APPENDIX B

Comparative analysis technical report

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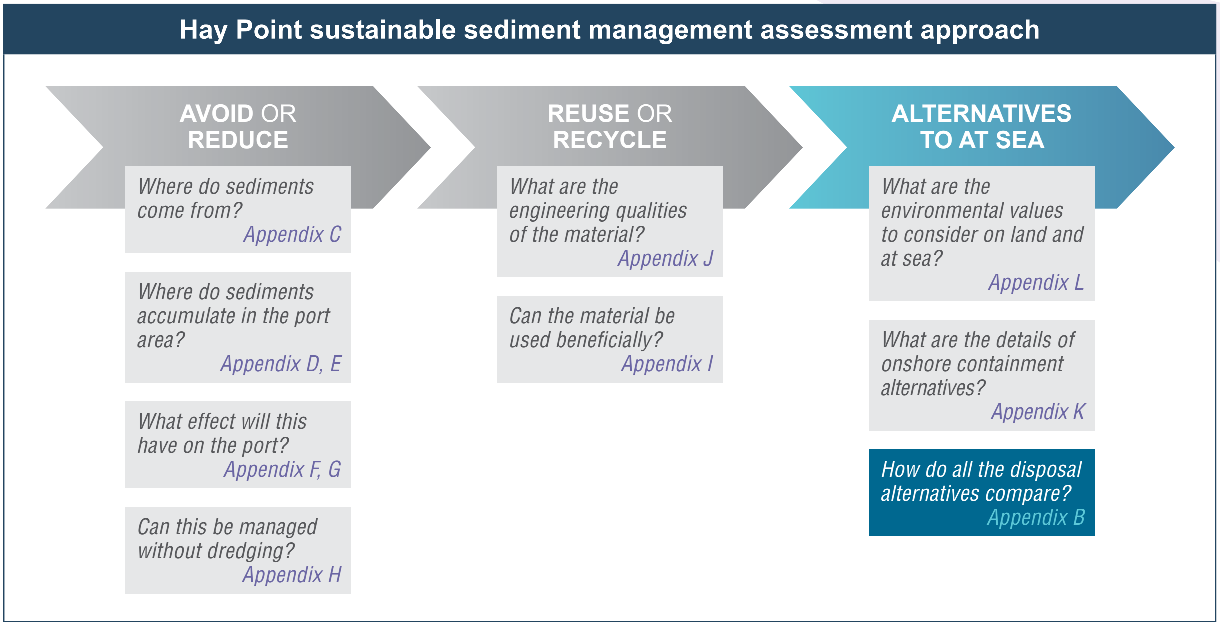
Comparative analysis technical report

SYNOPSIS

Independent technical specialist

Hemphill et al

January 2017



Purpose of study:

The purpose of this study was to undertake a comparative analysis of the various alternatives for managing marine sediments and maintaining effective port operations at the Port of Hay Point.

Broad study approach:

The study was undertaken using the principles of Structured Decision Making (*Gregory et al, 2012*) and involved:

- Understanding the decisions that needed to be made as part of the SSMA Project
- Identifying what is important to stakeholders in the form of a clear set of objectives and performance measures
- Developing a range of alternative approaches to managing marine sediments
- Understanding the performance of the alternative approaches against identified objectives
- Comparing alternative approaches and selecting a preferred option.

Key findings:

It is important to note, as the basis for this study, that previous technical reports undertaken as part of the SSMA (refer Appendices C-L) have established:

  - o Sediment at the Port of Hay Point needs to be managed
  - o Traditional maintenance dredging is required as part of the management solution
  - o There are a discrete set of feasible options that have the potential to provide long term solutions for reuse or disposal of sediment that is captured as part of the dredging.

- Given that maintenance dredging is required as part of the solution, the comparative analysis focussed in detail on how best to deal with the dredge material (relocation or disposal).

- Using a structured decision-making process, 11 decision objectives and 14 discrete measures were developed by a stakeholder advisory group. These spanned across a number of key categories or themes including:
  - Environmental
  - Cultural Heritage
  - Port Economics and Operations
  - Health and Safety
  - Social
  - Innovation
  - World Heritage
- There were 8 discrete alternative options for reuse and disposal identified (2 x on-land, 2 x reclamations, 1 x reuse and 3 x at-sea).
- An initial analysis of these 8 options indicated:
  - At-sea disposal at the existing or potential new mid-shelf Dredge Material Placement Area (DMPA) would be necessary to deal with the immediate maintenance dredging needs at the Port.
  - Other alternatives, if feasible, would take 4-5 years to implement.
  - Habitat restoration, if feasible, may only be a 'one-off' solution.
  - Disposing of dredged material within a constructed reclamation at the Port of Mackay was found to be the worst performing single alternative across most themes and did not warrant further analysis.
  - A combination of these alternatives may be required as part of a long-term solution.
- Eleven long term strategies were developed, combining the various alternatives, over a 25-year timeframe.
- The structured decision making process showed how each of the eleven strategies compared when equally considering each of the key themes.
- In addition, the structured decision-making process was able to show how the comparison would change if the outcomes were significantly weighted (75%) to any one particular theme.

Long Term Strategy	At Sea Existing x 1 Reclamation Hay Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 At Sea Existing x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Reclamation Hay Point x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Dudgeon Point x 3	At Sea Existing x 1 Onshore Dudgeon Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Mackay x 3	At Sea Existing x 1 Onshore Mackay x 4	At Sea Existing x 5	At Sea Mid-shelf x 5	At Sea Existing x 1 At Sea Coral Sea x 4	At Sea Mid-shelf x 1 Habitat Rehabilitation x 1 At Sea Mid-shelf x 3
Equal weights	41	70	45	54	52	47	44	71	68	56	68
Environment (75%)	39	69	44	63	60	61	57	65	72	46	75
Social (75%)	36	57	41	54	53	37	31	57	56	52	56
Economic (75%)	44	80	44	48	49	39	40	89	74	59	69
Cultural (75%)	74	92	78	73	68	71	65	92	91	88	91
WHA (75%)	42	68	50	64	60	62	57	65	55	68	60

Best score for an option under a particular weighting scenario

Second best score for an option under a particular weighting scenario

Worst score for an option under a particular weighting scenario

- A sensitivity analysis was undertaken to ensure that no one measure was substantially biasing the results.
- The results identified three higher performing options:
  - Continued and ongoing at-sea disposal at the existing DMPA.
  - A combination of continued at-sea disposal at the existing DMPA and habitat restoration at some time in the future (pending a range of additional studies and feasibility assessment), reverting to continue at-sea disposal thereafter.
  - A combination of at-sea disposal at a new mid-shelf DMPA and habitat restoration at some time in the future (pending a range of additional studies and feasibility assessment), reverting to continue at-sea disposal thereafter.

Port of Hay Point

Sustainable Sediment Management

Comparative analysis technical report

January 2017

OPENLINES
Environmental consulting

ADAPTIVE STRATEGIES

Contents

DOCUMENT TRACKING

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Executive summary

BACKGROUND

North Queensland Bulk Ports (NQBP) commissioned Adaptive Strategies and Open Lines Consulting (the consulting team) to undertake a comparative analysis of the various alternatives for managing marine sediments and maintaining effective port operations at the Port of Hay Point.

The comparative analysis is part of the *Port of Hay Point – Sustainable Sediment Management (SSM) Assessment for Navigational Maintenance* ('The SSM Project') which is investigating:

- Where sediment at the Port comes from.
- How it influences Port operations.
- Whether it can be eliminated or reduced before it influences Port operations.
- What options are available at the Port for the disposal of sediments that might have accumulated and need to be dredged.

APPROACH TO THE COMPARATIVE ANALYSIS

Undertaking a comparative analysis of the various options for managing marine sediments was a complex task. The analysis needed to consider:

- A series of questions about the actual need to manage sediment, the options for non-dredging management solutions, and the options for disposal of dredge material.
- Management issues over both the short term (next 3 years) and long term (next 25 years).
- A wide range of detailed and comprehensive technical information developed to inform the various elements of the project.
- A significant number of possible alternatives for managing sediments. For example, a wide range of non-dredge solutions, as well as many alternatives for beneficial reuse or disposal of dredge material.
- The diverse views of stakeholders about what was important to them in relation to the implications of managing sediment at the Port.
- A complex, dynamic environment comprising terrestrial, aquatic and marine areas.

To address these challenges, the consulting team adopted the principles of Structured Decision Making (Gregory *et al*, 2012) to help NQBP work through an organised and transparent approach for comparing alternatives. This involved the following five steps:

1. Understanding the decisions that needed to be made as part of the SSM Project.
2. Identifying what is important to stakeholders in the form of a clear set of objectives and performance measures.
3. Developing a range of alternative approaches for managing sediments.
4. Understanding the performance of the alternatives against the objectives.
5. Comparing alternatives and selecting a preferred option.

One of the key benefits of the structured decision making approach was the fact that the analysis was quantitative and was based on detailed technical information to measure the performance of each alternative. The quantitative nature of the analysis enabled direct comparisons between different management solutions in a clear and transparent way. It also enabled various weightings to be applied to understand how alternatives performed in different scenarios, and sensitivity analysis to be used to test the robustness of the results.

INITIAL FINDINGS OF THE COMPARATIVE ANALYSIS

The comparative analysis led to three key initial findings:

- Sediment at the Port of Hay Point needs to be managed.
- Dredging is required as part of the management solution.
- There are a discrete set of feasible options that have the potential to provide a long term solution for use or disposal of sediment that is captured as part of dredging.

These findings were derived from a number of technical studies that examined:

- The sediment management needs of the Port (e.g. the nature and sources of sediment, the drivers of sediment dynamics, and rates of accumulation).
- The feasible methods for managing sediment at the Port including:
    - Traditional maintenance dredging.
    - Constructed sediment traps.
    - Installation of Jet Arrays.
    - Using a drag bar or sea rake to mobilise the seabed sediments.
    - The use of propeller wash agitation equipment.

Given that maintenance dredging is required as part of the solution, the comparative analysis focused in detail on how best to deal with the dredge material.

ALTERNATIVES FOR REUSE OR DISPOSAL OF SEDIMENT

A detailed analysis of the feasible alternatives for reuse or disposal of sediment was conducted. This included consideration of issues such as the characteristics of the sediment, identification and analysis of beneficial reuse options, and identification and analysis of suitable material disposal/placement locations.

This work led to the development of eight discrete alternatives that were assessed in detail. They were:

- Three alternatives for beneficial reuse of the sediment:
    - Mangrove habitat rehabilitation at Sandringham Bay.
    - A land reclamation site at the Port of Hay Point.
    - A land reclamation site at Mackay Harbour.
- Two onshore disposal options:
    - An onshore pond at Mackay Harbour.
    - An onshore pond at Dudgeon Point.
- Three offshore disposal options:
    - The existing offshore dredge material placement area (DMPA).
    - A mid-shelf offshore DMPA.
    - A Coral Sea offshore DMPA.

FINDINGS OF THE COMPARATIVE ANALYSIS INTO OPTIONS FOR REUSE OR DISPOSAL OF SEDIMENT

Initial analysis

The initial analysis of options for reuse or disposal of dredge material looked at the eight discrete alternatives against the objectives of the project. From that work it was clear that:

- A combination of alternatives needed to be considered as part of a long term solution. This was because only two alternatives could be implemented in the short term and only four alternatives had the capacity to provide a long term solution on their own. It was also thought that analysis of different combinations of alternatives might provide an optimised long term solution (i.e. benefitting from the best components of different alternatives).
- Offshore disposal at the existing or potential new mid-shelf DMPA would be needed to deal with maintenance dredging in the next three years to keep the port operating effectively. The lead time of the other alternatives was too long.

- Reclamation at the Port of Mackay was the worst performing single alternative and did not warrant further analysis.

The eleven long term options over a 25-year period in the comparative analysis were:

- At Sea Existing x 1 followed by Reclamation Hay Point x 4 (1 Exist + 4 Rec HP).
- At Sea Existing x 1 followed by Habitat Rehabilitation x 1 followed by at Sea Existing x 3 (1 Exist + 1 Mangrove + 3 Exist).
- At Sea Existing x 1 followed by Habitat Rehabilitation x 1 followed by Reclamation Hay Point x 3 (1 Exist + 1 Mangrove + 3 Rec HP).
- At Sea Existing x 1 followed by Habitat Rehabilitation x 1 followed by Onshore Dudgeon Point x 3 (1 Exist + 1 Mangrove + 3 DP).
- At Sea Existing x 1 followed by Onshore Dudgeon Point x 4 (1 Exist + 4 DP).
- At Sea Existing x 1 followed by Habitat Rehabilitation x 1 followed by Onshore Mackay x 3 (1 Exist + 1 Mangrove + 3 Onshore Mack).
- At Sea Existing x 1 followed by Onshore Mackay x 4 (1 Exist + 4 Onshore Mack).
- At Sea Existing x 5 (5 Exist).
- At Sea Mid-shelf x 5 (5 Mid-shelf).
- At Sea Mid-shelf x 1 followed by Habitat Rehabilitation x1 followed by At Sea Mid-Shelf X 3 (1 Mid-shelf + 1 Mangrove + 3 Mid-shelf).
- At Sea Existing x 1 followed by at Sea Coral Sea x 4 (1 Exist + 4 Coral).

Analysis of long term options

Of the eleven long term options that were tested in the comparative analysis, three stood out as the best performers under a range of scenarios against the objectives of the project. They were:

- Offshore disposal at the existing DMPA (5 Exist).
- Offshore disposal at a new mid-shelf DMPA (5 Mid-shelf).
- A combination of offshore disposal at the existing dredge material placement area and mangrove rehabilitation at Sandringham Bay (1 Exist + 1 Mangrove + 3 Exist).

These three options scored the highest across a majority of measures and under a number of different scenarios about what stakeholders considered was important.

The options that generally performed poorly were those that included onshore disposal at Mackay and reclamation at Hay Point. The option that combined the existing DMPA with four campaigns of reclamation at Hay Point performed the worst.

Preferred long term solution

Based on the detailed comparative analysis, offshore disposal at the existing DMPA (5 Exist) consistently performed the best. It was the strongest of the three best performers.

On balance, offshore disposal at the existing DMPA (5 Exist) was considered to be the preferred solution. It provides both a short and long-term solution, is well understood and performs strongly in a range of scenarios.

It should be noted that mangrove rehabilitation at Sandringham Bay was also considered to have merit. It is an alternative that can provide a positive environmental benefit and it is recommended that it should be examined in more detail as part of an integrated solution with offshore disposal at the existing DMPA.

Introduction

North Queensland Bulk Ports (NQBP) are conducting a strategic assessment of the ongoing management of marine sediments at the Port of Hay Point. The project is called the *Port of Hay Point – Sustainable Sediment Management (SSM) Assessment for Navigational Maintenance* ('The SSM Project').

The aim of the SSM Project is to develop long term solutions for the management of marine sediments at the Port by investigating:

- Where sediment at the Port comes from (e.g. onshore sources, marine sources).
- How it influences Port operations (e.g. by reducing depth within the Port navigational areas).
- Whether it can be eliminated or reduced before it influences Port operations (e.g. through mitigation and management measures).
- What options are available at the Port for the disposal of sediments that might have accumulated and need to be dredged (e.g. beneficial reuse, onshore disposal, offshore disposal)?

To support the SSM Project, NQBP commissioned Adaptive Strategies and Open Lines Consulting (the consulting team) to undertake a comparative analysis of the various alternatives for managing marine sediments and maintaining effective port operations.

This report

This report documents the methods and results of the comparative analysis for the SSM Project. It is a technical report that is a supporting document to the overarching report for the SSM Project.

Challenges to conducting the comparative analysis

There are a number of significant challenges to undertaking a comparative analysis of the various alternatives for managing marine sediments. These include:

- The SSM Project is complex and the range of possible approaches to managing marine sediments is extensive. The options range from non-dredging management measures, to various alternatives for the beneficial reuse of dredge material, to a multitude of scenarios for dredging and placement of material on land or at sea.
- There is a large amount of detailed, technical information available to inform decisions. In some instances this information has been generated using different methods and there is an inevitable level of uncertainty associated with all technical information.
- Stakeholders hold a variety of different and sometimes competing views about what is important to them across social, economic and environmental factors in relation to the SSM Project.
- Decisions around the best approaches for the management of marine sediments at the Port are variously influenced by:
    - Technical, science based investigations and information.
    - Questions around engineering feasibility and design.
    - Detailed economic modelling and analysis.
    - Values based judgements around social, economic and environmental factors.

To address these challenges, the consulting team adopted the principles of Structured Decision Making (Gregory *et al*, 2012) to help NQBP work through an organised and transparent approach for comparing alternatives and making decisions as part of the SSM Project.

Structured decision making

Structured Decision Making sets out a process for identifying alternatives and comparing them against a range of objectives. It provides a technical method for comparative analysis that is able to accommodate both science based and values based objectives and deal with uncertainty in information.

It is defined by Gregory *et al* (2012) as an:

> "*organized, inclusive and transparent approach to understanding complex problems and generating and evaluating creative alternatives. It's founded on the idea that good decisions are based on an in-depth understanding of both values (what's important) and consequences (what's likely to happen if an alternative is implemented)*".

For the SSM Project, the process:

- Helped to scope the questions and decisions relevant to sediment management at the Port of Hay Point.
- Helped define the things that are important to stakeholders within this context.
- Encouraged consideration of a broad set of options or alternatives for sediment management.
- Helped decision makers and stakeholders to think explicitly about how to measure performance of each sediment management option, including identifying the various impacts of each alternative, how they influence objectives and how they can be measured or predicted.
- Provided a set of results that can be queried according to differing stakeholder values and objectives in order to provide insight to decision makers and ultimately help inform their decisions.

The consulting team worked with NQBP to apply the following five steps of Structured Decision Making to the SSM Project (see Figure 1):

1. Understanding the decisions.
2. Identifying what is important.
3. Developing alternatives.
4. Understanding the performance of alternatives.
5. Comparing alternatives and selecting a preferred option.

The method and results for these five steps are presented in the subsequent sections of this report.

It is important to note that the process was not linear and that there was significant iteration across and between the steps to reach the end point of the comparative analysis. However, the method and results are presented in a linear fashion across the five steps in this report for the sake of simplicity.

Figure 1: Steps in the Structured Decision Making Process (adapted from Gregory *et al*, 2012)

Step 1: Understanding the decisions

It is critical in a comparative analysis process to understand the context about the nature of the decision or decisions being considered. This understanding ensures any analysis of options is focused towards the appropriate decision making process and that stakeholders are all on the same page.

Step 1 involved framing the decision to clarify:

- What decisions need to be made and what is the relationship between different decisions?
- What is the temporal and spatial scope of the decisions?
- Who are the decision makers?
- Who are the stakeholders in the decisions?
- What is the outcome or deliverable of the decision making process?

Framing the decisions

WHAT DECISIONS NEED TO BE MADE?

The key decisions that need to be made for the SSM Project were identified as follows:

Within the context of maintaining port operations:

- Is it necessary to manage sediment at the Port of Hay Point in the short and/or long term?
- If yes, what are the feasible ways to manage sediment within the context of needing to maintain port operations and meeting legal requirements?
- If dredging is required, what are the feasible options for use or disposal of the material?
- What is the best package of measures to provide for long term sustainable management of marine sediments at the Port of Hay Point?

The first two questions were essentially higher order questions that needed to be addressed before more detailed analysis around short and long term options for managing dredge material could be considered.

WHAT IS THE TEMPORAL AND SPATIAL SCOPE OF THE DECISIONS?

It is recognised that the sediment management needs of the Port are different in the short term compared with the long term. Decision making in the context of maintaining port operations needs to accommodate both of these timeframes. In this instance:

- Short term relates to the management of sediment over the next three years.
- Long term relates to the management of sediment over the next 25 years.

The spatial scope of the decisions is defined by the port boundary and any onshore and offshore locations relating to the various sediment management options.

WHO ARE THE DECISION MAKERS?

NQBP is the decision maker for the SSM Project. The comparative analysis was used by NQBP as part of a process to develop a Business Case that defines (from their perspective) the best approaches to managing marine sediments at the Port of Hay Point.

It is recognised in this process that the views and input of stakeholders are critical (discussed below) and that there will also be a range of future decisions (e.g. by regulators) in relation to the project. Appropriate flow on decisions (e.g. relevant environmental approvals) will be addressed prior to commencement of any works.

WHO ARE THE STAKEHOLDERS IN THE DECISIONS?

Structured Decision Making is particularly useful for understanding and incorporating the views of stakeholders. There are a wide range of people with interests in the SSM Project and the decisions around the management of marine sediments. They include Commonwealth, State and Local Government; port operators; conservation groups; local community including Indigenous and fishing groups; researchers; and tourism operators.

A Stakeholder Advisory Group was established that comprised representatives from these different groups to provide input into the SSM Project (refer to Appendix A for a list of members). Their engagement is discussed in subsequent parts of this report.

WHAT IS THE OUTCOME OR DELIVERABLE OF THE DECISION MAKING PROCESS?

The outcome of the decision making process for the SSM Project is a Business Case (presented in the over-arching report for the SSM Project) that NQBP proposes to take forward for the long term sustainable management of marine sediments at the Port of Hay Point.

Initial analysis of the decisions

As described above, Structured Decision Making has provided a method for comparing alternatives for managing marine sediments against a range of objectives relevant to the Port. In order to arrive at a relevant set of alternatives and generally help to structure and clarify thinking, a number of technical studies were first needed to help answer the preliminary decisions set out above. That is, is it necessary to manage sediment at the port in the short and/or long term, and if yes, what are the feasible ways to do this?

A summary of the work and analysis around these first two decisions is presented below.

IS IT NECESSARY TO MANAGE SEDIMENT AT THE PORT OF HAY POINT IN THE SHORT AND/OR LONG TERM?

Port navigational areas are areas that have been deepened to allow the safe navigation, movement, loading and transit of ships trading at the Port. These areas include shipping channels, apron areas and berth pockets.

The departure path and apron area at the Port of Hay Point are constructed to a designed navigational depth of 14.9 m below Lowest Astronomical Tide (LAT). The design depth of the berth areas vary from 16.6 m to 19.6 m below LAT.

Currents, wave energy and tidal regimes are responsible for mobilising and transporting sediments in these deeper areas of the Port. The different depths and water movement can cause significant changes in the patterns of sediment scouring (erosion) and accumulation (accretion).

A number of technical studies were commissioned as part of the SSM Project to understand the sediment management needs of the Port. These studies answered key questions around:

- The nature and sources of marine sediments that accumulate in the navigational areas at the Port (Advisian, 2016; AECOM, 2016; Royal Haskoning, 2016a).
- What drives sediment dynamics at the local and regional scales (AECOM, 2016; Royal Haskoning, 2016a).
- Current and predicted rates of sediment accumulation (Royal Haskoning, 2016a; Royal Haskoning, 2016b).
- Risks to operations from increased sedimentation at the Port (Port and Logistics Solutions, 2016).

Table 1 provides a summary of the key outcomes of this work.

From this work it was concluded that it is necessary to manage marine sediments in both the short and long term. This is due to the accumulation of marine sediments within the Port navigational areas, which will substantially impact Port operations in the absence of measures to manage sediment. Current levels of marine sediment accumulation and predicted future rates necessitate a management approach that provides both short and long term solutions.

Table 1: Summary of key issues and findings of studies commissioned to understand the sediment management needs of the Port

Issues considered	Key findings
Nature of marine sediments in the navigational areas	Sediments were found to be fine clay/silt material (60%), mixed with sand (36%) and small amounts of gravel material (4%) (Advisian, 2016)
	The content of sand and gravel becomes higher further offshore
	Given the mixed nature of the sediment and dominance of fine material, it is considered that it would be unrealistic to be able to separate sediment types during maintenance dredging

Issues considered	Key findings
Source and movement of marine sediments in the region	The dominant source of sediments accumulating in the navigational areas at the Port of Hay Point are large stores of available sediments on the inner continental shelf which are transported through coastal processes
	Reducing fluvial sources of sediment through in-catchment sediment control measures will result in very little reduction in sediment accumulation
	Cyclones have the potential to resuspend and move large quantities of sediment in the Great Barrier Reef region. These events can have significant impacts on navigation access to ports in the region.
	The system is considered balanced, meaning almost the same volumes of sediments that are entering a location are leaving
Current sediment accumulation within the Port	Limited accretion has occurred over the apron and channel areas during the ten years since their development in 2006
	The current maintenance dredging requirements at the port of Hay Point to re-establish design depths are: • Apron and departure path - 59,300 m^3 • DBCT berths - 139,800 m^3 • HPCT berths - 6,700 m^3 • Total re-establishment volume - 205,800 m^3
Future predicted maintenance dredging requirements	In relation to the apron and departure paths, there is predicted to be some gradual encroachment of the southern bank of the channel in the Inner and Outer Channel areas. These areas are not expected to require regular maintenance dredging in the future. Volumes in the order of 10,000 m^3 might be required every ten years
	In relation to the northern apron and berth pockets, to maintain the design depths for ambient conditions maintenance dredging of the DBCT berths should be required approximately two out of every three years (in-situ volume of 38,450 m^3), the HPCT berths every two years (in-situ volume of 23,330 m^3)
	Total siltation volume above the design depth over the next 20 years was predicted to be between 885,000 m^3 and 1,129,000 m^3 depending on the occurrence of tropical cyclones
	Dredging of critical areas will be needed approximately every three years if designed depths and port efficiency is to be maintained. Volumes may vary between 200,000 m^3 and 270,000 m^3 if no sedimentation reduction measures are adopted
Impacts to port operations and economics	Accumulation of sediments are expected to reduce port efficiency and economics due to the following cause and effects: • Loading suspended to maintain underkeel clearance on falling time, resulting in longer loading times • Water depth falls below the maximum sailing draft for larger vessels, increasing reliance on small vessels, leading to more vessel arrivals and reduced terminal capacity • Lower throughput increases costs per tonne, leading to a fall in Government royalties • Loading delays slow supply chain velocities, reducing mine sales revenue • Competitive advantage of the Port reduced, impacting Port Authority revenues and secondary service providers • Degraded socio-economic environment impacts regional wealth
	DBCT data shows that revenue losses occur at berth pocket depths of 18m–LAT. At 16m–LAT revenue losses in the order of $500 million to $2,5 billion can be predicted, whilst at 14.5m –LAT the losses could be expected in the order of $1 billion to $4,5 billion
	At 16m–LAT losses to State Government royalty fees are in the order of $50 million to $250 million, whilst at 14.5m–LAT this increases to between $100 million to $600 million

IF YES, WHAT ARE THE FEASIBLE WAYS TO MANAGE SEDIMENT?

A set of technical work was undertaken to fully explore the options available to manage marine sediment at the Port of Hay Point.

Three broad strategies used to reduce siltation at ports and harbours were considered (Royal Haskoning, 2016d). These included:

- Keep Sediment Out – keeping sediment out of the area of interest that might otherwise enter and deposit.
- Keep Sediment Moving – raising flow velocities in quiescent areas to prevent sediment from settling as it passes through the area of interest.
- Keep Sediment Navigable – applicable to sites characterised by high turbidity near-bottom sediment regimes where navigability of fluid mud zones is permitted, thereby reducing the required dredged depth.

The work showed that many of the alternatives are more suited to ports located on river banks or enclosed by breakwalls or similar structures. As such, many were considered simply not achievable in an offshore coastal port such as the Port of Hay Point (Royal Haskoning, 2016d).

The alternatives that were considered feasible at the Port of Hay Point included:

- Traditional maintenance dredging.
- Constructed sediment traps.
- Installation of Jet Arrays.
- Using a drag bar or sea rake to mobilise the seabed sediments.
- The use of propeller wash agitation equipment.

For each of these alternatives, as well as for traditional maintenance dredging, an estimate of the associated costs and greenhouse gas emissions (tonnes/CO_2eq) was calculated. In addition, a constraints analysis for each of the alternatives was developed to get a high level understanding of environment impacts, operational impacts, ongoing maintenance requirements, the degree of confidence in achieving the desired outcomes and consideration of the regulatory pathways or approvals.

An important finding of this study (Royal Haskoning, 2016d) was that out of all the alternatives investigated, only traditional maintenance dredging would be successful in the removal of the existing material that has accumulated in the Port of Hay Point navigational areas.

The other key findings of the work are (Royal Haskoning, 2016d):

- Traditional maintenance dredging provides the most cost effective and lowest GHG emission solution, although these are defined with the approval pathways.
- Drag barring or sea raking in the berths is a feasible solution to prevent ongoing high accretion rates. However, this solution is likely to be more expensive and result in higher GHG emissions than maintenance dredging. It is not expected that this alternative would be as effective in other navigational areas of the port.
- Propeller wash agitation by tugs is not a feasible solution for managing the siltation.
- Only the northern apron area would benefit from a sediment trap, by deepening the northern apron area to act itself as a sediment trap. The solution could reduce the frequency of the required maintenance dredging in the northern apron from every four years to every ten years. However, it would result in an increase in the maintenance dredge volumes of 160,000 m^3 over a 20 year period due to the initial establishment dredging required.
- A combination of various methods could be utilised, but a trial period with ongoing bathymetric analysis would be necessary to quantify the usefulness.

