Cooling Tower Effluent for Irrigation - Statement of Environmental Effects February 2017

BOC Limited Kooragang Island

15 March 2017

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Executive Summary

The following report has been prepared by MJM Environmental Pty Ltd for BOC Limited Kooragang Island, herein referred to as BOC Kooragang. The report is intended for submission to the NSW Department of Planning and Environment, and NSW Environmental Protection Authority (EPA).

BOC Limited Kooragang Island, herein referred to as BOC Kooragang, owns and operates a gas facility for the production and supply of gas products located at 9 Egret Street Kooragang, New South Wales. The facility operates 24 hours per day, 7 days per week. BOC Kooragang holds NSW Environmental Protection Authority (EPA) Environmental Protection Licence (EPL) 20165.

The following report is intended for submission to NSW EPA with a Licence Variation Form for a proposed irrigation project.

BOC Kooragang owns and operates a gas facility for the production and supply of gas products located at 9 Egret Street Kooragang, NSW and holds NSW Environmental Protection Authority (EPA) Environmental Protection Licence (EPL) 20165.

BOC Kooragang currently possess two (2) cooling towers onsite. The wastewater is collected by an approved waste contractor approximately once per week. BOC Kooragang have performed internal investigations regarding the feasibility of utilising the cooling tower wastewater for irrigation purposes in grassed areas of the site. Therefore BOC Kooragang wishes to obtain consent to utilise the cooling tower blowdown stream as effluent to irrigate a selected area of land at the site, as a full reuse scheme.

The cooling tower wastewater was found to contain levels of fluoride above the ANZECC irrigation guidelines. MJM performed a pilot plant trial for the removal of fluoride using activated alumina, which was found to successfully remove fluoride to acceptable levels. The report has outlined the proposed system for treatment of the cooling tower wastewater to irrigation.

It is believed that the proposed irrigation system at BOC Kooragang is feasible for the following reasons:

- The water balance shows that the estimated percolation rate of the proposal is well below the typical range of percolation rates for the soil type at the facility. When managed appropriately at the estimated rate of application, is it believed the soil type is therefore able to handle the capacity of the effluent applied based upon percolation rates and unlikely to cause ponding.
- Nitrogen and phosphorus balances performed show that the concentration of these analytes are not limiting factors for irrigation purposes.
- The review of potential environmental factors shows that the proposed facility is not expected to adversely impact upon the environment.

As best practice, BOC Kooragang propose to implement the following practices and procedures to ensure the proposed system is managed sustainably and appropriately:

- Automated operation during permitted times of the day, including Supervisory Control and Data Acquisition (SCADA) control system in place on irrigation system with appropriate feedback systems.
- An effluent irrigation management plan, which will include but is not excluded to the following:
  - Internal monitoring programs, including site inspections of the processes and irrigation areas.
  - Description of irrigation system maintenance required.
  - Details of operation and mitigation during non-standard conditions, such as wet weather events.
- Implementation of regular soil, groundwater and effluent monitoring as part of EPL 20165.
- Waste management plan implemented for filter media.

It is believed that the proposed irrigation system at BOC Kooragang is beneficial for the following reasons:

- No reliance on town-supplied water for irrigation of the proposed grassed area.
- Removal of 18,200 litres per week that would be directed to a waste contractor, and ultimately to Hunter Water's sewer.
- Financial benefits to BOC Kooragang due to decreased operational costs and wastewater sent offsite.

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1 Introduction

1.1 BOC Limited Kooragang Island

The following report has been prepared by MJM Environmental Pty Ltd for BOC Limited Kooragang Island, herein referred to as BOC Kooragang. The report is intended for submission to the NSW Department of Planning and Environment (the Department) and NSW Environmental Protection Authority (EPA).

BOC Limited Kooragang Island, herein referred to as BOC Kooragang, owns and operates a gas facility for the production and supply of gas products located at Lot 5 DP 1015754 9 Egret Street Kooragang, New South Wales. The facility operates 24 hours per day, 7 days per week. BOC Kooragang holds NSW Environmental Protection Authority (EPA) Environmental Protection Licence (EPL) 20165.

1.2 Proposed modifications

BOC Kooragang currently possess two (2) cooling towers onsite. Currently the cooling tower blowdown (waste) water is produced at a rate of 18,200 litres per week. The effluent continues to two (2) 10,000 litre capacity storage tanks onsite, totalling a capacity of 20,000 litres of storage onsite. The wastewater is collected by an approved waste contractor approximately once per week.

BOC Kooragang have performed internal investigations regarding the feasibility of utilising the cooling tower wastewater for irrigation purposes in grassed areas of the site.

Further detail is provided in later sections of the report.

