Geology, Soils and Geotechnical

CHAPTER 11

11.1 Introduction

The purpose of this chapter is to identify and assess the potential impacts on geology and soils in the Project Area, arising from the construction and operation of the BGC Project.

The assessment for the Project Area has been based on a number of studies carried out in recent years in the area.

A more detailed assessment has been carried out for the proposed GTP site, located on the BIP, for which the description of the geology and the assessment of sediment, soil and geotechnical issues are based in part on the geotechnical field investigation and contamination assessment undertaken at the GTP site. These reports are *Report on Geotechnical Investigation: Orica GTP* (Douglas Partners, 2004) and *ENV 2949 – Analytical Report* (SGS, 2004).

11.2 Methodology

11.2.1 Geotechnical Investigations at the GTP Site

Geotechnical investigations at the GTP site were undertaken to provide information on the subsurface conditions for the design of new foundations for the GTP.

The work comprised nine cone penetration tests (CPTs) to develop the subsoil profile of the site.

In addition, SGS (an independent analytical laboratory) carried out soil sampling at nine nominated locations on the GTP site, as shown in **Figure 11.1**. Samples were collected at depths of 0.5 m and 1.0 m and analysed to understand the level of contamination. Samples were analysed for arsenic, cadmium, chromium, copper, lead, mercury, nickel, sulphide and total petroleum hydrocarbons (TPH). Soils were also tested for contamination by volatile and semi-volatile CHCs.

Any evidence indicating the presence of Acid Sulphate Soils (ASS) was also noted.

11.2.2 Desk-Top Assessment

The assessment for the other works has largely been based on various other studies carried out in recent years in the area, addressing various geotechnical and soil contamination issues. These include:

- *ICI Botany Groundwater Stage 1 Survey* (AG Environmental Engineers, 1990)
- *ICI Botany Groundwater Stage 2 Survey* (Woodward-Clyde, August 1996)
- *ICI Botany Groundwater Stage 3 Survey* (Woodward-Clyde, August 1998)
- *Environmental Impact Assessment Document for Botany Groundwater Remediation Project – Phase 2* (Orica Australia, April 2004)
- *Environmental Impact Assessment Document for Botany Groundwater Remediation Project – Phase 4* (Orica Australia, August 2004).

11.3 Existing Environment

11.3.1 Landscape and Topography

The Project Area is located within an area of former sand dunes and coastal swamps within the Botany Basin. The elevation of the area drops from approximately 20 m above sea level on the north-eastern boundary of the BIP to less than 5 m above sea level on the south-western boundary, and to sea level at Foreshore Beach and Penrhyn Estuary south of the SCA.

Natural drainage of the area is via two drains:

- Springvale Drain, whose catchment drains the low lying areas to the east (including the BIP), including domestic underground stormwater drains from as far afield as Maroubra, for discharge into the eastern side of Penrhyn Estuary; and
- Floodvale Drain, whose catchment includes several kilometres of domestic stormwater drains around east Botany, drains the low lying areas to the west, for discharge into the middle of Penrhyn Estuary.

The shoreline down-gradient of the SCA has been extensively previously modified to accommodate industrial, port and airport facilities, and the identified features have been developed from these works, including:

- Foreshore Beach: A sandy beach approximately 1.6 km long, constructed from sand dredged from Botany Bay in the late 1970s; and
- Penrhyn Estuary: A shallow, intertidal inlet at the south-eastern end of Foreshore Beach, formed in the late 1970s by construction of the existing facilities at Port Botany.

In addition, Bunnerong Canal drains stormwater via Bunnerong Creek from a small catchment that contains portions of the suburbs of Matraville, Malabar, Maroubra and Chifley within the Randwick City Council LGA.

Much of the Project Area has been built upon, with a range of industrial, commercial and infrastructure developments. The two principal undeveloped areas are:

- Botany Golf Course, within Banksmeadow Park, which originally comprised deep gullies, hills and undergrowth and was subsequently improved through deposition of spoil from the construction of Bunnerong Power Station; and
- Southlands, the undeveloped blocks of land just west of the BIP, as previously described.

11.3.2 Regional Geology

The Project Area lies within the Botany Basin, an 80 km^2 sub unit of the Sydney Basin. The Botany Basin is bounded by Centennial Park to the north, Randwick and Matraville to the east, Alexandria and Rockdale to the west, and the Kurnell Peninsula and part of the Sutherland Shire to the south.

