Department of Transport Maintenance Dredging
Environmental Management Framework

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Environmental Management Framework

Prepared for

Department of Transport and BMT JFA Consultants Pty Ltd

Prepared by

BMT Oceanica Pty Ltd

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Acronyms and Definitions

95% UCL	A value that, when repeatedly calculated for randomly drawn subsets of size n, equals or exceeds the true population mean 95% of the time
ABA	Acid-base accounting
AH Act	Aboriginal Heritage Act 1972
ASLP	Australian Standard Leaching Procedures
ASS	Acid sulfate soils
CL	Concentration limit
CS Act	Contaminated Sites Act 2003
CSD	Cutter suction dredge
CT	Contaminated threshold
DAA	Western Australian Department for Aboriginal Affairs
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DEC	Western Australian Department of Environment and Conservation
DEIA	Dredging Environmental Impact Assessment
DEMP	Dredging Environmental Management Plan
DER	Western Australian Department of Environment Regulation
DoE	Australian Department of the Environment
DoT	Western Australian Department of Transport
DoW	Western Australian Department of Water
DPaW	Western Australian Department of Parks and Wildlife
EAG	Environmental Assessment Guideline
EIL	Ecological investigation level
EMF	Environmental Management Framework
EPA	Environmental Protection Authority
EPB	Environmental Protection Bulletin
EP Act	Environmental Protection Act 1986
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
ESL	Ecological screening level
HCB	Hexachlorobenzene
HIL	Health investigation level
LoR	Limit of reporting
MCPA	2-methyl-4-chlorophenoxyacetic acid
MCBP	4-(4-chloro-o-tolyloxy)butyric acid
MPRA	Marine Parks and Reserves Authority
NAGD	National Assessment Guidelines for Dredging

NEPC	National Environment Protection Council
NtM	Notice to Mariners
PAG	Post Assessment Guideline
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PEP	Project Execution Plan
PS	Position Statement
SAP	Sediment Sampling and Analysis Plan
TOC	Total organic carbon
TPH	Total petroleum hydrocarbons
TRH	Total recoverable hydrocarbons
UCL	Upper confidence limit
Wrack	Seaweed or marine vegetation that is cast ashore

Executive Summary

The Western Australian Department of Transport (DoT) is responsible for the management of a number of coastal facilities and small craft waterways around Western Australia (WA). A fundamental component of the DoT's maintenance responsibilities is the requirement to retain navigable waters at these sites. The DoT, as the proponent of maintenance dredging activities at these sites, has ultimate responsibility to ensure the environment is protected under Part IV of the *Environmental Protection Act 1986*.

The purpose of this Maintenance Dredging Environmental Management Framework (EMF) is to guide the DoT in the effective and efficient environmental management of their maintenance dredging operations. The EMF outlines the following:

- the DoT's management of its maintenance dredging responsibilities
- the DoT's maintenance dredging program and an outline of the typical works completed at the various sites
- regulatory context for maintenance dredging at each facility
- environmental approvals pathways
- environmental and socio-economic issues typically arising from maintenance dredging activities
- typical environmental management and contingency measures
- typical environmental monitoring.

The DoT's maintenance dredging program is audited for compliance annually. Following the completion of each audit, the EMF shall be reviewed and updated to ensure it incorporates: amended or new environmental policies; new environmental guidelines; improved environmental understanding; and outcomes following the annual audit. This review schedule ensures the evolution and application of best practice environmental management to the DoT's maintenance dredging program.

1. Introduction

1.1 Background

The Western Australian Department of Transport (DoT) is responsible for the management of a number of coastal facilities and small craft waterways around Western Australia (WA) (Figure 1.1). A fundamental component of the DoT's maintenance responsibilities is the requirement to retain navigable waters at these sites and other regional channels. This is completed through an ongoing maintenance dredging program. This program is central to the viability of the State's commercial fishing and marine tourism industry and to the safe use of waterways by recreational boat users. The statewide program is coordinated by a team that includes the:

- Principal and Superintendent (DoT)
- engineering and project management consultant
- environmental consultant
- dredging contractor.

The DoT manages maintenance dredging (the removal of material from an ocean, estuary, river bed, beach or bank, including bypassing) at over 40 sites (Table 1.1, Figure 1.1). Twenty six of these maritime facilities are managed by the DoT, 14 of which have required maintenance dredging within the past 10 years. The authority for the DoT to carry out maintenance dredging works is given under Section 5(1) of the *Marine & Harbours Act 1981*. The DoT, as the proponent of maintenance dredging activities at these facilities, has ultimate responsibility to ensure the environment is protected under Part IV of the *Environmental Protection Act 1986* (EP Act). In the past, the DoT has also assisted other agencies with management of maintenance dredging at the following additional sites:

- two commercial ports (Wyndham Port and Derby Port)
- Ocean Reef Boat Harbour (under management deed) for the City of Joondalup
- various regional waterways within the Swan River, Canning River, Peel Harvey Estuary and Hardy Inlet
- Mandurah Entrance Channel and Dawesville Entrance Channel
- Collie River on behalf of South West Development Commission.

The Coastal Infrastructure Business Unit of the DoT manages a rolling five year maintenance dredging program. The rate of natural siltation is typically dependent on the frequency and intensity of metocean events and is difficult to predict. Therefore the dredging program is based on historic dredging frequency, a review of hydrographic survey data and assessment of actual dredging requirements, and feedback from users at each facility.

Table 1.1 Facilities where the Department of Transport manages maintenance dredging (in geographical order from north to south)

Region	Site	Facility
Kimberley	Wyndham Port	Port
Kimberley	Derby Port	Port
Pilbara	Point Samson Boat Harbour (John's Creek)	Small Boat Harbour
Pilbara	Onslow Maritime Facility	Channel and Harbour Basin
Gascoyne	Exmouth Boat Harbour	Small Boat Harbour
Gascoyne	Coral Bay Maritime Facility	Jetty
Gascoyne	Carnarvon Boat Harbour	Small Boat Harbour
Gascoyne	Teggs Channel	Channel
Gascoyne	Denham Maritime Facility	Channel and Harbour Basin
Mid West	Kalbarri Maritime Facility	Jetty
Mid West	Murchison River Channel (Kalbarri)	Channel
Mid West	Port Gregory Maritime Facility	Jetty
Mid West	Geraldton Batavia Coast Marina	Small Boat Harbour
Mid West	Port Denison Boat Harbour	Small Boat Harbour
Mid West	Leeman Maritime Facility	Jetty
Mid West	Green Head Maritime Facility	Jetty
Wheatbelt	Jurien Bay Boat Harbour	Small Boat Harbour
Wheatbelt	Cervantes Maritime Facility	Jetty
Wheatbelt	Lancelin Maritime Facility	Jetty
Metropolitan	Two Rocks Marina	Small Boat Harbour
Metropolitan	Ocean Reef Boat Harbour	Small Boat Harbour
Metropolitan	Hillarys Boat Harbour	Small Boat Harbour
Metropolitan	Barrack Street Jetties	Jetty
Metropolitan	Fremantle Fishing Boat Harbour	Small Boat Harbour
Peel	Mandurah Entrance Channel	Channel
Peel	Sticks Channel	Channel
Peel	Murray and Serpentine River Channels	Channel
Peel	Yunderup Approach Channel	Channel
Peel	Point Grey Channel	Channel
Peel	Dawesville Entrance Channel	Channel
South West	Collie River	Channel
South West	Bunbury Casuarina Boat Harbour	Small Boat Harbour
South West	Port Geographe Channel	Small Boat Harbour
South West	Hardy Inlet Channel	Channel
South West	Augusta Maritime Facility	Jetty
South West	Augusta Boat Harbour	Small Boat Harbour
Great Southern	Albany Waterfront Marina	Small Boat Harbour
Great Southern	Emu Point Boat Harbour (Albany)	Small Boat Harbour
Great Southern	Bremer Bay Boat Harbour	Small Boat Harbour
Goldfields/Esperance	Hopetoun Maritime Facility	Jetty
Goldfields/Esperance	Bandy Creek Boat Harbour (Esperance)	Small Boat Harbour

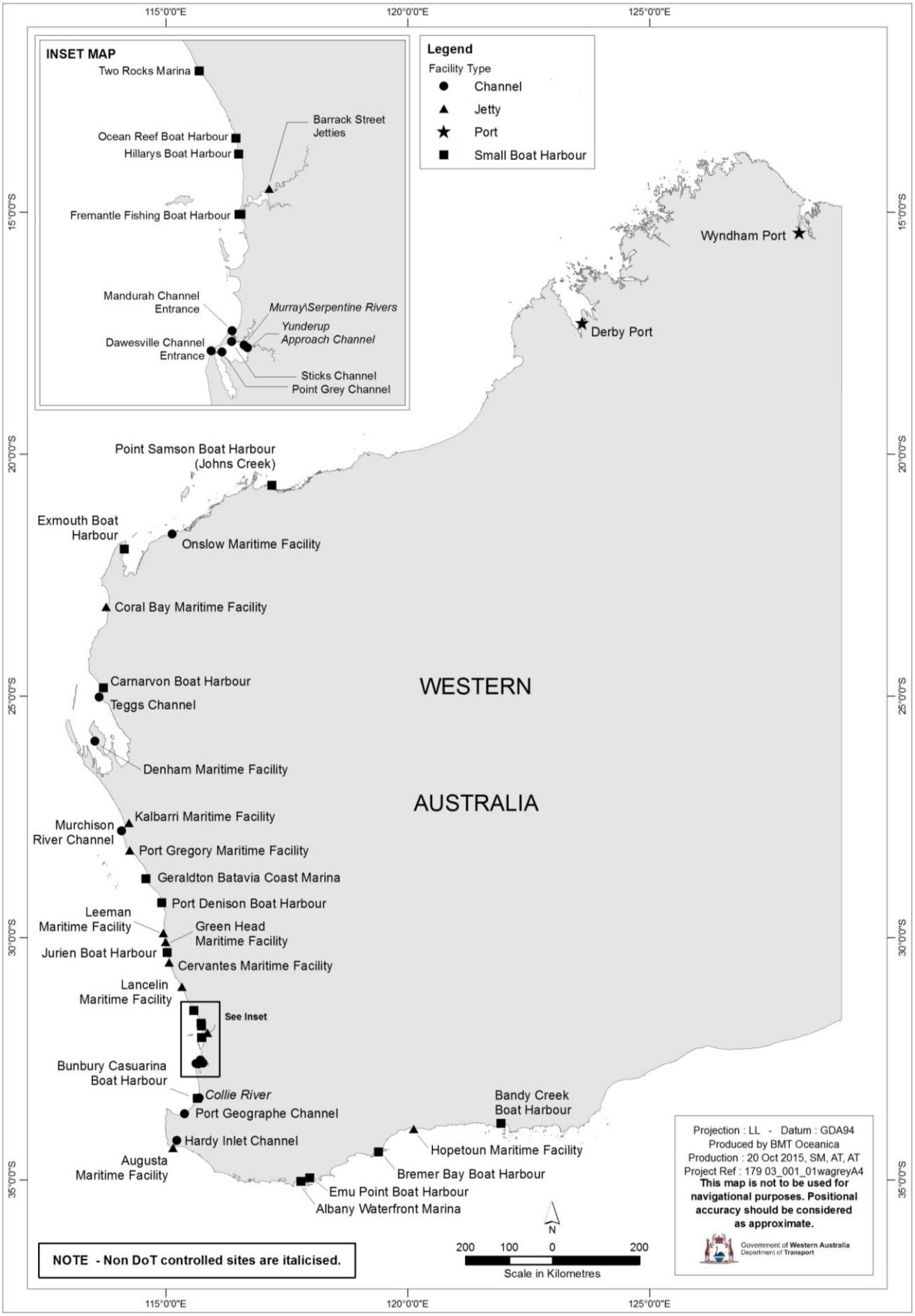


Figure 1.1 Maintenance dredging sites in Western Australia managed by the Department of Transport

1.2 Purpose

The DoT, as the proponent of maintenance dredging activities at these sites, has ultimate responsibility to ensure the environment is protected under Part IV of the EP Act. The purpose of this Environmental Management Framework (EMF) is to guide the DoT in the effective and efficient environmental management of their maintenance dredging operations. The EMF outlines the following:

- the DoT's management of its maintenance dredging responsibilities
- the DoT's maintenance dredging program and an outline of the typical works completed at the various sites
- regulatory context for maintenance dredging at each facility
- environmental approvals pathway
- environmental and socio-economic issues typically arising from maintenance dredging activities
- typical environmental management and contingency measures
- typical environmental monitoring.

This EMF is intended to ensure that the DoT's maintenance dredging activities are completed with due environmental care and transparency. The guidance is based upon the principles of:

- protection of the environment
- clear, relevant and practical identification of environmental issues
- efficient management and completion of environmental assessments as required.

The maintenance dredging program continues to be audited annually to track compliance (Section 7). Following the completion of each audit, the EMF shall be reviewed and updated to ensure that it incorporates: amended or new environmental policies; new environmental guidelines; improved environmental understanding; and outcomes following the annual audit. This review schedule should ensure the evolution and application of best practice environmental management to the DoT's maintenance dredging program.

2. Maintenance Dredging Program

The DoT manages maintenance dredging via the following steps to ensure projects are progressed openly, effectively and with close regard to the social, environmental and safety issues:

1. determine maintenance dredging requirements
2. assess the environmental impacts and associated approvals pathways
3. confirm the dredging scope with the dredging contractor
4. complete stakeholder consultation
5. supervise the maintenance dredging operation and coordinate environmental monitoring
6. complete close-out reporting and capture lessons learnt.

