



Figure 6-7 Instability risk plan

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## Soils

The soil landscapes and characteristics of the site have been described based on the Soil Landscapes of the Sydney 1:100,000 Sheet (Chapman, G.A. and Murphy, C.L., 1989). The proposed works area comprises the Hornsby, Lucas Heights and Hawkesbury soil landscapes. Relevant characteristics of these soil landscapes are described in **Table 6-34** and shown in **Figure 6-8**.

**Table 6-34 Soil landscapes**

| Soil landscape | Characteristics                                                                                                                                               |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hornsby        | Occurs on gently undulating rises to steep low hills on deeply weathered basaltic breccia.<br>Extreme soil erosion hazard and localised mass movement hazard. |
| Lucas Heights  | Occurs on gently undulating crests and ridges on the Mittagong Formation.<br>Generally a moderate erosion hazard but can range from slight to extreme.        |
| Hawkesbury     | Occurs on rugged, rolling to very steep hills on Hawkesbury Sandstone.<br>Extreme soil erosion and mass movement (rock fall) hazard.                          |

## Acid sulfate soils

A search of the Australian Soils Resource Information System (ASRIS) and the Hornsby LEP acid sulfate soils map indicates that there is a low probability of acid sulfate soils occurring across the site.

## Hydrogeology

Two groundwater systems occur within the proposed works area (PSM, 2007):

- System 1 consists of a shallow perched water system located within fill material and underlying weathered breccia rock. Groundwater is present in the soil, fill pores and in fractures in the weathered breccia.
- System 2 comprises a deeper system located within the fresh breccia and surrounding Hawkesbury Sandstone. Groundwater is present within secondary structural features such as joints, fractures and bedding planes.

Water flows into the quarry void as surface water runoff and groundwater inflow. Discharge from the quarry void is via water pumping and evaporative losses (PB, 2004). Recharge to the shallow and deep aquifers occurs via rainfall infiltration and runoff (PB, 2004). Discharge from the shallow aquifer occurs as leakage into the quarry void and via direct discharge into Old Mans Creek (PB, 2004). The shallow aquifer also leaks into the underlying fractured rock aquifer (PB, 2004).

Groundwater inflow to the quarry void was modelled by PSM (2007). Inflows were also calculated by AECOM as part of this project in order to estimate the amount of water which would be expected to flow into the quarry void as the filling of the void with spoil progressed. The model developed by PSM determined inflow to be at about 0.3 litres per second at a water level of 28.5 metres AHD (water level in the quarry pit at the time of the PSM (2007) assessment). AECOM calculated groundwater inflow at around RL 8 (the level at which spoil emplacement would commence following the initial dewatering of the void to base level), to be 12 litres per second.

The difference in calculated inflow rates between the PSM and AECOM groundwater calculations can be attributed to the use of different values of hydraulic conductivity. Although it is not clear from the PSM modelling report what value of hydraulic conductivity was used, the AECOM calculations used a conservative value of 0.01 metres per day for a fractured igneous rock.

The findings of both the PSM and the AECOM studies indicate that groundwater inflow would vary linearly with the height of water or fill in the quarry void. Groundwater inflows into the void would decrease with increasing water/fill levels, with inflow levels approaching zero when water/fill levels approach the rim of the quarry void. Weather conditions and water level in the quarry are considered to have the most impact on groundwater inflow (PSM, 2007, as cited in Cardno, 2013).

It is estimated that there is currently around 50 mega litres of water in the quarry void (advised by Hornsby Shire Council, 9 March 2015).

Six existing registered bores have been identified within two kilometres of the Hornsby Quarry site from a search of the Australian Groundwater Explorer (BOM, 2015) indicating groundwater usage in the area is limited. These registered bores are summarised in **Table 6-35** and **Table 6-34** and shown in **Figure 6-5**. These bores are at a sufficient distance not to be impacted by the quarry water management practices (PB, 2004).

**Table 6-35 Registered groundwater bores (BOM, 2015)**

| Bore ID      | Bore depth (metres) | Purpose      | Latitude | Longitude | Distance from quarry site (km) | Direction from quarry site |
|--------------|---------------------|--------------|----------|-----------|--------------------------------|----------------------------|
| GW111573.1.1 | 5                   | Monitoring   | -33.6901 | 151.1060  | 1.59                           | North east                 |
| GW111574.1.1 | 5                   | Monitoring   | -33.6900 | 151.1059  | 1.60                           | North east                 |
| GW111575.1.1 | 6                   | Monitoring   | -33.6900 | 151.1061  | 1.60                           | North east                 |
| GW111576.1.1 | 5                   | Monitoring   | -33.6899 | 151.1059  | 1.60                           | North east                 |
| GW108651.1.1 | 6                   | Water supply | -33.6852 | 151.1006  | 1.61                           | North east                 |
| 21210084.1.1 | Unknown             | Unknown      | -33.6931 | 151.0848  | 0.75                           | North west                 |

## Groundwater levels

Groundwater levels within the two groundwater systems have been derived using two sources of available piezometer data:

- One deep piezometer in the eastern portion of the site which was originally drilled by Coffey Partners in 1989, and relocated by PSM in 2006 approximately 140 metres east of the quarry void. (piezometer reference BH 18).
- A single, vibrating wire piezometer installed in a borehole drilled by PSM in November 2006, approximately 50 metres south west of the quarry void (piezometer reference BH HQ1). BH HQ1 was drilled through the breccia rock at the south western part of the site into the surrounding Hawkesbury sandstone.

The locations of the two bore holes from which piezometer data has been obtained are shown in **Figure 6-5**. The piezometer drilled by PSM in 2006 (BH HQ1) was installed to a vertical depth of approximately 80 metres at RL 27.45 metres, from which a water table at approximately RL 79.3 metres was calculated in December 2006 (PSM, 2007).

Piezometer data for the period 20 November 2006 to 2 July 2010 for BH HQ1 is included in **Figure 6-9**. Interpretation of the data suggests a gradual rise in the groundwater level in the south west of the site, followed by a moderately sharp decrease in groundwater levels in the period November 2009 to January 2010. PSM (2010) in correspondence with Hornsby Shire Council suggested that the decrease in groundwater levels in BH HQ1 in this time period would likely be associated with the commencement of groundwater dewatering from the quarry void and as such may be a reflection of the groundwater drawdown in the slope wall associated with pumping operations.

Modification of the quarry landscape since 1990 has been minimal so groundwater conditions are expected to be consistent with those measured by PSM in 2006. This conclusion is supported by groundwater level measurements, conducted by PSM at the deep piezometers originally installed by Coffey Partners in 1989 (BH 18 in the eastern portion of the site), which was relocated by PSM as part of its 2006 study. The PSM measurement of BH 18 found that the measured groundwater level determined by Coffey (as referenced in PB, 2004) was fundamentally the same as that measured by PSM in 2006.



Interrogation of the site suggests that fluctuations in groundwater levels within the Hawkesbury Sandstone and volcanic breccia are a response to climatic conditions, rainfall recharge via direct infiltration and evaporation from the quarry (PSM, 2007 and PB, 2004). Fluctuations are expected to oscillate seasonally in accordance with climatic seasonal variability (PB, 2004 and PSM, 2007)

The magnitude of groundwater level movements within the Hawkesbury Sandstone and Wianamatta Shale is currently unknown. As part of the project, groundwater monitoring, including the measurement and recording of groundwater levels beneath and around the site, would continue to be conducted in accordance with the conditions of the Hornsby Shire Council groundwater dewatering licence for the duration of the project.

