Contamination from hydrocarbons will be a concern during construction/operation given the high use of plant and equipment required for the proposed use.

**Bacteria**

To test for the presence of harmful pathogens, the total *thermotolerant coliforms* were analysed. These include species of faecal coliform bacteria which are normal intestinal flora of humans and animals but are also important pathogens responsible for serious infections. While many strains are harmless, some strains produce a powerful toxin and can cause severe illness. The presence of thermotolerant coliforms in water is generally an indication of recent sewage or animal waste contamination.

Levels of thermotolerant coliforms varied significantly over the monitoring events, with recorded values ranging from 0 to 300,000 cfu/100mL – significantly higher than the upper guideline value for primary contact recreational waters (150 cfu/100mL).

These high values may be due to a build-up of bacteria within the soil, subsequently being transferred during high stormwater flows.

### 3.6 Flooding

#### 3.6.1 Description of Baseline Flood Risk

Existing (baseline) flood risk has been defined by hydrologic and hydraulic modeling undertaken for a range of design events from the 2 year average recurrence interval (ARI) to the probable maximum flood (PMF). This modelling work was undertaken for the Northern and Mid catchments (those in which the development will be located) as shown in Figure 3-8. Modelling of the Southern Catchment was not undertaken as there is no development proposed in this area and therefore no changes in flood behaviour would occur.

Figures 3-9 and 3-10 present the modelled existing (baseline) flood depths and extents for the 100 year and PMF events respectively. This figure shows that existing floods within the site are generally confined to within the steep, narrow gullies. As a result, flood extents do not change significantly with increasing flood magnitude.

Runoff exits from the proposed disturbance footprint via two existing flow routes: via the Northern Catchment and via the Mid Catchment. Two reference locations (TS1 and TS2) have been nominated at the downstream ends of these routes near the site boundary. At these two reference locations series information on flows has been extracted from the model and is presented in the following ways:

- Figure 3-10 and Figure 3-10 illustrate the locations of the reference locations.
- Table 3-4 summarises the peak flow observed in the baseline model at these two locations for all modelled flood magnitudes.
- Figure 3-12 plots the flows against time, and demonstrates that the catchments are typically responsive with flows rising and falling quickly during and immediately following the triggering storm.
- Peak baseline velocities are presented in Figure 3-13 for the 100 year ARI event. It shows that velocities are typically 3 m/s in the lower reaches of the site although highly localised areas experience velocities in excess of this typical velocity.

### Table 3-4  Peak Baseline Flows Leaving Site

<table>
<thead>
<tr>
<th>ARI (Years)</th>
<th>Peak Flow (m$^3$/s)</th>
<th>Northern Catchment (TS1)</th>
<th>Mid Catchment (TS2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>13.4</td>
<td>24.7</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>17.8</td>
<td>34.4</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>20.6</td>
<td>40.2</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>24.3</td>
<td>48.4</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>31.8</td>
<td>58.2</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>36.2</td>
<td>67.4</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td>86.3</td>
<td>187.9</td>
</tr>
<tr>
<td>PMF</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Additional model results (including for other design rainfall events) are provided in Appendix H.
Title: Baseline PMF Flood Depths

Figure: 3-11

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

Filepath: 318995_1_BRH_Boral_SAD/PG/ELS_Report/FLD_005_121213_QPNCF_Depths.wcr

www.bmtwmb.com.au
Figure 3-12  100 year ARI Baseline Flows Leaving Site
Compliance with Guidelines

Compliance with SPP1/03 in relation to flood hazard is not required due to the fact that there is no local Defined Flood Event (DFE) extent within the development site boundary. Outcomes 1 and 2 of the SPP which relate to development applications within the DFE are therefore not applicable. The general principles of SPP1/03 and its accompanying guidance note have however been applied in this assessment. In particular the following has been undertaken:

- A detailed flood study (hydrologic/hydraulic modelling and mapping exercise), has been undertaken by a suitably qualified hydraulic engineer.
- A full suite of flood magnitudes has been considered in the study ranging from the 2 year ARI through to the PMF.
- The precautionary principle as advocated in SPP1/03 and defined in the Sustainable Planning Act has been applied with conservative assumptions applied over non-conservative ones.
- The potential future impacts to the site resulting from climate change have been considered in the assessment.

As for SPP1/03, compliance with the Gold Coast Planning Scheme is not required due to there being no local DFE extent within the development site boundary. The most applicable Outcome Measures have however been met as documented in Table 3-5.

