie Island following heavy rain, indicating that a lens of fresh water may occur at shallow depth (P. Kendrick pers. comm. 2009). A soak with brackish water is present on the southern end of Boodie Island, but this does not have surface water unless it is excavated (Morris 1990). No more occurrences of fresh water are known for this island, or on Middle and Double islands.

Drainage on Barrow Island Nature Reserve is predominantly to the west, and only two permanent water bodies exist (Biggada Creek and a smaller creek at the Ledge). Because of the sporadic nature of high rainfall events and the high evaporation and infiltration rates, all other seeps are ephemeral, though they probably contain fresh water at shallow depth year round (Chevron Australia 2005; Osborne et al. 2000; Smith 1962). Standing water may also be found in the clay pans for short periods, because of the lower permeability of the soils in these areas (Chevron Australia 2009a; Osborne et al. 2000).



Biggada Creek – Photo Kevin Crane (DEC)

The groundwater is described as anchialine because of the subsurface connection between the unconfined

aquifer and the ocean. This system, which is often influenced by tidal fluctuations, creates a halocline where the fresh groundwater meets the denser, saline seawater (Chevron Australia 2005; Humphreys 2001), providing critical habitat for many subterranean aquatic species and communities with highly specific ecological water requirements. If the integrity of this anchialine system is disturbed, it is likely to have serious consequences for any inhabitants, especially the halocline specialists (Humphreys 1995, 2001; Humphreys and Vine 1991). Currently, the groundwater in the planning area is in good condition, except for some sites that have been registered as contaminated (see section *Waste disposal, contamination and pollution*). Such sites are being remediated by BWIJV.

Hydrological alterations may adversely affect the subterranean environment and other surrounding ecosystems, including important vegetation communities. This can occur as a result of human activities such as the construction of infrastructure and roads, abstraction of groundwater or accidental leaks or spills. Hydrological changes that may be caused by such activities include:

- contamination via surface and/or subsurface drainage, and increased risk of contamination near open conduits (such as caves or bores) to groundwater
- alterations to natural water drainage patterns, depriving some areas of water and directing water movement into other areas where it may have serious impacts (for example, caverns, leading to subsidence and sometimes collapse or increased sedimentation)
- saltwater intrusion caused by upconing of saline waters due to over-abstraction of overlying freshwater
- the disruption of interrelationships between surface and aquifer environments (for example, altering recharge rates through vegetation clearing, soil profile modification, gravel extraction or burial of concrete waste).

There is no independent regulation of water use in the planning area but licences under Part V of the Environmental Protection Act and ministerial conditions assist with groundwater monitoring requirements. Section *Water resources* discusses this aspect in more detail.

Desired outcome

Geology, landforms, soils and hydrology are protected and conserved.

Objectives

Throughout the life of the plan, work with industry operators to avoid (unless otherwise permitted through appropriate environmental approval processes) significant and adverse disturbance or alterations by maintaining:

- surface drainage and groundwater integrity
- ecologically significant landforms/geology (for example, fossil sites and important habitats)
- the quality of topsoil (for example, sediment type, nutrients, soil-borne micro-organisms and seed store) where it has been temporarily removed for development purposes.

Management actions

1. Ensure the physical environment, especially those values that provide ecological support or contain significant heritage, are not impacted by the Gorgon gas project, outside its approved disturbance footprint in the terrestrial and intertidal areas.
2. Notify industry operators when the department detects unacceptable ecological impacts upon the physical environment that may be the result of petroleum and/or gas processing activities.
3. Ensure industry operators construct and install groundwater monitoring infrastructure (such as bores) and equipment (such as automatic data logging devices) that is required as part of the approvals to undertake petroleum and gas processing operations.

Key performance indicators

Performance measure	Target	Reporting requirements
Volume and quality of groundwater at selected sites inhabited by species and communities that are likely to have highly specific ecological water requirements (for example, halocline specialist species within the subterranean environment).	No significant change in the volume and quality of groundwater	Annually
Physical disturbance of important landforms or geological and soil-based habitats such as marine turtle nesting beaches, caves, cliffs, rock piles, limestone pavements, intertidal mudflats, termite mounds, warrens and clay pans.	No physical disturbance.	Annually
Process used to stockpile topsoil removed for development purposes.	No variation from the approved process to stockpile topsoil removed for development purposes without first seeking necessary environmental approvals.	Annually
Preservation of fossils.	No loss of significant specimens (especially those that are the only representative of a species) or damage to sites with significant fossil deposits (including type sections) such as Cape Malouet.	Every five years

11. Biological environment

This part of the management plan draws largely upon species records obtained from Naturemap¹⁰ (DEC 2009a), departmental environmental impact assessments and other publications by Chevron Australia Pty Ltd and various consultants including Astron Environmental; Bamford; Biota Environmental Sciences; Buckley; Humphreys; Mattiske Environmental Consultants; RPS BBG; Trudgen. Management actions are guided by the department's *Policy statement no 9: Conserving threatened species and ecological communities* (subject to final consultation) (CALM 1996).

11.1 Native plants and plant communities

Knowledge of the vascular flora on Barrow Island Nature Reserve is comprehensive but only a basic description of the vegetation on Boodie, Middle and Pasco islands has been described in Buckley (1980).

¹⁰Naturemap is an online mapping program that consolidates many spatial records associated with the natural biodiversity across the state. It is regularly updated and available for the public to make general inquiries.

Barrow Island Nature Reserve is predominantly arid, with 377 known species (Astron 2009). The lower plants such as mosses and lichens are not well known. Mattiske Consulting (1997) and Trudgen (1989) describe the known flora of Barrow Island Nature Reserve as, for the most part, typical of the arid Pilbara region but having floral affinities with the Cape Range area, especially along the coast. Some species and vegetation types are unique among the islands on the North West Shelf (Astron Environmental 2002). *Triodia* and *Acacia* genera and families such as Poaceae, Chenopodiaceae, Papilionaceae, Malvaceae and Asteraceae dominate the flora of Barrow Island Nature Reserve (Mattiske Consulting 1997).

The planning area contains many plant species of conservation significance, including:

- one endemic species (*Cucumis* sp. Barrow Island)
- twelve species that have a restricted distribution in the planning area and are at or near the extent of their range. Fifteen additional species are restricted in the planning area but are not at or near the extent of their range and, conversely, nine species are at or near the extent of their range but are not considered to be restricted in their distribution (Astron 2009). A single stand of *Cordia subcordata* that was recorded on Boodie Island may potentially be a disjunct isolate from its range (the northern Kimberley coastline). However, it could also be the result of a previous introduction (see also section *Potential introductions*)
- three priority species – *Helichrysum oligochaetum* (priority 1), *Cucumis* sp. Barrow Island (priority 2) and *Corchorus congener* (formerly *C. interstans*) (priority 3)
- species that have a low regeneration capacity for example, (*Melaleuca cardiophylla*)
- flora species that have been either rarely collected but specimens have been catalogued (42 species), rarely collected and no specimens are catalogued (53 species) or inadequately identified (74 species).

M. cardiophylla is important because it is one of the key habitat types for some restricted fauna species, including the Barrow Island population of the black and white fairy-wren (RPS BBG and Mattiske Consulting 2005). It predominantly grows within the petroleum and gas processing sites on Barrow Island Nature Reserve (V. Long pers. comm. 2010). Historically, this species has not responded well to ecosystem rehabilitation efforts and it is one of 15 species identified as recalcitrant¹¹ (Outback Ecology 2006a; see also section *Ecosystem rehabilitation*).

Astron (2009) identified 755 vegetation associations, representing five categories¹² across Barrow Island Nature Reserve. Two flora-based ‘priority one’ ecological communities (‘Barrow Island creekline vegetation’ and ‘Coastal dune soft spinifex grassland’) have been identified. The ‘Barrow Island creekline vegetation’ has recognised conservation status because of its relative rarity, the important habitat it provides for some native fauna, and the high level of historical disturbance or loss through activities such as gravel extraction (Chevron Australia 2009a; Outback Ecology 2005; RPS BBG and Mattiske Consulting 2005). The department’s priority ecological communities list indicates that the ‘Coastal dune soft spinifex grassland’ is also highly vulnerable to gravel extraction as well as invasion by buffel grass.



Bat's wing coral tree (*Erythrina vespertilio*) is restricted in distribution on Barrow Island Nature Reserve – Photo Kevin Crane (DEC)

¹¹Species that have not naturally re-established or occur infrequently on rehabilitated sites when compared with analogue vegetation communities (Chevron Australia 2007)

¹²The five categories of vegetation associations on Barrow Island Nature Reserve are:

- 1) restricted vegetation (distribution)
- 2) restricted vegetation (flora)
- 3) restricted vegetation (distribution and flora)
- 4) restricted vegetation (botanical relicts)
- 5) other vegetation.

Macroalgae is the most common vegetation type of the intertidal zone with seagrass meadows sparsely interspersed (Chevron Australia 2009b; DEC 2007). Both provide a direct food source for green turtles, and shelter, food and/or substrate for a large variety of benthic species. These in turn become a food source for other marine turtle species such as the flatback and hawksbill (DEC 2007; Pendoley Environmental and RPS BBG 2005; and RPS BBG 2005a). One species of mangrove (*Avicennia marina*) occurs on the south and east coasts of Barrow Island Nature Reserve. It provides protection and stabilisation of the shoreline as well as habitat for fauna, including a population of the red fiddler crab (RPS BBG 2005b and RPS Environment and Planning Pty Ltd 2009).



Mangroves (*Avicennia marina*) in Bandicoot Bay Conservation Area – Photo Michelle Rumball (DEC)

One of the biggest threats to native flora and vegetation communities in the planning area is land clearing. Clearing is undertaken under an Environmental Protection Act permit (section 51C) unless an exemption listed in Schedule 6 of that Act applies or the clearing is prescribed in the Environmental Protection (Clearing of Native Vegetation) Regulations 2004. An exemption applies for the clearing of no more than 300 hectares of previously uncleared land for the Gorgon gas processing project.

Native flora and vegetation communities may be adversely affected by activities that cause:

- alteration to soil conditions (for example, loss of nutrient-rich topsoil, contamination such as hydrocarbon spills or leaks, erosion, compaction, inversion and transportation [of soil and seed] through dust)
- physical disturbance/removal of landforms and substrates
- disturbance to the condition and availability of natural water resources (for example, drainage, abstraction and/or contamination)
- vegetation composition changes through invasion of colonising native species in areas surrounding disturbance
- introduction of non-indigenous species
- altered fire regimes.