2 Statutory Context

2.1 Land zoning

BOC Kooragang's site is located AT Lot 5 DP 1015754 9 Egret Street Kooragang, New South Wales. The location is zoned under the *State Environmental Planning Policy (State Significant Precincts) 2005* (SEPP 2005) as part of the *Three Ports* precinct. The Three Ports precinct includes Newcastle, Port Botany and Port Kembla. The Newcastle port site is zoned *SP1 Special Activities*.

The location is within the '*Port of Newcastle Lease Area'* of the *State Environmental Planning Policy (Three Ports) 2013* (SEPP 2013), as shown in Figure 2-1. Therefore the SEPP is the main planning instrument to which the proposed development will be evaluated.

Figure 2-1: BOC Kooragang site zoning (modified from SEPP 2013 map *Sheet LES_003*)

The objectives of Zone SP1 are shown in Table 2-1 as taken from the SEPP 2013.

Table 2-1: Zone SP1 objectives and evaluation comments

Objective	Evaluation comments
To provide for special land uses that are not provided for in other zones.	The SEPP provides for a broad range of activities on Kooragang Island including BOC Kooragang's current industrial activities. BOC Kooragang's site will remain and perform normal operations therefore is in keeping with the objective. Irrigation would be performed on an already grassed area of the BOC Kooragang site, therefore is appropriate.
To provide for sites with special natural characteristics that are not provided for in other zones.	The SEPP provides for a BOC Kooragang's current industrial activities within the Lease area. BOC Kooragang's site will remain and perform normal operations therefore is in keeping with the objective. Irrigation would be performed on an already grassed area of the BOC Kooragang site, therefore is appropriate.
To facilitate development that is in keeping with the special characteristics of the site or its existing or intended special use, and that minimises any adverse impacts on surrounding land.	The SEPP provides for a BOC Kooragang's current industrial activities within the Lease area. BOC Kooragang's site will remain and perform normal operations therefore meets the existing and intended uses of the area. Irrigation would be performed on an already grassed area of the BOC Kooragang site. Impacts on surrounding land will be minimised and this will be shown in the following sections of the SEE. Other industries exist at the Kooragang area that currently utilise irrigation to grassed areas of site, therefore the proposed project will not be foreign to the industrial area.
To maximise the use of waterfront areas to accommodate port facilities and industrial, maritime industrial, freight and bulk storage premises that benefit from being located close to port facilities.	The BOC Kooragang site does not exist on a waterfront area therefore will not have negative impacts on the waterfront areas.
To enable the efficient movement and operation of commercial shipping and to provide for the efficient handling and distribution of freight from port areas through the provision of transport infrastructure.	The BOC Kooragang site is an existing facility. The proposed modifications will not adversely impact upon efficient traffic movements or port infrastructure as shown in the appropriate section of the SEE.
To provide for port related facilities and development that support the operations of Port Botany, Port Kembla and the Port of Newcastle.	The proposed works will support port-related facilities through allowing BOC Kooragang to continue operating due to decreased operational costs and wastewater sent offsite.
To facilitate development that by its nature or scale requires separation from residential areas and other sensitive land uses.	The Lease Area is separate from residential and sensitive land uses, which is typical and beneficial for industry operations such as BOC Kooragang.
To encourage employment opportunities.	The proposed modifications will allow continued employment for BOC Kooragang personnel, initial construction and set-up contractors, and ongoing employment for continue operation and maintenance of the system.

The proposed irrigation modification is considered ancillary to the current development, as cooling tower effluent is created during normal operations and normally disposed offsite with a licensed waste contractor.

It is therefore believed that the proposed works meet the SP1 zone objectives.

2.2 Identification of Current Approvals, Consents and Applicable Guidelines

BOC Kooragang and MJM Environmental have contacted the following authorities with regard to the proposed project from 2016 to date:

- Department of Planning and Environment
- Newcastle City Council
- NSW EPA Newcastle office

BOC Kooragang's site is located within the '*Lease Area'* of the *State Environmental Planning Policy (Three Ports) 2013* (SEPP Three Ports 2013). Therefore the Department of Planning and Environment is the consent authority for modifications and development approval. Therefore the following submissions is a Part 4 development application (DA) under the *Environmental Planning and Assessment Act 1979* (EP&A Act) intended for submission to the Department.

The land is owned by Port of Newcastle Lessor Pty Limited c/o Property NSW (PON). Therefore approval has also been sought from PON and is provided with the application.

Newcastle City Council was contacted during October 2016 as the site was previously zoned under the jurisdiction of Newcastle City Council prior to 2013. The original facility development application was granted over 35 years ago around 1974. The following DAs are applicable from Newcastle City Council:

- DA 2013/904 – Replacement of one tank and additional liquid CO_2 storage tank
- DA 05/2271 for Construction of office, amenities and forklift store buildings, truck wash building, car and truck parking facilities and associated driveway
- DA 99/2795 for Subdivision of land into seven lots
- DA 90/0472 for Carbon dioxide purification and liquefaction plant

BOC Kooragang operates under SafeWork NSW. The *Acknowledgement for Notification of Hazardous Chemicals on Premises* (dangerous goods) issued by SafeWork NSW on 9 October 2016 is provided in Appendix G.