According to the *1:100,000 Sydney Region Geological Map* (Geological Survey of New South Wales, 1983) the regional geology around the area consists of bedrock of Triassic Hawkesbury Sandstone overlain by Quaternary sediments. The Hawkesbury Sandstone consists predominantly of crossbedded, medium to coarse quartz sand and resists weathering to crop out as prominent headlands that create Sydney's distinctive steep foreshores and rocky islands. Thin, steeply dipping Jurassic basaltic dykes, trending approximately east–west, have intruded the Hawkesbury Sandstone to the north of Penrhyn Estuary. There are no known geological faults within the Project Area.

Quaternary sediments (up to 80 m thick) have infilled drowned river valleys incised into Hawkesbury Sandstone bedrock. These sediments, otherwise known as the Botany Sands, are composed of predominantly unconsolidated to semi-consolidated permeable sands. These are interspersed with lenses and layers of peat, peaty sands, silts and clay (low permeability), which become more common in the lower part of the sequence. Hard iron cemented sand layers, locally referred to as "Waterloo Rock", are common in the upper layers of the formation.

11.3.3 GTP Site

The GTP site is predominantly covered in asphalt pavement with some areas of concrete hardstanding. The site was previously the location of the Silicates Plant, which was largely demolished in 2000. Concrete footings from that plant are still present on site. Prior to that, the site was used for the air drying of lime, and residues are expected to remain under the old foundations.

Asphaltic concrete pavements cover a large proportion of the site. Grassed and gravel covered areas are located over the western and southern portions of the site. A raised platform area about 1 m high is located in the central portion of the site, and a demountable building and brick substation are located close to the northern boundary of the site. Remains of old footings and steel structures are located within the southern portion of the site. Driveways extend into the site from 10th Avenue and 2nd Street and are connected by an internal asphaltic concrete roadway.

Geology

The geology at the proposed site is as described for the regional geology, underlain by Quaternary age sediments (Botany Sands) which overlie the Hawkesbury Sandstone bedrock at significant depth. The Botany Sands comprise predominantly unconsolidated to semi-consolidated permeable sands, with layers and lenses of alluvial material such as peat, peaty sands, silts and low permeability clays.

Hawkesbury Sandstone is a medium to very coarse grained quartz sandstone with minor laminated mudstone and siltstone lenses. Previous studies suggest that the depth to bedrock at the BIP site ranges between approximately 20 m and 40 m.

The results of the CPTs showed the following typical conditions over the site:

- Filling generally comprised poorly to moderately compacted gravelly sand, clayey sand or sandy clay extending to depths between 0.86 m and 3.46 m.
- Sand/silty sand underlying the filling are assessed to be generally medium dense to dense grading, to very dense at depths between 2.6 m and 4.0 m. Some medium dense to dense layers were encountered within the very dense sand/silty sand profile. There were also thin, hard clay bands at about 7.5 m depth in some locations.

Groundwater levels were measured at depths between 0.8 m and 2.3 m.

Soil

Results of the soils testing are presented in **Tables 11.1, 11.2 and 11.3**. The contaminant concentrations have been compared against appropriate local standards. Where no local standard is applicable, international standards have been applied.

Table 11.1 Metals, sulphide and moisture content in soil

Component	Units	NEPC HIL F (mg/kg)*	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9
Arsenic	mg/kg	500	<3	<3	<3	<3	<3	<3	<3	<3	<3
Cadmium	mg/kg	100	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium	mg/kg	500	2	5	5	5	14	11	13	13	7
Copper	mg/kg	5000	1.0	4	4	5	11	11	6	5	6
Lead	mg/kg	1500	6	26	14	20	27	36	28	14	25
Mercury	mg/kg	75	0.28	1.1	0.62	0.90	0.40	0.57	0.22	0.13	0.78
Nickel	mg/kg	3000	0.8	3	5	3	15	11	7	7	3
Zinc	mg/kg	35000	18	49	18	25	83	92	42	36	30
Sulphide	% w/w	-	<0.005	<0.005	0.010	0.007	0.014	0.006	0.010	<0.005	0.014
Moisture	%	-	16	14	8.8	10	6.2	6.6	8.8	5.9	15

* National Environment Protection Council, National Environment Protection (Assessment of Site Contamination) Measure 1999, Schedule B (1) – Table 5.A Health Investigation Level (HIL) F