Climate change and intensive grazing of young palatable seedlings by native mammals may also threaten vegetation communities, especially at rehabilitation sites.

11.2 Native animals and habitats

The planning area is recognised as one of the most important areas for native fauna conservation in the state because its geographic isolation has resulted in an important refuge for many species that have either declined in number or become extinct on the mainland (EPA 2006). Current vertebrate species records indicate the presence of 15 mammals, 119 birds, 48 reptiles, 3 frogs and 2 subterranean fish. At least 1,319 invertebrates, including 58 subterranean species, have been identified on Barrow Island Nature Reserve. The diversity of fish inhabiting intertidal areas remains unclear but is probably high.

The planning area contains many fauna species of regional, state, national and international conservation significance, such as:

- twenty-two threatened species including the Barrow Island boodie (*Bettongia lesueur ssp.*); the Barrow Island golden bandicoot (*Isodon auratus barrowensis*); the Barrow Island spectacled hare-wallaby (*Lagorchestes conspicillatus conspicillatus*); the Barrow Island euro (*Macropus robustus*)

isabellinus); the black-footed rock-wallaby (*Petrogale lateralis lateralis*); the Barrow Island black and white fairy-wren (*Malurus leucopterus edouardi*); the green (*Chelonia mydas*), flatback (*Natator depressus*), hawksbill (*Eretmochelys imbricata*) and loggerhead (*Caretta caretta*) turtles; and a range of subterranean fauna

- four priority species: the water-rat (*Hydromys chrysogaster*) (P4); Australian bustard (*Ardeotis australis*) (P4); spear-beaked cave shrimp (*Stygiocaris stylifera*) (P4); and a subterranean blind snake (*Ramphotyphlops longissimus*) (P2)
- thirty-nine migratory shorebird species listed under international agreements (that is, JAMBA, CAMBA, ROKAMBA and the Bonn Convention)
- fifty-four birds listed as marine species under the EPBC Act
- a high number of endemic fauna species, although the exact figure is unclear
- numerous (more than 40) potential short-range endemics (SREs)¹³ (Biota Environmental Sciences and RPS BBG 2005a) predominantly consisting of reptiles, invertebrates and subterranean fauna. Some of these species are new, only known from Barrow Island Nature Reserve or only known from one or two specimens.

The planning area is well recognised for its important subterranean faunal component. It contains:

- a high species richness (significant on an international scale, especially for amphipods)
- twelve threatened, one 'priority two' and one 'priority four' species
- a 'priority one' ecological community (Barrow Island subterranean fauna), which includes a suite of occurrences across Barrow Island Nature Reserve
- some relictual subterranean species with linkages within and outside of Australia
- species previously undescribed, not known from other locations or only known from one or two specimens. Two particularly noteworthy examples of this include the blind snake (see priority species listed above) and the blind gudgeon (*Milyeringa veritas*) (a threatened species). The snake is only known from Barrow Island Nature Reserve and is potentially the first troglobitic¹⁴ reptile to be described globally. The fish is only known from two localities (Barrow Island Nature Reserve and Cape Range) and is one of only two vertebrate stygobitic¹⁵ species recorded in Australasia. A subterranean eel has also been discovered on Barrow Island Nature Reserve, but it has not been formally identified. It is likely to have conservation significance.



Styofaunal blind gudgeon (*Milyeringa veritas*) – Photo Douglas Elford (Western Australian Museum)



Barrow Island black-footed rock-wallaby (*Petrogale lateralis lateralis*) – Photo Russel Lagdon (Chevron Australia Pty Ltd)

¹³Short range endemics are generally classified by having a distribution of less than 10,000km² (Harvey 2002).

¹⁴Terrestrial species that are obligatory inhabitants of air-filled caves, cavities or interstices in the karst above the watertable (Humphreys 1995; Biota Environmental Sciences and RPS BBG 2005b and Chevron Australia 2005).

¹⁵Aquatic species that are obligatory inhabitants of water-filled cavities and interstices in the karst (Humphreys 1995 and Chevron Australia 2005)

It is anticipated that the known diversity of subterranean fauna will increase with future investigations. More detail on subterranean fauna values can be found in Chevron Australia (2005); Biota Environmental Sciences and RPS BBG (2005b); Humphreys (1993, 1995, 2001); and Humphreys and Vine (1991).

The planning area contains a number of disjunct populations. This is the result of geographic isolation and it may possibly lead to genetic differentiation. If these populations lose genetic diversity, they become more vulnerable to threatening processes, increasing the risk of local extinction. Species with restricted habitat are also at risk, especially from events such as bushfire. The Barrow Island population of the black-footed rock-wallaby is an example where both of these circumstances apply (Chevron Australia 2005).

Termites make a significant contribution to key ecological processes on Barrow Island Nature Reserve by providing habitat and a food resource for other species, as well as mobilising nutrients within the ecosystem (Chevron Australia 2005). It is unclear whether any of these roles are unique to termites (that is, whether it is a keystone species) (K. Morris pers. comm. 2008). Subterranean ecosystems on Barrow Island Nature Reserve may be at least partially dependent upon energy derived via chemoautotrophic bacterial systems metabolising petroleum-sourced chemical products. These bacteria may be considered keystone species (Biota Environmental Sciences and RPS BBG 2005b; Humphreys 2001).

The diversity of fauna has been attributed to the range of habitats available¹⁵, as well as the geographical isolation of the island. The physical environment (that is, geology, landforms, soils and hydrology) is the foundation for these habitats, strongly influencing the distribution of vegetation (RPS BBG and Mattiske Consulting 2005), and ultimately terrestrial fauna species and communities. Oceanographic and geological processes (for example, currents, waves, and tidal and sediment movements) are integral in maintaining the ecological structure and function of the six intertidal habitats (limestone platform reefs, rocky shores, sandy beaches, sand/mud flats, coral reefs and mangroves) and the distribution of their inhabitants (Chevron Australia 2005; DEC 2007).

Some of the sandy beaches contain regionally significant rookery sites for two species of marine turtle (green and flatback), and its intertidal habitats are important for foraging juveniles, nesting females and/or those adults that appear to be resident (Chevron Australia 2009c; DEC 2007; Kendrick and Mau 2003). The national *Recovery plan for marine turtles in Australia* identifies the planning area as critical habitat to the survival of these species (DEH 2003). The planning area represents the south west extent of nesting of the flatback turtle. Hawksbill turtles are regular breeders and loggerhead nesting is only occasional.

The coastline of Barrow Island Nature Reserve is also recognised for its regional, national and international significance for migratory shorebird species. It is considered to be the range extent (terminus) for some species and the area between Town Point and Bandicoot Bay supports the majority of littoral bird species using the island. In recognition of this, Bandicoot Bay has been designated a conservation area (see also section *Other tenure and land arrangements*). The planning area is also equal tenth among the 147 important sites for migratory waders in Australia, the fourth and fifth most important site in Australia for the grey-tailed tattler and ruddy turnstone, respectively, and it is regionally significant for two other bird species (Bamford and RPS BBG 2005). Double Island is considered a regionally significant site for the breeding of wedge-tailed shearwaters (*Puffinus pacificus*). Other species such as the bridled tern and white-bellied sea eagle have also been observed breeding at these sites (Bamford and RPS BBG 2005). Buckley (1980) also noted a number of seabird nesting sites on Middle, Boodie and Pasco islands.

¹⁵Butler and Buckley have described eight major habitats for Barrow Island: 1) marine; 2) tidal; 3) creek or seasonal drainage lines; 4) coastal complex and dune system; 5) flats; 6) clay pans; 7) limestone ridges; and 8) valleys slopes and escarpment slopes (CALM 1999 and Outback Ecology 2005). On a finer scale, Outback Ecology 2005 lists specific animal habitat preferences for Barrow Island Nature Reserve.

Other important habitats include the karst system that extends throughout the majority of the planning area, supporting significant subterranean species and communities, and shelter habitats such as cliffs and rock piles important as refuges for fauna and fire-sensitive flora.

The department has concerns about the potential impacts that natural processes and anthropogenic activities may have upon the local marine turtle populations. This management plan only deals with terrestrial impacts¹⁶ (except where marine impacts occur in the intertidal zones), but when combined with marine impacts, the consequences, although unknown, are potentially severe, particularly with respect to the flatback turtle population. Publications by Pendoley Environmental, the department (DEC 2009b) and Chevron Australia (2009c) provide comprehensive information on the threats facing marine turtles. Below is a summary of those relevant to the planning area.

- Artificial lighting (onshore and offshore) – this has the potential to alter nesting behaviour, increase predator visibility, cause hatchlings and nesting females to move in the wrong direction (misorientation) or interfere with the marine turtle's ability to orient in a constant direction, including swimming (disorientation or entrapment) (Witherington and Martin 1996).
- Unplanned release of chemicals or oil into the environment – this can directly affect the viability of eggs and/or the health of hatchlings, adult turtles or the intertidal environment upon which turtles depend for food.
- Dredging – this can alter the condition of, or cause direct loss of species and/or communities inhabiting, intertidal areas upon which turtles depend for food and shelter, as well as cause the death of individual turtles through interaction with the dredge equipment.
- Noise and vibration – this can alter nesting behaviour or disturb nests (including the destruction of eggs).
- Direct disturbance by people or vehicles – this can alter nesting behaviour or cause nests to be disturbed (including the destruction of eggs).
- Accumulation of dust – this can alter nest temperature and sand cohesion, preventing hatchlings from emerging.
- Construction and/or physical presence of coastal infrastructure (for example, gas feed pipelines and jetties) – this can alter beach profiles, leading to the disturbance of existing nests (potentially uncovering them) and effect nesting suitability as well as restricting movement, causing entrapment and/or ultimately changing population status.
- Introduction of diseases such as fibropapillomatosis.
- Climate change – this has the potential to influence nest conditions or disturbance (due to erosion from more frequent and severe weather events and increased temperature), create gender imbalance (given that increased temperature favours females), affect the suitability of nesting beaches (due to loss from rising sea levels or erosion) and subsequently nesting behaviour, and alter the condition of foraging grounds (that is, loss of food source that has been impacted by climate change).

Other native fauna, faunal communities and habitats are also vulnerable to impacts causing unnatural behaviour (of fauna), injury (of fauna), destruction (of fauna and habitat) and/or physical alteration (of habitat). These threats are discussed in more detail in other sections of this plan.

