12. LAND CONTAMINATION AND ACID SULFATE SOILS

This chapter describes the existing land contamination and acid sulfate soils (ASS) environment in the project area. Impacts on existing contaminated land, and ASS that may result from construction, operation and decommissioning of the project are identified as well as the potential for the project to create new land contamination. This chapter is informed by the Arrow LNG Plant Preliminary Site Investigation and Contaminated Land Assessment prepared by Coffey Environments (Appendix 3) and the Arrow LNG Plant Acid Sulfate Soils Assessment prepared by Coffey Geotechnics (Appendix 4).

Impacts from the generation, storage and disposal of waste are discussed in Chapter 31, Waste Management.

Objectives have been developed for land contamination and acid sulfate soils based on the legislative context. These are set out in Box 12.1.

Box 12.1 Objectives: Land contamination and acid sulfate soils

- To identify and manage existing contaminated land within the project area.
- To reduce risk of land contamination by project activities during construction and operation.
- To manage and mitigate disturbance to ASS during project construction and operation.

12.1 Legislative Context and Standards

This section describes the legislation, guidelines and policies designed to protect land values during project construction and operation.

12.1.1 State Legislation

Legislative requirements relevant to contaminated land and ASS in Queensland include:

- *Environmental Protection Act 1994* (Qld). Administered by the Department of Environment and Resource Management (DERM), this act defines environmental objectives for the protection of Queensland's environment, and provides environmental strategies and requirements for reporting and compliance. The act specifies management of activities that contribute material and serious environmental harm, and delineates notifiable activities likely to cause land contamination.

  Properties subject to notifiable activities must be referred to, and recorded on, the Environmental Management Register (EMR). The register records properties that are currently or historically known to have been subject to notifiable activities or known to be impacted by a hazardous contaminant. Landowners or occupiers have obligations under the act to notify DERM of their properties upon identification of notifiable activities or existing contamination. The act prohibits removal of contaminated soil from land that is listed on the EMR without a permit from the administering authority. DERM also administers the Contaminated Land Register (CLR), a record of contaminated sites that are causing, or may cause, serious environmental harm. The act also sets out the requirements for contaminated land investigations, remediation and validation works.

- Environmental Protection Regulation 2008. This regulation made under the Environmental Protection Act, lists category A and B environmentally sensitive areas that are to be protected

and regulates environmentally relevant activities. The construction and operation of the Arrow LNG Plant will include environmentally relevant activities to be regulated under this regulation and the act. The potential to disturb ASS is considered to be one of these activities.

- *Sustainable Planning Act 2009* (Qld). This act provides a framework for sustainable development and the management of environmental effects. It also provides a mechanism for planning integration at local, regional and state levels. The act requires that a site investigation is undertaken where a material change of land use is proposed or for reconfiguration of a lot recorded on the EMR or CLR. Specific requirements are also set out for the management of ASS where these have the potential to do environmental harm through the land development.
- *Fisheries Act 1994* (Qld) and Fisheries Regulation 2008 (Qld). This act (and its subordinate regulation), regulate the management, use and protection of fishery resources and fish habitats. The act also addresses the potential for ASS disturbance to harm fishery resources and habitats.

12.1.2 Policies, Guidelines and Standards

The following policies and guidelines have been used to guide the assessment and management measures for land contamination and ASS:

- National Environment Protection (Assessment of Site Contamination) Measure (NEPC, 1999). This measure outlines objectives for the assessment of site contamination and the stages of investigation, including requirements for preliminary site investigation.
- Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland (DoE, 1998). The draft guidelines are the current standard used in the assessment of contaminated land in Queensland. The guidelines outline a process for staged assessment and site investigation of contaminated land. The first stage in the process is to complete a preliminary site investigation to identify all past and present activities that may have led to site contamination. A detailed site investigation is then required to delineate the extent of potential or actual site contamination.
- Queensland's State Planning Policy 2/02: Planning and Managing Development involving Acid Sulfate Soils (SPP 2/02). This policy, under the *Integrated Planning Act 1997*, describes the state's interests in development in low-lying coastal areas where there is the potential for ASS, prescribes investigation requirements and recommends appropriate management techniques and strategies. SPP 2/02 applies to all land, soil and sediment disturbance at or below reduced level (RL) 5 m Australian Height Datum (mAHD), or where the natural ground level is less than RL 20 mAHD. Excavations of 100 m^3 or more of soil or sediment, or the infilling of 500 m^3 or more of material (with an average depth of 0.5 m or greater), are covered by the policy.
- Draft Guideline on the Management of Acidic, Non-Acid Sulfate Soils (QASSIT, 2005). The guideline covers activities in or near areas where acidic soils are present and where the acidity is non-sulfuric. Recommendations are included for the application of lime where there are risks associated with disturbing acidic, non-acid sulfate soils.
- Queensland Acid Sulfate Soil Technical Manual - Soil Management Guidelines (Dear et al., 2002). These guidelines set out a preferred hierarchy of strategies for ASS management and monitoring. The guidelines allow the magnitude of the possible acid disturbance to be assessed, and set out requirements for lime neutralisation.

12.2 Assessment Method

The assessment method for the contaminated land preliminary site investigation and ASS risk assessment is discussed in this section.

12.2.1 Contaminated Land Assessment Method

A stage 1 preliminary site investigation was undertaken to identify existing potential contamination. The desktop and field study was undertaken to establish the existing environment, while a site history review was conducted to identify past and present potentially contaminating activities. A risk assessment was completed on the Arrow LNG Plant to assess the potential for the project to impact the contamination status of the respective project sites.

The study area for the preliminary site investigation and contaminated land assessment included the LNG plant and ancillary facilities on Curtis Island, TWAF 7, TWAF 8, launch site 1 and the mainland tunnel entrance and tunnel spoil disposal area. The study area excluded launch site 4N because this site is yet to be reclaimed as part of the Western Basin Dredging and Disposal Project. Dredge sites 1 (at launch site 1), 2 (at launch site 4N), 3 (at Boatshed Point materials offloading facility (MOF)), 4 (at Hamilton Point MOF) and 5 (at LNG jetty) were not subject to the preliminary site investigation as they are located on the seabed.

Baseline Assessment

The site history review was undertaken in general accordance with the draft guidelines for the assessment and management of contaminated land (DoE, 1998). The lots reviewed are listed in Table 12.1.

Table 12.1 Registered lots in the project area

Location	Lots
Curtis Island	Lot 3 on SP235936 Lot 4 on SP235936 Lot 5 on SP235936 Lot 6 on DS220 Lot 1 on RP602284 Lot 7 on SP239683
Mainland tunnel entry shaft and tunnel spoil disposal area	Lot 1 on SP235026 Lot 3 on SP235026 Lot 2 on SP147871
TWAF 7	Lot 200 on Plan CTN2173 Lot 32 on Plan USL15325
TWAF 8	Lot 200 on Plan CTN2173
Launch site 1	Part of Lot 69 on Plan P4247

Notes:

Lots 3, 4 and 5 on SP235936 have been subdivided from Lot 2 on SP207281. Some searches were conducted on Lot 2 and results encompass all three subdivided lots.

Lot 7 on SP239683 is located below the high tide mark and no titles or property searches were available at the time of investigation.

The site history review identified features and activities within the project area that may be potential sources of contamination. The review included a review or search of the following:

- Aerial photography and satellite imagery of the study area (1959 to 2007).
- EMR and CLR.
- Available current and historical land titles.

- DERM groundwater database.
- Public libraries and historical societies.
- Environmental impact statements prepared for projects in the surrounding area.
- Available topographic, geological and hydrogeological maps.
- Street maps.

A site visit was undertaken to all areas of proposed disturbance (excluding Lot 1 on RP602284 (Boatshed Point) which will be inspected prior to construction). The visit included site walkovers and consultation with available persons. At each site, records were made of the layout, onsite structures (e.g., storage facilities, disposal areas), current and adjacent land uses, evidence of previous use, visible ground contamination, discharges to land and water, and locations of underground services.