**Table 3-5  Gold Coast Planning Scheme Flood Code – Relevant Performance Criteria**

<table>
<thead>
<tr>
<th>Performance Criteria</th>
<th>Demonstration of Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PC5</strong> Development in flood affected areas must not cause, or have the cumulative potential to cause, real damage, must not increase the level of risk to life, or be to the detriment of flood evacuation procedures.</td>
<td>Detailed flood study (hydrologic and hydraulic modelling and mapping) undertaken for 2, 5, 10, 20, 50, 100 year ARI events and PMF. No significant increases to flood level, flow, velocity or duration as a result of the development.</td>
</tr>
<tr>
<td><strong>PC6</strong> Development with plans for earthworks in a floodplain or over a water body within a flood affected area below the Designated Flood Level must allow for the maintenance of flood storage, and flood conveyance of flood and drainage channels and overland flow paths.</td>
<td>Significant additional storage of floodwater during construction and operational phases of quarry as demonstrated through hydraulic modelling (see compliance for PC5). No significant offsite impacts observed and overall there is a significant reduction of in peak runoff during operational phases of the quarry (C1-Q5).</td>
</tr>
<tr>
<td><strong>PC8</strong> Development must consider hydrologic and hydraulic impacts of development in flood affected areas with regard to future climate change.</td>
<td>As part of the hydrologic and hydraulic impact assessment (see compliance for PC5), investigation has been undertaken to determine the sensitivity of site to potential impacts from climate change.</td>
</tr>
<tr>
<td><strong>PC11</strong> Any change in ground level, by way of filling, excavation or contouring, must not result in real damage, flood hazard or impediment to any Counter Disaster Plan, measure or create unreasonable change in the exposure to flood hazard.</td>
<td>Flood study (see compliance for PC5) demonstrates no significant offsite impacts with regard to increased flood levels, flows, velocities or duration.</td>
</tr>
</tbody>
</table>
3.6.2 Climate Change Impacts on Baseline Risk

Changes to the baseline risk resulting from climate change have been modelled by assuming a 10% increase in rainfall intensities.

Figure 3-14 presents a map showing the changes in extents and levels that would be expected by simulating this increase in rainfall.

It can be seen from Figure 3-14 that these local catchments are not highly sensitive to the additional rainfall with changes in peak levels generally less than 0.1m.
4 Potention impacts and mitigation measures
4 POTENTIAL IMPACTS AND MITIGATION MEASURES

4.1 Overview

This section outlines the potential impacts (including water quality, hydrology and flooding), that the project may have on water resources and the management measures recommended to mitigate these impacts. An overview of impacts is provided and potential impacts associated with the Project are assessed using a risk assessment approach. The impacts are assessed in terms of the likelihood of them occurring and the consequence (without mitigation measures), that the potential impacts may have on the environment and community.

Through this process, the potential impacts have been assigned a risk rating of either a “low”, “moderate”, “significant”, “high”, or “intolerable” risk. The risk assessment tables used in this risk assessment process are included in Appendix F.

Appendices A and B also provide a detailed assessment of the potential impacts of the project and address the TOR requirements for the preparation of a ‘stormwater quantity management plan’ and ‘stormwater quantity management plan’. Whilst these plans have been considered separately, an integrated approach to water management has been applied to the project.

A demonstrated commitment to best practice is evident in all aspects of the design and operation of the project that relate to the management of water quality and quantity. A summary of the key management measures according to the management hierarchy shown in Figure 4-1 and best practice philosophy is provided in the table below.

Figure 4-2 illustrates the proposed Water Management Strategy for Phase Q5. As described in Section 1.5.3, Phase Q5 is the final project phase and subsequently illustrates the ultimate project footprint (although the strategy is applicable to all project phases).
100% operational water demands satisfied through recycle, reuse, recover strategy

Best practice stormwater management with decrease in sediment loads discharged downstream (relative to existing site)

Limited disposal of flows/sediments balanced with sustained environmental flows. No increase in flood risk.

Reduced impact on waterways through layout design, rehabilitation and erosion and sediment control and where practical, dry season clearing/overburden removal

70% of the site (155 ha) avoided (proposed conservation area)
## Table 4-1 Summary of Key Management Measures

<table>
<thead>
<tr>
<th>Management Option</th>
<th>Description of Key Management Measures Adopted</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Avoid</strong></td>
<td>The proposed disturbance footprint has been designed so as to <strong>avoid</strong> approximately 155 ha (70%) of the site. This land is proposed to be voluntarily set aside, and not developed, as conservation area. Within this proposed conservation area, a range of offset rehabilitation activities are proposed to repair the land from historic agricultural use and damage from off road vehicles. The disturbance footprint also entirely <strong>avoids</strong> any impacts to one of the three catchments on the site.</td>
</tr>
<tr>
<td><strong>Reduce</strong></td>
<td>Existing sediment loads are proposed to be <strong>reduced</strong> by rehabilitating the degraded waterways and tracks within the conservation area. A range of rehabilitation activities are therefore proposed to repair the land from historic agricultural use and damage from off road vehicles. These rehabilitation activities may be subject to further licencing approvals under the Water Act unless the nature and extent of works determines them exempt. To <strong>reduce</strong> the volume of potential future sediment loads discharging from the site (and minimise flood risk), it is recommended that all vegetation and overburden removal is undertaken in accordance with the Erosion and Sediment Control Plan (ESCP) and as far as practical outside of the west season. Any disturbed areas which are not subject to extractive industry use should be stabilised in accordance with the ESCP, which has been prepared separate to this document (by others). The proposed disturbance footprint has been designed so as to <strong>reduce</strong> the direct impact of the proposed disturbance footprint on waterways.</td>
</tr>
<tr>
<td><strong>Recycle, Reuse, Recover</strong></td>
<td>The proposed quarry has a high water demand. Rather than using potable mains water to meet the site’s water demands, a <strong>recycle</strong>, <strong>reuse</strong>, <strong>recover</strong> philosophy has been adopted. Modelling has indicated that all site water demands for surface dust control, dust suppression and process water are predicted to be satisfied by the proposed water cycle management strategy i.e. 100% site water demands are expected to be met by <strong>recovery and reuse</strong> of stormwater. Any runoff of this water from the quarry pit is <strong>recycled</strong> back to the quarry dam to be <strong>reused</strong>. Stormwater has therefore been treated as an important water resource rather than a waste stream.</td>
</tr>
<tr>
<td><strong>Treat</strong></td>
<td>The <strong>treatment</strong> of sediment loads is a critical component of the proposed water management strategy for the site. Sediment loads will primarily be treated via a best practice Erosion and Sediment Control Plan (ESCP) which will form part of the overall Environmental Management Plan (EMP). The <strong>treatment</strong> of sediment laden stormwater will by default also assist in the removal of a range of other</td>
</tr>
</tbody>
</table>
potential pollutants.