Although biodiversity is relatively well known for Barrow Island Nature Reserve, a number of knowledge gaps still exist, particularly in the biology and ecology of some native species, communities and/or habitats. In addition, an assessment of the cumulative impacts of petroleum and gas processing activities is yet to be undertaken. Knowledge levels are even lower for the smaller surrounding islands (Boodie, Double and Middle islands). To assist in addressing these issues, a more comprehensive species and habitat inventory needs to be completed. Particular requirements for this inventory and other research priorities are detailed in section *Reporting, research and monitoring*.

¹⁶In partnership with industry operators, the department will manage the ecological impacts upon the marine environment (including marine turtles) in accordance with its management plan for the Montebello/Barrow islands marine conservation reserves (DEC 2007) and other relevant industry environmental management plans.



A flatback hatchling – Photo Kevin Crane (DEC)

Desired outcome

Native species, communities and habitats are protected and conserved.

Objectives

Throughout the life of the plan, work with industry operators to avoid (unless otherwise permitted through appropriate environment approval processes) significant and adverse disturbance or alterations to:

- important local populations and communities of native flora and fauna
- important habitat types (other than those identified in the section *Physical environment*).

Management actions

1. Ensure the biological environment is not impacted by the Gorgon gas project, outside its approved disturbance footprint in the terrestrial and intertidal areas. Particular focus will be given to:
 - the ‘Barrow Island creekline vegetation ecological community’
 - the ‘Coastal dune soft spinifex grassland ecological community’
 - migratory shorebird populations, especially between Bandicoot Bay and Town Point
 - local marine turtle populations, especially with respect to light, noise and dredging-related activities
 - species potentially restricted to areas of disturbance
 - species listed for special protection by the state and federal governments
 - other conservation significant species, communities and biological-based habitats (for example, mangroves and coral reefs in the intertidal areas) including those considered to have low tolerance for change.
2. Notify industry operators when the department detects unacceptable ecological impacts upon the biological environment that may be the result of petroleum and/or gas processing activities.
3. Ensure that others do not carry out unauthorised clearing and in particular maintain an independent record of areas that have been cleared of vegetation.
4. Collaborate with industry operators to determine an appropriate response to wildlife incidents.
5. Ensure management of Bandicoot Bay Conservation Area is consistent with the department’s *Management plan for the Montebello/Barrow islands marine conservation reserves 2007–2017*.

Key performance indicators

Performance measure	Target	Reporting requirements
Area comprising the 'Barrow Island creekline vegetation' and 'Coastal dune soft spinifex grassland' ecological communities.	No decrease in area.	Annually
Number and diversity of migratory shorebirds using Town Point to Bandicoot Bay as habitat and foraging grounds.	No sustained decrease in the number and diversity.	Annually
Number of flatback and green turtles nesting in the planning area.	No sustained decrease in the number.	Annually
Percentage of flatback and green turtle hatchlings emerging from nests in the planning area and reaching the ocean successfully.	No sustained decrease in the percentage.	Annually
Number of species and/or communities only found on Barrow Island Nature Reserve.	No loss of populations of species and/or occurrences of communities.	Annually
Recruitment within populations of threatened, priority and other conservation significant species and communities in the planning area.	No sustained decrease in the recruitment levels.	Every five years
Area comprising biological-based habitats such as mangroves and coral reefs within the intertidal area.	No sustained decrease in the area.	Every five years

12. Protecting the natural environment

12.1 Non-indigenous and other problem species

Non-indigenous species can be introduced via a range of pathways including vessels/aircraft carrying contaminated clothing, food and other materials such as personal luggage, plant, vehicles and machinery, floating debris and wind. Non-indigenous fauna may also fly or swim into the planning area. Introduction of non-indigenous species is the single biggest threat to biodiversity in the planning area because:

- they have a wide range of adverse impacts upon native ecosystems (for example, species competition and predation, and modification of ecosystem structure, function and composition)
- they are difficult and expensive to manage, given that they can spread and reproduce quickly, and despite having stringent quarantine procedures in place, it is still possible that seeds, insects and micro-organisms may be undetected until a significant population has established
- native island populations intrinsically experience local extinctions, especially those with low genetic diversity or restricted habitats. Disturbance caused by the presence of non-indigenous species is likely to exacerbate this occurrence.

A low level of non-indigenous species have established in comparison to other areas of conservation estate. Most of these species are currently in disturbed areas (Chevron Australia 2009d). The risk of introductions will substantially increase with large-scale mobilisations to Barrow Island Nature Reserve, such as those required for the Gorgon gas project.

Determining the origin or cause of an introduction has always been difficult, resulting in confusion about management responsibilities and liabilities. GJV has committed to the establishment and implementation of a Quarantine Management System that incorporates the entire planning area. The Quarantine Management System includes assessment processes for prioritising environmental weeds in relation to the risk of introductions (past and present) and subsequent management. Both joint ventures are required to comply with the Quarantine Management System and the department will also operate in accordance with it, except where immediate access may be required in an emergency (see sections *Legislative framework* and *Access*). The department is responsible for undertaking full-time audit of quarantine management in the planning area.

The GJV and BWIJV participants have agreed that the GJV operator will be the BICC manager and the integrated emergency response and quarantine operator, with responsibility for emergency response to, and where necessary, remediation of any suspected or actual breach of quarantine in the operations of any of the BICC participants. Responsibility for ongoing response and remediation in respect of such incidents will generally be handed over to the operator of the joint venture that has the tenure over the area where the incident occurs.

In accordance with the arrangements set out in the Gorgon/DEC Memorandum of Understanding, the department will liaise with the Chevron person in charge where it considers that a quarantine breach has occurred, and if it is involved in a quarantine incident, it will inform the Gorgon interface coordinator.

Imbalances in natural ecosystems can result in problem species¹⁷ that cause similar impacts to non-indigenous species (see above). If such a situation arises, it will need to be controlled where the risk to other native species becomes unacceptable.

Environmental weeds

Twenty-eight non-indigenous vascular plant species have been recorded on Barrow Island Nature Reserve. Thirteen species were present in 2009 (V. Long pers. comm. 2010).

Kendrick and Mau (2003) note that buffel grass (*Cenchrus ciliaris*), found on Barrow and Boodie islands, is the species of highest concern because of its known major impact upon island vegetation communities. New populations and expansion of known populations have recently been detected on Barrow Island Nature Reserve. There is a high risk that this species will spread further. Control of buffel grass will continue to remain a high priority.

Kendrick and Mau (2003) also identify kapok (*Aerva javanica*) as a species that has been difficult to eradicate from Middle Island and as such remains a high priority for surveillance and control.

¹⁷In the context of this plan, the term 'problem species' refers to a native species that has become unnaturally high in number and/or is causing severe adverse impacts on the surrounding natural environment.

Animals

Barrow Island Nature Reserve is particularly noteworthy for being the biggest land mass in Australia (and possibly the world) with no extant non-indigenous vertebrates. Thirteen non-indigenous invertebrates and seven other unconfirmed non-indigenous invertebrates have been recorded, including tramp ants (Chevron Australia 2009d). Historically black rats, house mice, honey bees, wasps, frogs and rock rats have all been introduced to the planning area, but have since been successfully eradicated (Chevron Australia 2005).

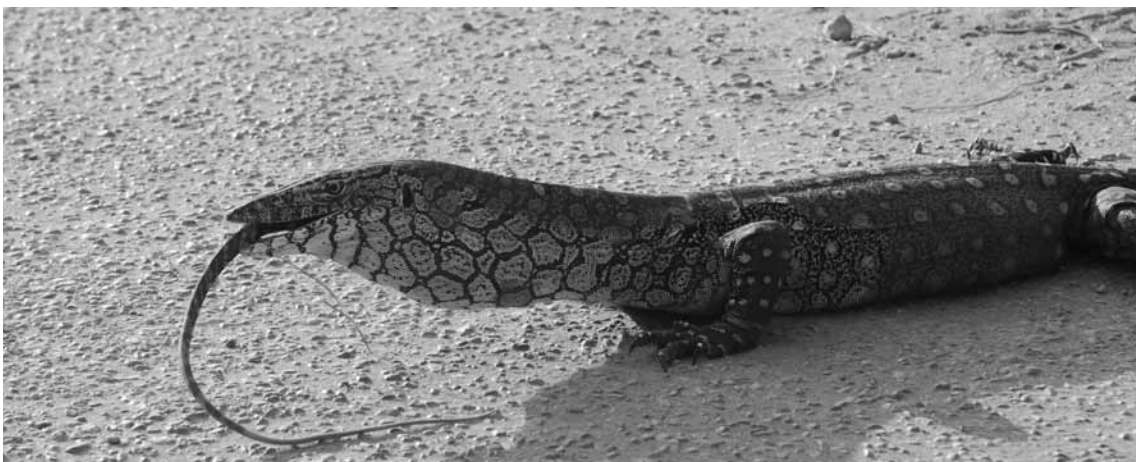
The native perentie (*Varanus giganteus*) and golden bandicoot (*Isodon auratus barrowensis*) are known to predate on turtle (and sometimes shorebird) eggs. While the local marine turtle and shorebird populations are able to withstand such natural predation, the cumulative impact when combined with petroleum and gas processing activities is expected to be more severe. For example, artificial lighting close to nesting beaches could reduce survivorship among turtle hatchlings that would otherwise survive natural predation because predator visibility is increased and there are higher occurrences of misorientation/disorientation. Management actions associated with reducing lighting impacts are addressed in sections *Native animals and habitats*, *Waste disposal, contamination and pollution* and *Accommodation and infrastructure*.



Barrow Island golden bandicoot (*Isodon auratus barrowensis*) feeding on turtle eggs – Photo Kevin Crane (DEC)

Petroleum and gas processing activities also have the potential to promote problem animals by providing scavenging opportunities where food wastes have been disposed of inappropriately, or through free water supply (see section *Waste disposal, contamination and pollution*).

Some native fauna species may intensively graze on particular native plants and/or plant communities, creating problems in other areas of management such as ecosystem rehabilitation.



Perentie (*Varanus giganteus*) feeding on another perentie – Photo Fran Stanley (DEC)

Diseases

There is potential for non-indigenous pathogens or diseases to be introduced. Adams and Fenwick (2004) and Shivas (2005) discuss diseases (with the exception of those associated with birds because control of this pathway is limited) that have the highest potential to occur. Marine turtles are vulnerable to the potential introduction of fibropapillomatosis, a debilitating neoplastic disease found in all major oceans and is commonly linked to heavily polluted coastal areas.