Table 11.2 Total recoverable petroleum hydrocarbons in soil

Component	Units	NSW DEC Threshold Conc (mg/kg)*	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9
TPH C_6-C_9	mg/Kg	65	<20	<20	<20	<20	<20	<20	<20	<20	<20
TPH C_{10}-C_{14}	mg/Kg	1000**	<20	<20	<20	<20	<20	<20	<20	<20	<20
TPH C_{15}-C_{28}	mg/Kg		<50	<50	<50	<50	84	55	<50	<50	<50
TPH C_{29}-C_{36}	mg/Kg		<50	<50	<50	<50	68	53	<50	<50	<50

* NSW DEC (formerly EPA) Service station sites: assessment and remediation 2002, Table 3. Threshold concentrations for sensitive land use: soils.

** Sum of TPH C10 to C40

TPH = Total Petroleum Hydrocarbon

Table 11.3 Semi-volatile chlorinated hydrocarbons in soil

Component	Units	USEPA Region 9 PRG (mg/kg)*	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9
Hexachloroethane	mg/Kg	120	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,2,4-Trichlorobenzene	mg/Kg	3000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Hexachloro-1,3-butadiene	mg/Kg	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1,2,4,5-Tetrachlorobenzene	mg/Kg	180	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pentachlorobenzene	mg/Kg	490	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	0.1	<0.1

* US EPA Region 9 Preliminary remediation Goals 2002, Industrial Soil

11.3.4 The Project Area

Geology and Soils

The stratigraphy of the other works areas has been assessed in the studies listed in **Section 11.2**. These studies indicate that the general stratigraphy across these sites is similar to that for the regional geology described above.

The soils in the Botany area are predominantly derived from aeolian (wind-blown) sand deposits. The natural soil profile is primarily heavily leached infertile grey sand with minimal organic material. This profile has been altered along the north and north-east coast of Botany Bay by land reclamation and filling.

Foreshore Beach is composed of estuarine sands dredged from Botany Bay during the construction of Port Botany and Sydney Airport. Penrhyn Estuary was formed from the reconfiguration of the northern shores of Botany Bay in the late 1970s, as a result of the construction of Port Botany. It is composed of sand (outer Estuary) and mudflats (upper Estuary).

A conceptual geological model of the BIP and Southlands site was developed by Woodward-Clyde as part of the Stage 2 Survey. **Figure 11.2** and **Figure 11.3** illustrate the geological cross section used as part of the Stage 4 investigation across Southlands and Foreshore Road. The stratigraphy across the BIP site is consistent with Southlands and Foreshore Road.

The BIP and Southlands sites are covered by a layer of surface fill resulting from a range of industrial land uses through previous activities across the area. At the BIP, the surface fill layer ranges from 1 m to 2 m thick and is predominantly composed of medium grained, poorly to well graded, loose, gravely, silty sand intermixed with building rubble comprising bricks and other waste material, including coal ash (URS, 2001).

On the Southlands site, the surface of Block 1 is composed mostly of boiler ash, with small areas of clay and sand. Block 2 consists of a superficial layer of clayey material. The material beneath this layer is comprised of solid inert fill including bricks, concrete rubble, steel, wood and a variety of other material (Woodward-Clyde, 1996).

Beneath these fill layers the stratigraphy of the Botany Sands has been interpreted as a three layer system (Woodward-Clyde, 1996). **Figure 11.3** illustrates these layers:

- Layer 1 is an upper zone of sand with few thin discontinuous peat or clay layers.
- Layer 2 is a middle zone of predominantly sand with intercalated peat, sandy peat and peaty sand.
- Layer 3 is a basal zone of clayey sand and sandy clay with discontinuous layers of gravel, peat and peaty sand.

Soil Contamination

A number of soil sampling investigations carried out over the last 10 to 15 years have identified the presence of contaminated soil around the BIP, Southlands and Foreshore Road. Studies have been carried out where required as part of development on the site, rather than as a specific study to assess the nature and extent of potential contamination across the site as whole. The studies completed have determined that the major form of soil contamination relates to volatile and semi-volatile CHCs dissolved in groundwater. The principal dissolved compounds include:

- Ethylene dichloride (EDC);
- Vinyl chloride (VC);
- Carbon tetrachloride (CTC);
- Tetrachloroethene (PCE); and
- Trichloroethene (TCE).