BOC Kooragang is licensed with NSW EPA under Section 55 of the *Protection of the Environment Operations Act 1997* (POEO Act), and operates under EPL 20165 with the following activities:

- Scheduled Activities:
    - Chemical Production
    - Chemical Storage
- Fee Based Activities:
    - Dangerous goods production
    - General chemicals storage
    - Chemical storage waste generation

The POEO Act lists *Irrigated Agriculture* as a scheduled activity, '*meaning the irrigation activity of an irrigation corporation within the meaning of the* Water Management Act 2000*'*. BOC Kooragang is not an irrigation corporation under the Water Management Act.

Utilisation of effluent for irrigation is not a scheduled activity under the POEO Act; however it has been advised that EPA approval will be required to perform irrigation at the site. BOC Kooragang is submitting an EPL Licence Variation form to NSW EPA for the proposed irrigation activities for approval to perform the proposed activities. If EPA grants approval, it is expected that the wastewater discharge point and proposed irrigation areas will be listed in the EPL 20165 as an identified emission point(s). Further detail is provided in *Section 9.3 EPL monitoring programs*.

In order to complete specific aspects of the SEE, the NSW EPA's *Environmental Guidelines – Use of Effluent by Irrigation* (2004) document has been used, herein referred to as the Effluent Guidelines. The Effluent Guidelines state that the following steps are required to be taken for assessment of effluent reuse for irrigation:

- Planning:

  - Consultation with relevant authorities.
- Site selection:
  - Identification of suitable site and assessment conducted.
- Design:
  - Establish minimum area of irrigation land required based on limiting loading rates.
  - Calculation of minimum irrigation land area and wet weather storage required.
  - Define operational processes to be used in effluent irrigation and management.
- Statutory requirements:
  - Comply with EPA and other relevant authorities in the planning and design stages.
  - Apply for necessary approvals.
- Installation:
  - Install system in accordance with conditions of relevant authorities.
  - Develop a monitoring and reporting program.
- Operation and maintenance:
  - Operate and maintain system in accordance with best management practices and any applicable approvals.

2.3 Applicable Legislation and Standards

The following legislation, documents and standards are considered applicable to the proposed BOC Kooragang project:

- State Environmental Planning Policy (Three Ports) 2013
- Environmental Planning and Assessment Regulation 2000
- Environmental Planning and Assessment Act 1979 (EPA&A Act)
- Environment Protection and Biodiversity Conservation Act 1999
- Environmentally Hazardous Chemicals Act 1985
- Protection of the Environment Operations Act 1997
- Protection of the Environment Operations Amendment Act 2011
- EPA's Environmental Guidelines – Use of Effluent by Irrigation (2004)
- SafeWork NSW Dangerous Goods Legislation
- AS1940 1993: The storage and handling of flammable and combustible liquids
- AS4452 1997: The storage and handling of toxic substances
- Work Health and Safety Act 2011
- National Environment Protection (Assessment of Site Contamination) Measure 1999
- Contaminated Land Management Act 1997
- Environmentally Hazardous Chemicals Act 1985
- Water Act 1912
- Water Management Act 2000
- Waste Classification Guidelines 2009
- NSW Acid Sulphate Soil Manual 1998
- NSW EPA Soil Sampling Guidelines
- AS4482.1-2005 - Guide to the investigation and sampling of sites with potentially contaminated soil
- NSW Industrial Noise Policy 2000
- NSW EPA Assessing Vibration: A Technical Guide 2006

2.4 Evaluation to Environmental Planning and Assessment Regulation 2000

The *Environmental Planning and Assessment Regulation 2000* (the Regulation) is used to determine whether a proposed development is Designated Development for the purposes of the DA. A Designated Development requires specific documentation and approval processes, including an Environmental Impact Statement (EIS).

The Regulation was consulted in terms of the proposed scope of BOC Kooragang's irrigation project. Clause 32, Schedule 3 of the Regulation states the following development is considered designated:

32(1)(a)(iii) Waste management facilities or works that store, treat, purify or dispose of waste or sort, process, recycle, recover, use or reuse material from waste and that dispose (by landfilling, incinerating, storing, placing or other means) of solid or liquid waste that comprises more than 1,000 tonnes per year of sludge or effluent.

BOC Kooragang intends to reuse cooling tower blowdown water (effluent) for irrigation purposes as an alternative to disposal offsite, therefore is required to consider Clause 32. The total volumes of wastewater produced at BOC Kooragang are described in detail in *Section 3 Proposed project summary*.