Potential introductions

One species native to the mainland (*Cordia subcordata*) unexpectedly occurs on Boodie Island (Morris 1990), which suggests that it has either been introduced or it represents the southern and western most extent of its range (see also section *Native plants and plant communities*).

Desired outcome

Minimal impacts of non-indigenous species on key values.

Objectives

Throughout the life of the plan, work with industry operators to:

- prevent new introductions
- progressively reduce in number, area and extent of distribution, existing non-indigenous species occurrences.

Management actions

1. Undertake quarantine audit as required, and at any time, including:
 - overseeing, or participating in, investigations and reporting of quarantine breaches and incidents
 - informing the BICC manager periodically of compliance or when the department is of the view that improvements in quarantine management are needed.
2. Liaise with the BICC manager to ensure the department is kept up-to-date on changes to quarantine plans and procedures.
3. In the event that the GJV operator fails to eradicate non-indigenous species, and with support from GJV including the provision of funding, implement control measures with a priority for those non-indigenous species with new populations or that are likely to have high species invasiveness, distribution and/or environmental impact.
4. Collaborate with industry operators to arrange regular species health checks and opportunistic examinations on deceased animals to identify the presence of any non-indigenous pathogens.
5. Conserve but prevent spread of the *Cordia subcordata* population on Boodie Island, unless it is confirmed during the life of the plan to be an environmental weed.

Key performance indicators

Performance measure	Target	Reporting requirements
Number, area and wider distribution of non-indigenous species populations.	A progressive reduction in number, area and wider distribution.	Annually
Number of introductions determined to be the result of non-natural causes.	No new introductions.	Annually

12.2 Fire

The vegetation of Barrow Island Nature Reserve is dominated by highly flammable spinifex (*Triodia spp.*) vegetation communities (Muller 2009). Boodie, Double and Middle Islands Nature Reserve supports much less *Triodia* vegetation. Records indicate a low incidence of bushfire on Barrow Island Nature Reserve, but reliable records have only been kept since petroleum activities began in the mid 1960s. No prescribed burning has taken place, and fires (caused mainly by lightning strikes, electrical malfunction or accidental ignition) have been suppressed and limited to only relatively small areas (CALM 1999).

The most recent major bushfire on Barrow Island Nature Reserve was recorded in 1961, in which about 90 per cent of the island was burnt (CALM 1999). The fire history of Boodie, Double and Middle Islands Nature Reserve is unknown.

Muller (2009) provides an analysis of the bushfire risk for Barrow Island Nature Reserve and below is a summary of the key findings.

- Large areas of Barrow Island Nature Reserve contain some of the densest *Triodia* fuels in the north-west. In such high fuel loads and despite the resources available, little success of direct attack suppression would be expected if a bushfire occurred under severe fire weather conditions (that is with an intensity of more than 20,000 kilowatts per metre). It would probably be impossible to control and therefore all fire-sensitive values downwind would be threatened.
- Rapid response and effective initial attack is paramount in suppressing bushfires.
- If additional resources from the mainland are required, they will almost certainly not arrive in time to contribute effectively.
- Suppression capability will be diminished when bushfire occurs outside the oilfield area.
- The risk of ignition is low.
- High value human assets occur at moderate densities, however high value and potentially fire regime-specific biodiversity assets occur at high density across Barrow Island Nature Reserve.

Biodiversity

Bushfire in the heavily fuelled landscape of Barrow Island Nature Reserve could result in direct loss of plants, animals and communities, clearing of habitat and increased vulnerability to soil erosion and loss of topsoil (seed bank). Most importantly, there is potential for a very large proportion of Barrow Island Nature Reserve to burn and, combined with its geographic isolation, this presents a considerable risk for the majority of native plants, animals and communities in the planning area.



The dense spinifex vegetation communities of Barrow Island Nature Reserve have the potential to fuel high-intensity island-wide bushfires – Photo Kevin Crane (DEC)

While Casson (2003) provides a more detailed discussion on the relationship of bushfire and spinifex ecosystems on Barrow Island Nature Reserve, fire ecology on Boodie, Double and Middle Islands Nature Reserve is not well understood. Fuel loads are not as high as Barrow Island Nature Reserve, and vegetation communities are both patchy and do not usually contain highly flammable *Triodia* hummock grass. Vegetation may also be salt laden, reducing its flammability. Despite these characteristics, biodiversity values can be adversely impacted depending on the size of the area burnt, the intensity of the bushfire and the weather conditions (P. Kendrick pers. comm. 2009).

It is unclear what unique benefits bushfire provides in maintaining biodiversity in the planning area. However, it has been suggested that it can influence nitrogen availability (see section *Ecosystem rehabilitation*) and although spinifex communities persist in long unburnt environments, it may also enhance the rate of spinifex regeneration (Casson 2003). Observations suggest that many palatable species are selectively grazed from burnt areas, to the point of local extinction. Rehabilitation trials have shown that palatable species will recover only when mammal grazers are excluded (P. Kendrick pers. comm. 2009).

Life and asset protection

Large fires pose a risk to human safety on Barrow Island Nature Reserve. They also pose a risk to infrastructure because it is expensive, dispersed across the island and flammable in nature. An oilfield network of roads containing many dead-ends and off-road obstacles such as flow lines, water mains, electrical cables and rugged terrain, could lead to entrapment of personnel in the event of a major fire.

Muller (2009) identifies human assets and associated risks from fire on Barrow Island Nature Reserve but the report did not consider the Gorgon gas project in its analysis because it had not been approved at the time. The Gorgon gas processing plant and associated facilities will be an additional risk once development has occurred but the major threat to human life and property will remain within the BWIJV oilfield.

A major fire within the oilfield may present indirect risks to fauna and flora. For example, glass-reinforced epoxy flowlines will burn under intense fire conditions (as observed in the M-Station fire, 2003: P. Kendrick pers. comm. 2008), resulting in contamination and/or pollution of the surrounding environment from pipeline contents and burn products.

The department has legislative responsibilities under the CALM Act and *Bush Fires Act 1954* to undertake bushfire management (that is, fire prevention and suppression) on lands that it manages. Bushfire management would normally be guided by the department's *Policy statement no. 19: Fire management policy* (CALM 2005b), code of practice for bushfire management (DEC 2008a), relevant bushfire management guidelines and advice from specialist departmental staff. The department has had little involvement in fire management on Barrow Island Nature Reserve in the past because of practical and legislative constraints. Furthermore, there is some uncertainty regarding liabilities in the event that a bushfire results in environmental harm or damage to infrastructure or persons.

It is proposed that the department will develop an integrated fire management strategy for the whole of Barrow Island Nature Reserve in consultation with BWIJV, GJV, Chevron Australia Pty Ltd, BICC, the Department of State Development, the Department of Mines and Petroleum and the Conservation Commission. The *Gorgon fire management plan* would be a subsidiary document attached to this strategy. A comprehensive bushfire threat analysis is proposed as the basis upon which risks are documented, with the preliminary work of Muller (2009) to be used as a starting point. The strategy will aim to protect human life, infrastructure and biodiversity from fire. It will also clarify roles and responsibilities of key stakeholders including defining the department's role of 'lead agency' and the BICC role of 'fire coordinator' as designated by the state Ministerial approval statement 800.

Bushfire management (including prescribed burning and bushfire suppression) on Boodie, Double and Middle Islands Nature Reserve is not considered a high priority and will only be undertaken if the risk to key values becomes unacceptably high.

Desired outcomes

1. Biodiversity is protected from harm caused by bushfire.
2. Humans are protected from uncontrolled fires.

Management actions

1. Develop and implement a single, integrated Barrow Island Nature Reserve fire management strategy.
2. As far as possible and practicable, suppress bushfires where the risk to biodiversity on Boodie, Double and Middle Islands Nature Reserve becomes unacceptably high.

12.3 Waste disposal, contamination and pollution

Petroleum and gas processing activities produce a variety of wastes¹⁸ that require disposal. Some of the key documents that guide management of industrial solid, liquid and hazardous waste include Chevron Australia (2007, 2009e, 2009f, 2009g, 2009h, and 2009i) and RPS BBG (2007). State and federal Ministerial conditions apply to GJV's waste management, including the specific requirement for at least 80 per cent of the reservoir carbon dioxide removed during its gas processing operations to be trapped and disposed of via deep well injection.

Accidental spills and inappropriate historical oilfield practices in petroleum production, waste disposal and storage of dangerous goods have already resulted in soil, groundwater and coastal contamination over some areas of Barrow Island Nature Reserve. Contamination¹⁹ and/or pollution²⁰ are high risk events, particularly with regard to potential impacts upon subterranean and marine environments. Generally speaking, contamination differs from pollution in that it is restricted to a medium such as land or water (that is, it does not include light or noise emissions) and it does not necessarily (although it can) result in environmental harm. There is potential for both events to occur and thus, both terms are used in this plan.

The department's Contaminated Sites Unit maintains a register of contaminated sites across the state. No contaminated sites are registered on Boodie, Double and Middle Islands Nature Reserve. Thirteen contaminated sites have been registered for Barrow Island Nature Reserve including the terminal tanks, the airport, processing infrastructure such as separator stations and along flowlines (DEC 2008b). A large number of additional contamination incidents have not been captured in the register, because they are relatively small and easily remediated. All existing sites of contamination have originated from BWIJV operations on Barrow Island Nature Reserve.



Terminal tanks on the east coast of Barrow Island Nature Reserve near Town Point – Photo Fran Stanley (DEC)

The potential impacts upon karst environments (including its inhabitants) and the extent of environmental harm has not yet been determined, although it is likely to be serious. Currently, it is understood that key factors in relation to the impacts of hydrocarbons on species and communities include oxygen removal or smothering (S. Appleyard pers. comm. 2008) and toxicity (Battelle 2007). Therefore it is necessary to remove as much of the contaminants as possible.

BWIJV has a monitoring and mitigation program in operation for existing contaminated sites on Barrow Island Nature Reserve. Remediation is

undertaken by implementing oil recovery processes such as manual, absorbent, vacuum or skimmer recovery, as well as mechanical collection and trenching. Remediation efforts are limited where contaminants are in close proximity to infrastructure and generally involve less disruptive methods such as monitoring and attempting to enhance *in situ* natural remediation through chemoautotrophic bacterial systems (see section *Native animals and habitats*). RPS BBG (2007) gives a brief description of each of these processes. A bioremediation facility also exists on Barrow Island Nature Reserve to assist with hydrocarbon-contaminated soil remediation. However, the department has uncertainties with its construction, holding capacity and current operational status (K. Laszig pers. comm. 2009).