Risk Assessment

A qualitative risk assessment was undertaken in accordance with the draft guidelines for the assessment and management of contaminated land in Queensland (DoE, 1998) and Australian/New Zealand Standard AS/NZS ISO 3100:2009 Risk management: principles and guidelines.

For contaminants of concern to present a risk, there must be a source of contamination, an exposure pathway and receptors that may be adversely affected by exposure to the contaminants. This source-pathway-receptor relationship therefore establishes the potential for adverse impacts on human health or the environment. The significance of risks guided the development of mitigation measures that aim to minimise the impact of these risks during construction, operation and decommissioning of the Arrow LNG Plant.

Common exposure pathways include:

- Direct contact through dermal contact (inhalation or congestion for human receptors and surface exposure for environmental receptors).
- Surface runoff that may mobilise contaminants from surface soils.
- Groundwater leaching of contaminants that may migrate or discharge into surface water bodies.
- Airborne dust that may transport contaminants off site.
- Volatilisation where vaporisation of contaminating material can accumulate in enclosed spaces and be transported off site.

Receptors typically include sensitive receptors (property occupiers or owners), onsite workers (individuals involved in construction and operation of the project), and environmental receptors (surrounding environment including flora and flora, freshwater and marine ecosystems). The risk assessment identifies current and future receptors, which may be exposed to contaminants of concern.

Risk has been assessed though consideration of both the likelihood and the consequence of an effect occurring during the project. Likelihood is a measure of the probability that the impact will occur, given a certain event. Consequence is a function of the nature, severity, geographical extent and duration of the impact. Criteria used to classify likelihood and consequence are provided in Table 12.2.

Table 12.2 Criteria used to describe likelihood and consequence

	Descriptor
Likelihood	
Almost certain	Expected to occur during site construction and operation.
Likely	Likely to occur during site construction and operation.
Possible	May occur during site construction and operation.
Unlikely	Not expected to occur during site construction and operation.
Consequence	
Significant	Irreversible human health impact on multiple receptors or persistent environmental impact over a large area. Impact is evident both on site and off site.
Moderate	Non debilitating human health impacts on multiple receptors or onsite environmental impact. May include minor offsite impact. Environmental rehabilitation is medium term (up to 10 years).
Low	Low-impact acute human health effects on site or minor localised environmental impact. All impacts are reversible.
Negligible	No evidence of human health impact or environmental harm.

The risk assessment matrix in Table 12.3 is applied to arrive at a ranking for each identified risk.

Table 12.3 Risk assessment matrix

	Consequence			
Likelihood	**Significant**	**Moderate**	**Low**	**Negligible**
Almost certain	High	High	High	Moderate
Likely	High	High	Moderate	Low
Possible	High	Moderate	Moderate	Low
Unlikely	Moderate	Low	Low	Low

12.2.2 Acid Sulfate Soil Assessment Method

A desktop study, soil investigation and risk assessment were undertaken to identify the presence and severity of ASS horizons in the study area and the extent of potential soil disturbance within these horizons.

The ASS assessment method was guided by SPP 2/02 and associated guidelines, and was informed by the outcomes of consultation with DERM. The relevant guidelines include:

- AS 4482.1-2005 Guide to the sampling and investigation of potentially contaminated soil. Part 1: Non-volatile and semi-volatile compounds. This is a guide for the collection of information for the assessment of potentially contaminated sites.
- Acid sulfate soil laboratory methods guidelines (Ahern et al., 2004). These guidelines detail test methods to be used in the analyses of soils, to determine their ASS status.
- Guidelines for sampling and analysis of lowland acid sulfate soils in Queensland (Ahern et al., 1998). These guidelines detail the frequency of test locations, sampling depths and qualitative and quantitative test methods required for ASS investigations.

The ASS study area included the project area where activities occur at or below 5 m AHD, or areas with a natural ground level below 20 m AHD. Launch site 4N is located on land yet to be reclaimed (as part of the Western Basin Reclamation Area) and was not included in this assessment.

Baseline Assessment

The baseline assessment included both field investigations and laboratory analysis. The desktop study reviewed information from the following sources:

- Preliminary geotechnical investigations (Coffey Geotechnics, 2009).
- Publicly available data including reports by the Queensland Government.
- ASS risk mapping by DERM.
- Environmental impact statements prepared for other projects in the area.

AHD contours and ASS borehole locations are shown in Figure 12.1.

The assessment identified deficiencies in the existing data, with no or inadequate previous ASS data available for the following sites:

- Hamilton Point haul road option, mainland tunnel entry shaft, dredge site 1 and dredge site 2.
- Hamilton Point and Boatshed Point MOF and dredge site 3 (although ASS boreholes are located in the vicinity).

Assessment of dredge site 1 (launch site 1), 2 (launch site 4N), 3 (Boatshed Point MOF), 4 (Hamilton Point MOF) and 5 (LNG jetty) was in accordance with SPP 2/02 requirements as available ASS bores are located within the footprint of these sites.

Risk Assessment

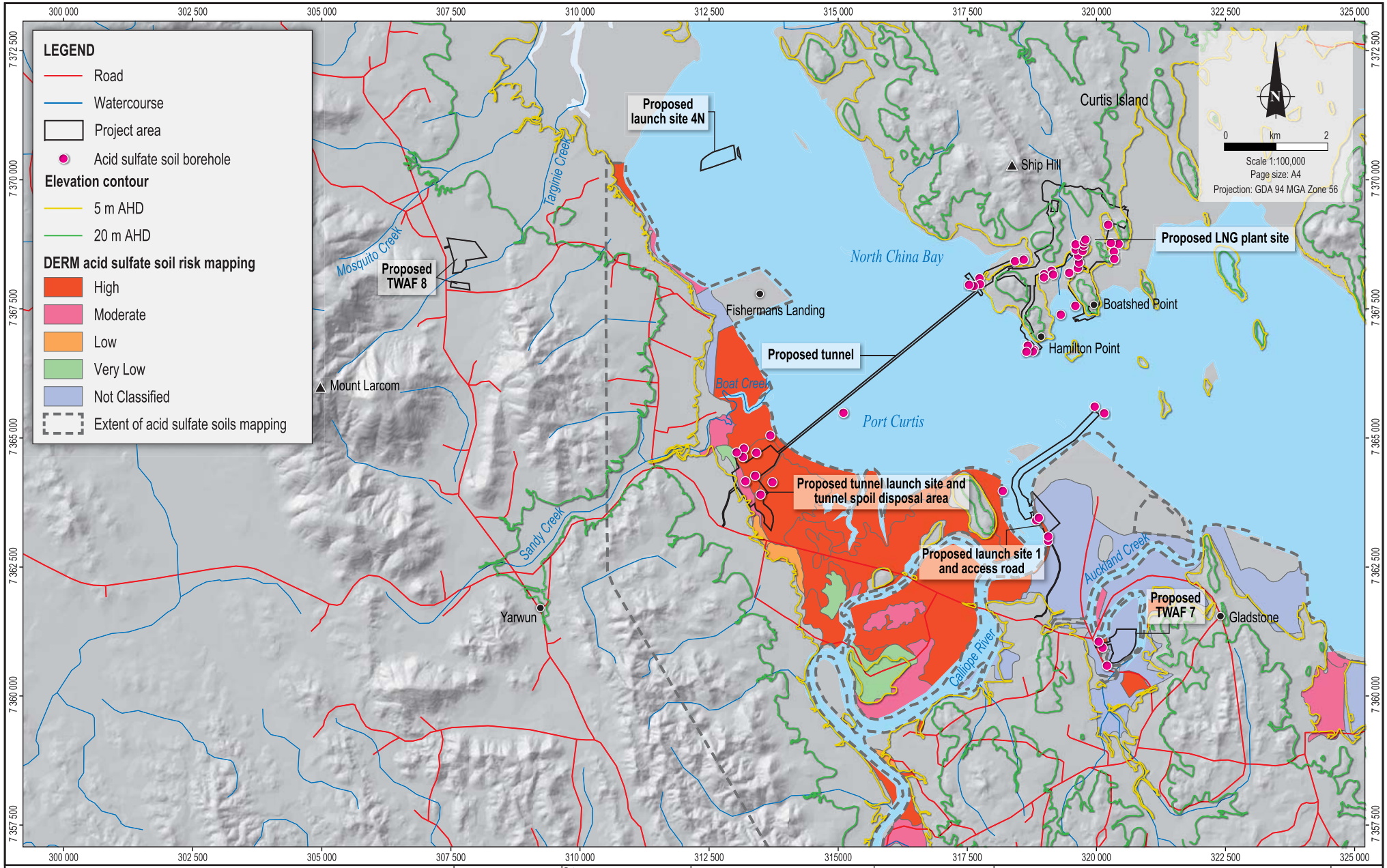
The assessment of ASS risk was based on the available data and the nature of proposed activities and construction methods. Quantitative soils data from borehole samples within or in the vicinity (less than 200 m) of project areas were assessed against the SPP 2/02 action criteria for sulfuric acidity of net acidity. The action criteria are equivalent to 0.03% oxidisable sulfur in areas that disturb more than 1,000 t of material. Soils with net acidity levels in excess of the action criteria were classed as ASS and will require management if disturbed.