2.1 Determine maintenance dredging requirements

The DoT coordinates hydrographic surveys to support the maintenance dredging program. The frequency of hydrographic surveys at each site is determined from a consideration of the rate of sedimentation, the navigational risks, and feedback from users of the facility. Annual hydrographic surveys are typically done at 17 sites, and at another 14 sites hydrographic surveys are generally at a frequency of 2–5 years (Table 2.1). At a further five sites, hydrographic surveys are infrequent (>5 years; Table 2.1).

The hydrographic survey data provides information on the form and stability of any previous disposal sites, the presence of significant accretion or erosion, and assists in prioritising areas for maintenance dredging. The hydrographic survey data is assessed, together with any input from users/operators, to determine the need for further action. This survey assessment is documented in a survey review document which recommends further actions that could include maintenance dredging or alternative methods to delay the maintenance dredging requirement (e.g. relocation of navigation aids).

If maintenance dredging is required, then the most recent hydrographic survey shall be used to define the areas and volumes to be dredged. Several alternative disposal options should also be identified at this point. This planning work should also be informed by a review of the close-out reports from previous maintenance dredging campaigns at the site. This information is used for the preparation of scoping documentation for the dredging contractor and for the preparation of a Dredging Environmental Impact Assessment (DEIA; Section 2.2). The typical frequency of maintenance dredging at the DoT dredging sites is given in Table 2.1.

Table 2.1 Maintenance dredging frequency

Site	Typical frequency
Wyndham Port	Annual
Derby Port	Infrequent
Point Samson Boat Harbour (John's Creek)	Infrequent
Onslow Maritime Facility	5–10 years
Exmouth Boat Harbour	5 years (channel) 2–3 years (sand trap)
Coral Bay Maritime Facility	No previous maintenance dredging
Carnarvon Boat Harbour	10 years
Teggs Channel	5–10 years
Denham Maritime Facility	7–10 years
Kalbarri Maritime Facility	Infrequent
Murchison River Channel (Kalbarri)	Annual
Port Gregory Maritime Facility	Infrequent
Geraldton Batavia Coast Marina	No previous maintenance dredging
Port Denison Boat Harbour	Infrequent
Leeman Maritime Facility	Infrequent
Green Head Maritime Facility	Infrequent
Jurien Boat Harbour	5–10 years
Cervantes Maritime Facility	Infrequent
Lancelin Maritime Facility	3–5 years
Two Rocks Marina	Infrequent
Ocean Reef Boat Harbour	Annual
Hillarys Boat Harbour	No previous maintenance dredging
Barrack Street Jetties	Infrequent
Fremantle Fishing Boat Harbour	Infrequent
Mandurah Entrance Channel	Annual
Sticks Channel	No previous maintenance dredging
Murray and Serpentine River Channels	5–10 years
Dawesville Entrance Channel	Annual
Point Grey Channel	5–10 years
Collie River	Infrequent
Bunbury Casuarina Boat Harbour	No previous maintenance dredging
Port Geographe Channel	2 years
Augusta Maritime Facility	Infrequent
Hardy Inlet Channel	5–10 years
Albany Waterfront Marina	Infrequent
Emu Point Boat Harbour	Infrequent
Bremer Bay Boat Harbour	Annual
Hopetoun Maritime Facility	Infrequent
Bandy Creek Boat Harbour (Esperance)	2 years

2.2 Environmental impact assessment

A DEIA should be prepared prior to commencement of the maintenance dredging works. The DEIA should outline the proposed dredging and disposal campaign; present the results of any environmental sampling; consider the potential environmental and socio-economic impacts of the proposed campaign; provide information on any stakeholder consultation that has been

completed; and recommend environmental monitoring and management measures to minimise any potential impacts of the campaign.

Preparation of the DEIA requires an understanding of the various impact pathways and a consideration of the magnitude of these potential impacts versus natural variations experienced at the proposed dredging and disposal sites. The DEIA may be referred for formal environmental approval depending on the scale of the environmental and socio-economic impacts and the proposed location of the dredging and disposal works (see Section 2.3, Section 3.1, and Section 5).

The DEIA is considered current for a period of five years after the environmental sampling is completed, but shall be briefly reviewed prior to each campaign (within the 5-year period) to ensure its suitability. However, the DEIA may require revision (within the 5-year period) if there has been any contamination events or major changes to the dredging or disposal method that could have an adverse impact on the environment.

2.3 Approvals pathway

Most of the DoT maintenance dredging projects are not formally referred to the Environmental Protection Authority (EPA) as the dredging is of small-scale and occurs in already disturbed areas where no significant environmental impact is anticipated. Furthermore, there is generally strong community support for the dredging works. However, if significant adverse environmental impacts are anticipated, or there is a high level of stakeholder concern, then it is appropriate to refer the proposed works to the EPA under Part IV of the EP Act. There are a number of additional approvals that may be required (Figure 2.1, Section 3):

- if the proposed works are likely to impact on a matter of national significance, the proposal needs to be referred to the Australian Department of Environment (DoE) under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act; with consideration of the bilateral assessment agreement)
- if the proposed disposal site falls within State or Commonwealth waters (and not in Internal Waters), a Sea Dumping Permit from the DoE is required. The Sea Dumping Permit application process must commence prior to any sediment sampling and alternative disposal options must be investigated and documented
- if the dredging or disposal site is in proximity to or within a Marine Park, the WA Department of Parks and Wildlife (DPaW) must be notified and a Lawful Authority may be required. This will involve consultation with the Marine Parks and Reserves Authority (MPRA)
- if the dredging or disposal site falls within a Waterway Management Area managed by the WA Department of Water (DoW), then a Licence to Dredge is required (Figure 2.1)
- if the dredging or disposal activities disturb or have the potential to create a contaminated site then liaison with the WA Department of Environment Regulation (DER) is required
- if the dredging or disposal activities will disturb or remove native vegetation then a vegetation clearing permit from the DER is likely to be required.

In the case of emergency dredging works, safety issues may take precedence over environmental issues and the DoT Marine Safety Unit should be consulted.

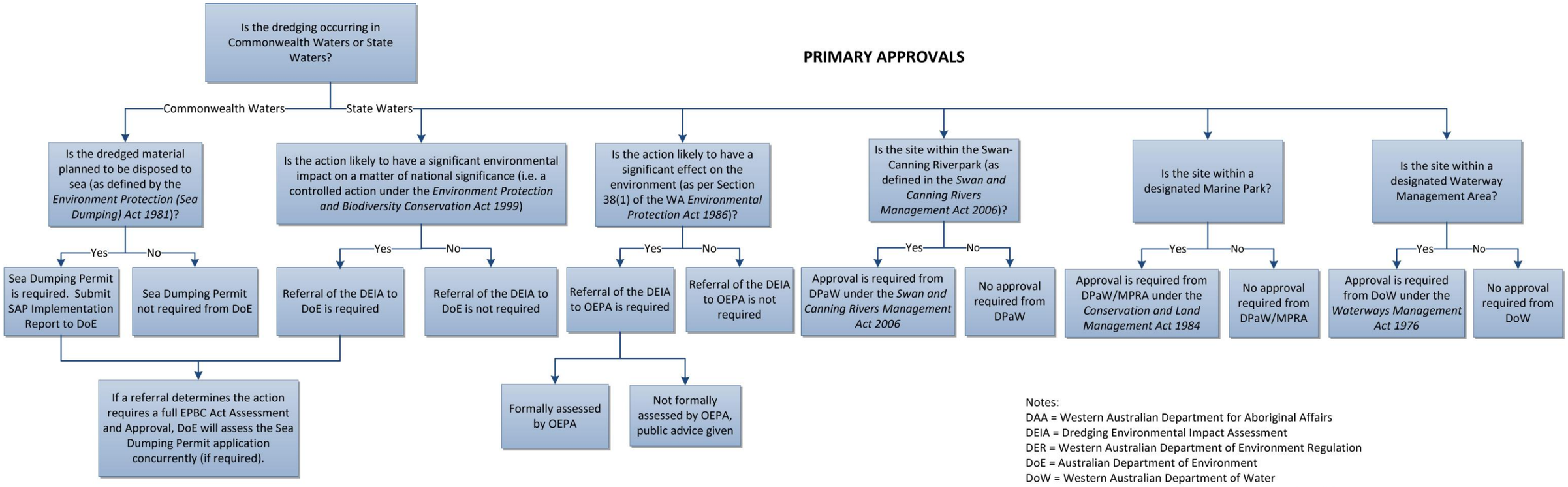


Figure 2.1 Primary and secondary environmental approvals pathways

2.4 Confirm dredging scope and management

The DoT has a long-term contract with a dredging contractor for the supply of dredging and related works for the DoT's coastal facilities. This contract includes a General Specification for Dredging which covers general requirements that are applicable to all sites which ensure the works are carried out with minimal environmental impacts.

To manage the specific environmental aspects of each dredging campaign the Principal (DoT) shall prepare a Dredging Environmental Management Plan (DEMP), in consultation with the contractor. The DEMP should succinctly define the environmental monitoring program, management measures and management actions. The DEMP shall undergo a brief review (where appropriate) prior to each campaign to ensure its suitability. A full revision of the DEMP may be required if there are any major changes to the dredging or disposal method that have been deemed by the DEIA to have a potential impact on the environment. The contractor shall then prepare a Project Execution Plan (PEP) that describes the scope of dredging works, and shows how the environmental requirements of the DEMP shall be addressed.

2.5 Stakeholder consultation

Prior to each dredging campaign, where appropriate, the relevant DoT Regional Coordinator and the DoT Regional Manager, and/or the Harbour Manager (if applicable) shall be notified of the works. The DoT shall also notify the local DPaW, the local DER, and the relevant local government authority of the works.

Depending on the location, duration and scope of work, other consultation may be completed as follows:

- consultation with community and stakeholder groups such as surf clubs, sea rescue groups, resident associations, commercial and recreational fishing associations
- consultation with Aboriginal Heritage groups
- placement of public information signage.

All stakeholder consultation (verbal or written) shall be documented and uploaded to Pearl. If the dredging works are planned in a navigation area, a Notice to Mariners (NtM) shall be issued through the DoT Marine Safety Unit. A NtM is only required when works are being completed in a navigational area (e.g. NtM not required for Mandurah and Dawesville Entrance Channels, Ocean Reef bypassing).

2.6 Supervision of maintenance dredging operation

When the environmental impact assessments are complete, relevant government authorities have been notified, and a DEMP and a PEP have been prepared, the dredging operation may commence. The DoT are responsible for the overall supervision of the dredging operation, including management and environmental monitoring. Weekly progress reports that include updates on dredging operations, site inspections and environmental monitoring results, are prepared by the engineering consultant for submission to the Principal. On completion of the dredging operation, the dredge is demobilised from site and a close-out report is prepared. The close-out report provides a summary of the maintenance dredging operation and environmental monitoring including any operational and/or environmental issues that arose. It shall also capture lessons learnt and recommendations for future dredging campaigns at the site. The close-out report provides an important reference for planning any future maintenance dredging works and should be completed within three months of completion of dredging.

2.7 Maintenance dredging method

Many of the DoT's maintenance dredging projects are executed using a small cutter-suction dredge (CSD; Figure 2.2). The dredge uses a small rotating cutter-head on the end of a 'ladder' to loosen material off the seabed which is immediately recovered by a suction tube directly behind the cutter head. The material is then pumped to the disposal site via flexible floating or submerged pipelines. During dredging, the CSD is kept in position using anchors and/or spud poles. The main, or 'working' spud is used as a reaction point against which the dredge is moved forward and pushes the cutter head into the dredge cut. The cutter head of the dredge moves from one side of the cut to the other by winching on the anchors deployed either side of the dredge, causing the dredge to rotate around the main spud pole. A land-based excavator and slurry-pumping system is used at the Mandurah and Dawesville Entrance Channels to bypass large volumes of sediment annually (Figure 2.3). At other sites, land-based machinery is used and typically consists of a long-reach excavator, often working from a temporary bund or barge, with front end loaders and trucks on shore (Figure 2.4). Isolated high-spots may be removed using a trawl bar or plough and wrack[1] material has also been removed from the seabed and water column at some sites using a trawl net (Figure 2.5).

Source: BMT JFA Consultants Pty Ltd (May 2013)

Figure 2.2 Cutter-suction dredge at Bandy Creek Boat Harbour

[1] *Seaweed or marine vegetation that is cast ashore.*

Source: BMT JFA Consultants Pty Ltd (July 2013)

Figure 2.3 Slurry pumping system (Slurrytrak) at Mandurah Entrance Channel

Source: BMT JFA Consultants Pty Ltd (January 2013)

Figure 2.4 Long-reach excavator at Ocean Reef Boat Harbour

Source: BMT JFA Consultants Pty Ltd (November 2013)

Figure 2.5 Trawling to remove wrack in Jurien Bay Boat Harbour

3. Environmental Legislation

It is preferred that potential environmental impacts are managed through the careful design and implementation of the dredging works to meet recognised environmental criteria. In this way, formal environmental assessment is often not required. In keeping with the EPA's 'General Guide for State Government Departments and Local Authorities (as Decision-Making Authorities)', the DoT shall liaise with the appropriate local authorities regarding the impacts of their proposal (see Section 2.3). Formal approvals may be required if (Figure 2.1):

- significant environmental impacts are anticipated (*Environmental Protection Act 1986*)
- dredging is located within a Waterway Management Area (*Waterways Conservation Act 1976*)
- dredging is likely to impact on a Marine Park (*Conservation and Land Management Act 1984*)
- dredging is likely to disturb or create a contaminated site (*Contaminated Sites Act 2003*)
- dredging results in disturbance of Aboriginal heritage (*Aboriginal Heritage Act 1972*)
- dredged material is disposed to sea (*Environment Protection (Sea Dumping) Act 1981*)
- dredging will impact on a matter of national environmental significance (*Environment Protection and Biodiversity Conservation Act 1999*).