CONCLUSION

It was concluded through the initial consideration of the decisions that:

- It is necessary to manage sediment at the Port.
- Maintenance dredging is required as part of the solution for managing sediment, and that other methods (e.g. drag barring) require further trialling and would not in themselves provide a complete solution.

The comparative analysis from this point onwards focused on how best to deal with the dredge material.

Step 2: Identifying what is important

The second step in the comparative analysis process identified what is important to NQBP and stakeholders within the context of the third and fourth components of the decisions identified in Step 1 – i.e.:

> *If dredging is required, what are the feasible options for use or disposal of the material?*
>
> *What is the best package of measures to provide for long term sustainable management of marine sediments at the Port of Hay Point?*

Step 2 encouraged values or outcomes focussed thinking, helping to define the things that really matter in relation to the consequences of sediment management at the Port and then setting up a process to assess the alternatives against those objectives.

This step generated two key components of the comparative analysis process:

1. Objectives to consider in the decision making process. In other words, the things that really matter to NQBP and stakeholders when trying to make comparisons between sediment management options.
2. Performance measures for each of the objectives that provide a clear and transparent way of measuring how each of the sediment management alternatives perform.

Approach

A workshop was held with the Stakeholder Advisory Group in June 2016 to help define objectives and performance measures. Through this process a range of values were identified as relevant to the Port. These values fall within the following seven broad themes:

- Environment.
- Cultural heritage.
- Port economics.
- Health and safety.
- Social.
- Innovation.
- World Heritage.

Objectives were defined across the seven themes. The objectives aimed to be (Gregory *et al,* 2012):

- Complete – objectives were designed to capture all of the things that matter at the Port in the context of the decisions being made.
- Concise – unnecessary or similar objectives were removed to avoid double counting.
- Sensitive – objectives were developed that distinguish between the alternatives, thereby helping to differentiate them to aid decision making.
- Independent – objectives were developed in a way that ensures that performance against an objective could be considered independently of any other objective.

Performance measures were then defined for each objective. These measures provided a mechanism for predicting how well each of the alternatives performed against the objectives. Similar to the objectives, the performance measures were developed with a set of principles in mind to ensure they were useful and appropriate. The key issues considered when defining a performance measure were (Gregory *et al,* 2012):

- Coverage - the measures addressed the range of relevant consequences of each alternative.
- Practicality – the measures needed to be predictable, which means the data required to assess them could be obtained or generated.
- Direct and specific – the measures reported directly on the relevant consequences and effectively highlight differences in the alternatives to allow informed value trade-offs.

The objectives and measures were refined and finalised following the workshop based on a review of the technical information that was available to conduct the analysis.

Objectives and performance measures

Eleven objectives and fourteen performance measures were defined. These are shown in Table 2.

Further discussion of each of the performance measures, including a rationale for their use and how they have been calculated and analysed is provided at Step 4 and Appendix B.

Table 2: Objectives and performance measures for the SSM Project

Theme	Objective	Measure
ENVIRONMENT	1. Avoid and minimise impacts to coastal ecosystems	A) Predicted performance in relation to avoidance and minimisation of impacts to coastal ecosystems
		B) Predicted risk on dredge material placement plumes and/or tailwater discharge exceeding ambient variation (percentile above median ambient TSS)
	2. Minimise carbon emissions	C) Forecast Greenhouse gas emissions
CULTURAL HERITAGE	3. Minimise impact on cultural heritage within the area	D) Nature and scale of any impact on cultural heritage
PORT ECONOMICS & OPERATION	4. Maintain effective and efficient port operations	E) Number of days disruption to terminal loading operations
		F) Predicted lead time to dredge material placement
		G) Capacity to provide a long term solution for the port
	5. Ensure solution is cost effective	H) Assessment of costs[1]
	6. Avoid significant loss of future port expansion opportunities	I) Strategic Port Land (SPL) affected
HEALTH & SAFETY	7. Avoid or mitigate health and safety risks	J) Relative risk
SOCIAL[2]	8. Minimise interference to social activities within the region	K) Scale and duration of any impacts on social activities
	9. Provide increased economic and social opportunities	L) Predicted number of FTE jobs created
INNOVATION	10. Promote innovation in port management	M) Ability of a solution to advance current dredging practice information, technology and techniques
WORLD HERITAGE	11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area	N) Scale and duration of activity within the Great Barrier Reef World Heritage Area

[1] The various reports support the SSM Project calculated the cost of different options in slightly differing ways depending on assumptions, inclusions and exclusion in the cost. Accordingly a standardized approach was adopted and this was applied to costing all alternatives. Refer Appendix H.

[2] The social theme includes consideration of other industries such as fisheries, aquaculture and tourism. It also takes into account recreational activities.

Step 3: Developing alternatives for reuse or disposal of sediment

Following the analysis of sedimentation rates and options to avoid or reduce sedimentation in key port navigational areas (described under Step 1), it was concluded that maintenance dredging cannot be avoided and that it will be necessary to maintain effective port operations.

There is currently approximately 200,000 m^3 of material to be dredged from the port for maintenance of safe depths in the port's operational areas. It is expected that maintenance dredging of this quantum will be required approximately every five years over at least the next 25 years.

After establishing the need to dredge marine sediments, the subsequent decision that needed to be addressed was:

If dredging is required, what are the feasible options for use or disposal of the material?

The third step in the structured decision making process worked through this question in order to identify a set of relevant, feasible alternatives for consideration in the comparative analysis. This work aimed to consider as broad a range of options as possible and to not be limited by precedent or traditional thinking. The development of feasible alternatives was informed by detailed work to identify and describe the environmental, social and cultural values of the region (Jacobs 2016).

Analysis to identify feasible alternatives for reuse or disposal of sediment

A number of studies were undertaken to help identify the most appropriate solutions for reuse or disposal of the maintenance dredge material. This work involved:

- Consideration of the sediment properties (Advisian, 2016).
- Identification and analysis of beneficial reuse options (Advisian, 2016).
- Identification and analysis of suitable material disposal/placement locations (a range of assessments, as identified below).

SEDIMENT PROPERTIES

The analysis of the geotechnical properties of the material to be dredged shows that the sediment is (Advisian, 2016):

- Largely fine clay/silt material (60%), mixed with sand (36%) and small amounts of gravel material (4%).
- Free of contamination and therefore suitable for ocean placement.
- Likely to contain high plasticity clay.
- Likely to have very high moisture content, and therefore significant effort would be required to dry out the sediment as may be required for various reuse options.
- Likely to have very low to medium compressibility and have some potential to swell and shrink, making it unsuitable for heavy load bearing uses.
- Likely to be potential acid sulfate soil (PASS). However, the sediment contains sufficient acid neutralising capacity to buffer inherent acidity to negligible concentrations and as such are unlikely to require ASS treatment.

ANALYSIS OF OPTIONS FOR BENEFICIAL REUSE OF DREDGE MATERIAL

Advisian (2016) identified eleven potential options for the beneficial reuse of dredge material (see Table 3). These options were selected based on the sediment properties and the views of an expert team with local, international and specific dredging and materials use experience.

Table 3: Beneficial reuse options considered for feasibility

Reuse category	Option
Reuse of dredge material as an engineering material	• Land reclamation • Construction fill (low strength) • Road base • Lining material • Concrete products (low strength) • Shoreline protection • Beach nourishment

Recycle of dredge material as an environmental enhancement	• Coastal (tidal) habitat rehabilitation including
	    o Direct placement
	    o Indirect placement
	• Deep water habitat creation

Reuse of dredge material as an agricultural application	• Aquaculture • Topsoil for agricultural use

These options were analysed in detail to determine what may be feasible at the Port of Hay Point. Advisian (2016) considered a range of performance criteria when comparing options, including:

- Sediment suitability.
- Greenhouse gas emissions.
- Opportunity or demand.
- Conceptual cost.
- Confidence in beneficial reuse process.
- Duration from construction to use.
- Environmental implications.
- Socio-economic implications.
- Environmental approvals.
- Constraints.
- Knowledge gaps (requiring research).
- Longevity of the beneficial reuse option.

The analysis found that the majority of options were limited due to factors such as the suitability of the sediment (high plasticity, high moisture content, low compressibility), economic demand or cost.

Based on the analysis of feasibility, two options were selected for further consideration. These are habitat rehabilitation and land reclamation. These options were selected as they were generally amongst the higher-ranking options, they performed well against sediment suitability criteria and were also considered to have high or moderate demand/opportunity.

From these two beneficial reuses, three alternatives were developed based on likely suitable locations. These are:

- Habitat (mangrove) rehabilitation - Sandringham Bay.
- Land reclamation - Port of Hay Point.
- Land reclamation - Mackay Harbour.

It is important to note that a number of the beneficial reuse options listed in Table 3 would require the material to be brought onshore for drying and processing. Although these options are not considered individually as feasible alternatives, onshore disposal (as described below) is considered as part of the comparative analysis and essentially captures these options.

ANALYSIS OF OPTIONS FOR DISPOSAL/PLACEMENT OF DREDGE MATERIAL

Over time a number of studies have been undertaken to identify potential locations for the disposal or placement of dredge material from the Port of Hay Point. These studies have included examination of options for both maintenance dredging material and material from capital dredging projects, including:

- Spoil Ground Site Selection – Port of Hay Point (WBM 2004a).
- Assessment of Land Disposal Options for Dredge Spoil at the Port of Hay Point (WBM 2004b).
- Dredge Spoil Disposal Options Assessment Hay Point Coal Terminal Expansion BM Alliance Coal Operations Pty Ltd (Connell Hatch 2009).
- Literature Review and Cost Analysis of Land-based Dredge Material Re-use and Disposal Options, Revision 2.4, (SKM 2013 for GBRMPA Strategic Assessment).
- Dudgeon Point Coal Terminals Project: Dredge Material Relocation Options (Worley Parsons 2012).
- Maintenance Dredging Management Plan Port of Hay Point (Worley Parsons 2013a).

Additionally, a number of offshore placement locations have been considered in the past, of these three were selected for consideration and comparison. These were selected on the basis that:

- One is the existing placement area that has been used at the Port for a number of years with success, monitoring has shown very low levels of environmental impact.
- A mid shelf option in deeper water less influenced by tides and currents and well away from sensitive environments
- A third option beyond the eastern limits of the Great Barrier Reef WHA and Marine Park, well away from sensitive environments and internationally listed areas.

In all two onshore and three offshore placement options were selected as possible alternatives for consideration in the comparative analysis. These are:

- Onshore pond at Mackay Harbour.
- Onshore pond at Dudgeon Point.
- Existing offshore dredge material placement area.
- Mid-shelf offshore dredge material placement area.
- Coral sea offshore dredge material placement area.

Description of the alternatives for reuse or disposal of sediment

As outlined above, the analysis of feasible options for the use or disposal of dredge material at Hay Point arrived at eight alternatives to be considered in the comparative analysis. Following is a short description of each alternative and Figure 2 provides a map of their respective locations.

RECLAMATION AT HAY POINT

Dredge material would be used to construct a reclamation area of approximately 20 ha located to the north of the existing tug harbour at Hay Point. This option involves construction of a 1,250 m rock wall embankment. It is estimated to have capacity for approximately four dredging campaigns.

Proposed land use of the reclaimed area following completion of the dredging campaigns is yet to be determined. The reclaimed area would have low strength due to the use of predominantly fine-grained sediments from the maintenance dredging. It would therefore be unsuitable for industrial use with heavy load bearing, although ground improvement measures could be undertaken to increase the strength.

RECLAMATION AT MACKAY HARBOUR

Dredge material would be used to construct a reclamation area of approximately 20 ha adjacent to the existing north harbour wall. The reclamation area would be protected by a rock wall approximately 860 m in length. It is estimated to have capacity for approximately five maintenance dredging campaigns.

The area has been identified for use as future strategic port lands. However, the reclaimed area at Mackay Harbour would have low strength due to the use of predominantly fine-grained sediments from the maintenance dredging.

It would therefore be unsuitable for industrial use with heavy load bearing, although ground improvement measures could be undertaken to increase the strength.

MANGROVE REHABILITATION AT SANDRINGHAM BAY

Dredge material would be used to create intertidal mudflats to support new areas of mangrove habitat. This option offers a unique opportunity to achieve environmental gains. Mangrove habitats provide an important ecological function including stabilizing shorelines, improving water quality and providing habitat and nutrients for a variety of fauna species. Mangroves also have a large capacity for absorbing substantial amounts of greenhouse gases.

The process would involve the use of coarser dredge material to create an underwater bund, with fine dredge material deposited behind the bund and retained to form new mudflats in which mangrove habitat can be created. For the purposes of this analysis it is assumed that it could contain the volume from a single maintenance dredging campaign.

This process is generally well understood; however there are few examples of it being used in environments similar to Hay Point using maintenance dredge material. There are significant knowledge gaps around coastal dynamics, sediment material and potential impacts on foreshore dynamics, demand for habitat rehabilitation and detailed design that would be need to be addressed if this option is pursued. At least five years of further scientific investigations and environmental assessment are expected to be required.

ONSHORE POND AT DUDGEON POINT

Dredge material would be pumped into an onshore pond located at Dudgeon Point. The pond would comprise an area of approximately 50 ha and would be contained within bund walls constructed using material from the site.

The site has capacity for one dredging campaign. However, future campaigns could be accommodated by either removing the dried out dredge material from the pond to create sufficient capacity for any subsequent maintenance dredging campaign or by increasing the height of the bunds to increase the capacity of the pond.

ONSHORE POND AT MACKAY HARBOUR

Dredge material would be pumped into an onshore pond located to the west of Slade Road in the Port of Mackay. The pond would comprise an area of approximately 20 ha and would be contained within bund walls constructed using material from the site.

The site has capacity for one dredging campaign. However, future campaigns could be accommodated by either removing the dried out dredge material from the pond to create sufficient capacity for any subsequent maintenance dredging campaign or by increasing the height of the bunds to increase the capacity of the pond.

EXISTING OFFSHORE DREDGE MATERIAL PLACEMENT AREA

Dredge material would be placed on the seabed within an offshore Dredge Material Placement Area (DMPA) located approximately 3 km to the north east of the berth facilities. This location has previously been used to dispose of maintenance dredge material from the Port of Hay Point since 2006 and is approximately 1,800 ha. A single dredging program would take approximately 14 days to complete.

This alternative:

- Is in close proximity to the berth area to be dredged.
- Is in a previously disturbed area.
- Uses dredge material relocation techniques that are well understood.

MID-SHELF OFFSHORE DREDGE MATERIAL PLACEMENT AREA

Dredged material would be placed on the seabed at a mid-shelf DMPA. This area is located approximately 25 km north-east of berth facilities at the Port of Hay Point. Typical travel time to the mid-shelf disposal location by a TSHD would be approximately 6 hours return. A single dredging program would take approximately 23 days to complete.

This alternative:

- Is located in deep water offshore.
- Is within an area that has not been previously disturbed.
- Uses dredge relocation techniques that are well understood.

CORAL SEA OFFSHORE DREDGE MATERIAL PLACEMENT AREA

Dredged material would be placed within an offshore area of the Coral Sea Reserve, east of the outer boundary of the Great Barrier Reef Marine Park/World Heritage boundaries. The DMPA would be within an area zoned

Multiple Use of the Coral Sea Reserve. This site would be located approximately 300 – 400 km offshore of the mainland. A single dredging program would take approximately 58 days to complete.

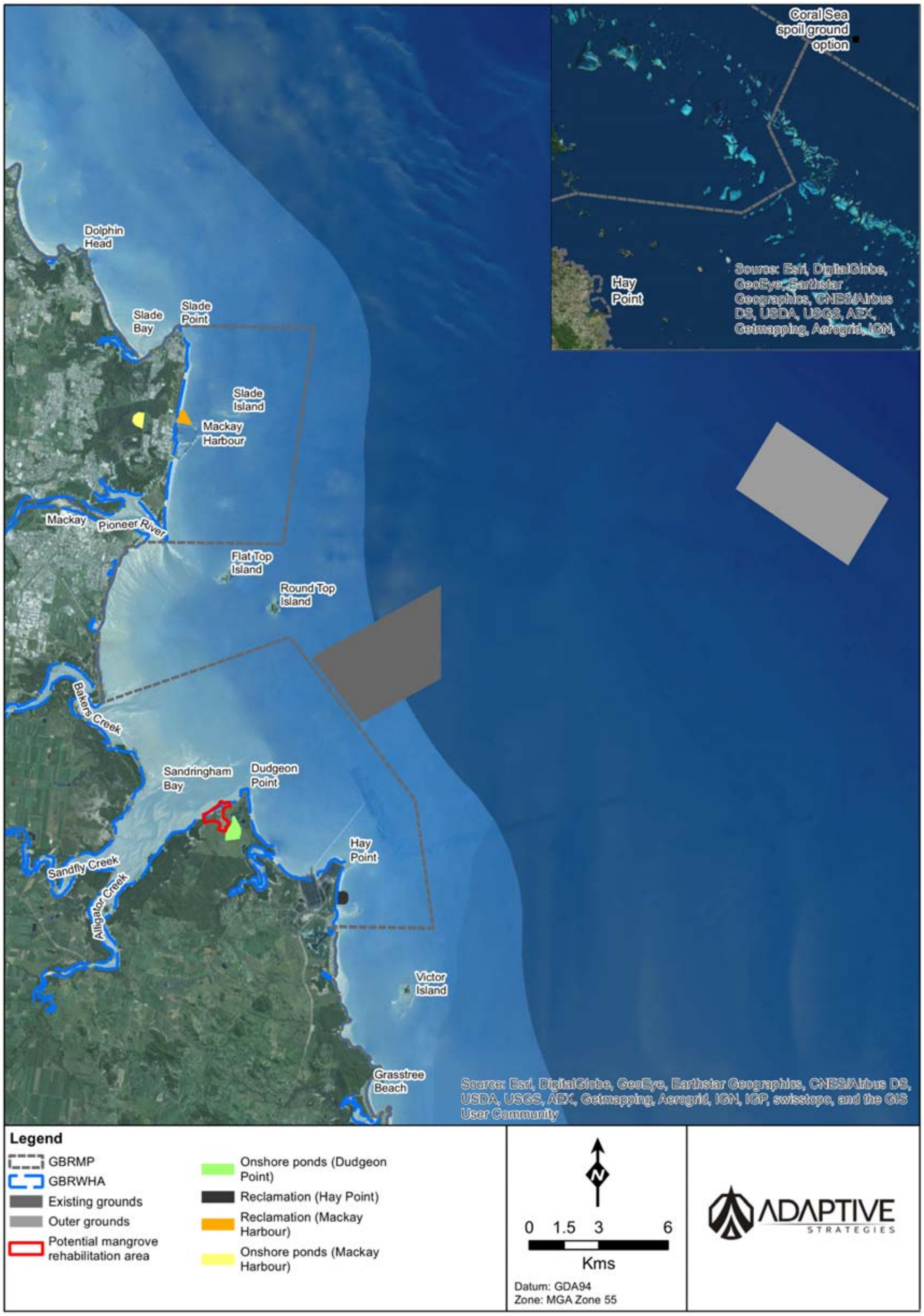


Figure 2: Location of the eight alternatives for dredge material placement

Step 4: Understanding the performance of alternatives

As described under Step 2, objectives and performance measures were defined to allow the performance of each alternative to be measured and compared. A set of detailed, technical work was undertaken following identification of the alternatives to generate the data and scores against each performance measure.

In order to compare alternatives using different performance measures it is necessary to apply standard statistical methods to ensure the comparisons are valid and balanced. In particular this involves the process of normalisation whereby different measures and units of score are standardised to a score in a range from 0 to 1.

The formula that was used to normalise raw scores was:

$$\text{Normalised score} = \frac{\text{raw score} - \text{worst score}}{\text{best score} - \text{worst score}}$$

This work is summarised below and explained in full with results and reference material in Appendix B.

Objective 1: Avoid and minimise impacts to coastal ecosystems

Stakeholders agreed that it was important to look for opportunities to avoid or minimise impacts on coastal ecosystems. Two performance measures were generated in relation to this objective:

A. Predicted performance in relation to avoidance and minimisation of changes to coastal ecosystems.

B. Predicted risk on dredge material placement plumes and/or tailwater discharge exceeding ambient variation (percentile above median ambient TSS).

A) COASTAL ECOSYSTEMS

Theme:	Environment
Objective:	1. Avoid and minimise impacts to coastal ecosystems
Measure:	A) Predicted performance in relation to avoidance and minimisation of changes to coastal ecosystems
	Unit of measure: Performance score ranging from 4-16
	Which direction of the measure is better? Higher

The coastal ecosystems performance measure examined potential impacts from each alternative in relation to the following coastal ecosystems:

- Land based ecosystems: threatened ecological communities (TECs), and other native vegetation.
- Freshwater and estuary ecosystems: wetlands, estuaries and mangroves.
- Coastal landforms: salt marsh, saline coastal flats / swamp, beaches, and rocky headlands.
- Marine ecosystems: coral reefs, seagrass and/or seabed.

Changes or losses to these coastal ecosystems or landforms can lead to a variety of adverse environmental impacts, as well as serious implications for industries dependent on the Great Barrier Reef Marine Park. Stakeholders commonly agreed that rather than attempting to analyse potential impacts on individual species at this point in the project, the potential changes more broadly on coastal ecosystems and landforms (which provide the habitat for species) was an appropriate measure for understanding the potential impacts of each alternative. More detailed environmental impact assessment will form part of any future assessment and approval processes.

A performance score (higher score is better) was generated for each alternative based on a set of criteria that considered:

- Scale of change.
- Ecosystem status.
- Species habitat status.
- Duration of change.

B) MARINE WATER QUALITY

Theme:	Environment
Objective:	1. Avoid and minimise impacts to coastal ecosystems
Measure:	B) Predicted risk of dredge material placement plumes and/or tailwater discharge exceeding ambient variation (percentile above median ambient TSS)
	Unit of measure: Performance score ranging from 0-21
	Which direction of the measure is better? Lower

Marine waters are the vector to disturbance of a range of receptors, including benthic communities (e.g. seagrass and coral), fishes, and a range of megafauna such as dolphins, turtles and whales. All stakeholders felt that the potential impacts on these waters was an important criteria to assess when considering the alternatives for long term sustainable sediment management at the Port of Hay Point.

NQBP conduct an ambient water quality monitoring program that extends from Freshwater Point to the south of the Port, extending to Keswick Island to the north (approximately 55 km of the coastal strip). This program provides the background data for the performance measure.

A performance score (lower score is better) was generated for each alternative based on the predicted risk of dredge material placement plumes and/or tailwater discharge exceeding ambient variation (percentile above median ambient TSS).

Objective 2: Minimise carbon emissions

Consideration of the potential Greenhouse Gas (GHG) emissions from the construction and operational activities of each alternative is an important component of comparing the alternatives. Stakeholders agreed that understanding how each alternative performed in relation to forecast GHG emissions should form part of the decision making process.

C) GHG EMISSIONS

Theme:	Greenhouse Gas (GHG) emissions
Objective:	2. Minimise carbon emissions
Measure:	C) Forecast GHG emissions
	Unit of measure: Tonnes of CO2 equivalent (tCO2-e)
	Which direction of the measure is better? Lower

Calculating forecast GHG emissions was undertaken in accordance with the internationally recognised methodology outlined in the GHG Protocol. In accordance with the Protocol, the assessment considered the following emissions:

- Direct emissions – e.g. emissions associated with fossil fuel consumption by vessels/construction plant/vehicles during transport and construction. These are known as 'Scope 1' emissions in the GHG Protocol.
- Indirect emissions from supporting activities – e.g. emissions associated with the production of construction materials. These are known as 'Scope 3' emissions in the GHG Protocol. For this project high level estimates are used.

None of the alternatives were considered likely to result in significant indirect emissions due to the consumption of purchased electricity (known as 'Scope 2' emissions in the GHG Protocol). Scope 2 emissions were therefore not part of this assessment.

Objective 3: Minimise impact on cultural heritage within the area

The sustainable sediment management project aims to further improve the management of port sediments while ensuring the continued operation of the port, ensuring social and cultural features are respected and that environmental and cultural heritage values are protected. Stakeholders wanted to ensure that the potential for impacts on cultural heritage arising from the various options were considered in the decision making process.

D) CULTURAL HERITAGE

Theme:	Cultural Heritage
Objective:	3. Minimise impact on cultural heritage within the area
Measure:	D) Nature and scale of any impact on cultural heritage
	Unit of measure: Performance score ranging from 3 - 9
	Which direction of the measure is better? Lower

The Yuwibara (Yuibera) People are the registered claimants of the port area. Indigenous cultural heritage values have been identified in the Port of Hay Point's environs, primarily in the Dudgeon Point coastal zone. The majority of these sites are concentrated on the bar of sand that extends from Dudgeon Point to Mount Hector (Alligator Creek) along the coast. This dune system separates the freshwater lagoon from the littoral zone and appears to have been a focal point for subsistence activity. There are also coloured rocks in the Louisa Creek area and a fish trap at Hay Point that are of particular significance to the local Indigenous people.

A cultural heritage performance score (lower score is better) was generated for each alternative based on a set of criteria that considered:

- The nature of any interaction with or disturbance to identified Indigenous cultural heritage or potential unknown sites and/or artefacts.
- The nature of any interaction with landscape/cultural connection of importance to Indigenous people.
- Impact on access for Indigenous people to culturally important places.

Objective 4: Maintain effective and efficient port operations

Stakeholders agreed that it was important to examine alternatives that provided for effective and efficient port operations. Three performance measures were generated in relation to this objective:

E. Number of days disruption to terminal loading operations.

F. Predicted lead time to dredge material placement.

G. Capacity to provide a long term solution for the port.

E) PORT DISRUPTION

Theme:	Port Economics & Operation
Objective:	4. Maintain effective and efficient port operations
Measure:	E) Number of days disruption to terminal loading operations
	Unit of measure: Days
	Which direction of the measure is better? Lower

A critical aspect to sustainable sediment management at the Port of Hay Point is providing a solution that ensures ongoing port efficiency but also provides for minimal disruption to port operations during the actual dredging and placement activity.

Disruptions to terminal operations are most likely while the dredge is operating in the berth and apron areas of the port. During these times other vessel movements may be limited and one or more berths may remain unoccupied for a longer period than usual. With some constraints on movement from other vessel traffic and tidal movements these disruptions can become extended and of some consequence.

F) LEAD TIME

Theme:	Port Economics & Operation
Objective:	4. Maintain effective and efficient port operations
Measure:	F) Predicted lead time to dredge material placement
	Unit of measure: Years
	Which direction of the measure is better? Lower

Stakeholders agreed that finding appropriate solutions that could be implemented within required timeframes was important (i.e. how long it will take to plan, get approval, and prepare works). The last maintenance dredging campaign occurred in 2010 and the most recent surveys show that depths, particularly in certain berth areas, are reducing due to sediment accumulation.

Accordingly, it is necessary to conduct maintenance dredging in the near future if port operations are to continue without serious restrictions. Optimal timing would be to conduct maintenance dredging within the next three years (any longer would be problematic).

The lead time for each alternative was calculated based on industry experience in relation to the following key preparatory stages:

- Research/studies.
- Engineering design.
- Planning and approval.
- Construction.

G) LONG TERM SOLUTION

Theme:	Port Economics & Operation
Objective:	4. Maintain effective and efficient port operations
Measure:	G) Capacity to provide a long term solution for the port
	Unit of measure: Years
	Which direction of the measure is better? Higher

A critical aspect to the project is providing a long term solution that can address the requirements of multiple dredging campaigns. A well designed and implemented long term solution will provide certainty for all stakeholders and the best outcomes across the various project themes (environment, cultural heritage, port economics & operation, health & safety, social, innovation, and World Heritage).

The capacity of each alternative was calculated based on the need for 200,000 m^3 of maintenance dredging every five years to maintain effective and safe operation of the port.

Objective 5: Ensure solution is cost effective

All stakeholders recognised that cost was an important criteria to assess when considering the alternatives and that ensuring that solutions are cost effective is critical.

H) COST

Theme:	Port Economics
Objective:	5. Ensure solution is cost effective
Measure:	H) Assessment of costs
	Unit of measure: AUD and Present Value
	Which direction of the measure is better? Lower

It is important to note that the assessment of cost did not attempt to provide a full, detailed costing of each option. Rather it took a high level approach to determine the rough order of magnitude costs for each alternative using present dollar values.