12.3 Existing Environment

Existing land contamination and acid sulfate soils within the project area are described in this section.

12.3.1 Contaminated Land

No lots in the project area are listed on the EMR or CLR as at October 2011; however, it should be noted that a notifiable activity, a cattle dip, has been identified on the LNG plant site (Lot 2 on Plan SP207281) on Curtis Island. Under the Environmental Protection Act, the identification of a notifiable activity requires the site owner or occupier to notify the administering authority, which will result in the listing of that property on the EMR.



Source:
Place names, roads and watercourses from DME.
Acid sulfate soils data and contours from DERM.
Project area and digital elevation model from Coffey Environments.
Western Basin Reclamation Area from Gladstone Ports Corporation.

coffey environments

Date: 12.12.2011
MXD: 7033CA_07_GIS034_v1_8
File Name: 7033_07_F12.01_GIS_GL

Arrow Energy

Arrow LNG Plant

arrow energy go further

Critical elevation contours, acid sulfate soil boreholes and risk mapping

Figure No: 12.1

The Gladstone Regional Council advised that no dangerous goods records were available for these properties as at October 2011.

Potential contaminants of concern that may occur within the project area include:

- Pesticides and herbicides including organochlorine pesticides (OCP) and organophosphorus pesticides (OPP), which are known to be toxic to humans and the environment. OCPs and OPPs are potentially carcinogenic to humans and have been linked to acute and chronic health impacts. They are also persistent in the environment and are known to be bioaccumulative.
- Metals, including arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, barium, magnesium and manganese. Metals may be associated with pesticides and herbicides, paints and the burning of fossil fuels, or they can naturally occur in soils. Mobility of metals and extent of receptor exposure varies with the form of the metal and pH of the environment.
- Petroleum hydrocarbons including total petroleum hydrocarbons (TPH); benzene, toluene, ethyl benzene and xylene (BTEX); and polycyclic aromatic hydrocarbons (PAH). Petroleum hydrocarbons are most commonly associated with fuels, lubricants and solvents. These may biodegrade in the environment, volatise from water and moist soil surfaces, and bioconcentrate in water. Petroleum hydrocarbons can cause health-related impacts on the central nervous system, resulting in neurological effects.
- Other hydrocarbons. These may be associated with pesticides, paints, wood preservatives, adhesives, cleaning agents and the partial burning of carbon-based material.
- Asbestos. A mineral comprising amosite, actinolite, anthophyllite, chrysotile, tremolite or crocidolite. Asbestos fibres are known to be carcinogenic and are a risk to human health if inhaled.

12.3.2 Acid Sulfate Soils

Acid sulfate soils contain iron sulfides (commonly pyrite) that are formed under specific conditions. There are two primary types of ASS:

- Actual acid sulfate soils – where the pyrite has been oxidised and sulfuric acid is present in the soil.
- Potential acid sulfate soils – where the pyrite is present but has not been oxidised.

Both forms of ASS have the potential to cause negative environmental impacts and a distinction is not made between the two types in this assessment.

In eastern Australia, ASS generally occurs in Holocene aged alluvial deposits below 5 m AHD, but can occur up to 20 m AHD. ASS may also be found in other soil types immediately below the Holocene materials as a result of pyritic material migration. In the Gladstone region, ASS usually occurs in Holocene marine and estuarine mud below 2.5 m AHD. Soils below the lowest astronomical tide (LAT) are also likely to be ASS, although they can be self neutralising.

DERM ASS risk mapping illustrating the extent of mapped ASS in the Tannum Sands and Gladstone area is shown on Figure 12.1.

12.3.3 Contaminated Land and Acid Sulfate Soils within the Project Area

Potential contaminants of concern and the presence of ASS across each project area are discussed below.

LNG Plant and Curtis Island Infrastructure

This section discusses the existing land contamination and ASS in the project area on Curtis Island.

Contaminated Land

Properties on Curtis Island have been privately owned since 1869, although the Queensland Government acquired land in 1919, possibly related to wartime activities. In 1959, the project areas on Curtis Island comprised bushland, grassland and mudflats on the coastal fringes. At this time, the area was likely used for agricultural or rural residential purposes. Since then, the most notable changes include construction of an access track from Boatshed Point and a small dam. Potential sources of contamination from historical agricultural use include stock dips, waste disposal, workshops areas and fuel storage.

The site visit of the LNG plant site on Curtis Island (former Lot 2 on Plan SP207281) identified an abandoned cottage, site sheds, stockyards and a former cattle dip (Plate 12.1). Scrap metal and other debris were observed around the cottage. The cattle dip contained about 0.5 m water with a visible sheen, and was surrounded by scrap metal. Two piles of used batteries were observed in the vicinity of the cottage; one adjacent to the eastern wall (general purpose lead positive plate batteries) and one to the south (lead acid batteries) (Plate 12.2). These batteries are regulated waste items under the Environmental Protection Act.

The cattle dip site corresponded with that identified on Lot 2 on Plan SP207281 in Santos' Gladstone LNG Project (URS, 2009a). Seven surface soil samples previously collected and analysed by URS in the vicinity of the cattle dip indicated arsenic concentrations exceeding the National Environment Protection (Assessment of Site Contamination) Measure health based investigation levels for commercial and industrial sites (NEPC, 1999).

Inspection of Lot 6 on Plan DS220 identified additional abandoned stockyards, stockpiles of timber and steel approximately 300 m northeast of the cottage. In this area, empty corroded 205 litre drums were observed, but no soil staining was evident. Although Lot 1 on RP602284 (Boatshed Point) was not inspected as part of the contaminated land investigation, other inspections of this property have identified the remains of an old house site (approximately 10 m by 6 m in area) and two long drop toilets.

The cattle dip located within (current) Lot 5 on SP235936 (LNG plant site) is a notifiable activity under the Environment Protection Act (livestock dip or spray race operations). The act requires the landowner or occupier to notify DERM of the presence of the cattle dip, which would result in the property being listed on the EMR.

