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July 24th, 2020

Project #: EART-05

Attn: Bronya Lipski
Lawyer Environmental Justice Australia

Dear Ms. Lipski:

Subject: Technical Review of Coal Ash Management in Environmental Impact Statement for Bayswater Power Station Upgrade SSD-9697--

INTRODUCTION

AGL Macquarie (AGL) owns and operates the Bayswater Power Station (Bayswater), which is located approximately 80 km northwest of Newcastle, NSW (Figure 1). AGL is proposing to undertake a range of upgrades to Bayswater aimed at improving the environmental performance of ash, salt and water management infrastructure and associated rehabilitation outcomes referred to as the Bayswater water and other associated operational works project (Project, Figure 2). Bayswater has a current generation capacity of 2,640 megawatts (MW) and approval for efficiency upgrades that would increase capacity to 2,740 MW. AGL retained Jacobs to complete an Environmental Impact Statement for the Project, which is currently in the period of public consultation.

Environmental Justice Australia and Earthjustice retained Burgess Environmental Ltd. (Burgess) to review and comment on the Project EIS, focusing on environmental issues associated with waste coal ash and salt management. The following documents were filed and available for this review (see References) as part of the EIS:

- Water and Other Associated Operational Works Project: Environmental Impact Statement. Report for AGL Macquaire (Jacobs, 2020). Supported by: Appendix A – Secretary's Environmental Assessment Requirements (Jacobs, 2020a); Appendix B – SEARs Compliance (Jacobs, 2020b); Appendix C – Biodiversity Development Assessment Report (Jacobs, 2020c); Appendix D – Water and Other Associated Operational Works Project: Surface Water, Groundwater and Flooding Technical Paper (Jacobs, 2020d); Appendix E - Water Balance Modelling Report (Jacobs, 2019a); Appendix F - Air Quality Impact Assessment (Jacobs, 2019b); Appendix G – Land Contamination Constraints Assessment (Jacobs, 2020e); Appendix H – Aboriginal Culture Heritage Assessment Report (Jacobs, 2019c); Appendix I – Non-Aboriginal Heritage Assessment (Jacobs, 2019d); Appendix J - Traffic and Transport Assessment Report (Jacobs, 2019e); Appendix K – Landscape Visual Assessment (Jacobs, 2019f); and, Appendix L - Current Mining and Exploration Titles and Applications Mapping (Jacobs, 2020f).

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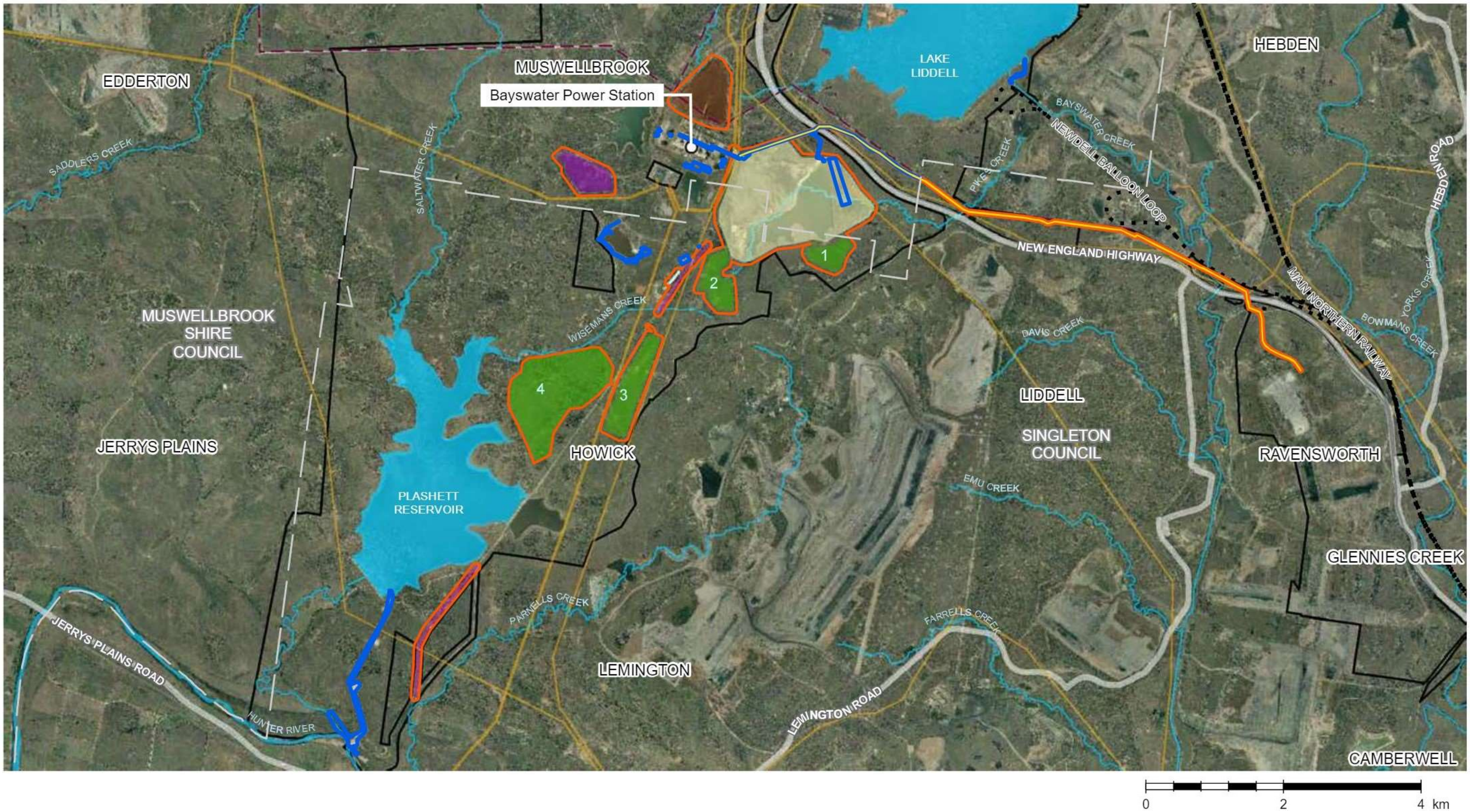
Site Location