Cost estimates for the options of reclamation at Hay Point, reclamation at Mackay, onshore disposal at Dudgeon Point, and onshore disposal at Mackay were derived from the report Royal Haskoning DHV (2016) Port of Hay Point - Onshore Pond and Reclamation Engineering Design. The cost estimate for the habitat rehabilitation alternative was derived from Advisian (2016) Comprehensive Beneficial Reuse Assessment. In order to provide comparable costings, some reconciliation between the methods of the two reports occurred. In addition, further analysis was done to provide cost estimates for the three offshore disposal alternatives based on previous port planning activities that considered these options.

Objective 6: Avoid significant loss of future port expansion opportunities

Maintaining effective port operations and future port development opportunities is a critical component of the decision making process.

I) SPL AFFECTED

Theme:	Port Economics & Operation
Objective:	6. Avoid significant loss of future port expansion opportunities
Measure:	I) Strategic Port Land (SPL) affected
	Unit of measure: Hectares
	Which direction of the measure is better? Lower

One of the factors to consider around this objective is the impact of each of the alternatives on the statutory designated port land in the Ports of Hay Point and Mackay. Strategic Port Land (SPL) is set aside through the planning system to facilitate the operation and future development of port related activities.

Stakeholders agreed that any loss of available port land (SPL) and thus restrictions on future opportunities for growth should be considered.

The area that would be potentially impacted was calculated based on the location and land area needed to deliver each alternative. Calculations include maritime port area that may also be used to facilitate port activities in the future.

Objective 7: Avoid or mitigate health and safety risks

All stakeholders felt that the impacts on human health and safety was an important criteria to assess when considering the alternatives for long term sustainable sediment management at the Port of Hay Point.

J) HUMAN HEALTH AND SAFETY

Theme:	Human Health and Safety
Objective:	7. Avoid or mitigate health and safety risks
Measure:	J) Relative risk
	Unit of measure: Performance score ranging from 8-24
	Which direction of the measure is better? Lower

To assess this component, a range of human health and safety measures were developed along with some simple performance criteria to rank them.

It is important to note the process was not intended to replicate a full risk assessment (based on unmitigated and mitigated risks derived from likelihood and consequences of various activities). Rather it took a high level approach around potential risk pathways and complexity. More detailed assessment will be considered for the preferred alternative as part of any future project planning and management. A performance score (lower score is better) was generated for each alternative based on a set of criteria that considered:

- Interaction with public areas.
- Dust and emissions.
- Duration of activity (influences likelihood of occurrence).
- Spills and contaminants.
- Heavy vessel / machinery interaction.
- Isolated areas – proximity to medical support.
- Weather exposure.
- Personnel requirements.

Objective 8: Minimise interference to social activities within the region

The coastal areas and inner waters of the GBR around Mackay and Hay Point support a range of social and commercial activities, including: farming, commercial fishing, recreational fishing, boating, informal recreation (swimming, surfing, walking). People living in the area need to access a wide range of services from Mackay.

Stakeholders wanted to ensure that the potential for impacts on social features and activities arising from the various options were considered in the decision making process.

K) SOCIAL

Theme:	Social
Objective:	8. Minimise interference to social activities within the region
Measure:	K) Scale and duration of any impacts on social activities
	Unit of measure: Performance score ranging from 3 - 9
	Which direction of the measure is better? Lower

A performance score (lower score is better) was generated for each alternative based on a set of criteria that considered:

- The nature of any interaction with social features or activities.
- The length of time any interaction or disturbance will occur for.
- Number of people affected.

Objective 9: Provide increased economic and social opportunities

As part of the broader social theme, all stakeholders recognised that a positive consideration would be to measure and compare the jobs created by each option. In particular local job creation is seen as important as it will contribute to the regional economy and enhance the social fabric of the region. Jobs created at a broader level are also of value but for the purposes of comparison have been weighted at a lower factor.

L) EMPLOYMENT

Theme:	Social
Objective:	9. Provide increased economic and social opportunities
Measure:	L) Predicted number of FTE jobs created
	Unit of measure: Full Time Equivalent (FTE) jobs created
	Which direction of the measure is better? Higher

For each alternative the forecast number of part-time and full time jobs (if any) was determined to create an overall jobs score.

Objective 10: Promote innovation in port management

In line with the 'net benefits concept' promoted in the Reef 2050 Plan and various findings from the Independent Review of the Port of Gladstone it is desirable to seek and examine new port and environmental management options that promote best practice and deliver improved sustainable solutions.

Stakeholders were of the opinion that the innovative nature of alternatives should inform the decision making process

M) INNOVATION

Theme:	Innovation
Objective:	10. Promote innovation in port management
Measure:	M) Ability of a solution to advance current dredging practice information, technology and techniques
	Unit of measure: Performance score ranging from 3-9
	Which direction of the measure is better? Higher

A performance score (higher score is better) was generated for each alternative based on a set of criteria that considered:

- Application of information.
- Application of technology/techniques.
- Use of ingenuity.

Objective 11: Avoid and minimise impacts to the Great Barrier Reef World Heritage Area

NQBP operates three ports within the Great Barrier Reef World Heritage Area (GBRWHA), including the Port of Hay Point. The Port undertakes a number of water quality management and monitoring initiatives to ensure that impacts to the WHA are avoided and minimised as far as practicable. These initiatives actively ensure that the Port is operating in accordance with the objectives and actions of the Reef 2050 Plan. The sustainable sediment management project aims to further improve the management of port sediments within the WHA through long-term, strategic management actions.

Stakeholders wanted to ensure that the potential for direct impacts and increased operational activities from different alternatives within the GBRWHA was captured in the decision making process.

N) WORLD HERITAGE

Theme:	World Heritage
Objective:	11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area
Measure:	N) Scale and duration of activity within the Great Barrier Reef World Heritage Area
	Unit of measure: Performance score ranging from 3 - 9
	Which direction of the measure is better? Higher

A World Heritage performance score (higher score is better) was generated for each alternative based on a set of criteria that considered:

- The size of the seabed area within the WHA directly altered by the sediment management alternative.
- The length of time the alteration to the seabed within the WHA would occur.
- The time it takes to complete the dredger operational activities associated with a single dredge campaign within the WHA.

Step 5: Comparing alternatives and selecting a preferred option

The final step in the comparative analysis was the application of a process to:

A. Initially compare the alternatives against the objectives and performance measures using the results of the analysis in Step 4.

B. Based on the results of that initial analysis, develop a set of long term options for management of sediment at the port by combining alternatives over a 25 year period.

C. Analyse and compare the long term options against the objectives and performance measures to arrive at a preferred solution.

The process was extensive and involved:

- Comparing alternatives against the objectives and performance measures identified in Step 2.
- Removing clearly inferior alternatives (e.g. alternatives that performed extremely poorly against one or more objectives).
- Ranking alternatives using various methods (e.g. different weightings, sensitivity analysis).
- Clarifying stakeholder views on their preferred alternatives.
- Refining alternatives as needed to reach an optimal long term solution.
- Recommending a preferred solution based on the outcomes of the analysis.

The methods and results of this work are presented in this section of the report with more detailed information included in Appendix C.

5a. Initial comparison of alternatives

The initial comparison of alternatives examined the eight possible options for reuse or disposal of sediment identified in Step 3:

- Land reclamation - Port of Hay Point (Rec - HP).
- Land reclamation - Mackay Harbour (Rec – M).
- Habitat (mangrove) rehabilitation - Sandringham Bay (Rehab).
- Onshore pond at Dudgeon Point (Onshore – DP).
- Onshore pond at Mackay Harbour (Onshore – M).
- Existing offshore Dredge Material Placement Area (Existing).
- Mid-shelf offshore Dredge Material Placement Area (Mid-shelf).
- Coral sea offshore Dredge Material Placement Area (Coral sea).

RAW SCORES CONSEQUENCE TABLE

The raw scores from each performance measure (see Step 4 and Appendix B) were used to generate a consequence table. A consequence table is a matrix that illustrates and compares the performance of each alternative with respect to the objectives. Key elements of the table (Table 4) include:

- The table includes all of the objectives and performance measures identified in Step 2.
- The table indicates which direction is better for each performance measure in the “Dir” column. “H” is higher, and “L” is lower.
- The best scores for a performance measure are highlighted in green.
- The worst scores for a performance measure are highlighted in red.

Table 4: Raw scores for single dredge campaign

Theme	Objectives	Performance measure	Units	Dir	Rec - HP	Rec - M	Rehab	Onshore - DP	Onshore - M	Existing	Mid-shelf	Coral sea
ENV	1. Avoid and minimise impacts to coastal ecosystems	A) Coastal ecosystems performance	4-16	H	4	4	16	7	6	6	8	8
		B) Water quality performance	0-21	L	0	0	0	0	0	6	1	0
	2. Minimise carbon emissions	C) GHG emissions	tCO2-e	L	24,774	19,485	1,674	7,421	4,886	618	1,012	6,693
CULTUR	3. Minimise impact on cultural heritage within the area	D) Cultural heritage performance	3-9	L	4	4	3	5	5	3	3	3
ECON	4. Maintain effective and efficient port operations	E) Port disruption	Days	L	23	31	20	23	31	14	23	16
		F) Lead time	Years	L	4	4	5.5	3.75	4.25	1	1.5	4
		G) Long term solution	Years	H	20	25	10	20	20	25	25	25
	5. Ensure solution is cost effective	H) Cost	$ million	L	$35.26	$26.02	$6.97	$22.94	$15.56	$1.83	$2.97	$29.47
	6. Avoid significant loss of future port expansion opportunities	I) SPL area affected	ha	L	40	40	20	50	50	0	0	0
H&S	7. Avoid or mitigate health and safety risks	J) Relative risk	8-24	L	16	16	10	15	16	8	11	15
SOCIAL	8. Minimise interference to social activities within the region	K) Social performance	3-9	L	6	7	3	3	7	3	3	3
	9. Provide increased economic and social opportunities	L) Employment	FTE	H	8.37	5.46	1.58	5.77	2.73	0.25	0.5	0.175
INNO	10. Promote innovation in port management	M) Innovation	3-9	H	3	3	8	3	3	3	5	5
WH	11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area	N) World Heritage performance	4-12	H	7	6	11	9	9	9	8	10

Best score for a performance measure

Worst score for a performance measure

ANALYSIS

The analysis of the eight alternatives shows how they each perform against the objectives and measures.

One of the critical findings is that only two alternatives have the potential to be implemented within three years – the existing and mid-shelf offshore dredge material placement areas. The technical studies that investigated sediment dynamics and rates of sediment accumulation in the port navigational areas found that maintenance dredging within the next three years is necessary if port operations are to continue without serious restrictions (see performance measure F in Appendix B).

The other critical objective to consider when looking at each alternative is the long-term sediment management requirements of the Port. There is a demonstrated need for ongoing maintenance dredging every five years in the order of 200,000 m^3 of material for the next 25 years. Looking at Table 4 only four alternatives have the potential to provide this capacity over a 25 year period – reclamation at Mackay and the three offshore options.

With only two offshore alternatives able to deliver on both the three year lead time objective and the 25 year capacity, the next stage of the analysis therefore looked at combinations of alternatives to determine whether performance against the full range of objectives could be better optimised. This next step recognised that there is merit in the other alternatives as long as they are considered as part of a combined option that provides for both a short and long term solution.

5b. Development of long term options for reuse or disposal of sediment

Further analysis of the individual alternatives was undertaken in order to generate a combination of options that could:

- Provide for maintenance dredging in the next three years.
- Offer a long-term solution over 25 years.
- Optimise performance against the range of other objectives.

This further analysis included:

- Normalising the scores so that a quantitative comparison could be made between performance measures with different units.
- Applying weightings to performance measures to arrive at an overall performance score for each alternative.

NORMALISED SCORES

Because many of the performance measures were reported in different units, the raw scores were normalised in order to enable further analysis and comparison. Various approaches were used depending on the nature of the performance measure to normalise the scores as unitless numbers between 0 and 1, where 0 is the worst value and 1 is the best.

An example of a calculation used to normalise scores is as follows:

$$\textit{Normalised score} = \frac{\textit{score} - \textit{worst score}}{\textit{best score} - \textit{worst score}}$$

The specific formula and normalised scores for each performance measure can be seen in Appendix B.

Water quality example

A useful example to consider in relation to normalisation is the water quality performance measure. The raw scores were calculated based on a performance score ranging from 0-21 (where 0 is the best raw score for water quality). The normalisation process distributed the raw scores between 0-1 (where 1 is the best normalised score for water quality). The formula that was used was:

$$\textit{Normalised water quality score} = \frac{21 - \textit{raw score}}{21}$$

The results of this work are shown in Table 5. In this example:

- Six of the alternatives have the best possible raw score for water quality and consequently received a normalised score of 1.

- Two alternatives have slightly poorer raw scores. For example the existing offshore DMPA has a raw score of 6 and consequently received a normalised score of 0.71. It is worth noting that this still represents a good overall performance score.

Table 5: Raw and normalised scores for water quality (performance measure B)

Water quality performance measure (B)	Rec - HP	Rec - M	Rehab	Onshore - DP	Onshore - M	Existing	Mid-shelf	Coral sea
Raw scores (range from 0-21)	0	0	0	0	0	6	1	0
Normalised scores (range 0-1)	1.00	1.00	1.00	1.00	1.00	0.71	0.95	1.00

WEIGHTINGS

The second step involved weighting the normalised scores for each performance measure and calculating an overall performance score for each alternative out of 100. A score of 100 would mean that an alternative performs perfectly against every performance measure.

Weighting scenarios

Weighting is an important step in the decision making process. It is a process that people often undertake subconsciously by placing more value on some objectives over others when trying to make a decision between options. The structured decision making process provides a transparent way of applying and testing weightings.

It is recognised that stakeholders value objectives differently and will therefore apply different weightings. Given this, no attempt was made to reach a consensus on how to apply weightings. Rather a number of different weighting scenarios were generated to see how each alternative would perform. The weighting scenarios (see Table 6) were:

- Equal weights - all performance measures were weighted equally.
- Environment focus - performance measures relating to the environment theme were attributed with 75% of the weightings.
- Social focus – performance measures relating to the social theme were attributed with 75% of the weightings.
- Economic focus - performance measures relating to the port economics and operation, and health and safety themes were attributed with 75% of the weightings.
- Cultural focus – the performance measure relating to the cultural heritage theme was attributed with 75% of the weightings.
- World Heritage – the performance measure relating to the World Heritage theme weighted was attributed with 75% of the weightings.

In addition to these scenarios, stakeholders were provided with the opportunity to apply and test their own weightings to understand how each option would perform under a range of different situations.

Table 6: Weighting scenarios

Objectives	Performance measure	Equal weights	Enviro focus	Social focus	Economic focus	Cultural focus	WHA
1. Avoid and minimise impacts to coastal ecosystems	A) Coastal ecosystems performance	8.3	25.0	2.5	3.1	2.3	2.3
	B) Water quality performance	8.3	25.0	2.5	3.1	2.3	2.3
2. Minimise carbon emissions	C) GHG emissions	8.3	25.0	2.5	3.1	2.3	2.3
3. Minimise impact on cultural heritage within the area	D) Cultural heritage performance	8.3	2.8	2.5	3.1	75.0	2.3
4. Maintain effective and efficient port operations	E) Port disruption	8.3	2.8	2.5	18.8	2.3	2.3

Objectives	Performance measure	Equal weights	Enviro focus	Social focus	Economic focus	Cultural focus	WHA
5. Ensure solution is cost effective	H) Cost	8.3	2.8	2.5	18.8	2.3	2.3
6. Avoid significant loss of future port expansion opportunities	I) SPL area affected	8.3	2.8	2.5	18.8	2.3	2.3
7. Avoid or mitigate health and safety risks	J) Relative risk	8.3	2.8	2.5	18.8	2.3	2.3
8. Minimise interference to social activities within the region	K) Social performance	8.3	2.8	37.5	3.1	2.3	2.3
9. Provide increased economic and social opportunities	L) Employment	8.3	2.8	37.5	3.1	2.3	2.3
10. Promote innovation in port management	M) Innovation	8.3	2.8	2.5	3.1	2.3	2.3
11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area	N) World Heritage performance	8.3	2.8	2.5	3.1	2.3	75.0
	Total	**100**	**100**	**100**	**100**	**100**	**100**

Weighted scores

A summary of the overall performance of each option under the six weighting scenarios is provided in Table 7. The best performing option under each scenario is highlighted in green and the worst performing is highlighted in red.

Table 7: Summary of weighted scores (max 100) for each alternative across the six weighting scenarios

	Rec - HP	Rec - M	Rehab	Onshore - DP	Onshore - M	Existing	Mid-shelf	Coral sea
Equal weights	42	40	70	53	43	75	73	65
Environment focus	36	40	89	62	59	67	75	68
Social focus	65	46	62	75	35	58	58	54
Economic focus	39	39	58	46	38	89	80	66
Cultural focus	72	72	92	63	60	93	93	91
WHA	39	29	83	60	57	66	56	72

Best score for an option under a particular weighting scenario

Second best score for an option under a particular weighting scenario

Worst score for an option under a particular weighting scenario

ANALYSIS

Review of the raw scores (Table 4) led to the following conclusions:

- The three offshore options all perform relatively well across a range of measures. The existing offshore alternative generally outperforms the mid-shelf alternative, which generally outperforms the Coral Sea alternative.
- The two reclamation options and the two onshore pond options generally result in the worst scores across a range of measures. This particularly relates to GHG emissions and cost.
- Reclamation at Mackay performs slightly worse than reclamation at the Port of Hay Point.
- The mangrove rehabilitation project generally scores well except for lead in time and the capacity to provide a long term solution.

- All of the alternatives perform well in relation to the marine water quality performance score. The existing offshore dredge material placement area performs the worst but still receives a good score (6 out of 24 with lower being better).

The weighted scores (Table 7) provided the following additional insights:

- Under an equal weights scenario, existing offshore DMPA, mid-shelf DMPA and mangrove rehabilitation ranked as the three highest performing alternatives.
- The lowest performing alternative under an equal weights scenario was reclamation at Mackay Harbour.
- Three alternatives ranked amongst the three highest performers under at least three different weighting scenarios. This result implies that these alternatives can be expected to respond well to a broader range of stakeholder values and factors that might influence decision makers. These were:
    - Mangrove rehabilitation, which ranked highly under the four scenarios of Equal, Environment, Cultural and World Heritage.
    - Existing offshore DMPA which ranked highly under the three scenarios of Equal, Economic and Cultural.
    - Mid-shelf DMPA, which ranked highly under the four scenarios of Equal, Environment, Economic and Cultural.
- Reclamation at Mackay and the onshore pond at Mackay never ranked amongst the three highest performers under different weighting scenarios. They can therefore both be expected to respond poorly to the range of stakeholder values and factors that might influence decision makers.

DEVELOPMENT OF THE COMBINED OPTIONS

The detailed analysis of the eight individual alternatives helped to generate eleven combined options that have the potential to address both the short and long-term sediment management needs of the Port.

There are two important things to note in the configuration of the long-term options:

- In order to provide for maintenance dredging within the next three years, the existing or mid-shelf offshore DMPAs were always included. Given the existing offshore alternative outperforms the mid-shelf alternative under an equal weights scenario it was used in the majority of cases.
- Reclamation at Mackay was dropped entirely as it was deemed clearly inferior to the other seven alternatives. This conclusion was reached based on the fact that reclamation at Mackay was the lowest performing alternative under an equal weights scenario and never ranked amongst the three highest performers under any of the weighting scenarios.

The eleven long term options were:

- At Sea Existing x 1 followed by Reclamation Hay Point x 4 (1 Exist + 4 Rec HP).
- At Sea Existing x 1 followed by Habitat Rehabilitation x 1 followed by at Sea Existing x 3 (1 Exist + 1 Mangrove + 3 Exist).
- At Sea Existing x 1 followed by Habitat Rehabilitation x 1 followed by Reclamation Hay Point x 3 (1 Exist + 1 Mangrove + 3 Rec HP).
- At Sea Existing x 1 followed by Habitat Rehabilitation x 1 followed by Onshore Dudgeon Point x 3 (1 Exist + 1 Mangrove + 3 DP).
- At Sea Existing x 1 followed by Onshore Dudgeon Point x 4 (1 Exist + 4 DP).
- At Sea Existing x 1 followed by Habitat Rehabilitation x 1 followed by Onshore Mackay x 3 (1 Exist + 1 Mangrove + 3 Onshore Mack).
- At Sea Existing x 1 followed by Onshore Mackay x 4 (1 Exist + 4 Onshore Mack).
- At Sea Existing x 5 (5 Exist).
- At Sea Mid-shelf x 5 (5 Mid-shelf).
- At Sea Mid-shelf x 1 followed by Habitat Rehabilitation x1 followed by At Sea Mid-Shelf X 3 (1 Mid-shelf + 1 Mangrove + 3 Mid-shelf).
- At Sea Existing x 1 followed by at Sea Coral Sea x 4 (1 Exist + 4 Coral).

5c. Comparison of long term options for reuse or disposal of sediment

The performance of the long term options were scored against the objectives and performance measures over a 25 year time frame. The methodology and results for each performance measure are described in Appendix B.

It is important to note that two performance measures did not flow through to the long term assessment. These were the performance measures relating to lead in time (measure F) and the capacity to provide a long term solution (measure G). These were removed from this stage of the analysis as all of the long term solutions were designed so they could be implemented within the next three years and provide capacity for 25 years.

The analysis for the long term options involved the same steps and similar level of detail to the analysis described above for the individual alternatives. Noting that in addition to reviewing the raw scores and weighted scenarios, a sensitivity analysis was performed to help address uncertainty.

RAW SCORES

The raw scores for each long term option are shown in Table 8. These scores indicate that:

- The options comprising solely of the existing or mid-shelf offshore DMPAs generally perform well across a range of measures.
- Options that include onshore disposal at Mackay and reclamation at Hay Point generally perform poorly.
- Options that include mangrove habitat rehabilitation perform moderately well.

WEIGHTED SCORES

The weighted scores under the equal weights scenario are shown in Table 9. The weighted scores under the other five scenarios are provided in Appendix C.

A summary of the overall performance of each option under the six weighting scenarios is provided in Table 10. Again, the best performing option under each scenario is highlighted in green and the worst performing is highlighted in red.

Analysis across various weighting scenarios indicated that:

- Three options clearly outperformed the rest. These options ranked as the three highest performers under all scenarios except for World Heritage. They were:
    - '5 exist' which performed the best under the Equal, Social, Economic and Cultural Heritage scenarios. It still performed well (ranking third) under the Environment and World Heritage scenarios.
    - '1 exist, 1 mangrove, 3 exist' which ranked first under the Social, Cultural Heritage and World Heritage scenarios. It also ranked second under the Equal, Environment and Economic scenarios.
    - '1 mid-shelf, 1 mangrove, 3 mid-shelf' which performed the best under the Environment scenario, ranked second under the Social and Cultural Heritage scenarios, and third under Equal weights.
- The performance of the three top options listed above indicates that they can be expected to respond well to a broader range of stakeholder values and factors that might influence decision makers when compared to the other options. It should be noted, that these three options still perform well up to the point that the World Heritage performance measure is attributed up to 40-65% of the weightings (a significant proportion for a single measure). This is discussed further in the sensitivity analysis below.
- The '1 exist, 4 rec HP' option generally performed the worst, ranking amongst the lowest across all scenarios other than Cultural Heritage. This option performed the worst under the Equal, Environment and World Heritage scenarios.

Table 8: Raw scores for each long term option

Theme	Objectives	Performance measure	Units	Dir	1 Exist + 4 Rec HP	1 Exist + 1 Mangr+ 3 Exist	1 Exist + 1 Mangr + 3 Rec HP	1 Exist + 1 Mangr + 3 DP	1 Exist + 4 DP	1 Exist + 1 Mangr + 3 Onshore Mack	1 Exist + 4 Onshore Mack	5 Exist	5 Mid-shelf	1 Exist + 4 Coral	1 Mid-shelf + 1 Mangr + 3 Mid Shelf
ENV	1. Avoid and minimise impacts to coastal ecosystems	A) Coastal ecosystems performance	20-80	H	22	40	34	43	34	40	30	30	40	38	48
		B) Water quality performance	0-105	L	6	24	6	6	6	6	6	30	5	6	4
	2. Minimise carbon emissions	C) GHG emissions	(tCO2-e)	L	27,777	4,146	28,656	11,303	10,424	9,544	9,053	3,090	5,060	32,018	5,722
CULTUR	3. Minimise impact on cultural heritage within the area	D) Cultural heritage performance	15-45	L	19	15	18	21	23	21	23	15	15	15	15
ECON	4. Maintain effective and efficient port operations	E) Port disruption	Days	L	106	76	103	103	106	127	138	70	115	78	112
	5. Ensure solution is cost effective	H) Cost	$ millions (present value)	L	$25.73	$7.57	$20.76	$17.33	$20.72	$16.13	$14.49	$4.38	$7.11	$42.93	$9.60
	6. Avoid significant loss of future port expansion opportunities	I) SPL area affected	ha	L	40	20	60	70	50	70	50	0	0	0	20
H&S	7. Avoid or mitigate health and safety risks	J) Relative risk	8-24	L	16	10	16	15	15	16	16	8	11	15	11
SOCIAL	8. Minimise interference to social activities within the region	K) Social performance	15-45	L	27	15	24	15	15	27	31	15	15	15	15
	9. Provide increased economic and social opportunities	L) Employment	FTE jobs created	H	0.3748	0.1032	0.428	0.344	0.3008	0.2224	0.1792	0.05	0.1	0.038	0.1432
INNO	10. Promote innovation in port management	M) Innovation	15-45	H	15	20	20	20	15	20	15	15	25	23	28
WH	11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area	N) World Heritage performance	20-60	H	37	47	41	47	45	47	45	45	40	49	43

Best score for a performance measure

Worst score for a performance measure

Table 9: Weighted scores under the equal weights scenario for each long term option

Theme	Objectives	Performance measure	Units	Dir	Equal weights	1 Exist + 4 Rec HP	1 Exist + 1 Mangr + 3 Exist	1 Exist + 1 Mangr + 3 Rec HP	1 Exist + 1 Mangr + 3 DP	1 Exist + 4 DP	1 Exist + 1 Mangr + 3 Onshore Mack	1 Exist + 4 Onshore Mack	5 Exist	5 Mid-shelf	1 Exist + 4 Coral	1 Mid-shelf + 1 Mangr + 3 Mid Shelf
ENV	**1. Avoid and minimise impacts to coastal ecosystems**	A) Coastal ecosystems performance	20-80	H	8.3	0	3	2	3	2	3	1	1	3	3	4
		B) Water quality performance	0-105	L	8.3	8	6	8	8	8	8	8	6	8	8	8
	2. Minimise carbon emissions	C) GHG emissions	(tCO2-e)	L	8.3	1	8	1	6	6	6	7	8	8	0	8
CULTUR	**3. Minimise impact on cultural heritage within the area**	D) Cultural heritage performance	15-45	L	8.3	7	8	8	7	6	7	6	8	8	8	8
ECON	**4. Maintain effective and efficient port operations**	E) Port disruption	Days	L	8.3	4	8	4	4	4	1	0	8	3	7	3
	5. Ensure solution is cost effective	H) Cost	$ millions (present value)	L	8.3	4	8	5	6	5	6	6	8	8	0	7
	6. Avoid significant loss of future port expansion opportunities	I) SPL area affected	ha	L	8.3	4	6	1	0	2	0	2	8	8	8	6
H&S	**7. Avoid or mitigate health and safety risks**	J) Relative risk	8-24	L	8.3	4	7	4	5	5	4	4	8	7	5	7
SOCIAL	**8. Minimise interference to social activities within the region**	K) Social performance	15-45	L	8.3	5	8	6	8	8	5	4	8	8	8	8
	9. Provide increased economic and social opportunities	L) Employment	FTE jobs created	H	8.3	1	0	1	1	1	0	0	0	0	0	0
INNO	**10. Promote innovation in port management**	M) Innovation	15-45	H	8.3	0	1	1	1	0	1	0	0	3	2	4
WH	**11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area**	N) World Heritage performance	20-60	H	8.3	4	6	4	6	5	6	5	5	4	6	5
					TOTAL SCORE	**41**	**70**	**45**	**54**	**52**	**47**	**44**	**71**	**68**	**56**	68

Best score for a performance measure

Worst score for a performance measure

Table 10: Summary of weighted scores (max 100) across the six weighting scenarios

	1 Exist + 4 Rec HP	1 Exist + 1 Mangr + 3 Exist	1 Exist + 1 Mangr + 3 Rec HP	1 Exist + 1 Mangr + 3 DP	1 Exist + 4 DP	1 Exist + 1 Mangr + 3 Onshore Mack	1 Exist + 4 Onshore Mack	5 Exist	5 Mid-shelf	1 Exist + 4 Coral	1 Mid-shelf + 1 Mangr + 3 Mid-shelf
Equal weights	41	70	45	54	52	47	44	71	68	56	68
Environment focus	39	69	44	63	60	61	57	65	72	46	75
Social focus	36	57	41	54	53	37	31	57	56	52	56
Economic focus	44	80	44	48	49	39	40	89	74	59	69
Cultural focus	74	92	78	73	68	71	65	92	91	88	91
WHA	42	68	50	64	60	62	57	65	55	68	60

Best score for an option under a particular weighting scenario

Second best score for an option under a particular weighting scenario

Worst score for an option under a particular weighting scenario

ADDRESSING UNCERTAINTY

Uncertainty is an inherent component to the complex type of analysis and decision making involved with the SSM Project. There is a level of uncertainty in:

- The scores against each performance measure (e.g. the cost calculations for each option).
- The weightings that may be applied by different stakeholders and how influential those weightings are to the selection of a preferred solution.