In summary, BOC Kooragang will be producing effluent from the cooling tower operation at a maximum rate of 18,200 litres per week. The maximum volume produced over one (1) year equates to 946,400 litres which is equivalent to 946 tonnes. Therefore BOC Kooragang does not intend to utilise effluent that comprises more than 1,000 tonnes of effluent per year and does not trigger the threshold for designated development.

Further sections of the SEE summarise upgrade works to be performed that will further reduced the volume of effluent produced by BOC Kooragang. The volume of effluent produced will not be increased under any circumstance above 946 tonnes per year.

2.5 Evaluation to SEPP (Three Ports) 2013

Part 2 of the SEPP (Three Ports) 2013 covers *Permitted or Prohibited Development*. Zone objectives and land usage was discussed previously in *Section 2.1 Land zoning*.

Part 3 of the SEPP (Three Ports) 2013 covers *Exempt or Complying Development*. The proposed modifications are not considered exempt or complying development.

Part 4 of the SEPP (Three Ports) 2013 covers *State Significant Development and Infrastructure*. The proposed modifications are not considered state significant development or infrastructure.

Part 5 of the SEPP (Three Ports) 2013 covers *Miscellaneous* which are:

- Preservation of trees or vegetation:
  - No vegetation is required to be removed for the project.
  - As the proposed project is irrigation to grassed areas, the potential impacts to vegetation are a major aspect of the project. Potential impacts and mitigation methods for the proposed project are therefore presented in the body of the SEE.
- Heritage conservation:
  - The site is not identified as a heritage conservation area.
  - The site is not identified as an Aboriginal place of heritage significance.

Therefore it is believed that the proposed project is considered to be in line with the requirements of the appropriate planning instruments.

3 Proposed project summary

3.1 Current Operations and Existing Site Conditions

BOC Kooragang operates a gas facility approximately 12 km from the Newcastle CBD for the production and supply of gas products. The plant boundary and vicinity is shown in Figure 3-1 at Lot 5 DP 1015754, 9 Egret Street Kooragang Island.

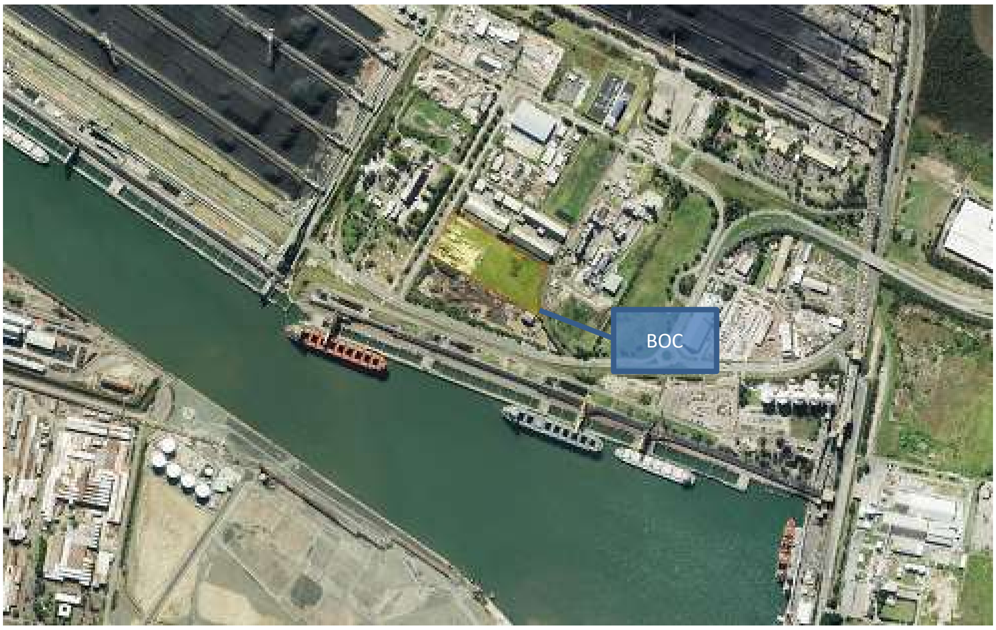

Figure 3-1: BOC Kooragang site boundary and vicinity (Spatial Information Exchange [SIXMaps] 2017)

The facility supplies and manufactures compressed and bulk gases for industry. BOC Kooragang processes waste carbon dioxide gas to liquefied form, and manufactures liquefied nitrogen gas as a by-product. The facility operates 24 hours a day, 7 days a week. The waste carbon dioxide is provided from Orica's Kooragang facility through a pipeline, liquefied, and stored in aboveground tanks prior to processing. The by-product nitrogen gas is stored, and sold as a product redistributed from BOC Kooragang via a direct pipeline to the nearby Cargill facility.

Liquid nitrogen gas, liquid argon gas, and liquid oxygen gas are also stored onsite and redistributed to industry.