Insoluble components include:

- Hexachlorobenzene (HCB);
- Hexachloroethane (HCE); and
- Hexachlorobutadiene (HCBD).

CHC contamination of soils and groundwater is likely to have occurred via spills, leaks and historical disposal practices in areas where CHCs were manufactured and/or stored (Woodward-Clyde, 1996). In addition to CHC contamination, other contaminants such as mercury and chromium have been detected.

Stage 1 investigations conducted at Southlands similarly indicated the presence of volatile and semi-volatile CHCs and mercury in the soil. Further work was carried out as part of the Stage 2 investigations, with samples taken across Blocks 1 and 2.

The soils on Blocks 1 and 2 contained few volatiles with concentration exceeding 1 mg/kg, except for one sample toward the south of the Block 1 (Woodward-Clyde, 1996). Low levels of semi-volatiles (less than 8 mg/kg) were detected across Block 1, and all concentrations on Block 2 were less than 2 mg/kg. Heavy metals such as mercury and chromium were also detected across both blocks.

Extensive further investigations have been conducted on the BIP in response to the NCUA requirements, to confirm whether inferred DNAPL source areas are actual source areas, and to obtain more data on the distribution of DNAPL in the subsurface (URS, 2004). The results showed a range of results for different CHCs across the investigation areas.

The land used for Foreshore Road was constructed from sediments recovered from Botany Bay during the 1970s, which may have been contaminated prior to reclamation. However, there is no specific data that indicates soil contamination in the area, as soil samples obtained during October 2004 have proven to be uncontaminated.

In addition, the land where the underground discharge pipeline is located has been extensively used for various industrial and commercial activities, and hence may be contaminated from those activities. This is particularly the case where the pipeline route is within the boundaries of the Sydenham–Botany goods railway line.

Acid Sulphate Soils (ASS)

The Department of Land & Water Conservation's *Acid Sulphate Soil Risk Map No.93 (Botany Bay)* (DLWC, 1997) indicates that the BIP and Southlands sites have the classifications presented in **Table 11.4**.

Table 11.4 ASS risk map descriptions (DLWC, 1997)

Site	Map Class Description
BIP	Low Probability (Wa4) Greater than 3 m below the ground surface
	No Known Occurrence
Southlands	Low Probability (Wa4) Greater than 3 m below the ground surface
	No Known Occurrence
	Disturbed Terrain
Foreshore Road	Disturbed Terrain
Discharge Pipeline	Low Probability (Wa4) Greater than 3 m below the ground surface
	Disturbed Terrain

Previous investigations on the BIP site to assess the soils for the presence of ASS or potential ASS (PASS) have been carried out as part of individual developments on the site. The geology across the BIP, Southlands and Foreshore Road sites is such that the stratigraphy of the Botany Sands is fairly uniform, but with localised lenses of peat material interspersed through the layers of sand.

The DLWC's *ASS Manual* (DLWC, 1998) states that positive results on peaty material, such as that found on the BIP site, may be attributed to high organic sulphur content in the organic matter in the peat, and not to any identifiable pyrite material.

Historical monitoring of groundwater levels around the Orica Botany sites show that levels were lowest during the 1960s and 1970s. Groundwater levels ranged from +1 to –8m AHD around the BIP and Southlands due to excessive groundwater abstraction (Merrick, 2004). If PASS did exist in this area prior to this groundwater lowering, it is most likely that it would have been converted to actual ASS during this period.

Testing of soil and groundwater pH across Southlands and the BIP, carried out as part of the Stage 2 Survey by Woodward-Clyde in 1996, showed soil pH levels ranging from 4.9 to 9.4 and groundwater pH levels ranging from 5.50 to 10.0. Ongoing monitoring and assessment work has shown pH to be generally 4.5–6 in the main contaminant areas. The variation of pH levels around the sites showed that the soil characteristics across the area generally did not indicate the existence of ASS.

However, previous construction works on the BIP, as well as corrosion of existing infrastructure, have shown the presence of ASS at the Qenos Alkathene and Alkatuff Plant sites, which are located within 200 m of the GTP site.

In addition, soils with high acid sulphate potential encountered at Port Botany during works at the hydrocarbon terminal at 39 Friendship Road, are believed to have shown evidence of randomly distributed deposits of soils with very high PASS within the sediments derived from Botany Bay.