Date: 7/22/2020	Project #:	**Figure 1**



- Study area
- Local Government Area boundary
- Footprints of approvals to be surrendered
- AGL owned land
- Railway
- Electricity transmission line
- Coal supply conveyor

Project elements:

- Ash Dam Augmentation, Ash Harvesting and Water Management Works
- Ravensworth Ash Line
- Coal Handling Plant Water and Wastewater Infrastructure Upgrades
- HP Pipe Clearing
- LSP Sludge Line Clearing
- Clay Borrow Pits
- Salt Cake Landfill

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AGL Site Plan and Project Elements

Date: 7/22/2020	Project #: EART-05	**Figure 2**

This Technical Review considers the following aspects of the Project, which I consider to be within my areas of expertise:

- dam safety and issues related to dam stability;
- identification of issues relevant to closure of the coal ash impoundment and long-term risks related to impoundment erosion, contaminant migration and potential for future failure;
- plans to expand the use of coal ash;
- the continued use of coal ash to fill underground mine workings;
- assessment of the salt cake landfill and its potential to impact groundwater quality; and,
- potential alternatives to waste management strategies outlined above.

The following documentation was not made available for review by AGL, which I consider to be critical to supporting an EIS.

- detailed Design of the Dam Expansion and the related Dam Safety Review;
- detailed Design of the Salt Cake Landfill; and,
- hydrogeological Assessment Reports, including a complete set of surface water and groundwater data.

SUMMARY OF OPINION

The EIS and supporting documents repeatedly state or imply that the primary objectives of the Project are to improve water and waste management, and environmental outcomes, which is somewhat misleading and disingenuous. The primary motivations for the Project appear to be to increase the capacity of the coal ash impoundment by 12.5 M m^3, and build a salt cake landfill.

The descriptions of the proposed Project elements are general in nature and often incomplete, which make it difficult to develop a full understanding of the Works that will be implemented and their potential environmental impacts. Further, the environmental data that is included in the submission do not differentiate between the interpreted pre-development conditions, the impacts that have already occurred as a result of the mining and power generating activities in the region, and the anticipated impacts from the proposed Works and continued operation of Bayswater.

My opinion of the Project elements that I consider to be within my expertise are summarized as follows and are described in greater detail in the main body of this letter:

1. The impoundment that is being used for coal ash disposal is not suited to permanent containment and disposal of industrial waste because of the potential to contaminate surface water and groundwater. Portions of the coal ash have been placed over alluvial deposits of Pikes Creek, which was partially buried and is contained by the coal ash impoundment. This is evidenced by the high rates of seepage (>100 l/s) that occur beneath and through the dam (Jacobs, 2019e). These high rates of seepage also suggest that the dam itself may be permeable. This could indicate an elevated risk of piping failure, which occurs when seepage through a dam or dam foundation gradually erodes material critical to dam stability.

2. The limited available borehole records within the BWAD indicate that coal ash is in direct contact with the alluvial deposits of Pikes Creek. The alluvial deposits formed under Pikes Creek are permeable and a conduit for local groundwater flow, and can therefore be characterized as an unconfined surficial aquifer. Leachate from the BWAD is in direct hydraulic communication with the alluvial deposits formed under Pikes Creek, which represents a pathway for leachate to seep into and contaminate the local groundwater system.

3. The coal ash and contaminated water are contained by a dam. While the stability of this dam has been assessed, it continues to present a risk of failure, where the consequences of failure to the downstream infrastructure and the environment are significant. The continued use of a dam to contain liquefiable coal ash is not necessary and introduces risks that can be eliminated by changing to solid coal ash disposal.

4. The coal ash impoundment may be susceptible to failure and does not include engineered containment systems to prevent contaminants from seeping into the environment. A preferred alternative is to move the coal ash into a secure, engineered landfill with appropriate containment, monitoring and design redundancies to ensure permanent safe containment.

5. Coal ash leachate is seeping out of the dam in multiple locations (Table 2), as is evidenced by surface water (Table 3) and groundwater (Table 1) monitoring data. Because the contaminants in coal ash are inorganic, they do not degrade over time. Collection and treatment or disposal of this and other contaminated water will be required for a very long period following closure, which represents a long-term risk to the environment and public. Contaminant concentrations above ANZG (2018) 95% Protection Levels include arsenic, boron, cadmium, chloride, lead, manganese, nickel, selenium, sodium and zinc.

6. I agree that the beneficial use of coal ash should be increased; however, assessments should be completed to determine the nature of these beneficial uses and to assess what, if any, environmental risks are introduced by those uses.

7. An assessment of the potential environmental advantages and disadvantages associated with the continued use of coal ash to fill the Ravensworth mining works is warranted given that these underground workings appear to be close to the surface and that contaminants within the coal ash have the potential to migrate out of the mine. Injection of coal ash will also displace mine water, which could further impact surrounding surface water and groundwater quality.

8. I agree that the salt cake landfill is preferable to the current Hunter River salt trading scheme where salts are released to the environment; however, there appear are some shortcomings in the landfill proposal. First, the clay liners and caps that are referenced in the Project description are not appropriate for containment of crystalized salt because the clay structure is essentially destroyed by high concentrations of dissolved sodium salts. References to natural clay liners appear to indicate a lack of technical understanding of the geochemical processes at play. Given the long term contaminating potential of the salts I would recommend designing the landfill to hazardous waste standards. Alternatives to landfilling the salt cake, such as deep well disposal of the brine, should be investigated. Second, NSW EPA (2018) rules indicate that the landfill EIS should be supported by detailed engineered drawings, which are not included in the documents made available for review.

A regulatory jurisdiction that is comparable to Australia regarding the management of coal ash is the United States, where regulators are moving away from these sorts of coal ash management practices. Relevant case histories are located in North Carolina where Duke Energy has been ordered to remove 80 million tons of coal ash at six power generating stations in the state (Citizen-Times, 2020). Coal ash at four of these facilities is impounded behind dams that were constructed on top of permeable soils and located upstream of recreational reservoirs, similar in nature to the situation at Bayswater. The regulator's decision was based on the need to remedy water contamination in a timely manner and implement more permanent and reliable disposal practices. The security, permanence and control associated with moving coal ash into a contained, lined and monitored landfill was seen to be in the long-term interests of the people and environment of North Carolina. In this case, the areas surrounding the Bayswater plant appear to be well suited to development of an engineered landfill. It is also worth noting that the Bayswater coal ash impoundment would likely not comply with Location Restrictions for coal ash impoundments (U.S. EPA, 2015, § 257.60) because the impounded coal ash is in direct contact with the uppermost aquifer, which in this case is the gravel alluvium encountered by BQ-MW10.