To respond to these challenges, sensitivity analysis was undertaken at two levels:

- Analysis to understand how influential changes to the performance measure scores would be to overall performance.
- Analysis to understand how overall performance scores may change under different weighting scenarios.

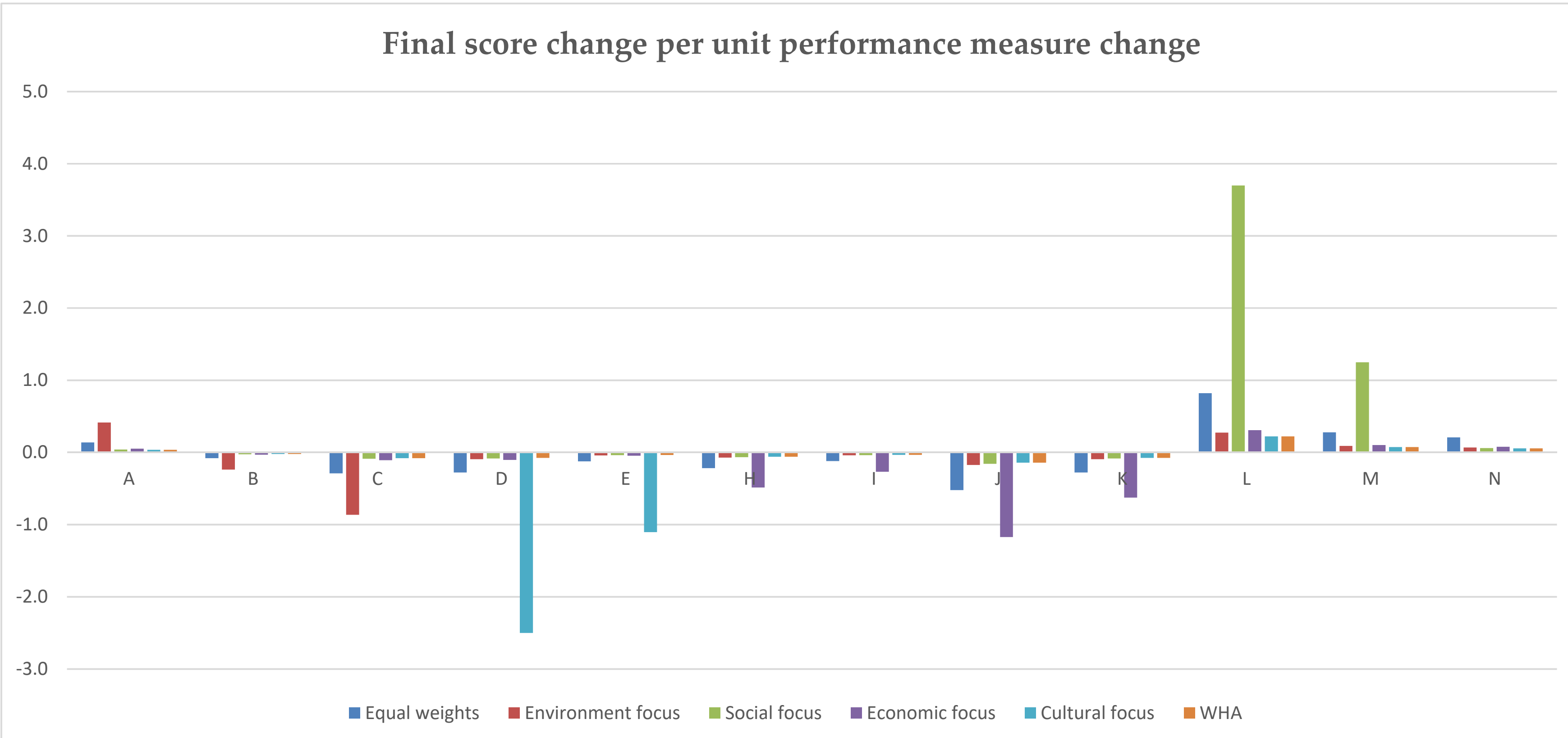
Sensitivity analysis around performance measure scores

An analysis was undertaken to understand how influential changes to individual performance measure scores would be to overall performance scores. This was done for all measures under the six weighting scenarios. The process involved examining how much the overall performance score would change for every one unit of change in a performance measure. The method provides confidence in the performance measures by testing their sensitivity and it addresses any outliers. Figure 3 plots the result of that analysis.

The results indicate that small changes to the performance measures will generally lead to very small changes in the overall performance of an alternative. This suggests that there is some margin for error in the scores assigned to each performance measure, which helps to address concerns around uncertainty in this aspect of the analysis.

A useful example to consider is the water quality performance measure (see B in Figure 3). A decrease in the performance score of one unit will lead to a maximum reduction in the overall performance of an alternative by 0.2 (this occurs under the environment weighting scenario).

The exception to this is where a performance measure is highly influential under a particular weighting scenario (e.g. the cultural heritage measure under the cultural focus weighting scenario). In this instance, small changes to the key performance measure(s) will have a much greater affect on the overall score. This result is to be expected given the method used in deriving the weighted scores.



PERFORMANCE MEASURES - A: coastal ecosystems. B: marine water quality. C: GHG emissions. D: cultural heritage performance. E: port disruption. H: Cost. I: SPL affected. J: human health and safety. K: social performance. L: employment. M: innovation. N: World Heritage performance.

Figure 3: How changes in performance measure scores influence overall performance scores under each weighting scenario

Sensitivity analysis around weightings

The second important component to the sensitivity analysis was understanding how performance varied as the weighting scenarios varied.

An indicative 75% weighting was used to derive the initial scenarios (e.g. 75% of the weights applied to economic measures to create the economic focus scenario). To understand how that might change, weights were varied for each scenario between 5% and 95% and the overall performance scores for each option plotted to provide a comparison. These are illustrated in:

- Figure 4: Environment focus sensitivity analysis.
- Figure 5: Social focus sensitivity analysis.
- Figure 6: Social focus sensitivity analysis.
- Figure 7: Cultural focus sensitivity analysis.
- Figure 8: World Heritage focus sensitivity analysis.

The following conclusions were reached from results of this analysis:

- Changes to the weights applied to the environment focus would have minimal impact on the overall outcome. Two of the three highest performing options maintain their top performance rankings regardless of changes in the weighting used. The '5 exist' option is an exception, noting that this option steadily declined from being the best performing option when the environment weighting was low, to the point of dropping out of the top three rankings around the 75% mark.
- Increasing the weighting applied to the social focus led to a steady decline in the three highest performing options. Based on this result, you could expect to see a different set of highest performing options once the weighting much exceeded 75%. This suggests that stakeholders with a very strong focus on social outcomes might arrive at a preferred option, which is different to those that performed well under the social scenario used in this report.
- Changes to the weights applied to the economic focus would have no impact on the overall outcome. Increasing the weighting under this scenario only improved the scores of the three highest performers, further strengthening their rankings compared with the other options.
- Similarly, changes to the weights applied to the cultural heritage focus would have no impact on the overall outcome, with an increase in the weighting leading to an increase in the scores of the three highest performers.
- The World Heritage focus is the most responsive to changes in the weightings used. The ranked performances of the different options begin to change when World Heritage is given a weighting of around 40%. Up until this point, the options that perform well under all other scenarios continue to rank amongst the highest.

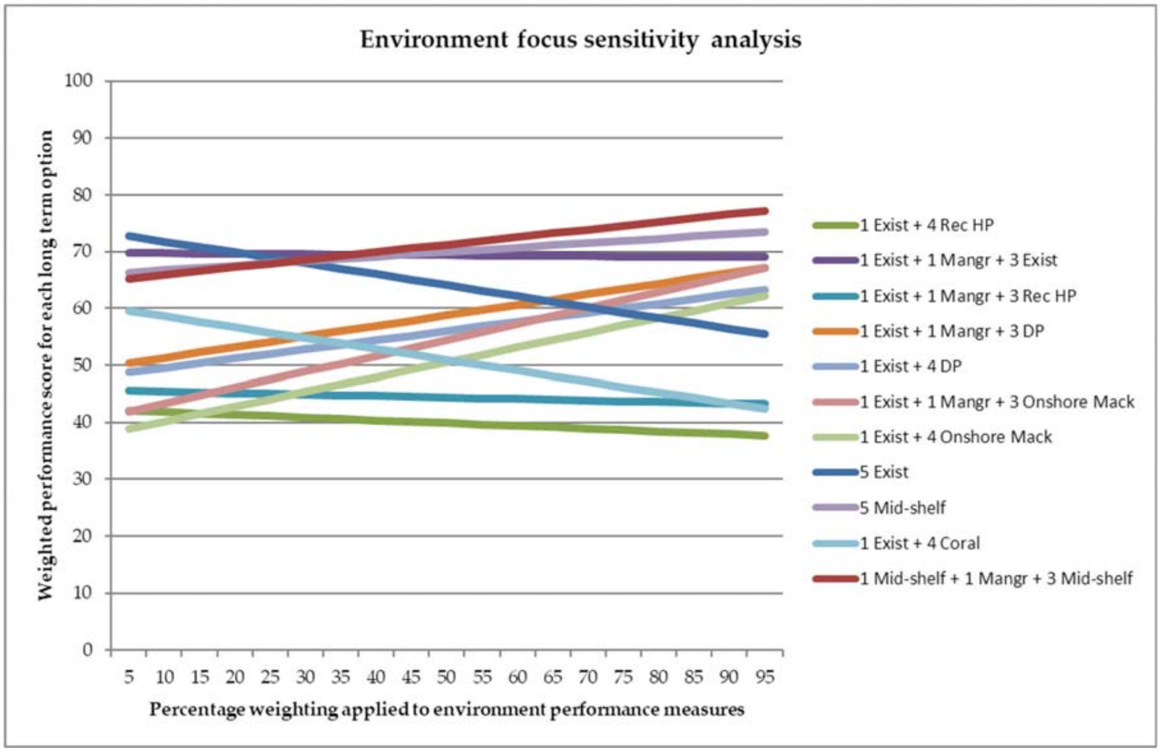


Figure 4: Environment focus sensitivity analysis

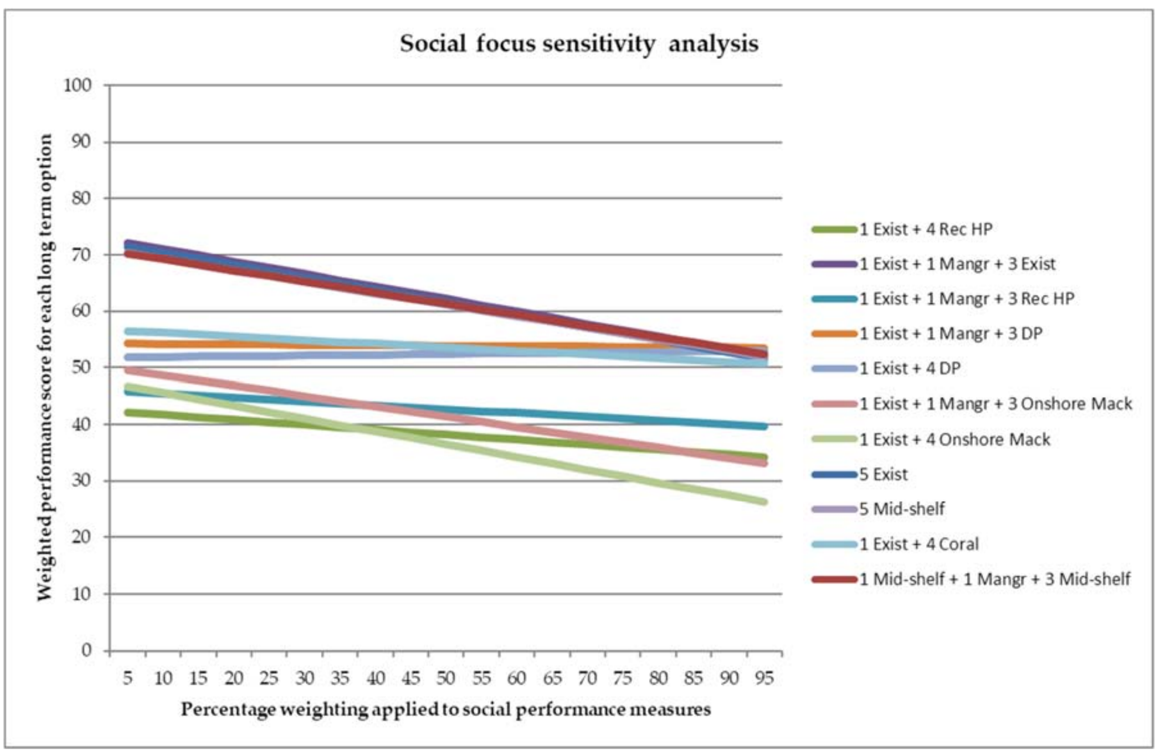


Figure 5: Social focus sensitivity analysis

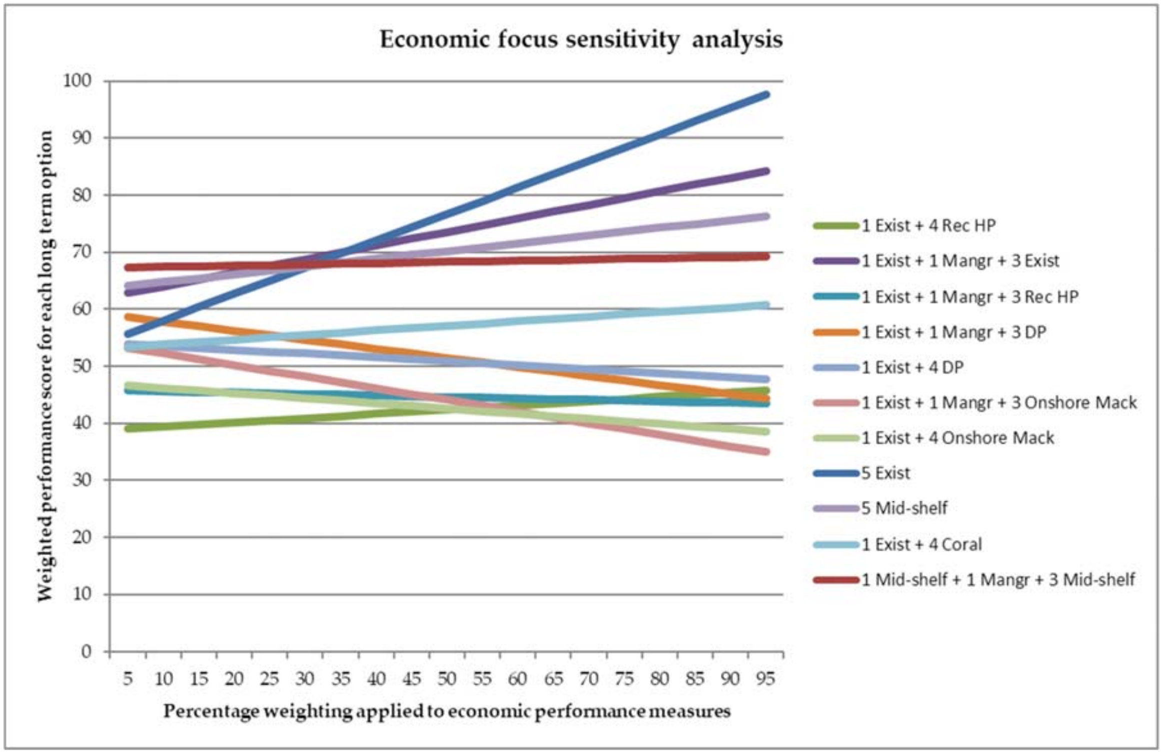


Figure 6: Economic focus sensitivity analysis

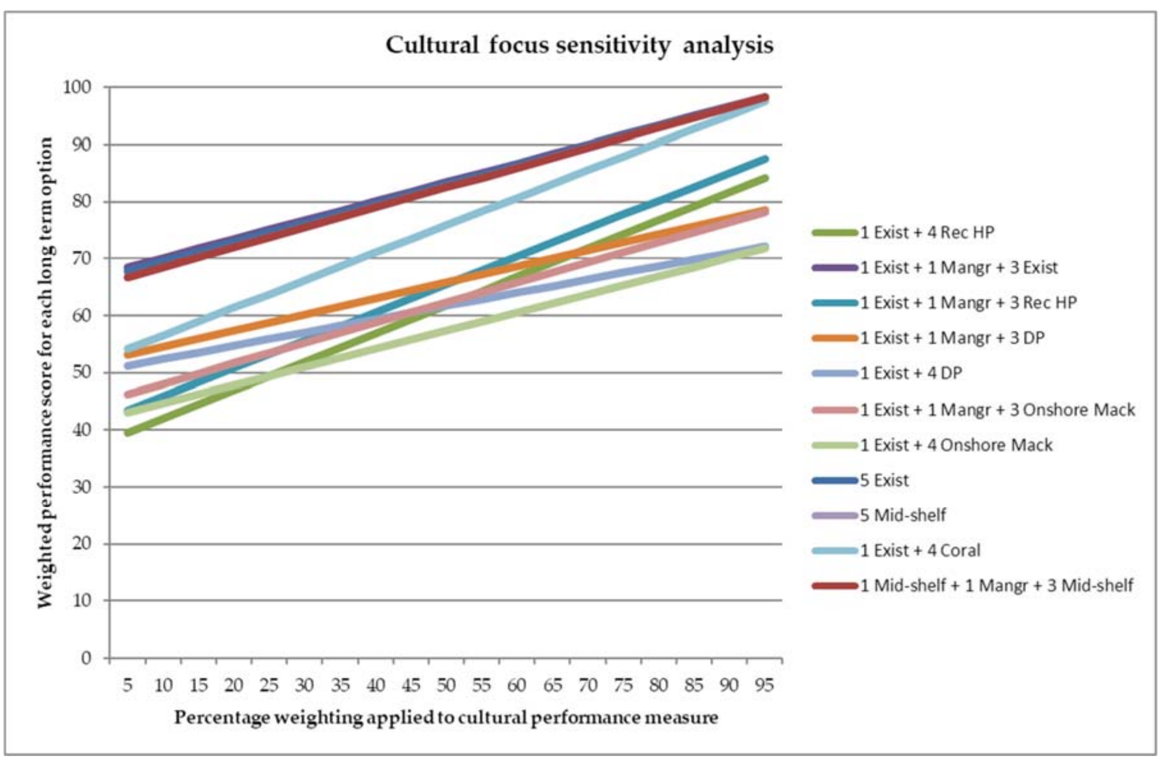


Figure 7: Cultural focus sensitivity analysis

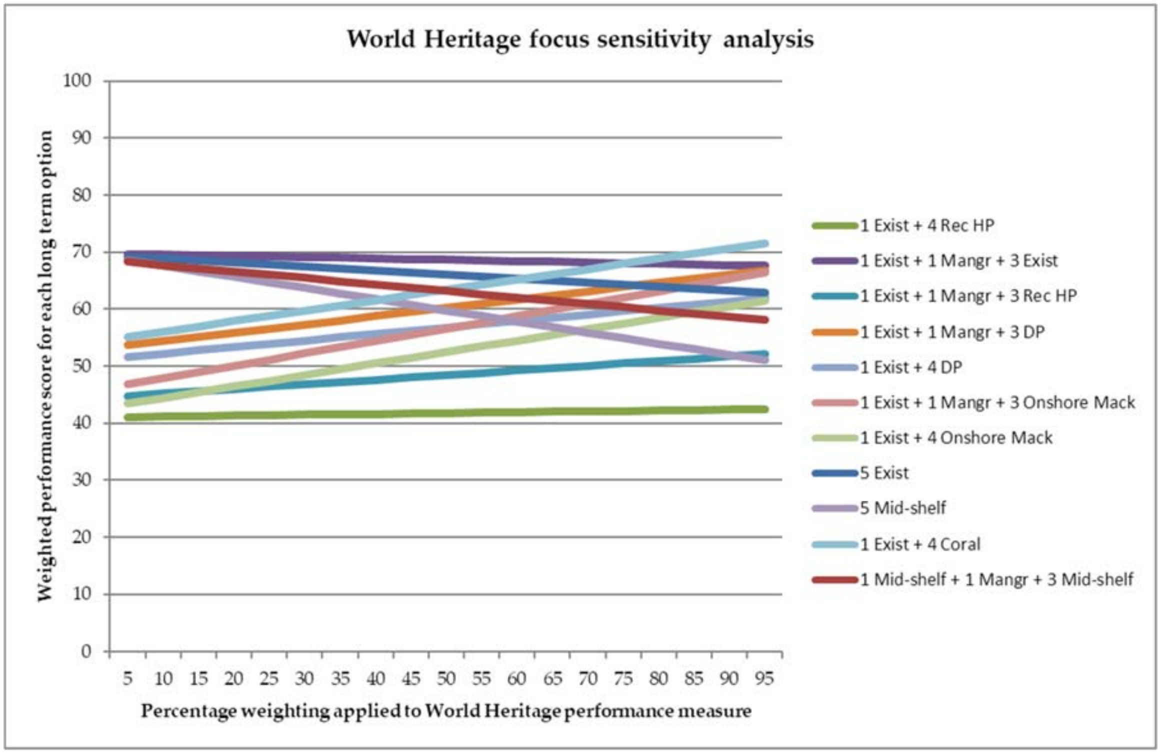


Figure 8: World Heritage focus sensitivity analysis

Overall analysis and conclusion

The analysis in the SSM Project has led to three key findings:

- Sediment at the Port of Hay Point needs to be managed.
- Dredging is required as part of the management solution.
- There are a discrete set of feasible options that have the potential to provide a long term solution for use or disposal of sediment.

Initial analysis

The initial analysis of options for reuse or disposal of dredge material looked at eight discrete alternatives against the objectives of the project. From that work it was clear that:

- A combination of alternatives needed to be considered as part of a long term solution. This was because only two alternatives could be implemented in the short term and only four alternatives had the capacity to provide a long term solution on their own. It was also thought that analysis of different combinations of alternatives may provide an optimised long term solution (i.e. benefitting from the best components of different alternatives).
- Offshore disposal at the existing or potential new mid-shelf DMPA would be needed to deal with maintenance dredging in the next three years to keep the port operating effectively. The lead time of the other alternatives is too long.
- Reclamation at the Port of Mackay was the worst performing single alternative and did not warrant further analysis.

Eleven long term options were developed as a result of this initial analysis for further consideration.

Analysis of long term options

Of the eleven long term options that were tested in the comparative analysis, three stood out as the best performers under a range of scenarios against the objectives of the project. They were:

- Offshore disposal at the existing DMPA (5 Exist).
- Offshore disposal at a new mid-shelf DMPA (5 Mid-shelf).
- A combination of disposal at a new mid-shelf DMPA and mangrove rehabilitation at Sandringham Bay (1 Mid-shelf + 1 Mangrove + 3 Mid-shelf).

These three options scored well[3] against a number of performance measures including coastal ecosystems, water quality, GHG emissions, cultural heritage, cost, affected SPL area, relative risk to health and safety and social performance. These performance measures largely represent the range of measures influencing the different weighting scenarios. As a result, these three high performing options were also found to perform well under most scenarios used to represent the different values or focus that might be applied by a range of stakeholders.

The exception to this was the World Heritage scenario. The three highest performing options generally began to shift once a weighting of around 40-65% or greater was applied. This suggests that a stakeholder with a very strong focus on World Heritage outcomes might select a different preferred option to the three best performers identified here. However, it is worth noting that a weighting to the single World Heritage performance measure that approaches 40% would still represent a significant stakeholder focus on this value.

The options that generally performed poorly were those that included onshore disposal at Mackay and reclamation at Hay Point. The option that combined the existing DMPA with four campaigns of reclamation at Hay Point performed the worst. This result was consistent across all scenarios other than cultural heritage.

[3] It should be noted that even though some scenarios scored the lowest for a performance measure (i.e. water quality) across the range of scenarios considered, the scenario still scored well for the performance measure.

Preferred long term solution

Based on the detailed comparative analysis, offshore disposal at the existing DMPA (5 Exist) consistently performed the best. It was the strongest of the three best performers and achieved the best score across four weighting scenarios (equal, social, economic and cultural). It also performed strongly under the environment weighting scenario and was close to the best performer under World Heritage up to a 65% weighting.

On balance, offshore disposal at the existing DMPA (5 Exist) is considered to be the preferred solution. It provides both a short and long-term solution, is well understood, and performs strongly in a range of scenarios.

It should be noted that mangrove rehabilitation at Sandringham Bay is also considered to have merit. It is an alternative that can provide a positive environmental benefit and it is recommended that it should be examined in more detail as part of an integrated solution with offshore disposal at the existing DMPA.

Combinations involving disposal at a new Mid-shelf DMPA also performed strongly and could be considered if for environmental or other reasons it became unacceptable to use the closer to shore existing DMPA.

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Appendix A – Port of Hay Point Community Reference Group members

Conservation Volunteers Australia

Dalrymple Bay Coal Terminal Management

Dalrymple Bay Coal Terminal Pty Ltd

Department of Agriculture, Fisheries and Forestry

Department of Environment

Department of Environment and Heritage Protection

Department of Transport and Main Roads

Great Barrier Reef Marine Park Authority

Hay Point Coal Terminal – BHP Billiton

James Cook University – TropWATER (Marine Water Quality)

James Cook University – TropWATER (Seagrass)

Mackay Conservation Group

Mackay Conservation Group

Mackay Local Marine Advisory Committee (LMAC)

Mackay Recreational Fishers Association

Mackay Regional Council

Mackay Tourism Limited

Maritime Safety Queensland

North Queensland Bulk Ports Corporation

Queensland Seafood Industry Association

Reef Catchments Limited

Reef Catchments Traditional Owner Reference Group (TORG)

Did not attend in person – but received email consultation

Australian Marine Conservation Society

North Queensland Land Council

Appendix B – Performance Measures

The following performance measures are described in this appendix:

A) Predicted performance in relation to avoidance and minimisation of impacts to coastal ecosystems

B) Predicted risk on dredge material placement plumes and/or tailwater discharge exceeding ambient variation (percentile above median ambient TSS)

C) Forecast Greenhouse gas emissions

D) Nature and scale of any impact on cultural heritage

E) Number of days disruption to terminal loading operations

F) Predicted lead time to dredge material placement

G) Capacity to provide a long term solution for the port

H) Assessment of costs

I) Strategic Port Land (SPL) affected

J) Relative risk

K) Scale and duration of any impacts on social activities

L) Predicted number of FTE jobs created

M) Ability of a solution to advance current dredging practice information, technology and techniques

N) Scale and duration of activity within the Great Barrier Reef World Heritage Area

A) Coastal ecosystems performance

Theme: Environment

Objective: 1. Avoid and minimise impacts to coastal ecosystems

Measure: A) Predicted performance in relation to avoidance and minimisation of changes to coastal ecosystems

Unit of measure: Performance score ranging from 4-16

Which direction of the measure is better? Higher

Coastal ecosystems and landforms are areas where the land and water meet in a distinct environment of high diversity, connectivity and flow. They provide a range of ecological services including water distribution, food and habitat, nutrient and chemical cycling, as well as important links between land, freshwater and marine environments and breeding grounds for many coastal species. There are a range of coastal ecosystems and landforms that are relevant to the assessment of alternatives for long term sustainable sediment management at the Port of Hay Point. They include:

- Land based ecosystems: threatened ecological communities (TECs), and other native vegetation.
- Freshwater and estuary ecosystems: wetlands, estuaries, and mangroves.
- Coastal landforms: salt marsh, saline coastal flats / swamp, beaches, and rocky headlands.
- Marine ecosystems: coral reefs, seagrass and/or seabed.