BOC Kooragang operates under SafeWork NSW. The *Acknowledgement for Notification of Hazardous Chemicals on Premises* (dangerous goods) issued by SafeWork NSW on 9 October 2016 is provided in Appendix G.

The BOC Kooragang office and plant has, on average, three (3) staff members onsite during normal operating hours. The office and plant contains one kitchen, and toilets. BOC Kooragang does not have access to Hunter Water's sewer system. Onsite treatment of amenity wastewater (toilets and sinks) is performed by an onsite septic wastewater treatment system, which is managed using an approved contractor. No irrigation occurs as a result of septic wastewater treatment.

BOC Kooragang currently possess two (2) cooling towers onsite. The cooling tower blowdown (waste) water continues to two (2) 10,000 litre capacity storage tanks onsite, with a total a capacity of 20,000 litres storage onsite. The location of the cooling towers and wastewater storage tanks are shown in Figure 3-2 through to Figure 3-4.

Wastewater (effluent) from the cooling tower process is produced from the following process streams and volumes as shown in Table 3-1 based upon process information provided by BOC Kooragang. Recent upgrades of the filter backwash procedures have allowed for the total wastewater production as shown in Table 3-1.

Table 3-1: Cooling tower wastewater production volumes

Process stream	Volume
Cooling tower blowdown wastewater	16,200 L/week
Filter backwash wastewater stream	2,000 L/week
Total volume per week	**18,200 L/week**
Total annual volume produced	**946.4 kL/y** **(946.4 t/y)**

BOC Kooragang therefore produce effluent from the cooling tower operation at a maximum rate of 18,200 litres per week.

Currently cooling tower blowdown water of volume up to 18,200 litres is collected by an approved and licensed waste contractor once a week.

Current site plans are provided in Appendix E.

Figure 3-2: Location of BOC Kooragang's cooling towers and wastewater tanks

Figure 3-3: Current cooling tower blowdown wastewater storage tanks

Figure 3-4: BOC Kooragang cooling towers

3.2 Cooling tower operation

BOC Kooragang’s cooling tower is a heat rejection device which rejects waste heat to the atmosphere through the cooling of a water stream to a lower temperature. The cooling tower uses the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature.

The BOC Kooragang cooling tower classification is based on the type of air induction into the tower, in this case a mechanical induced draft cooling tower, which uses power-driven fan motors to force or draw air through the tower.

Quantitatively, the material balance around a wet, evaporative cooling tower system is governed by the operational variables of make-up flow rate, evaporation and windage losses, draw-off rate, and the concentration cycles.

Water pumped from the tower basin is the cooling water routed through the process coolers and condensers in an industrial facility. The cool water absorbs heat from the hot process streams which need to be cooled or condensed, and the absorbed heat warms the circulating water. The warm water returns to the top of the cooling tower and trickles downward over the fill material inside the tower. As it trickles down, it contacts ambient air rising up through the tower either by natural draft or by forced draft using large fans in the tower. That contact causes a small amount of the water to be lost as windage/drift and some of the water to evaporate. The heat required to evaporate the water is derived from the water itself, which cools the water back to the original basin water temperature and the water is then ready to recirculate. The evaporated water leaves its dissolved salts behind in the bulk of the water which has not been evaporated, thus raising the salt concentration in the circulating cooling water. To prevent the salt concentration of the water from becoming too high, a portion of the water is drawn off/blown down for disposal. Fresh water make-up is supplied to the tower basin to compensate for the loss of evaporated water, the windage loss water and the draw-off water.

The blowdown water is the wastewater produced from the cooling towers.

3.3 Proposed modifications to current operations

The amount of cooling tower blowdown water produced and disposed of is a significant cost to BOC Kooragang’s operations. The direct cost to BOC Kooragang is approximately $40,000 per quarter.

Therefore BOC Kooragang wishes to obtain consent to utilise the cooling tower blowdown stream as effluent to irrigate selected area(s) of land at the site, as a full reuse scheme. BOC Kooragang have performed internal investigations regarding the feasibility of utilising the cooling tower wastewater for irrigation purposes in grassed areas of the site.

The wastewater from the amenities at BOC Kooragang will remain in place and serviced by an approved contractor. No wastewater from amenities is planned to be utilised for irrigation.

It is understood that BOC Kooragang may perform further cooling tower filter upgrades in the future, which are expected to reduce volumes of effluent produced from the filter backwash. The upgrades will therefore reduce the total amount of cooling tower effluent proceeding to irrigation. If upon installation of the upgrades it is determined that the reduction in cooling tower effluent may result in an effluent stream that differs to the expected quality, the wastewater quality will be sampled and analysed. If necessary the site water balance will be repeated to ensure quality remains suitable for irrigation purposes.

4 Preliminary cooling tower water quality investigation

4.1 Existing effluent quality

In order to research the possibility of utilising the cooling tower wastewater for onsite irrigation, MJM was engaged by BOC Kooragang from 2014 to 2016 to undertake wastewater sampling and analysis to obtain baseline data.