In summary, it is likely that there are areas of PASS at different sites within the Project Area.

Aggressivity of Soils/Groundwater

The soil testing also included assessment of potential aggressivity/corrosivity towards concrete and steel, based on a selection of the upper sand filling samples taken from the site tested for sulphate, pH and electrical conductivity. The results are presented in **Table 11.5**. The sulphate content and pH test results indicate that the sand filling soils are non-aggressive when exposed to concrete. The electrical conductivity test results indicate electrical resistivity values of 140 ohms and 180 ohms, indicating a severe exposure classification for steel piled structures.

No steel piles are proposed to be used for the construction of the GTP.

Table 11.5 Soil analysis results

Sample	Depth (m)	Sulphate SO_4 (mg/kg)	pH	Conductivity (µS/cm)
A	0.2 - 0.3 m	26	8.8	71
B	0.25 m	32	9.2	55

11.4 Assessment of Impacts During Construction

11.4.1 GTP Construction

The construction of the GTP would involve a number of different phases with the potential for impacts on soils and geology:

- clearance of the existing concrete slabs and remnant footings, and regrading of the site to required ground level using *in situ* material; and
- installation of site pavements.

The potential impacts are considered in the following sections.

Soil Contamination

The soil testing carried out at the proposed GTP site found that concentrations of metals, TPH and CHCs were below appropriate investigation levels. Potential risks to human health during or after construction are therefore considered negligible. This is assessed further in **Chapter 24**.

It is not anticipated that any soils would be removed from the site during construction. However, if any excess soils are generated during construction, the contamination results indicate that these could be classified as 'solid waste' for disposal purposes, if required.

Foundation Performance

The results of the investigation indicate that the site is underlain by up to 3.5 m of variable compacted filling which, although appearing uncontrolled, would likely provide suitable support for foundations and pavements.

The preferred option is for the entire site to be subjected to high energy impact compaction, using an impact roller to improve the compaction level of the upper 2 to 3 m. After impact rolling, the surface materials would be graded smooth and the surface layer compacted to minimum 80% density index.

This approach is preferred over the alternative option of removing the filling to 1 m below final surface level, (i.e. to RL 7.2), segregating any organic matters, deleterious substances or oversize material, and then reusing and compacting. This option would generate a quantity of waste material requiring disposal, and could require extensive dewatering due to the presence of groundwater at shallow depths.

Shallow footings, such as strip and pad footings, could then be founded within the compacted filling. An alternative approach would be founding on piles taken to very dense sand at about 4 m depth. Following this approach, given the relatively high water table, grout injected piles or concrete screw piles would be proposed.

Driven piles are not considered suitable for this site because of potential adverse noise or vibration effects. Bored piles would also not be considered favourably, because of the potential contamination in both the surplus soil and water generated during their construction.

Groundwater

Groundwater levels were measured at depths between 0.8 m and 2.3 m. However, the proposed use of shallow footings or screw piles would result in minimal disturbance of the groundwater.

Soil Erosion

Construction works at the GTP site would involve a limited amount of excavation and site clearing that would disturb soils, with the possibility of soil erosion. These activities include:

- clearance of existing remnant structures (e.g. concrete slab);
- excavation works for foundations;

- movement of construction equipment and other vehicles within the construction zone; and
- stockpiling of materials for site levelling.

The site is served by the stormwater drainage system for the BIP, and therefore has the potential for erosion to eventually discharge to Botany Bay during wet weather events.

The potential for erosion would be reduced by employing effective soil conservation measures during construction.

Acid Sulphate Soils

The desk-top assessment suggests that ASS conditions are possibly present at the site for the GTP. These are unlikely to have become acidic due to the presence of lime residues in the shallow soil.

11.4.2 Other Construction Activities

The other construction activities would involve various works with the potential to affect soils and geology:

- well installations on the PCA and the BIP, resulting in generation of drilling spoils and slurries;
- pipeline installation on the BIP, resulting in minimal generation of spoil; and
- excavation of underground discharge pipeline, resulting in minimal generation of spoil (as it would be directly reused).

Where excess spoil is generated, this would require appropriate management and disposal, to ensure that no impacts occur if the spoil is contaminated.

As the desk-top assessment suggests that PASS may be present, appropriate assessment and management measures would be required to minimise the potential for impact.