The use of a dam to contain free water and liquefiable coal ash is a risk that can and should be avoided. Even in a modern regulatory jurisdiction with knowledgeable consultants and experienced engineers, disastrous dam failures have occurred (Morgenstern, 2018). The TVA Kingston coal ash dam failure is a directly relevant example as are the two recent iron ore tailings failures in Brazil that have resulted in massive devastation and loss of life.

Dr. Morgenstern raises the following concerns regarding tailings dams that apply equally to coal ash dams. In his words,

> *'currently, the weakest safety culture is associated with tailings dams. Here, several high-profile failures have, in recent years, created a crisis due to loss of trust and confidence in the design, construction, and operation of such facilities . . . this appears to be justified, particularly due to weak engineering in many instances.'*

PROJECT DESCRIPTION

Project Description

The primary purpose of the Project appears to be to increase the size of the coal ash impoundment and construct a salt cake landfill. Aspects that include modifications to ash management and other waste management processes include the following:

- augmenting the existing ash disposal area, replacement of the Ravensworth ash transfer pipeline and increasing the capacity of the existing ash harvesting and recycling facilities; and,

- constructing a salt cake disposal landfill to complete the alternative process for managing water impurities and reduce the reliance on the Hunter River Salinity trading scheme.

The Project will include the following elements related to coal ash and salt waste management (Figure 2):

- expansion of the existing Bayswater Ash Dam (coal ash impoundment) to provide additional ash storage capacity of 12.5 M m^3;

- modifications to water management structures and systems to collect and reuse process water and return waters from the coal ash impoundment;

- increasing coal ash recycling activities to reuse an average of 600,000 tonnes per annum of ash derived product material; and,

- modifications to fly ash use infrastructure including the installation of weighbridges, construction of a new 240 tonne silo, tanker wash facility and additional truck parking.

These aspects of the Project are described as improvements, though it is not always explained what problems exist that need to be overcome and/or how the Project addresses these problems. The Project elements are described at a very superficial level (Jacobs, 2020, Section 2), which makes it difficult to replicate the EIS assessments or even to fully understand the Project components.

Coal Ash Disposal and Impoundment

Coal ash (fly ash and bottom ash) is a waste generated by the burning of coal to produce electricity. A portion of the fly ash is used as an amendment to concrete manufacturing and road construction materials. A portion of the coal ash is placed hydraulically in the former Ravensworth underground mine workings. The remaining coal ash waste is disposed within a large coal ash impoundment located to the east of the facilities. Bayswater mixes the fly and bottom ash with water, transports the mixture hydraulically to the coal ash impoundment, where it discharges, the solids settle out and supernatant water is returned to the process. The coal ash impoundment is being expanded, the capacity of the coal ash management systems for reuse is being increased, and infrastructure is being upgraded. Otherwise, the coal ash disposal schemes are unchanged.

The coal ash impoundment is located east-southeast of the plant and covers an area of approximately 3 km^2. Fluidized coal ash is discharged into the west portion of the impoundment and the coal ash and water mixture is contained by topography and a dam constructed primarily along the east edge of the impoundment. Supernatant water is returned to the plant. The New England Highway and Lake Liddell are located east and downgradient of this dam.

AGL plans to increase the available disposal capacity in the coal ash impoundment by 12.5 million m^3 by increasing the area of coal ash disposal by approximately 17 hectares and the height of coal ash dam segments by varying amounts. These proposed modifications are not described in any technical detail. The nature of the existing dam construction is not described in the EIS and the Bayswater Ash Dam Augmentation Design Report completed by Aurecon (2019) was not included in the information package made available by AGL. Infrastructure upgrades include modifications to the coal ash slurry and water return systems.

The following upgrades are planned to the BWAD seepage collection system in order to increase the seepage capture rate:

- installing a seepage collection system below the saddle dam wall;

- enlarging and deepening of the existing seepage collection ponds;

- installing larger capacity pumps to increase the maximum volume of seepage water that can be pumped back to the BWAD following large storm events; and,

- increasing the duration of pumping from the seepage collection ponds to the ash dam.

It is important to note that the seepage flow rates bypassing the seepage collection systems are similar under existing and post-augmentation conditions. Accordingly, the proposal does not prevent or minimize the release of coal ash impacted water to the environment.

Coal Ash Re-use

The following new facilities are planned to increase the capacity and efficiencies of the coal ash re-use operations to an anticipated average coal ash reuse rate of 600,000 tonnes per year and a maximum of 1 million tonnes per year:

- improved road access and weigh bridges;
- buildings and utilities, including a laboratory;
- ancillary equipment; and,
- water management and truck wash facilities.

Ravensworth Mine Filling

Bayswater also plans to continue to inject a mixture of coal ash and water into the former Ravensworth underground mine workings, possibly to reduce groundwater flow and the risk of a mine collapse. Other than the plan to add a hydraulic pipeline that delivers this mixture to the mine, there is very little specific information on this important aspect of Bayswater's ongoing operations.

Salt Cake Disposal

The Project includes the development of a landfill to dispose of salt cake waste produced by the power generating process. This landfill replaces a salt trading scheme involving the Hunter River, which is not fully explained in the EIS, but is considered an improvement. The Salt Cake Landfill would be located west of the plant and would cover an area of approximately 60 hectares.

The Salt cake landfill facility has been designed to include 10 individual cells which would be constructed and reclaimed progressively. Each cell would be able to hold more than three years of salt cake, assuming that around 50,000 tonnes of salt cake is generated per year. The salt cake landfill would have capacity to hold approximately 600,000 tonnes of salt cake over its operational life.

In accordance with the NSW EPA Environmental Guidelines for solid waste landfills (Second Edition, 2016) a leachate barrier system is included to contain leachate and prevent the contamination of surface water and groundwater over the life of the landfill. Each cell would be lined with 'at least one metre of clay, or other suitably impermeable material' (Jacobs, 2019), as per the EPA Environmental Guidelines.