The water management strategy includes the following treatment measures:

- Pit storage – providing significant opportunity for the storage of stormwater flows from the quarry catchment, allowing suspended material to be settled (prior to pumping retained waters to the quarry dam).
- Quarry dam – providing a stormwater treatment function by allowing further settlement of suspended material and by harvesting stormwater flows (and pollutant loads) for subsequent use on site (e.g. for dust suppression).
- Rock channels – conveying flows from the plant area and providing some pre-treatment of flows prior to discharging into the sediment basin.
- Sediment basin – retaining stormwater flows to facilitate sediment removal, prior to discharging treated flows to the downstream waterway.
- Additional soil erosion and sediment control best management practices.

With the beneficial use of harvested flows (from the quarry dam catchment, and pumped flows from the quarry pit), stormwater pollutant loads within these harvested flows are prevented from discharging into downstream waterways thereby providing additional water treatment.

Dispose Disposal has been adopted as the least preferred method of water treatment as dictated by the management hierarchy adopted for the site. The only water proposed to be disposed of includes:

- Water which overtops the quarry dam during/ following major rainfall events.
- Water which overtops the sediment basin during/ following major rainfall events.
- Water which is treated in the sediment basin and control released.
- Environmental flows in waterways which will not be impacted by the proposed disturbance footprint.

It is noted that due to the “avoid”, “reduce” and “reuse” strategies discussed in this table above, environmental flows are still maintained to the downstream receiving waterways so that there is not an over-use of water resources.

Where water is disposed (e.g. over-topping of quarry dam and sediment basin during major rainfall events), some sediments and associated pollutants within this water will also be disposed (and conveyed downstream). Nevertheless, the quarry operations will still be required satisfy relevant discharge requirements.
4.2 Floodplain Management Impacts and Mitigation Measures

Impacts with regard to flood risk are typically assessed in terms of risk to offsite receptors. Risk can be increased to receptors through changes in both the runoff magnitude and the rate of runoff. The quarry has the potential to cause such increases in flood risk. The risk level is higher during preliminary development phases before large scale removal of material (overburden and quarry rock), from the site occurs.

The principal causes of flood related impacts are likely to result from the removal of vegetation from the site and the potential for compaction of soils within the proposed disturbance footprint. Both factors can increase the volume and rate of runoff. If undertaken on a significant scale, these impacts have the potential to manifest in terms of increased downstream peak levels, velocities and duration of inundation.

Typically, the removal of material (overburden and quarry rock), from the site will increase the potential flood storage available which can then attenuate site runoff leading to a reduced offsite peak flow. This is not always the case as attenuation may delay the hydrograph from one tributary and put it in phase with the hydrograph from a neighbouring tributary, thus increasing the overall peak runoff.

Early phases of the development, which are likely to be a ‘worst-case’ with regard to offsite flood impacts, will generally be of limited temporal scales, in the order of months. Provided off-site impacts are not significant during these phases, then it is expected that flood risk can be minimised through provisions such as ensuring that the removal of vegetation and stripping of overburden occur during the dry season.

As described in Appendix A, modelled increases in downstream flows however have been shown to be minimal and only present in the temporary phase before large scale earthworks are undertaken.

To further minimise potential increases in runoff potential, vegetation removal should be undertaken outside of the wet season where practical up to and including Stage E3 of the proposed quarry. No negative impacts were identified in terms of increased downstream flood levels, flows, velocities or duration for any of the other modelled phases. No further floodplain mitigation measures are therefore recommended.

4.2.1 Impact Assessment

Table 4-2 outlines the potential impacts associated with the project, along with a risk rating based on the risk assessment tables provided in Appendix F. The first risk rating column is based on the unmitigated impacts, while the second risk rating column is based on the risk level once mitigation measures have been implemented.