A number of the DoT maintenance dredging sites have previously received approval under the EP Act for facility construction and/or maintenance works. In these instances, further approval may not be required if the works were considered within the original approval. The relevant legislation and approval processes for each of the above Acts are summarised below.

3.1 Environmental Protection Act 1986

The *Environmental Protection Act 1986* (EP Act) is the key legislation governing the requirement for environmental protection and management in WA including the assessment of the impacts of any proposed new works. The EP Act (mainly Part IV) together with its subsidiary Environmental Impact Assessment Administrative Procedures 2012 (EPA 2012), specifies the objectives and requisite procedures for environmental impact assessment of proposed works that must be complied with by all stakeholders including the proponent, the EPA and any other relevant party.

The approach taken by the EPA during the Environmental Impact Assessment process has been documented by the EPA in a number of Environmental Assessment Guidelines (EAGs; formerly known as Guidance Statements). The EAGs of particular relevance to the DoT's maintenance dredging program include:

- Protection of Benthic Primary Producer Habitat in WA's Marine Environment (EAG3; EPA 2009)
- Marine Dredging Proposals (EAG7; EPA 2011)
- Environmental Factors and Objectives (EAG8; EPA 2013a)
- Application of a Significance Framework in the EIA Process (EAG9; EPA 2013b)
- Protecting the Quality of Western Australia's Marine Environment (EAG15; EPA 2015a)
- Preparation of Management Plans under Part IV of the *Environmental Protection Act 1986* (EAG17; EPA 2015b).

The view of the EPA on various environmental or procedural matters are presented in a series of Environmental Protection Bulletins (EPBs; formerly known as Position Statements) that are applicable to the DoT's maintenance dredging program, such as EPB No. 1 Environmental Offsets – Biodiversity, and also Position Statements (PSs) and PS2 Environmental Protection of Native Vegetation in WA.

The Office of the EPA (OEPA) has prepared a number of Post Assessment Guidelines (PAGs) to assist proponents to meet their statutory requirements under Part IV of the EP Act. The following PAGs are relevant to the DoT's maintenance dredging program:

- Preparing an Audit Table (PAG1)
- Preparing a Compliance Audit Plan (PAG2)
- Preparing a Compliance Assessment Report (PAG3).

All of the EAGs, PAGs, EPBs, and PSs are available on the EPA website (www.epa.wa.gov.au).

3.1.1 Environmental referral

Under Section 38(1) of the EP Act (Part IV), where a proposed project development is likely to have a significant impact on the environment, the proponent must refer the proposal to the EPA for a decision on whether it requires formal environmental impact assessment, and if so, at what level of assessment. The DoT shall refer maintenance dredging projects to the EPA if they are anticipated to have a significant effect on the environment and no environmental approvals have previously been obtained. It may also be appropriate to refer a project if there is a high level of community/stakeholder concern. When referring a project it is necessary to submit a referral pro-forma (obtained from www.epa.wa.gov.au). The referral form outlines the project details and likely environmental impacts, management and consultation commitments. Typically the referral form is appended and references a detailed DEIA.

3.1.2 Level of assessment

The referral is advertised by the EPA and subject to a 7-day public comment period. The EPA then determines a level of assessment based on a review of the referral and any public comments received. Historically, the EPA has typically decided not to formally assess the DoT's maintenance dredging projects and determined the projects to be 'Not Assessed—Public Advice Given'. There are three levels of formal assessment that the EPA can set:

- Assessment on Proponent Information Level A – for projects in which impacts can be readily managed
- Assessment on Proponent Information Level B – for projects in which the impacts are considered to be unacceptable
- Public Environmental Review – typically for large-scale complex projects with potential to impact a number of environmental factors and/or with high level of public concern.

The EPA is required to give written notice within 28 calendar days of its assessment level decision. However, if the EPA determines that the referral does not contain adequate information upon which to base a decision, it may request that this information is provided, and the EPA's assessment level decision will not begin until all information is received. It is therefore very important to ensure that sufficient detail is included in the referral to facilitate the EPA's determination of the level of assessment and avoid delays.

3.2 Waterways Conservation Act 1976

Dredging projects that occur within DoW's jurisdiction (Waterway Management Areas) require a Licence to Dredge under the *Waterways Conservation Act 1976.* The DoT maintenance dredging sites within, or in close proximity to, Waterway Management Areas include (Figure 3.1):

- Mandurah Entrance Channel
- Sticks Channel
- Dawesville Entrance Channel
- Point Grey Channel
- Emu Point Boat Harbour (Albany).

Dredging at these sites shall require the preparation of an 'Application for a Licence to Carry Out Dredging and/or Reclamation' which is submitted to the DoW and is typically supported with a DEIA. For dredging sites within or in proximity to Catchment Management Areas (e.g. Port Geographe Channel, Figure 3.1) consultation with DoW and the relevant Catchment Management Authority should be completed.

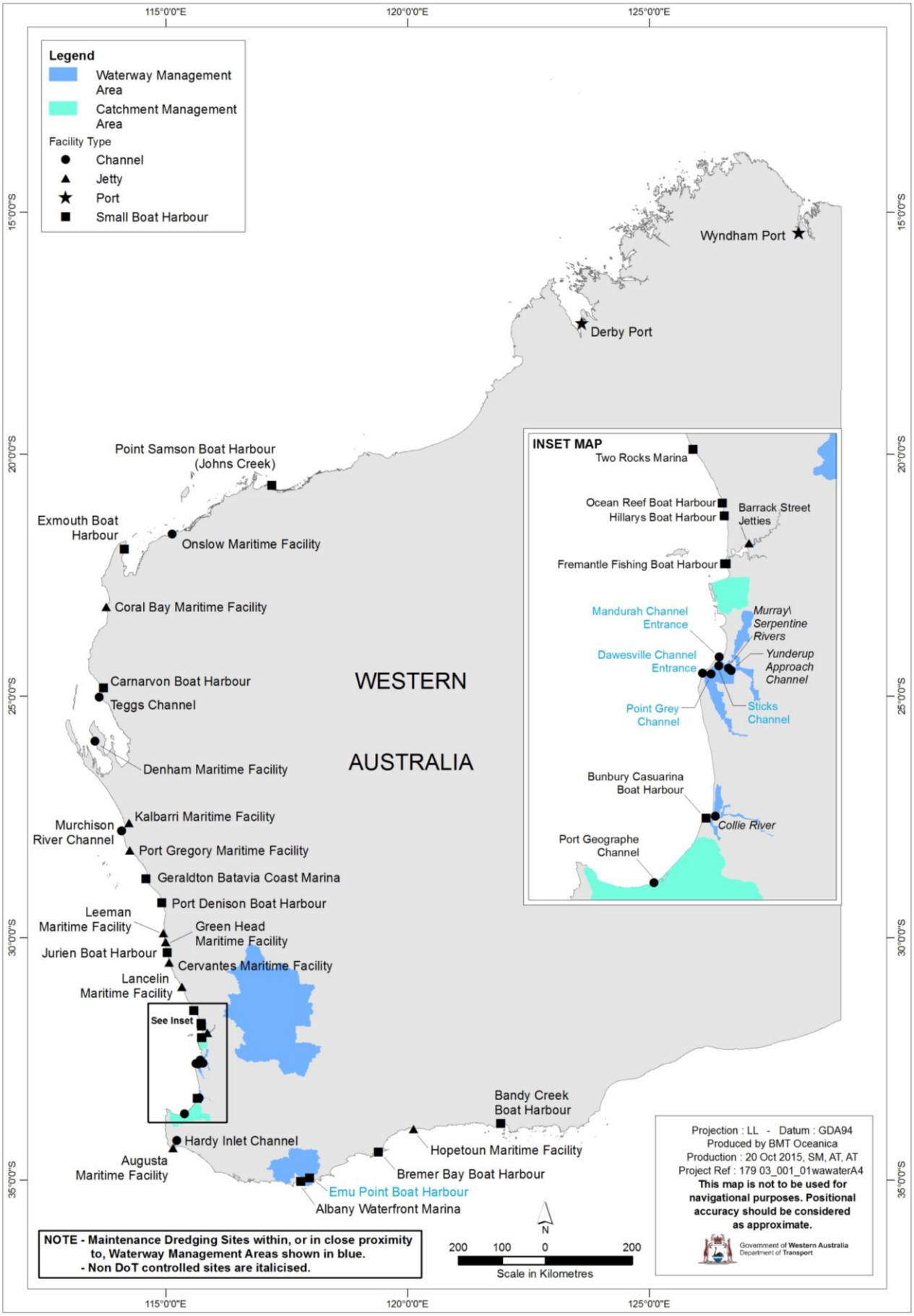


Figure 3.1 Maintenance dredging sites and defined Waterway Management Areas and Catchment Management Areas

3.3 Conservation and Land Management Act 1984

Projects that are likely to impact on a Marine Park should be submitted to the DPaW and the MPRA under the *Conservation and Land Management Act 1984*. Ten of the DoT maintenance dredging sites are within, or in close proximity to a Marine Park (Table 3.1, Figure 3.2). Maintenance dredging works at these sites may require referral if there is a possibility for the works to affect a Marine Park.

Table 3.1 Maintenance dredging sites within or adjacent to Marine Parks

Site	Marine Park
Exmouth Boat Harbour	Approximately 12 km south of the Ningaloo Marine Park
Coral Bay Maritime Facility	Within the Ningaloo Marine Park
Teggs Channel (Carnarvon)	Approximately 3 km north of the Shark Bay Marine Park
Denham Maritime Facility	Within an exclusion zone of the Shark Bay Marine Park
Green Head Maritime Facility	Approximately 1 km north of the Jurien Bay Marine Park
Jurien Bay Boat Harbour	Within an exclusion zone of the Jurien Bay Marine Park
Cervantes Maritime Facility	Within the Jurien Bay Marine Park
Ocean Reef Boat Harbour	Within an exclusion zone of the Marmion Marine Park
Hillarys Boat Harbour	Within an exclusion zone of the Marmion Marine Park
Port Geographe Channel	Within an exclusion zone of the Ngari Capes Marine Park

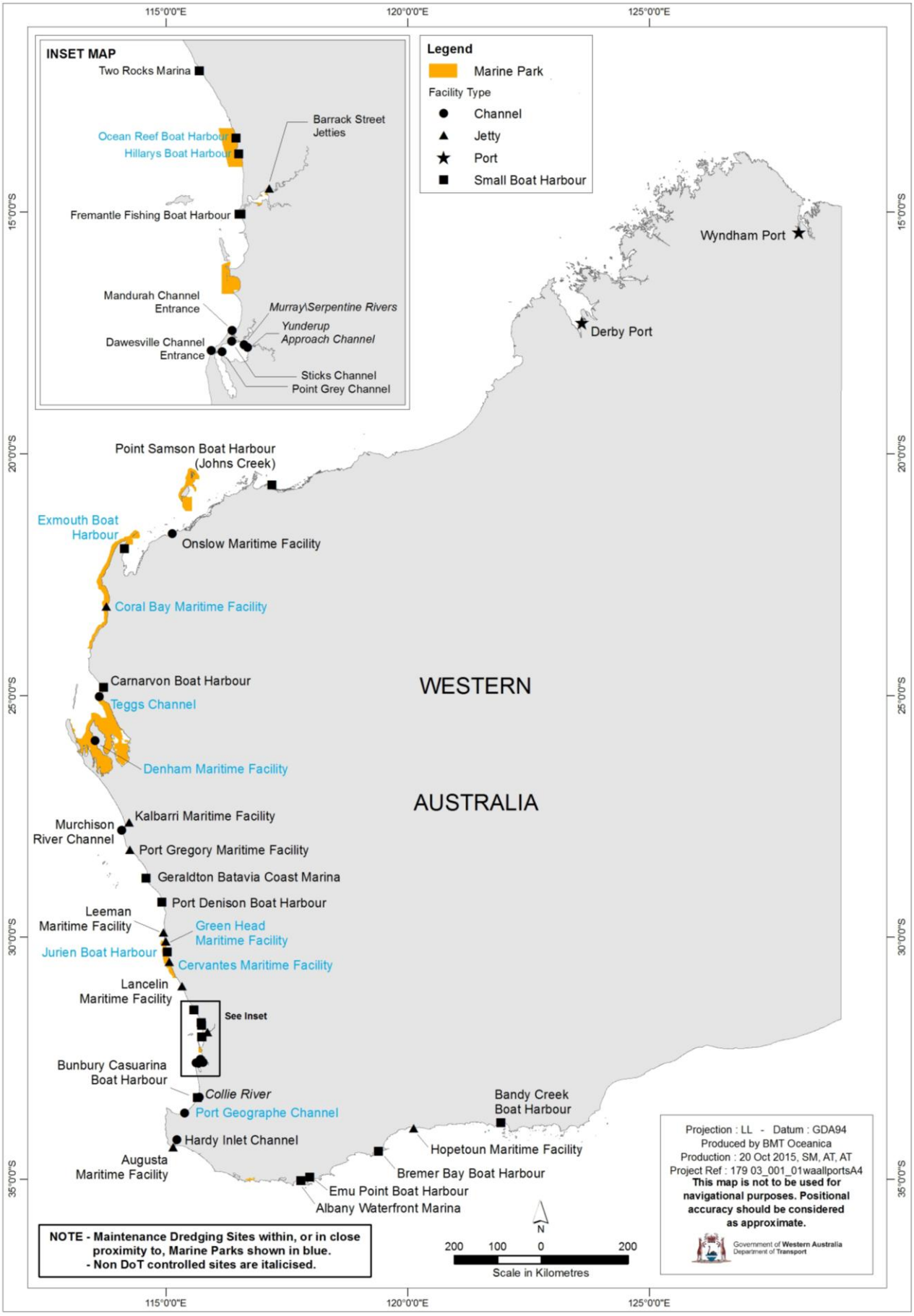


Figure 3.2 Maintenance dredging sites with potential to affect Marine Parks

3.4 Contaminated Sites Act 2003

The disposal of dredged material to land has the potential to create a contaminated site. The identification, management and remediation of contaminated sites are covered by the WA *Contaminated Sites Act 2003* (CS Act). The Contaminated Sites Guidelines document 'Assessment and management of contaminated Sites' (DER 2014) provides guidance on the assessment and management of contaminated sites under the CS Act (Section 4.2).