SITE DESCRIPTION

Location and Land Uses

The Project is largely located within the AGL owned lands. Some Project infrastructure also crosses road reserves owned by Transport for New South Wales, Singleton Council, and a small area of NSW Crown Land (Crown land). Neighbouring industrial developments include Liddell Power Station, coal mines, the

Main Northern Railway Line and the New England Highway. Agricultural clearing for the purposes of grazing is also present within and surrounding the AGL landholding.

The village of Camberwell is located over 7 km south east of the Ravensworth ash line and the village of Jerrys Plains is located approximately 2 km south of the nearest HP Pipe clearing and over 5 km from the southern extent of the Borrow Pits. The closest residential area is the Antiene subdivision, which is located behind a ridge line approximately 5 km north of the Project. The nearest residential receiver is located approximately 1.8 km south southwest of the HP pipe clearing works (Jacobs, 2020, see Figure 1).

Topography and Drainage

The topography and primary drainage features of the area are shown in Figure 2. The Bayswater plant is located in hilly terrain that slopes to the Hunter River valley, which is located approximately 10 km south of the power generating facilities. Total topographic relief of the area varies from approximately 100 to 300 metres above sea level (masl).

The primary water bodies are Lake Liddell and Plashett Reservoir, both artificial reservoirs constructed to support power plants in the area. Saltwater Creek and Wisemans Creek flow into Plashett Reservoir, which is also connected to the Hunter River by a canal. Pikes Creek, which has been largely covered by the coal ash impoundment, flows into Lake Liddell, which drains into the Hunter River through Bayswater Creek. Emu Creek and Davies Creek also flow into Bayswater Creek. Saddlers Creek and Parnell Creek are other water courses in the area that flow south into the Hunter River.

The ground surface and drainage in the area as a whole have been largely altered by coal mining and power plant developments that include diversions, impoundments and open pit mines.

Geology

The surface bedrock geology of the Project area is illustrated in Figure 3. Regionally, the area's surface geology generally consists of sedimentary rock formations, with some Quaternary alluvium deposits (Jacobs, 2020d).

The western two-thirds of the coal ash impoundment is underlain by Mulbring Siltstone of the Maitland Group comprising siltstone, claystone and minor fine grained sandstone. The remaining eastern third is underlain by the Saltwater Creek Formation of the Wittingham Coal Measures comprising sandstone, siltstone and minor coaly bands. The Saltwater Creek Formation is younger than the Mulbring Siltstone. Both the formations are mapped as dipping to the east or south east at between 4 to 10 degrees. Alluvium is expected to be present in the former Pikes Creek drainage course that was largely filled by the coal ash impoundment.

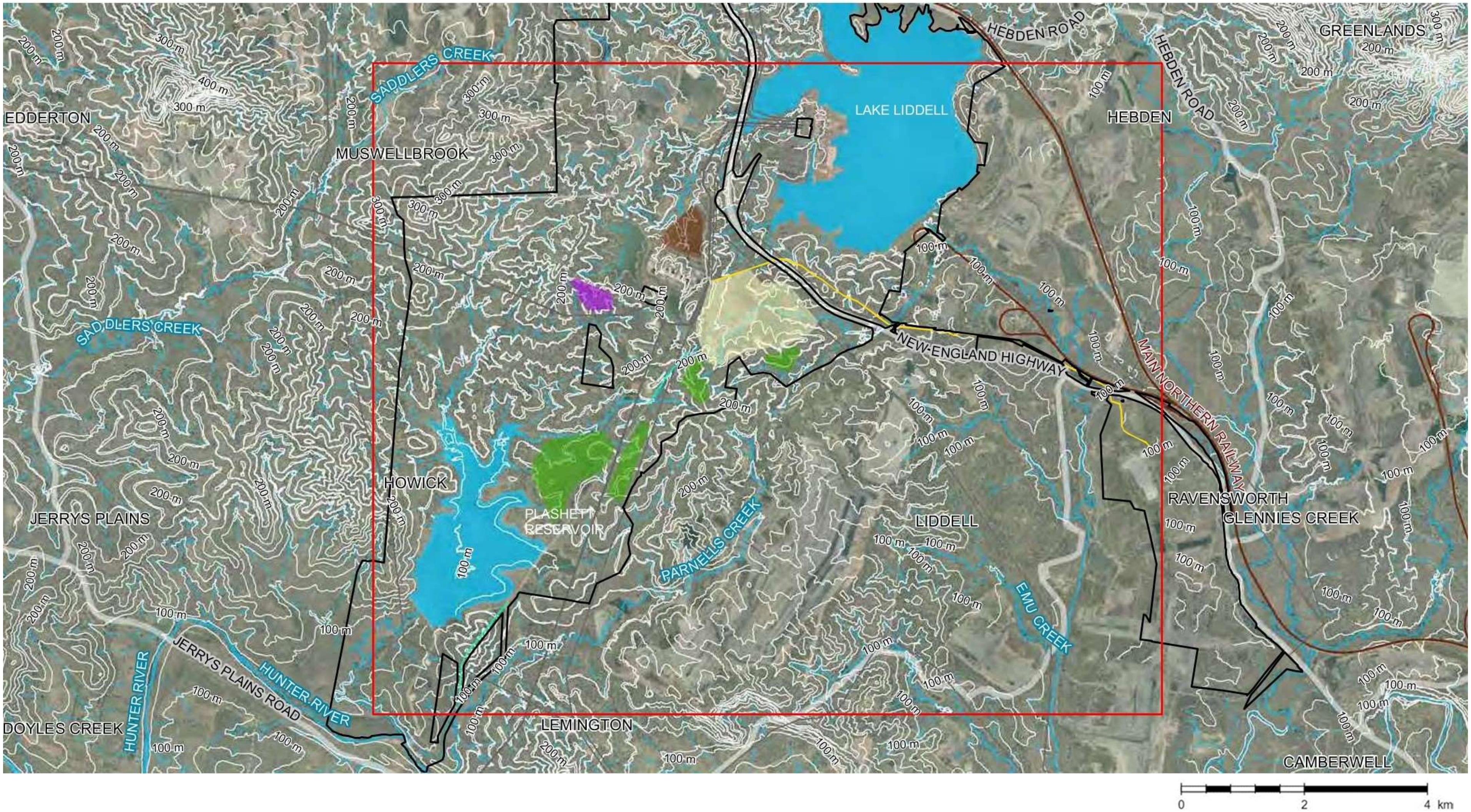
The area of the proposed salt cake landfill is mapped as the Branxton Formation comprising conglomerate, sandstone and siltstone. There is no mapped alluvial immediately adjacent to the landfill with the nearest mapped alluvial deposit approximately 2.4 km to the southwest.