The analytes tested are presented in Table 4-1, which are taken from the Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 guidelines. The water sampling analysis results were compared to the ANZECC guidelines presented in *Section 4: Primary Industries - 4.2 Water Quality for irrigation and general water use*.

Table 4-1: Cooling tower wastewater sampling analytes

Analytes		
pH	Herbicides	Iron
Enterococci	Pesticides	Lead
Faecal (thermotolerant) Coliforms	Cadmium	Lithium
Electrical conductivity	Zinc	Manganese
Sodium Absorption Ratio (sodicity)	Aluminium	Mercury
Alkalinity as calcium carbonate (hardness)	Arsenic	Molybdenum
Chloride	Beryllium	Nickel
Sodium	Boron	Selenium
Fluoride	Chromium VI	Uranium
Nitrogen (total)	Cobalt	Vanadium
Phosphorus	Copper	

Water quality sampling was performed in 2014 to 2016. Three samples (3) were performed in August 2014, one (1) sample in April 2015 and one (1) sample was performed in August 2016.

Sampling was performed in accordance with ANZECC monitoring standards AS/NZS 5667.1:1998 and AS/NZS 5667.11:1998. These procedures include the documentation of the name and location of the sample point, date and time of sample collection, the type of sample point, method of sample collection and sample appearance at the time of collection. The water samples were then transferred into clean plastic bottles provided by a NATA accredited laboratory. The water quality reports including laboratory results are presented in Appendix A.

The results for the cooling tower wastewater sampling from 2014 to 2016 are presented in Table 4-2.

Table 4-2: BOC Limited Cooling Tower Wastewater Sampling Results

Analyte	Units	Result 27/08/2014	Result 03/09/2014	Result 11/09/2014	Result 01/04/2014	Result 18/09/2016	Average	Recommended Irrigation Thresholds [1]
pH	pH Unit	7.85	7.95	7.83	-	8.18	7.95	6 – 9
Enterococci	CFU/100mL	~9	~4	<1	-	~4	~5	-
Faecal (thermo tolerant) Coliforms	CFU/100mL	<1	<1	<1	-	~1	~1	<10,000 [4]
Electrical conductivity	µS/cm	1,670	1,690	1,650	-	1,550	1,640	-
Sodium Absorption Ratio	-	5.2	4.61	4.32	-	4.08	4.55	-
Alkalinity as calcium carbonate (hardness)	mg/L	60	58	68	-	97	71	-
Chemical oxygen demand (COD)	mg/L	-	-	-	50	-	50	-
Suspended solids (SS)	mg/L	-	-	-	13	-	13	-
Chloride	mg/L	294	292	349	-	307	311	-
Sodium	mg/L	223	198	179	-	177	194	-
Fluoride	mg/L	**7.7**	**7.3**	**7.5**	-	**3.5**	**6.5**	1.0[2] 2.0[3]
Nitrogen (total)	mg/L	**11.0**	**10.0**	**8.9**	-	3.8	**8.4**	25 - 125[2] 5[3]
Phosphorus	mg/L	**3.62**	**2.77**	**4.17**	-	**2.13**	**3.17**	0.8 - 12[2] 0.05[3]
Cadmium	mg/L	<0.0001	0.0001	<0.0001	-	<0.0001	0.0001	0.01[2] 0.05[3]
Zinc	mg/L	0.025	0.025	0.018	-	0.012	0.020	2.0[2] 5.0[3]
Aluminium	mg/L	0.04	0.07	0.04	-	0.12	0.07	5.0[2] 20[3]
Arsenic	mg/L	0.003	0.003	0.003	-	0.002	0.003	0.1[2] 2.0[3]
Beryllium	mg/L	<0.001	<0.001	<0.001	-	<0.001	<0.001	0.1[2] 0.5[3]
Boron	mg/L	0.2	0.22	0.17	-	0.18	0.19	0.5[2] 2 – 4[5]
Chromium VI	mg/L	<0.01	<0.01	<0.01	-	<0.01	<0.01	0.1[2]