---

11 It is acknowledged that this may not be feasible for an operating quarry however clearing in the dry season is not considered essential given the minimal modelled increases in downstream flows and temporary risk timeframe.
### Table 4-2  Floodplain Potential Impacts

<table>
<thead>
<tr>
<th>ID</th>
<th>Construction Activities</th>
<th>Associated Potential Impacts</th>
<th>Unmitigated Risk Score</th>
<th>Rating</th>
<th>Mitigated Risk Score</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>Vegetation clearing and soil compaction</td>
<td>Increases in the volume of runoff and increase the rate of runoff resulting in increased downstream peak levels, velocities and length of inundation threatening people and/or property.</td>
<td>3,1 Low</td>
<td></td>
<td>3,1 Low</td>
<td></td>
</tr>
</tbody>
</table>

### 4.3 Receiving Water Hydrologic Impacts and Mitigation Measures

Impacts in relation to hydrologic changes are assessed in terms of the change in frequency and volume of flows discharged to downstream waterways. Risk can be increased through changes to flow frequency and magnitude through changes to the catchment upstream of the waterways.

The project has the potential to significantly impact the hydrology of waterways within the site boundary through three principal methods including:

- The proposed disturbance footprint extending into waterways;
- Changes to catchment conditions (e.g. removal of vegetation, increase in imperviousness); and
- Redirection and storage of flows from upstream areas.

These impacts are described further below. A hydrologic management strategy (including a detailed assessment of the hydrologic impacts) for the project is also provided in Appendix B.

#### 4.3.1 Extension into Waterways

The extension of the disturbance footprint into waterways can have direct and obvious impact to waterways. It can significantly reduce the function and values of the waterway immediately within the footprint – and also upstream and downstream of the footprint area due to reduced connectivity and changed flow characteristics.

The proposed disturbance footprint, however, has been designed to minimise any extension into waterways. The only works proposed in any watercourse is the armouring of stream bed and banks so as to protect the streams from the erosive forces of high velocities downstream of the proposed quarry dam and sediment basin. Any such works may be subject to further approvals and State consent. The extraction of quarry material or any other works are not proposed within any watercourse.

The majority of waterways within the site boundary are external to the proposed disturbance footprint. This includes all waterways within the Southern Catchment, and all second and third order streams in the Northern and Mid catchments apart from where minor waterway stabilisation works are proposed (see Figure 3-8). This subsequently greatly reduces potential impacts to waterway hydrology.

---

12 Note: Consequence and likelihood scores as defined in Appendix F.
4.3.2 Changes to Catchment Conditions

The project will result in the removal of vegetation and increased imperviousness within the proposed disturbance footprint. This has the potential to increase the volume, velocity and frequency of runoff from the site and decrease catchment baseflow. These changes would subsequently alter the hydrology in downstream waterways potentially impacting on waterway ecosystems and increasing the risk of erosion in these areas.

These impacts are proposed to be mitigated by the storage and reuse of stormwater flows, namely:

- Temporarily storing flows within the quarry pit (and pumping these flows to the quarry dam);
- Storage of flows (from the dam catchment and quarry pit area) in the quarry dam;
- Use of stored water within the quarry dam to satisfy site water demands (e.g. dust suppression, surface dust control, process water);
- Temporary storage of water in the sediment basin; and
- Decreased gradient across the plant area (decreasing runoff velocity).

4.3.3 Redirection and Storage of Flows from Upstream Areas

The project will change the direction of catchment flow across the site. The construction and operation of the quarry pit, in particular, will result in a significant diversion of flows. This will change the hydrology of waterways downstream of the project footprint and subsequently potentially impact aquatic ecosystems within these waterways.

The area designated for the quarry pit is on a ridge and currently drains in two directions (to the north-west towards the second order stream in the Northern Catchment, and to the east and south-east towards the second and third order streams in the Mid Catchment). Flows from the quarry pit will be pumped (from within a sump in the quarry pit), to the quarry dam, which would have significant potential to decrease the flows to the south-east and increase the flows to the north-east. It may also be possible to direct some flow from the pit storage to the Southern Catchment.

The decrease in flows to the south-east is partially mitigated by the construction of the plant area, which also flows to the south-east. The construction of the plant area (and associated changed catchment conditions, e.g. increased imperviousness), will increase flows from this area.

The increase in flows to the north-east will be partially mitigated by the construction of the quarry dam and the extraction of water from the quarry dam to satisfy site water demands (e.g. dust suppression, surface dust control, process water).

4.3.4 Dewatering of Sediment Basin

The proposed sediment basin is designed to temporarily retain stormwater flows from the upstream catchment to facilitate the removal of particulate matter from stormwater flows, subsequently reducing pollutant loads discharging into downstream waterways. Stormwater flows up to a requisite volume are retained within the sediment basin and mixed with an appropriate flocculent (where required). The flocculent promotes the settlement of particulate matter within the water. Once appropriate discharge limits are satisfied, the retained water will be discharged to the downstream waterway.
The flows will be discharged from the sediment basin in accordance with the Erosion and Sediment Control Plan (ESCP) for the site.

This controlled release of retained waters from the sediment basin will be subsequently different to the existing hydrology. This changed hydrology has potential to negatively impact on downstream aquatic ecosystems.