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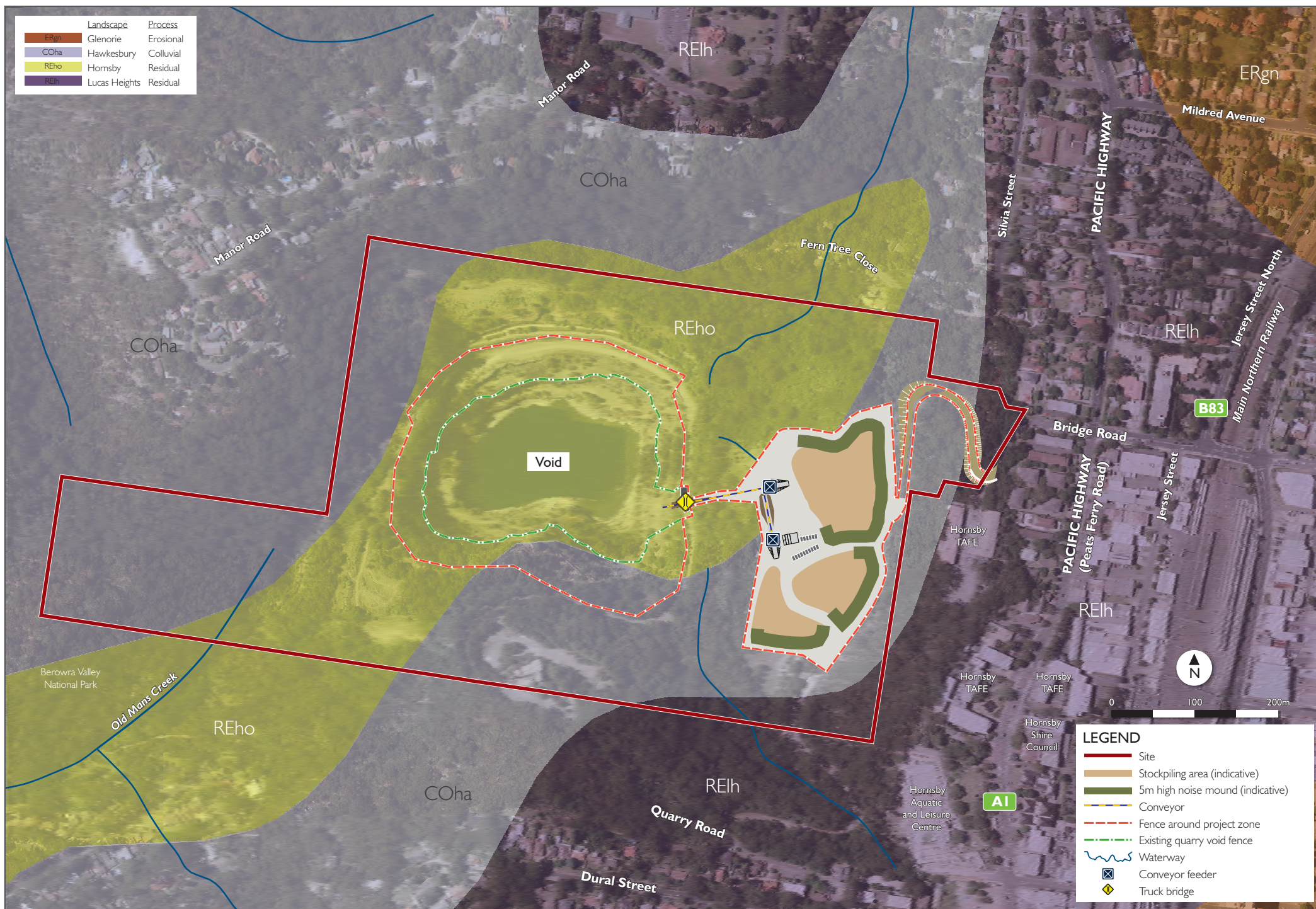


Figure 6-8 Soil landscapes



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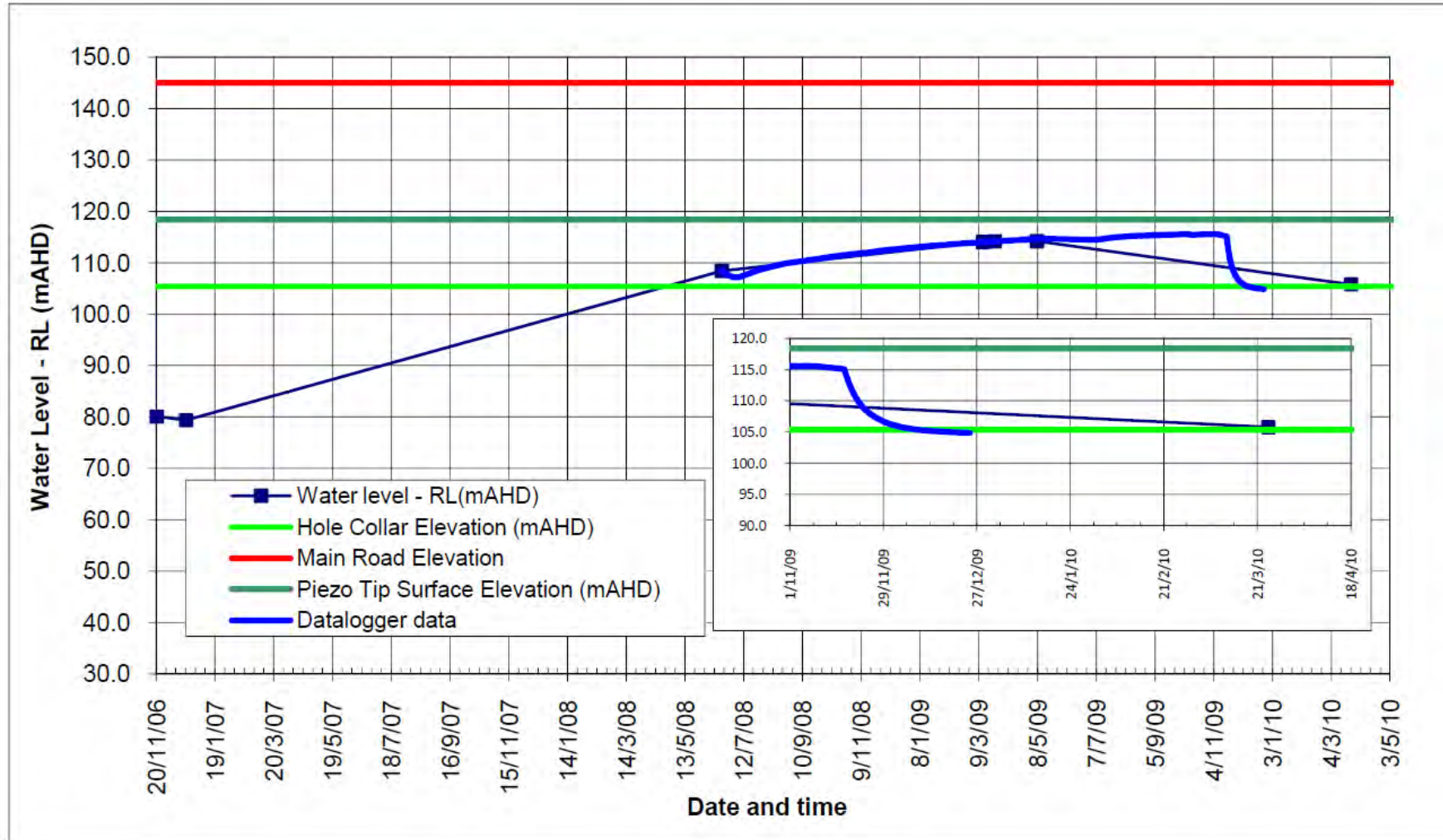


Figure 6-9 Piezometer Record BH HQ1 2006 to 2010 (PSM, 2010)

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## Groundwater quality

Groundwater within Hawkesbury Sandstone across the Sydney basin is of low to moderate salinity, with electrical conductivity typically between 500 microsiemens per centimetre ( $\mu\text{S}/\text{cm}$ ) and 2,000  $\mu\text{S}/\text{cm}$ . The groundwater is also slightly acidic with pH generally varying between 4.5 and 6.5. The groundwater tends to have naturally elevated iron concentrations. The quality of groundwater in the shale of the Wianamatta Group tends to be inferior to groundwater in sandstone, with electrical conductivity varying between 2,000  $\mu\text{S}/\text{cm}$  to more than 10,000  $\mu\text{S}/\text{cm}$  in the Sydney Basin (AECOM, 2015). The results of groundwater quality analysis undertaken for the NorthConnex project broadly aligned with these findings.

Historical groundwater monitoring data has been analysed to identify potential groundwater contamination and to characterise groundwater quality around the site. This data has included information from:

- An assessment conducted by PB in 2004, which included monitoring data provided by Hornsby Shire Council dating from April 2004.
- An assessment conducted by PSM in 2007, which included monitoring data provided by Hornsby Shire Council for a period stated by PSM to be from August 2004 to October 2005.
- Monthly physico-chemical measurements of the discharge water from the quarry void taken by Hornsby Shire Council during the period 19 January 2010 to 11 September 2014. The measurement point comprises site 085, a square notch weir uphill of the quarry water discharge point in Old Mans Creek, south west of the quarry void.