Hydrogeology

The EIS reports do not describe the hydrogeology of the Project area in any detail. There is no detailed information regarding groundwater flows, recharge areas and discharge areas. The EIS also fails to define aquifers in the area that could be affected by the industrial operations and coal ash disposal practices;

hence, the EIS fails to assess the nature, extent and long term implications associated with continuing coal ash disposal in the impoundment.

The primary aquifers in the surface (Quaternary) deposits are expected to be associated with alluvium, which is present in the main water courses. The primary bedrock aquifers are expected to be associated with secondary permeability (fractures and joints) associated with coarser grained bedrock deposits (sandstones and conglomerate). The coal measures that are mined in the area are also expected to be classified as aquifers.



Groundwater Impact Assessment Study Area (approximately 14km x 12km)
AGL owned land

Project elements:
- Ash Dam Augmentation, Ash Harvesting and Water Management Works
- Salt Cake Landfill
- Coal Handling Plant Water and Wastewater Infrastructure Upgrades
- HP Pipe Clearing
- LSP Sludge Line Clearing
- Clay Borrow Pits
- Ravensworth Ash Line

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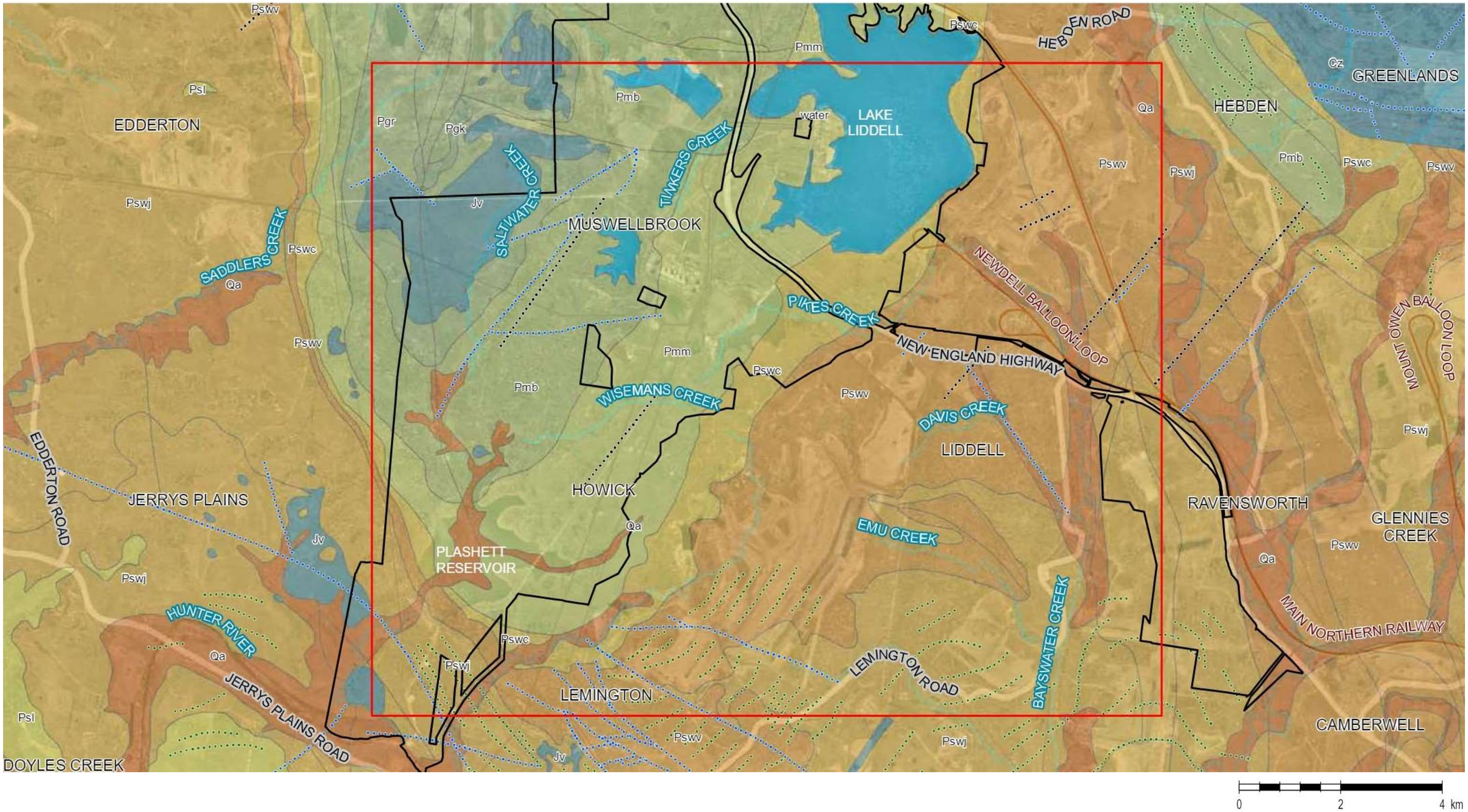
Topography and Drainage

Date: 7/23/2020 | Project #: EART-05 | **Figure 3**



Groundwater Impact Assessment Study Area (approximately 14km x 12km)
AGL owned land

Structure
Fault
Dyke

Cz
Jv
Pgk
Pgr
Pmb
Pmm
Psl
Pswc
Pswj
Pswv
Qa
water

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Surface Geology

Date: 7/23/2020 | Project #: EART-05 | **Figure 4**

TECHNICAL REVIEW

Dam Stability

The coal ash dam stability has been assessed by Aurecon (2019), in accordance with Dam Safety Regulations of NSW. Aurecon is an experienced international consultancy and the NSW Dam Safety Committee is staffed with knowledgeable regulators. Although the Aurecon assessment was not available for review, I expect that it was completed adequately. The Aurecon (2019) assessment concluded that the coal ash impoundment was classified as a Significant Consequence Category dam.