4.3.5 Impact Assessment

A detailed assessment of the hydrologic impacts associated with the project is provided in Appendix B, but in summary:

- The project is anticipated to reduce flows for all waterways downstream of the disturbance footprint within the Northern and Mid Catchments with the exception of waterways downstream of the quarry dam where flows are predicted to increase.

- Reductions in dry season flows are also predicted downstream of the disturbance footprint, except immediately downstream of the sediment basin. With this reduction in flows, the duration of ‘low flow spells’ (i.e. when daily flow does not exceed the 50th percentile daily flow for the existing site) increases at these sites.

- The project is predicted to increase dry weather flows in waterways downstream of the sediment basin. The probability of low flow spells (relative to the existing case) will also decrease at these sites.

- Project environmental scientists and ecologists involved in the assessment of both the terrestrial and aquatic ecology have assessed the ecological risk associated with the predicted changes to hydrology as ‘moderate’.

Table 4-3 outlines the potential impacts associated with the project, along with a risk rating based on the risk assessment tables provided in Appendix F. The first risk rating column is based on the unmitigated impacts, while the second risk rating column is based on the risk level once mitigation measures have been implemented.
Table 4-3  Potential Hydrologic Impacts

<table>
<thead>
<tr>
<th>ID</th>
<th>Construction Activities</th>
<th>Associated Potential Impacts</th>
<th>Unmitigated Risk</th>
<th>Mitigated Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Score</td>
<td>Rating</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H1</td>
<td>Extension into waterways</td>
<td>Reduced ecological functioning of waterway immediately within waterway consumed by project footprint, upstream and downstream.</td>
<td>3,5</td>
<td>Intolerable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1, 3 Low</td>
</tr>
<tr>
<td>H2</td>
<td>Changes to catchment conditions</td>
<td>Increased volume and frequency of runoff and decreased baseflow, altering the hydrology of downstream waterways, impacting on waterway ecosystems and increasing erosion risk.</td>
<td>3,5</td>
<td>Intolerable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2, 3 Moderate</td>
</tr>
<tr>
<td>H3</td>
<td>Redirection &amp; storage of flows from upstream areas</td>
<td>Changed hydrology of downstream areas, impacting on aquatic ecosystems and increasing erosion risk (in areas receiving more flows than existing).</td>
<td>3,5</td>
<td>Intolerable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2, 3 Moderate</td>
</tr>
<tr>
<td>H4</td>
<td>Dewatering of sediment basin</td>
<td>Changed hydrology of downstream areas, impacting on aquatic ecosystems and increasing erosion risk.</td>
<td>3,5</td>
<td>Intolerable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2, 1 Low</td>
</tr>
</tbody>
</table>

### 4.4 Receiving Water Quality Impacts and Mitigation Measures

Stormwater runoff from the proposed development has the potential to impact receiving water quality including: freshwater creeks downstream of the site, an important wetland just downstream of the site; high risk estuarine lakes and canals; and high value estuarine waterways (Tallebudgera Creek, the Nerang River and the Southport Broadwater).

Activities which may result in impacts upon the waterways generally relate to the following:

- Hydrologic changes;
- Vegetation clearing and mulching;
- Earthworks associated with the construction of the plant site, access roads and quarry dam;
- Earthworks including excavation and stockpiling of overburden and quarrying of rock;
- Overflow or dewatering (controlled release) of the sediment basins and quarry dam;
- Operation of the quarry and associated plant and equipment;
- Potential wastewater overflows; and
- Bushfire and vegetation management.

Each one of these points is described further below. Appendix B also outlines the stormwater quality management strategy for the site providing a more comprehensive assessment of the predicted changes in stormwater flows and pollutant loads from the site.

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Note: Consequence and likelihood scores as defined in Appendix F.
4.4.1 Hydrologic Changes

Section 4.4.1 outlines the proposed impacts and mitigation measures for hydrologic changes associated with the project. Receiving water quality is highly influenced by these impacts and mitigation measures such as the generation and transportation of pollutant loads is closely linked to catchment hydrology. With increased runoff volume, velocity and frequency, the generation and transportation of pollutant loads to waterways will generally increase – and vice versa.

Subsequently, mitigation strategies integrated within the design of the project that reduce runoff volume, velocity and frequency (such as the storage, harvesting and reuse of stormwater flows), will decrease pollutant loads discharged to waterways. These mitigation strategies will also generally mitigate potential impacts associated with decreased water quality in receiving waterways.

4.4.2 Vegetation Clearing and Earthworks

Activities relating to vegetation clearing and earthworks have the potential to expose soils to wind and rain, resulting in erosion and sediment loss from the site. Sediment loss can impact on the water quality of receiving waterways which in turn, impacts aquatic fauna and habitat values. Sediment can carry various other pollutants (e.g. heavy metals) to downstream receiving waterways further exacerbating impacts from sediment loads.