PB (2004) determined that there was little variation with depth in the field parameters from the quarry void indicating that under the conditions at the time of the assessment, stratification had not occurred. Water quality within the quarry pond was classified as being generally fresh, good quality water. Total metal concentrations were found to be low and to reflect natural, uncontaminated conditions. Nutrient calculations were also low and did not indicate any contamination.

The results of the PSM (2007) study of groundwater and quarry pond water quality are generally consistent with the findings of the earlier PB analysis. PSM also concluded that shallow water within the quarry pond was of low salinity approaching potable water quality.

In addition, analysis of a total of 65 samples taken by Hornsby Shire Council of the discharge water from the quarry void during the period 19 January 2010 to 11 September 2014 found that the quality of the quarry void water being discharged met or exceeded the requirements for water quality as specified in Hornsby Shire Council's groundwater dewatering licence and was therefore consistent with the quarry void water quality findings of PSM (2007) and PB (2004), where the water in the quarry void was found to be of low salinity and approaching potable water quality.

The results of this sampling are summarised in **Table 6-42** and **Table 6-43** of **Section 6.4** (Surface water). Discharge water is drawn by pump in the quarry void at four metres below surface water level. The quality of the water at the discharge point is assumed to be equivalent to the quality of the water within the quarry void as there is no water treatment currently taking place prior to discharge.

## Groundwater Dependent Ecosystems

Groundwater Dependant Ecosystems (GDEs) are defined as ecosystems whose current species composition, structure and function are reliant on a supply of groundwater as opposed to surface water supplies from overland flow paths. The frequency of groundwater influence may range from daily to inter-annually, however it becomes clearly apparent when either the supply of groundwater or its quality (or both) is altered for a sufficient length of time to cause changes in plant function. Groundwater use by an ecological community or individual species does not necessarily imply groundwater dependence.

In Australia, the majority of ecosystems have little to no dependence on groundwater, although the full understanding of the role of groundwater in maintaining ecosystems is generally poor. The exception to this is wetland communities, for which it is thought that most have some level of dependence on groundwater resources.

Groundwater in the Hornsby Quarry study area has a current water level of around 19 metres AHD (C Clendinning (Hornsby Shire Council) 2015, pers. comm., 2015). Land surrounding the quarry rim is between 60 and 180 metres AHD, resulting in a water table of between 31.5 metres and 121.5 metres below ground level.

As detailed in **Section 7.3** (Biodiversity) and in the technical working paper: biodiversity (**Appendix G**), the main GDE in the study area is Sandstone Blackbutt Woodland. While this vegetation type has a 'moderate' chance of being groundwater dependent, the water levels in the void are likely to be significantly lower than the root zone for the plants in this vegetation type.

### **Known and potential sources of contamination**

Known and potentially contaminated sites identified within the vicinity of the Hornsby Quarry site are presented in **Figure 6-10**. These sites were identified through searches of:

- The public register of notices issued by the EPA under the CLM Act.
- The public register of sites notified to the EPA under the CLM Act.
- A review of current and former land uses adjacent to the project area including the potential for asbestos containing materials, synthetic mineral fibres, lead-based paint and polychlorinated biphenyls in buildings present on and adjacent to the site.

Where a 'notice' has been issued by the EPA, it indicates that a site is known to be contaminated to an extent that warrants regulation. A site that has been notified to the EPA indicates that the landowner or person, whose activities have contaminated land, has informed the EPA that a site may be contaminated at a level triggering regulatory action. Notified sites may or may not be contaminated to an extent to warrant regulation by the EPA.

An online search of the record of notices returned one result:

- A 'declaration of significantly contaminated land' pertaining to the Shell Hornsby site at 194-206 Pacific Highway, Hornsby, 2077, located approximately 800 metres to the south east of the proposed works area (EPA, 2015).

PB (2004) summarised previous site inspections and NSW WorkCover records relating to the keeping of dangerous goods at the Hornsby Quarry site, identifying a number of potential sources of contamination. The findings of the PB investigation have been combined with investigations by PSM (2007), Cardno (2013) and consultation with Hornsby Shire Council, to establish primary areas of potential contamination as being in the vicinity of the following:

- Crushing plant facility located south of the quarry void.
- Partial remains, consisting primarily of foundation material, of (demolished) workshop buildings, located west of the quarry void.
- Fuel storage and dispensing facilities located near to the demolished workshop buildings on the western side of the quarry void.
- Two 28,000 litre aboveground storage tanks on the western side of the quarry void. One tank is currently being used for storage of diesel for groundwater maintenance pumping being undertaken by Hornsby Shire Council.
- One 1,000 litre diesel generator at approximately RL 46 AHD on the western side of the quarry void, located inside of a container. The generator is currently being used by Hornsby Shire Council to undertake groundwater level maintenance pumping within the quarry void.
- Explosive magazines near the historic cemetery south-east of the quarry void.
- A detonator magazine located to the west of the quarry void in the vicinity of the demolished workshop area.

- Areas of fill, consisting predominantly of overburden material generated during quarry operations, on the northern, eastern and south western sides of the quarry void.

A summary of these potential contamination sources and associated contaminants of potential concern is provided in **Table 6-36** and their location is shown in **Figure 6-10**.

**Table 6-36 Potential contamination sources and associated contaminants of concern (PB, 2004)**

| Area                                                                                        | Potential contaminant source                                      | Potential contaminants of concern                                                                                            |
|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Workshop and office area buildings                                                          |                                                                   |                                                                                                                              |
| Two above ground storage tanks and bowsers, each with a capacity of 28,000 litres.          | Fuel (diesel).                                                    | Total petroleum hydrocarbons (TPH), benzene/ toluene/ ethylbenzene/ xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs). |
| One above ground storage tank with a capacity of 1,000 litres.                              | Fuel (diesel).                                                    | TPH, BTEX, PAHs.                                                                                                             |
| Previous petrol underground storage tank and associated pipe work/bowsers.                  | Fuel (petrol).                                                    | TPH, BTEX, lead.                                                                                                             |
| One above ground storage tank and sump.                                                     | Waste oil/ solvents.                                              | TPH, BTEX, PAHs, phenols, solvents (volatile hydrocarbons, semi-volatile organic compounds), heavy metals.                   |
| Storage of oils.                                                                            | Oils (lubricants, hydraulic).                                     | TPH, PAHs.                                                                                                                   |
| Storage of derelict machinery.                                                              | Corrosion of equipment.                                           | Heavy metals.                                                                                                                |
| Degraded building materials.                                                                | Fibrous cement sheeting and corrosion of metal surfaces.          | Asbestos and heavy metals.                                                                                                   |
| Electricity substation.                                                                     | Transformer oil.                                                  | TPH, PAH, polychlorinated biphenyls (PCBs).                                                                                  |
| Weed spraying.                                                                              | Weed control chemicals.                                           | Organochlorine pesticides (OCPs), organophosphate pesticides (OPPs) and arsenic.                                             |
| Crushing Plant Facility                                                                     |                                                                   |                                                                                                                              |
| Machinery and vehicle parking.                                                              | Leakages of hydraulic and lubricant oils as well as fuels.        | TPH, BTEX, PAHs, heavy metals.                                                                                               |
| Storage/use of oils and stabilising agents (e.g. cement, limes).                            | Oils, cements and limes.                                          | TPH/PAHs, heavy metals and elevated (alkaline) soil pH.                                                                      |
| Degraded building materials.                                                                | Fibrous cement sheeting and corrosion of metal surfaces.          | Asbestos and heavy metals.                                                                                                   |
| Filled Areas                                                                                |                                                                   |                                                                                                                              |
| Fill material other than that derived from quarrying operations (i.e. overburden material). | Imported fill materials (uncontrolled activities).                | Heavy metals, TPH, BTEX, PAHs, OCPs, PCBs, asbestos and other contaminants associated with unknown fill material.            |
|                                                                                             | Equipment breakdowns and fluid loss (oils, fuels and hydraulics). |                                                                                                                              |
| Explosive and detonator magazines                                                           |                                                                   |                                                                                                                              |
| Storage of explosives and detonators.                                                       | Explosives (gelignite) detonators.                                | Nitrates and heavy metals.                                                                                                   |
| Weed spraying.                                                                              | Weed control chemicals.                                           | OCPs, OPPs and arsenic.                                                                                                      |
| Degraded building materials.                                                                | Fibrous cement sheeting and corrosion of metal surfaces.          | Asbestos and heavy metals.                                                                                                   |

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Figure 6-10 Known and potentially contaminated sites



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### 6.3.3 Assessment of potential impacts

Potential impacts resulting from the proposed works including management of groundwater inflow and drawdown, contamination and ground movement have been assessed based on the available background data. Environmental management measures are provided in **Section 6.3.4**.