As construction works would involve some site clearing and soil excavation that would disturb soils, appropriate management measures would be implemented to minimise the potential of soil erosion.

11.5 Assessment of Impacts During Operation

The full operation of the BGC Project within the Project Area comprises:

- extraction of groundwater at all three containment lines;
- transfer of groundwater to the GTP; and
- treatment, reuse and discharge of treated groundwater.

The potential impacts associated with operation are considered in the following sections.

Contamination

The operation of the extraction wells and pipelines would be designed and managed to minimise the risk of leaks or failure, through the use of design standards and conservative design limits, and the installation of secondary containment systems (for underground pipelines) and leak detection monitors (as described in **Chapter 13**). In addition, ongoing monitoring and inspection would be carried out to check the integrity of the infrastructure. Major leaks would result in extraction and transfer operations being shut down.

At the GTP itself, the site area would be paved, with a first-flush tank installed to contain any spills, for treatment or discharge. In addition, storage of contaminated groundwater and other chemicals (caustic soda and hydrochloric acid) would be in bunded tanks, to provide containment of spills.

Acid Sulphate Soils

Predicted drawdown of groundwater levels around the groundwater extraction wells due to pumping would range from 1 m to 3 m around the different wells. The maximum drawdown at an external production bore would be 0.4 m. This minimal drawdown effect is not anticipated to affect any localised areas of potential ASS that may exist at the extraction well locations.

11.6 Mitigation Measures

11.6.1 Construction

General

A soil and water management plan (SWMP) would be developed in the detailed design phase to ensure that an adequate standard is applied to erosion and sediment control for the construction activities of the proposed project.

The SWMP would be incorporated in the Construction EMP (CEMP) for the project. All work would be carried out to avoid erosion and sedimentation of the site and surrounding areas. Erosion and sediment control measures would include:

- minimising open areas of excavations;
- using temporary structures to prevent offsite movement of sediment, such as silt fences surrounding stockpiles or in the vicinity of existing stormwater drains;
- maintaining sediment and erosion control measures in an effective condition until the works have been completed;
- ensuring temporary excavations (such as those for the refurbishment of the discharge line) are refilled with excavated soils, which are reinstated to ensure ‘clean’ fill is used at the top layer to avoid potential contamination being discharged to stormwater;
- minimising dust from active earthwork areas and stockpiles using water spray;

- ceasing work, or implementing further suppression measures, if excessive fugitive dust emissions are observed;
- minimising traffic in construction zones and dedicated parking areas; and
- inspecting soil loads on vehicle wheels and undercarriages, and ensuring removal if required.

Erosion and sediment control planning and implementation would apply to all areas that may be disturbed. Regular inspections would occur after heavy rain and during periods of prolonged rainfall.

Acid Sulphate Soils

Although the work to date has identified limited potential for acid sulphate soils, an ASS Management Plan would be developed in accordance with the *NSW Acid Sulphate Soil Manual* (DLWC, 1998), to provide an approach for management of any ASS that may be identified during the construction phase.

In addition, ongoing monitoring of groundwater pH as part of the groundwater monitoring regime would be carried out throughout the operation of the GTP. As part of the ASS Management Plan, if this monitoring indicated a significant change in groundwater pH, further investigation would be carried out to determine whether the change was due to ASS.

The ASS Management Plan would include:

- training of construction personnel to remain alert for signs of ASS;
- prompt sampling and analysis to ensure management measures can be implemented appropriately;
- spoil containing ASS to be dosed with lime to neutralise the acidity, before storage pending disposal; and
- temporarily excavated spoil to be dosed with lime to neutralise the acidity before being returned to the hole on completion of the work.

Contamination

The objectives for the construction of the GTP would be minimal disturbance of soils, and for no soils to be removed from the site for disposal, notwithstanding that contamination results show the soils would be classified as ‘solid waste’ and suitable for disposal to landfill.

As for the practices agreed with the EPA for the installation of the extraction wells on Foreshore Road, drilling spoil from the well installations would be transferred to Southlands. The materials would be stockpiled in the existing containment structures on Block 2 (constructed of geotextile base and hay bale containment), to be dried, analysed and assessed.

Samples of the dried soils would then be assessed for compliance with landfill requirements in accordance with EPA guidelines (DEC, 2004). Where materials do not meet the criteria, these would be retained in the stockpile for further treatment to render them suitable for landfilling.

