Department of Primary Industries

Ashby Quarry Hydrogeological Review

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1. Issue

Concerns have been raised by local Ashby community members about the potential impact of water extraction from the Ashby Quarry (the Quarry) on Sandy Creek . This abstracted water is being used for dust suppression and associated works during construction of the nearby Pacific Highway Upgrade.

Department of Primary Industries Water (DPIW) and Environment Protection Authority (EPA) staff inspected the site on 2 August 2016. During the site visit the hydrogeology of the site was investigated, local water quality field parameters were recorded and the quarry conditions and operating procedures with respect to local surface and groundwater were noted.

This report documents the findings and conclusions from this visit. It does not address other water quality aspects (other than field parameters), flora and fauna aspects, soil erosion and sediment aspects, nor any other issues associated with the quarried material.

2. Background

2.1. Quarry

Ashby Quarry is a privately owned sandstone quarry, located on a ridge on the Ashby-Tullymorgan Road across the Clarence River from the township of Maclean.

The Quarry has been in operation for many decades. From late 2015 until present, water has been extracted from the quarry floor for use in dust suppression associated with construction of the Pacific Highway Upgrade Project.

In 2012 the development consent was amended to cover an increase in production from 54,000 cubic metres to 94,000 cubic metres annually. The purpose of the amendment was to supply material for the construction Pacific Highway upgrade.

The Quarry is located within the small catchment of Sandy Creek, a tributary of the Clarence River Estuary. Sandy Creek catchment area is 350 hectares and the total quarry area is 4.9 hectares, representing 1.4% of the catchment area.

2.2. Hydrogeology

The Quarry operates within the Kangaroo Creek Sandstone of the Clarence Morton Basin. This formation consists of medium grained quartz sandstone.

Bores constructed within this sandstone generally obtain low salinity groundwater and low yields (average 0.4 litres per second (L/s), with potential for maximum yields of up to 10 L/s) (DLWC, 2000).

The Grafton Formation, which overlies the Kangaroo Creek Sandstone in this area, consists of inter-bedded sandstone, siltstone and claystone, with groundwater salinity is often too high for domestic, irrigation or farming purposes.

Within 2 km of the quarry, existing bore depths range from 18 m to 150 m depth below surface, with the average being 45 m. The target water bearing zones is variable but generally between 30 to 40 m depth below surface. Yields within these bores are also variable but are typically around 1 L/s. Bores near the quarry are licensed solely for stock and domestic purposes.

2.3. Water Sharing Plans

The groundwater resources of the Clarence Moreton Basin are managed under the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources (hereafter referred to as the Plan) that commenced on 1 July 2016.

The Plan covers 13 fractured and porous rock groundwater sources with the Clarence Moreton Basin Groundwater Source, in which Ashby Quarry is located, being the largest.

The Plan sets the rules for sharing water between the environment and extractive users to ensure sustainable use of the resource. The long-term average annual extraction limit set in the Plan for the Clarence Moreton Basin Groundwater Source is 300,000 ML/yr. A large portion of this is unassigned, that is it is not held under licences or required to account for basic landholder rights such as stock and domestic use. The volume of unassigned water may change throughout the life of the plan as a result of new licences being granted or existing licences being cancelled.

Surface water resources within the Clarence River Catchment are managed under the Water Sharing Plan for the Clarence Unregulated and Alluvial Water Sources that commenced on the 1 July 2016. The quarry is located within the Clarence Coastal Water Source as provided by the aforementioned plan. Access rules for surface waters require extractors to cease to pump if there is no visible flow at the pump site. Trading rules require that there be no net gain in total allocations as a result of trading water into the water source.

2.4. Licence rerquirements

There are no requirements for the Quarry to hold surface water or groundwater licenses for the site. Extraction of water by a Public Authority for dust suppression is exempt from requiring a licence. Water retained in the silt trap (excavation) in accordance with conditions imposed on the quarry's development consent is contaminated. It therefore can not be discharged to the environment unless in accordance with an Environmental Pollution License granted by the EPA. Use of this contaminated water for operational needs within the Quarry may occur without the authority of a surface water licence.

There are no requirements for groundwater monitoring bores to be installed at the quarry site.

3. Site Assessment

3.1. Quarry Excavations

On the date of the inspection there were 3 main bodies of water (herein referred to as excavations) within the quarry.

An exploratory borehole drilled in September 2015 as part of the resource availability assessment indicated there is 24 m of grey sandstone beneath the quarry floor. The quarry itself is currently about 20 to 25 m deep.