#### Erosion and sedimentation

The proposed works would result in surface excavation and earthmoving in and around the quarry site during the establishment works. Bridge Road and track would be widened and stockpile and spoil loading areas would be established at Old Mans Valley. During operation a significant quantity of spoil would be transported to the site, handled at the stockpile sites and conveyed into the quarry void. The works would have the potential to result in erosion from the construction site and sedimentation impacts to downstream watercourses. The risk of erosion and sedimentation would be amplified by the steep topography of the quarry site. Further details regarding erosion and sedimentation are provided in **Section 6.4** (Surface water and flooding).

#### Acid sulfate soils

Acid sulfate soils or potential acid sulfate soils are not expected to occur within the Hornsby Quarry site. However, in the unlikely event that acid sulfate soils are encountered, they would be effectively managed in accordance with the Acid Sulfate Soil Manual (Acid Sulfate Soil Management Advisory Committee, 1998).

#### Groundwater

The project has the potential to affect groundwater in the following ways:

- Changes to the quantity and quality of groundwater during spoil management activities.
- Changes to the quantity and quality of groundwater once spoil material has been placed into the quarry void and compacted.

An assessment of the impact that filling the quarry void with ENM and VENM would have on the flow of groundwater in the vicinity of the quarry has been undertaken (AECOM, 2015).

Published hydraulic conductivity values for a fractured igneous rock (comparable to the volcanic breccia that was historically removed from the site) range from 0.0007 metres per day to 30 metres per day. Hydraulic conductivity values for sandstone range from 0.00003 metres per day to 0.5 metres per day (Domenico and Schwartz, Physical and Chemical Hydrogeology, 1990 as cited in AECOM, 2015).

The ENM and VENM to be beneficially reused at the Hornsby quarry site would be derived from crushed sandstone, which would be compacted into the quarry void. Once compacted, the hydraulic conductivity of this material is likely to be around 0.01 to 0.001 metres per day, which is towards the middle of the range of values published for fractured igneous rock. It is therefore anticipated that hydraulic conductivity through the compacted, crushed sandstone would be similar to the material historically removed from the quarry void.

In addition, the groundwater flow velocity through the compacted ENM and VENM and volcanic breccia would be dependent on the groundwater flow through the surrounding bedrock where the groundwater is recharged and discharged. These variables would remain constant before and after emplacement of spoil within the quarry void, suggesting that the groundwater flow velocity following completion of the project would be comparable to the groundwater flow velocity that would have existed through the site prior to historical quarrying activities.

The quarry void would be dewatered through initial and ongoing maintenance pumping, to lower and maintain groundwater at safe levels during the handling of spoil within the void. Dewatering and maintenance pumping would be conducted in accordance with the groundwater dewatering licence issued to Hornsby Shire Council. The licence provides for an annual extraction allowance of 370 mega litres (or approximately 1 mega litre per day) per year over the five year term of the licence (17 April 2014 to 16 April 2019).

AECOM (2015) calculated the anticipated groundwater inflow for each of the 33 months of the project to estimate the amount of water that would be extracted from the quarry void during the project. The dewatering would consist of initial dewatering of the quarry void and ongoing maintenance pumping whilst the quarry void is progressively filled to around RL 64 metres. AECOM found that the dewatering required for the project would be in accordance with the licence conditions. The calculation has accounted for the changing base levels, changing hydraulic gradients, changing quarry geometry and changing saturated surface area of the quarry void as it is progressively filled.

The assessment concluded that groundwater inflow would be greatest when the quarry void is first dewatered to around RL 8 metres and would progressively decrease as the quarry void is infilled with spoil material. A total of around 636 mega litres would be extracted over the 33 month period including the initial pumping of 50 mega litres to dewater the void to RL 8, which would be in accordance with the limits established in the groundwater dewatering licence issued to Hornsby Shire Council.

In the first month of spoil emplacement the flow rate was estimated to be 12.5 litres per second decreasing to 7.9 litres per second after the first year. These flow rates are based on the use of conservative hydraulic conductivity values for fractured igneous rocks of 0.01 metres per day. Based on these flow rates, it was calculated that after the first 12 months an estimated 360 mega litres would be pumped from the quarry (initial dewatering and maintenance pumping) declining to 190 mega litres for the second year (maintenance pumping) and 85 mega litres for the last nine months of year 3 (maintenance pumping).

The lateral extent of groundwater drawdown as a consequence of initial quarry void dewatering would depend on the hydraulic conductivity of the surrounding bedrock (Wianamatta Shale), and the duration of dewatering. Because the hydraulic conductivity and transmissivity of the Wianamatta Shale is low (transmissivity of 4 square metres per day in AGL, 2013) groundwater drawdown within the shale would be very steep adjacent to the quarry and the drawdown would decrease rapidly away from the quarry.

Summary calculations using the Cooper Jacob modified non-equilibrium equation (flow rate of 10 litres per second, storativity of 0.1, and transmissivity of 4 square metres per day) indicate that after 30 days of void dewatering:

- The drawdown at a distance of 10 metres from the quarry void would be 56 metres.
- The drawdown at a distance of 50 metres from the quarry void would be 1.3 metres.

These calculations support the conclusion that drawdown influence would decrease rapidly with distance from the edge of the quarry void.

Following the completion of spoil emplacement activities, the height of the quarry void would be about RL 64 metres. As the height of fill would not reach the rim of the quarry, it is anticipated that groundwater would continue to seep into the quarry void after the completion of spoil emplacement activities at around RL 64 metres. Ongoing management of groundwater inflows, including any ongoing requirement for dewatering of the quarry void following the completion of the project, would be undertaken by Hornsby Shire Council in accordance with the existing groundwater dewatering licence.

Where ongoing dewatering is required following the completion of the project and site handover, ongoing monitoring of the groundwater levels would be undertaken by Hornsby Shire Council in accordance with the conditions of the groundwater dewatering licence.

Whilst residual groundwater inflow is likely to continue following the completion of the project, this is expected to be an improvement on existing conditions. The current project would involve the partial filling of the void enabling the hydraulic gradient around the quarry site to become closer to pre-quarrying conditions, in comparison to the current situation of an unfilled void. In the absence of the project, there are no other tangible or viable options for filling the void available in the near future and the void would potentially need to be maintained under existing conditions (and groundwater inflow rates) indefinitely. As such it is considered that the project would result in an improvement to the

current situation in terms of groundwater inflow outcomes and help address an ongoing legacy issue of land rehabilitation.

During the project, water quality testing of the groundwater pumped from the quarry void would be conducted in accordance with the conditions of Hornsby Shire Council's existing groundwater dewatering licence. Specifically, the discharge criteria outlined in the licence require that:

- The pH of the discharge water must be between 6.5 and 8.5 and no other contaminants must be present; or
- The water to be discharged must be treated to bring the pH to a level between 6.5 and 8.5 and contaminants must be removed prior to discharge; or
- The water to be discharged to a receiving water body must be conducted in accordance with the conditions of a licence granted under the POEO Act; or
- The water may be discharged to sewer only under written agreement with the relevant authority.

Where practical and feasible, water pumped from the quarry void during the project would be beneficially reused on the site for dust suppression, with surplus water discharged in accordance with Hornsby Shire Council's existing groundwater licence.

Impacts and potential mitigation measures associated with discharge of groundwater pumped from the quarry void are addressed in detail in **Section 6.4** (Surface water and flooding).

The footings of infrastructure constructed to facilitate spoil emplacement may intersect the shallow perched aquifer. Excavations may intersect water stored in surface unconsolidated sediments (Parsons Brinckerhoff, 2004), however, this is unlikely to significantly impact the groundwater flow or groundwater extraction bores in the vicinity of the site (Cardno, 2013).