¹⁸Defined in the Environmental Protection Act

¹⁹Defined in the Contaminated Sites Act

²⁰Defined in the Environmental Protection Act

The BWIJV is also replacing its carbon steel flowlines with glass-reinforced epoxy flowlines, which are less likely to leak through corrosion. However the department believes that this could represent another contamination risk because glass-reinforced epoxy flowlines are vulnerable to fire (see section *Fire*).

A significant increase in light emissions along important marine turtle nesting beaches and in intertidal areas, is expected to result from flaring and lights on the Gorgon gas processing plant, associated infrastructure and vessels (Chevron Australia 2005). Chevron (2009c) and the department (2009b) have described the potential impacts that artificial lighting may have on populations of flatback turtles. Some of the key lighting impacts may include:

- misorientation or disorientation of hatchlings (on land and in water)
- increased vulnerability to predation in high visibility conditions
- abnormal nocturnal behaviours
- attempts by gravid female turtles to nest at sub-optimal sites, or shed their eggs at sea.

Shorebird populations, including those breeding on Double Island, may also be affected by lighting impacts (Bamford and RPS BBG 2005; Chevron Australia 2008, 2009a). The majority of lighting impacts are expected to occur as a result of the GJV gas processing operations. Management of lighting impacts has been addressed through the environmental approvals process and subsequent environmental management plans.

Noise and vibration may impact on fauna movement and behaviour as well as cause the destruction of eggs and nests. Disposal by deep well injection, including geosequestration of carbon dioxide, may impact on subterranean fauna and karst habitat if there is a leak or if unpredicted migration of the gas or other disposed material occurs. Other waste management actions that may lead to pollution incidents include contamination of the intertidal zone through discharge of brine, treated wastewater and accidental leaks, atmospheric emissions and dust, littering and inappropriate disposal of food scraps.

Any person, company or other entity that causes pollution or contamination is primarily responsible for remediation of the site, and where possible, to the standard outlined in section *Ecosystem rehabilitation*. In the initial stages, the BICC is responsible under the State Agreement for planning and coordinating the BICC's role in emergency response to and undertaking where necessary, remediation of escape of hydrocarbons or other pollutants from the operations on Barrow Island of any of the BICC participants. The BWIJV and GJV have agreed that the responsibility for ongoing response and remediation, where necessary, will generally revert to the operator of the joint venture that holds the tenure where the incident has occurred. The department is responsible for the same in all other circumstances.

The department administers state legislation that governs contamination and pollution management (see section *Legislative framework*). In particular, the department oversees waste disposal and issues prescribed premises licences. BWIJV has a prescribed premises licence for oil and gas production from wells, and operation of a sewage facility – Licence Number 4467. GJV has a prescribed premises licence for operation of a sewage facility – Licence Number 4602, and it will also likely be issued a prescribed premises licence for oil and gas production in the future. These prescribed premises licences are re-issued annually if the department determines that compliance has been achieved by the relevant joint venture. The department also oversees remediation efforts of contaminated or polluted sites and this has been done in the past via review of reports submitted to the department by the BWIJV, and the conduct of an annual external audit.

Other legislation also applies to prevent contamination from petroleum infrastructure such as pipelines. The Department of Mines and Petroleum is responsible for administering this legislation and also conducts an annual external audit that includes overseeing pipeline maintenance. The Department of Transport is responsible for shipping activities in state waters and in regard to oil spills a state-wide *Oil Spill Contingency Plan* (Department of Transport 2000) exists. Documents such as the environmental management plan associated with the BWIJV lease agreement and relevant industry environmental

management plans required under the state and federal Ministerial approval statements assist in preventing the occurrence of contamination and/or pollution, and stipulating remediation requirements if an incident does occur.

Desired outcome

Key values are protected from inappropriate waste disposal and occurrence of pollution and/or contamination.

Objectives

Throughout the life of the plan, work with industry operators to:

- prevent new incidents of contamination and/or pollution
- progressively remediate existing sites of contamination and/or pollution
- maintain appropriate records of contamination and/or pollution.

Management actions

1. Monitor industry operator compliance of the Environmental Protection Act (including associated licences) and the Contaminated Sites Act with respect to waste and escaped pollutants.
2. Liaise with the BICC manager to ensure the department is updated on changes to plans and procedures for emergency response to escaped pollutants.
3. Notify industry operators of environmental compliance or when the department detects unacceptable ecological impacts that may be caused by inappropriate waste management, contamination or pollution associated with petroleum and gas processing activities.
4. Report, and encourage others to report, contamination and/or pollution incidents in accordance with section *Reporting, research and monitoring*.
5. Support others in undertaking research trials associated with alternative remediation techniques (for example, use of chemoautotrophic bacterial systems to remove hydrocarbons, especially in locations close to infrastructure).
6. Prevent, and respond (where prevention fails) to, any occurrence of non-industry-related contamination and/or pollution incidents.
7. Ensure the remediation costs of contaminated and/or polluted sites are borne by those responsible for the disturbance.

Key performance indicators

Performance measure	Target	Reporting requirements
Number of new contamination and/or pollution incidents.	No new contamination and/or pollution incidents.	Annually
Status of remediation at existing contaminated and/or polluted sites (including migrating plumes).	A progressive decrease in the concentration and/or extent.	Annually
Level of detail and currency of information associated with the planning area on the Register of Contaminated Sites.	The Register of Contaminated Sites is adequately maintained.	Annually

12.4 Ecosystem rehabilitation

In accordance with the principles stated in *Policy statement no. 10: Rehabilitation of disturbed land*, it is the department's first preference to avoid significant disturbance to any natural environment. Where disturbance does occur, for example following clearing, ecosystem rehabilitation should be considered (CALM 1986). GJV and BWIJV have committed to rehabilitation of disturbed areas upon decommissioning. GJV will also undertake, at the request of the department, rehabilitation at any site outside its disturbance footprint where fire relating to its operations occurs. Ecosystem rehabilitation on Barrow Island Nature Reserve has already commenced over an area of 236 hectares (since records began in 1990) and has included decommissioned gravel pits, well sites and roads (Chevron Australia 2007; Outback Ecology 2007).



Ecosystem rehabilitation is already progressing over some cleared and unused areas of Barrow Island Nature Reserve – Photo Michelle Rumball (DEC)

The necessity for, and complexity of, ecosystem rehabilitation varies according to the type and extent of disturbance. In some cases natural regeneration, with little or no intervention, may be preferred. Regardless of the method used, success will be measured by assessing information on physical values such as water, nutrients, top soil and organic matter, against completion criteria derived from key ecological processes which evaluate ecosystem function. Remote sensing at appropriate resolution is valuable for demonstrating overall outcomes, but programs may require additional information such as targeted fauna survey to demonstrate full ecosystem rehabilitation.

State and federal ministerial conditions for long-term rehabilitation of disturbed sites require that such sites are:

- self-sustaining
- comparable to, compatible with, and able to be managed as part of, surrounding areas
- as close as practicable, to the pre-disturbance biodiversity and ecosystem functional values
- consistent with the objectives of a class A nature reserve
- re-colonised by key species and communities that were originally displaced when the site was disturbed.

Additional considerations include application of fire (an important process in nutrient flows and availability), which in turn is important for vegetation and ecosystem development (Outback Ecology 2006b, 2007). Absence of fire from the planning area may reduce the occurrence of palatable natural regeneration, contributing to increased grazing pressures at rehabilitation sites (Outback Ecology 2007).

Outback Ecology (2006a) has identified 15 recalcitrant species in the planning area. For example, domination by *Triodia angusta* in rehabilitated communities on Barrow Island Nature Reserve is apparent, with a reduced rate of *Triodia wiseana* establishment within sites previously dominated by this species (Outback Ecology 2006b). It is also possible that some species may have a phytotoxic effect (allelopathic) that inhibits the growth of other species being rehabilitated in the area.

Desired outcome

Disturbed ecosystems are rehabilitated to a stable condition that resembles as close as practicable the natural ecosystem composition, function and processes.

Objectives

Throughout the life of the plan, work with industry operators to ensure disturbed and unused land (for example, borrow pits, surplus roads and tracks, areas cleared following weed removal or bushfire management or any other activity related to petroleum or gas processing operations that has caused disturbance to the environment) is progressively rehabilitated in accordance with completion criteria agreed to by the department.

Management actions

1. Ensure those responsible for disturbance undertake ecosystem rehabilitation, including covering all associated costs.
2. Ensure GJV involves the department when it reviews and/or updates environmental management plans associated with ecosystem rehabilitation.
3. Support the decision of industry operators to allow natural regeneration (that is, no intervention required) where it is evident, appropriate and likely to be successful in restoring the entire disturbed site.
4. Encourage others to minimise other impacts upon ecosystem rehabilitation sites (for example, no unauthorised access, protection from bushfire, adjacent land clearing and altered surface hydrology).
5. Notify industry operators when the department is of the view that improvements in ecosystem rehabilitation may be needed (for example, assessment of completion criteria).
6. Encourage industry operators to undertake targeted research (for example, investigating ecological requirements of recalcitrant species) and spatial/temporal trend monitoring using techniques such as fauna surveys and aerial photography or remote sensing.

Key performance indicators

Performance measure	Target	Reporting requirements
Area of each cleared and unused site (especially where 'Barrow Island creekline vegetation' has previously occurred).	Each cleared and unused site is progressively decreasing due to rehabilitation works.	Every five years
Achievement of completion criteria at sites being rehabilitated.	Completion criteria agreed to by the relevant joint venture and the department are progressively being met within a suitable timeframe.	Annually

Managing cultural heritage

Activities being undertaken in the planning area (including land management), have potential to disturb cultural heritage sites. *The Aboriginal Heritage Act 1972* (Aboriginal Heritage Act) and the department's *Policy statement no. 18: Recreation, tourism and visitor services* (DEC 2006) provide guidelines for the department to identify and protect such sites and/or objects from non-industry related impacts in partnership with relevant stakeholders (for example, local Aboriginal groups). GJV and BWIJV have responsibilities to manage their own impacts on cultural heritage.