I have two primary concerns regarding the coal ash impoundment. First, the coal ash is transported and placed hydraulically, which means that the settled coal ash will be susceptible to liquefaction if disturbed (Ohio State University, 2018). Liquefaction occurs when pore pressures in the coal ash rise to a level that the coal ash/water mass effectively behaves as a fluid. This is an important consideration should the dam fail because the liquefied coal ash has the potential to flow for great distances as was the case at the Tennessee Valley Authority failure (U.S. EPA, 2014). Second, seepage through the impoundment is significant, which may reflect a higher risk situation for piping failure of the dam. Piping failure occurs when seepage through the dam gradually erodes particles along the seepage path, ultimately accelerating and causing failure.

A review completed by Morgenstern (2018) concluded that the record of mine tailings dam safety, and by extension coal ash impoundments, is poor, even in advanced jurisdictions and when designed by experienced engineers. In his own words,

> *The recent failures of major dams in technically advanced regions of the world, operated by mature mining organizations and designed by recognized consulting engineers, has created a crisis in terms of a loss of confidence and trust associated with the design, construction, operation, and closure of tailings storage facilities. Responses to these failures are analyzed, and all are found wanting, particularly since the widespread evidence for weak engineering is inadequately recognized*.

In this light and in my opinion, continued use and expansion of the coal ash impoundment represents an unnecessary risk that can be eliminated by constructing an engineered landfill for disposal of the coal ash.

Coal Ash Impoundment

The documents available for review did not include a detailed assessment of hydrogeological conditions, although the water balance report indicates that seepage through the dam is significant (Jacobs, 2019a). There is potential for contaminant migration via the following groundwater pathways:

- Lateral migration of coal ash leachate through permeable zones within the dam.
- Lateral migration of contaminated groundwater through more permeable surface alluvial sands and gravels where permeable surface sands are present within the former Pikes Creek drainage channel.

It is noteworthy that AGL currently captures contaminated coal ash leachate that is seeping through the toe of the dam and is returning that contaminated water to the process. The rate of leachate seepage out of this impoundment is somewhat alarming (>100 l/s or 9,000 m^3/day, Jacobs, 2019a). This leachate is impacted by soluble contaminants entrained in the coal ash. The most representative monitoring points for potential impacts by coal ash leachate are BQ_MW10, which is a monitoring well completed in alluvial gravel, and Pikes Gulley, a monitoring point in a portion of the Pikes Creek watershed that flows adjacent to the coal ash impoundment. Results at these and other monitoring points are compared to water quality monitoring results for the Hunter River and BQ-MW4, monitoring locations where water quality does not appear to be significantly affected by coal ash. Measured concentrations are also compared to the 95% Protection Levels specified in the water quality assessment (Jacobs, 2010d).

Groundwater

Concentrations of selected metals and boron in groundwater that are typically indicative of coal ash contamination are summarized in Table 1. Concentrations are compared to BQ-MW4 and the 95% Protection Levels specified in the water quality assessment (Jacobs, 2010d). BQ-MW4 is considered the only low-impact monitoring well and the measured concentrations for the remaining monitoring wells are combined for this summary. The following observations can be made by reviewing Table 1:

- The high concentrations for all parameters measured in the ash impoundment wells, with the exception of selenium, exceed the 95% Protection Level.
- The median concentrations for all parameters measured in the ash impoundment wells, with the exception of selenium and arsenic, exceed the 95% Protection Level.
- The high and median concentrations for all parameters measure in the ash impoundment wells, with the exception of selenium, exceed the measured concentrations in BQ-MW4.
- The source of boron and metals contamination is most likely the coal ash impoundment, although elevated manganese concentrations may also be related to anaerobic sub-surface conditions.

Table 1: Summary of Water Quality Monitoring (Jacobs, 2019d)

Contaminant	95% Protection Level (ANZG, 2018) (mg/L)	Low Impact Groundwater (BQ-MW4) (mg/L)	Summary of Monitoring Wells in Ash Dam Augmented Area		
			High (mg/L)	Median (mg/L)	Low (mg/L)
Arsenic	0.024	<0.001	**0.025** (MW03)	**0.013**	<0.001
Boron	0.37	0.17 to 0.37	**4.62** (MW10)	**2.2**	<0.21
Cadmium	0.0002	<0.0001 to 0.0004	**0.00244** (MW01)	**0.00122**	<0.0001
Manganese	1.9	0.003 to 0.2	**43.8** (MW01)	**21.65**	0.003
Lead	0.0034	<0.001 to 0.0007	**0.061** (MW03)	**0.03**	<0.001
Nickel	0.011	0.003 to 0.006	**0.298** (MW04)	**0.152**	0.003
Selenium	0.011	<0.01	<0.01	<0.01	<0.01
Zinc	0.008	0.005 to 0.008	**0.329** (MW10)	**0.165**	<0.005

Red indicates exceedance of 95% Protection Level. Bold indicates exceedance of BQ-MW4 samples.

The high levels of seepage out of the coal ash impoundment (Table 2) are direct indications that the coal ash is in direct contact with a permeable surface layer (aquifer, BQ-MW10), which does not comply with Location Restrictions for coal ash impoundments (U.S. EPA, 2015, § 257.60). While the U.S. EPA rules do not apply to Bayswater, the rule exists because coal ash presents a very long-term risk to water quality because contaminants within it are inorganic, and do not degrade over time. Selenium has the potential to bioaccumulate in fish (U.S. EPA, 2015); other heavy metals associated with coal ash also have the potential to bioaccumulate in aquatic receptors.

Surface Water

There is potential for contaminant migration through the following surface water pathways:

- Seepage of coal ash leachate from the ash pond into surface watercourses downgradient of the coal ash dam.

- Direct discharges/overflow into watercourses associated with the operation of Bayswater Coal Handling Plant.

There are also direct discharges into Tinkers Creek. Overflow from the BWAD during high precipitation events discharges via the dam flood spillway into Chilcotts Creek, which feeds into Lake Liddell.