Where subsurface contamination is found in excavated soils on the discharge line, the excavated holes would be reinstated to ensure that the contamination remains below the surface, and clean fill would be used on the top layer to prevent contamination of stormwater run-off.

Foundations

The geotechnical assessment concluded that the geological conditions at the proposed GTP site do not pose any significant constraints for the use of shallow foundations or screw piles. However, if shallow foundations were to be used, appropriate compaction would be required to provide the compacted fill suitable for shallow foundations.

If concrete screw piles were selected, some form of corrosion protection—such as cathodic protection—would be required, due to the nature of the existing soils and groundwater.

The use of either shallow foundations or screw piling would minimise surplus soil or groundwater generation.

Groundwater

The only works that would be expected to affect the groundwater would be the extraction well installation. As described in **Chapter 13,** drilling slurries and excess groundwater would be collected directly during the installation activities, and transferred to storage on the BIP before treatment.

11.6.2 Operation

General

An ongoing Soil and Water Management Plan would be maintained for the operational phase of the project, to ensure that a suitable management standard is maintained in the event of spills or leaks from the groundwater extraction and transfer systems.

The development of the Operation SWMP would be based on the Construction SWMP, and would take into account relevant industry guidelines.

Contamination

The overall project objective would be to avoid potential contamination of soils from leaks or spills. This would be achieved through various measures, including:

- design of the transfer pipelines (as described in **Chapter 5**) to minimise the risk of leak or failure, and to ensure containment in underground pipelines;
- installation of pipelines aboveground where possible, to be regularly monitored for leaks by visual inspection, with leak detection in underground pipelines;
- installation of bunds with 110% capacity for storage of materials, such as contaminated groundwater and treatment plant chemicals, providing containment in the event of leaks or spills;

- temporary storage of recovered waste EDC liquid from the operation of the SSU in an existing, fully sealed and bunded storage tank at Terminals Pty Ltd's bulk liquid storage facility; providing containment of any leaks or spills, and
- including containment of the recovered waste EDC liquid in a purpose-built isotainer in a fully bunded area on the GTP site.

In the event of major leaks or spills, contamination from the groundwater extraction and transfer systems would be contained through the overall hydraulic containment system.

As noted above, the ASS Management Plan would be maintained through the operational phase of the project to ensure that issues are addressed before potential impacts are realised.

11.6.3 Summary of Mitigation Measures

Mitigation measures that would be implemented during pre-construction, construction or operation are summarised in **Table 11.6**.

Table 11.6 Summary of mitigation measures

Safeguard	Design	Pre-construction	Construction	Operation
General				
Development and implementation of SWMP as part of the EMP		✓	✓	✓
Development and implementation of ASS Management Plan		✓	✓	✓
Construction				
Keep open areas of excavations to a minimum			✓	
Install temporary structures to prevent offsite movement of sediment, such as silt fences surrounding stockpiles			✓	
Maintain sediment and erosion control measures in an effective condition until the works have been completed			✓	
Refill temporary excavations to ensure any subsurface contamination is replaced at subsurface level, with clean fill at surface level to avoid contamination of run-off.			✓	
Divert surface water run-off from areas upstream around the site to minimise the volume of water entering construction areas			✓	
Dust minimisation of active earthwork areas and stock piles using water			✓	

Safeguard	Design	Pre-construction	Construction	Operation
Cessation of work, or implementation of further suppression measures, if excessive fugitive dust emissions are observed			✓	
Minimisation of traffic in construction zones and dedicated parking areas			✓	
Inspection of soil loads on vehicle wheels and undercarriages, and removal if required			✓	
Preferred option is compaction of entire site to minimise waste generation and dewatering			✓	
Use of shallow foundations or screw piles			✓	
Operation				
Design groundwater extraction wells and transfer pipelines to minimise risk of failure or leaks	✓			
Design and manage the groundwater extraction wells and transfer pipelines to minimise soil erosion	✓			✓
Storage of materials such as contaminated groundwater and treatment chemicals in bunded tanks on the GTP site	✓			✓
Ongoing monitoring and inspection of wells and pipelines to check for leaks, spills, etc.				✓

11.7 Conclusion

Given the results of the contamination assessment of the site, and provided that the proposed mitigation measures are implemented, no impacts from the BGC Project on the soil or geology in the Project Area would be expected.