An assessment of the potential impacts on groundwater dependent ecosystems is included in **Section 7.3** (Biodiversity) of this EIS and in the technical working paper: biodiversity (**Appendix G**). In summary, significant impacts to groundwater users or GDEs are not considered likely as a result of the project due to:

- The distance of nearest groundwater bores to the site (more than 750 metres) and the drawdown influence of dewatering activities being centred in close proximity to the quarry void (within 10 to 50 metres).
- Sandstone Blackbutt Woodland (identified as having a 'moderate' chance of being groundwater dependent) has been mapped greater than 50 metres from the quarry void. Given the close proximity of the drawdown influence to the edge of the quarry void itself, it is considered unlikely that this vegetation community would be adversely influenced by drawdown from the project. In addition, the removal of the void as a source of groundwater following its filling would not directly impact on any vegetation due to the levels of water within the quarry being well below the root zone of this vegetation community. Following the filling of the quarry, the hydraulic gradient around the quarry site is also expected to be closer to pre-existing conditions. This would ultimately be of benefit to any GDEs in the area by assisting to stabilise groundwater levels at the site.
- Old Mans Creek is approximately 250 metres from the nearest point of the quarry void. As drawdown influence has been found to decrease rapidly with distance from the edge of the quarry void, groundwater drawdown impacts on Old Mans Creek are considered to be negligible.
- The project is unlikely to affect groundwater quality as the quarry would be filled with ENM and VENM and would not include contaminated material. The use of only ENM or VENM spoil material means that impacts on groundwater quality beyond naturally occurring conditions are unlikely.



## Water Sharing Plan

The rules of the Sydney Basin Central groundwater source as part of the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011 (NOW, 2011) and their application to the project have been considered in **Table 6-37**.

The potential impacts to groundwater have been assessed against the minimal impact considerations of the NSW Aquifer Interference Policy (Department of Primary Industries, 2012). For the purpose of this assessment and in accordance with the determination criteria developed for groundwater source categories in the Aquifer Interference Policy, the groundwater aquifer is considered to be a less productive groundwater source and a porous rock water source. The minimal impact considerations and their application to the project are provided in **Table 6-37**. The term 'water supply work' as it is used in **Table 6-37** and defined in the *Water Management Act 2000* (Water Act), broadly encompasses works constructed for the purpose of taking, storing, conveying, diverting or impounding water from a water source.

**Table 6-37 Groundwater sharing plan rules**

| Rule                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Application to project                                                                                                                                                                                                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Access rules</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                          |
| <b>Rules for granting of access licences</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                          |
| <p>Granting of access licences may be considered for the following:</p> <ul style="list-style-type: none"> <li>Local water utility, major water utility, domestic and stock, and town water supply</li> <li>These are specific purpose access licences in clause 19 of the Water Management (General) Regulation 2004.</li> <li>Aquifer (Aboriginal cultural), up to 10 ML/yr</li> <li>Commercial access licences under a controlled allocation order made in relation to any unassigned water in this water source.</li> </ul>                                                                                                                                                                                                                                                                                                                                            | <p>Dewatering of the quarry void would be conducted in accordance with the dewatering groundwater licence issued to Hornsby Shire Council, valid from 17 April 2014 until 16 April 2019 (licence number 10BL602842).</p> |
| <b>Rules for managing water allocation accounts</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                          |
| <p>Carryover</p> <p>Up to 10% entitlement allowed.</p> <p>Carryover is not allowed for domestic and stock, major utility, local water utility or specific purpose access licences.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <p>Not applicable. The aquifer interference is not a carryover water allocation.</p>                                                                                                                                     |
| <b>Rules for managing access licences</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                          |
| <p>Managing surface and groundwater connectivity</p> <p>From year 7 of the plan, for areas adjoining unregulated water sources (i.e. rivers and creeks), existing works within 40 metres of the top of the high bank of a river or creek, except existing works for, local water utility, town water supply, food safety or essential dairy care purposes, will have conditions which establish:</p> <ul style="list-style-type: none"> <li>the flow class of the river established under the water sharing plan for the corresponding unregulated water source, or</li> <li>in the absence of a flow class, visible flow in the river at the closest point of the water supply works to the river.</li> </ul> <p>These distances and rules may be varied for an applicant if the work is drilled into the underlying parent material and the slotted intervals of the</p> | <p>Not relevant. The plan has not yet reached year 7.</p>                                                                                                                                                                |

| Rule                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Application to project                                                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| works commences deeper than 30 metres or no minimal impact on base flows in the stream can be demonstrated.<br>For major utility and local water utility access licences these rules apply to new water supply works from plan commencement.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Rules for granting and amending water supply works approvals</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <p>To minimise interference between neighbouring water supply works</p> <p>No water supply works (bores) to be granted or amended within the following distances of existing bores:</p> <ul style="list-style-type: none"> <li>• 400 metres from an aquifer access licence bore on another landholding, or</li> <li>• 100 metres from a basic landholder rights bore on another landholding, or</li> <li>• 50 metres from a property boundary (unless written consent from neighbour), or</li> <li>• 1,000 metres from a local or major water utility bore, or</li> <li>• 200 metres from a NSW Office of Water monitoring bore (unless written consent from NSW Office of Water)</li> </ul> <p>The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.</p> | <p>The project is not a water supply work.</p> <p>Consideration has been given to the potential impact on surrounding water supply works (bores). <b>Table 6-34</b> concludes that there is a low likelihood of the proposed works impacting on any existing bores.</p> <p>In the event the project does render an existing bore unviable, consultation would be undertaken with the bore owner to develop appropriate mitigation measures.</p> |
| <p>To protect bores located near contamination</p> <p>No water supply works (bores) are to be granted or amended within:</p> <ul style="list-style-type: none"> <li>• 250 metres of contamination as identified within the plan, or</li> <li>• 250 metres to 500 metres of contamination as identified within the plan unless no drawdown of water will occur within 250 metres of the contamination source,</li> <li>• a distance greater than 500 metres of contamination as identified within the plan if necessary to protect the water source, the environment or public health and safety.</li> </ul> <p>The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.</p>                                                                                  | <p>The project is not a water supply work.</p> <p>Consideration has been given to the potential impact on surrounding water supply works (bores). <b>Table 6-34</b> concludes that there is a low likelihood of the proposed works impacting on existing bores.</p> <p>In the event the project does render an existing bore unviable, consultation would be undertaken with the bore owner to develop appropriate mitigation measures.</p>     |

| Rule                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Application to project                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>To protect water quality</p> <p>To minimise the impact on water quality from saline interception in the shale aquifers overlying Sydney basin sandstone, the bore being used to take groundwater must be constructed with pressure cement to seal off the shale aquifer as specified by the Minister.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <p>The project is unlikely to impact on existing groundwater quality. Extracted groundwater would be tested and if necessary treated to meet the requirements of the existing groundwater licence prior to discharge.</p> <p>Water discharge quality from the quarry would comply with the requirements of Hornsby Shire Council's existing groundwater licence and ANZECC water quality guidelines.</p> <p>This discharge water quality is likely to be higher quality than the receiving surface water environment.</p> <p>Only ENM and/ or VENM would be emplaced into the quarry void.</p> <p>Refer to <b>Section 6.4</b> (Surface water and flooding) for a detailed discussion of surface water and flooding impacts.</p> |
| <p>To protect bores located near sensitive environmental areas</p> <p>No water supply works (bores) to be granted or amended within the following distances of high priority Groundwater Dependent Ecosystems (GDEs) (non Karst) as identified within the plan:</p> <ul style="list-style-type: none"> <li>• 100 metres for bores used solely for extracting basic landholder rights, or</li> <li>• 200 metres for bores used for all other access licences.</li> </ul> <p>The above distance restrictions for the location of works from high priority GDEs do not apply where the GDE is a high priority endangered ecological vegetation community and the work is constructed and maintained using an impermeable pressure cement plug from the surface of the land to a minimum depth of 30 m.</p> <p>No water supply works (bores) to be granted or amended within the following distances from these identified features:</p> <ul style="list-style-type: none"> <li>• 500 metres of high priority karst environment GDEs, or</li> <li>• a distance greater than 500 metres of a high priority karst environment GDE if the Minister is satisfied that the work is likely to cause drawdown at the perimeter of the high priority karst GDE, or</li> <li>• 40 metres of a river or stream or lagoon (3rd order or above),</li> </ul> | <p>The technical working paper: biodiversity includes an assessment of potential GDEs.</p> <p>This assessment, and a review of the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011 (NOW, 2011) did not identify GDEs within the vicinity of the quarry.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                     |