The surface watercourses which are directly susceptible to contamination from seepage of coal ash leachate originating in the impoundment are Pikes Creek and Chilcotts Creek, and further downstream, Lake Liddell and Bayswater Creek. Most of the coal ash leachate seepage from the impoundment discharges under the dam wall towards Pikes Gully, where a portion is intercepted by the seepage collection ponds. The portion of the seepage that bypasses the seepage collection ponds ultimately discharges into Pikes Creek and subsequently Bayswater Creek. A smaller portion of the coal ash leachate seepage from the impoundment discharges beneath the Saddle Dam into Chilcotts Creek, which flows into Lake Liddell. Table 2 shows the seepage discharge rates to the respective surface water bodies under average and high rainfall scenarios, as reported by Jacob (2019a).

Table 2: Seepage Rates from Coal Ash Impoundment

Ash Dam Outputs (m^3/day)	Average Scenario (Mean)		Wet Scenario (95th Percentile)	
	Existing	Proposed	Existing	Proposed
Overflow	0	0	50	2,042
Seepage to Collection Ponds	528	356	54	508
Seepage to Lake Liddell	94	94	94	94
Seepage to Pikes Creek and Bayswater Creek	8,715	8,886	8,757	9,241

Accordingly, the most representative monitoring points for potential impacts to surface water by seepage of coal ash leachate are in Pikes Creek, Lake Liddell, and Bayswater Creek since no water quality data are available for Chilcotts Creek. Concentrations of contaminants in surface water that are typically indicative of coal ash (salts and some metals) are summarized in Table 3. These monitoring points are compared to water quality monitoring results for the Hunter River, and Plashett Reservoir for sodium and chloride, monitoring locations where surface water does not appear to be significantly affected by coal ash. Measured concentrations are also compared to the 95% Protection Levels specified in the water quality assessment (Jacobs, 2010d).

Table 3: Summary of Surface Water Quality Monitoring (Jacobs, 2019d)

Contaminant	95% Protection Level (ANZG, 2018) (mg/L)	Low Impact Surface Water (Hunter River)	Pikes Creek	Bayswater Creek	Lake Liddell
Electrical Conductivity (uS/cm)	125 – 2,200	827.55	**5,322**	**2,864 – 3,452**	**2,310**
Arsenic, (mg/L)	0.024	<0.001	0.015	0.02	0.005
Boron (mg/L)	0.37		**310**	**<1**	**1.185**
Cadmium (mg/L)	0.0002	<0.0002	<0.01	<0.0002	0.0005
Chloride (mg/L)	350	87	**785**	**510 - 620**	**437**
Manganese (mg/L)	1.9	0.1	0.06	<0.01 – 0.06	**81.8**
Lead (mg/L)	0.0034	<0.001	**0.01**	<0.001	<0.001
Nickel (mg/L)	0.011	0.002	**0.49**	0.002-0.008	0.004
Selenium (mg/L)	0.011	<0.001	**0.019**	0.002-0.005	<0.01
Sodium (mg/L)	230	54.2	**789**	**430 - 650**	**315.5**
Zinc (mg/L)	0.008	<0.01	0.01	<0.01 - **0.06**	0.0025

Orange indicates parameters measured from Plashett Reservoir samples because there are no data for Hunter River. Red indicates exceedance of 95% Protection Level. Bold indicates exceedance of Hunter River samples.

The Protection Level is the degree of protection afforded to a water body based on its ecosystem condition (current or desired health status of an ecosystem relative to the degree of human disturbance). The level of protection informs the acceptable water/sediment quality for a water way. The protection levels were derived using cumulative frequency plots of species sensitivity to various toxicants, which were developed from toxicity tests performed for a variety of aquatic organisms. A 95% Protection Level denotes a concentration that protects 95% of species in a given aquatic environment. As different elements and compounds affect aquatic organism differently, multiple exceedances could be additive, meaning that if 95% Protection concentrations were exceeded by two elements, up to 10% of the species could be at risk. The following observations can be made by reviewing Table 3:

- Electrical Conductivity, boron, chloride, lead, nickel, selenium, and sodium concentrations measured in Pikes Creek are significantly above the ANZG 95% Protection Level and the concentrations measured in the low impacted surface water. Boron levels in Pikes Creek are approximately 800 times higher than the ANZG 95% Projection Level. These elevated concentrations are likely attributable to seepage from the coal ash impoundment.

- Electrical Conductivity, chloride, and sodium concentrations measured in Bayswater Creek are above the ANZG 95% standards and the concentrations measured in Hunter River/Plashett Reservoir. No boron was detected in Bayswater Creek; however, the detection limit was 1 mg/L which is 3 times the ANZG 95% standard and significantly above the typical detection limit. The elevated salt concentrations are likely attributable to seepage from the coal ash impoundment and flow from Pikes Creek into Bayswater Creek.

- Electrical Conductivity, boron, chloride, manganese, and sodium concentrations measured in Lake Liddell are above the ANZG 95% standards and concentrations measured in Hunter River/Plashett Reservoir samples. These impacts are most likely attributable, at least in part, to seepages from the coal ash impoundment.

Water quality results from the surface water monitoring locations should be compared to water quality results from background monitoring locations and monitoring locations in the coal ash leachate. If concentrations of contaminants typically indicative of coal ash are elevated above background levels, then the contamination can likely be attributed to coal ash.

It is important to note that interception and treatment or disposal of this contaminated water will be required for a very long period following closure because the inorganic contaminants within coal ash do not degrade over time. This is the primary reason why jurisdictions in the United States are ordering power companies to remove coal ash dumps contained within dammed structures and move the coal ash and associated wastes into secure landfills (Citizen-times, 2020). While there are no site-specific data presented regarding the quality of the coal ash leachate at Bayswater, coal ash in general is known to contain toxic metals (EIP, 2019).

Filling Ravensworth Mine Workings

Filling the abandoned mine workings with a mixture of coal ash is to be continued, presumably to reduce risks associated with mine roof collapse and to reduce groundwater flows in these mine workings. There is insufficient information in the documents reviewed to assess what technical analyses were completed to arrive at the planned course of action. In my opinion, it is not reasonable to conclude that the presence of the coal ash fill will stabilize the mine roof or impede groundwater flow, as follows:

1. To fully support the roof of the mine it will be necessary for the coal ash fill to bond to and support the mine roof over all areas potentially prone to collapse. This will be very difficult to achieve and impractical to verify.