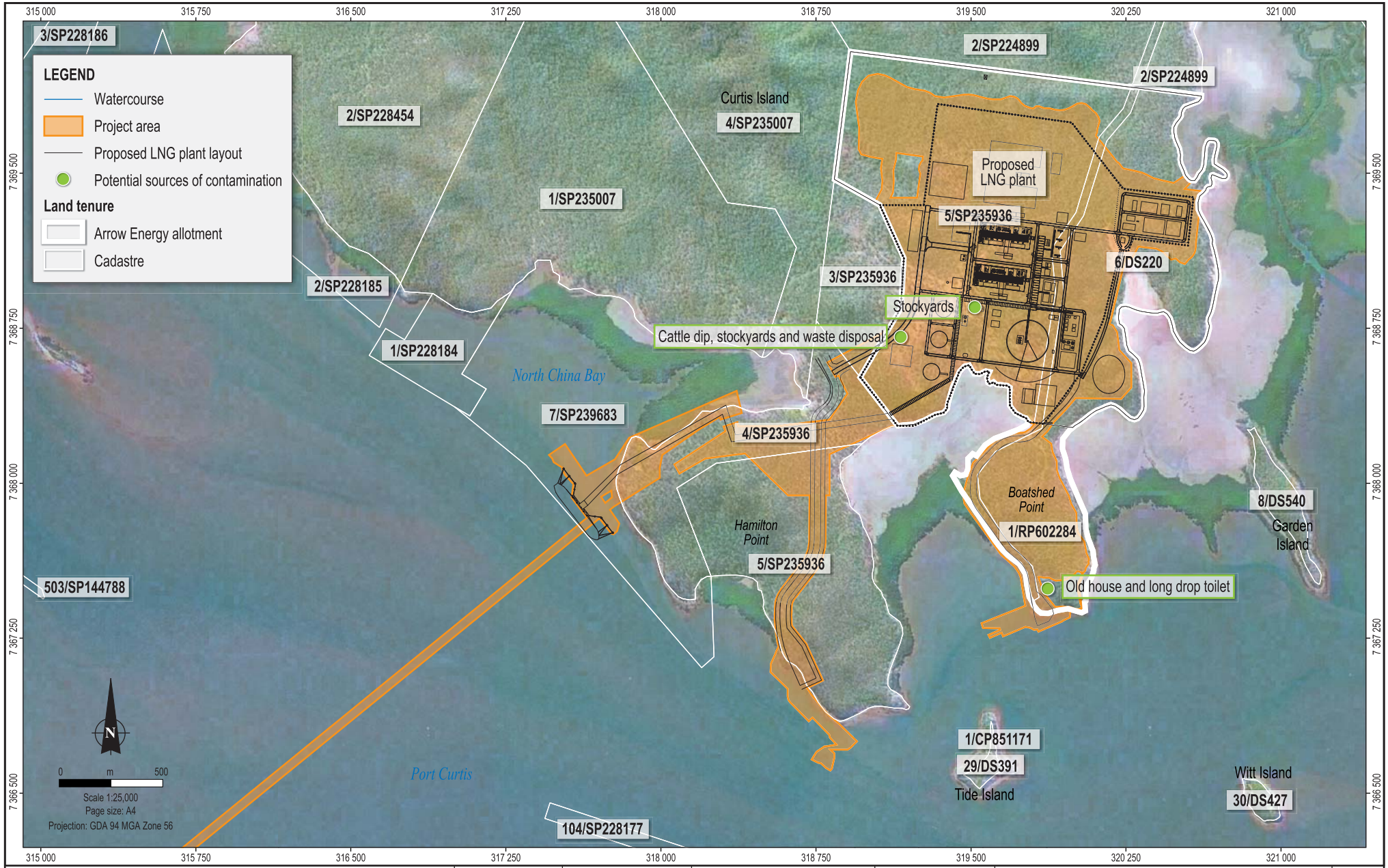
No evidence of stressed vegetation was observed in the vicinity of any infrastructure on the site.

In summary, features identified as sources of potential contamination at the LNG plant site on Curtis Island (Figure 12.2) and their associated potential contaminants of concern include:

- A former cattle dip containing scrap metal that may contain OCP/OPP and metals.
- Unauthorised onsite waste disposal (piles of scrap metal and other debris) that may contain metals, TPH, BTEX, OCP/OPP, PAH polychlorinated biphenyls (PCB) and asbestos.
- Two stockpiles of used batteries that may contain metals.
- Corroded storage drums that may contain volatile organic compound/volatile halogenated compound, TPH, BTEX, PAH, PCB and OCP/OPP.

Plate 12.1
Former cattle dip

Plate 12.2
Battery stockpiles



Source:
Place names and watercourses from DME.
Cadastre from DERM (May 2011).
Proposed LNG plant layout from Arrow Energy.
Potential contaminate sources and project area from Coffey Environments.
Imagery from SPOT (2004-2007).

coffey environments

Date: 17.11.2011
MXD: 7033CA_07_GIS175_v1_3
File Name: 7033_07_F12.02_GIS_GL

Arrow Energy

Arrow LNG Plant

arrow energy go further

Potential sources of contamination at the LNG plant site

Figure No: **12.2**

- Former waste disposal (landfill and septic systems) that may contain metals, TPH, BTEX, OCP/OPP, PCB, PAH, asbestos and microbiological contaminants.

Acid Sulfate Soils

Areas identified as likely to contain ASS on Curtis Island are identified in Table 12.4.

Table 12.4 Potential for acid sulfate soils on Curtis Island

Location	ASS Potential
LNG plant	Expected in soils below 5 m AHD. Available soil data showed 79% of samples with net acidity in excess of action criteria.
LNG loading lines	Expected on the lower part of the hillside slopes and some foreshore areas below 5 m AHD. Available soil data showed 80% of samples with net acidity in excess of action criteria.
Boatshed Point haul road	Expected in soils below 5 m AHD. Available soil data showed 90% of samples with net acidity in excess of action criteria.
Hamilton Point haul road	Unlikely. Sited on residual soils above 5 m AHD. Residual soils may contain non-sulfuric acidity.
Boatshed Point MOF and personnel jetty	Expected. Available soil data showed 60% of samples with net acidity in excess of action criteria.
LNG jetty	Expected. Available soil data showed 31% of samples with net acidity in excess of action criteria.
Hamilton Point MOF and personnel jetty	No data available.

Feed Gas Pipeline and Mainland Tunnel Entrance

The feed gas pipeline mainland tunnel entrance site comprises mudflats and mangrove marshland. No changes are apparent to the site between 1959 and the present day. The mudflats are bounded by mangroves and bushland to the north, east and west, and open to the waters of Port Curtis to the northeast.

Sources of contamination may include discharges of contaminants from surrounding industrial and agricultural land uses and overland flow during stormwater events. No onsite features were observed during the site visit; however, six abandoned car shells were present across the surrounding area.

Sources of potential hazardous contaminants for the feed gas pipeline mainland tunnel entrance include abandoned car bodies, other general waste and contaminated sediment from adjacent industrial land uses. Potential contaminants of concern associated with these features include metals, TPH, BTEX, OCP/OPP, PCB, PAH and asbestos.

ASS are likely to be present in areas below 5 m AHD, up to depths about 1.5 m below the surface of the mainland tunnel entrance. Available soil data showed that all samples had net acidity in excess of the action criteria. The pipeline tunnel is expected to run through rock under Port Curtis where ASS will not be present.

On Hamilton Point, ASS are likely to be present in areas below 5 m AHD along the feed gas pipeline alignment up to depths about 1.5 m below the surface. Deeper Holocene horizons are inferred in soil profiles in this area. The available soil data showed that 90% of samples had net acidity in excess of the action criteria.

TWAF 7

The TWAF 7 site was used as settling pond for fly ash by-products generated by the NRG Gladstone Power Station. Records show that in 1959 the site comprised mangrove marshland with some exposed soil in the centre of the lot. By 1989, ash settling ponds and an access road had been constructed on the southern half of the site. A power station was located 1.4 km to the west. Ash ponds extended to the northern half of the site by 2003. The capping of fly ash with soil appears to have taken place by 2003 for the southern portion of the site and, by 2007, for the northern half. In 2007, a small ash pond remained at the north of the site and some trees appeared to have been planted around the boundary.

The site visit identified TWAF 7 as a vacant lot of land with no onsite structures, storage facilities or disposal areas. The site is raised above the surrounding landscape and Auckland Creek; is covered by clay topsoil, grasses, shrubs and small trees; and is crossed by access roads. All runoff drains have been backfilled with rock except an operational drain to the northeast of the site. Discussions with a NRG Gladstone Power Station representative indicate that TWAF 7 is underlain with approximately 8 to 9 m of fly ash with a 100 to 200 mm thick clay topsoil capping. The settling ponds may or may not be lined. Areas to the north and west of TWAF 7 have been developed for industrial and commercial use, with residential properties to the east and parkland to the south. Auckland Creek borders the site on most sides.