Land disposal of dredged material is not dealt with specifically in the guidelines, but falls under the CS Act in that land is created, and potential human and environmental impacts must be subject to a risk assessment. This involves the comparison of sediment contaminant concentrations against the levels in the National Environment Protection (Assessment of Site Contamination) Measures guidelines (NEPC 2013) as referenced in the Contaminated Sites Guidelines (Section 4.2, DER 2014).

3.5 Aboriginal Heritage Act 1972

Dredging activities has the potential to disturb sites of Aboriginal Heritage significance. The Department for Aboriginal Affairs (DAA) maintain a register of over 22 000 Aboriginal Heritage sites (which can include artefacts, engravings, paintings, mythological or ceremonial places) in WA which have been defined under the *Aboriginal Heritage Act 1972* (AH Act). If evidence of Aboriginal Heritage is located during the assessment or implementation of a project, it must be reported to the Registrar of Aboriginal Sites under the AH Act. Furthermore, where a project might impact upon an Aboriginal site, an Aboriginal Heritage survey should be commissioned, addressing anthropological and archaeological matters in the proximal area. If disturbance to an Aboriginal Heritage site is unavoidable an application for consent to the disturbance must be submitted via a notice under Section 18 of the AH Act.

To assess whether an Aboriginal site is likely to be impacted during a maintenance dredging project the following information is reviewed:

- the Aboriginal Heritage Inquiry System (DAA 2013) to determine if there are there any registered Aboriginal sites within the vicinity of the works. The DAA may also be queried to confirm that there are no known Aboriginal Heritage sites in the dredging and disposal areas
- the nature and previous usage of the dredging site. Maintenance dredging is considered less likely to impact an Aboriginal Heritage site than capital dredging as the site has already been disturbed
- the dredging design and dredging method is considered. There is a greater risk of disturbing an Aboriginal site if the dredging methods involve land-based excavation works in previously undisturbed area.

A heritage survey shall be done if assessment of the above information suggests that the level of risk is not low.

3.6 Environment Protection (Sea Dumping) Act 1981

The disposal of dredged material to sea[2] requires a Sea Dumping Permit from the Australian Department of the Environment (DoE) (Figure 2.1). Applications for a Sea Dumping Permit for ocean disposal of dredged material are assessed under the *Environment Protection (Sea Dumping) Act 1981*. Through this Act, the Australian Government assesses proposals to load and dump wastes and other materials at sea, permits acceptable activities and sets conditions of approval to mitigate and manage environmental impacts.

To apply for a Sea Dumping Permit it is necessary to characterise the sediment prior to disposal. To ensure that the sediment sampling is appropriate, it is required to prepare and submit a Sediment Sampling and Analysis Plan (SAP) to the DoE for their approval prior to sampling (Figure 3.3). The National Assessment Guidelines for Dredging (NAGD; CA 2009) provide specific guidance for the preparation of SAPs. The DoE shall review the SAP and either approve or request amendments within ~20 working days. Following approval of the SAP, sediment sampling is completed and the results shall be submitted to the DoE in a SAP Implementation Report (Figure 3.3). Once the SAP Implementation Report has been endorsed by the DoE, a sea dumping permit application may be submitted to the DoE and should include the:

- approved SAP
- endorsed SAP Implementation Report
- DEIA
- completed Sea Dumping Permit application form.

An application fee is required to be paid within 30 days after the submission of the permit application and the DoE shall review the application within 90 days of receipt of the application fee. However, if additional information is required the 90 days starts from the day the additional information is received by the DoE. It is therefore very important to ensure that sufficient information is provided initially to enable comprehensive scoping of the potential environmental issues and other appropriate information (outlined in the NAGD; CA 2009) to avoid delays.

[2] *The Environment Protection (Sea Dumping) Act 1981 applies in all Australian waters except for: a) when disposal is in Internal Waters; or b) when the dredge pipeline is laid on land before discharging to Australian waters.*

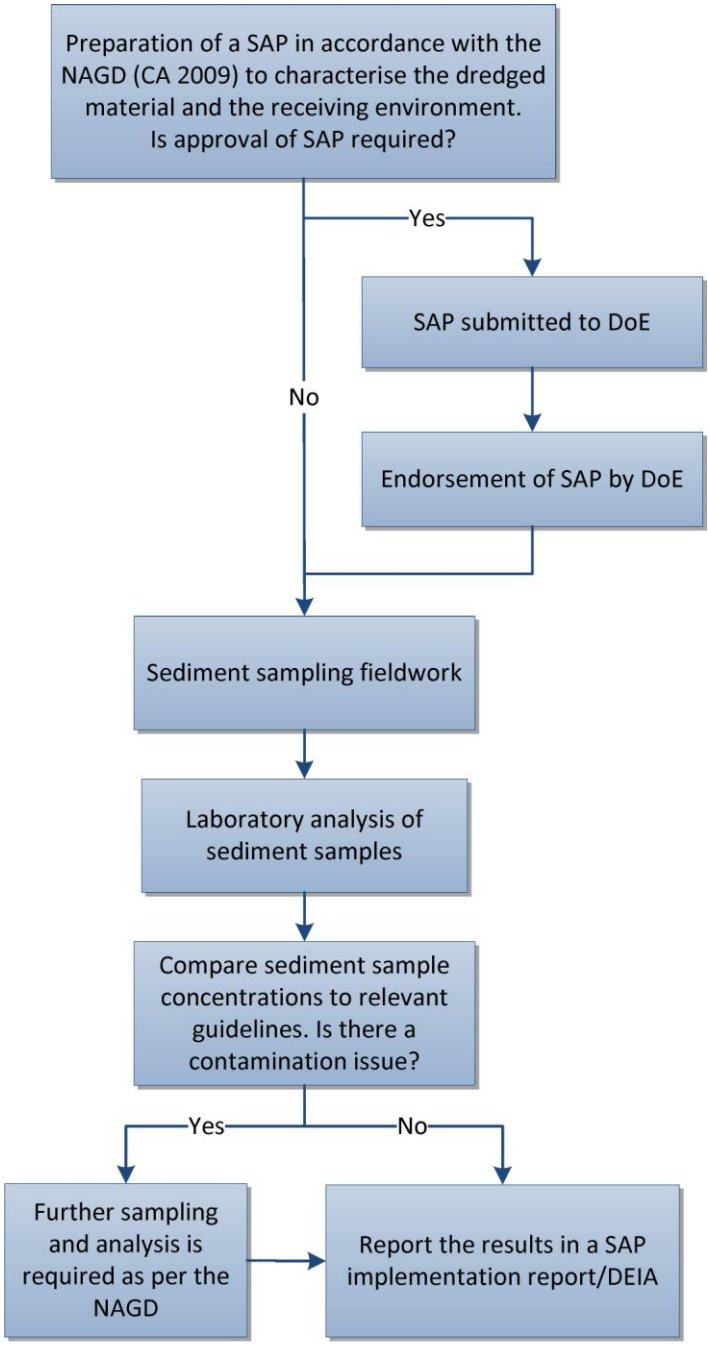


Figure 3.3 Environmental assessment for ocean disposal

3.7 Environment Protection and Biodiversity Conservation Act 1999

If a maintenance dredging project is likely to have a significant impact on matters of national environmental significance it will also require assessment under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Figure 2.1). Environmental matters of national significance are defined by the EPBC Act as:

- listed threatened species and ecological communities
- migratory species protected under international agreements
- Ramsar wetlands of international importance
- the Commonwealth marine environment
- the Great Barrier Reef Marine Park
- World Heritage properties
- National Heritage places
- nuclear actions.

Where there is the potential (or uncertainty) that a proposal may significantly impact upon any of these matters, a referral to DoE (or to the WA EPA under the assessment bilateral agreement) is required for a determination whether the proposal constitutes a 'controlled action' necessitating assessment and approval under the EPBC Act. DoE shall decide if the proposal requires formal assessment within ~20 business days of receipt.

4. Environmental Guidelines

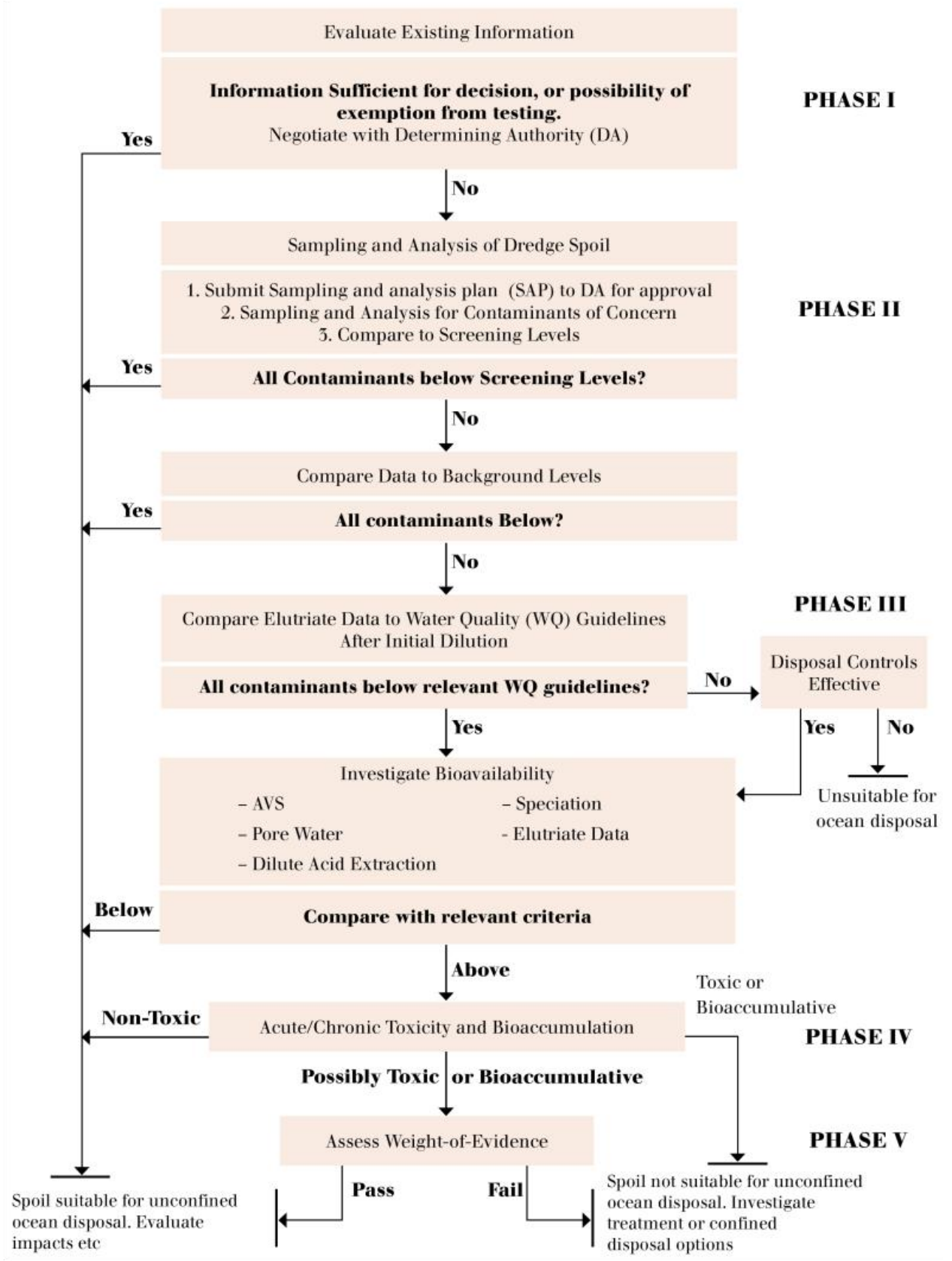
A number of environmental guidelines apply to the management and assessment of maintenance dredging works. Different guidelines may apply depending on the proposed dredging and disposal methods. The NAGD (CA 2009) were prepared to cover ocean disposal of sediments, but provide a useful reference for the assessment of all dredging projects (regardless of whether the works involve land disposal or ocean disposal). Where dredging is proposed in an estuarine environment the Acid Sulfate Soils Guidelines (DER 2015) should be considered. Where disposal to land (above the low water mark) is considered then the Contaminated Sites Guidelines (DER 2014) are applicable. If dredged material is planned to be disposed to landfill or if there is the potential for leachate to reach groundwater or surface water, the Landfill Waste Classification Guidelines need to be considered (DEC 2009). When sediment pore water is potentially contaminated or where dredge return water may be discharged back to the marine environment, the ANZECC & ARMCANZ (2000) Water Quality Guidelines should be considered. Details on these relevant guidelines are outlined below.

4.1 National Assessment Guidelines for Dredging

The NAGD (CA 2009) provide a framework for the review and assessment of ocean disposal of dredged material in support of the federal EPBC Act and is also applicable to the EP (Sea Dumping) Act. The guidelines include information on:

- evaluating alternatives to ocean disposal
- assessing sediment quality
- assessing dredging and disposal sites
- assessing potential impacts on the marine environment and other users
- determining management and monitoring requirements.