3.1.1. Excavation One

This excavation has been in existence for much of the life of the quarry and has been stocked with bass The water level in this excavation was at a higher elevation than the other 2 excavations, indicating it is unlikely to be connected with other water bodies on the quarry floor. The water level in this excavation is reported to be very stable over time. Water is occasionally pumped from this excavation in order to provide additional volume to the other 2 excavations.

3.1.2. Excavation Two

Excavation 2 is located immediately to the south of excavation 1. The water level in excavation 2 is lower than the water level in excavation 1. The excavation is estimated to have a maximum depth of over one metre and is known to dry up. This is evident from air photos of the quarry site This excavation is the primary extraction point for the water carts utilising the quarry water for the Pacific Highway Upgrade Project. Water is also extracted from this excavation to provide water for general quarry operations.

During periods of above average rainfall, water is pumped from this excavation to excavation 3, to assist with water movement to the quarry outlet which is an unnamed 1st order tributary to Sandy Creek.

3.1.3. Excavation Three

Excavation 3 is located on the western side of the quarry, and is connected to the quarry's hydrological outlet; a remnant of what would have been a small, 1st order tributary to Sandy Creek prior to the commencement of quarrying operations This excavation has recently been reduced in extent to provide space to stockpile graded rock. The water level in this excavation was visually assessed and appeared to be at the same level as in excavation 2.

Table 1: Excavation size and volume

Excavation	Average Depth	Surface area	Volume
1	unknown	1843m^2	Unable to be calculated
2	0.7 m	1796 m^2	1.3 ML
3	0.7 m	1110 m^2	0.8 ML

Note: The depths of the excavations were estimated on the day of the site visit to be a maximum of 1.5 m and average of 0.7 m.

3.2. Rainfall, evaporation and infiltration

The average annual rainfall recorded at the nearest Bureau of Meteorology climate monitoring station to the quarry, Harwood Sugar Mill is 1,304 mm. The total area of quarry as calculated from the most recent available aerial imagery (November 2015), is 4.96 hectares.

The total volume of rain falling within the quarry footprint each year is approximately 65 ML.

Average annual evaporation at Ashby quarry is 1,841 mm/yr as determined through the National Centre for Engineering in Agriculture web site (NCEA USQ 2016). The total volume lost to evaporation from excavation 2 and excavation 3 therefore equates to 3.31 ML/year and 2.04ML/yr respectively.

Data assessed for the Water Sharing Plan for the Clarence Moreton Basin Groundwater Source indicated that 5% of rainfall infiltrates to groundwater, equating to a volume lost to infiltration over the footprint of the quarry of 3.3 ML.

Thus, the total volume of rainwater available in the quarry floor and excavations is estimated to be approximately 56 ML/year. In contrast, the total volume of rainwater available across sandy creek catchment is 4,500 ML/year.

3.3. Water management within the quarry

The entire quarry floor is fractured to a depth of 0.5 to 1 m, and the general gradient of the floor falls towards excavation 2. As a result, when water extraction occurs from excavation 2, its water level declines during the extraction period and is replenished overnight as water stored in the fractured quarry floor flows into the excavation equalising the water levels.

During periods of above average rainfall, water is pumped from this excavation 2 to excavation 3, for subsequent discharge from the quarry outlet.

On the day of the site visit the outlet had an access road crossing it. This crossing is made of crushed aggregate and has no culvert pipe beneath it. It was observed that water was being held to a depth of approximately 0.5 m behind this causeway.

Aquatic vegetation growth indicates that the water level in both excavation 2 and excavation 3 are relatively stable and does not fluctuate markedly**.** This is probably a result of the stored rainfall within the fractured quarry floor.

Minor groundwater seepage was evident along the eastern quarry face in 3 areas from approximately 2-3 m below the natural ground level. Staining on the surface of the quarry walls indicates this seepage is somewhat regular. However, this seepage appears to have evaporated by the time it reaches the base of the quarry wall. It is therefore surmised that the volume of this seepage is relatively minor.

It is probable that this seepage is a result of shallow groundwater discharge coming from the direct rainfall recharge up gradient of the quarry. The infiltrating rainwater is likely to meet a layer of rock with low permeability then travels down gradient and discharges at the quarry face. Since the catchment area upslope from the quarry is very small, it is probable that this water seepage is associated with recent rainfall.

The sandstone formation is dipping towards the west, which would result in any such shallow groundwater flowing west toward the quarry.

The volume of water extracted for quarry operations, e.g. washing quarry material and water for dust suppression is likely to be relatively small. As detailed above, there are no requirements to licence extraction of surface water for this use.