Features identified as sources of potential hazardous contaminants for TWAF 7 include fly ash settling ponds. Potential contaminants of concern associated with this feature include TPH, PAH and metals. Any hydrocarbons present in the ash are expected to be strongly adsorbed to the particles and would only mobilise with the particle through erosion, dust or soil transport.

At the TWAF 7 site, ASS are likely to be present in natural soils below 5 m AHD. Soil samples show net acidity in excess of the action criteria. Naturally occurring soils at the edge of the site along Auckland Creek and at the entrance to the site may also contain ASS.

TWAF 8

The TWAF 8 site comprises vacant bush land. Historical site uses are unknown and, in 1959, this site was covered in native vegetation. A strip of cleared land along the western boundary was evident by 1965. Vegetation cover along the southern and northeastern boundary decreased between 1989 and 2003. The site is surrounded by farmland and rural residential properties. Overhead powerlines run north to south along Targinie Road.

No evidence of current or historical land uses was observed during the site visit. No features were identified as sources of potential hazardous contaminants, and no potential contaminants of concern were noted.

TWAF 8 is located above 20 m AHD, and no ASS has been identified.

Launch Site 1

In 1959, launch site 1 comprised mangrove marshlands and sand flats. By 1973, a road had been constructed along the western boundary. The southern portion of the site was developed as fly ash settling ponds for the Gladstone Power Station (1 km to the south) at this time. Ponds

extended to the northern portion of the site by 1999, and remained until present day. Raised road access was provided by 2003.

The site visit identified launch site 1 as a vacant lot with no onsite structures. An abandoned piece of earthmoving machinery was present in the centre of the site. Uncapped ash settling ponds were observed during the site walkover.

The RG Tanna Export Coal Terminal is located adjacent to launch site 1 to the northeast. The coal terminal (lot 210 on Plan SP120888) is listed on the EMR for the notifiable activity of petroleum product or oil storage. Coal dust could be deposited on launch site 1, given the transport and handling of significant quantities of coal at the terminal.

Onsite features identified as sources of potential hazardous contaminants include fly ash settling ponds and ASS. Offsite features that may act as potential contamination sources include the RG Tanna Export Coal Terminal. Potential contaminants of concern associated with ash ponds and airborne coal dust from the RG Tanna Export Coal Terminal include TPHs, PAHs and metals.

ASS may be present below 5 m AHD and are very likely below 2 m AHD. Soil samples show that net acidity exceeds the action criteria.

Launch Site 4N

Launch site 4N is located on the site of future land reclamation. The site is currently situated within the waters of Port Curtis. No features are identified as sources of potential hazardous contaminants at this site.

ASS are expected to be associated with the natural soils within the footprint of the site. Future soils will be of imported fill of unknown origin.

Dredge Sites

No features at the dredge sites are currently identified as sources of potential hazardous contaminants.

Quaternary period sediments consisting of both Holocene and Pleistocene geological units occur within the expected dredge footprint of all dredge site options. ASS is likely to occur within the marine and estuarine muds associated with Holocene sediments.

Soil samples indicate dredge sites 1 (launch site 1), 3 (Boatshed Point MOF) and 5 (LNG jetty) are likely to have ASS. Soil data from dredge site 4 (Hamilton Point MOF) indicates that the dredge footprint may not disturb ASS, with all samples tested deemed to be self neutralising. No data was available for dredge site 2 (launch site 4N).

12.3.4 Summary of Potential Sources of Contamination and Potential Contaminants of Concern

A summary of the potential sources of contamination and potential contaminants of concern identified at the sites are presented in Table 12.5 below.

Table 12.5 Potential sources of contamination and potential contaminants of concern

Site	Potential Source of Contamination	Potential Contaminants of Concern
LNG plant site	Former cattle dip, splashing/spraying/spills of pesticides.	OCP, OPP and metals.
	Existing onsite waste disposal – possible presence of lead, asbestos products, minor volumes of fuels, oils, paints, solvents and other regulated wastes.	Metals (particularly lead), TPH, BTEX, OCP/OPP, PCB, PAH and asbestos.
	Corroded storage drums.	Volatile organic compound/volatile halogenated compound, TPH, BTEX, PAH, PCB and OCP/OPP.
	Potential former waste disposal, landfill and septic systems at rural properties.	Metals, TPH, BTEX, OCP/OPP, PCB, PAH, asbestos and microbiological contaminants.
Mainland tunnel entry shaft and tunnel spoil disposal area	Abandoned car bodies and other waste and contaminated sediment from adjacent industrial land uses.	Metals, TPH, BTEX, OCP/OPP, PCB, PAH and asbestos.
TWAF 7, launch site 1	Ash from settling ponds.	TPH, PAH, metals and PCBs.
TWAF 8	None identified.	None identified.
Launch site 1	Airborne coal dust from RG Tanna Export Coal Terminal.	TPH, PAH and metals.

Notes:

TPH - total petroleum hydrocarbons
BTEX - benzene, toluene, ethylbenzene, xylenes
PAH - polycyclic aromatic hydrocarbons
OCP - organochlorine pesticides
OPP - organophosphorous pesticides
PCB - polychlorinated biphenyls

12.4 Issues and Potential Impacts

The risk of land contamination, ASS and acidic, non-acid sulfate soil disturbance as a result of project construction and operation is discussed in this section.

12.4.1 Contaminated Land

The proposed construction and operation activities within the LNG plant area will include those described within the Environmental Protection Act as notifiable activities, requiring listing on the EMR. Notifiable activities are likely to include petroleum product or oil storage, hazardous chemical storage and engine reconditioning workshops. All wastes generated on the LNG plant site will be collected, segregated, reused or removed from Curtis Island for appropriate recycling or disposal.

Potential impacts from contamination may be associated with the general construction or operation of the project and include:

- Unidentified contaminated soils encountered during earthworks, which could lead to contamination being spread across the site, impacting environmental receptors or being removed from site in an uncontrolled manner.
- Putrescible wastes generated at the LNG plant site, launch sites and TWAF sites during construction. Poor waste storage or disposal could result in uncontrolled release of leachate from construction waste, and general waste at construction camps.
- Chemicals and fuel stored and used at the plant site, launch sites, TWAF sites, mainland tunnel entrance and Hamilton Point tunnel reception shaft during construction. Poor storage or

handling of chemicals and fuel would have the potential to result in uncontrolled releases that may cause contamination of soil and groundwater.

- Fires involving chemicals and fuels, as well as other engineered materials and liquids. This could result in significant land contamination.

In the event that groundwater dewatering is required during construction, discharge of the extracted water may affect soil and surface water chemistry.

As a result of leaks or spills during hydrostatic testing, hydrotest water may acquire contaminants from pipelines and soil contamination. Hydrostatic test water will be obtained from the sea and discharged to the sea, or from freshwater which may be generated through a reverse osmosis plant, or piped, or barged from the mainland. If biocides or oxygen scavengers are used, the hydrostatic test water will be treated before discharge to the sea; therefore disposal of hydrotest will not be a potential source of contamination. Hydrostatic test water would only potentially affect areas adjacent to the pipelines being tested (LNG plant site, tunnel entry site and the feed gas pipeline between them).

Prior to construction, fill material will be imported for land reclamation at launch site 4N by Gladstone Ports Corporation, as part of the Western Basin Dredging and Disposal Project. This imported fill could potentially contain contaminants of concern including TPH, BTEX, PAH, metals, OCP/OPP, PCB and asbestos.

Putrescible wastes will be generated at the plant site during operation. Uncontrolled releases of waste and leachate from waste have the potential to cause contamination of onsite and offsite soils, surface water and groundwater.