| Rule                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Application to project                                                                                                                                                                                                                               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>40 metres of a 1st or 2nd order stream, unless drilled into underlying parent material and slotted intervals commence deeper than 30 metres (30 metres may be amended if demonstrate minimal impact on base flows in the stream), or 100 metres from the top of an escarpment.</li> </ul> <p>The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                      |
| <p>To protect groundwater dependent culturally significant sites</p> <p>No water supply works (bores) to be granted or amended within the following distances of groundwater dependent cultural significant sites as identified within the plan:</p> <ul style="list-style-type: none"> <li>100 metres for bores used for extracting for basic landholder rights, or</li> <li>200 metres for bores used for all other aquifer access licences</li> </ul> <p>The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <p>No groundwater dependent culturally significant sites have been identified in the vicinity of the proposed works area.</p>                                                                                                                        |
| <p>Rules for replacement groundwater works</p> <p>A replacement groundwater work must be constructed to take water from the same water source as the existing bore and to a depth specified by the Minister.</p> <p>A replacement bore must be located within:</p> <ul style="list-style-type: none"> <li>20 metres of the existing bore; or</li> <li>If the existing bore is located within 40 metres of the high bank of a river the replacement bore must be located within:</li> <li>20 metres of the existing bore but no closer to the high bank of the river or a distance greater if the Minister is satisfied that it will result in no greater impact</li> </ul> <p>Replacement works may be at a greater distance than 20 metres if the Minister is satisfied that doing so will result in no greater impact on the groundwater source and its dependent ecosystem.</p> <p>The replacement work must not have a greater internal diameter or excavation footprint than the existing work unless it is no longer manufactured. If no longer manufactured the internal diameter of the replacement work must be no greater than 110% of the existing work</p> | <p>Not applicable.</p> <p>The project is not a replacement groundwater work.</p> <p>In the event that a replacement bore is required for an existing user, the project would consult with the DPI Water and would consider these relevant rules.</p> |



| Rule                                                                                                                                                                                                                                                                                                                                                                                                                                             | Application to project                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Rules for the use of water supply works approvals</b>                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <p>To manage bores located near contaminated sites</p> <p>The maximum amount of water that can be taken in any one year from an existing work within 500 metres of a contamination source is equal to the sum of the share component of the access licence nominating that work at commencement of the plan.</p>                                                                                                                                 | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <p>To manage the use of bores within restricted distances</p> <p>The maximum amount of water that can be taken in any one year from an existing work within the restricted distances to minimise interference between works, protect sensitive environmental areas and groundwater dependant culturally significant sites is equal to the sum of the share component of the access licence nominating that work at commencement of the plan.</p> | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <p>To manage the impacts of extraction</p> <p>The Minister may impose restrictions on the rate and timing of extraction of water from a water supply work to mitigate the impacts of extraction.</p>                                                                                                                                                                                                                                             | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Limits to the availability of water</b>                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <p>Available Water Determinations (AWDs)</p> <p>100% stock and domestic, local and major utilities and specific purpose access licences</p> <p>1 ML/unit of share aquifer access licences</p> <p>AWD for aquifer access licences may be reduced in response to a growth in use.</p>                                                                                                                                                              | <p>Inflow during works would vary according to the progression of the spoil reuse activities.</p> <p>At the conclusion of works, the groundwater flow regime is anticipated to return closer to pre quarrying conditions by reducing the groundwater sink that the quarry void has become. Groundwater velocity through the compacted ENM and VENM is expected to be similar to that of the volcanic breccia which formerly occupied the quarry void.</p> |
| <b>Trading rules</b>                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <p>INTO groundwater source</p> <p>Not permitted</p>                                                                                                                                                                                                                                                                                                                                                                                              | Not applicable.                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <p>WITHIN groundwater source</p> <p>Permitted subject to local impact assessment</p>                                                                                                                                                                                                                                                                                                                                                             | Not applicable.                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <p>Conversion to another category of access licence</p> <p>Not permitted</p>                                                                                                                                                                                                                                                                                                                                                                     | Not applicable.                                                                                                                                                                                                                                                                                                                                                                                                                                           |

**Table 6-38 NSW Aquifer Interference Policy minimal impact considerations**

| No                    | Consideration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Potential impact                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Water table</b>    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 1                     | <p>Water Table – Level 1</p> <p>Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic “post-water sharing plan” variations, 40 metres from any:</p> <p>(a) high priority groundwater dependent ecosystem; or<br/>(b) high priority culturally significant site;</p> <p>listed in the schedule of the relevant water sharing plan.</p> <p>A maximum of a two metre decline cumulatively at any water supply work.</p>                                                                                                                                                                                                                   | <p>There are no high priority groundwater dependent ecosystems or high priority culturally significant sites listed under Schedule 4 of the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources (2011) within 40 metres of the proposed works area.</p> <p>Based on the calculations presented previously, no water supply works (i.e. groundwater bores) would undergo a cumulative decline of more than two metres.</p> |
| 2                     | <p>Water Table Level 2</p> <p>If more than ten per cent cumulative variation in the water table, allowing for typical climatic “post-water sharing plan” variations, 40 metres from any:</p> <p>(a) high priority groundwater dependent ecosystem; or<br/>(b) high priority culturally significant site;</p> <p>listed in the schedule of the relevant water sharing plan if appropriate studies demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site.</p> <p>If more than a two metre decline cumulatively at any water supply work then make good provisions should apply.</p> | <p>Level 2 does not apply as Level 1 criteria is not exceeded</p>                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Water pressure</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 1                     | <p>Water Pressure – Level 1</p> <p>A cumulative pressure head decline of not more than a 2 m decline, at any water supply work.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <p>Based on the calculations presented previously, no water supply works (i.e. groundwater bores) would undergo a cumulative pressure head decline of more than two metres.</p>                                                                                                                                                                                                                                                                  |
| 2                     | <p>Water Pressure Level 2</p> <p>If the predicted pressure head decline is greater than requirement 1. above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.</p>                                                                                                                                                                                                                                                                                                                                             | <p>Level 2 does not apply as Level 1 criteria is not exceeded</p>                                                                                                                                                                                                                                                                                                                                                                                |

| No                   | Consideration                                                                                                                                                                                                                                                                                 | Potential impact                                                                                                                                                                                                                 |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Water quality</b> |                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                  |
| 1                    | <p>Level 1</p> <p>Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.</p>                                                                                                                             | <p>The beneficial use category of the groundwater resource would not be changed beyond 40 metres from the quarry void.</p> <p>There are no highly connected surface water sources (alluvial aquifers) in the quarry vicinity</p> |
| 2                    | <p>Level 2</p> <p>If condition 1 is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.</p> | <p>Level 2 does not apply as Level 1 criteria is not exceeded</p>                                                                                                                                                                |

## Ground movement

Studies by PSM (2007) and Coffey and Partners (1990) concluded that the risk of ground movement at the quarry was constrained to the quarry void and immediate surrounds. Ground movement at the quarry void would not present a risk to neighbouring properties.

Filling of the quarry void would provide the primary mitigation measure to manage instabilities at the quarry site. However, a moderate to high risk of small scale instability (at bench scale) around all four faces of the quarry has been previously identified by Coffey (1990) and PSM (2007). Whilst the PSM report concluded that there is no risk to neighbouring residential properties, instability of the quarry faces and the immediate surrounds of the quarry would present a risk to site personnel, facilities and access associated with the proposed spoil reuse works.

Dewatering of the quarry void may result in a temporary build-up of groundwater pressure within the volcanic breccia and Hawkesbury Sandstone as hydraulic gradients steepen. Stabilisation of the quarry face during this period, for example drilling of drainage holes to relieve groundwater pressure, the use of shotcrete and/or mesh to support zones of weakness and/or installation of rock bolts to secure loose blocks may be employed to mitigate potential impacts if required.

The eastern side of the quarry site would house the temporary construction compound and temporary infrastructure required to undertake the works. Coffey (1990) and PSM (2007) found that fill material on the eastern side of the quarry, consisting predominantly of overburden material generated during quarry operations, would require further analysis to determine its suitability for structural support. Excavation and re-compaction of the fill may be required in those areas where structural support is required. Further investigation into the potential for the proposed works to be exposed to instability risks and potential management measures would be undertaken as part of ongoing design development. Details of stabilisation measures, if determined to be required, would be provided in the Construction Method Statement (CMS) to be compiled by the Contractor. The CMS would be prepared well in advance of works commencing, with the primary aim to identify and detail high level risks/hazards, resources, plant and equipment, procurement lead times, approvals, detail drawings and other details associated with the specific construction methodology processes to be performed for that element.

At the completion of spoil reuse works, the ground levels over filled areas of the quarry void would be subject to some degree of settlement, which is likely to be most significant at the centre of the filling area. Where compaction is not undertaken, settlements would be anticipated to be up to one metre in the first 10 years following completion of the filling and a further metre during the following 90 years (PSM, 2007). Compaction during the spoil reuse process would reduce the potential for significant levels of future settlement.

## Contamination

As detailed above, a number of sites exist in the immediate vicinity of the construction footprint with the potential to be contaminated as a result of historical land uses and development. In addition, one known contaminated site is located approximately 800 metres from the proposed project footprint (Shell Hornsby).