A small portion of this ‘operational water’ would be lost to evaporation with the balance returned to storage within the bed of the quarry. Therefore this water has been discounted and is not considered in the following calculations.

The records obtained from RMS recording the Pacific Highway Upgrade for water tanker loads, indicate a total of 9.8 ML was extracted within this same 8.5 month period.

3.4. Water discharging via the gorge

The outlet of excavation 3 is located in an area referred to as “the gorge”. Any discharge of water from the quarry via the gorge must be done so in accordance with the conditions of an Environmental Protection License (EPL) issued by the EPA. This EPL regulates the quality of water that may be discharged. Water is typically discharged after rainfall events exceeding 50mm in 5 days (if not stored on site).

Rainfall records recorded by the Bureau of Meteorology (BOM) show that only 11 mm of rain fell between 17th until 22nd July 2016 and that 11 days prior to our site visit (2nd August) there had been no rain at all. Lack of flow in Sandy Creek combined with this information infers that there is not a large volume of water continually discharging from the quarry floor in the absence of pumping.

It further suggests that Sandy Creek is not reliant on continual discharges of groundwater.

3.5. Base flow Assessment

There are no stream gauges on Sandy Creek to allow for a base flow assessment to be undertaken. At the time of the site visit there was no flow between pools upstream of the quarry and only very minor flow downstream of the quarry.

Other tributaries to Sandy Creek that are hydrologically disconnected from the quarry were visually inspected on the day, also had no flow on the day of the site visit.

3.6. Climatic Assessment

A climatic assessment has been undertaken for the area using rainfall figures taken from the BOM Harwood Sugar Mill rain gauge. This involved the production of a rainfall regression assessment for rainfall over the last 10 years. The average annual rainfall over this 10 year period is 1,419 mm. Interpretation of the assessment results suggests that there was a period of consistent below average monthly rainfall pre-2006 to July 2007, with a particularly dry time between September 2006 and July 2007. Following this, there was an above average rainfall period from July 2007 to February 2013 (5 year and 7 months). During this period the first 6 months of 2009 were particularly wet. A dry period followed from February 2013 to May 2016 (3 years and 3 months), with particularly dry periods between November 2013 and July 2014, and January 2016 until the end of record being May 2016.

As such, this data infers that we have just experienced a period of below average rainfall for the last 3 years and 3 months including a particularly recent dry period.

3.7. Local Licensed Groundwater Use

There are 10 groundwater work approvals for groundwater bores within 1 km, and 20 works approvals for groundwater bores within 2 km of the quarry,

Of the 20 bores within 2 km, all are used for domestic and / or stock supply. There are no commercial or irrigation licensed bores within this distance.

3.8. Water Quality Assessment

During the site visit, a total of 20 sites within and around the quarry and along Sandy Creek were tested for field water quality parameters. These parameters included; temperature, pH, electrical conductivity (EC), total dissolved solids, and salinity. It is noted that the latter 3 are essentially a function of each other and as such, results of temp, pH and EC will be discussed.

3.8.1. Temperature

Temperature varied across all sites from a low of 12.5 °C upstream of the Sandy Creek weir on the Murrayville Rd to a high of 19.0°C within a recently construction sediment retention basin which collects surface water runoff from the service road along the southern edge of the quarry

Field assessment of the variation in temperature within the samples indicates that temperature varied depending on the amount of tree cover and / or pool / stream depth at the site of measurement. As such it is not considered to be a reliable indicator for the degree of connection between Sandy Creek, the Quarry, and the local groundwater. As such temperature will not be discussed further.

3.8.2. pH

The pH of the water contained within the Quarry ranges from 7.84 within excavation 1 to 8.22 at the eastern end of the western pit, excavation 3.

The slightly alkaline water quality could be a result of rainfall infiltrating through the quarried and broken material taking on the chemistry due to the increased surface area contact with the quarry rock. However, water contained within excavation 1 has a pH of 7.84. It does not come into contact with broken / quarried material indicating that the water contained here and within the Quarry floor is most likely naturally alkaline (pH above 7).

In contrast, the pH measured in Sandy Creek is acidic and ranges from a maximum of 6.84 in the mid-section of the creek to 5.02 towards the end of the system (pH below 7).

If water emanating from the quarry were the dominant source of flow in Sandy Creek, the creek water would have a pH closer to that of the quarry water.

3.8.3. Electrical Conductivity (EC)

The EC of the water contained within the Quarry consistently displays elevated levels of EC compared to the creek. Quarry floor EC levels are in the range of 1,120 µS/cm at the eastern end of excavation 3 to 2,700 µS/cm within pooled water in excavation 2

Similarly to the pH data, it is possible the high salinity of the water is a result of surface water infiltrating through the quarried / broken material and taking on the material's chemistry due to increased surface area contact.