13. Aboriginal heritage

Archaeological records show that traditional Aboriginal use of Barrow Island Nature Reserve has occurred, although more recently (for about 6,000 years) this had been reduced or prevented as a consequence of Holocene sea level rise (Osborne et al. 2000 and Smith *et al.* 2006). Some evidence suggests that Aboriginal people were present on these islands during times of forced involvement in the pearling industry following European settlement (Hook *et al.* 2004).

Barrow Island Nature Reserve has thirteen sites that are recorded on the Department of Indigenous Affairs' *Register of Aboriginal Sites*. The most significant of these is a pearler's camp at Bandicoot Bay (site no: 891), which is of national, state and regional importance (Hook *et al.* 2004). Little cultural heritage information is available for Boodie, Double and Middle Islands Nature Reserve but it is highly probable that other sites may exist (especially in areas of clay pans, coastal dunes, habitable caves and drainage lines) that are not currently known or officially registered (Chevron Australia 2009j; Hook *et al.* 2004).

More than 150 Aboriginal artefacts have been collected from Barrow Island Nature Reserve. Of great interest are those stone tools that indicate cultural links from areas beyond the Pilbara (Hook *et al.* 2004). A mythological narrative about the origin of Pannawonica Hill and its links to Barrow Island Nature Reserve is also described by Dench (Hook *et al.* 2004).

The Conservation Commission and the department acknowledge the strong desire of traditional custodians to care for country according to their traditional laws, to be involved in the management of conservation estate in WA and to strengthen cultural ties to the land. This can lead to the preservation of natural and cultural heritage, enriching cross-cultural awareness and providing cultural, spiritual and economic benefits to Aboriginal people and the wider community.

To this end, three main Aboriginal groups (Yabburara/Mardudhunera, Kurama/Marthurudunera and Thalanyji) have expressed their interests in the area (Hook *et al.* 2004). Although departmental impacts are unlikely during the life of the plan, each of the abovementioned Aboriginal groups will be consulted and involved in any mandatory assessments (including on-ground surveys) if the department proposes any development or management that may potentially affect cultural heritage. Approvals may also be required under the Aboriginal Heritage Act before any departmental works that may impact on Aboriginal cultural heritage values can proceed.

14. Non-indigenous heritage

The planning area and its surrounds has a long history associated with exploration, whaling, quarantine and hospitalisation, barracoon and slave markets, pastoralism, turtle hunting, fishing, phosphate mining, oil and gas extraction, and nature conservation (Hook *et al.* 2004). Atomic testing on the nearby Montebello Islands in the early 1950s resulted in entry around the planning area being temporarily restricted up until about 1954. Almost 12 years later, Barrow Island Nature Reserve was declared the site of WA's first commercial oil discovery (Crank 1973; Parry 1967). These petroleum production operations are still being undertaken by BWIJV.

Some informal pearling camp sites (historical material has been collected) have been discovered on Barrow Island Nature Reserve. Little non-Indigenous heritage information is recorded for Boodie, Double and Middle Islands Nature Reserve but they are also likely to contain historical archaeological material (Hook *et al.* 2004). Any formally registered non-Indigenous site is protected under the *Heritage of Western Australia Act 1990* and possibly federal legislation (the EPBC Act). In this case, approval may be required before any works that may impact on non-Indigenous heritage values.

Although it has never been found, the *Marietta*, possibly a pearling lugger, is recorded as having been wrecked in the waters off Barrow Island Nature Reserve in 1905 (Osborne *et al.* 2000). It is believed that other shipwrecks may occur in the vicinity and any pre-1900 shipwrecks or debris discovered in the planning area will be protected under relevant state and/or federal government legislation (DEC 2007).

Managing resource use

15. Petroleum and gas development

The planning area and its surrounds contain extensive petroleum and gas resources including significant petroleum reservoirs located beneath Barrow Island Nature Reserve. These resources will continue to be extracted and processed for commercial purposes throughout the life of this plan, and will contribute to the regional, state and national economy for many years to come. More detail on specific petroleum operations and their titles can be found in section *Other tenure and land arrangements*.

Petroleum and gas processing activities cause the majority of impacts (for example, clearing, spills or leaks, non-indigenous species introductions, disturbance of marine turtle breeding and feeding, and altered fire regimes) that this management plan aims to address (refer to the relevant sections throughout this plan for more detail). The department will continue to work closely with industry operators to protect key values from these impacts.

The department and the Office of the Environmental Protection Authority have a legislative role in auditing industry environmental management (see section *Legislative framework*). The Department of Mines and Petroleum regulates existing petroleum activities within the planning area by undertaking external audits to ensure compliance with industry environmental management plans and more generally good oilfield practice. Internal audits/monitoring are carried out by the relevant joint venture operator to ensure statutory and internal policy compliance.



A lufkin at Bandicoot Bay – Photo Fran Stanley (DEC)

Desired outcome

Minimal impact of petroleum and gas development on key values.

Management action

1. Where possible, ensure existing industry environmental management plans are updated in consultation with the department and are consistent with this management plan.

16. Basic raw materials

Gravel has been extracted as a basic raw material within the planning area for infrastructure development and road construction/maintenance (Chevron Australia 2009a) since 1967. A large number (more than 10) of decommissioned, and a small number (less than five) of active borrow pits, exist on Barrow Island Nature Reserve. These pits, along with any future pits, may adversely affect the structure, function and composition of ecosystems, in particular, creekline systems where most gravel extraction has occurred. Gravel extraction has been identified as a principal threat to some vegetation types on Barrow Island Nature Reserve, including two 'priority one' ecological communities (see section *Native plants and plant communities*).

Petroleum legislation does not permit any unreasonable or unnecessary levels of interference with soils or geomorphology. However, BWIJV is able to extract gravel and other basic raw materials within its lease in order to carry out its operations.

The GJV is not permitted to access any basic raw materials on Barrow Island Nature Reserve outside the site of the Gorgon gas processing facility (Chevron Australia 2005). Where importation of additional basic raw materials is required for construction purposes on Barrow Island Nature Reserve, it will be subject to the Quarantine Management System.

There is potential for reclamation of gravel for re-use from decommissioned leases, roads and windrows, subject to appropriate consideration of weed quarantine and other concerns. Both joint ventures are required to rehabilitate their respective borrow pits upon decommissioning.

Desired outcome

Basic raw material extraction and use does not significantly impact on key values.

Management actions

1. Ensure only approved use of basic raw materials is undertaken in the planning area.
2. Ensure key values of the planning area are not impacted from basic raw material use except where otherwise permitted (for example, in the approved disturbance footprint of the terrestrial and intertidal areas).
3. Ensure industry operators apply appropriate quarantine management during extraction, transport and use of basic raw materials.
4. Ensure the 'Barrow Island creekline vegetation' and 'Coastal dune soft spinifex grassland' ecological communities are protected from impacts associated with basic raw material use.
5. Notify industry operators when the department detects unacceptable ecological impacts that may be caused from activities associated with basic raw material use.
6. Ensure all borrow pits on Barrow Island Nature Reserve are restored as soon as practicable in accordance with section *Ecosystem rehabilitation*.

17. Water resources

BWIVJ uses water from the Flacourt Sands and the unconfined shallow aquifer to supply its oilfield operation for processing and domestic uses respectively (URS Australia Pty Ltd 2009). The GJV will source its process and potable water supplies through reverse osmosis desalination plants (Chevron Australia 2009f).

Water abstraction can alter groundwater levels (availability) and overdrawing can cause saltwater intrusion, leading to a disruption in the groundwater halocline (Humphreys 1993, 2001). These effects may significantly impact upon species with specific ecological water requirements (for example, subterranean fauna and native plants and plant communities), which may have flow-on effects to other parts of the ecosystem.

A licence under the *Rights in Water and Irrigation Act 1914* is not required for water abstraction in the planning area because it does not fall within a proclaimed groundwater area. The Department of Water thus has no regulatory role in water resource use. The Department of Mines and Petroleum only regulates water abstraction where it is associated with management of a petroleum reservoir that falls within the scope of the *Petroleum and Geothermal Energy Resources Act 1967*. No other water use in the planning area is independently regulated, although it is generally guided by industry groundwater monitoring and abstraction plans, which are self-audited/self-monitored by the relevant industry operator. Management of the groundwater integrity is further discussed in section *Physical environment*.

18. Accommodation and infrastructure

Departmental and industry personnel, contractors and volunteers on Barrow Island Nature Reserve are accommodated in camps located on the east coast, south of Town Point. About 200 staff are permanently rostered on Barrow Island Nature Reserve to service the BWIVJ oilfield. Accommodation needs will increase significantly during construction of the Gorgon gas project, with most of the 3,500 jobs directly associated with it expected to be located on Barrow Island Nature Reserve (DMP and DSD 2009). A permanent workforce of about 150–200 is expected during the operations phase of this project. A significant amount of infrastructure such as roads, airport, well pads, storage tanks, pipelines, bores, a processing facility and a material off-loading facility is present on Barrow Island Nature Reserve. No accommodation or permanent infrastructure exists on Boodie, Double and Middle Islands Nature Reserve.



A significant amount of infrastructure exists on Barrow Island Nature Reserve including this tanker loading pipeline shore crossing on the east coast, near Town Point – Photo Kevin Crane (DEC)

The installation and long-term presence of any structure can be the cause of the following threats:

- direct disturbance or removal of landforms and/or soils (including extraction of gravel or other basic raw materials)
- vegetation clearing or removal of habitat
- alteration of surface hydrology
- alteration of coastal processes (including near-shore currents, wave action and sediment processes) leading to changes in marine turtle nesting behaviours and smothering or structural changes of intertidal ecosystems
- physical barriers to faunal movement
- fauna entrapment (in trenches on land and by lighting in intertidal areas)
- increased risk of introducing non-indigenous species (from importation of materials)
- cause of fire (by a fault) or exacerbation of fire (through contact with flammable material)
- production of environmentally harmful waste products such as light and carbon emissions
- accidental spills or leaks of environmentally harmful substances such as hydrocarbons.

Under Clause 5(1) of the State Agreement, GJV has a legislative responsibility to consider utilising existing services and structures on Barrow Island Nature Reserve to minimise cumulative impacts on key values. The GJV and BWIJV must undertake appropriate approval processes for any significant new works or constructions (including the establishment of additional structures or expansions to existing structures).