- Chemicals and fuel will be stored and used at the plant site during operation. Uncontrolled releases of chemicals and fuel have the potential to cause contamination of soil, surface water and groundwater.
- Fires and other emergency releases involving chemicals and fuels, as well as other engineered materials and liquids, have the potential to cause contamination of soil, surface water and groundwater.

Given the proposed waste management, construction and operational controls to be established for the project, the risk of significant land contamination occurring is considered low; therefore potential impacts are low. Management practices to be employed for the generation, storage and disposal of waste are discussed in Chapter 31, Waste Management.

Table 12.6 presents the risk assessment carried out for the project. The risks summarise exposure pathways that may be present during the construction, operation and decommissioning of the project for potential sources of contaminants identified in the study area.

Table 12.6 Contamination risk assessment

Source	Potential Event	Receptor	Consequence	Likelihood	Risk
All project areas					
Pre-existing contamination not previously identified	Contamination of soil and groundwater, causing environmental impact.	Onsite workers and environmental receptors.	Moderate	Unlikely	Low
LNG Plant on Curtis Island					
Former cattle dip	Construction activities disturbing contaminated area, leading to greater area of impact.	Onsite workers and environmental receptors.	Moderate	Possible	Moderate
	Impact on surface water bodies.	Environmental receptors.	Moderate	Possible	Moderate
Existing onsite waste disposal (possible presence of asbestos products, minor volumes of fuels, oils, paints, solvents and other regulated wastes)	Exposure of workers to asbestos and other contaminants.	Onsite workers.	Moderate	Unlikely	Low
	Construction activities disturbing contaminated area, leading to greater area of impact.	Environmental receptors.	Moderate	Unlikely	Low
Corroded storage drums	Contact with contaminated soil.	Onsite workers.	Moderate	Unlikely	Low
	Construction activities disturbing contaminated area, leading to greater area of impact.	Environmental receptors.	Moderate	Unlikely	Low
Waste battery stockpiles	Construction activities disturbing contaminated area, leading to greater area of impact.	Onsite workers and environmental receptors.	Moderate	Possible	Moderate
	Impact to surface water bodies.	Onsite workers and environmental receptors.	Moderate	Possible	Moderate
Potential former waste disposal (landfill and septic systems at rural properties)	Exposure of workers to asbestos and other contaminants.	Onsite workers.	Moderate	Unlikely	Low
	Construction activities disturbing contaminated area, leading to greater area of impact.	Onsite workers and environmental receptors	Moderate	Unlikely	Low
Potential unidentified existing livestock dip/spray race operations	Exposure of contaminants and disturbance of impacted material.	Onsite workers and environmental receptors.	Moderate	Unlikely	Low
Waste storage (putrescible waste and leachate)	Contamination of soil and groundwater, causing environmental impact.	Environmental receptors.	Low	Unlikely	Low
Future chemicals and fuel use or storage	Contamination of soil and groundwater, causing environmental impact due to leaks, spills or pipe or tank failures.	Environmental receptors.	Moderate	Possible	Moderate

Table 12.6 Contamination risk assessment (cont'd)

Source	Potential Event	Receptor	Consequence	Likelihood	Risk
LNG Plant on Curtis Island (cont'd)					
Fires and emergency releases of hazardous materials	Emergency event or failure of plant/equipment, resulting in the release of a contaminant.	Onsite workers and environmental receptors.	Significant	Unlikely	Moderate
Groundwater disposal	Release of groundwater to surface waters, affecting soil and surface water chemistry.	Environmental receptors.	Low	Unlikely	Low
Hydrotest water	Contamination of soil, groundwater or surface waters due to leaking of hydrotest water.	Environmental receptors.	Moderate	Unlikely	Low
Disposal of treated effluent through irrigation	Contamination of soils from contaminated effluent.	Environmental receptors.	Low	Unlikely	Low
Mainland Tunnel Entry Shaft and Tunnel Spoil Disposal Area					
Abandoned cars on mudflats	Disturbance of impacted material.	Onsite workers and environmental receptors.	Low	Unlikely	Low
TWAF 7					
Ash from settling ponds	Exposure of contaminated buried ash during construction.	Onsite workers.	Low	Possible	Moderate
	Migration of exposed ash with surface water runoff.	Environmental receptors (Auckland Creek).	Low	Possible	Moderate
	Airborne migration of exposed ash.	Onsite workers, environmental receptors and general public.	Low	Possible	Moderate
Waste storage (putrescible waste and leachate)	Contamination of soil and groundwater, causing environmental impact.	Environmental receptors.	Low	Unlikely	Low
Launch Site 4N					
Imported fill material for land reclamation	Contact with contaminated soil.	Onsite workers.	Moderate	Unlikely	Low
	Mobilisation of potentially contaminated fill material due to construction and operational activities.	Onsite workers and environmental receptors.	Moderate	Unlikely	Low
Future chemicals and fuel use or storage	Contamination of soil and groundwater, causing environmental impact due to leaks, spills or pipe or tank failures.	Environmental receptors.	Moderate	Unlikely	Low

Table 12.6 Contamination risk assessment (cont'd)

Source	Potential Event	Receptor	Consequence	Likelihood	Risk
Launch Site 1					
Ash from settling ponds	Exposure to ash during construction.	Onsite workers.	Low	Possible	Moderate
	Mobilisation of ash with surface water runoff.	Environmental receptors (Calliope River, Port Curtis and Auckland Inlet).	Low	Possible	Moderate
	Mobilisation of ash via airborne dust.	Environmental receptors, onsite workers and general public.	Low	Possible	Moderate
Contaminated dredge spoil	Disturbance and mobilisation of impacted marine sediments due to dredging activities.	Environmental receptors (Gladstone Harbour and associated ecosystems).	Moderate	Unlikely	Low
Coal dust from adjacent coal terminal	Disturbance of accumulated coal dust, causing the generation of particulate emissions.	Environmental receptors, onsite workers and surrounding land users.	Moderate	Unlikely	Low
	Exposure to contaminants within the coal dust (polycyclic aromatic hydrocarbons and metals) during construction).	Onsite workers.	Moderate	Unlikely	Low
Imported fill material for land reclamation	Contact with contaminated soil.	Onsite workers.	Moderate	Unlikely	Low
	Mobilisation of potentially contaminated fill material due to construction and operational activities.	Environmental receptors.	Moderate	Unlikely	Low
Chemicals and fuel use or storage	Contamination of soil and groundwater causing environmental impact due to leaks, spills and/or pipe or tank failures.	Environmental receptors.	Moderate	Unlikely	Low

The assessment identified five sources of contamination that presented a potential risk level of **moderate** as follows:

- Former cattle dip (LNG plant). Construction of the LNG plant will disturb the former cattle dip. Construction activities may spread contamination into a greater area of impact, which would affect onsite workers and environmental receptors, including surface water.
- Waste battery stockpiles (LNG plant). Construction of the LNG plant will disturb the battery stockpiles. This may spread contamination into a greater area, exposing onsite workers and environmental receptors, including surface water.
- Ash from settling ponds (TWAF 7 and launch site 1). Construction will disturb the fly ash settling ponds on TWAF 7 and launch site 1, potentially exposing workers to fly ash (which may also be mobilised with surface water runoff or as airborne dust).
- Chemicals and fuel use or storage (LNG plant and TWAF). Poor storage or handling of chemicals and fuel may result in uncontrolled releases, which may contaminate onsite and offsite environmental receptors (soil, surface water and groundwater).
- Fires and emergency releases of hazardous materials (all sites). Fires and emergency releases of chemicals and fuels may contaminate soil, surface water and groundwater, and cause exposure to onsite workers.

12.4.2 Acid Sulfate Soils

Pyrite oxidises when exposed to oxygen and forms sulfuric acid when combined with water. Sulfuric acid can leach out of affected soils and mobilise through surface waters and groundwater. Impacts on water and soils include a lowering of pH, increased mobilisation of metals from the soil, and the stripping of natural neutralising capacity.