These guidelines were specifically prepared to inform assessment of dredging projects and sea dumping under the EPBC Act, however they do provide a useful reference even if ocean disposal of the dredged material is not intended. The various phases for assessment of dredged material for ocean disposal are outlined in Figure 4.1. The initial sediment screening phases (Phase I–II; Figure 4.1) are described in detail in Section 4.1.1, and further analyses (Phases III–V; Figure 4.1) are described in Section 4.1.2.



Source: CA (2009).

Figure 4.1 Assessment pathway for ocean disposal

4.1.1 Initial sediment screening (Phases I–II)

The NAGD state that where there are no alternatives to ocean disposal, assessment of sediment quality is required and includes reviewing existing sediment quality information for the site. If existing data were collected from the site within five years, and the contamination status is not likely to have changed, further testing may not be required.

Where sufficient data are not available, sampling and analysis of the material to be dredged is required. The NAGD sets out guidelines for the sampling and analysis of sediments. The 95% upper confidence limit (UCL) of the sediment contaminant concentrations are compared against set Screening Levels that are used for initial assessment of the sediment (Table 4.1). The Screening Levels are presently the same as the Interim Sediment Quality Guidelines – Low values (ISQG-Low) from ANZECC & ARMCANZ (2000) (Table 4.1).

In the event that the initial sediment screening identifies contaminants above the NAGD Screening Levels, the concentrations of these contaminants shall be compared against concentrations found in the ambient sediments at the proposed ocean disposal site.

Table 4.1 Screening Levels for sediment analytes from the National Assessment Guidelines for Dredging

Analytical parameter	Screening Level (ISQG-Low value)
Metals & metalloids[1] (mg/kg)	
Antimony	2
Arsenic	20
Cadmium	1.5
Chromium	80
Copper	65
Lead	50
Mercury	0.15
Nickel	21
Silver	1.0
Zinc	200
Organics[2] (µg/kg)	
Total PCBs	23
DDD	2
DDE	2.2
Total DDT	1.6
Dieldrin	280
Chlordane	0.5[3]
Lindane	0.32[3]
Endrin	10
Total polycyclic aromatic hydrocarbons (PAHs)	10 000
Total petroleum hydrocarbons (TPHs)	550 mg/kg
Tributyltin (as Sn)	9 µg Sn/kg
RADIONUCLIDES[4] (sum of gross alpha and gross beta)	35 Bq/g

Notes:

1. For other metals, compare to ambient baseline levels for sediments of comparable grain size in the vicinity of the disposal site (if available)
2. Normalised to 1% total organic carbon (TOC)
3. These Screening Levels are often below the typical laboratory limit of reporting (LoR). In these instances the results for these analytes should be reported as either 'detected' or 'not detected'
4. Maximum (Bq/g is becquerels per gram)
5. ISQG = Interim Sediment Quality Guideline, PCB = polychlorinated biphenyls, DDD = dichlorodiphenyldichloroethane, DDE = dichlorodiphenyldichloroethylene, DDT = dichlorodiphenyltrichloroethane

Source: CA (2009)

4.1.2 Further analysis (Phases III–V)

If the concentrations in the sediments to be dredged are greater than at the disposal site, the guidelines recommend further testing to assess the suitability of the dredged material for unconfined ocean disposal. The assessment framework for Phases III–V (Figure 4.1) is outlined below.

Phase III assessment – Elutriate and bioavailability testing

If the Screening Levels are exceeded then further analysis of the sediment should be completed via elutriate and bioavailability testing for the exceeding analytes.

Elutriate testing uses a dilution ratio of 1:4 (NAGD; CA 2009, p. 40). The elutriate results are compared against the ANZECC & ARMCANZ (2000) trigger values for Marine Water (Section 4.4). If the elutriate concentrations are below the relevant ANZECC & ARMCANZ (2000) trigger values after initial dilution (after 4 hours), then the material is considered suitable for ocean disposal (pending results of bioavailability testing). However, if the elutriate concentration is above the ANZECC & ARMCANZ (2000) trigger value, more detailed modelling of the expected dilution after ocean disposal (potentially using site specific hydrodynamic data from the disposal area) may be required. If modelling shows insufficient dilution after 4 hours (i.e. elutriate concentrations are still above the trigger values) the sediment is deemed unsuitable for ocean disposal unless effective controls can be put in place (Figure 4.1).

Bioavailability testing (e.g. dilute acid extraction of metals, pore water concentrations, elutriate data) assesses the potential for sediment contaminants to impact organisms (Figure 4.1). The bioavailable concentration (95% UCL) shall be compared to the relevant criteria and if below, the material is considered suitable for ocean disposal. If the criteria are exceeded, toxicity and/or biaccumulation testing may then be implemented (see below).

Phase IV assessment – Toxicity/bioaccumulation testing

If elutriate concentrations of contaminants are below the ANZECC & ARMCANZ (2000) trigger values, but the bioavailable fractions are above relevant criteria, toxicity and/or bioaccumulation testing is required. However, small dredging campaigns (less than 15 000 m^3) can be exempt from toxicity testing where bioavailable contaminants exceed the Screening Level, but are below the SQG-High Value (CA 2009, Table 4.1).

If a contaminant is found to be bioavailable, a desktop study of the bioaccumulation potential shall be done for those contaminants. If a contaminant is identified as bioavailable and has a potential to bioaccumulate, a bioaccumulation study may be completed. The bioaccumulation tests can be difficult to perform on some analytes, and it is permitted to skip these tests and do toxicity testing instead (CA 2009). The types of toxicity tests available vary between laboratories, and the types of tests needed vary between tropical and temperate ecosystems. The NAGD provides guidelines on how to choose the appropriate tests which should be done in consultation with the relevant local regulatory authority (e.g. DoE).

Phase V assessment

A Phase V 'weight-of-evidence' assessment shall only be necessary if testing from the previous Phases I–IV is inconclusive. This assessment would review all relevant data, including field results/ecology, chemistry (bioavailability and desorption), laboratory ecotoxicity and bioaccumulation, to assist determination of the suitability for ocean disposal (CA 2009).

4.2 Contaminated Sites Guidelines

The Contaminated Sites Guidelines (DER 2014) provide guidance on the assessment and management of contaminated sites under the CS Act (Section 3.4). While land disposal of

dredged material is not dealt with specifically in the guidelines, this still falls under the CS Act in that the land created may result in potential human and environmental impacts that must be subject to a risk assessment. This involves a preliminary disposal site investigation, and then the material to be dredged needs to be characterised and assessed to determine its compatibility with the receiving environment and associated land uses on a site-specific basis (DER 2014). The assessment involves the comparison of dredged sediment contaminant concentrations against investigation levels and screening levels from the National Environment Protection (Assessment of Site Contamination) Measure guidelines (NEPC 2013) as referenced in DER (2014). The investigation or screening level is the concentration of a contaminant above which further appropriate investigation and evaluation shall be required (DER 2014).

4.2.1 Ecological investigation levels and ecological screening levels

The ecological investigation levels (EILs) and ecological screening levels (ESLs) provide an initial screening assessment to determine whether there is a potential risk to the environment (Table 4.2, Table 4.3). There are EILs published in Schedule B5C of NEPC (2013) for arsenic, chromium III, copper, dichlorodiphenyltrichloroethane (DDT), lead, naphthalene, nickel and zinc. The maximum and the 95% UCL of the arithmetic mean are to be used for comparison against the EILs and ESLs.

If the EILs or ESLs are exceeded, a further, site-specific, risk-based investigation shall be required to determine whether contaminants levels are likely to pose an actual risk (DER 2014). These investigations may include comparison with background concentrations and/or consideration of environmental factors at the study site which may affect contaminant availability. Guidance on the nature of these investigations is provided in DER (2014).

Table 4.2 Contaminated Sites Guidelines ecological investigation levels for onshore disposal

	Ecological investigation levels (mg/kg)		
	Area of ecological significance[1]	**Urban residential/public open space**[2]	**Commercial/industrial**[3]
Metals/metalloids			
Arsenic	20	50	80
Chromium III	25–50	75–160	120–270
Copper	15–60	30–120	45-200
Lead	110	270	440
Nickel	1–25	10–170	20–350
Zinc	7–130	25–500	45–800
Polycyclic aromatic hydrocarbons			
Naphthalene	10	170	370
Organochlorine pesticides			
p,p'-DDT[4]	3	180	630

Notes:

1. Area of ecological significance = 99% standard protection level
2. Urban residential/public open space = 80% standard protection level
3. Commercial/industrial = 60% standard protection level
4. DDT = dichlorodiphenyltrichloroethane. Guideline is for total DDT which consists of p,p'-DDT and o,p'-DDT but o,p'-DDT is far less common than p,p'-DDT and generally found only when p,p' concentrations are high (NMI pers. comm. Jan 2015)

Source: NEPC (2013)

Table 4.3 Contaminated Sites Guidelines ecological screening levels for onshore disposal

	Ecological screening levels (mg/kg dry weight)		
	Area of ecological significance[1]	**Urban residential/public open space[2]**	**Commercial/industrial[3]**
Total recoverable hydrocarbons			
C_6-C_{10} less BTEX[4] coarse/fine	125	180	215
>C_{10}-C_{16} less naphthalene coarse/fine	25	120	170
>C_{16}-C_{34} coarse	–	300	1700
>C_{16}-C_{34} fine	–	1300	2500
>C_{34}-C_{40} coarse	–	2800	3300
>C_{34}-C_{40} fine	–	5600	6600
Monocyclic aromatic hydrocarbons			
Benzene (coarse)	10	50	75
Benzene (fine)	10	65	95
Toluene (coarse)	10	85	135
Toluene (fine)	65	105	135
Ethylbenzene (coarse)	1.5	7	165
Ethylbenzene (fine)	40	125	185
Xylene (coarse)	10	105	180
Xylene (fine)	1.6	45	95
Polycyclic aromatic hydrocarbons			
Benzo(a)pyrene	0.7	0.7	0.7

Notes:
1. Area of ecological significance = 99% standard protection level
2. Urban residential/public open space = 80% standard protection level
3. Commercial/industrial = 60% standard protection level
4. BTEX = Benzene, toluene, ethylbenzene, xylene

Source: NEPC (2013)

4.2.2 Health investigation levels

Contaminated soils disposed to land can pose a risk to human health through direct exposure (such as ingestion and inhalation) or indirect exposure (such as through groundwater contamination). The appropriate health investigation level (HIL) will depend on the future usage of the disposal site (Table 4.4):

- residential with garden/accessible soil (exposure level A)
- residential with minimal opportunities for soil access (exposure level B)
- public open space such as parks, playgrounds, and playing fields (exposure level C)
- commercial/industrial (exposure level D).

The arithmetic mean of the sample concentrations should be compared against the relevant HIL. The standard deviation of the sample concentrations should be less than 50% of the HIL and no single concentration should be greater than 250% of the HIL (NEPC 2013). Where the HIL is exceeded and the criteria above not met, further risk-based investigations shall be required to determine whether modified, site specific, assessment levels can be developed.

Table 4.4 Contaminated Sites Guidelines health investigation levels for onshore disposal

Analytical parameter	HIL "A"	HIL "B"	HIL "C"	HIL "D"
Metals & metalloids (mg/kg)				
Arsenic	100	500	300	3000
Beryllium	60	90	90	500
Boron	4500	40 000	20 000	300 000
Cadmium	20	150	90	900
Chromium VI	100	500	300	3600
Cobalt	100	600	300	4000
Copper	6000	30 000	17 000	240 000
Lead	300	1200	600	1500
Manganese	3800	14 000	19 000	60 000
Mercury (methyl)	10	30	13	180
Mercury (inorganic)	40	120	80	730
Nickel	400	1200	1200	6000
Selenium	200	1400	700	10 000
Organics (mg/kg)				
Total PAHs (16 PAHs)	300	400	300	4000
Carcinogenic PAHs	3	4	3	40
Total PCBs	1	1	1	7
Organochlorine and organophosphorus pesticides				
HCB	10	15	10	80
Heptachlor	6	10	10	50
Chlordane (trans- + cis- + oxy-)	50	90	70	530
Aldrin + dieldrin	6	10	10	45
DDT+DDD+DDE	240	600	400	3600
Endrin	10	20	20	100
Endosulfan (alpha- + beta- + -sulfate)	270	400	340	2000
Methoxychlor	300	500	400	2500
Mirex	10	20	20	100
Toxaphene	20	30	30	160
Atrazine	320	470	400	2500
Bifenthrin	600	840	730	4500
Chlorpyrifos	160	340	250	2000
Inorganics (mg/kg)				
Cyanides (free)	250	300	240	1500
Herbicides				
2,4,5-T	600	900	800	5000
2,4-D	900	1600	1300	9000
MCPA	600	900	800	5000
MCBP	600	900	800	5000
Mecoprop	600	900	800	5000
Picloram	4500	6600	5700	35 000

Notes:

1. Not all of the health investigations levels (HILs) are listed as they are often not relevant to the Department of Transport's maintenance dredging sites
2. HIL = health investigation level, PAH = polycyclic aromatic hydrocarbon, PCB = polychlorinated biphenyls, HCB = hexachlorobenzene, DDT = dichlorodiphenyltrichloroethane, DDD = dichlorodiphenyldichloroethane, DDE = dichlorodiphenyldichloroethylene, MCPA = 2-methyl-4-chlorophenoxyacetic acid, MCBP = 4-(4-chloro-o-tolyloxy) butyric acid.

Source: NEPC (2013)

4.3 Acid Sulfate Soils Guidelines

If dredging is occurring in an estuarine environment then there may be environmental risks associated with acid sulfate soils (ASS). The disturbance of ASS can increase pH levels and acidity, and cause mobilisation of metals into the water column. The Acid Sulfate Soils Guidelines Series (DER 2015) contains guidance on how to identify ASS risk areas and subsequent assessment methods including sampling and reporting for material intended for land reclamation purposes. These guidelines outline a risk assessment approach for ASS under the CS Act.