Changes or losses to these coastal ecosystems or landforms can lead to a variety of adverse environmental impacts, as well as serious implications for industries dependent on the Great Barrier Reef Marine Park. Stakeholders commonly agreed that rather than attempting to analyse potential impacts on individual species at this point in the project, the potential changes more broadly on coastal ecosystems and landforms (which provide the habitat for species) was an appropriate measure for understanding the potential impacts of each alternative. More detailed environmental impact assessment will form part of any future assessment and approval processes.

METHOD OF CALCULATION

The performance of each alternative in relation to avoiding and minimising changes to coastal ecosystems and landforms was determined through the application of a set of criteria that considered:

- The scale of predicted direct changes to coastal ecosystems and landforms.
- Relative significance of effects to ecosystems in terms of listing status and condition (as recorded in the GBR Outlook Report).
- Relative significance of changes in terms of species habitat.
- Duration of changes.
- Any positive contributions to coastal ecosystems and landforms.

The process involved:

- Defining a coastal ecosystem and landform spatial layer (see Table 16 in the data source section for a description of the data used to generate this layer).
- Intersecting the spatial footprint of each alternative with the coastal ecosystem and landform data to determine the potential scale and relative significance of predicted changes to coastal ecosystems.
- Applying the performance criteria (see Table 11) to arrive at a performance score for each alternative.

Table 11: Coastal ecosystem and landform performance criteria

Measure	Performance Criteria			
	Very High (Score = 4)	**High (Score = 3)**	**Medium (Score = 2)**	**Low (Score = 1)**
Scale of change	Increase in extent of ecosystem	Small or no area affected (<5 ha)	Moderate area affected (5-15 ha)	Large area affected (> 15 ha)
Ecosystem status	Positive contribution to ecosystem	No changes OR Changes to least concern or unlisted ecosystem+ OR Changes to ecosystem in very good condition^	Changes to of concern or vulnerable ecosystem+ OR Changes to ecosystem in good condition^	Changes to critically endangered or endangered ecosystem+ OR Changes to ecosystem in poor or very poor condition^
Species habitat status	Positive contribution to species habitat	No changes OR Changes to habitat used by unlisted or near threatened species*	Changes to 'general habitat' used by vulnerable species*	Changes to 'important habitat' or habitat used by critically endangered or endangered species*
Duration of change	No changes	Short term changes (recovery within natural/seasonal variations 1-2 years)	Medium term changes (recovery expected within 5-10 years)	Permanent changes

+ Applies to ecosystems listed under Queensland or Commonwealth legislation. Predominately applies to land based ecosystems.

^ As described in the GBR Outlook Report (GBRMPA 2014). Predominately applies to coastlines and marine ecosystems and less so to land based ecosystems.

* Relevant to species listings under Queensland or Commonwealth legislation. 'Important habitat' refers to habitats identified in relevant policy documents (e.g. EPBC Act Policy Statement 3.21 for migratory shorebirds) or habitats that contribute significantly to the Outstanding Universal Value of the GBRWHA. 'General habitat' refers to other habitat used by threatened species.

RESULTS

The results are presented across the following three tables:

- Table 12 – Predicted area of direct effects to coastal ecosystems and landforms.
- Table 13 – Commentary on the performance of each alternative.
- Table 14 – Performance scores for each alternative.
- Table 15 – Performance scores for each alternative over 25 years.

Table 12: Predicted area* of direct effects to coastal ecosystems and landforms

	Reclamation Hay Point	Reclamation Mackay	Habitat Rehabilitation	Onshore Dudgeon Point	Onshore Mackay	At Sea Existing	At sea Mid-shelf	At Sea Coral Sea
Land based ecosystems								
TECs (ha)	0.9	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Other native vegetation (ha)	0.9	0.7	0.0	0.0	17.1	0.0	0.0	0.0
Freshwater and estuary ecosystems								
Wetlands (ha)	0.0	0.0	1.9	0.0	0.7	0.0	0.0	0.0
Estuaries (ha)	0.0	0.0	41.6	4.1	0.0	0.0	0.0	0.0
Mangroves (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Marine ecosystems								
Coral reefs (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Seagrass and/or seabed (ha)	**Seabed** 26.68	**Seabed** 26.46	**Seabed (excl. estuary)** 14.94	0.0	0.0	**Seabed** 1840 (incl. 1520 of seagrass)	**Seabed** 2009	**Seabed** 1198
Coastal landforms								
Salt marsh (ha)	0.0	0.0	0.0	0.0	19.0	0.0	0.0	0.0
Saline coastal flats / Swamp (ha)	0.0	0.0	21.8	11.1	0.2	0.0	0.0	0.0
Beaches (ha)	2.4	1.8	5.5	0.0	0.0	0.0	0.0	0.0
Rocky headlands (ha)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

* There is some overlap in the data layers. Areas cannot be summed.

Table 13: Commentary on the performance of each alternative

Alternative	Commentary*
Reclamation Hay Point	• Small scale permanent impacts to: o Littoral Rainforest and Coastal Vine Thickets of Eastern Australia TEC (~0.9 ha) o Other native vegetation (~0.9 ha) o Beach (~2.4 ha) which: ▪ Has been identified as suitable (low density) habitat for nesting turtles ▪ Is recorded as being in good condition with a stable trend in the GBR Outlook Report • Large scale (~26.68 ha) permanent impacts to the seabed of the inshore marine area

Alternative	Commentary*
Reclamation Mackay	• Small scale permanent impacts to: o Littoral Rainforest and Coastal Vine Thickets of Eastern Australia TEC (~0.7 ha) o Other native vegetation (~0.7 ha) o Beach (~1.8 ha) which: ▪ Has been identified as suitable (low density) habitat for nesting turtles ▪ Is recorded as being in good condition with a stable trend in the GBR Outlook Report • Large scale (~26.46 ha) permanent impacts to the seabed of the inshore marine area
Habitat Rehabilitation Area	• Positive benefit to the estuary ecosystem through the regeneration of mangrove habitat (~70 ha). Mangrove forests are recorded as being in good condition with a stable trend in the GBR Outlook Report • No permanent changes to other ecosystems or landforms
Onshore Dudgeon Point	• Small scale permanent changes to estuaries (~4.1 ha) • Moderate scale permanent changes to saline coastal flats / swamps (~11.1 ha) • Changes are likely to interact with important migratory shorebird habitat • No marine area changes
Onshore Mackay	• Small scale permanent changes to: o Wetlands (~0.7 ha) which are recorded as being in poor condition (no trend) in the GBR Outlook Report o Saline coastal flats / swamps (~0.2 ha) • Large scale permanent changes to: o Other native vegetation (~17.1 ha) including REs that are potentially of concern or endangered o Salt marsh (~19 ha) which is recorded as being in good condition (no trend) in the GBR Outlook Report • No marine area changes
At Sea Existing Inshore	• Large scale short term changes (monitoring indicates recovery within 1-2 years) to previously disturbed areas of the seabed (~1840 ha) within the existing dredge material placement area. This includes approximately 1520 ha of seagrass. Seagrass is recorded as being in poor condition with a declining trend in the GBR Outlook Report • No changes to coral • No land based changes • No changes to known important habitat for species. However, site likely to provide variable foraging value for a number of species (e.g. turtles and dugong)
At Sea Mid-shelf Area	• Large scale short term changes to the seabed environment (~2009 ha) • No changes to mapped seagrass • Unknown species changes • No land based changes
At Sea Offshore Coral Sea	• Large scale changes (likely to be short term) to the seabed environment (~1198 ha) • Unknown ecosystem and species changes (assigned a medium score) • No land based changes

* Where possible condition and trend from the GBR Outlook Report are used. Not all ecosystems as described in this report have applicable data.

Table 14: Coastal ecosystem and landform performance scores for each alternative for the first dredging campaign (higher score is better)

	Reclamation Hay Point	Reclamation Mackay	Habitat Rehabilitation	Onshore Dudgeon Point	Onshore Mackay	At Sea Existing	At sea Mid-shelf	At Sea Coral Sea
Scale of change	1	1	4	2	1	1	1	1
Ecosystem status	1	1	4	3	1	1	2	2
Species habitat status	1	1	4	1	3	1	2	2
Duration of change	1	1	4	1	1	3	3	3
Total score	**4**	**4**	**16**	**7**	**6**	**6**	**8**	**8**

Very High Performance

High Performance

Medium Performance

Low Performance

Table 15: Coastal ecosystem and landform performance scores for each long term option over a 25 year period (higher score is better)

	At Sea Existing x 1 Reclamation Hay Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 At Sea Existing x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Reclamation Hay Point x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Dudgeon Point x 3	At Sea Existing x 1 Onshore Dudgeon Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Mackay x 3	At Sea Existing x 1 Onshore Mackay x 4	At Sea Existing x 5	At Sea Mid-shelf x 5	At Sea Existing x 1 At Sea Coral Sea x 4	At Sea Mid-shelf x 1 Habitat Rehabilitation x 1 At Sea Mid-shelf x 3
Years 1- 5	6	6	6	6	6	6	6	6	8	6	8
Years 6- 10	4	16	16	16	7	16	6	6	8	8	16
Years 11- 15	4	6	4	7	7	6	6	6	8	8	8
Years 16 - 20	4	6	4	7	7	6	6	6	8	8	8
Years 21 - 25	4	6	4	7	7	6	6	6	8	8	8
Total score	**22**	**40**	**34**	**43**	**34**	**40**	**30**	**30**	**40**	**38**	**48**

DATA SOURCES

Great Barrier Reef Marine Park Authority 2014, *Great Barrier Reef Outlook Report 2014*, GBRMPA, Townsville

Table 16: Description of the coastal ecosystem spatial layer

Ecosystem / Landform	Description of the spatial data
Land based ecosystems	
TECs	Biodiversity status of pre-clearing and remnant regional ecosystems series - version 9.0 – 2013. State of Queensland (Department of Science, Information Technology and Innovation) 2016. Updated data available at http://qldspatial.information.qld.gov.au/catalogue//
Other native vegetation	
Freshwater and estuary ecosystems	
Wetlands	Wetland protection area - high ecological significance wetland. State of Queensland (Department of Environment and Heritage Protection) 2016. Updated data available at http://qldspatial.information.qld.gov.au/catalogue//
Estuaries	Queensland waterways for waterway barrier works - State of Queensland (Department of Agriculture and Fisheries) 2016. Updated data available at http://qldspatial.information.qld.gov.au/catalogue//
Mangroves	Mangroves - Wetland management area - wetland. State of Queensland (Department of Environment and Heritage Protection) 2016. Updated data available at http://qldspatial.information.qld.gov.au/catalogue//
Marine ecosystems	
Coral reefs	Reefs and shoals – Queensland - State of Queensland (Department of Natural Resources and Mines) 2016
Seagrass and/or seabed	Multiple datasets from NQBP
Coastal landforms	
Salt marsh	Biodiversity status of pre-clearing and remnant regional ecosystems series - version 9.0 – 2013. State of Queensland (Department of Science, Information Technology and Innovation) 2016. Updated data available at http://qldspatial.information.qld.gov.au/catalogue//
Saline coastal flats / Swamp	Flats – Queensland. State of Queensland (Department of Natural Resources and Mines) 2016
Beaches	As there was no GIS spatial data available for beaches in the Mackay Region at low tide, an estimate of the area of beach within each footprint was calculated from satellite images of the areas. The areas of beach potentially removed as a result of the reclamation options at Hay Point and Mackay Harbour are indicative estimates only
Rocky headlands	As there was no GIS spatial data available for rocky headlands in the Mackay Region, an estimate of the area of rocky headland within each footprint was calculated from satellite images of the areas. The areas of rocky headland potentially removed are indicative estimates only

B) Marine water quality performance

Theme: Environment

Objective: 1. Avoid and minimise impacts to coastal ecosystems

Measure: B) Predicted risk of dredge material placement plumes and/or tailwater discharge exceeding ambient variation (percentile above median ambient TSS)

Unit of measure: Performance score ranging from 0-21

Which direction of the measure is better? Lower

Marine waters are the vector to disturbance of a range of receptors, including benthic communities, nekton (fishes), and a range of megafauna such as dolphins, turtles and whales. Changes in water quality in the nearshore environment have been well documented in the area around the Port of Hay Point. NQBP have implemented an ambient monitoring program that extends from Freshwater Point to the south of the Port, extending to Keswick Island to the north, approximately 55 km of the coastal strip (Figure 9).

Figure 9: Coastal transect of water quality monitoring locations

All stakeholders felt that the potential impacts on these waters was an important criteria to assess when considering the alternatives for long term sustainable sediment management at the Port of Hay Point. Stakeholders also expressed that specific receptors such as fringing coral communities and seagrasses where also important to consider in the decision making process.

Changes in total suspended solids (TSS) concentrations is a water quality variable for which a healthy dataset of natural conditions exists in the coastal area of Hay Point and Mackay. TSS concentration not only provide a good indicator of water quality but also provide a useful surrogate for potential impacts on receptors such as fringing corals and seagrasses, particularly in the context of differentiating between alternatives for dredge material relocation. Using hydrodynamic modelling techniques, sedimentation deposition rates can also be derived from TSS data, coupled with information related to coastal hydrology and processes.

Elevated TSS can reduce the amount of light reaching the seafloor and impact on photosynthesising organisms such as hard corals and seagrasses (Erftemeijer and Lewis 2006; Erftemeijer et al 2012). Extended period of greater than 15mg/l TSS may lead to sub-lethal biota, depending on the sensitivity of individual organisms[1], whereas extended periods of greater than 100mg/l has been shown to reduce the Surface Irradiation (SI) reaching the seafloor to below 1% in some environmnets[1], which can lead to mortality of some species. TSS data from NQBP's ambient monitoring program for 2014-15 is shown in Figure 10 at number of sensitive receiving locations from the coastal transect of monitoring sites, where:

- Bottom whisker - 5th percentile (TSS concentration occur 95% of the time).
- Bottom box - 20th percentile (TSS concentration occur 80% of the time).
- Line - Median (midpoint of the observed/predicted TSS concentrations).
- Top box - 80th percentile (TSS concentrations occur 20% of the time).
- Top whisker - 95th percentile (TSS concentrations occur 5% of the time).

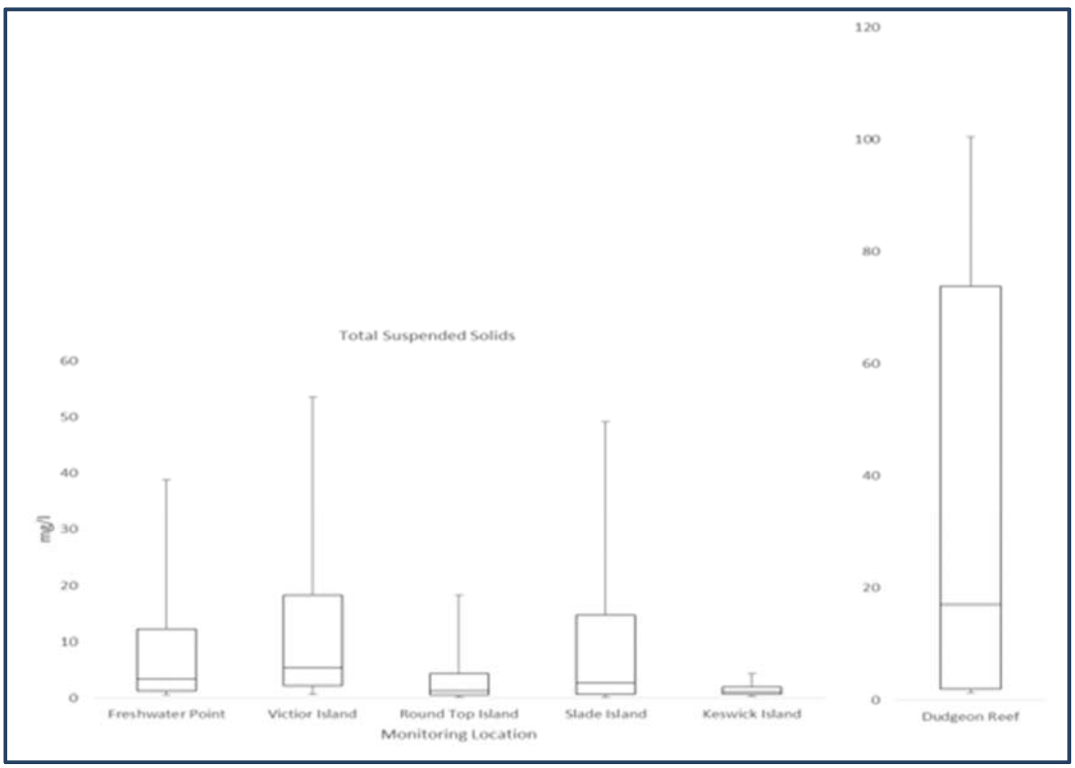

Figure 10: TSS data from NQBP's ambient monitoring program for 2014-15

Interestingly the total rainfall for the 2014-15 monitoring was within the 10th percentile of the total annual wet season rainfall distribution recorded for the region in the last 105 years (1910 to 2015), so the data presented represent a year with minimal catchment influence on TSS.

Hydrodynamic modelling has been undertaken for each of the disposal alternatives and similarly percentile data has been generated for each. The results indicated no predicted concentrations in excess of 15mg/l at any of the sensitive receiving locations from the coastal transect of monitoring sites.

To distinguish between the disposal alternatives a stringent set of water quality criteria was established and described below.

METHOD OF CALCULATIONS

To assess the performance of each alternative a number of performance criteria were developed to compare the modelled TSS data associated with potential plumes from each of the alternatives, which compares the summary statistics against natural median TSS concentrations recorded during the low rainfall monitoring period of 2014-2015. (Note: the 2004-2014 data has been used for Dudgeon Reef due to data losses of the logger in 2014/15)

- Onshore alternatives – a tailwater outflow of 50mg/l at the proposed tailwater discharge site has been assumed.
- Reclamation alternatives – a failure event has been modelled and assumes a significant tear in the filter lining.
- At-sea alternatives – have used modelled outputs from plume modelling undertaken by Worley Parsons for 207,000m^3 (developed for the 2013 disposal permits).
- Habitat Rehabilitation alternative – has used the same failure criteria as for the reclamation alternatives.

PERFORMANCE CRITERIA

For each alternative a water quality performance score was determined by comparing predicted changes in TSS against natural variability at a seven sensitive receiver locations along the coast from Freshwater Point in the south, to Keswick Island to the north. See Table 17 for the performance criteria. The score at receiver location is summed to give an overall performance score.

Table 17: Marine water quality performance criteria

Measures	Performance Criteria			
	Very High (Score 0)	High (Score = 1)	Medium (Score = 2)	Low (Score = 3)
Total Suspended Solids (TSS)	95th percentile TSS concentrations not shown to occur above natural median concentration	TSS concentrations occur above natural median concentrations between 5% and 20% of the time	TSS concentrations occur above natural median concentrations for 20% to 80% of the time	TSS concentrations occur above natural median concentrations greater than 80% of the time

RESULTS

The results are presented across the following two tables:

- Table 18: Summary results for Total Suspended Solids.
- Table 19: Overall performance score for marine water quality (lower score is better).

Table 18: Summary results for Total Suspended Solids

	2014-15 ambient monitoring	Reclamation Hay Point			Reclamation Mackay			Habitat Rehabilitation			Onshore Dudgeon Point		
Location	Natural Median^	95th ‰	80th ‰	20th ‰	95th ‰	80th ‰	20th ‰	95th ‰	80th ‰	20th ‰	95th ‰	80th ‰	20th ‰
Freshwater Point	3.40	0.20	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Victor Island	5.41	1.10	0.70	0.20	0.00	0.00	0.00	0.20	0.10	0.00	0.00	0.00	0.00
Hay Reef	3.18	1.10	0.80	0.10	0.00	0.00	0.00	0.70	0.60	0.20	0.00	0.00	0.00
Dudgeon Reef		0.00	0.00	0.00	0.10	0.00	0.00	6.60	4.90	0.60	0.20	0.20	0.00
Round Top Island	1.28	0.00	0.00	0.00	0.10	0.10	0.00	0.10	0.10	0.00	0.00	0.00	0.00
Slade Island	2.72	0.00	0.00	0.00	1.10	0.90	0.50	0.00	0.00	0.00	0.00	0.00	0.00
Keswick Island	1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 30 continued.

	Onshore Mackay			At-sea Existing			At-sea Mid-shelf			At-sea Coral Sea		
Location	95th ‰	80th ‰	20th ‰	95th ‰	80th ‰	20th ‰	95th ‰	80th ‰	20th ‰	95th ‰	80th ‰	20th ‰
Freshwater Point	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	N/A	N/A
Victor Island	0.00	0.00	0.00	2.61	0.76	0.06	2.16	0.54	0.04	N/A	N/A	N/A
Hay Reef	0.00	0.00	0.00	5.86	3.48	0.46	4.32	2.24	0.30	N/A	N/A	N/A
Dudgeon Reef	0.00	0.00	0.00	5.05	1.62	0.02	1.74	1.42	0.24	N/A	N/A	N/A
Round Top Island	0.00	0.00	0.00	10.33	7.78	0.60	1.06	0.80	0.15	N/A	N/A	N/A
Slade Island	0.00	0.00	0.00	6.23	5.61	0.97	0.87	0.65	0.01	N/A	N/A	N/A
Keswick Island	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	N/A	N/A

(Note: although no specific location has been selected for an 'At-sea Coral Sea' alternative, if this was to a feasible option the disposal site would be located to ensure no influence on sensitive habitats as a result of changes in water quality).

Table 19: Overall performance score for marine water quality (lower score is better)

Sensitive receiver locations	Reclamation Hay Point	Reclamation Mackay	Habitat Rehabilitation	Onshore Dudgeon Point	Onshore Mackay	At Sea Existing	At sea Mid-shelf	At Sea Coral Sea
Freshwater Point	0	0	0	0	0	0	0	0
Victor Island	0	0	0	0	0	0	0	0
Hay Reef	0	0	0	0	0	2	1	0
Dudgeon Reef	0	0	0	0	0	0	0	0
Round Top Island	0	0	0	0	0	2	0	0
Slade Island	0	0	0	0	0	2	0	0
Keswick Island	0	0	0	0	0	0	0	0
Total score	**0**	**0**	**0**	**0**	**0**	**6**	**1**	**0**

Very High Performance

High Performance

Medium Performance

Low Performance

Table 20: Marine water quality performance scores for each long term option over a 25 year period (lower score is better)

	At Sea Existing x 1 Reclamation Hay Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 At Sea Existing x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Reclamation Hay Point x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Dudgeon Point x 3	At Sea Existing x 1 Onshore Dudgeon Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Mackay x 3	At Sea Existing x 1 Onshore Mackay x 4	At Sea Existing x 5	At Sea Mid-shelf x 5	At Sea Existing x 1 At Sea Coral Sea x 4	At Sea Mid-shelf x 1 Habitat Rehabilitation x 1 At Sea Mid-shelf x 3
Years 1- 5	6	6	6	6	6	6	6	6	1	6	1
Years 6- 10	0	0	0	0	0	0	0	6	1	0	0
Years 11- 15	0	6	0	0	0	0	0	6	1	0	1
Years 16 - 20	0	6	0	0	0	0	0	6	1	0	1
Years 21 - 25	0	6	0	0	0	0	0	6	1	0	1
Total score	**6**	**24**	**6**	**6**	**6**	**6**	**6**	**30**	**5**	**6**	**4**

C) GHG emissions

Theme: Greenhouse Gas (GHG) emissions

Objective: 2. Minimise carbon emissions

Measure: C) Forecast GHG emissions

Unit of measure: Tonnes of CO_2 equivalent (tCO_2-e)

Which direction of the measure is better? Lower

Consideration of the potential Greenhouse Gas (GHG) emissions from the construction and operational activities of each alternative is an important component of comparing the long term sustainable sediment management alternatives at the Port of Hay Point. Stakeholders agreed that understanding how each alternative performed in relation to forecast GHG emissions should form part of the decision making process.

Forecast GHG emission estimates are provided for each alternative in relation to:

- An initial dredge campaign.
- Subsequent dredge campaigns.

METHOD OF CALCULATION

Calculating forecast GHG emissions was undertaken in accordance with the internationally recognised methodology outlined in the GHG Protocol. In accordance with the Protocol, the assessment considered the following emissions:

- Direct emissions – e.g. emissions associated with fossil fuel consumption by vessels/construction plant/vehicles during transport and construction. These are known as 'Scope 1' emissions in the GHG Protocol.
- Indirect emissions from supporting activities – e.g. emissions associated with the production of construction materials. These are known as 'Scope 3' emissions in the GHG Protocol. For this project high level estimates are used.

None of the alternatives were considered likely to result in significant indirect emissions due to the consumption of purchased electricity (known as 'Scope 2' emissions in the GHG Protocol). Scope 2 emissions were therefore not part of this assessment.

Initial dredge campaign calculations

Calculations of the forecast GHG emissions for each alternative for an initial dredge campaign were drawn predominantly from:

- Royal Haskoning DHV (2016) Port of Hay Point Engineering Options report.
- Advisian (2016) Comprehensive Beneficial Reuse Assessment report.

Other sources of emission parameters and rates for specific calculations included:

- Calculations of the direct GHG emissions from the consumption of bunker fuel during the operation of the Trailer Suction Hopper Dredger (TSHD) Brisbane (dredging, pumping and transport to the mooring areas) for each option were calculated using guidance from USEPA (2009). The emission parameters and rates used in the assessment were derived using the USEPA methodology and the TSHD Brisbane specification (described in Royal Haskoning DNV 2016).
- Direct GHG emissions associated with diesel fuel consumption from construction plant for each option were calculated using emission factors from the Australian National Greenhouse Accounts (2015). The construction plant engine power figures were obtained from the specification based on the model used for each construction vehicle and load factors for each vehicle were obtained from the USEPA (2010).
- Construction material GHG emissions were calculated from the volume of construction materials used for each alternative management option and resultant emissions were obtained from the Inventory for Carbon & Energy (2011).

Assumptions for GHG emission calculations for each of the alternatives are outlined below.

Reclamation and onshore alternatives assumptions

- Use of the TSHD Brisbane involving a dredge campaign of 200,000m^3.
- Quantities of maintenance material and dredge vessel operational activities as defined in the comparative analysis for cost (Performance Measure H).
- Vessel engine, pump and generator operational capacity for dredge establishment, dredging and material transport as described in Royal Haskoning DHV (2016).

Habitat rehabilitation alternative assumptions

- Use of the TSHD Brisbane involving a dredge campaign of 200,000m^3.
- The estimate of GHG emissions has been based upon a habitat creation option described in Advisian (2016). The estimate does not include construction material emissions, as the specific location, extent and type of construction materials are unknown at this stage. However, the current calculation is considered appropriate for inclusion in the comparison.
- Quantities of maintenance material and dredge vessel operational activities as defined in comparative analysis for cost (Performance Measure H).
- Vessel engine, pump and generator operational capacity for dredge establishment, dredging and material transport as described in Royal Haskoning DHV (2016).

Offshore disposal alternative assumptions

- Use of the TSHD Brisbane involving a dredge campaign of 200,000m^3 for the existing and mid-shelf alternatives.
- Use of a larger dredge for the Coral Sea alternative involving a dredge campaign of 200,000m^3.

<u>Subsequent dredge campaign calculations</u>

Calculations of the forecast GHG emissions for subsequent campaigns for each alternative were also taken from Royal Haskoning DHV (2016) and Advisian (2016). The following assumptions were made:

- All construction activities would be complete.
- Use of the TSHD Brisbane involving dredge campaigns of 200,000m^3 (apart from the Coral Sea alternative).
- Use of a larger dredge for the Coral Sea option involving a dredge campaign of 200,000m^3.
- Quantities of maintenance material and dredge vessel operational activities as defined in comparative analysis for cost (Performance Measure H).
- Vessel engine, pump and generator operational capacity for dredge establishment, dredging and material transport as described in Royal Haskoning DHV (2016).

RESULTS

Results for the GHG assessment are presented below as follows:

- Table 21: Summary of GHG emission estimates for the initial dredge campaign and subsequent dredge campaigns for each alternative (CO_2-e Tonnes).
- Table 22: Detailed calculations for GHG emission estimates for initial dredge campaigns of each alternative (CO_2-e Tonnes).
- Table 23: GHG emission estimates for each long term option over a 25 year period (lower is better).

Table 21: Summary of GHG emission estimates for the initial dredge campaign and subsequent dredge campaigns for each alternative (CO_2-e Tonnes) (lower is better)

	Reclamation Hay Point	Reclamation Mackay	Habitat Rehabilitation	Onshore Dudgeon Point	Onshore Mackay	At Sea Existing	At sea Mid-shelf	At Sea Coral Sea
Initial dredge campaign estimate (Scope 1 and Scope 3)	**24,774**	**19,485**	**1,674***	**7,421**	**4,886**	**618**	**1,012**	**6,693**
Subsequent dredge campaign estimate (Scope 1 emissions only)	**795**	**1,183**	**1,674***	**795**	**1,183**	**618**	**1,012**	**6,693**

* Based upon the approach defined in Advisian (2016). Excludes construction material emissions (Scope 3).