In contrast, the EC measured in Sandy Creek ranges from 253 µS/cm headwaters to 952 µS/cm towards the middle of the system.

Regardless of the source of the higher salinity quarry water, and in similar context to pH, it is noted that should the creek flow be reliant on large volumes of water discharging from the Quarry, it is expected that the creek water would also display this higher salinity. The results of this assessment show the quarry water to be an order of magnitude higher than that of the creek.

3.10 Sandy Creek Hydrology Assessment

During the site visit, field parameters were obtained from various reaches of Sandy Creek, ranging from the reach up-gradient of the quarry, to the tidal limit. Bedrock was visible in numerous locations in the upper reaches). Small isolated pools were present on the surface of the bedrock at numerous locations. The presence of the pooled water in the absence of creek flow indicates the bedrock is of low permeability preventing the pooled water from being lost to the underlying groundwater system.

This is typical of many sandstone environments, where local rainfall infiltrates through the local soil and weathered profile until it hits a layer of low permeability and thence moves as groundwater along the gradient of this low permeability layer until it discharges, typically in a creek line or cliff line (causing the formation of hanging swamps). This same process was visible in a number of locations high on the eastern quarry wall close to the natural surface level. The presence of vegetation, possibly coral ferns which are typical of hanging swamp communities was also noted along southern wall of the quarry.

The low salinity within Sandy Creek, suggests that the water present in pools has only travelled relatively short distances through shallow weathered material and has not picked up salts produced from the weathering process. Further, it is probable that the relatively low pH is potentially a result of the presence of humic acid produced by the decay of vegetation which is then picked up by the groundwater as it moves laterally through the shallow soils layer subsequently discharging to Sandy Creek.

Within systems similar to Sandy Creek, i.e. with poor soils and extensive rocky outcrops, and in periods of dryer weather, depending on the travel distance and soil water storage, the discharge of soil water into creeks and hanging swamps may cease during dry periods, commencing again after rain has recharged the shallow groundwater system again.

The quarry has excavated a large proportion of a 1st order tributary of Sandy Creek, with a reach of approximately 50 metres remaining intact downstream of the quarry outlet. It is noted that this creek remnant was much less developed with respect to indicators of fluvial processes than the 1st order creek coming from the head water of Sandy Creek adjacent to the quarry. This indicates that flow volumes emanating from the former 1st order stream were smaller than those emanating from the Sandy Creek head water.

3.11 Survey Assessment

Detailed survey maps of the quarry showing the base of the excavations (ponds) and the floor of the quarry were used to estimate the depth of the quarry.

4. Conclusions

It is evident that the water extraction from the Quarry has only minor impact on flows within Sandy Creek given that the area of the quarry is approximately 1.4% of the Sandy Creek Catchment. This is supported by the following:

- The distinct difference between the Sandy Creek and quarry floor water chemistry suggests that any the water being accessed by the quarry is not significantly supporting the Sandy Creek system / flow. If the quarry was contributing significant flows to Sandy Creek, the creek water chemistry would more closely reflect the quarry water chemistry, i.e. it would be more alkaline with higher EC, rather than more acidic and fresh;

- Analysis of rainfall data for the last 10 years indicates the last 3 years have been below average rainfall. As such, shallow weathered rock and soil profiles surrounding the creek are not substantially recharging;
- The lack of flow seen in Sandy Creek down gradient of the quarry is also consistent with the conditions of the head water of Sandy Creek which is, situated up-gradient and out of influence of the of the quarry;
- The lack of streamflow was also observed in other 1st and 2nd order creeks outside the quarry catchment but within the local area;
- With the Quarry having been in operation for many decades, any interruption of shallow groundwater flow from the quarry footprint would have been longstanding rather than manifest in the reported recent flow impacts arising since 2015.
- The rainfall collection capacity of the quarry, after evaporation, is on average 60 ML/yr, or 42.5 ML. Over the 8.5 month period of extraction record provided by Pacific Complete which indicates a total of 10 ML was extracted over this period.
- Excavation 1 on the northern edge of the quarry has only minor water level fluctuations over time indicating it is possibly buffered from short term rainfall variation by connected groundwater. The water level within this pond is also above the quarry floor.
- Evidence that the creek flow is largely sourced from the discharge of shallow local ground water in the weathered rock and soil profile surrounding the creek. This is typical for sandstone environments where local rainfall infiltrates, travels along a low permeability layer then discharges at a creek line displaying bedrock outcrops at the creek bed.

5. References

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