2. The mine workings underlying the coal ash will remain highly permeable relative to the surrounding rock; hence, they will continue to be the main conduit for potential contaminated groundwater migration. Filling the voids will not significantly reduce the hydraulic conductivity relative to the surrounding rock, but introducing coal ash into these voids may increase risk of groundwater contamination.

If the underground workings are flooded, injecting fluidized coal ash will displace mine water that may also be contaminated. Seepage of contaminated mine water and coal ash slurry water could also permeate into potable groundwater or flow to surface water features. Based on the above, it is my opinion that a technical evaluation of the advantages and disadvantages of using coal ash to backfill these mine workings is warranted, but is not included in the EIS or the Project plans.

Coal Ash Use

AGL's efforts and initiative to increase the proportion of coal ash that is used beneficially is important to recognize as a positive outcome of this Project. For example, fly ash amendment to cement is well known to enhance the performance of concretes in certain applications. In my opinion, an assessment of environmental risks associated with coal ash use is warranted to identify preferred uses and methodologies to ensure that there are no unintended environmental impacts associated with this strategy. This assessment would identify accepted uses of the coal ash from the perspective of environmental protection rather than simply from the perspective of economic benefit.

A large proportion of coal ash is being placed in abandoned coal mines (HBM, 2019). I would consider this a coal ash disposal practice and not a beneficial reuse of the coal ash. As stated above, coal ash disposed in an abandoned mine still has the potential to contaminate surface water and groundwater, which can have significant environmental implications (EarthJustice, 2020).

Salt Cake Landfill

In my opinion, the removal of salt from the power generation and wastewater disposal process is a key benefit of the Project because salt contamination is an important environmental concern for the Hunter River watershed (Jacobs, 2020d). The management of crystalized salt cake is a potentially viable option for disposing of this salt; however, the contained salt presents a risk of water contamination in perpetuity. Accordingly, any landfill that is constructed to contain this salt should be specifically designed for this purpose.

The EIS cites the NSW EPA Environmental Guidelines for solid waste landfills (Second Edition, 2016) as the primary regulatory reference that pertains to the Salt Cake Landfill; however, the EIS (Jacobs, 2020) does not appear to comply with EPA (2016) in a number of important aspects. For example, the EIS does not include details of the engineered features of the landfill, details of waste reprocessing, or an assessment of disposal alternatives other than the status quo.

The EIS (Jacobs, 2020) states that, "in accordance with the NSW EPA Environmental Guidelines for solid waste landfills (Second Edition, 2016) a leachate barrier system would be required to contain leachate and prevent the contamination of surface water and groundwater over the life of the landfill. Each cell would be lined with at least one metre of clay, or other suitably impermeable material, as per the EPA Environmental Guidelines (EPA, 2016)". The EIS does not state that a composite (geomembrane and clay soil) liner is required in addition to specific leachate collection systems. Further, there is no mention of the requirement that "pollutants with the potential to degrade the quality of groundwater must not migrate through the strata to any point beyond the boundary of the premises or beyond 150 metres from the landfill footprint, whichever is smaller", as is required by EPA (2016). The groundwater modeling results presented in Section 6.2.2 of Appendix D (Jacobs, 2019d) appear to show that salt impacts to groundwater quality will extend more than 150 m from the landfill footprint.

The implication in the EIS Project description (Jacobs, 2020) that salt can be safely contained in a conventional clay-lined cell is troubling because it reveals a lack of understanding of the factors at play. Salts interact with the double-layers of clay soil particles, which adversely effects the structure of the compacted clay liner. This, in turn, increases the permeability and reduces the effectiveness of the clay soil liner. This problem will be progressively aggravated by increasing seepage through the clay soil liner and progressive deterioration of the clay liner structure. A better option is to design to a hazardous waste standard, which typically includes an upper chemically resistant geomembrane liner, interstitial leak detection layer and lower composite (geomembrane and clay soil) liner. The landfill should also be covered using a chemically resistant geomembrane liner.

Alternatives

There are two significant, avoidable risks that are associated with the impoundment of liquid wastes behind a large dam: (1) the risk of dam failure, which has happened on too many occasions; and, (2) seepage of contaminated water out of the unlined coal ash pond. According to AGL's plan, this coal ash impoundment and the above-noted risks will be present for a long time to come, perhaps indefinitely.

The root-cause of these risks is AGL's decision to continue to transport the coal ash to a dammed impoundment as a liquid slurry. It is not necessary to transport the coal ash as a slurry. The coal ash can be moisture conditioned at the plant and transported to the disposal site in a manner that controls dust. This would enable the coal ash impoundment to be operated dry, or, more appropriately, would allow the coal ash to be transferred to an engineered, secure landfill. Going forward, the coal ash should be transferred to a purpose-built, secure landfill facility and the existing coal ash impoundment should be either secured and closed, or preferably should be removed in its entirety and transferred to the secure landfill. Transferring the coal ash into an engineered landfill allows contaminants to be reliably contained, whereas closure of the coal ash impoundment will require seepage to be managed and treated over a very long period following closure. It is noted that the coal ash is in direct contact with alluvial deposits of Pikes Creek, which would likely be considered an aquifer under U.S. EPA (2015) Rules; hence, this location does not comply with the Location Restriction of these Rules.

More secure landfill containment systems should be implemented for the salt cake landfill because the contaminating potential of the salt cake landfill will exist in perpetuity and because salt contamination is recognized as a critical environmental concern for the Hunter River watershed (Jacobs, 2020d). The containment schemes should utilize chemically resistant geo-membranes, double liners and leak detection capability in its designs, which are considerably more protective than the standards identified in the EIS (Jacobs, 2020).

In addition, the efficacy and viability of using deep well injection to dispose of brines generated by the power generating operations should be investigated. This sort of water disposal strategy is common in the oil and gas industry and is proven to be safe in most circumstances. There is insufficient information available to me at this time to evaluate this option.

CLOSURE

I trust that this letter provides the information and assessment that you require at this time. If you require further information or if you have any additional questions, please contact me. I appreciate having the opportunity to provide my services on this file.

Yours sincerely,

Gordon J. Johnson, M.Sc., P.Eng.
President

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