Table 22: Detailed calculations for GHG emission estimates for initial dredge campaigns of each alternative (CO_2-e Tonnes)

		Reclamation Hay Point	Reclamation Mackay	Habitat Rehabilitation	Onshore Dudgeon Point	Onshore Mackay	At sea Existing	At sea Mid Shelf	At sea Coral Sea
Direct emissions (Scope 1)	Emissions from dredging	795	1,183	1,674	795	1,183	618	1,012	6,693
	Emissions from construction machinery	4,160	2,433	-	4,200	1663	0	0	0
Total direct emissions		**4,955**	**3,616**	**1,674**	**4,995**	**2,846**	**618**	**1,012**	**6,693**
Scope 3 emissions		19,819	15,869	-	2,426	2,040	0	0	0
Total emissions		**24,774**	**19,485**	**1,674**	**7,421**	**4,886**	**618**	**1,012**	**6,693**

Table 23: GHG emission estimates for each long term option over a 25 year period (lower is better)

	At Sea Existing x 1 Reclamation Hay Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 At Sea Existing x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Reclamation Hay Point x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Dudgeon Point x 3	At Sea Existing x 1 Onshore Dudgeon Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Mackay x 3	At Sea Existing x 1 Onshore Mackay x 4	At Sea Existing x 5	At Sea Mid-shelf x 5	At Sea Existing x 1 At Sea Coral Sea x 4	At Sea Mid-shelf x 1 Habitat Rehabilitation x 1 At Sea Mid-shelf x 3
Years 1- 5	618	618	618	618	618	618	618	618	1,012	618	1,012
Years 6- 10	24,774	1,674	1,674	1,674	7,421	1,674	4,886	618	1,012	6,693	1,674
Years 11- 15	795	618	24,774	7,421	795	4,886	1,183	618	1,012	6,693	1,012
Years 16 - 20	795	618	795	795	795	1,183	1,183	618	1,012	6,693	1,012
Years 21 - 25	795	618	795	795	795	1,183	1,183	618	1,012	6,693	1,012
Total score	**27,777**	**4,146**	**28,656**	**11,303**	**10,424**	**9,544**	**9,053**	**3,090**	**5,060**	**27,390**	**5,722**

D) Cultural heritage performance

Theme: Cultural Heritage

Objective: 3. Minimise impact on cultural heritage within the area

Measure: D) Nature and scale of any impact on cultural heritage

Unit of measure: Performance score ranging from 3 - 9

Which direction of the measure is better? Lower

Mackay was first settled by Europeans in 1862 and developed into a large city in the 1870s and 1880s with a booming sugar industry. The process of European settlement had a significant impact on the Aboriginal people of the region. In the 1930s Mackay became Queensland's first regional city to have a town plan when the outer harbour was constructed. The first coal from the large purpose built coal-export terminal at Hay Point was loaded in 1971. Since 1983 a government-owned wharf, leased to the private sector, has operated nearby at Dalrymple Bay.

The Yuwibara (Yuibera) People are the registered claimants of the port area. Indigenous cultural heritage values have been identified in the Port of Hay Point's environs, primarily in the Dudgeon Point coastal zone. The majority of these sites are concentrated on the bar of sand that extends from Dudgeon Point to Mount Hector (Alligator Creek) along the coast. This dune system separates the freshwater lagoon from the littoral zone and appears to have been a focal point for subsistence activity. There are also coloured rocks in the Louisa Creek area and a fish trap at Hay Point that are of particular significance to the local Indigenous people.

The sustainable sediment management project aims to further improve the management of port sediments while ensuring the continued operation of the port, social and cultural features are respected and that environmental and cultural heritage values are protected.

Stakeholders wanted to ensure that the potential for impacts on cultural heritage arising from the various options were considered in the decision making process.

METHOD OF CALCULATION

The performance for each alternative was calculated based on a set of criteria (see Table 24) that consider:

- The nature of any interaction with or disturbance to identified Indigenous cultural heritage or potential unknown sites and/or artefacts.
- The nature of any interaction with landscape/cultural connection of importance to Indigenous people.
- Impact on access for Indigenous people to culturally important places.

Table 24: Cultural heritage performance criteria

Measure	Performance Criteria		
	High (Score = 1)	Medium (Score = 2)	Low (Score = 3)
Nature of interaction or disturbance – site/artefact	None	Potential risk to identified site but can be mitigated or avoided, or Potential risk to unknown site/artefact but can be adequately managed	Destruction, loss of identified or unknown site or artefact
Nature of interaction or disturbance - landscape/cultural connection	None or positive	Connection and identified value lost due to change in environment on site specific scale	Connection and identified value lost due to change in environment on regional scale
Impact on access to culturally important places	None or positive	Access lost or disrupted temporarily	Access lost permanently

RESULTS

The results are presented across the following three tables:

- Table 25: Commentary on the performance criteria for each alternative.
- Table 26: Cultural heritage performance scores for each alternative for the first dredging campaign (lower score is better).
- Table 27: Cultural heritage performance scores for each long term option over a 25 year period (lower score is better).

Table 25: Commentary on the performance criteria for each alternative

Alternative	Commentary
Reclamation Hay Point	• The construction of a reclamation area at Hay Point (Half Tide Tug Harbour). • Potential to be considered part of the landscape connection for traditional owners.
Reclamation Mackay	• Direct removal and permanent alteration of an area of 26 ha of inshore marine area adjacent to the northern breakwall. • Potential to be considered part of the landscape connection for traditional owners.
Habitat Rehabilitation Area	• An area of 70 ha will be altered as dredge material is placed within a bund to create the habitat rehabilitation area. • No known cultural heritage. Activity will restore the natural vegetation, improving connection with landscape.
Onshore Dudgeon Point	• An area of 50 ha will be altered as dredge material is placed within a bund system. • No identified cultural sites but the area may contain artefacts and has recognised connection for the traditional owners.
Onshore Mackay	• An area of 50 ha will be altered as dredge material is placed within a bund system. • No identified cultural sites but the area may contain artefacts and has recognised connection for the traditional owners.
At Sea Existing Inshore	• No identified cultural heritage and no connection to landscape or island importance.
At Sea Mid-shelf Area	• No identified cultural heritage and no connection to landscape or island importance.
At Sea Offshore Coral Sea	• No identified cultural heritage and no connection to landscape or island importance.

Table 26: Cultural heritage performance scores for each alternative for the first dredging campaign (lower score is better)

	Reclamation Hay Point	Reclamation Mackay	Habitat Rehabilitation	Onshore Dudgeon Point	Onshore Mackay	At Sea Existing	At sea Mid-shelf	At Sea Coral Sea
Nature of interaction or disturbance – identified site	1	1	1	2	2	1	1	1
Nature of interaction or disturbance - landscape/cultural connection	2	2	1	2	2	1	1	1
Impact on access to culturally important places	1	1	1	1	1	1	1	1
Total performance score	**4**	**4**	**3**	**5**	**5**	**3**	**3**	**3**

High Performance

Medium Performance

Low Performance

Table 27: Cultural heritage performance scores for each long term option over a 25 year period (lower score is better)

	At Sea Existing x 1 Reclamation Hay Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 At Sea Existing x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Reclamation Hay Point x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Dudgeon Point x 3	At Sea Existing x 1 Onshore Dudgeon Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Mackay x 3	At Sea Existing x 1 Onshore Mackay x 4	At Sea Existing x 5	At Sea Mid-shelf x 5	At Sea Existing x 1 At Sea Coral Sea x 4	At Sea Mid-shelf x 1 Habitat Rehabilitation x 1 At Sea Mid-shelf x 3
Years 1- 5	3	3	3	3	3	3	3	3	3	3	3
Years 6- 10	4	3	3	3	5	3	5	3	3	3	3
Years 11- 15	4	3	4	5	5	5	5	3	3	3	3
Years 16 - 20	4	3	4	5	5	5	5	3	3	3	3
Years 21 - 25	4	3	4	5	5	5	5	3	3	3	3
Total score	**19**	**15**	**18**	**21**	**23**	**21**	**23**	**15**	**15**	**15**	**15**

E) Port disruption

Theme: Port Economics & Operation

Objective: 4. Maintain effective and efficient port operations

Measure: E) Number of days disruption to terminal loading operations

Unit of measure: Days

Which direction of the measure is better? Lower

A critical aspect to sustainable sediment management at the Port of Hay Point is providing a solution that ensures ongoing port efficiency but also provides for minimal disruption to port operations during the actual dredging and placement activity.

Disruptions to terminal operations are most likely while the dredge is operating in the berth and apron areas of the port. During these times other vessel movements may be limited and one or more berths may remain unoccupied for a longer period than usual. With some constraints on movement from other vessel traffic and tidal movements these disruptions can become extended and of some consequence.

METHOD OF CALCULATION

The maximum potential disruption to terminal loading has been calculated in days lost.

The timeframe for dredging campaign varies by option given the time taken to travel to the placement location and to deposit the material from the hopper either by opening the hopper doors or pumping to certain locations. Disruptions to terminal operations will only occur during the time the dredger is in the port area. Based on this the following assumptions have been applied:

- 200,000m3 of maintenance dredging is required every five years to maintain effective and safe operation of the port.
- The first dredge campaign starts in year 0. Therefore, a maximum capacity of 1 dredge campaign would have a timeframe of five years, two campaigns would be ten years, and so on.
- A total timeframe of 25 years.
- Disruption is counted as a whole day during the dredging campaign as there is in sufficient time to turn around a vessel loading in the time taken to dredge, transport, unload and return. The only exception to this is for the Coral Sea option where return travel times are approximately 70 hours and dredging times will be 1-2 hours. In this case a calculation has been made on 50% disruption factor.

RESULTS

The results are presented across the following tables:

- Table 28: Maximum disruption time for each alternative for the first dredging campaign (lower is better).
- Table 29: Maximum disruption for each long term option over a 25 year period (lower is better).

Table 28: Maximum disruption time for each alternative for the first dredging campaign (lower is better)

	Reclamation Hay Point	Reclamation Mackay	Habitat Rehabilitation	Onshore Dudgeon Point	Onshore Mackay	At Sea Existing	At sea Mid-shelf	At Sea Coral Sea
Days	**23**	**31**	**20**	**23**	**31**	**14**	**23**	**16**

Table 29: Maximum disruption for each long term option over a 25 year period (lower is better)

	At Sea Existing x 1 Reclamation Hay Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 At Sea Existing x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Reclamation Hay Point x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Dudgeon Point x 3	At Sea Existing x 1 Onshore Dudgeon Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Mackay x 3	At Sea Existing x 1 Onshore Mackay x 4	At Sea Existing x 5	At Sea Mid-shelf x 5	At Sea Existing x 1 At Sea Coral Sea x 4	At Sea Mid-shelf x 1 Habitat Rehabilitation x 1 At Sea Mid-shelf x 3
Years 1- 5	14	14	14	14	14	14	14	14	23	14	23
Years 6- 10	23	20	20	20	23	20	31	14	23	16	20
Years 11- 15	23	14	23	23	23	31	31	14	23	16	23
Years 16 - 20	23	14	23	23	23	31	31	14	23	16	23
Years 21 - 25	23	14	23	23	23	31	31	14	23	16	23
Total score	**106**	**76**	**103**	**103**	**106**	**127**	**138**	**70**	**115**	**78**	**112**

F) Lead time

Theme: Port Economics & Operation

Objective: 4. Maintain effective and efficient port operations

Measure: F) Predicted lead time to dredge material placement

Unit of measure: Years

Which direction of the measure is better? Lower

Maintaining effective port operations is a critical component of the decision making process for sustainable sediment management at the Port of Hay Point. One of the factors to consider around this objective is the implementation time for each of the alternatives (i.e. how long it will take to plan, get approval, and prepare works).

The last maintenance dredging campaign occurred in 2010 and the most recent surveys show that depths, particularly in certain berth areas, are reducing due to sediment accumulation. It is necessary to conduct maintenance dredging in the near future if port operations are to continue without serious restrictions. Optimal timing would be to conduct maintenance dredging within the next three years, any longer would be problematic.

Stakeholders agreed that finding appropriate solutions that could be implemented within required timeframes was important.

METHOD OF CALCULATION

The lead time for each alternative was calculated based on industry experience in relation to the following key preparatory stages:

- Research/studies: prior to commencing or planning an action it may be necessary to gather additional information, scientific data, knowhow or develop technology. This may include background research, field/ocean studies, feasibility, environmental constraints and management, and design.
- Engineering design: Detailed design work.
- Planning and approval: For example, work required to prepare management plans (e.g. environment, health and safety) and apply for regulatory approvals (applications, assessment processes).
- Construction: Construction works required to prepare each alternative for dredge material placement (e.g. site preparation, construction of bunds, etc).

The following assumptions were made in calculating lead times:

- Where time periods might overlap subsequent time estimates are based on the additional time period required to complete the stage. Accordingly time periods are cumulative not overlapping.
- Alternatives that involve new approaches, have significant environmental risks or involve locations where little environmental information is available will require considerable time to work through the earlier three stages (research, design, planning and approval).

RESULTS

The results are presented across the following two tables:

Table 30: Commentary on the lead times for each alternative.

- Table 31: Lead time for each alternative.

It is important to note that lead time was not relevant in relation to long term options as all options were designed to be implemented within three years.

Table 30: Commentary on the lead times for each alternative

Alternative	Commentary
Reclamation Hay Point	• Reclamation activities are well understood; short term investigations on coastal process and environmental impacts would be required, followed by engineering and management design. • A number of approvals would be necessary at National, State and local level. • Construction estimated at 1 year.
Reclamation Mackay	• Reclamation activities are well understood; short term investigations on coastal process and environmental impacts would be required, followed by engineering and management design. • A number of approvals would be necessary at National, State and local level. • Construction estimated at 1 year.
Habitat Rehabilitation Area	• Significant investigation is needed into the techniques to be applied, location and logistics of this activity. Mangrove rehabilitation is well practised and proved but good local planning is required to ensure success. • A number of approvals would be necessary possibly at National, State and local level. • Minimal construction time is anticipated.
Onshore Dudgeon Point	• Onshore placement activities are well understood; short term investigations on local topography and environmental impacts would be required, followed by engineering and management design. • A number of approvals would be necessary possibly at National, State and local level. • Construction estimated at approximately 9 months.
Onshore Mackay	• Onshore placement activities are well understood; short term investigations on local topography, avoidance of adjacent activities and environmental impacts would be required, followed by engineering and management design. • A number of approvals would be necessary possibly at National, State and local level. • Construction estimated at approximately 9 months.
At Sea Existing Inshore	• Extensive knowledge and data already exists for this location and the likely impacts that may result. No engineering design or construction is required. • Statutory approval times are moderate.
At Sea Mid-shelf Area	• Some knowledge and data already exists for this location further oceanographic modelling and environmental studies will be necessary. • No engineering design or construction is required. • Statutory approval times are moderate.
At Sea Offshore Coral Sea	• Little detailed knowledge and data exists for this location considerable oceanographic modelling and environmental studies will be necessary. • No engineering design or construction is required. • Statutory approval times are long given the unique nature of this option. • Since zoning of this area is under review, approval may be further delayed.

Table 31: Lead time for each alternative

	Reclamation Hay Point	Reclamation Mackay	Habitat Rehabilitation	Onshore Dudgeon Point	Onshore Mackay	At Sea Existing	At sea Mid-shelf	At Sea Coral Sea
Research/studies	0.5	0.5	3	0.5	1	-	0.5	2
Engineering design	0.5	0.5	0.5	0.5	0.5	-	-	-
Planning and approval	2	2	1.5	2	2	1	1	2
Construction	1	1	0.5	0.75	0.75	-	-	-
Total # of years	**4**	**4**	**5.5**	**3.75**	**4.25**	**1**	**1.5**	**4**

G) Long term solution

Theme: Port Economics & Operation

Objective: 4. Maintain effective and efficient port operations

Measure: G) Capacity to provide a long term solution for the port

Unit of measure: Years

Which direction of the measure is better? Higher

A critical aspect to sustainable sediment management at the Port of Hay Point is providing a long term solution that can address the requirements of multiple dredging campaigns. A well designed and implemented long term solution will provide certainty for all stakeholders and the best outcomes across the various project themes (environment, cultural heritage, port economics & operation, health & safety, social, innovation, and World Heritage).

METHOD OF CALCULATION

The maximum potential timeframe that each alternative could operate was determined by:

- Assuming:
  a. 200,000m^3 of maintenance dredging is required every five years to maintain effective and safe operation of the port.
  b. The first dredge campaign starts in year 0. Therefore, a maximum capacity of 1 dredge campaign would have a timeframe of five years, two campaigns would be ten years, and so on.
  c. A total timeframe of 25 years.
  d. No lead time for any of the alternatives (e.g. related to planning and approvals). Lead time is addressed specifically in performance measure F.
- Considering the maximum capacity of each alternative to receive dredge material over that time.

RESULTS

The results are presented across the following tables:

- Table 32: Commentary on the capacity of each alternative to receive dredge material.
- Table 33: Maximum capacity of each alternative to receive dredge material

It is important to note that capacity was not relevant in relation to long term options as all options were designed to be implemented over 25 years.

Table 32: Commentary on the capacity of each alternative to receive dredge material

Alternative	Commentary
Reclamation Hay Point	• Due to the large tidal range in the area and the relatively high cost for construction, this alternative has been configured to contain the volume from four maintenance dredging campaigns.
Reclamation Mackay	• Due to the large tidal range in the area and the relatively high cost for construction, this alternative has been configured to contain the volume from five maintenance dredging campaigns.
Habitat Rehabilitation Area	• The habitat rehabilitation area has been designed to contain the volume from a single maintenance dredge campaign. • However, it has the potential to be expanded and for the purposes of this analysis it is assumed that it could contain the volume from two maintenance dredging campaigns.

Alternative	Commentary
Onshore Dudgeon Point	• Both of the onshore pond concept designs have been initially configured to contain the volume from a single maintenance dredging campaign. • Two options are considered realistic for the ponds to enable them to contain additional volumes of material from future campaigns: o Remove the dry material from the pond to create sufficient capacity for the subsequent maintenance dredging campaign. A suitable site for disposing of the dry material, or a reuse option for the material would be required. o Increase the height of the bunds to increase the capacity of the pond. It is possible that some of the dry material could be used to increase the bund heights, although additional imported material would be expected to be required to improve the quality of the sediment. • It is assumed for the purposes of this analysis that the capacity of the onshore ponds could be increased to contain the volume from four maintenance dredging campaigns. The additional costs associated with this are addressed in the cost performance measure.
Onshore Mackay	
At Sea Existing Inshore	• All of the at sea dredge material placement areas have the capacity to contain significant volumes. For the purposes of this analysis it is assumed they can contain the maximum required volume from five maintenance dredging campaigns.
At Sea Mid-shelf Area	
At Sea Offshore Coral Sea	

Table 33: Maximum capacity of each alternative to receive dredge material

	Reclamation Hay Point	Reclamation Mackay	Habitat Rehabilitation	Onshore Dudgeon Point	Onshore Mackay	At Sea Existing	At sea Mid-shelf	At Sea Coral Sea
Maximum capacity (campaigns)	4	5	2	4	4	5	5	5
Maximum capacity (years)	**20**	**25**	**10**	**20**	**20**	**25**	**25**	**25**

H) Cost

Theme: Port Economics

Objective: 5. Ensure solution is cost effective

Measure: H) Assessment of costs

Unit of measure: AUD millions and Present Value

Which direction of the measure is better? Lower

All stakeholders recognised that cost was an important criteria to assess when considering the alternatives for long term sustainable sediment management at the Port of Hay Point. Ensuring that solutions are cost effective is critical.

METHOD OF CALCULATION

It is important to note that the assessment of cost used here does not attempt to provide a full, detailed costing of each option. Rather it takes a high level approach to determine the rough order of magnitude (ROM) costs for each alternative using present dollar values.

Cost estimates for the options of reclamation at Hay Point, reclamation at Mackay, onshore disposal at Dudgeon Point, and onshore disposal at Mackay were derived from the report Royal Haskoning DHV (2016) Port of Hay Point - Onshore Pond and Reclamation Engineering Design.

The cost estimate for the habitat rehabilitation alternative is derived from Advisian (2016) Comprehensive Beneficial Reuse Assessment. In order to provide comparable costings some reconciliation between the methods in the two reports has occurred and standardised assumptions, inclusions and exclusions were applied. Accordingly, the costs used here are not exactly the same as documented in the different supporting reports.

In addition, further analysis was done to provide cost estimates for the three offshore disposal alternatives based on previous port planning activities that considered these options.

Cost estimates are provided for each alternative in relation to single dredge campaign. Over a 25 year period the long term options are costed using present dollar values.

Important assumptions underpinning the assessment of costs are detailed below.

ASSUMPTIONS

Cost estimates for each of the alternatives are based around a number of assumptions.

In estimating the ROM costs for a **single dredge campaign** the following assumptions are made:

(i) Dredging with the exception of the Coral sea option

- Use of the TSHD Brisbane.
- An in-situ volume of maintenance material of 1,500 m^3 per load.
- A total time of 1.25 hours for dredging to fill the hopper.
- Vessel steaming speed of 10 knots when fully laden and 12 knots when empty.
- An allowance of 1 hour to moor up and connect to the pipeline and to de-connect after.
- An allowance of 1 hour to pump a full hopper load ashore.
- Operational downtime of 10% (i.e. working for approximately 21.5 hours per day, 150 hours per week).
- Sailing distances of 4.5 km from the dredging area to the mooring location for the HTTH reclamation and Dudgeon Point onshore sites.
- Sailing distances of 7.5 km from the dredging area to the mooring location for the Sandringham Bay habitat rehabilitation site.
- Sailing distances of 18.5 km from the dredging area to the mooring location for the Mackay reclamation and onshore sites.
- Sailing distances of 7.7 km from the dredging area to the existing DMPA, 23.5 km to the at sea mid-shelf option and 310 km to the at sea Coral Sea location.

(ii) Dredging with the exception of the Coral sea option

- The use of the *TSHD Brisbane* for the Coral Sea alternative involves approximately 204 days of operation as it is limited to carrying 1,500 meters square of material per trip. Weather conditions in the open waters of the Coral Sea may extend this period as there is likely to be many occasions when conditions are unsuitable for a vessel of its size. Use of a larger TSHD dredge with a capacity to carry greater volumes (e.g. 30,000 m^3) and operate more frequently in oceanic conditions will markedly reduce the duration of dredging (potentially to approximately 20 days). Accordingly, calculations with a larger dredge have been used. Establishment costs often range from $2-$5 million (depend upon location) and operational costs may be $400,000 -$600,000 per day.
- An in-situ volume of maintenance material of 30,000 m^3 per load.
- Operational downtime of 30%.
- 30 hrs travel time (return) associated with use of Hydrographers Passage for the Coral Sea option (including use of compulsory pilotage).

(iii) Pump ashore

- No requirements for booster pumps for onshore or reclamation options.
- Installation of temporary infrastructure to pump the dredged material to the reclamation area/onshore pond location/habitat rehabilitation area including a floating pipeline and a submerged pipeline.
- Mooring for the 'Brisbane' to hold the vessel into position without swinging during pumping. This could either be through pick up moorings or by using a small tug to hold the vessel while pumping.

(iv) Habitat rehabilitation

- Material to be pumped ashore to within a intertidal or shallow subtidal area that has been bunded to isolate it from surrounding waters;
- Detailed environmental investigations and engineering design are required to define the specific location and extent. To accommodate the dredge slurry volume of 800,000 m^3, an area of 60-80 ha is likely to be required (allows 0.5 - 1m freeboard on bund wall);
- Land access to the site is possible;
- The bund is constructed from coarse material dredged from the channel areas first and/or dredged selectively by using overflow to separate the fines. It has been assumed that sufficient coarse dredge material is available;
- Geotextile fabric is incorporated into bund design (both seaward and landward slopes) to prevent the loss of fines;
- The area is sufficiently sheltered such that the bund can be designed to withstand storm damage/wave action without the need for rock armouring;
- Sufficient area is available within the site to manage tailwater (e.g. through the use of internal bunds to extend flow paths and multiple selected dredge discharge points) without the need for a weir box discharge system;
- Monitoring is required for turbidity management at and near rehabilitation site; and
- A general contingency of 30% has been assumed given the depth limitations around Sandringham Bay (i.e. extensive tidal flats exposed during low tides) that may affect dredge access, the potential for weather conditions to influence suitable periods for bund wall construction and the unique nature of the option.

In estimating the ROM costs for the **twenty five year timeframe** the following assumptions are made:

- Use of the TSHD Brisbane and associated assumptions as described above.
- 5 dredge campaigns of 200,000 m^3. One every five years.
- The Mackay reclamation has sufficient capacity to accommodate 5 campaigns.
- The Hay Point reclamation has sufficient capacity to accommodate 4 campaigns after which it is assumed material would need to be removed to accommodate the final campaign (assumed cost of $4 million) rather than a new reclamation being constructed.
- The onshore ponds at Dudgeon Point and Mackay have capacity sufficient only to accommodate material from one campaign. Subsequent campaigns require material to be removed and relocated or reused to create sufficient capacity ($4 million). Alternatively, the surrounding bunds could be raised ($8 million). A conservative approach has been adopted and it is assumed that bund raising would occur given the probable limitations on repeated material relocation or reuse considering its properties and the lack of demand for such material.

No allowance has been made for approval fees or investigatory studies to support applications for development or operational approvals. Costs for any required environmental management techniques defined in approvals (e.g. monitoring) have not been included.

RESULTS

The results are presented across the following tables:

- Table 34: Cost estimates for options for a single dredge campaign - $ million.
- Table 35: Cost estimates for each long term option over a 25 year period (lower is better).

Table 34: Cost estimates for options for a single dredge campaign - $ million

	Reclamation Hay Point	Reclamation Mackay	Habitat Rehabilitation	Onshore Dudgeon Point	Onshore Mackay	At Sea Existing	At sea Mid-shelf	At Sea Coral Sea
Site preparation & land based access			$0.50	$0.01	$0.1			
Earthworks & bund formation				$10.6	$4.9			
Rockwall construction	$26.6	$18.0						
Weir boxes				$0.01	$0.01			
Geotextiles	$0.2	$0.18	$0.4	$4.3	$3.4			
Perimeter drainage				$1.4	$0.9			
Monitoring			$1.5					
Miscellaneous			$0.2	$0.2	$0.2			
Dredging (Inc. Transport and pumping/disposal)	$2.6	$3.5	$2.8	$2.6	$3.5	$1.7	$2.7	$22.7
Cost estimate	***$29.4***	***$21.7***	***$5.4***	***$19.1***	***$13.0***	***$1.7***	***$2.7***	***$22.7***
Contingencies	20%	20%	30%	20%	20%	10%	10%	30%
Total (excl GST)	**$35.26**	**$26.02**	**$6.97**[4]	**$22.94**	**$15.56**	**$1.83**	**$2.97**	**$29.47**

4 As part of a feasibility assessment that will be undertaken for the option of mangrove rehabilitation, the costs will be comprehensively reviewed and confirmed.

Table 35: Cost estimates for each long term option over a 25 year period (lower is better)

Options	Year						
	1-5	6-10	11-15	16-20	21-25	PV @ 10%	Total 2016 AUD
Existing Offshore Placement Area + Reclamation Hay Point	$1.83	$35.26	$2.60	$2.60	$2.60	**$25.73**	$44.89
Existing Offshore Placement Area + Mangrove rehabilitation + Existing Offshore Placement Area +	$1.83	$6.97	41.83	$1.83	$1.83	**$7.57**	$14.28
Existing Offshore Placement Area + Mangrove rehabilitation + Reclamation Hay Point	$1.83	$6.97	$35.26	$2.60	$2.60	**$20.76**	$49.26
Existing Offshore Placement Area + Mangrove Rehabilitation + Onshore Mackay	$1.83	$6.97	$15,56	$6.00	$6.00	**$14.49**	$36.36
Existing Offshore Placement Area + Mangrove Rehabilitation + Dudgeon Point Placement	$1.83	$6.97	$22.94	$6.00	$6.00	**$17.33**	$43.74
Existing Offshore Placement Area + Dudgeon Point Placement	$1.83	$22.94	$6.00	$6.00	$6.00	**$20.72**	$42.77
Existing Offshore Placement Area + Onshore Mackay	$1.83	$15.56	$6.00	$6.00	$6.00	**$14.49**	$35.39
At Sea Existing Inshore	$1.83	$1.83	$1.83	$1.83	$1.83	**$4.38**	$9.13
At Sea Mid-shelf Area	$2.97	$2.97	$2.97	$2.97	$2.97	**$7.11**	$14.85
Existing +At Sea Existing + Offshore Coral Sea	$1.83	$29.47	$29.47	$29.47	$29.47	**$42.93**	$119.71
Mid-shelf Area + Mangrove Rehabilitation + Mid-shelf Area	$2.97	$6.97	$2.97	$2.97	$2.97	**$9.60**	$18.85

I) SPL affected

Theme: Port Economics & Operation

Objective: 6. Avoid significant loss of future port expansion opportunities

Measure: I) Strategic Port Land (SPL) affected

Unit of measure: Hectares

Which direction of the measure is better? Lower

Maintaining effective port operations and future port development opportunities is a critical component of the decision making process for sustainable sediment management at the Port of Hay Point. One of the factors to consider around this objective is the impact of each of the alternatives on the statutory designated port land in the Ports of Hay Point and Mackay. Strategic Port Land (SPL) is set aside through the planning system to facilitate the operation and development of port related activities.