The nature of the project requires significant vegetation clearing and earthworks. However, the extent of the proposed disturbance footprint has been designed to minimise the extent of clearing required. For example, as described in Section 1.3, approximately 155 hectares within the site (70% of the site), is proposed to be voluntarily set aside, as conservation area and not developed. This will significantly limit any water quality impacts associated with vegetation clearing and earthworks.

To minimise impacts on downstream receiving environments, it is recommended that all vegetation and overburden removal is undertaken in accordance with the ESCP and as far as practical outside of the wet season. Any disturbed areas which are not subject to extractive industry use should be stabilised in accordance with the ESCP.

Furthermore, a range of offset rehabilitation activities are proposed to repair the land from historic agricultural use and damage from off road vehicles. These rehabilitation works are proposed within the proposed conservation area. The focus of the rehabilitation activities will be on the waterways and 4WD tracks. By rehabilitating the waterways and tracks within the conservation area, the volume of sediments loads from these areas will substantially be reduced.

For any in-stream works (e.g. earthworks directly in streams or riparian vegetation removal), there is the potential to impact on downstream water quality through disturbance of waterway beds and banks. The disturbance footprint has also been designed to minimise extension into waterways within the site. The only works proposed in watercourses is the armouring of stream bed and banks so as to protect the streams from the erosive forces of high velocities downstream of the proposed quarry dam and sediment basin. Such works may be subject to further approvals and State consent. The extraction of quarry material or any other works are not proposed within any watercourse.

If vegetation within a waterway requires removal, or excavation or filling is required within a waterway, a permit may be required under the Water Act 2000 unless the extent and type of works are exempt.
Impacts associated with vegetation clearing and earthworks will be mitigated through the implementation of an appropriate Erosion and Sediment Control Plan (ESCP) and an accompanying Staged Clearing Plan. These documents will be prepared by a Certified Professional in Erosion and Sediment Control (CPESC), who should also be responsible for the coordination of ESC activities.

4.4.3 Dewatering

The operation of the site will not rely on the use of town water. All site water demands (with the exception of personnel usage) will be met through a stormwater harvesting and reuse (detailed in Appendix B). During and/or after high rainfall, excess water in the quarry dam and sediment basin may need to be released into the downstream receiving waterways. If this runoff is not suitably treated prior to controlled releases, the stormwater could contaminate receiving waterways with associated pollutants.

The most significant impact would most likely be associated with high sediment loads although as noted above, sediment can also carry various other pollutants (e.g. heavy metals) to downstream receiving waterways.

Settling of sediments in the pit sump, quarry dam and sediment basin will be the primary mitigation measure proposed for the management of sediments. Flocculation of sediments in the sediment basin may also be undertaken (if required) to assist in minimising the impacts of higher sediment concentrations discharging from the site. If aluminium-based flocculants (for example), are over-used however, these may result in toxic levels of aluminium in receiving waterways. Similarly, if the quarry dam needs to be dewatered for whatever reason, the discharge of cold, deoxygenated water from a stratified dam could have serious implications on downstream ecology.

An appropriate dewatering strategy for the quarry dam will need to be developed to minimise any impacts associated with infrequent dewatering.

An appropriate flocculation and dewatering strategy will also be required for the sediment basin, and this will be detailed in required ESCP (see Section 4.4.2). It is proposed that the sediment basin should incorporate beyond best practice management (BBMP) sediment capture technology (described in Section 4.4.3.1 below).

If runoff from the plant site infrastructure area is not separated from other parts of the work areas, hazardous chemicals could also contaminate receiving waterways. Runoff should subsequently be appropriately separated to minimise any potential contamination of waterway areas.

4.4.3.1 Beyond Best Practice Water Quality Management

It is proposed that the management of sediment will rely predominantly on detention of water in the proposed pit, sediment basin and quarry dam. A similar strategy in Boral’s West Burleigh quarry directly on the opposite side of the highway has been undertaken for a number of years and has successfully demonstrated compliance with concentration-based water quality objectives.

14 If turbidity is high, alum-based flocculants typically reduce aluminium in the water column because they remove sediment. They typically only contribute to the Al concentration if the Al concentration is already low.
If additional sediment removal is required beyond which can be achieved through detention, beyond best management (BBMP) sediment capture technology should be employed. Second generation sediment basins for example have been developed in New Zealand by the Auckland Regional Council and trials by the Sunshine Coast Council (SCRC) have established their effectiveness regionally.

'High efficiency', flow though sediment basin designs have been monitored and the outlet sediment concentration has been assessed by the Sunshine Coast Regional Council (SCRC). The results of this monitoring program showed that with coagulation/flocculation, 75 NTU and 50 mg/L TSS concentration targets can be successfully met.

The high efficiency basins utilise a combination of technology including:

- A rainfall activated coagulant dosing station;
- A hydraulically efficient design; and
- Floating off-takes to decant clean treated water.

This design varies significantly from the standard batch treatment basins (otherwise referred to as type F or type D basins), currently commonly used throughout the rest of the state that rely on manual treatment and manual pumping of water.