The proposed works area footprint would be constrained to the eastern side of the quarry site and the interior of the quarry void as shown in **Figure 6-6**. There would also be the potential for disturbance of ancillary infrastructure on the western side of the quarry void associated with Hornsby Shire Council's groundwater maintenance pumping program. Potential disturbance of areas of known potential contamination would therefore consist of:

- The eastern fill area, which is likely to consist of overburden material extracted from the quarry pit during quarry operations (PB, 2004). **Figure 6-6** shows the locations and depth of fill in the eastern fill area.
- The 1,000 litre diesel generator located inside of a container at RL 46 AHD on the western side of the quarry void, which would be relocated to a higher elevation at the completion of initial dewatering and prior to the commencement of spoil emplacement.

The risk of contamination from these two sources would be low. Further investigation of the nature of the uncontrolled fill materials on the eastern side of the quarry void would be undertaken during detailed design to ensure that any disturbance of the fill material would not result in the spread of contamination.

Relocation of the existing 1,000 litre diesel generator would be undertaken in a manner that would minimise the risk of potential contamination. In addition, it is unlikely that significant contamination of the site in the immediate vicinity of the generator has occurred, as the generator is a self-bunded unit and is housed within a container.

The risk of contamination from the known contaminated site (Shell Hornsby) footprint would be low as this site is located around 800 metres from the project and there is no disturbance of the contaminated site or neighbouring properties proposed.

Groundwater quality has previously been assessed by PB (2004) and PSM (2007) and has been found to be reflective of natural, uncontaminated conditions. Groundwater was measured to have low total metal concentrations and low nutrient calculations. Investigations by PB (2004) indicated that there was no geochemical stratification within the upper ten metres of the quarry water, therefore salinity, pH and other geochemical conditions are not expected to alter significantly with depth. Minimal changes in land use on the site, and within neighbouring properties, indicates groundwater quality would be relatively static.

Refuelling facilities are not proposed around the perimeter of the quarry void. However there may be storage of some fuels, oils or hazardous chemicals associated with the project. To minimise the likelihood of spills and groundwater contamination, hazardous chemicals and fuels would be stored in a bunded hardstand area, with spill kits to manage spills. Stormwater and sewer facilities associated with buildings and structures constructed for the filling activities have the potential to leak and contaminate groundwater. Construction of these waste water facilities in accordance with the relevant Australian Standards and good management practices would minimise the likelihood of contaminant spills.

The potential to cause further contamination through accidents or spills of fuels, oils and chemicals during the project is therefore considered to be negligible. Refer to **Section 6.5** (Hazards and risk) for a detailed discussion of dangerous goods and hazardous substances and associated management and mitigation measures.

There is the potential for contaminants to be imported to the site within the material that would be used to fill the quarry. However, this is considered unlikely as, in accordance with the SEARs for the project, the material proposed to be used to fill the quarry void would consist only of VENM and ENM generated solely from tunnelling activities required for NorthConnex.

VENM is naturally occurring rock and soil (including material such as sandstone, shale, clay and soil) that has been excavated or quarried from areas that are not contaminated with manufactured chemicals, or with process residues, as a result of industrial, commercial, mining or agricultural activities and that does not contain any sulfidic ores or soils or any other waste.

ENM is naturally occurring rock and soil (including materials such as sandstone, shale, clay and soil) that has been excavated from the ground, that contains at least 98 per cent (by weight) natural material, that does not include material that has been processed or contains acid sulphate soils or potential acid sulphate soils and does not meet the definition of VENM.

A key difference between VENM and ENM is that VENM exists in its natural undisturbed state at the time of its excavation, whereas material cannot be classified as VENM if it has been disturbed, such as through mixing or if there is foreign material present.

Testing of VENM would not be required provided the material meets the definition of VENM in the POEO Act. Testing and sampling of ENM would be conducted in accordance with the Generator requirements as specified in clause 93 of the *Protection of the Environment Operations (Waste) Regulation 2014*.

### 6.3.4 Environmental management measures

The emplacement works associated with filling of the quarry void with VENM and ENM would be expected to alter groundwater flows positively by returning them closer to a pre-quarrying groundwater flow regime. Impacts associated with groundwater drawdown and ground settlement are anticipated to be negligible and in accordance with the anticipated future rehabilitation and use of the site by Hornsby Shire Council. Contamination impacts are considered to be low as the design of the footprint has sought to avoid areas of potential contamination, and where this would not be possible, controls would be established so that interaction with any potential sources of contamination present on the quarry site would be managed appropriately. Excavation works would not impede on the deeper groundwater aquifer, and only VENM and ENM would be used to fill the quarry void.

Filling of the quarry void would provide the primary mitigation measure to mitigate the potential impacts associated with instabilities at the quarry site. Further investigation into the potential for works to be exposed to instability risks and potential management and mitigation measures would be required as part of ongoing design development and details of any mitigation measures would be provided in the CEMP.

Environmental management measures relating to hydrogeology and soils are provided in **Table 6-39**.

**Table 6-39 Environmental management measures – hydrogeology and soils**

| Impact             | No. | Environmental management measure                                                                                                                                                                                                                                                                       | Timing                                |
|--------------------|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| General            | HS1 | Project personnel would be competent and trained in systems and procedures.                                                                                                                                                                                                                            | Pre-commencement / during the project |
| Acid sulfate soils | HS2 | If acid sulfate soils are encountered, they would be managed in accordance with the Acid Sulfate Soil Manual (Acid Sulfate Soil Management Advisory Committee, 1998).                                                                                                                                  | During the project                    |
| Groundwater        | HS3 | Undertake groundwater monitoring for the duration of the project in accordance with Hornsby Shire Council's licence requirements.                                                                                                                                                                      | Pre-commencement / during the project |
|                    | HS4 | Compliance records of any groundwater monitoring undertaken would be retained.                                                                                                                                                                                                                         | During the project                    |
|                    | HS5 | Where available, and of appropriate chemical and biological quality, subject to a health risk assessment, stormwater, recycled water, groundwater inflows or other water sources would be used in preference to potable water for construction activities, including concrete mixing and dust control. | During the project                    |



| Impact                         | No.  | Environmental management measure                                                                                                                                                                                                                                                                                                                                                                                                                              | Timing                                |
|--------------------------------|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| Ground movement and settlement | HS6  | Further investigation would be undertaken during detailed design to determine if stabilising is required to minimise localised instability of the quarry walls.                                                                                                                                                                                                                                                                                               | Pre-commencement / during the project |
|                                | HS7  | Ongoing assessments would be undertaken during detailed design and construction to determine the level of potential impact on personnel and structures and to identify feasible and reasonable mitigation and management measures required to minimise potential ground movement impacts. This includes assessment of the potential for instability risks associated with the quarry walls and the design and development of appropriate mitigation measures. | During the project                    |
| Contamination                  | HS8  | A CEMP prepared for the project would include provisions to manage potential contaminants and hazardous materials identified during works.                                                                                                                                                                                                                                                                                                                    | Pre-commencement / during the project |
|                                | HS9  | Potentially contaminated areas directly affected by the project would be managed in accordance with the requirements of the CLM Act and Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites (EPA, 1997).                                                                                                                                                                                                                           | During the project                    |
|                                | HS10 | Procedures to address spills and leaks would be developed and implemented during the works.                                                                                                                                                                                                                                                                                                                                                                   | Pre-commencement / during the project |
|                                | HS11 | A procedure to relocate the existing 1,000 litre AST containing diesel on the western side of the quarry void would be established to ensure relocation would not result in any potential contaminants being leached from the tank.                                                                                                                                                                                                                           | During the project                    |
|                                | HS12 | ENM imported to the site for the purpose of emplacement into the quarry pit would meet chemical and other material requirements of the 'excavated natural material order' under Part 9, clause 93 of the Protection of the Environment Operations (Waste) Regulation 2014.                                                                                                                                                                                    | During the project                    |
|                                | HS13 | A CEMP prepared for the project would include provisions to manage unexpected finds and hazardous materials identified during works.                                                                                                                                                                                                                                                                                                                          | Pre-commencement, during the project  |
| <b>Demobilisation</b>          |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                       |
| General                        | HS14 | Demobilisation personnel would be competent and trained in systems and procedures.                                                                                                                                                                                                                                                                                                                                                                            | Demobilisation                        |
| Contamination                  | HS15 | Procedures to address spills and leaks would be developed and implemented during demobilisation of the project.                                                                                                                                                                                                                                                                                                                                               | Demobilisation                        |

## 6.4 Surface water and flooding

This section describes the physical environment within the project area in relation to surface water, including details of catchments, sensitive environments, water quality and flooding. It also details the impacts associated with the removal of water from the quarry void. An assessment of the existing groundwater environment and the impacts associated with groundwater inflow and drawdown is provided in **Section 6.3** (Hydrogeology and soils). The discharge water quality monitoring data obtained from Hornsby Shire Council (data monitored at the flow monitoring tank at the Quarry site prior to discharge into Old Mans Creek) and analysed as part of this assessment is provided in **Appendix N**.