Sampling for ASS should be completed as described in DER (2015) and submitted to the laboratory for chromium reducible sulfur suite analysis. The chromium reducible sulfur suite method measures the reduced inorganic sulfur content (%S) of the sediment which is then compared against Texture-based Action Criteria (DER 2015, Table 4.5). If the Action Criteria are exceeded, the laboratories complete acid base accounting (ABA) which assesses both the potential of a soil material to produce acidity from sulfide oxidation and also its ability to neutralise any acid formed (Ahern et al. 2004). If the total net acidity determined by ABA indicates sediments with positive net acidity, potential management measures will need to be considered to prevent the generation of actual ASS.

Table 4.5 Texture-based acid sulfate soil Action Criteria

Type of material		Action Criteria			
		<1000 tonnes of materials is disturbed		>1000 tonnes of materials is disturbed	
Texture range	Approx. clay content (%)	Equivalent sulfur (%S) (oven-dry basis)	Equivalent acidity (mol H^+/tonne) (oven-dry basis)	Equivalent sulfur (%S) (oven-dry basis)	Equivalent acidity (mol H^+/tonne) (oven-dry basis)
Coarse texture sands to loamy sands	<5	0.03	18	0.03	18
Medium texture sandy loams to light clays	5–40	0.06	36	0.03	18
Fine texture medium to heavy clays and silty clays	>40	0.1	62	0.03	18

Source: DER (2015) with texture range based on McDonald et al. (1990)

4.4 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

Dredging causes the release of sediment pore water into the water column and return water from disposal sites is often discharged back into the marine environment. The impact of these discharges may be reviewed by comparing the water quality parameters (of elutriate sample concentrations of the proposed material prior to dredging and/or of the return water concentrations during dredging) with the ANZECC & ARMCANZ (2000) trigger values for physical and chemical stressors (Table 4.6) and toxicants (Table 4.7).

The ANZECC & ARMCANZ (2000) Guidelines for Fresh and Marine Water Quality include values for a range of analytes to assess adverse effects on the marine environment. Default low-risk water quality guideline trigger values are presented for tropical (north of Carnarvon) and south-west Australia (south of Carnarvon). These trigger values are applicable to coastal lagoons (excluding estuaries) and embayments and waters less than 20 m depth.

The trigger values are for 'chemical contaminants that have the potential to exert toxic effects at concentrations that might be encountered in the environment' (ANZECC & ARMCANZ 2000). Trigger values for toxicants are defined for different levels of protection (Table 4.7) that signify the percentage of species expected to be protected within the ecosystem. The 99% or 95% protection level is most commonly applied in 'slightly-moderately' disturbed ecosystems, which would generally classify most of the DoT's maintenance dredging sites. However, some facilities would be considered highly disturbed ecosystems. Therefore the application of the guidelines should be assessed on a case-by-case basis. The mean of the water sample concentrations should be compared to the trigger values.

Table 4.6 Default trigger values for marine water physical and chemical stressors in tropical and south-west Australia for slightly disturbed ecosystems

Ecosystem type	Chl-*a*	TP	FRP	TN	NO_x	NH_4^+	DO (%)[1]		pH	
Units	**µg/L**						**Lower limit**	**Upper limit**	**Lower limit**	**Upper limit**
Tropical Australia										
Estuaries[2]	2	20	5	250	30	15	80	120	7.0	8.5
Marine inshore	0.7–1.4[3]	15	5	100	2–8[3]	1–10[3]	90	n/a	8.0	8.4
Marine offshore	0.5–0.9[3]	10	2–5[3]	100	1–4[3]	1–6[3]	90	n/a	8.2	8.2
South-west Australia										
Estuaries	3	30	5	750	45	40	90	110	7.5	8.5
Marine inshore	0.7	20[4]	5[4]	230	5	5	90	n/a	8.0	8.4
Marine offshore	0.3[4]	20[4]	5	230	5	5	90	n/a	8.2	8.2

Notes:

1. Dissolved oxygen (DO) trigger values derived from daytime measurements; DO concentrations may vary diurnally and with depth
2. Derived trigger values do not include any data from tropical Western Australian estuaries therefore values should be applied with caution
3. The lower values are typical of clear coral-dominated waters, while higher values are typical of turbid macrotidal systems
4. These trigger values represent summer (low rainfall) conditions; the following values are appropriate for winter: Chl-*a* (1.0 µgL^{-1}), TP (40 µg P L^{-1}), FRP (10 µg P L^{-1})
5. Not all of the trigger values for stressors and toxicants are listed in Table 4.4 as they are often not relevant to the Department of Transport's maintenance dredging sites
6. n/a = not applicable, Chl-*a* = chlorophyll-*a*, TP = total phosphorus, FRP = filterable reactive phosphorus, TN = total nitrogen, NO_x = nitrate and nitrite, NH_4^+ = ammonium, DO = dissolved oxygen

Source: ANZECC & ARMCANZ (2000)

Table 4.7 Trigger values for toxicants in marine water at alternative levels of species protection

Toxicant	Trigger values for marine water (µg/L)[1,2]			
	Level of protection (% species)			
	99%	95%	90%	80%
Metals & metalloids				
Cadmium[2,3]	0.7	5.5[4]	14[4]	36
Chromium (Cr III)[2]	7.7	27.4	48.6	90.6
Chromium (Cr VI)	0.14	4.4	20[4]	85[4]
Cobalt	0.005	1	14	150[4]
Copper[2]	0.3	1.3	3[4]	8
Lead[2]	2.2	4.4	6.6[4]	12[4]
Mercury (inorganic)[3]	0.1	0.4[4]	0.7[4]	1.4[4]
Nickel[2]	7	70[4]	200	560
Silver	0.8	1.4	1.8	2.6[4]
Tributyltin (as µg/L Sn)	0.0004	0.006[4]	0.02[4]	0.05[4]
Vanadium	50	100	160	280
Zinc[2]	7	15[4]	23[4]	43[4]
Non-metallic inorganics				
Ammonia[5]	500	910	1200	1700
Aromatic hydrocarbons				
Benzene[4]	500	700	900	1300
Polycyclic aromatic hydrocarbons				
Naphthalene[4]	50	70	90	120

Notes:

1. Values in grey shading are typically applied to slightly-moderately disturbed systems (ANZECC & ARMCANZ 2000)
2. The values have been calculated using a hardness of 30 mg/L $CaCO_3$. These should be adjusted to the site specific hardness (see Section 3.4.3 of ANZECC & ARMCANZ 2000)
3. For these toxicants, the potential for bioaccumulation and secondary poisoning effects should also be considered (see Sections 8.3.3.4 and 8.3.5.7 of ANZECC & ARMCANZ 2000)
4. Trigger value may not protect key target species from chronic toxicity (see Section 8.3.7 of ANZECC & ARMCANZ 2000 for more information)
5. Ammonia expressed as total ammonia [NH_3-N] at pH 8
6. Trigger values for other contaminants are available but are not listed here as they are not considered relevant to the Department of Transport's maintenance dredging sites

Source: ANZECC & ARMCANZ (2000)

4.5 Landfill Waste Classifications and Definitions

If dredged material is planned to be disposed to a licensed or registered landfill site and there is the potential for leachate to reach groundwater or surface water, the Landfill Waste Classification and Waste Definitions (DEC 2009) need to be considered. This document provides a classification of landfill and waste types, and also criteria for the classification of wastes for acceptance to landfills licensed or registered in Western Australia under Part V of the EP Act (DEC 2009). If the material cannot be classified, sediment sampling will be required. The number of sediment samples depends on the volume to be disposed (Table 4.8). The sampling and the costs of disposal of non-inert material to classified landfill sites can be quite expensive and this should be considered in the planning phase of the maintenance dredging program (along with other sediment sampling programs to characterise dredged material; Section 4.1.1).

Table 4.8 Minimum number of sampling locations to support landfill waste classification

Volume (m^3)	Number of sampling locations
100 to 200	4
200 to 500	6
500 to 1000	8
1000 to 2000	11
2000 to 3000	15
3000 to 4000	18
4000 to 5000	20
5000 to 10 000	24
>10 000	24 (plus 4 for each additional 10 000 m^3)

Source: DEC (2009)

The first assessment phase involves testing for total contaminant values (Table 4.9). If any contaminant exceeds the maximum Class IV contaminant threshold values, the second assessment phase should determine the Australian Standard Leaching Procedures (ASLP) leachate concentrations and compare values to the concentration limits (CL; Table 4.10).

During the first assessment phase, the sediment samples should be analysed for all the contaminants of concern and these levels compared with the maximum contaminant threshold values and assigned a classification (Class I, II, III or IV; Table 4.9). The waste is then classified according to the highest class assigned for any of the analysed contaminants and may then be disposed to an appropriate landfill site.

Table 4.9 Contaminant thresholds (for total concentration) for landfill wastes

Contaminant	CT1 (mg/kg) Class I	CT2 (mg/kg) Class II	CT3 (mg/kg) Class III	CT4 (mg/kg) Class IV
Metals				
Arsenic	14	14	140	1400
Beryllium	2	2	20	200
Cadmium	0.4	0.4	4	40
Chromium VI	10	10	100	1000
Lead	2	2	20	200
Mercury	0.2	0.2	2	20
Molybdenum	10	10	100	1000
Nickel	4	4	40	400
Selenium	2	2	20	200
Silver	20	20	200	2000
Non-chlorinated organics				
Benzene	0.2	0.2	2	20
Cresols (total)	400	400	4000	40 000
2,4-D (dichlorophenoxyacetic acid)	0.02	0.02	0.2	2
Ethylbenzene	60	60	600	6000
Petroleum hydrocarbons	–	–	–	–
Phenol (total, non-halogenated)	28.8	28.8	288	2880
Polycyclic aromatic hydrocarbons (total)	–	–	–	–
Styrene (vinyl benzene)	6	6	60	600
Toluene	160	160	1600	16 000
Xylenes (total)	120	120	1200	12 000

Contaminant	CT1 (mg/kg) Class I	CT2 (mg/kg) Class II	CT3 (mg/kg) Class III	CT4 (mg/kg) Class IV
Chlorinated organics				
Organochlorine pesticides, polychlorinated biphenyls etc.	–	–	–	–
Other metals[2]	**% by weight**			
Aluminium , barium, boron, cobalt, copper, manganese, vanadium and zinc	5	5	10	20

Notes:

1. '–' means no contaminant threshold applicable, refer to values in Table 4.10
2. For waste containing significant quantities of these metals, preference should be given to recovery and recycling rather than disposal
3. Not all of the contaminants are listed in Table 4.9 as they are often not relevant to the Department of Transport's maintenance dredging sites

Source: DEC (2009)

During the second assessment phase, the leachate concentrations should be compared against both the leachable concentration and the concentration limit values for the relevant waste classification (Table 4.10). The waste should then be classified according to the highest class assigned to any contaminant (Class I, II, III or IV) and disposed to an appropriate landfill site. If the leachable concentrations exceed the Class IV values then the material will need to be treated until the ASLP values are met (Table 4.10).

Table 4.10 Australian Standard Leaching Procedures (ASLP) leachable concentration and the concentration limit (CL) values for waste classification

Contaminant[1]	ASLP1 Class I	CL1 Class I	ASLP2 Class II	CL2 Class II	ASLP3 Class III	CL3 Class III	ASLP4 Class IV	CL4 Class IV
Units	**mg/L**	**mg/kg**	**mg/L**	**mg/kg**	**mg/L**	**mg/kg**	**mg/L**	**mg/kg**
Metals								
Arsenic	0.5	500	0.5	500	5	5000	50	20 000
Beryllium	0.1	100	0.1	100	1	1000	10	4000
Cadmium	0.1	100	0.1	100	1	1000	10	4000
Chromium VI	0.5	500	0.5	500	5	5000	50	2000
Lead	0.1	1500	0.1	1500	1	15 000	10	60 000
Mercury	0.01	75	0.01	75	0.1	750	1	3000
Molybdenum	0.5	1000	0.5	1000	5	10 000	50	40 000
Nickel	0.2	3000	0.2	3000	2	30 000	20	120 000
Selenium	0.5	50	0.5	50	5	500	50	2000
Silver	1	180	1	180	10	1800	100	7200
Aluminium, barium, boron, cobalt, copper, manganese, vanadium and zinc	–	5% by weight		5% by weight	–	10% by weight	–	20% by weight
Non-chlorinated organics								
Benzene	0.01	18	0.01	18	0.1	180	1	720
Cresols (total)	20	7200	20	7200	200	72 000	2000	288 000
Ethylbenzene	3	1080	3	1080	30	10 800	300	n/a
C_6-C_9 petroleum hydrocarbons (PH)	–	2800	–	2800	–	28 000	–	112 000
C_{16}-C_{35} PHs	–	450	–	450	–	4500	–	18 000

Contaminant[1]	ASLP1 Class I	CL1 Class I	ASLP2 Class II	CL2 Class II	ASLP3 Class III	CL3 Class III	ASLP4 Class IV	CL4 Class IV
Units	**mg/L**	**mg/kg**	**mg/L**	**mg/kg**	**mg/L**	**mg/kg**	**mg/L**	**mg/kg**
(aromatics)								
C_{10}->C_{35} PHs (aliphatics)	–	28 000	–	28 000	–	280 000	–	–
Phenols (total, non-chlorinated)	1.44	42 500	1.44	42 500	14.4	425 000	144	–
PAHs (total)	–	100	–	100	–	1000	–	4000
Benzo(a)pyrene	0.0001	5	0.0001	5	0.001	50	0.01	200
Styrene	0.3	108	0.3	108	3	1080	30	4320
Toluene	8	518	8	518	80	5180	800	–
Xylenes (total)	6	1800	6	1800	60	18 000	600	–
Chlorinated organics								
2,4-D	0.3	360	0.3	360	3	1440	30	5760
OCP scheduled wastes	–	50	–	50	–	50	–	50
Other solvents	–	50	–	50	–	500	–	2000
PCBs	–	50	–	50	–	50	–	50

Notes:

1. Not all of the contaminants are listed in Table 4.8 as they are often not relevant to the Department of Transport's maintenance dredging sites
2. ALSP = Australian Standard Leaching Procedures; CL = concentration limit, PH = petroleum hydrocarbons, PAHs = polcyclic aromatic hydrocarbons, D = dichlorophenoxyacetic acid, OCP = organochlorine pesticides, PCBs = polychlorinated biphenyls

Source: DEC (2009)

4.6 Sediment nutrient guidelines

No guidelines have been defined for nutrients in marine sediment in Western Australia and further research is required before nutrient guidelines can be developed (ANZECC & ARMCANZ 2000). Nutrient analyses shall instead be compared against available background concentrations.