Stakeholders agreed that any loss of available port land (SPL) and thus restrictions on future opportunities for growth should be considered in the decision making process.

METHOD OF CALCULATION

The area potentially affected by each alternative was calculated based on the location and land area needed to deliver each alternative. Calculations include maritime port area that may also be used to facilitate port activities in the future.

RESULTS

The results are presented across the following three tables:

- Table 36: Commentary on the lead times for each alternative.
- Table 37: SPL potentially affected by each alternative (lower is better).
- Table 38: SPL potentially affected by each long term option over a 25 year period (lower is better).

Table 36: Commentary on the lead times for each alternative

Alternative	Commentary
Reclamation Hay Point	• Reclamation activities will occur on both land and maritime area within the port boundary. The poor load bearing nature of the reclamation will make this area unsuitable for primary port operations. The will be a loss of SPL of 40 ha.
Reclamation Mackay	• Reclamation activities will occur on both land and maritime area within the port boundary. The poor load bearing nature of the reclamation will make this area unsuitable for primary port operations. The will be a loss of SPL of 40 ha.
Habitat Rehabilitation Area	• Rehabilitation will primarily be in tidal areas away from existing port infrastructure. A small loss of 20 ha of SPL is expected as a result of the immediate onshore areas that will be rehabilitated as part of the this option and the areas for staging ponds that would be lost to any future port development.
Onshore Dudgeon Point	• Onshore placement will occur on port land within the port boundary. The will result in a loss of SPL of 50 ha.
Onshore Mackay	• Onshore placement will occur on port land within the port boundary. The will result in a loss of SPL of 50 ha

Alternative	Commentary
At Sea Existing Inshore	• Placement is outside of port limits.
At Sea Mid-shelf Area	• Placement is outside of port limits.
At Sea Offshore Coral Sea	• Placement is outside of port limits.

Table 37: SPL potentially affected by each alternative (lower is better)

	Reclamation Hay Point	Reclamation Mackay	Habitat Rehabilitation	Onshore Dudgeon Point	Onshore Mackay	At Sea Existing	At sea Mid-shelf	At Sea Coral Sea
SPL or maritime port area impacted (ha)	**40**	**40**	**20**	**50**	**50**	**0**	**0**	**0**

Table 38: SPL potentially affected by each long term option over a 25 year period (lower is better)

	At Sea Existing x 1 Reclamation Hay Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 At Sea Existing x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Reclamation Hay Point x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Dudgeon Point x 3	At Sea Existing x 1 Onshore Dudgeon Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Mackay x 3	At Sea Existing x 1 Onshore Mackay x 4	At Sea Existing x 5	At Sea Mid-shelf x 5	At Sea Existing x 1 At Sea Coral Sea x 4	At Sea Mid-shelf x 1 Habitat Rehabilitation x 1 At Sea Mid-shelf x 3
Years 1- 5	0	0	0	0	0	0	0	0	0	0	0
Years 6- 10	40	20	20	20	50	20	50	0	0	0	20
Years 11- 15	0	0	40	50	0	50	0	0	0	0	0
Years 16 - 20	0	0	0	0	0	0	0	0	0	0	0
Years 21 - 25	0	0	0	0	0	0	0	0	0	0	0
Total score	**40**	**20**	**60**	**70**	**50**	**70**	**50**	**0**	**0**	**0**	**20**

J) Human health and safety

Theme: Human Health and Safety

Objective: 7. Avoid or mitigate health and safety risks

Measure: J) Relative risk

Unit of measure: Performance score ranging from 8-24

Which direction of the measure is better? Lower

All stakeholders felt that potential impacts on human health and safety was an important criteria to assess when considering the alternatives for long term sustainable sediment management at the Port of Hay Point. To assess this component, a range of human health and safety measures were developed along with some simple performance criteria to rank them.

METHOD OF CALCULATIONS

It is important to note the process is not intended to replicate a full risk assessment (based on unmitigated and mitigated risks derived from likelihood and consequences of various activities). Rather it takes a high level approach around potential risk pathways and complexity. More detailed assessment will be considered for the preferred alternative as part of any future project planning and management.

For each alternative, each measure is assessed against the performance criteria and graded (see Table 39). A total performance score for each alternative is then derived from the sum of performance criteria.

The performance scores for the long term options were taken from the worst performing component of that option.

Table 39: Human health and safety measures and performance criteria

Measures	Performance Criteria		
	High (Score = 1)	Medium (Score = 2)	Low (Score =3)
Interaction with public areas	Remote from public areas or is in an area of low public usage	Regular interaction with public areas but is able to be easily managed	High use public area requiring ongoing management
Dust and emissions	No dust or emissions expected above natural air quality variants	Dust or emissions expected but is able to be managed easily	Dust or emissions requiring ongoing management
Duration of activity (influences likelihood of occurrence)	0 - 2 weeks	2 weeks – 8 weeks	> 8 weeks
Spills and contaminants	Limited sources of spills or contamination in easily contained environment	Multiple sources of spill or contamination over single onsite area	Multiple sources of spill or contamination extending to multiple offsite areas
Heavy vessel / machinery interaction	Single vessel or machinery only	Multiple vessels or machinery with limited interaction with each other	Multiple vessels or machinery with regular interaction with each other
Isolated areas – proximity to medical support	Access to medical support similar to normal regional services	Short delays (hrs) in obtaining normal regional medical support	Long delays (days) in obtaining normal regional medical support
Weather exposure	Able to easily retreat in adverse weather	Short delays (hrs) in seeking retreat in adverse weather	Long delays (days) in seeking retreat from adverse weather
Personnel requirements	Small (<10) workforce in single location	Small to medium (up to 20) workforce working across multiple locations	Medium to large (>20) workforce operation across multiple locations

RESULTS

The results are presented across the following three tables:

- Table 40: Commentary on the human health and safety performance of each alternative.
- Table 41: Human health and safety performance scores for each alternative (lower is better).
- Table 42: Human health and safety performance scores over a 25 year period (lower is better).

Table 40: Commentary on the human health and safety performance of each alternative

Alternative	Commentary
Reclamation Hay Point	• Location will require access restrictions and fencing • Long term (>8 weeks) construction period • Increase in dust is possible • Import of construction material by heavy vehicle and multiple traffic movements • Multiple ongoing machinery interactions and multiple vessels for manoeuvring dredge • Ongoing interaction and personnel management during operational phase will be required
Reclamation Mackay	• Location will require access restrictions and fencing • Long term (>8 weeks) construction period • Increase in dust is possible • Import of construction material by heavy vehicle and multiple traffic movements • Multiple ongoing machinery interactions • Ongoing management during operational phase will be required
Habitat Rehabilitation Area	• Remote location on boundary of Strategic Port Land • Short term (4 weeks) construction of retaining walls and material handling facilities • Multiple machinery requirements with limited direct interaction with each other • Short-term management of small workforce
Onshore Dudgeon Point	• Remote location on boundary of Strategic Port Land • Medium term (<8 weeks) construction of retaining walls and material handling facilities • Increase in dust possible • Multiple machinery requirements with direct interaction with each other • Medium-term management of medium workforce
Onshore Mackay	• Location will require access restrictions and fencing • Medium term (<8 weeks) construction of retaining walls and material handling facilities • Increase in dust possible • Multiple machinery requirements with direct interaction with each other • Medium-term management of medium workforce
At Sea Existing Inshore	• Maritime location with limited public activity • Short term (1-2 weeks) • Single dredger with limited interaction with other machinery • Small to medium workforce, on single vessel
At Sea Mid-shelf Area	• Maritime location with limited public activity • Medium term (< 8 weeks) • Single dredger with limited interaction with other machinery • Small to medium workforce, on single vessel
At Sea Offshore Coral Sea	• Maritime location with limited public activity • Long term (< 12 weeks) • Single dredger with limited interaction with other machinery • Medium workforce, on single vessel although long period requiring shift and fatigue management • Long delays possible to retreat in adverse weather and seek medical support

Table 41: Human health and safety performance scores for each alternative (lower is better)

	Reclamation Hay Point	Reclamation Mackay	Habitat Rehabilitation	Onshore Dudgeon Point	Onshore Mackay	At Sea Existing	At sea Mid-shelf	At Sea Coral Sea
Public Interaction	3	3	1	1	2	1	1	1
Dust and Emissions	2	2	1	2	2	1	1	1
Duration	3	3	1	3	3	1	2	3
Spills and Contamination	2	2	2	2	2	1	1	1
Machinery Interaction	3	3	2	3	3	1	1	1
Isolation - medical	1	1	1	1	1	1	2	3
Retreat	1	1	1	1	1	1	2	3
Personnel	1	1	1	2	2	1	1	2
Total score	**16**	**16**	**10**	**15**	**16**	**8**	**11**	**15**

High Performance

Medium Performance

Low Performance

Table 42: Human health and safety performance scores over a 25 year period (lower is better)

	At Sea Existing x 1 Reclamation Hay Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 At Sea Existing x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Reclamation Hay Point x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Dudgeon Point x 3	At Sea Existing x 1 Onshore Dudgeon Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Mackay x 3	At Sea Existing x 1 Onshore Mackay x 4	At Sea Existing x 5	At Sea Mid-shelf x 5	At Sea Existing x 1 At Sea Coral Sea x 4	At Sea Mid-shelf x 1 Habitat Rehabilitation x 1 At Sea Mid-shelf x 3
Score	**16**	**10**	**16**	**15**	**15**	**16**	**16**	**8**	**11**	**15**	**11**

K) Social performance

Theme: Social

Objective: 8. Minimise interference to social activities within the region

Measure: K) Scale and duration of any impacts on social activities

Unit of measure: Performance score ranging from 3 - 9

Which direction of the measure is better? Lower

The Mackay region supports a population of 200,000 people with an estimated 21,200 living in the immediate area of Hay Point (including the town of Sarina). Of these 14.4 per cent are aged 65 years and above, 7.3 per cent are born overseas and 4.1 per cent identify as being Indigenous. In the area, 46.8 per cent of households are couples with children. The top three employment sectors in the area are transport, postal and warehousing, agriculture, forestry and fishing, and construction. People holding a non-school qualification make up 47.6 per cent of the population.

The coastal areas and inner waters of the GBR around Mackay and Hay Point support a range of social and commercial activities, including: farming, commercial fishing, recreational fishing, boating, informal recreation (swimming, surfing, walking). People living in the area need to access a wide range of services from Mackay.

The sustainable sediment management project aims to further improve the management of port sediments while ensuring the continued operation of the port, social and cultural features are respected and that environmental values are protected.

Stakeholders wanted to ensure that the potential for impacts on social features and activities arising from the various options were considered in the decision making process.

METHOD OF CALCULATION

The performance criteria for each alternative was calculated based on:

- The nature of any interaction with social features or activities.
- The length of time any interaction or disturbance will occur for.
- Number of people affected.

Table 43: Social performance criteria

Measure	Performance Criteria		
	High (Score = 1)	**Medium (Score = 2)**	**Low (Score = 3)**
Nature of interaction or disturbance	None or positive	Results in a need for alteration or relocation of an area or activity	Activity must cease.
Duration of interaction	None	Short to medium term – life of the dredging campaign.	Permanent or long-term
Number of people affected	None	Small numbers of participants, single interest group (1 to 30 people)	Larger numbers (+30) or multiple interest groups, whole community.

RESULTS

The results are presented across the following three tables:

Table 44: Commentary on the performance criteria for each alternative.

- Table 45: Social performance score for each alternative (lower score is better).
- Table 46: Social performance score for each long term option over 25 years (lower score is better).

Table 44: Commentary on the performance criteria for each alternative

Alternative	Commentary
Reclamation Hay Point	• The construction of a reclamation area at Hay Point (Half Tide Tug Harbour) has the potential to impact on recreational boating access (boat ramp) and also beach access, particularly during the construction and dredging phases. • Dredge vessel will need to operate for approximately 23 days during each campaign.
Reclamation Mackay	• Direct removal and permanent alteration of an area of 26 ha of inshore marine area adjacent to the northern breakwall. This area is known to be used by surfers and suitable wave action in this location may be lost. • Dredge vessel will need to operate for approximately 31 days during each campaign.
Habitat Rehabilitation Area	• An area of 70 ha will be altered as dredge material is placed within a bund to create the habitat rehabilitation area • No known social activities are know from the site, the area is on and adjacent to port land. • The dredge vessel will need to operate for approximately 7 weeks, 24 hours a day with minimal downtime.
Onshore Dudgeon Point	• An area of 50 ha will be altered as dredge material is placed within a bund system. • No known social activities are known from the site, the area is on port land. • The dredge vessel will be required to operate for approximately 23 days during each campaign.
Onshore Mackay	• An area of 50 ha will be altered as dredge material is placed within a bund system. • No known social activities are know from the site, the area is on port land. However, some disturbance to adjacent industrial activities, road ways etc can be anticipated. • The dredge vessel will be required to operate for approximately 31 days during each campaign.
At Sea Existing Inshore	• No specific activities are known for the location, some minor disruption to fishing and boating activity may result. • The dredge vessel will operate for approximately 14 days during each campaign.
At Sea Mid-shelf Area	• No specific activities are known for the location. • The dredge vessel will operate for approximately 23 days during each campaign.
At Sea Offshore Coral Sea	• No specific activities are known for the location. • 58 days of operation as the dredge vessel moves between the Port and the material placement location.

Table 45: Social performance score for each alternative (lower score is better)

	Reclamation Hay Point	Reclamation Mackay	Habitat Rehabilitation	Onshore Dudgeon Point	Onshore Mackay	At Sea Existing	At sea Mid-shelf	At Sea Coral Sea
Nature of interaction	2	3	1	1	2	1	1	1
Duration	2	2	1	1	2	1	1	1
Number of people affected	2	2	1	1	3	1	1	1
Total performance score	**6**	**7**	**3**	**3**	**7**	**3**	**3**	**3**

High Performance

Medium Performance

Low Performance

Table 46: Social performance score for each long term option over 25 years (lower score is better)

	At Sea Existing x 1 Reclamation Hay Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 At Sea Existing x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Reclamation Hay Point x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Dudgeon Point x 3	At Sea Existing x 1 Onshore Dudgeon Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Mackay x 3	At Sea Existing x 1 Onshore Mackay x 4	At Sea Existing x 5	At Sea Mid-shelf x 5	At Sea Existing x 1 At Sea Coral Sea x 4	At Sea Mid-shelf x 1 Habitat Rehabilitation x 1 At Sea Mid-shelf x 3
Years 1- 5	3	3	3	3	3	3	3	3	3	3	3
Years 6- 10	6	3	3	3	3	3	7	3	3	3	3
Years 11- 15	6	3	6	3	3	7	7	3	3	3	3
Years 16 - 20	6	3	6	3	3	7	7	3	3	3	3
Years 21 - 25	6	3	6	3	3	7	7	3	3	3	3
Total score	**27**	**15**	**24**	**15**	**15**	**27**	**31**	**15**	**15**	**15**	**15**

L) Employment

Theme: Social

Objective: 9. Provide increased economic and social opportunities

Measure: L) Predicted number of FTE jobs created

Unit of measure: Full Time Equivalent (FTE) jobs created

Which direction of the measure is better? Higher

As part of the broader social theme, all stakeholders recognised that a positive consideration would be to measure and compare the jobs created by each option. In particular local job creation is seen as important as it will contribute to the regional economy and enhance the social fabric of the region. Jobs created at a broader level are also of value but for the purposes of comparison have been weighted at a lower factor.

METHOD OF CALCULATION

For each management option the forecast number of part-time and full time jobs (if any) has been determined to create an overall jobs score. All jobs created have been included in the comparative analysis, however the calculations below for the 25 year time frame have applied a different multiplier to the jobs in the local (Mackay) region (x1) at a national level (x 0.5) and internationally (x 0.25). Indirect jobs supported or created beyond the region (such as work for regulatory agencies, consultants etc.) are not included as they are too intangible for inclusion.

Full-time Equivalent (FTE) is a unit equivalent of a full-time employee's workload. It represents a business's total number of full-time equivalent employees by summing the total hours worked by employees, both full and part-time, then dividing by the number of working hours available in a given period (days, week or year). In this way, it is used to determine the number of full-time equivalents regardless of the number of actual employees and variations in the number of hours worked during a period.

The formula used is:

number of employees X number of hours worked / number of available working hours.

e.g. 3 x 20/(3 x 40) = 0.5

In this instance the formula has been based on a yearly period to account for full time, part time and contract personnel who may work full time for a period of weeks rather than a full year. A worked example is shown in the table below.

Employment profile	# of personnel	FTE
Full time all year	1 person	1
Part time all year	2 people x 2 days a week (2 x 2/5 = 0.8)	0.8
Full time part year (e.g. 3 months)	20 personnel x 12 weeks (20 x 12/52 = 4.6)	4.6
Totals	**23 individuals**	**6.4 FTE**

The calculations for the mixed alternatives over the 25 year period are based on an annual FTE multiplied by the weightings as follows.

- Local by 1.0
- National by 0.5
- International by 0.10

RESULTS

The results are presented across the following three tables:

- Table 47: Commentary on the performance criteria for each alternative.
- Table 48: FTE performance scores for each alternative based on a single campaign (higher score is better).
- Table 49: FTE performance score for each long term option over 25 years (higher score is better).

Table 47: Commentary on the performance criteria for each alternative

Alternative	Commentary
Reclamation Hay Point	• Place core material (14 people for 19 weeks), geotextile installation (2 people for 12 weeks), armour material – upper reaches (14 people for 6 weeks) and armour material – lower reaches (5 people for 12 weeks). 8.12 FTE in total.
Reclamation Mackay	• Place core material (8 people for 20 weeks), geotextile installation (2 people for 12 weeks), armour material – upper reaches (8 people for 7 weeks) and armour material – lower reaches (3 people for 9 weeks). 4.96 FTE in total.
Habitat Rehabilitation Area	• Site preparation (2 people for 2 weeks), shaping (11 people for 1 to 4 weeks), planting (5 people for 3 weeks). 1.08 FTE in total.
Onshore Dudgeon Point	• Site preparation (7 people for 4 weeks), earthworks (12 people for 16 weeks), bund formation (12 people for 4 weeks), liner installation (2 people for 3 weeks). 5.27 FTE in total.
Onshore Mackay	• Site preparation (7 people for 2 weeks), earthworks (12 people for 4 weeks), bund formation (12 people for 4 weeks), liner installation (2 people for 3 weeks). 2.23 FTE in total.
At Sea Existing Inshore	• Employment restricted to onboard dredge vessel crew (TSHD Brisbane = 13 crew for two weeks).
At Sea Mid-shelf Area	• Employment restricted to onboard dredge vessel crew (TSHD Brisbane = 13 crew for 4 weeks).
At Sea Offshore Coral Sea	• The open ocean location of this option would probably necessitate a larger dredging vessel. Employment restricted to onboard dredge vessel crew (Dredger Charles Darwin = 20 crew for 32 days).

Table 48: FTE performance scores for each alternative based on a single campaign (higher score is better)

	Reclamation Hay Point	Reclamation Mackay	Habitat Rehabilitation	Onshore Dudgeon Point	Onshore Mackay	At Sea Existing	At Sea Mid-shelf	At Sea Coral Sea
Local (FTE)	8.12	4.96	1.08	5.27	2.23	0	0	0
National (FTE)	0.5	1	1	1	1	0.5	1	-
International (FTE)	-	-	-	-	-	-	-	1.75
Adjusted (FTE)	**8.37**	**5.46**	**1.58**	**5.77**	**2.73**	**0.25**	**0.5**	**0.175**

Table 49: FTE performance score for each long term option over 25 years (higher score is better)

	At Sea Existing x 1 Reclamation Hay Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 At Sea Existing x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Reclamation Hay Point x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Dudgeon Point x 3	At Sea Existing x 1 Onshore Dudgeon Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Mackay x 3	At Sea Existing x 1 Onshore Mackay x 4	At Sea Existing x 5	At Sea Mid-shelf x 5	At Sea Existing x 1 At Sea Coral Sea x 4	At Sea Mid-shelf x 1 Habitat Rehabilitation x 1 At Sea Mid-shelf x 3
Years 1- 5	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.5	0.25	0.5
Years 6- 10	8.37	1.58	1.58	1.58	5.77	1.58	2.73	0.25	0.5	0.175	1.58
Years 11- 15	0.25	0.25	8.37	5.77	0.5	2.73	0.5	0.25	0.5	0.175	0.5
Years 16 - 20	0.25	0.25	0.25	0.5	0.5	0.5	0.5	0.25	0.5	0.175	0.5
Years 21 - 25	0.25	0.25	0.25	0.5	0.5	0.5	0.5	0.25	0.5	0.175	0.5
Total FTE	9.37	2.58	10.7	8.6	7.52	5.56	4.48	1.25	2.5	0.95	3.58
FTE/Yr	**0.375**	**0.103**	**0.428**	**0.344**	**0.301**	**0.222**	**0.179**	**0.05**	**0.1**	**0.038**	**0.143**

M) Innovation

Theme: Innovation

Objective: 10. Promote innovation in port management

Measure: M) Ability of a solution to advance current dredging practice information, technology and techniques

Unit of measure: Performance score ranging from 3-9

Which direction of the measure is better? Higher

In line with the 'net benefits concept' promoted in the Reef 2050 Plan and various findings from the Independent Review of the Port of Gladstone it is desirable to seek and examine new port and environmental management options that promote best practice and deliver improved sustainable solutions.

Innovation can be defined as the deliberate application of information, technology and ingenuity in deriving greater or different values from a process. Within the broader comparative analysis a consideration of the innovative status of an option may make that option more attractive or worthy of greater consideration if it demonstrates usefulness beyond the Port of Hay Point. Accordingly, stakeholders were of the opinion that the innovative nature of alternatives should inform the decision making process.

Throughout Australia and internationally a variety of approaches and solutions are already used to maintain navigational infrastructure areas, these approaches include:

- Upstream controls of sediment sources (erosion reduction, sediment traps etc).
- Sediment bypass systems.
- Sediment agitation to move sediment from port areas.
- Recycling of sediment back into the originating marine or land environment.
- Reuse of sediment for beach nourishment, reclamation, construction, habitat rehabilitation.
- Dredging and material disposal.

The selection and use of approaches is dependent on a large number of factors specific to an individual location, type of sediment, volumes, port operations and frequency of maintenance needs.

The Hay Point SSM project has objectively examined the full range of options, both existing and new, in order to consider and compare alternatives in an open and comprehensive manner. From this analysis a number of options have been selected as being potentially suitable or feasible at Hay Point and thus worthy of further examination. It is these options that have been included in the comparative analysis. An assessment of the innovative nature of these possible options has been undertaken.

METHOD OF CALCULATION

An assessment of the innovative nature of possible options has been undertaken using a small set of performance criteria as a means of examining if the options offer solutions to advancing current dredging practice information, technology and techniques.

For each alternative an innovation performance score is determined through an analysis against the criteria.

Table 50: Innovation measures and performance criteria

Measures	Performance Criteria		
	High (Score = 3)	**Medium (Score = 2)**	**Low (Score = 1)**
Application of information	Provides an opportunity to trial new approaches and enhance current knowledge base	Provides an opportunity to apply recent knowledge advances in a practical manner	Is well understood and offers limited opportunities for new learning
Application of technology/techniq	Requires the imaginative use and development of new technology or	Requires the application of recently developed	Uses known and existing technology or techniques

ues	techniques	technology or techniques	
Use of ingenuity	Offers a new solution that could enhance environmental or business outcomes	Is a rarely used option that if effective could reduce adverse environmental or business outcomes	Is a well established option that produces known and expected results

RESULTS

It is important to note that few ports have exactly the same scenario in terms of material type, volumes, land/sea availability. This analysis has assumed that circumstances are favourable for a wider application of options. Each port and each scenario would need to be assessed taking into account the needs and situation at an individual port.

The results are presented across the following three tables:

- Table 51: Commentary on the innovation performance of each alternative.

- Table 52: Innovation performance scores for each alternative (higher score is better).
- Table 53: Innovation performance scores for each long term options over 25 years (higher score is better).

Table 51: Commentary on the innovation performance of each alternative

Alternative	Commentary
Reclamation Hay Point	• Reclamation is a well established and understood activity based around existing techniques
Reclamation Mackay	• Reclamation is a well established and understood activity based around existing techniques
Habitat Rehabilitation Area	• Habitat rehabilitation offers significant opportunities to trial new approaches and enhance the current knowledge base • The activity has been done before in a limited number of cases and will be based on the application of recently developed techniques • It potentially offers a new solution to other ports that could enhance environmental and business outcomes
Onshore Dudgeon Point	• Onshore disposal is a well established and understood activity based around existing techniques
Onshore Mackay	• Onshore disposal is a well established and understood activity based around existing techniques
At Sea Existing Inshore	• Placement of dredge material at the existing placement area is a well established and understood activity based around existing techniques
At Sea Mid-shelf Area	• Placement of dredge material at sea is a well established and understood activity based around existing techniques • Mid-shelf placement has not been undertaken frequently, modelling and monitoring results would be informative to other ports and future activities.
At Sea Offshore Coral Sea	• Placement of dredge material at sea is a well established and understood activity based around existing techniques • Deep water placement has not been undertaken in Australia previously, predictive modelling, site specific studies and monitoring results would be informative to other ports and future activities.

Table 52: Innovation performance scores for each alternative (higher score is better)

	Reclamation Hay Point	Reclamation Mackay	Habitat Rehabilitation	Onshore Dudgeon Point	Onshore Mackay	At Sea Existing	At Sea Mid-shelf	At Sea Coral Sea
Information	1	1	3	1	1	1	2	2
Technology	1	1	2	1	1	1	1	1
Ingenuity	1	1	3	1	1	1	2	2
Total score	**3**	**3**	**8**	**3**	**3**	**3**	**5**	**5**

High Performance

Medium Performance

Low Performance

Table 53: Innovation performance scores for each long term options over 25 years (higher score is better)

	At Sea Existing x 1 Reclamation Hay Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 At Sea Existing x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Reclamation Hay Point x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Dudgeon Point x 3	At Sea Existing x 1 Onshore Dudgeon Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Mackay x 3	At Sea Existing x 1 Onshore Mackay x 4	At Sea Existing x 5	At Sea Mid-shelf x 5	At Sea Existing x 1 At Sea Coral Sea x 4	At Sea Mid-shelf x 1 Habitat Rehabilitation x 1 At Sea Mid-shelf x 3
Years 1- 5	3	3	3	3	3	3	3	3	5	3	5
Years 6- 10	3	8	8	8	3	8	3	3	5	5	8
Years 11- 15	3	3	3	3	3	3	3	3	5	5	5
Years 16 - 20	3	3	3	3	3	3	3	3	5	5	5
Years 21 - 25	3	3	3	3	3	3	3	3	5	5	5
Total score	**15**	**20**	**20**	**20**	**15**	**20**	**15**	**15**	**25**	**23**	**28**

N) World Heritage performance

Theme: World Heritage

Objective: 11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area

Measure: N) Scale and duration of activity within the Great Barrier Reef World Heritage Area

Unit of measure: Performance score ranging from 4 - 12

Which direction of the measure is better? Higher

North Queensland Bulk Ports (NQBP) operates three ports within the Great Barrier Reef World Heritage Area (GBRWHA), including the Port of Hay Point. Stakeholders wanted to ensure that the potential for direct impacts and increased operational activities from different alternatives within the GBRWHA was captured in the decision making process.

METHOD OF CALCULATION

The performance criteria (Table 54) for each alternative was calculated based on:

- The size of the seabed area within the WHA directly altered by the sediment management alternative.
- The length of time the alteration to the seabed within the WHA will occur.
- The time it takes to complete the dredger operational activities associated with a single dredge campaign within the WHA.
- The potential risk to adjacent values that contribute to the WHA.