Before introducing the new specification, SCRC engaged BMT WBM to investigate the performance of standard batch treatment basins compared to the new high efficiency basins. The BMT WBM report (see BMT WBM, 2009) found that the new high efficiency basins are expected to capture 4 – 5.6 times more sediment than standard batch treatment basins. This study also found that standard batch treatment basin were only capable of capturing between 15-20% of all sediment whereas the high efficiency sediment basins were found to be capable of stopping up to 80-90% of sediment from mobilising off site.

This latest design therefore exceeds performance of standard BMP in Queensland and represents the first significant advancement in basin technology in Queensland in the last 16 years. The use of second generation, high efficiency, flow though sediment basins is recommended for use on the site.

4.4.4 Operation of Plant and Equipment

Impacts on surface water resources may also result from the operation of plant and equipment which could be a source of accidental spills and leaks of chemicals. Use and storage of chemicals will include hydrocarbons (fuels, oils and greases), fire fighting equipment and cleaning chemicals. The plant site infrastructure area will generate stormwater runoff and have the ability to act as a point source of pollutants (e.g. through spills).

Depending on the size of the spill, this contaminated material may enter a nearby drainage channel or waterway directly, or be washed into downstream waterways as pollutants in sediment laden runoff during rainfall events. The impact from major spills and leaks can have acute and potentially toxic impacts that can impact on the environmental values of the waterway and downstream users.

An Environmental Management Plan for the site will be developed to define operational requirements for plant and equipment and appropriate management responses for potential accidental releases of contaminants to waterways.
4.4.5 Sewerage

Without appropriate sewerage infrastructure, sewage from the site could contribute high nutrient loads, coliforms and wastewater chemicals to waterways causing impacts on the environmental values of the waterway and downstream users.

The installation and management of appropriate sewerage infrastructure will subsequently be required to ensure any potential impacts from sewage are minimised. In the earlier phases of the quarry however, temporary infrastructure will be required during which time there is greatest risk to receiving waterways due to potential overflows.

4.4.6 Bushfire and Vegetation Management

Bushfire and vegetation management includes the maintenance of vegetation in accordance with a bushfire management plan that is expected to include maintaining fire buffers and access trails. Potential impacts associated with this activity include: leaks from herbicide application; hydrocarbon spills; leaks from plant and equipment; and excessive vegetation removal leading to bank instability and erosion.

Bushfires may also contribute to water quality impacts through a range factors such as increased rates of runoff and erosion, increased water repellence, loss of surface vegetation and canopy cover, and ash sealing of soil pores (Smith et al. 2011). Inappropriate fire management may therefore lead to increased sediment, nutrients, organic matter, ash and metal contaminants entering streams. These contaminants produce a range of ecological and social impacts including a decline in downstream aquatic ecosystem health, direct impacts to aquatic fauna, smothering of vegetation and algal blooms. The changes in post fire hydrology can also lead to increased scour of waterways which can result in destabilised channel bed and banks and the associated increase in sediment basin, as well as direct impact to macroinvertebrate communities.

An appropriate bushfire management plan has been prepared to ensure any potential impacts associated with bushfires are appropriately mitigated. Parts of this plan are already being implemented on site.

4.4.7 Impact Assessment

The quality of runoff flowing into surrounding drainage features and waterways should be protected in order to maintain the integrity and value receiving waterways. This protection is necessary to ensure that aquatic ecosystems are not adversely impacted while also avoiding water contamination risk to downstream water users (e.g. secondary contact recreation).

A stormwater quality management strategy has been proposed for the site, incorporating several stormwater management measures including the quarry pit, quarry dam, rock channels, sediment basin and additional erosion and sediment control practices. Modelling has been undertaken to assess the stormwater pollutant loads predicted to leave the site (i) in its current condition and (ii) with the proposed quarry operations. Appendix B provides further information in relation to the proposed stormwater quality management strategy and the modelling.
The modelling has assessed three project phases (C1, Q1 and Q5), and these phases have been selected as they show the diverse range conditions within the development. The pollutant modelling has focussed on ‘total suspended solids’ for several reasons (i.e.: TSS is likely to be the key pollutant from the site in its existing state and with the proposed quarry operations; TSS is readily modelled using existing software packages; can be readily monitored pre development as well as during construction and operation; and TSS is important from both ecological and social perspectives in downstream receiving waterways).

Our assessment indicates that the project (and associated stormwater quality management strategy) will likely decrease stormwater pollutant loads discharging from the site (relative to the existing site).

It is noted that Appendix B includes an assessment of the quality of stormwater runoff discharging from the site. If an assessment of the changes in downstream receiving water quality were to be required, receiving water quality modelling would need to be undertaken. While potential changes to the concentration of pollutants in downstream receiving waters are acknowledged, receiving water quality modelling is not recommended given the predicted reduction in stormwater pollutant loads associated with the project (and associated water strategy) relative to the existing site.