5. Environmental Impacts and Management

The DoT's statewide maintenance dredging program includes sites with a wide range of climatic, oceanographic, biogeographic and social conditions. This diversity requires careful consideration of the relevant environmental factors to ensure appropriate environmental impact pathways are considered and that the monitoring and management for each maintenance dredging campaign is effective to address the relevant environmental objectives. This is described in detail in the following sections.

5.1 Environmental factors and objectives

An environmental factor is part of the environment that may be impacted by an aspect of the proposal (EPA 2013a). The environmental objective for each factor is the desired goal that, if met, will indicate that the proposal is not expected to have a significant impact on the environment (EPA 2013a). The EPA's environmental factors and associated environmental objectives underpin the EIA process in Western Australia and are described in EAG8 (EPA 2013a; Table 5.1). The EPA uses these factors and objectives (which are grouped into themes) as a basis for assessing whether a proposal's impact on the environment is acceptable (Section 3.1). The most relevant environmental factors for the DoT's maintenance dredging works are likely to be:

- benthic communities and habitats
- coastal processes
- marine environmental quality
- marine fauna
- flora and vegetation
- terrestrial environmental quality
- hydrological processes
- inland waters environmental quality
- amenity
- heritage.

Table 5.1 Environmental factors and objectives used by the Environmental Protection Authority for assessing a proposal's impact on the environment

Theme	Environmental factor	Environmental objective
Sea	Benthic communities and habitat	To maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales.
	Coastal processes	To maintain the morphology of the subtidal, intertidal and supratidal zones and the local geophysical processes that shape them.
	Marine environmental quality	To maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected.
	Marine fauna	To maintain the diversity, geographic distribution and viability of fauna at the species and population levels.
Land	Flora and vegetation	To maintain representation, diversity, viability and ecological function at the species, population and community level.
	Landforms	To maintain the variety, integrity, ecological functions and environmental values of landforms and soils.
	Subterranean fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.
	Terrestrial environmental quality	To maintain the quality of land and soils so that the

Theme	Environmental factor	Environmental objective
		environment values, both ecological and social, are protected.
	Terrestrial fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.
Water	Hydrological processes	To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected.
	Inland waters environmental quality	To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.
Air	Air quality	To maintain air quality for the protection of the environment and human health and amenity.
People	Amenity	To ensure that impacts to amenity are reduced as low as reasonably practicable.
	Heritage	To ensure that historical and cultural associations are not adversely affected.
	Human health	To ensure that human health is not adversely affected.
Integrating factors	Offsets	To counterbalance any significant residual environmental impacts or uncertainty through the application of offsets.
	Rehabilitation and closure	To ensure that premises are closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed outcomes and land uses, and without unacceptable liability to the State.

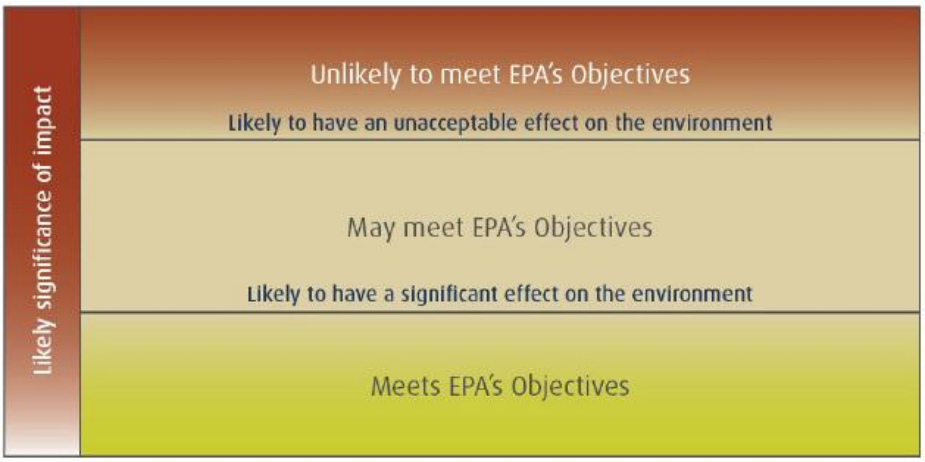
Source: EPA (2013a)

5.2 Significance framework

The EPA's significance framework for assessing environmental impact, as outlined in EAG9 (EPA 2013b), aims to understand the likely 'significance' (similar to 'consequence' in a traditional risk assessment terminology) of the environmental impacts of a proposal. The EPA's significance framework relates to the extent to which a project is likely to meet the EPA's environmental objectives (Figure 5.1; EPA 2013a). The EPA significance framework is applied as per the following (see also Section 3.1):

- if the EPA considers that a proposal can meet all of its environmental objectives then the proposal is considered unlikely to have a significant impact on the environment
- if the EPA considers that a proposal may not meet one or more of the EPA's environmental objectives its impact on the environment is considered likely to be significant. Subsequently, key environmental factors are identified when the EPA's environmental objectives may be met, but there is the need for further information or conditions related to proposal implementation
- if the EPA considers that a proposal is unlikely to meet one or more of its environmental objectives then its effect on the environment is likely to be unacceptable.

Through this approach it is intended that the environmental impact assessment shall focus on the impacts to each environmental factor that are most likely to be significant (EPA 2013a). The EPA's significance framework should be applied throughout the EIA process for DoT's maintenance dredging operations. In addition, a traditional risk assessment framework has been adopted (Section 5.3) to identify the potential key environmental factors as described in EPA (2013a).



Source: EPA (2013b)

Figure 5.1 Environmental Protection Authority's significance framework for the environmental impact assessment process

5.3 Environmental impacts of maintenance dredging operations

The DoT's maintenance dredging projects typically involve removal of relatively small volumes of clean marine sands from navigation channels adjacent to existing facilities. Nonetheless, a number of biophysical and social impacts may arise during a maintenance dredging project (Table 5.2). DoT maintenance dredging projects would usually fall into the "acceptable" zone of the EPA's significance framework. However to provide further resolution of the potential environmental issues, presented herein is a review of recent DoT maintenance dredging projects that determines the range of potential impacts, their consequence (Table 5.3) and likelihood (Table 5.4), to determine a risk level (Table 5.5) for a "typical" maintenance dredging campaign. The lists in these tables are not exhaustive and other appropriate management measures may be available at specific sites. Management measures shall be outlined in campaign-specific DEMPs. The highest risks, for a typical maintenance dredging campaign, are likely to be associated with turbidity and sedimentation, and mobilisation of contaminants.

Table 5.2 Potential impacts associated with the Department of Transport's maintenance dredging operations

Environmental factor(s)	Issue	Potential impacts
Biophysical		
• Benthic communities and habitat • Marine environmental quality	Turbidity and sedimentation	• Light limitation to benthic flora • Smothering of benthic habitat • Abrasion of marine organisms
• Benthic communities and habitat • Marine environmental quality • Terrestrial environmental quality	Mobilisation of contaminants	• Deteriorating water quality • Contamination of marine organisms
• Benthic communities and habitat • Marine environmental quality • Terrestrial environmental quality	Nutrient release from sediment	• Nuisance algal growth
• Benthic communities and habitat • Marine environmental quality • Terrestrial environmental quality • Inland waters environmental quality	Acid sulfate soils	• Acidification of waters • Deoxygenation of the water column • Release of heavy metals
• Coastal processes • Landforms	Sediment removal/alteration of local topography	• Downdrift erosion • Updrift accretion
• Benthic communities and habitat • Marine environmental quality • Terrestrial environmental quality	Hydrocarbon spill	• Contamination of marine organisms
• Marine fauna	Noise	• Disturbance of marine/terrestrial fauna
• Marine fauna	Vessel movement	• Collision with marine fauna
• Benthic communities and habitat • Marine environmental quality	Introduced marine pest species	• Introduction of invasive marine pest species into previously un-impacted sites
Social		
• Amenity	Turbid plume	• Reduced aesthetics and recreational values
• Amenity	Unsightly disposal site	• Reduced aesthetics
• Human health	Exposure to contaminants in dredged material	• Reduced health of local community
• Amenity	Restricted public access to dredging and/or disposal sites	• Restricted commercial and/or recreational values
• Air quality • Amenity • Human health	Odour	• Reduced aesthetics and health of local community
• Amenity • Human health	Noise	• Reduced aesthetics and health of local community
• Air quality • Amenity • Human health	Dust	• Reduced aesthetics and health of local community

5.4 Environmental management

The DoT implements a number of management measures to reduce the potential impacts of maintenance dredging operations, including:

- initial consideration of the timing, scale, methods and potential impacts of the maintenance dredging project (including review of any previous close-out reports)
- determining the status of environmental approvals for maintenance dredging at the site
- design of the dredging project to minimise environmental impacts at both the dredging and disposal site
- liaison with affected stakeholders
- preparation (or update) of a DEIA and submission to regulatory authorities if required
- preparation (or update) of a DEMP in consultation with the dredging contractor to ensure effective monitoring and management of the works on site
- communication with the dredging contractor to ensure environmental commitments are understood and included in the PEP
- regular supervision of site works
- collection and review of environmental monitoring data obtained during dredging works
- communication of monitoring results to relevant parties
- post-dredging monitoring
- maintaining a complaints register
- completion of close-out report to document project and inform future campaigns.

The potential biophysical and social impacts from maintenance dredging can generally be reduced to a low risk through the implementation of management measures. The greatest potential environmental risk is likely to be associated with turbidity and release of contaminants and nutrients.

Table 5.3 Description of consequences

Value	Description	Natural environment	Human environment	Marine fauna (individuals)
1	Insignificant	• Negligible impact with no remediation required • No alteration to ecosystems	• Very minor disruption to small section of community • Insignificant impacts on quality of life • No community interest/concern	Behaviour, physiology, and well-being barely or weakly affected
2	Minor	• Minor impacts with minimal remediation required • Minor alteration to ecosystems • Recovery period of weeks to months	• Isolated short-term disruption to some communities • Minor impacts on quality of life • Limited community interest/concern • Possible isolated local and individual concerns	Behaviour, physiology, and well-being affected to a degree that minimally influences individual reproductive success
3	Moderate	• Moderate impacts with some remediation required • Moderate alteration to ecosystems • Recovery period of months to years	• Small number of minor illnesses • Significant disruption to some communities • Significant short-term or minor long-term impact on quality of life • Moderate community interest/concern, limited (if any) regional or state interest	Behaviour, physiology, and well-being affected to a degree that individual reproductive success is reduced
4	Major	• Major impacts with considerable remediation required • Major alteration to ecosystems • Recovery period of years to decades	• Small number of illnesses or loss of life • Significant, widespread disruption to communities • Significant long-term impact on quality of life • Widespread community interest/concern – regional and state interest	Behaviour, physiology, and well-being substantially affected with reduction in individual reproductive success
5	Catastrophic	• Catastrophic impacts with significant remediation required • Irreversible alteration to ecosystems • Long-term environmental recovery period of decades	• Large number of illnesses or loss of life • Severe and widespread disruption to communities • Severe long-term impacts on quality of life • State, national and potential international interest/concern	Behaviour, physiology, and well-being severely (or mortally) affected with individual reproductive success greatly reduced or ceased

Table 5.4 Descriptions of likelihoods

Value	Descriptor	Description
1	Rare	Occurs only in exceptional circumstances
2	Unlikely	Could occur but not expected
3	Possible	Should occur at some time
4	Likely	Will probably occur in most circumstances
5	Almost certain	Is expected to occur in most circumstances

Table 5.5 Risk matrix

		Likelihood				
		Rare	Unlikely	Possible	Likely	Almost certain
Consequence	Insignificant	1	2	3	4	5
	Minor	2	4	6	8	10
	Moderate	3	6	9	12	15
	Major	4	8	12	16	20
	Catastrophic	5	10	15	20	25

Risk severity	Low (1–4)	Medium (5–10)	High (11–25)

Table 5.6 Risk assessment of key biophysical and social issues that may be associated with the Department of Transport's maintenance dredging operations