All areas of decommissioned structures are to be restored in accordance with industry requirements (for example, legislation and Ministerial conditions), and where compatible, the *Ecosystem rehabilitation* section. If any structure is currently or potentially able to assist in the monitoring of ecological impacts (for example, groundwater bores), its retention should be considered for future use by the department.

Desired outcome

Accommodation and infrastructure does not significantly impact on key values.

Management actions

1. Assist the Department of Mines and Petroleum in assessing industry operators in their planning and implementation of appropriate management to minimise disturbance and the subsequent need for rehabilitation associated with the installation, operation, maintenance and/or decommissioning of infrastructure and accommodation. In particular infrastructure and accommodation should be:
 - shared where possible to prevent unnecessary vegetation clearing
 - regularly maintained to prevent leaks, spills and unplanned fires
 - designed and upgraded (where possible) to reduce environmentally harmful emissions (for example, artificial lighting and carbon dioxide)
 - progressively restored upon decommissioning (and where possible in accordance with section *Ecosystem rehabilitation*).
2. Assist the Department of Mines and Petroleum where assessment of potential impacts upon key values relating to the expansion, or establishment of a new structure, is proposed.
3. Permit the establishment of low impact structures in the planning area for the purposes of managing its key values.
4. Consider the retention of decommissioned infrastructure to assist in monitoring ecological impacts in the future.

19. Workforce recreation

The BWIJV and permanently-rostered GJV workforce based on Barrow Island Nature Reserve will recreate under the internal regulations of Chevron Australia Pty Ltd. It is the department's intention to have its own officers undertake recreation consistent with this approach. Recreational opportunities include limited fishing, bushwalking and water-based activities. Consultation has indicated that continuing to permit these activities, especially fishing, is important to the workforce.

Unlimited recreational access for the workforce could compromise key values where the presence of humans or recreational equipment (including vehicles for transport) may disturb or harm native species and/or important habitats. Legislative fishing restrictions are already in place at Bandicoot Bay Conservation Area and all other workforce recreation will need to be managed and directed away from areas of high conservation significance, to ensure it is sustainable. GJV has restricted its large construction (non-permanent) workforce to recreation activities within the confines of the accommodation camp.



Recreation should be avoided in conservation significant areas, including high density marine turtle nesting beaches as shown above – Photo Michelle Rumball (DEC)

Desired outcome

Workforce recreation does not significantly and adversely impact on key values.

Management actions

1. Ensure those responsible for recreation facilitation:
 - prohibit the workforce from recreating in areas of high conservation significance such as cave systems, significant turtle nesting beaches, significant migratory shorebird habitat and sites of cultural significance, or alternatively ensure supervision (to a level acceptable by the department) of recreation is undertaken at these sites
 - limit disturbance in high-use recreation sites by restricting access to single tracks
 - apply vehicle restrictions (for example, speed reductions, multiple occupancy) for recreation purposes as required
 - modify recreation arrangements where required.
2. Manage departmental recreation consistent with arrangements for permanently-rostered GJV and BWIJV staff.
3. Support the Department of Fisheries in its monitoring of sustainable recreational fishing, especially in Bandicoot Bay Conservation Area.
4. Educate the workforce (including contractors) and volunteers on the potential impacts of recreation (including wildlife interactions) and importance of maintaining sustainability. This could include promoting and/or facilitating environmental-based recreation activities such as spot-lighting.

20. Access

Access to the planning area will be limited to departmental and other state and federal government personnel, GJV and BWIJV (including contractors, other individuals associated with operations), other industry personnel such as Apache who are in transit to their respective work places, and volunteers working on specific programs. Access within industrial sites is further restricted by requirements of occupational health and safety considerations requiring specific briefings, inductions, training and demonstrated competence, including use of road networks. All authorised access is controlled by the GJV operator through implementation of the Quarantine Management System (see section *Non-indigenous and other problem species*). However, if the department requires immediate access to the planning area to undertake its legislative responsibilities under the Environmental Protection Act, such as in an emergency, it can not be restricted by this process.

Unauthorised public access to areas could result in additional disturbance to key values (for example, quarantine breach, disturbance of fauna or habitats) and potentially expose the public to danger. Therefore, the department will consider prohibiting public access to the planning area under section 62(1) (b) of the CALM Act ²¹. This would also assist in ensuring a safe working environment for those people working on Barrow Island Nature Reserve.

All roads and tracks are managed by the relevant joint venture operator that authorised the construction. Where the roads or tracks are poorly located, in poor condition and difficult to maintain, no longer required by GJV or BWIJV or where there is an adverse and unacceptable impact on the environment, consideration should be given to their closure and rehabilitation. This should be subject to endorsement of the department to ensure appropriate roads and tracks remain open for departmental management access. In some instances, off-road driving can result in vegetation clearing. For this reason, the activity is regulated by permit under Chevron Australia Pty Ltd's environmental management system, or by permission of the department under the Environmental Protection Act.

Desired outcome

Access is restricted to avoid personal injury and disturbance to key values.

Management actions

1. Work with the GJV operator to ensure the key values of the planning area are protected from inappropriate access (via implementation of the Quarantine Management System).
2. Ensure the department has immediate and unrestricted access to the planning area to undertake its legislative responsibilities under the Environmental Protection Act, where an emergency has arisen.
3. Consider restricting public access in accordance with s 62(1)(b) of the CALM Act and associated regulations.
4. Inform the wider community of the reasons why public access may need to be prohibited, in order to maintain trust and support for ongoing conservation of key values.
5. Work with the relevant joint venture operator to provide and maintain strategic road and track access consistent with managing key values.
6. Ensure the relevant joint venture operator closes and rehabilitates any roads or tracks unsuitable for access or no longer required by the department and/or other major users.
7. Prohibit off-road driving that could result in clearing, unless permitted under the arrangement outlined in this section.

²¹Limited low impact recreational opportunities by departmental and industry operations staff will be permitted on Barrow Island Nature Reserve. Any activities will be subject to company policies and the approval of the department. Access to recreational sites will be restricted to existing roads.

Involving the community

21. Community involvement and support

Community involvement and support is an integral part of the department's operations, including the development and implementation of this management plan. The department's *Policy statement No. 18: Recreation, tourism and visitor services* (DEC 2006) provides guidance for facilitating this. It aims to develop community awareness and appreciation of the state's natural environment and promote community involvement in, and support for, its protection and conservation (DEC 2006). However, because access may be limited to the planning area (see section *Access*), community involvement is primarily focused on volunteers and the island-based workforce. Their contribution is important because it not only assists the department with its work capabilities and skills base, but also fosters communication links, establishes wider ownership of, and appreciation for, land management and conservation and encourages appropriate behaviour. Aboriginal involvement in caring for country is also recognised as being important in the conservation of key values. This issue is discussed in more detail in the section *Aboriginal heritage*.

Initial comments on the issues within the planning area were sought early in the planning process. Interested community members and organisations now have the opportunity to formally comment on the proposed management plan by written submission to the department, or by electronic submission on the department's website (see page iii of this plan). Ongoing community support will be essential for the successful implementation of the approved final management plan.

Desired outcome

Ongoing community involvement in, support for and increased understanding and appreciation of, conservation of key values.

Management actions

1. Continue to promote and/or facilitate opportunities for volunteers and the island-based workforce to contribute to conservation programs such as turtle monitoring as well as make informal observations and participate in regular monitoring and reporting procedures.
2. Provide, and support others, in providing, the workforce, volunteers and the wider community with educational material (including training opportunities) to increase understanding of the importance of the key values, their associated threats and ecological impacts, and how they are being managed.

Reporting, research and monitoring

22. Reporting, research and monitoring

Reporting is an important part of protecting the key values. It consists of three major areas:

1. environmental performance
2. breaches and/or incidents
3. research results.

The first two components keep all stakeholders with legislative management responsibilities informed of the current situation and allow for prompt responses to assist with amelioration of any impacts, where required. Examples of these reports include the effectiveness of lighting controls, the number of fire incidents, introductions of non-indigenous species and contamination or pollution incidents, amount of vegetation that has been cleared, non-compliances and the number of incidents involving fauna injury or death. The third type of reporting assists in understanding spatial and temporal changes in biodiversity and should be undertaken as an essential part of research and monitoring. These types of reports may include inventories for native species and communities that are updated on an annual basis, new species identifications, changes observed in local native populations and results of ecosystem rehabilitation trials.

The planning area is one of the most important areas in the state for long-term ecological research because:

- it already has a well-established knowledge base to support further investigations, including better understanding of the local ecology
- in general, its biological assemblages are relatively unaltered, especially with respect to fauna. In particular, there are opportunities to research and monitor small to medium-sized mammals that are now absent or rare on the mainland
- it contains many species and communities of conservation significance and a number of species are unique to subterranean habitats on Barrow Island Nature Reserve
- it contains significant habitats ranging from local to international importance
- there are low levels of some major threatening processes that occur on the mainland.

Research on the key values of Barrow Island Nature Reserve, especially its natural biodiversity, has been undertaken over the years, particularly since the mid 1960s when petroleum operations began. Issues have arisen where methodologies and mapping scales such as vegetation classifications have been inconsistent between various research and monitoring projects, which prevented easy comparison of data and the assessment of ecological changes over time. The evaluation of management actions has been further complicated by the use of output-based indicators, rather than outcome-based indicators.

Throughout the life of this plan, the department will endeavour to address (in collaboration with others) gaps in knowledge, focussing on those with the highest priority for research and monitoring. Such gaps include:

- establishing broadscale mapping of vegetation communities, at a resolution consistent with contemporary expectations of an important and intensively managed nature reserve
- gathering information on past and present species and community occurrences (including the requirement to maintain annual species and communities lists), status of populations and communities, ecological requirements of species and communities, threatening processes and population trends of known species. Marine turtles, subterranean fauna, other potential short-range endemic species and restricted vegetation types should remain a key focus for monitoring, especially where there is high potential for adverse cumulative impacts resulting from petroleum and gas processing activities
- gaining an understanding of the function of the key ecosystems such as the subterranean environment
- investigating new methods to better manage ecosystem rehabilitation, quarantine, control of non-indigenous species, risk of uncontrolled bushfire and contamination/pollution occurrences
- establishing baseline information for Boodie, Double and Middle Islands Nature Reserve as well as components of the ecosystem on Barrow Island Nature Reserve that are not extensively known (for example, invertebrates and fish)
- investigating the taxonomy and biology of new or unclassified species
- investigating the heritage value of clay pans, habitable caves and coastal dunes.