The key objectives of the surface water and flooding assessment were to:

- Identify potential impacts on surface water, sensitive environments and water quality associated with the project.
- Identify potential flooding implications of the project, including changes to local drainage and flooding characteristics, and the potential for the project to be affected during a flooding event.
- Identify environmental management measures that would be required to manage the identified impacts.
- Inform the future detailed design of the project with respect to surface water flows and quality.

**Table 6-40** sets out the SEARs as they relate to surface water and flooding and where in the EIS these have been addressed.

**Table 6-40 SEARs – surface water and flooding**

| SEARs                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Where addressed                                                                                                                                                                                                           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Assessment of construction and operational erosion and sediment impacts, and details of proposed controls.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | An assessment of erosion and sedimentation impacts associated with the project has been completed and is described in <b>Section 6.4.3</b> .<br>Management and mitigation measures are outlined in <b>Section 6.4.4</b> . |
| Assessment of surface water impacts, including details of proposed stormwater management systems, having consideration to impacts on Old Mans Creek and all other watercourses and riparian corridors potentially affected by the proposal. The assessment of water quality impacts is to have reference to relevant public health and environmental water quality criteria, including those specified in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ 2000), and any applicable regional, local or site specific guidelines. | Potential surface water impacts, having regard to relevant public health and environmental water quality criteria, have been assessed and are described in <b>Section 6.4.3</b> .                                         |

### 6.4.1 Assessment methodology

The assessment methodology for the surface water and flooding assessment involved:

- Compilation and review of background information (previous studies, survey and mapping data) relevant to the project, including data on watercourse conditions and water quality to characterise the existing surface water environment within the potentially affected watercourses.
- Identification and assessment of project activities that may impact on the water quality and flood potential of receiving environments.
- Review of Hornsby Shire Council flood maps to determine flood prone areas.

- Identification of mitigation measures, including type of controls and design criteria required to manage potential impacts.

The surface water assessment also considered the following current policies and guidelines applicable to water quality management:

- Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition (Landcom, 2004) (Blue Book).
- NSW Water Quality and River Flow Objectives (EPA, 2006) available at <http://www.environment.nsw.gov.au/ieo/index.htm>.
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000) (ANZECC Guidelines).
- Using the ANZECC Guidelines and Water Quality Objectives in NSW (DEC, 2006b).

## 6.4.2 Existing environment

### Catchment and waterways

The project area lies within Old Mans Valley which has a general surface drainage flow direction from the east to the west. The nearest named watercourse, Old Mans Creek, drains from the south west of the project area to the west, joining Waitara Creek which flows north to Berowra Creek. The project area and surface water drainage from it lie within the Berowra Creek sub-catchment of the Hawkesbury-Nepean Catchment. **Figure 1-2** shows the main waterways around the project area.

The Berowra Creek sub-catchment lies between the Cattai sub-catchment to the west and Cowan/Pittwater sub-catchments to the east. It flows directly into the Hawkesbury Estuary. It is a tidal river sub-catchment, with 40 per cent of the total stream length having tidal influences. Much of the lower reaches to the north are located within reserved land (Marramarra National Park and Muogamarra Nature Reserve), while parts of the upper reaches to the south are located in Berowra National Park. The catchment is highly developed in the south with the residential, industrial and commercial development of Hornsby and its surrounding suburbs. The semi-rural areas of Arcadia, Galston and Glenorie are situated to the west of Berowra Creek. Two wastewater treatment plants (WWTP) discharge into waterways of the Berowra sub-catchment, one on Waitara Creek in West Hornsby, and the other on Calna Creek in Hornsby Heights. Water quality in the sub-catchment is generally poor.

Old Mans Creek, which accepts the majority of the surface water flows from the project area, has a number of minor tributaries that originate from outside of the Hornsby Quarry site and converge in the eastern part of the site including:

- A remnant and incised drainage line entering the site from the north east, which collects and conveys residential stormwater flows.
- A drainage line which drains areas to the east of the site, and which runs adjacent to the eastern boundary of the site before joining the north eastern drainage line.
- A minor watercourse entering the site from the south east.

These minor tributaries combine and pass through a gross pollutant trap before descending (through two 1.2 metre diameter pipes in a three metre embankment) into an open concrete lined stormwater channel (2.6 metres wide by 0.28 metres deep) located on the northern edge of the quarry void. The concrete lined stormwater channel diverts flows around the quarry void to a discharge point at Old Mans Creek. **Figure 6-11** shows the location and configuration of this surface drainage system.

The drainage lines in the eastern part of the site, which includes an area proposed for the project stockpiles, have been significantly altered by historical filling activities, realignment of drainage lines and installation of stormwater pipes. The original east to west drainage line through the site has been previously filled with waste rock material from the quarry. Substantial groundwater flow is known to occur through this infilled drainage line following periods of heavy rain. In 1990, Coffey recommended that a large rock drain be constructed within the old gully to control subsurface pressures. In 2007, PSM reported that there was no evidence to suggest that this work had been undertaken and that fill continued to be placed in this area by the quarry operators after 1990.

## Water quality

An annual water quality monitoring program for the Hornsby Shire LGA (including the Berowra Creek sub-catchment) has been conducted by Hornsby Shire Council since the signing of the Statement of Joint Intent in 1994. The Statement of Joint Intent was established in response to environmental issues which included the regular occurrence of algal blooms in the estuarine section of Berowra Creek, increasing pressures of urban development and sewage discharge issues, tighter pollution regulations coming into force, the publication of Australian environmental water quality guidelines, and the recognition of the detrimental impacts of catchment activities on water quality. During 2013-14 water quality was routinely monitored at 57 sites across the Hornsby LGA in both freshwater and estuarine locations (Hornsby Shire Council, 2014).

The main existing impacts on water quality in Berowra Creek sub-catchment arise from the discharge of tertiary treated sewage from the West Hornsby and Hornsby Heights WWTPs into Waitara and Calna Creeks, and from stormwater run-off from the developed urban and commercial areas located in the south eastern parts of the Hornsby Shire LGA. The rural and rural-residential areas in the southern end of the Hornsby Shire LGA flow to upper Berowra, Tunks, Still and Calabash Creeks. Along the south western edge, similar areas flow to Colah and Fiddletown Creeks then to Marramarra Creek which flows to lower Berowra Creek, close to the Hawkesbury River

The ANZECC Guidelines recommend using trigger values developed on a local or regional scale in preference to using the 'default' values within the guidelines. Water quality data collected by Hornsby Shire Council from 2002 to 2010 showed that using the 'default' values would not be appropriate, given there were existing exceedances for some parameters.

In order to provide appropriate trigger values, Hornsby Shire Council developed a set of Regional Environmental Health Values (REHV). These are presented in **Table 6-41**. These values in some cases are more stringent than the ANZECC guidelines, and in other cases are less stringent. However, these values are considered to be more appropriate than the ANZECC 'default' values as they have been determined in the context of the existing ecosystem condition, and provide a realistic baseline to monitor water quality impacts downstream. These values would continue to be adopted for the project.

**Table 6-41 Hornsby Shire Council - REHVs for water quality**

| Parameter               | Unit                | REHV triggers              |
|-------------------------|---------------------|----------------------------|
| Electrical conductivity | ms/cm               | 0.32                       |
| Turbidity               | NTU                 | 8                          |
| Dissolved oxygen        | per cent saturation | 75 to 118                  |
| pH                      | pH                  | 4.8 to 7                   |
| Suspended solids        | mg/L                | 7                          |
| Oxidised nitrogen       | mg/L                | 0.05                       |
| Total nitrogen          | mg/L                | 0.32                       |
| Total phosphorus        | mg/L                | 0.01                       |
| Faecal coliforms        | CFU/100ml           | Median <150 and 80th% <600 |

\* Extract from Hornsby Shire Council Water Quality Monitoring Program, Annual Report 2013-2014.