Environmental factors	Issue	Potential impacts	Likelihood	Consequence	Inherent risk rating	Possible management measures[1]	Likelihood	Consequence	Residual risk rating
Biophysical									
• Benthic communities and habitat • Marine environmental quality	Turbidity and sedimentation	• Light limitation to benthic flora • Smothering of benthic habitat • Abrasion of marine organisms	4	3	12	• Select appropriate dredge plant • Review dredging method • Time dredging to specific environmental conditions (e.g. winter and onshore winds) • Construct containment bunds, weirs, overflow systems, spreader plates, submarine discharge	3	2	6
• Benthic communities and habitat • Marine environmental quality • Terrestrial environmental quality	Nutrient release from sediment	• Nuisance algal growth	3	2	6	• Select appropriate dredge plant • Dispose to land instead of sea • Time dredging to specific environmental conditions (e.g. winter and onshore winds)	2	2	4
• Benthic communities and habitat • Marine environmental quality • Terrestrial environmental quality	Mobilisation of contaminants	• Deteriorating water quality • Contamination of marine organisms	3	4	12	• Dispose to land instead of sea • Containment at disposal site • Select appropriate dredge plant	2	4	8
• Benthic communities and habitat • Marine environmental quality • Terrestrial environmental quality • Inland waters environmental quality	Acid sulfate soils	• Acidification of waters • Deoxygenation of the water column • Release of heavy metals	2	4	8	• Minimise oxidation during dredging and at disposal site • Dispose to sea instead of land • Contain fine fraction	1	3	3
• Coastal processes • Landforms	Sediment removal/alteration of local topography	• Downdrift erosion • Updrift accretion	3	2	6	• Discharge material back into sediment cell (i.e. sand bypassing)	3	1	3
• Benthic communities and habitat • Marine environmental quality • Terrestrial environmental quality	Hydrocarbon spill	• Contamination of marine organisms	3	3	9	• Inspect dredge daily • Review oil spill and refuelling procedures • Audit spill response and clean-up procedures	2	2	4
• Marine fauna	Noise	• Disturbance of marine/terrestrial fauna	2	2	4	• Select appropriate dredge plant • Selection of disposal site • Time dredging to non-migratory periods • Time dredging to avoid migratory periods for marine mammals	2	1	3
• Marine fauna	Vessel movement	• Collision with marine fauna	2	4	8	• Time dredging to avoid migratory periods for marine mammals	1	4	4
• Benthic communities and habitat • Marine environmental quality	Introduced marine pest species	• Introduction of invasive marine pest species into previously un-impacted sites	2	3	6	• Weekly clean of dredge using fresh water and brush the sides of the hull to minimise growth • Clean dredge and pipes at the end of a campaign and ensure remaining water and sediment is flushed out when loading vessel onto the trailer for transport • Transport dredge via road between maintenance dredging sites	1	3	4
Social									
• Amenity	Turbid plume	• Reduced aesthetics and recreational values	4	2	8	• Select appropriate dredge plant • Time dredging to specific environmental conditions (e.g. winter) • Public education, including signage/public notices and community liaison	4	1	4
• Amenity	Unsightly disposal site	• Reduced aesthetics	3	2	6	• Rehabilitation of site upon completion of disposal • Modify disposal method	2	1	3

Environmental factors	Issue	Potential impacts	Likelihood	Consequence	Inherent risk rating	Possible management measures[1]	Likelihood	Consequence	Residual risk rating
• Human health	Exposure to contaminants in dredged material	• Reduced health of local community	2	3	6	• Selection of disposal site • Capping of disposal site on completion • Restrict public access to disposal site • Dredging without overflow	1	3	3
• Amenity	Restricted public access to dredging and/or disposal sites	• Restricted commercial and/or recreational values	4	2	8	• Selection of disposal site • Public education, including signage/public notices and community liaison • Provide alternate access to areas	3	1	3
• Air quality • Amenity • Human health	Odour	• Reduced aesthetics and health of local community	3	2	6	• Time dredging to specific environmental conditions • Limit proximity of public to dredging operation	2	2	4
• Amenity • Human health	Noise	• Reduced aesthetics and health of local community	3	2	6	• Time dredging to specific environmental conditions • Implement noise emission control measures (e.g. silencers)	2	2	4
• Air quality • Amenity • Human health	Dust	• Reduced aesthetics and health of local community	2	2	4	• Time dredging to specific environmental conditions • Implement dust emission control measures (e.g. silt fences)	1	2	3

Note:

1. This list is not exhaustive and other appropriate management measures may be available at specific sites. Management measures shall be outlined in campaign-specific Dredging Environmental Management Plans

6. Environmental Monitoring of Dredging Operations

Environmental monitoring may be completed before, during and after a dredging campaign to quantify the biophysical and social impacts and to help ensure that any impacts are minimised. Environmental monitoring prior to dredging is typically done to characterise the material to be dredged, and determine background water quality conditions and benthic habitats at the dredging and disposal site (where applicable). Environmental monitoring is completed during and after the dredging campaign to document any environmental impacts from the works. Environmental issues associated with turbidity and release of contaminants and nutrients are the focus of the environmental monitoring for the DoT's maintenance dredging program (Section 5.3).

The environmental monitoring for a dredging campaign should be informed by an understanding of the: dredged material (volume and characteristics), dredging method, location (of dredging and disposal sites), and duration and timing of the dredging works. Comprehensive environmental monitoring is often not warranted for small-scale projects of short duration (e.g. <2 weeks) and involve small volumes (e.g. <1500 m^3). The monitoring recommended herein is considered appropriate for the small-scale maintenance dredging done by the DoT and/or by leasees within DoT facilities.

Detailed methods for monitoring are presented below for pre-dredging (Section 6.1) and during dredging (Section 6.2). Post-dredging monitoring is generally only required if there are significant environmental issues associated with the works and shall be dependent on the findings of the EIA process (e.g. TBT monitoring at Beadon Creek).

6.1 Pre-dredging sampling

Pre-dredging monitoring typically involves sediment sampling of the proposed dredged material (and soil sampling at the disposal site if relevant) and may include benthic habitat surveys. The procedures for determining the pre-dredging monitoring requirements are presented in (Figure 6.1). Sediment sampling is completed to characterise the environmental and engineering characteristics of the dredged material in the dredging area. Soil sampling is required to determine the existing contaminant status of the onshore disposal site. The dredged material for the DoT maintenance dredging campaigns is typically marine sand, and occasionally the dredged material may be predominantly detached seagrass/algal material, known as wrack.

The need for pre-dredging benthic habitat surveys shall be assessed on a case-by-case basis and only completed when sensitive benthic habitats in the vicinity of the dredging area may be impacted by smothering or light reduction (Figure 6.1).

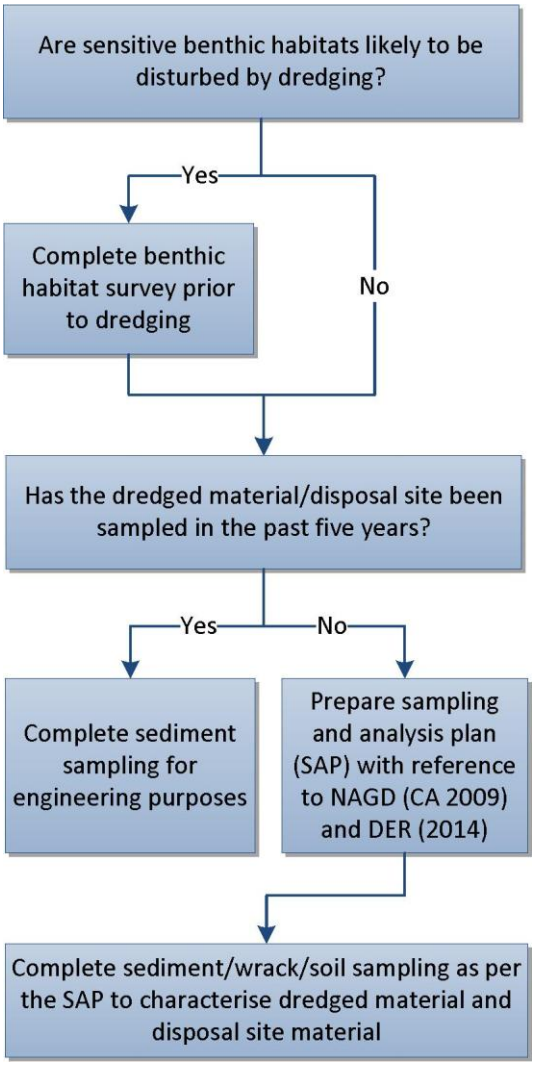
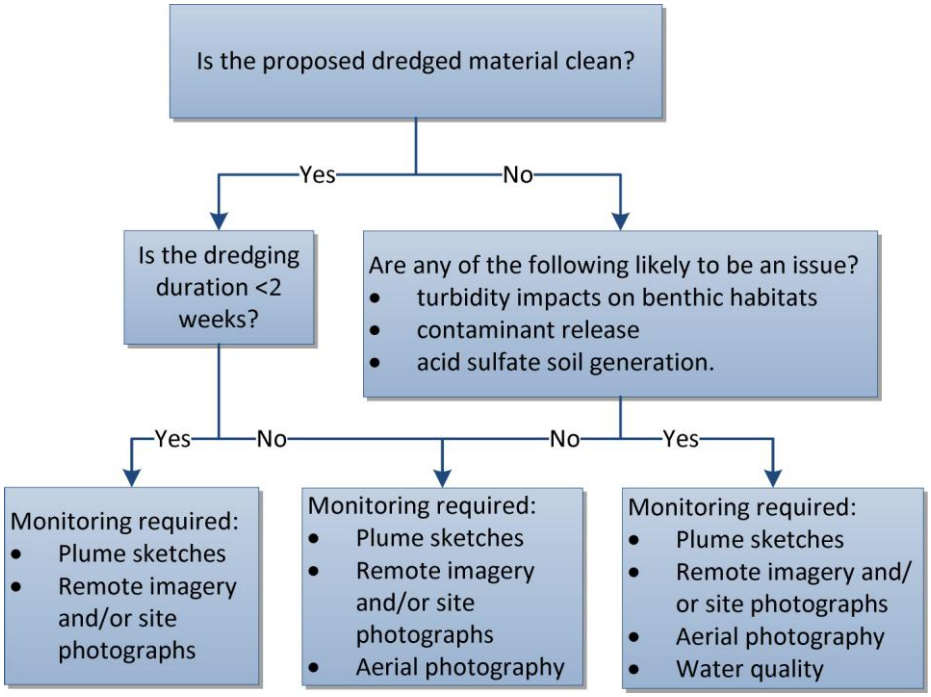


Figure 6.1 Decision tree for monitoring prior to dredging

6.2 During-dredging monitoring

A range of environmental monitoring is often completed during dredging to ensure the environmental impacts of maintenance dredging works are documented and understood. Monitoring components could include site photographs, plume sketches, remote imagery, aerial photography and water quality monitoring (Figure 6.2). The relevant procedures for each of the monitoring components are provided in the sections below and should be included in the individual DEMPs. These monitoring procedures should be discussed with the dredging contractor during the preparation of the DEMP to ensure that the monitoring commitments are feasible, well understood, and that the required monitoring equipment is available. Environmental monitoring data should be provided by the dredging contractor to the Principal weekly. This (together with other relevant information) is tracked using environmental monitoring checklists that accompany the weekly progress reports (Section 2.6, Section 6.3).



Note:

1. The dredged material is considered to be clean if all contaminants are below the relevant guidelines (Section 4)

Figure 6.2 Decision-tree for monitoring during dredging

6.3 Reporting

All environmental monitoring data collected during dredging should be reviewed weekly to assess whether there is any possibility of environmental or socio-economic impacts from the dredging campaign. Weekly environmental monitoring checklists should be completed by the environmental consultant and provided to the engineering consultants for inclusion in the weekly progress reports to the Principal. The dredging contractor should also provide daily logs and weekly reports for inclusion in these progress reports.

The environmental data from a dredging campaign shall be analysed and interpreted in the close-out report on completion of dredging (Section 2.6). A plume coverage figure shall be included in the close-out report along with a discussion on the proximity of the plume to nearby sensitive benthic habitats (if applicable).

6.4 Monitoring summary

A summary of the pre-dredging and during dredging monitoring commitments that may be required to be implemented by the Principal and the dredging contractor during the dredging campaign is provided in Table 6.1.

Table 6.1 Environmental monitoring summary table

Monitoring	Frequency	Responsibility
Pre-dredging		
Sediment sampling	Every five years[1]	Principal
Wrack sampling	Every five years[1]	Principal
Sediment sampling for engineering purposes	Prior to or during each campaign	Principal
Benthic habitat survey	Prior to campaign where deemed necessary	Principal
During dredging		
Plume sketches	Daily during dredging	Contractor
Remote imagery	Before, during and after dredging	Principal
Site photographs	Daily during dredging	Contractor
Aerial photography	At least once per campaign	Principal
Water quality monitoring	Dependent on length of dredging (approximately once every three weeks)	Principal

Note:

1. Unless contamination of the site is likely to have increased or new pollution sources are present (CA 2009). For sites that are infrequently dredged (i.e. greater than five years) sediment samples shall be obtained prior to each campaign

7. Review and Audits

The EMF is intended to be a 'live' document, which is able to undergo regular revision to ensure best practice methods continue to be applied as knowledge, technology and requirements change. This is possible because the EMF document is available on the online extranet system, Pearl, which allows it to be quickly edited and updated by designated authors, and personnel working on the program can be efficiently notified of any changes.

Any recommended changes to the EMF shall be captured as part of the ongoing monthly meetings (attended by the Principal, engineering consultant, environmental consultant and dredging contractor), and the close-out report of each dredging campaign. These changes can be quickly incorporated into the online version of the EMF, which in turn can be downloaded as a pdf document. Any changes made to the online version of the EMF document are documented in Pearl as they may be used for audit purposes.

An annual internal audit of the maintenance dredging program and the EMF (carried out by the environmental consultant) shall ensure that all environmental commitments have been met during the 12-month audit period, and clearly identify any pending environmental commitments. The audit shall be carried out in Pearl against the current online version of the EMF and the EMF pages will be locked against editing during the audit. Any non-conformances can then be investigated in the context of the documented changes to the EMF made in the previous year (see above). The audit shall be efficient and transparent as all of the lines of evidence required for the audit are expected to be available on Pearl and therefore easily checked and linked into the audit report. The audit report shall discuss any non-conformances and the EMF may then be reviewed to address any issues in consultation with the Principal, engineering consultant and the dredging contractor.

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