Analyte	Units	Result 27/08/2014	Result 03/09/2014	Result 11/09/2014	Result 01/04/2014	Result 18/09/2016	Average	Recommended Irrigation Thresholds [1]
								1.0[3]
Cobalt	mg/L	<0.001	<0.001	<0.001	-	<0.001	<0.001	0.05[2] 0.1[3]
Copper	mg/L	0.154	0.136	0.146	-	0.120	0.14	0.2[2] 5.0[3]
Iron	mg/L	0.1	0.1	0.07	-	0.15	0.11	0.2[2] 10[3]
Lead	mg/L	<0.001	<0.001	<0.001	-	<0.001	<0.001	2.0[2] 5.0[3]
Lithium	mg/L	0.005	0.005	0.005	-	0.005	0.005	2.5[2] 2.5[3]
Manganese	mg/L	0.008	0.007	0.007	-	0.003	0.006	0.2[2] 10[3]
Mercury	mg/L	<0.0001	<0.0001	<0.0001	-	<0.0001	<0.0001	0.002[2] 0.002[3]
Molybdenum	mg/L	0.002	0.002	0.002	-	<0.001	0.0016	0.01[2] 0.05[3]
Nickel	mg/L	0.003	0.003	0.003	-	0.012	0.005	0.2[2] 2.0[3]
Selenium	mg/L	<0.01	<0.01	<0.01	-	<0.01	<0.01	0.02[2] 0.05[3]
Uranium	mg/L	<0.001	<0.001	<0.001	-	<0.001	<0.001	0.01[2] 0.1[3]
Vanadium	mg/L	<0.01	<0.01	<0.01	-	<0.01	<0.01	0.1[2] 0.5[3]
Herbicide (Phenoxyacetic Acid Herbicides)								
4-Chlorophenoxy acetic acid	µg/L	<10	<10	<10	-	<10	<10	1,000[6]
2.4-DB	µg/L	<10	<10	<10	-	<10	<10	1,000
Dicamba	µg/L	<10	<10	<10	-	<10	<10	1,000
Mecoprop	µg/L	<10	<10	<10	-	<10	<10	1,000
MCPA	µg/L	<10	<10	<10	-	<10	<10	1,000
2.4-DP	µg/L	<10	<10	<10	-	<10	<10	1,000
2.4-D	µg/L	<10	<10	<10	-	<10	<10	1,000
Triclopyr	µg/L	<10	<10	<10	-	<10	<10	1,000
2.4.5-TP (Silvex)	µg/L	<10	<10	<10	-	<10	<10	1,000
2.4.5-T	µg/L	<10	<10	<10	-	<10	<10	1,000
MCPB	µg/L	<10	<10	<10	-	<10	<10	1,000
Picloram	µg/L	<10	<10	<10	-	<10	<10	1,000
Clopyralid	µg/L	<10	<10	<10	-	<10	<10	1,000

Analyte	Units	Result 27/08/2014	Result 03/09/2014	Result 11/09/2014	Result 01/04/2014	Result 18/09/2016	Average	Recommended Irrigation Thresholds [1]
Fluroxypyr	µg/L	<10	<10	<10	-	<10	<10	1,000
2.6-D	µg/L	<10	<10	<10	-	<10	<10	1,000
2.4.6-T	µg/L	<10	<10	<10	-	<10	<10	1,000
Pesticide (Organochlorine Pesticides)								
alpha-BHC	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000[6]
Hexachlorobenzene (HCB)	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
beta-BHC	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
gamma-BHC	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
delta-BHC	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Heptachlor	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Aldrin	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Heptachlor epoxide	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
trans-Chlordane	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
alpha-Endosulfan	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
cis-Chlordane	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Dieldrin	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
4.4-DDE	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Endrin	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
beta-Endosulfan	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
4.4-DDD	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Endrin aldehyde	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Endosulfan sulfate	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
4.4-DDT	µg/L	<2.0	<2.0	<2.0	-	<2.0	<2.0	1,000
Endrin ketone	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Methoxychlor	µg/L	<2.0	<2.0	<2.0	-	<2.0	<2.0	1,000
Pesticide (Organophosphorus Pesticides)								
Dichlorvos	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Demeton-S-methyl	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Monocrotophos	µg/L	<2.0	<2.0	<2.0	-	<2.0	<2.0	1,000
Dimethoate	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Diazinon	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Chlorpyrifos-methyl	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Parathion-methyl	µg/L	<2.0	<2.0	<2.0	-	<2.0	<2.0	1,000
Malathion	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Fenthion	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Chlorpyrifos	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Parathion	µg/L	<2.0	<2.0	<2.0	-	<2.0	<2.0	1,000
Pirimphos-ethyl	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Chlorfenvinphos	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000

Analyte	Units	Result 27/08/2014	Result 03/09/2014	Result 11/09/2014	Result 01/04/2014	Result 18/09/2016	Average	Recommended Irrigation Thresholds [1]
Bromophos-ethyl	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Fenamiphos	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Prothiofos	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Ethion	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Carbophenothion	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000
Azinphos Methyl	µg/L	<0.5	<0.5	<0.5	-	<0.5	<0.5	1,000

[1] Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 guidelines - *Section 4: Primary Industries - 4.2 Water Quality for irrigation and general water use*.
[2] Short-term trigger value (STV) – The STV is the maximum concentration (mg/L) of contaminant in the irrigation water which can be tolerated for a shorter period of time (20 years).
[3] Long-term trigger value (LTV) – The LTV is the maximum concentration (mg/L) of contaminant in the irrigation water which can be tolerated assuming 100 years of irrigation.
[4] Trigger value chosen for areas with restricted public access.
[5] Trigger value chosen for moderately tolerant crops.
[6] General limit set for herbicides for NSW.