Table A- 2 outlines the potential impacts associated with the project, along with a risk rating based on the risk assessment tables provided in Appendix F. The first risk rating column is based on the unmitigated impacts, while the second risk rating column is based on the risk level once mitigation measures have been implemented.
### Table 4-4 Water Quality Potential Impacts

<table>
<thead>
<tr>
<th>ID</th>
<th>Construction Activities</th>
<th>Associated Potential Impacts</th>
<th>Unmitigated Risk</th>
<th>Mitigated Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Score&lt;sup&gt;15&lt;/sup&gt;</td>
<td>Rating</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Score&lt;sup&gt;15&lt;/sup&gt;</td>
<td>Rating</td>
</tr>
<tr>
<td>W1</td>
<td>Hydrologic changes</td>
<td>Increased generation and transport of pollutant loads associated with changes in hydrology.</td>
<td>3,5</td>
<td>Intolerable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W2</td>
<td>Vegetation clearing</td>
<td>Increased sediment loads in runoff (from cleared areas) entering receiving waterways, impacting on water quality and hence aquatic flora and fauna.</td>
<td>3,5</td>
<td>Intolerable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organic material (from mulch stockpiles) entering waterways and impacting on water quality (e.g. depletion of dissolved oxygen levels).</td>
<td>3,2</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accidental spills or leaks of chemicals or hydrocarbons from plant and equipment, potentially impacting on aquatic ecosystems if the material enters waterways.</td>
<td>1,4</td>
<td>Low</td>
</tr>
<tr>
<td>W3</td>
<td>Earthworks, including excavation of the quarry pit and stockpiling of overburden</td>
<td>Increased sediment loads in runoff (from earthworks) entering receiving waterways, impacting on water quality and hence aquatic flora and fauna.</td>
<td>3,5</td>
<td>Intolerable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accidental spills or leaks of chemicals or hydrocarbons from plant and equipment, potentially impacting on aquatic ecosystems if the material enters waterways.</td>
<td>1,4</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lack of erosion and sediment controls leading to sediment laden runoff entering waterways, impacting on water quality.</td>
<td>3,5</td>
<td>Intolerable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inappropriate changes to bank and bed of channels may lead to geomorphic responses in the channels during rainfall events. This can result in erosion which may increase water column and bed loads of sediments.</td>
<td>3,3</td>
<td>Significant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Land disturbing activities within drainage lines and creeks resulting in increased sediment loads due to exposed soils.</td>
<td>3,3</td>
<td>Significant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lack of erosion and sediment controls leading to sediment laden runoff entering waterways, impacting on water quality.</td>
<td>3,5</td>
<td>Intolerable</td>
</tr>
<tr>
<td>W4</td>
<td>Dewatering (controlled release) of storage and settling pond/dam</td>
<td>Controlled release of inadequately treated stormwater from quarry dam or sediment basin contaminating receiving waterways with associated pollutants.</td>
<td>4,5</td>
<td>Intolerable</td>
</tr>
</tbody>
</table>

<sup>15</sup> Note: Consequence and likelihood scores as defined in Appendix DF.
## Potential Impacts and Mitigation Measures

<table>
<thead>
<tr>
<th>ID</th>
<th>Construction Activities</th>
<th>Associated Potential Impacts</th>
<th>Unmitigated Risk</th>
<th>Mitigated Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Score&lt;sup&gt;13&lt;/sup&gt;</td>
<td>Rating</td>
</tr>
<tr>
<td>W5</td>
<td>Operation of the quarry and associated plant and equipment</td>
<td>Discharge of polluted stormwater runoff from the plant site infrastructure area into downstream receiving environments leading to impacts on aquatic biota or habitats.</td>
<td>2.3</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Uncontrolled runoff from wheel wash and vehicle wash down facilities leading to impacts on aquatic biota or habitats.</td>
<td>2.3</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accidental spills of chemicals - these can impact aquatic (and terrestrial) biota and ecosystems.</td>
<td>1.3</td>
<td>Moderate</td>
</tr>
<tr>
<td>W6</td>
<td>Sewage</td>
<td>Accidental spills or overflows entering receiving waterways, impacting on water quality.</td>
<td>1.1</td>
<td>Low</td>
</tr>
<tr>
<td>W7</td>
<td>Fire management</td>
<td>Bushfires leading to increased sediment, nutrients, organic matter, ash and metal contaminants entering streams resulting in a range of ecological and social impacts including decline in aquatic ecosystem health, direct impacts to aquatic fauna, smothering of vegetation and algal blooms. Also, changes in post fire hydrology leading to increased scour of waterways, sediment basin and direct impacts to macroinvertebrate communities.</td>
<td>3.5</td>
<td>Intolerable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accidental spills of chemicals, e.g. herbicides, hydrocarbons, etc. - these can impact aquatic (and terrestrial) ecosystems.</td>
<td>1.3</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soil and stream instability due to excessive vegetation removal, leading to impacts on downstream water quality from sediment laden runoff.</td>
<td>2.4</td>
<td>Significant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bushfires leading to increased sediment, nutrients, organic matter, ash and metal contaminants entering streams resulting in a range of ecological and social impacts including decline in aquatic ecosystem health, direct impacts to aquatic fauna, smothering of vegetation and algal blooms. Also, changes in post fire hydrology leading to increased scour of waterways, sediment basin and direct impacts to macroinvertebrate communities.</td>
<td>3.5</td>
<td>Intolerable</td>
</tr>
</tbody>
</table>