These processes can lead to degradation of terrestrial flora through stunting of root growth; toxication from excess aluminium, iron and manganese; deficiency of plant minerals and nutrients; and reduced resistance to pathogen attacks. Soil sterility can occur where acid reduces or removes nitrogen fixation from soil microorganisms. Long term impacts may include species die off and changes in vegetation cover, resulting in altered vegetation assemblages dominated by more acid tolerant species.

The following project activities have been identified as potentially impacting to ASS. The quantum of disturbance has been expressed as the disturbed area in square metres for surface disturbances (e.g., traffic movements or filling), and cubic metres for excavations (representing total soil volume).

Excavation

Excavation of soils can place ASS into aerobic conditions, potentially exposing pyrite to oxygen and water, and promoting formation of sulfuric acid. Any excavation of soils below 5 m AHD has the potential to expose ASS.

Construction activities that have the potential to disturb ASS through excavation are identified in Table 12.7.

Table 12.7 Excavations with potential to disturb acid sulfate soils

Location	Construction Activities	Approximate Volume Soil Disturbed
LNG plant site	Bulk and civil excavation of topsoil (stripped to a depth of 200 mm).	24,000 m^3
Feed gas pipeline - Curtis Island	Trenching.	12,000 m^3
Boatshed Point or Hamilton Point	Topsoil stripping for the haul road.	4,000 m^3
LNG jetty	Mucking out of anchored piles and tension piles.	500m^3
MOF	Topsoil stripping to a depth of 300 mm. Mucking out of anchored piles and tension piles.	3,000 m^3 100 m^3
Personnel jetty	Topsoil stripping. Mucking out of anchored piles and tension piles.	300m^3 10m^3
Launch site 1	Trenching for civil works. Mucking out of tension piles.	2,000m^3 100m^3
Mainland tunnel entrance	Excavation.	1200m^3
TWAF 7	High level footing excavation. Trenching.	3,000m^3 6,00m^3

Filling (Consolidation of Subsoils)

ASS are generally low strength soils so placement of loads in the form of fill or structures on affected areas can result in consolidation of material. Consolidation involves a reduction of soil permeability and expulsion of water, which can be acidic, from pores within the soil matrix. If acidic water is mobilised into the surrounding environment, it can lead to acidification and corrode susceptible items of infrastructure.

Construction activities that have the potential to disturb ASS include filling of 20,000 m^2 over natural soils on TWAF 7 and filling 70,000 m^3 between pile enclosures at the MOF.

Load (Shear Failure and Heaving)

The presence of embankments and structures can create loads on underlying soils that may result in shear failure of the underlying soils and upward heave of soils adjacent to the load. Holocene deposits with high levels of acid generating potential are of low strength; therefore they are likely to fail and shear, creating upward heave of adjacent soils. This may raise potential ASS into aerobic conditions above the water level, promoting the development of sulfuric acid.

During construction, load impacts are expected on approximately 100 m^3 of unconsolidated soil at TWAF 7.

Surface Disturbances

Various project activities such as land clearance and traffic movements can disturb soils and lead to direct contact of ASS with air. Where ASS occur at or near the surface (i.e., supratidal flats), these disturbances can potentially increase pyritic soil material oxidation rates, leading to acid generation. ASS soils are likely to occur on the surface at elevations below 2.5 m AHD.

Construction activities have the potential to disturb ASS through surface disturbances at the following locations:

- LNG plant (3,000 m^2).

- Haul roads on Curtis Island (3,000 m^2).
- LNG jetty (2,000 m^2).
- Reception shaft on Curtis Island (600 m^2).
- MOF (2,000 m^2).
- Personnel jetty (2,000 m^2).
- Feed gas pipeline tunnel entrance (200 m^2).
- TWAF 7 (200 m^2).

Disturbance will also occur from construction of the access road to TWAF 7.

Dewatering

Dewatering may lower the groundwater level within the cone of groundwater depression, which can expose subsurface ASS to oxygen. Exposure of these soils can result in the oxidation of pyrite, producing sulfuric acid. The resulting reduction of pH can promote an increase in the solubility of some metals within the groundwater, causing an acidic discharge with elevated metal concentrations. Increased metal concentrations may pose a risk to groundwater receptors and influence offsite impacts.

Construction activities that have the potential to disturb ASS through dewatering include trenching or tunnelling of the following material:

- LNG loading lines and feed gas pipeline on Curtis Island (10,000 m^2).
- Feed gas pipeline mainland tunnel entrance (4,000 m^2).
- Feed gas pipeline recieval shaft (5,000 m^2).

Dewatering within piles at the MOF is not expected to disturb in situ ASS, as dewatering will be undertaken below LAT (i.e., dewatering will not result in a cone of depression).

Dredging

Dredging may expose ASS to oxygenated waters or air (if dredge material is not kept saturated throughout the dredge process, or it is stored in an aerobic condition after dredging). Dredged material released into water through unmanaged dredge overflow can also distribute ASS. Dredging activities at dredge site 1 (900,000 m^3), dredge site 3 (50,000 m^3) and dredge site 5 (120,000 m^3) have the potential to disturb ASS (note that dredge volumes are indicative at this stage). The presence of ASS at dredge site 4 is unknown.

ASS Treatment Category

The ASS assessment (carried out under the SPP 2/02 guidelines) indicates that the project is classed in the extra high treatment category. This category applies where in excess of 25 t of lime are required to manage the ASS likely to be disturbed during construction.

12.4.3 Acidic, Non-acid Sulfate Soils

Acidic, non-acid sulfate soils can occur in residual soils that are underlain by ASS, as some pyritic materials can migrate into the upper soil profile. These soils commonly contain low to moderate levels of acidity that is non-sulfuric, and less harmful and less mobile than the products of ASS. The local environment is adapted to these soils in their undisturbed condition. Excavation and placement of these soils in conditions with increased rates of soil drainage could facilitate the release of acidic leachates. If soils of this nature exist at the LNG plant site, they are likely to be cut from above 5 m AHD and used as fill for construction.

Construction activities that may disturb acidic, non-acid sulfate soils, if present, include:

- Structural fill requirements for construction of the LNG plant (will disturb an estimated 3,000,000 m^3 of soil).
- Structure fill requirements for the haul road on Curtis Island (will disturb an estimated 10,000 m^3 of soil).
- Development of on-land infrastructure at the LNG jetty (will disturb an estimated 4,000 m^3 of soil).
- Backfill pile enclosure with residual soils at the MOF (will disturb an estimated 70,000 m^3 of soil).
- Backfill with residual soils at the personnel jetty (will disturb an estimated 7,000 m^3 of soil).

12.5 Avoidance, Mitigation and Management Measures

Avoidance, mitigation and management measures for contaminated land and ASS are discussed below.

12.5.1 Contaminated Land

Prior to construction, the extent of contamination will be further defined where required, and mitigation measures will be refined as appropriate. [C12.01] Appropriate personal protective equipment will be used by construction workers in areas of known contamination during construction activities.