Some science-based offset programs (North West Shelf Flatback Turtle Conservation Program; North West Shelf Flatback Turtle Intervention Program, Threatened Species Translocation and Reintroduction Program and Dredging Surveillance and Audit Program) have already been identified as part of the state government approvals for the Gorgon gas project. These programs will be established and implemented by the department. Portions of these programs will be implemented within the planning area.

Reporting, research and monitoring are all important components in making informed decisions to achieve best practice environmental management and in determining the success of this management plan. With multiple managers in the planning area, this goal will require coordination and integration between different management groups, including the sharing of information. This will also ensure that funds and resources will be used in the most effective and efficient way.

Desired outcome

Management of key values is assisted through appropriate and ongoing reporting, research and monitoring.

Objectives

Throughout the life of the plan, work with industry operators to:

- share information relevant to management of key values that is gained through reporting, research and monitoring. This should be undertaken in a timely manner and between all key stakeholders with management or auditing responsibilities within the planning area
- continue developing the ecological knowledge base and subsequent management (including adaptive management) requirements.

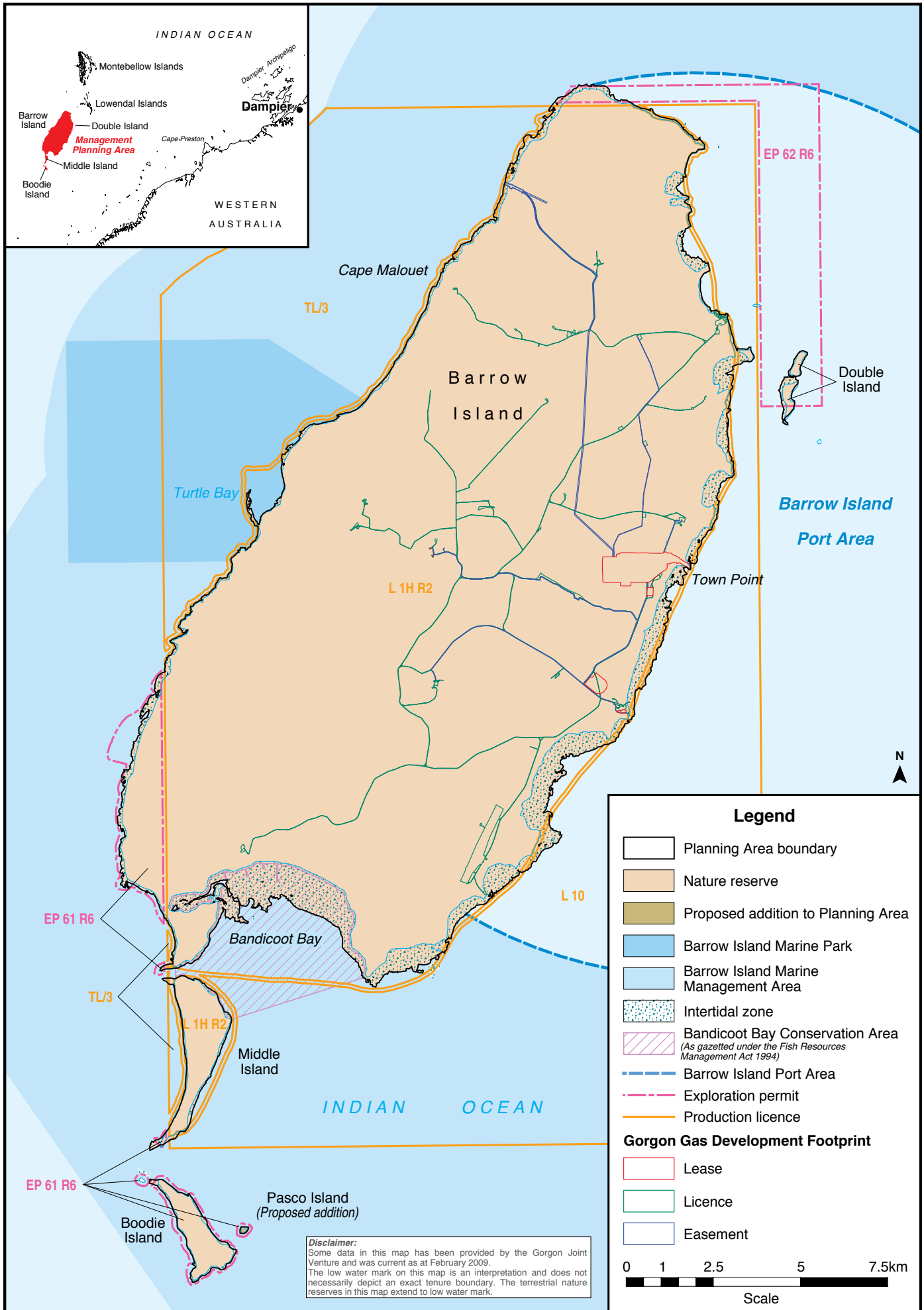
Management actions

1. Develop and implement a research and monitoring program for Barrow Island Nature Reserve that:
 - provides for implementation of research priorities identified in this management plan
 - standardises data collection methods, mapping and presentation to assist with trend analysis
 - specifies outcome (rather than output) based evaluation methods (that may include the use of indicator species) to identify spatial and temporal trends
 - uses appropriate control sites, where necessary
 - integrates where possible, with GJV and BWIJV research and monitoring requirements to reduce stress on fauna.
2. Continue to monitor the state of the environment on Boodie, Double and Middle Islands and:
 - respond to any non-industry-related management issues, where practicable
 - ensure the relevant industry operator responds to industry-related management issues where required.
3. Ensure industry operators provide to the department as a minimum, data and reports such as incident, environmental performance and compliance reports, where required by their environmental approval processes or licences issued by the department.
4. Provide departmental data and reports associated with management of key values to industry operators where it considers it to be appropriate.
5. Encourage the island-based workforce and volunteers to assist with reporting as well as any research or monitoring opportunities that arise.

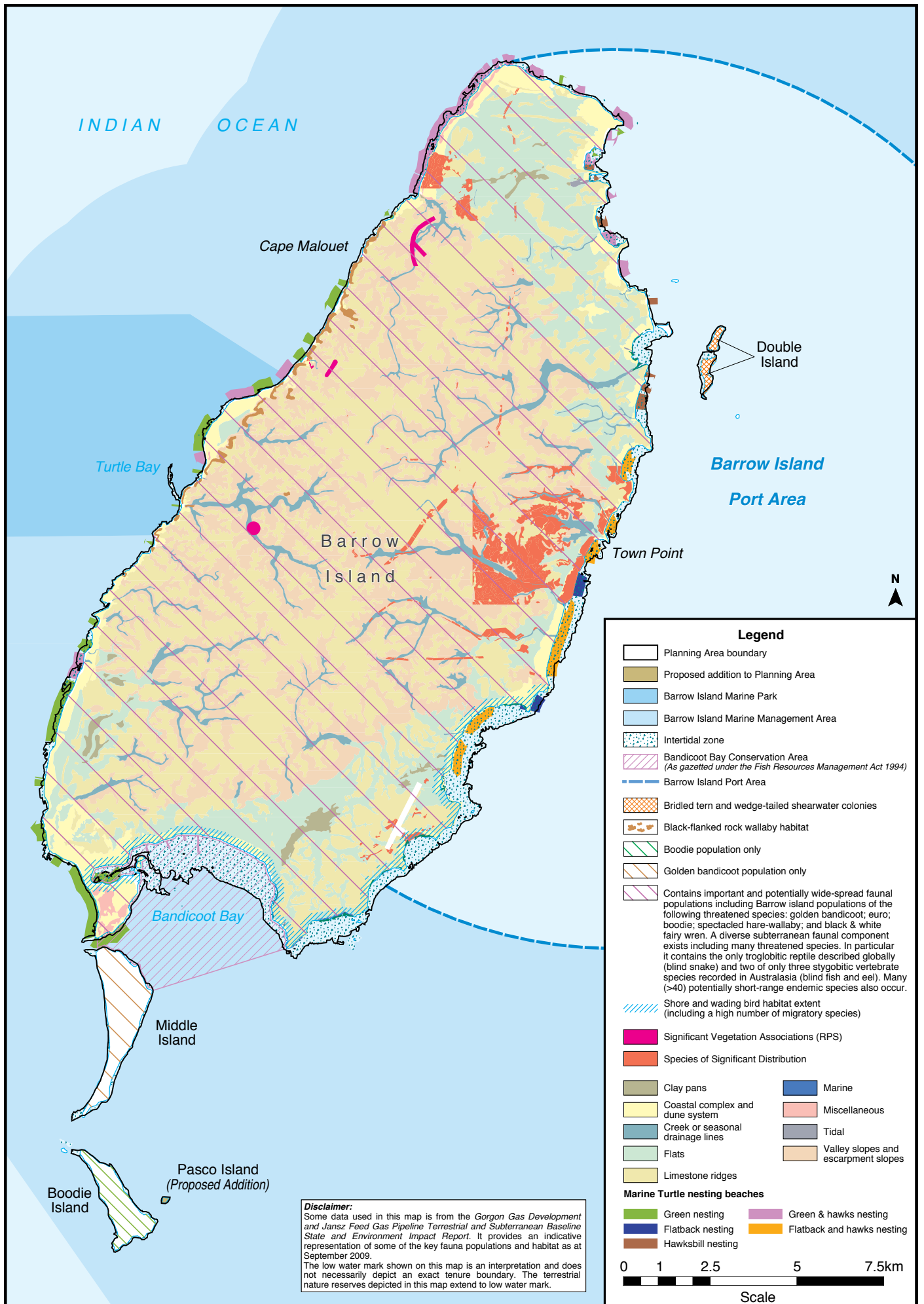
Key performance indicators

Performance measure	Target	Reporting requirements
Percentage of incidents appropriately reported to all key stakeholders with management responsibilities within the planning area.	All incidents are appropriately reported.	Annually
Level of information shared between key stakeholders.	Information is provided to key stakeholders as outlined in this management plan.	Annually
Implementation of research and monitoring.	Research and monitoring is progressively undertaken in accordance with the research and monitoring program.	Every three years

Map 1. Management plan area and tenure



Map 2. Key species and habitats



Map 3. Accommodation, infrastructure and access



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Further reading

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Documents listed in *References* and *Further reading* should be sought by contacting the author/owner.