The following assumptions have been made when calculating the performance criteria for each alternative:

- Scale of change has been calculated by intersecting the spatial footprint of each alternative with the most current GBRWHA spatial layer (see Data Sources below).
- Analysis of the duration of change to the GBRWHA represents a worst-case scenario of possible direct impacts. It is therefore assumed that the maximum direct changes would occur during the initial dredge campaign.
- All alternatives, except the Coral Sea option assume the use of the TSHD Brisbane that has a maximum hopper capacity of 2,900 m^3. The Coral Sea option assumes a larger dredge would be used (e.g. Charles Darwin) that has a maximum hopper capacity of 30,000 m^3.

Table 54: Great Barrier Reef World Heritage performance criteria

Measure	Performance Criteria		
	High (Score = 3)	**Medium (Score = 2)**	**Low (Score = 1)**
Scale of change within GBRWHA	Small or no change to GBRWHA (<5 ha)	Moderate change to GBRWHA (5-15 ha)	Large change to GBRWHA (> 15 ha)
Duration of change within GBRWHA	Positive or no change to GBRWHA	Short to medium term change to GBRWHA (recovery within 1-10 years)	Permanent or long-term change to GBRWHA
Duration of operational activities within GBRWHA	Short term operational activities within the GBRWHA (≤20 days)	Medium term operational activities within the GBRWHA (20-30 days)	Long term operational activities within the GBRWHA (>31 days)
Potential risk to values that contribute to GBR World Heritage	No identified risk	Low level risks, temporary or minor	Confirmed risk and potential impact to values

RESULTS

The results are presented across the following three tables.

Table 55: Commentary on the performance criteria for each alternative

Alternative	Commentary
Reclamation Hay Point	• Direct impact to GBRWHA integrity through removal of 27 ha of marine habitat within the boundaries of the GBRWHA and permanent change to the low tide mark. • Dredge vessel will need to operate for approximately 23 days.
Reclamation Mackay	• Direct removal and permanent alteration of an area of 27 ha of inshore marine habitat within the boundaries of the GBRWHA. • Dredge vessel will need to operate for approximately 31 days.
Habitat Rehabilitation Area	• An area of 6 ha within the GBRWHA boundaries will be altered as dredge material is placed within a bund to create the habitat rehabilitation area. • The alteration to the area within the GBRWHA will be permanent and will increase contribution of area to OUV through the rehabilitation of the mangrove areas. • The dredge vessel will need to operate for approximately 20 days.
Onshore Dudgeon Point	• There will be no direct changes within the boundaries of the GBRWHA as dredge material will be placed onshore. • The dredge vessel will be required to operate for approximately 23 days. • High potential impact roosting and feeding areas for migratory birds that contribute to adjacent GBR values.
Onshore Mackay	• There will be no direct changes occurring within the GBRWHA as dredge material will be placed inland of the Port of Mackay. • The dredge vessel will be required to operate for approximately 31 days. • Low level risks to adjacent values such as habitat and waterways.
At Sea Existing Inshore	• Large, temporary direct changes to an 1840 ha area within the GBRWHA. • The dredge vessel will operate for approximately 14 days.
At Sea Mid-shelf Area	• Large, temporary direct changes to an 2009 ha area within the GBRWHA. • The dredge vessel will operate for approximately 23 days.
At Sea Offshore Coral Sea	• There will be no changes occurring within the GBRWHA as dredge material placement will occur outside GBRWHA. • 32 days of operation within the GBRWHA as the dredge vessel moves between the Port and the material placement location.

Table 56: World Heritage performance score for each alternative (higher score is better)

	Reclamation Hay Point	Reclamation Mackay	Habitat Rehabilitation	Onshore Dudgeon Point	Onshore Mackay	At Sea Existing	At sea Mid-shelf	At Sea Coral Sea
Scale of change	1	1	2	3	3	1	1	3
Duration of change	1	1	3	3	3	2	2	3
Duration of operational activities	2	1	3	2	1	3	2	1
Risk to adjacent values	3	3	3	1	2	3	3	3
Total performance score	**7**	**6**	**11**	**9**	**9**	**9**	**8**	**10**

High Performance

Medium Performance

Low Performance

Table 57: World Heritage performance score for each long term option over 25 years (higher score is better)

	At Sea Existing x 1 Reclamation Hay Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 At Sea Existing x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Reclamation Hay Point x 3	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Dudgeon Point x 3	At Sea Existing x 1 Onshore Dudgeon Point x 4	At Sea Existing x 1 Habitat Rehabilitation x 1 Onshore Mackay x 3	At Sea Existing x 1 Onshore Mackay x 4	At Sea Existing x 5	At Sea Mid-shelf x 5	At Sea Existing x 1 At Sea Coral Sea x 4	At Sea Mid-shelf x 1 Habitat Rehabilitation x 1 At Sea Mid-shelf x 3
Years 1- 5	9	9	9	9	9	9	9	9	8	9	8
Years 6- 10	7	11	11	11	9	11	9	9	8	10	11
Years 11- 15	7	9	7	9	9	9	9	9	8	10	8
Years 16 - 20	7	9	7	9	9	9	9	9	8	10	8
Years 21 - 25	7	9	7	9	9	9	9	9	8	10	8
Total score	**37**	**47**	**41**	**47**	**45**	**47**	**45**	**45**	**40**	**49**	**43**

Appendix C – Detailed results of the comparative analysis

Table 58: Single campaign raw scores

Theme	Objectives	Performance measure	Units	Dir	Rec - HP	Rec - M	Rehab	Onshore - DP	Onshore - M	Existing	Mid-shelf	Coral sea
ENV	**1. Avoid and minimise impacts to coastal ecosystems**	A) Coastal ecosystems performance	4-16	H	4	4	16	7	6	6	8	8
		B) Water quality performance	0-21	L	0	0	0	0	0	6	1	0
	2. Minimise carbon emissions	C) GHG emissions	tCO2-e	L	24774	19485	1674	7421	4886	618	1012	6693
CULTUR	**3. Minimise impact on cultural heritage within the area**	D) Cultural heritage performance	3-9	L	4	4	3	5	5	3	3	3
ECON	**4. Maintain effective and efficient port operations**	E) Port disruption	Days	L	23	31	20	23	31	14	23	16
		F) Lead time	Years	L	4	4	5.5	3.75	4.25	1	1.5	4
		G) Long term solution	Years	H	20	25	10	20	20	25	25	25
	5. Ensure solution is cost effective	H) Cost	$ million	L	$35.26	$26.02	$6.97	$22.94	$15.56	$1.83	$2.97	$29.47
	6. Avoid significant loss of future port expansion opportunities	I) SPL area affected	ha	L	40	40	20	50	50	0	0	0
H&S	**7. Avoid or mitigate health and safety risks**	J) Relative risk	8-24	L	16	16	10	15	16	8	11	15
SOCIAL	**8. Minimise interference to social activities within the region**	K) Social performance	3-9	L	6	7	3	3	7	3	3	3
	9. Provide increased economic and social opportunities	L) Employment	FTE	H	8.37	5.46	1.58	5.77	2.73	0.25	0.5	0.175
INNO	**10. Promote innovation in port management**	M) Innovation	3-9	H	3	3	8	3	3	3	5	5
WH	**11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area**	N) World Heritage performance	4-12	H	7	6	11	9	9	9	8	10

Best score for a performance measure

Worst score for a performance measure

Table 59: Single campaign normalised scores

Theme	Objectives	Performance measure	Units	Dir	Rec - HP	Rec - M	Rehab	Onshore - DP	Onshore - M	Existing	Mid-shelf	Coral sea
ENV	1. Avoid and minimise impacts to coastal ecosystems	A) Coastal ecosystems performance	4-16	H	0.00	0.00	1.00	0.25	0.17	0.17	0.33	0.33
		B) Water quality performance	0-21	L	1.00	1.00	1.00	1.00	1.00	0.71	0.95	1.00
	2. Minimise carbon emissions	C) GHG emissions	tCO2-e	L	0.00	0.22	0.96	0.72	0.82	1.00	0.98	0.75
CULTUR	3. Minimise impact on cultural heritage within the area	D) Cultural heritage performance	3-9	L	0.83	0.83	1.00	0.67	0.67	1.00	1.00	1.00
ECON	4. Maintain effective and efficient port operations	E) Port disruption	Days	L	0.47	0.00	0.65	0.47	0.00	1.00	0.47	0.88
		F) Lead time	Years	L	0.33	0.33	0.00	0.39	0.28	1.00	0.89	0.33
		G) Long term solution	Years	H	0.67	1.00	0.00	0.67	0.67	1.00	1.00	1.00
	5. Ensure solution is cost effective	H) Cost	$ million	L	0.00	0.28	0.85	0.37	0.59	1.00	0.97	0.17
	6. Avoid significant loss of future port expansion opportunities	I) SPL area affected	ha	L	0.20	0.20	0.60	0.00	0.00	1.00	1.00	1.00
H&S	7. Avoid or mitigate health and safety risks	J) Relative risk	8-24	L	0.50	0.50	0.88	0.56	0.50	1.00	0.81	0.56
SOCIAL	8. Minimise interference to social activities within the region	K) Social performance	3-9	L	0.50	0.33	1.00	1.00	0.33	1.00	1.00	1.00
	9. Provide increased economic and social opportunities	L) Employment	FTE	H	1.00	0.64	0.17	0.68	0.31	0.01	0.04	0.00
INNO	10. Promote innovation in port management	M) Innovation	3-9	H	0.00	0.00	0.83	0.00	0.00	0.00	0.33	0.33
WH	11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area	N) World Heritage performance	4-12	H	0.38	0.25	0.88	0.63	0.63	0.63	0.50	0.75

Best score for a performance measure

Worst score for a performance measure

Table 60: 25 year raw scores

Theme	Objectives	Performance measure	Units	Dir	1 Exist + 4 Rec HP	1 Exist + 1 Mangr + 3 Exist	1 Exist + 1 Mangr + 3 Rec HP	1 Exist + 1 Mangr + 3 DP	1 Exist + 4 DP	1 Exist + 1 Mangr + 3 Onshore Mack	1 Exist + 4 Onshore Mack	5 Exist	5 Mid-shelf	1 Exist + 4 Coral	1 Mid-shelf + 1 Mangr + 3 Mid-shelf
ENV	1. Avoid and minimise impacts to coastal ecosystems	A) Coastal ecosystems performance	20-80	H	22	40	34	43	34	40	30	30	40	38	48
		B) Water quality performance	0-105	L	6	24	6	6	6	6	6	30	5	6	4
	2. Minimise carbon emissions	C) GHG emissions	(tCO2-e)	L	27,777	4,146	28,656	11,303	10,424	9,544	9,053	3,090	5,060	32,018	5,722
CULTUR	3. Minimise impact on cultural heritage within the area	D) Cultural heritage performance	15-45	L	19	15	18	21	23	21	23	15	15	15	15
ECON	4. Maintain effective and efficient port operations	E) Port disruption	Days	L	106	76	103	103	106	127	138	70	115	78	112
	5. Ensure solution is cost effective	H) Cost	$ millions (present value)	L	$25.73	$7.57	$20.76	$17.33	$20.72	$16.13	$14.49	$4.38	$7.11	$42.93	$9.60
	6. Avoid significant loss of future port expansion opportunities	I) SPL area affected	ha	L	40	20	60	70	50	70	50	0	0	0	20
H&S	7. Avoid or mitigate health and safety risks	J) Relative risk	8-24	L	16	10	16	15	15	16	16	8	11	15	11
SOCIAL	8. Minimise interference to social activities within the region	K) Social performance	15-45	L	27	15	24	15	15	27	31	15	15	15	15
	9. Provide increased economic and social opportunities	L) Employment	FTE jobs created	H	0.3748	0.1032	0.428	0.344	0.3008	0.2224	0.1792	0.05	0.1	0.038	0.1432
INNO	10. Promote innovation in port management	M) Innovation	15-45	H	15	20	20	20	15	20	15	15	25	23	28
WH	11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area	N) World Heritage performance	20-60	H	37	47	41	47	45	47	45	45	40	49	43

Best score for a performance measure

Worst score for a performance measure

Table 61: 25 year normalised scores

Theme	Objectives	Performance measure	Scale	Dir	1 Exist + 4 Rec HP	1 Exist + 1 Mangr + 3 Exist	1 Exist + 1 Mangr + 3 Rec HP	1 Exist + 1 Mangr + 3 DP	1 Exist + 4 DP	1 Exist + 1 Mangr + 3 Onshore Mack	1 Exist + 4 Onshore Mack	5 Exist	5 Mid-shelf	1 Exist + 4 Coral	1 Mid-shelf + 1 Mangr + 3 Mid-shelf
ENV	**1. Avoid and minimise impacts to coastal ecosystems**	A) Coastal ecosystems performance	20-80	H	0.03	0.33	0.23	0.38	0.23	0.33	0.17	0.17	0.33	0.30	0.47
		B) Water quality performance	0-105	L	0.94	0.77	0.94	0.94	0.94	0.94	0.94	0.47	0.95	0.94	0.96
	2. Minimise carbon emissions	C) GHG emissions	3-33 KtCO2-e	L	0.15	0.96	0.12	0.72	0.75	0.78	0.79	1.00	0.93	0.00	0.91
CULTUR	**3. Protect and maintain access to sites of cultural and heritage significance**	D) Cultural heritage performance	15-45	L	0.87	1.00	0.90	0.80	0.73	0.80	0.73	1.00	1.00	1.00	1.00
ECON	**4. Maintain effective and efficient port operations**	E) Port disruption	70-138 days	L	0.47	0.91	0.51	0.51	0.47	0.16	0.00	1.00	0.34	0.88	0.38
	5. Ensure solution is cost effective	H) Cost	4-43 $ millions (present value)	L	0.45	0.92	0.58	0.66	0.58	0.70	0.74	1.00	0.93	0.00	0.86
	6. Avoid significant loss of future port expansion opportunities	I) SPL area affected	0-70 ha	L	0.43	0.71	0.14	0.00	0.29	0.00	0.29	1.00	1.00	1.00	0.71
H&S	**7. Avoid or mitigate health and safety risks**	J) Relative risk	8-24	L	0.50	0.88	0.50	0.56	0.56	0.50	0.50	1.00	0.81	0.56	0.81
SOCIAL	**8. Minimise interference to social activities within the region**	K) Social performance	15-45	L	0.60	1.00	0.70	1.00	1.00	0.60	0.47	1.00	1.00	1.00	1.00
	9. Provide increased economic and social opportunities	L) Employment	0-5 FTE jobs created	H	0.07	0.02	0.09	0.07	0.06	0.04	0.04	0.01	0.02	0.01	0.03
INNO	**10. Promote innovation in port management**	M) Innovation	15-45	H	0.00	0.17	0.17	0.17	0.00	0.17	0.00	0.00	0.33	0.27	0.43
WH	**11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area**	N) World Heritage performance	20-60	H	0.43	0.68	0.53	0.68	0.63	0.68	0.63	0.63	0.50	0.73	0.58

Best score for a performance measure

Worst score for a performance measure

Table 62: 25 year scores under equal weights

Theme	Objectives	Performance measure	Dir	Equal weights	1 Exist + 4 Rec HP	1 Exist + 1 Mangr + 3 Exist	1 Exist + 1 Mangr + 3 Rec HP	1 Exist + 1 Mangr + 3 DP	1 Exist + 4 DP	1 Exist + 1 Mangr + 3 Onshore Mack	1 Exist + 4 Onshore Mack	5 Exist	5 Mid-shelf	1 Exist + 4 Coral	1 Mid-shelf + 1 Mangr + 3 Mid-shelf
ENV	1. Avoid and minimise impacts to coastal ecosystems	A) Coastal ecosystems performance	H	8.3	0	3	2	3	2	3	1	1	3	3	4
		B) Water quality performance	L	8.3	8	6	8	8	8	8	8	4	8	8	8
	2. Minimise carbon emissions	C) GHG emissions	L	8.3	1	8	1	6	6	6	7	8	8	0	8
CULTUR	3. Minimise impact on cultural heritage within the area	D) Cultural heritage performance	L	8.3	7	8	8	7	6	7	6	8	8	8	8
ECON	4. Maintain effective and efficient port operations	E) Port disruption	L	8.3	4	8	4	4	4	1	0	8	3	7	3
	5. Ensure solution is cost effective	H) Cost	L	8.3	4	8	5	6	5	6	6	8	8	0	7
	6. Avoid significant loss of future port expansion opportunities	I) SPL area affected	L	8.3	4	6	1	0	2	0	2	8	8	8	6
H&S	7. Avoid or mitigate health and safety risks	J) Relative risk	L	8.3	4	7	4	5	5	4	4	8	7	5	7
SOCIAL	8. Minimise interference to social activities within the region	K) Social performance	L	8.3	5	8	6	8	8	5	4	8	8	8	8
	9. Provide increased economic and social opportunities	L) Employment	H	8.3	1	0	1	1	1	0	0	0	0	0	0
INNO	10. Promote innovation in port management	M) Innovation	H	8.3	0	1	1	1	0	1	0	0	3	2	4
WH	11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area	N) World Heritage performance	H	8.3	4	6	4	6	5	6	5	5	4	6	5
				TOTAL SCORE	41	70	45	54	52	47	44	69	68	56	68

Best score for a performance measure

Worst score for a performance measure

Table 63: 25 year scores under environment focus

Theme	Objectives	Performance measure	Dir	Environment focus	1 Exist + 4 Rec HP	1 Exist + 1 Mangr + 3 Exist	1 Exist + 1 Mangr + 3 Rec HP	1 Exist + 1 Mangr + 3 DP	1 Exist + 4 DP	1 Exist + 1 Mangr + 3 Onshore Mack	1 Exist + 4 Onshore Mack	5 Exist	5 Mid-shelf	1 Exist + 4 Coral	1 Mid-shelf + 1 Mangr + 3 Mid-shelf
ENV	1. Avoid and minimise impacts to coastal ecosystems	A) Coastal ecosystems performance	H	25.0	1	8	6	10	6	8	4	4	8	8	12
		B) Water quality performance	L	25.0	24	19	24	24	24	24	24	12	24	24	24
	2. Minimise carbon emissions	C) GHG emissions	L	25.0	4	24	3	18	19	19	20	25	23	0	23
CULTUR	3. Minimise impact on cultural heritage within the area	D) Cultural heritage performance	L	2.8	2	3	3	2	2	2	2	3	3	3	3
ECON	4. Maintain effective and efficient port operations	E) Port disruption	L	2.8	1	3	1	1	1	0	0	3	1	2	1
	5. Ensure solution is cost effective	H) Cost	L	2.8	1	3	2	2	2	2	2	3	3	0	2
	6. Avoid significant loss of future port expansion opportunities	I) SPL area affected	L	2.8	1	2	0	0	1	0	1	3	3	3	2
H&S	7. Avoid or mitigate health and safety risks	J) Relative risk	L	2.8	1	2	1	2	2	1	1	3	2	2	2
SOCIAL	8. Minimise interference to social activities within the region	K) Social performance	L	2.8	2	3	2	3	3	2	1	3	3	3	3
	9. Provide increased economic and social opportunities	L) Employment	H	2.8	0	0	0	0	0	0	0	0	0	0	0
INNO	10. Promote innovation in port management	M) Innovation	H	2.8	0	0	0	0	0	0	0	0	1	1	1
WH	11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area	N) World Heritage performance	H	2.8	1	2	1	2	2	2	2	2	1	2	2
				TOTAL SCORE	39	69	44	63	60	61	57	59	72	46	75

Best score for a performance measure

Worst score for a performance measure

Table 64: 25 year scores under social focus

Theme	Objectives	Performance measure	Dir	Social focus	1 Exist + 4 Rec HP	1 Exist + 1 Mangr + 3 Exist	1 Exist + 1 Mangr + 3 Rec HP	1 Exist + 1 Mangr + 3 DP	1 Exist + 4 DP	1 Exist + 1 Mangr + 3 Onshore Mack	1 Exist + 4 Onshore Mack	5 Exist	5 Mid-shelf	1 Exist + 4 Coral	1 Mid-shelf + 1 Mangr + 3 Mid-shelf
ENV	1. Avoid and minimise impacts to coastal ecosystems	A) Coastal ecosystems performance	H	2.5	0	1	1	1	1	1	0	0	1	1	1
		B) Water quality performance	L	2.5	2	2	2	2	2	2	2	1	2	2	2
	2. Minimise carbon emissions	C) GHG emissions	L	2.5	0	2	0	2	2	2	2	3	2	0	2
CULTUR	3. Minimise impact on cultural heritage within the area	D) Cultural heritage performance	L	2.5	2	3	2	2	2	2	2	3	3	3	3
ECON	4. Maintain effective and efficient port operations	E) Port disruption	L	2.5	1	2	1	1	1	0	0	3	1	2	1
	5. Ensure solution is cost effective	H) Cost	L	2.5	1	2	1	2	1	2	2	3	2	0	2
	6. Avoid significant loss of future port expansion opportunities	I) SPL area affected	L	2.5	1	2	0	0	1	0	1	3	3	3	2
H&S	7. Avoid or mitigate health and safety risks	J) Relative risk	L	2.5	1	2	1	1	1	1	1	3	2	1	2
SOCIAL	8. Minimise interference to social activities within the region	K) Social performance	L	37.5	23	38	26	38	38	23	18	38	38	38	38
	9. Provide increased economic and social opportunities	L) Employment	H	37.5	3	1	3	3	2	2	1	0	1	0	1
INNO	10. Promote innovation in port management	M) Innovation	H	2.5	0	0	0	0	0	0	0	0	1	1	1
WH	11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area	N) World Heritage performance	H	2.5	1	2	1	2	2	2	2	2	1	2	1
				TOTAL SCORE	36	57	41	54	53	37	31	56	56	52	56

Best score for a performance measure

Worst score for a performance measure

Table 65: 25 year scores under economic focus

Theme	Objectives	Performance measure	Dir	Economic focus	1 Exist + 4 Rec HP	1 Exist + 1 Mangr + 3 Exist	1 Exist + 1 Mangr + 3 Rec HP	1 Exist + 1 Mangr + 3 DP	1 Exist + 4 DP	1 Exist + 1 Mangr + 3 Onshore Mack	1 Exist + 4 Onshore Mack	5 Exist	5 Mid-shelf	1 Exist + 4 Coral	1 Mid-shelf + 1 Mangr + 3 Mid-shelf
ENV	1. Avoid and minimise impacts to coastal ecosystems	A) Coastal ecosystems performance	H	3.1	0	1	1	1	1	1	1	1	1	1	1
		B) Water quality performance	L	3.1	3	2	3	3	3	3	3	1	3	3	3
	2. Minimise carbon emissions	C) GHG emissions	L	3.1	0	3	0	2	2	2	2	3	3	0	3
CULTUR	3. Minimise impact on cultural heritage within the area	D) Cultural heritage performance	L	3.1	3	3	3	3	2	3	2	3	3	3	3
ECON	4. Maintain effective and efficient port operations	E) Port disruption	L	18.8	9	17	10	10	9	3	0	19	6	17	7
	5. Ensure solution is cost effective	H) Cost	L	18.8	8	17	11	12	11	13	14	19	17	0	16
	6. Avoid significant loss of future port expansion opportunities	I) SPL area affected	L	18.8	8	13	3	0	5	0	5	19	19	19	13
H&S	7. Avoid or mitigate health and safety risks	J) Relative risk	L	18.8	9	16	9	11	11	9	9	19	15	11	15
SOCIAL	8. Minimise interference to social activities within the region	K) Social performance	L	3.1	2	3	2	3	3	2	1	3	3	3	3
	9. Provide increased economic and social opportunities	L) Employment	H	3.1	0	0	0	0	0	0	0	0	0	0	0
INNO	10. Promote innovation in port management	M) Innovation	H	3.1	0	1	1	1	0	1	0	0	1	1	1
WH	11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area	N) World Heritage performance	H	3.1	1	2	2	2	2	2	2	2	2	2	2
				TOTAL SCORE	44	80	44	48	49	39	40	88	74	59	69

Best score for a performance measure

Worst score for a performance measure

Table 66: 25 year scores under cultural heritage focus

Theme	Objectives	Performance measure	Dir	Cultural focus	1 Exist + 4 Rec HP	1 Exist + 1 Mangr + 3 Exist	1 Exist + 1 Mangr + 3 Rec HP	1 Exist + 1 Mangr + 3 DP	1 Exist + 4 DP	1 Exist + 1 Mangr + 3 Onshore Mack	1 Exist + 4 Onshore Mack	5 Exist	5 Mid-shelf	1 Exist + 4 Coral	1 Mid-shelf + 1 Mangr + 3 Mid-shelf
ENV	1. Avoid and minimise impacts to coastal ecosystems	A) Coastal ecosystems performance	H	2.3	0	1	1	1	1	1	0	0	1	1	1
		B) Water quality performance	L	2.3	2	2	2	2	2	2	2	1	2	2	2
	2. Minimise carbon emissions	C) GHG emissions	L	2.3	0	2	0	2	2	2	2	2	2	0	2
CULTUR	3. Minimise impact on cultural heritage within the area	D) Cultural heritage performance	L	75.0	65	75	68	60	55	60	55	75	75	75	75
ECON	4. Maintain effective and efficient port operations	E) Port disruption	L	2.3	1	2	1	1	1	0	0	2	1	2	1
	5. Ensure solution is cost effective	H) Cost	L	2.3	1	2	1	2	1	2	2	2	2	0	2
	6. Avoid significant loss of future port expansion opportunities	I) SPL area affected	L	2.3	1	2	0	0	1	0	1	2	2	2	2
H&S	7. Avoid or mitigate health and safety risks	J) Relative risk	L	2.3	1	2	1	1	1	1	1	2	2	1	2
SOCIAL	8. Minimise interference to social activities within the region	K) Social performance	L	2.3	1	2	2	2	2	1	1	2	2	2	2
	9. Provide increased economic and social opportunities	L) Employment	H	2.3	0	0	0	0	0	0	0	0	0	0	0
INNO	10. Promote innovation in port management	M) Innovation	H	2.3	0	0	0	0	0	0	0	0	1	1	1
WH	11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area	N) World Heritage performance	H	2.3	1	2	1	2	1	2	1	1	1	2	1
				TOTAL SCORE	74	92	78	73	68	71	65	92	91	88	91

Best score for a performance measure

Worst score for a performance measure

Table 67: 25 year scores under World Heritage focus

Theme	Objectives	Performance measure	Dir	WHA	1 Exist + 4 Rec HP	1 Exist + 1 Mangr + 3 Exist	1 Exist + 1 Mangr + 3 Rec HP	1 Exist + 1 Mangr + 3 DP	1 Exist + 4 DP	1 Exist + 1 Mangr + 3 Onshore Mack	1 Exist + 4 Onshore Mack	5 Exist	5 Mid-shelf	1 Exist + 4 Coral	1 Mid-shelf + 1 Mangr + 3 Mid-shelf
ENV	1. Avoid and minimise impacts to coastal ecosystems	A) Coastal ecosystems performance	H	2.3	0	1	1	1	1	1	0	0	1	1	1
		B) Water quality performance	L	2.3	2	2	2	2	2	2	2	1	2	2	2
	2. Minimise carbon emissions	C) GHG emissions	L	2.3	0	2	0	2	2	2	2	2	2	0	2
CULTUR	3. Minimise impact on cultural heritage within the area	D) Cultural heritage performance	L	2.3	2	2	2	2	2	2	2	2	2	2	2
ECON	4. Maintain effective and efficient port operations	E) Port disruption	L	2.3	1	2	1	1	1	0	0	2	1	2	1
	5. Ensure solution is cost effective	H) Cost	L	2.3	1	2	1	2	1	2	2	2	2	0	2
	6. Avoid significant loss of future port expansion opportunities	I) SPL area affected	L	2.3	1	2	0	0	1	0	1	2	2	2	2
H&S	7. Avoid or mitigate health and safety risks	J) Relative risk	L	2.3	1	2	1	1	1	1	1	2	2	1	2
SOCIAL	8. Minimise interference to social activities within the region	K) Social performance	L	2.3	1	2	2	2	2	1	1	2	2	2	2
	9. Provide increased economic and social opportunities	L) Employment	H	2.3	0	0	0	0	0	0	0	0	0	0	0
INNO	10. Promote innovation in port management	M) Innovation	H	2.3	0	0	0	0	0	0	0	0	1	1	1
WH	11. Avoid and minimise impacts to the Great Barrier Reef World Heritage Area	N) World Heritage performance	H	75.0	32	51	39	51	47	51	47	47	38	54	43
				TOTAL SCORE	42	68	50	64	60	62	57	64	55	68	60

Best score for a performance measure

Worst score for a performance measure