Mitigation measures have been identified for moderate risks only (as identified in the risk assessment and based on the desktop study and preliminary field investigations). If disturbance of potentially contaminating areas of the sites cannot be avoided, or contaminated areas present an unacceptable ongoing risk to the environment, the following mitigation measures will be employed:

- Former cattle dip:
  - Undertake additional assessment of the area of potential contamination and develop management or remediation via a DERM-accepted method. Validate the impacted area as per the draft guidelines for the assessment and management of contaminated land in Queensland 1998 (DoE, 1998) and national environment protection (assessment of site contamination) measure (NEPC, 1999). [C12.02]
  - Remove livestock dip and spray race structure. [C12.03]
  - Manage or, where possible, remediate impacted soil and groundwater in accordance with current Queensland and national guidelines. [C12.04]
- Ash in settling ponds:
  - Undertake stage 2 assessment of ash to determine contamination status. [C12.05]
  - Where practical, avoid disturbance of buried ash during construction. [C12.06]
  - Establish effective management methods for disturbed ash during construction activities including erosion and sediment controls and dust suppression. Use of appropriate personal protective equipment will be required. [C12.07]
  - Place suitable capping material and develop a site management plan if required. [C12.08]
- Waste battery stockpiles:
  - Remove batteries from site for recycling. [C12.09]
  - Undertake shallow surface soil validation sampling. [C12.10]
- Chemicals and fuel use or storage:

  - Construct facilities in accordance with current Australian standards. [C12.11]
  - Appropriately train staff in the use of hazardous materials. [C12.12]
  - Immediately clean up any spills and conduct investigations into any relevant releases. [C12.13]

- Fires and emergency releases of hazardous materials:
  - Provide emergency response training to staff handling dangerous goods. [C12.14]
  - Construct facilities and spill containment in accordance with current Australian standards. [C12.15]
  - Regularly inspect infrastructure using or storing hazardous materials, or test for integrity. [C12.16]

Management and remediation strategies will be required if construction activities disturb contaminated areas. The extent of mitigation and management will depend upon the nature and extent of contamination identified, but may include removal of the source of contamination, treatment or removal of contaminated soil, and collection of validation samples of the remaining soils to confirm that hazardous materials have been removed. Any remediation works will be informed by site assessments that characterise the nature and extent of contamination present. Following remediation works, sites will be validated to ensure that the contamination status of the site does not present unacceptable risks or potential impacts to human health and the environment.

Decommissioning and rehabilitation of disturbance areas will be undertaken to maintain the smallest practical project footprint. Decommissioning and rehabilitation works will include a contaminated land investigation undertaken in accordance with the relevant legislation and guidelines at the time. Areas of contamination that have resulted from the project will be remediated to a level that protects human health and the environment. [C12.18]

12.5.2 Acid Sulfate Soils

Additional site-specific ASS investigations for all project sites below 5 m AHD will be required prior to construction to facilitate quantitative risk assessments and the development of an ASS management plan. The ASS management plan will be developed prior to construction work. The plan will specify how onsite ASS disturbances should be managed in accordance with SPP 2/02 and the methods set out in Queensland acid sulfate soil technical manual soil management guidelines (Dear et al., 2002). [C12.17]

The management strategies included in the ASS management plan will broadly include:

- Excavation. The extent of excavations required will be minimised by using design and build methods such as filling over rather than excavating, tunnelling (where practical) and replacing and maintaining surface integrity prior to fill placement in ASS areas. Where excavation of ASS cannot be avoided, adequate and appropriate disposal, or neutralisation of excavated soils, will be carried out in accordance with guidelines established in the ASS management plan.

- Dredging. Further assessment of impacts on ASS at dredging locations will be undertaken prior to construction. The ASS management plan and dredge management plan will set out measures to manage the impacts of ASS in these areas.

- Filling. Measures will be developed for any areas of fill overlying ASS. This will ensure acidic groundwater that may migrate from under the fill area is neutralised to levels defined in the approved ASS management plan, which will include a factor of safety.

- Load. Heave shall be prevented by appropriate design and construction methods based on the soil strength parameters determined during geotechnical investigations. If the design reveals soil improvement techniques are required to stabilise embankment slopes, neutralising materials such as lime will be used.
- Surface disturbances. Local traffic will be restricted where ASS are identified. Any disturbed areas will be treated with neutralising materials such as lime to restrict the acidification of disturbed surfaces, as appropriate.
- Dewatering. Dewatering activities will be managed and monitored to ensure that groundwater quality is not affected by the disturbance of ASS.

12.5.3 Acidic, Non-acid Sulfate Soils

Acidic, non-acid sulfate soils will be treated in accordance with processes described in the ASS management plan. The treatment methods may include neutralising soils to prevent generation of acidic groundwater, or installing barriers to neutralise mobilised acidic groundwater.

12.6 Residual Impacts

Residual risk is the ranking assigned to the potential risk of contamination following implementation of the identified mitigation measures. The potential contaminated land risks to human health and the environment were identified to be between low and moderate prior to implementation of appropriate mitigation measures. Moderate risks were associated with an existing cattle dip, existing battery stockpiles, future storage of hazardous materials, future emergency responses, and historic ash disposal areas. The level of potential risk will be reduced at project sites through the implementation of appropriate mitigation measures.

In the areas of existing identified moderate contamination risk, mitigation measures may include characterisation and quantification of contaminated material, remediation/validation, qualitative risk assessment or implementation of appropriate management controls. Risk associated with assessment or remediation works on known contaminated sites (which many cause impacts to human health or the environment from spills and disturbance of contaminated material) is expected to be low.

The mitigation measures are designed to reduce the potential risk associated with contamination. This will be achieved by demonstrating the contamination does not pose a reasonable risk to human health and the environment, removing the contamination risk through remediation or implementing engineering controls and management procedures that eliminate complete exposure pathways.

The assessment of residual impacts on ASS assumes that all recommendations for the management and mitigation of impacts, including the need for additional investigations, are implemented successfully. On this basis, the residual impacts are low and adverse environmental impacts are not likely to occur during construction.

12.7 Inspection and Monitoring

Inspection and monitoring programs will be designed to meet the ongoing requirements of any managed contaminated sites where engineering or procedural controls are implemented. Inspection and monitoring requirements will be detailed in management plans and may include:

- Inspection of engineering controls such as surface seals/capping layers.
- Monitoring of surface and groundwater.

- Monitoring of sediment within drainage lines.

The ASS monitoring, reporting and auditing regime will be detailed in the ASS management plan in accordance with SPP 2/02.

12.8 Commitments

The measures (commitments) that Arrow Energy will implement to manage impacts on geology, landform and soils are set out in Table 12.8.

Table 12.8 Commitments: Land contamination and acid sulfate soils

No.	Commitment
C12.01	Prior to construction, the extent of contamination will be further defined where required, and mitigation measures will be refined as appropriate.
C12.02	Former cattle dip: Undertake additional assessment of the area of potential contamination and develop management or remediation via a DERM-accepted method. Validate the impacted area as per the draft guidelines for the assessment and management of contaminated land in Queensland 1998 (DoE, 1998) and national environment protection (assessment of site contamination) measure (NEPC, 1999).
C12.03	Former cattle dip: Remove livestock dip and spray race structure.
C12.04	Former cattle dip: Manage or remediate impacted soil and groundwater in accordance with current Queensland and national guidelines.
C12.05	Ash in settling ponds: Undertake Stage 2 assessment of ash to determine contamination status.
C12.06	Ash in settling ponds: Where practical, avoid disturbance of buried ash during construction.
C12.07	Ash in settling ponds: Establish effective management methods for disturbed ash during construction activities including erosion and sediment controls and dust suppression. Use of appropriate personal protective equipment will be required.
C12.08	Ash in settling ponds: Place suitable capping material and develop a site management plan if required.
C12.09	Waste battery stockpiles: Remove batteries from site for recycling.
C12.10	Waste battery stockpiles: Undertake shallow surface soil validation sampling.
C12.11	Chemicals and fuel use or storage: Construct facilities in accordance with relevant Australian standards.
C12.12	Chemicals and fuel use or storage: Appropriately train staff in the use of hazardous materials.
C12.13	Future chemicals and fuel use or storage: Immediately clean up any spills and conduct investigations into any relevant releases.
C12.14	Fires and emergency releases of hazardous materials: Provide emergency response training to staff handling dangerous goods.
C12.15	Fires and emergency releases of hazardous materials: Construct facilities and spill containment in accordance with current Australian standards.
C12.16	Fires and emergency releases of hazardous materials: Regularly inspect infrastructure using or storing hazardous materials, or test for integrity.
C12.17	Develop an ASS management plan prior to construction work. In the plan, specify how onsite ASS disturbances should be managed in accordance with SPP2/02 and the methods set out in Queensland acid sulfate soil technical manual soil management guidelines (Dear et al., 2002). Common with Chapter 14, Groundwater.
C12.18	Remediate areas of contamination that have resulted from the project to a level that protects human health and the environment.