The Short-term Trigger Values (STV) and Long-term Trigger Values (LTV) presented in Table 4-2 are recommendations from the *Australian and New Zealand Environment and Conservation Council (ANZECC) 2000* guidelines (ANZECC guidelines). The guidelines for irrigation were chosen for comparison with the cooling tower wastewater quality.

Table 4-2 shows that Fluoride exceeded the STV and LTV for all three samples with an average of 6.5 mg/L. It is noted that the guidelines state '*the LTV has been set on the assumption that irrigation water could potentially be phytotoxic to sensitive plant or contaminate stock drinking water*'.

Nitrogen (total) was within the STV range, however exceeded the LTV for all three samples with an average of 10.0 mg/L. It is noted that the guidelines state for nitrogen that '*the LTV has been set at a concentration low enough to ensure no decrease in crop yields or quality due to excessive nitrogen concentrations during later flowering and fruiting stages*'. The proposed irrigation area is grassed area only.

Phosphorus concentrations for all three samples also exceeded the LTV with an average of 3.52 mg/L. However it is noted that the guidelines state the LTV for phosphorus is set '*to minimise bioclogging of irrigation equipment only*'. It is therefore possible to balance phosphorus levels with routine maintenance of irrigation equipment.

The remaining analytes were compliant with the recommended threshold levels.

Therefore it was identified that Fluoride was the main analyte of concern. Investigations were commenced to provide a treatment option for removal of fluoride from the cooling tower wastewater.

4.2 Pilot plant trial for removal of fluoride

In September and October 2016, MJM performed a pilot plant trial for the removal of fluoride using a specialised media (activated alumina) in a pilot scale filter unit. It was found that the pilot scale filter unit successfully removed fluoride to acceptable levels, and also reduced phosphorus concentrations. Table 4-3 presents the results of the analytes monitored and the pilot trial report and NATA-accredited laboratory results are provided in Appendix C.

The study was focused on fluoride removal to meet the ANZECC guidelines for LTV (100 years of irrigation) and therefore analytes were chosen that were of concern for irrigation. Analytes such as metals, herbicides and pesticides were not targeted and therefore not monitored as the concentrations of the analytes were already below the ANZECC guidelines or not detected in the raw water.

Table 4-3: BOC Kooragang pilot trial treated water quality results

Analyte	Units	Treated water quality	Recommended Irrigation Thresholds [1]
pH	pH Unit	7	6 – 9
Electrical conductivity	µS/cm	1,520	-
Sodium Absorption Ratio (SAR)	-	7	-
Chloride	mg/L	300	-
Sodium	mg/L	229	-
Fluoride	mg/L	0.2	1.0[2] 2.0[3]
Nitrogen (total)	mg/L	3	25 - 125[2] 5[3]
Phosphorus	mg/L	0.02	0.8 - 12[2] 0.05[3]

[1] Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 guidelines - *Section 4: Primary Industries - 4.2 Water Quality for irrigation and general water use*.
[2] Short-term trigger value (STV) – The STV is the maximum concentration (mg/L) of contaminant in the irrigation water which can be tolerated for a shorter period of time (20 years).
[3] Long-term trigger value (LTV) – The LTV is the maximum concentration (mg/L) of contaminant in the irrigation water which can be tolerated assuming 100 years of irrigation.

5 Detail of proposed modifications

5.1 Water treatment system

In September and October 2016, MJM performed a pilot plant trial for the removal of fluoride using a specialised media (activated alumina) in a pilot scale filter unit. It was found that the pilot scale filter unit successfully removed fluoride to acceptable levels, and also reduced phosphorus concentrations as shown previously in Table 4-3 and Appendix C.

It was determined that no other pre-treatment would be required for removal of fluoride from the wastewater. Appendix D contains an irrigation system design report for the proposed treatment system. The proposed system for treatment of the cooling tower wastewater would consist of installation of the following:

- Existing 2 X 10 kL cooling tower blowdown storage tanks (totalling 20 kL storage capacity)
- 2 X 10 kL additional water storage tanks
- Use of existing cooling tower blowdown pump facility
- 1 X flow meter
- Activated alumina filtration through 2 X open gravity filters
- 1 X treated water storage tank submersible pump

- Irrigation pipework

It is not believed that construction will be required for the project. The majority of the proposed pipeline infrastructure is existing at BOC Kooragang, and the abovementioned equipment requires installation only.

A new segment of the irrigation line is to be installed. The pipeline will be run above-ground to the irrigation point above-ground as shown in Figure 5-1. Where required, such as where there is an existing footpath, it will be run underground for the short distance using directional drilling.

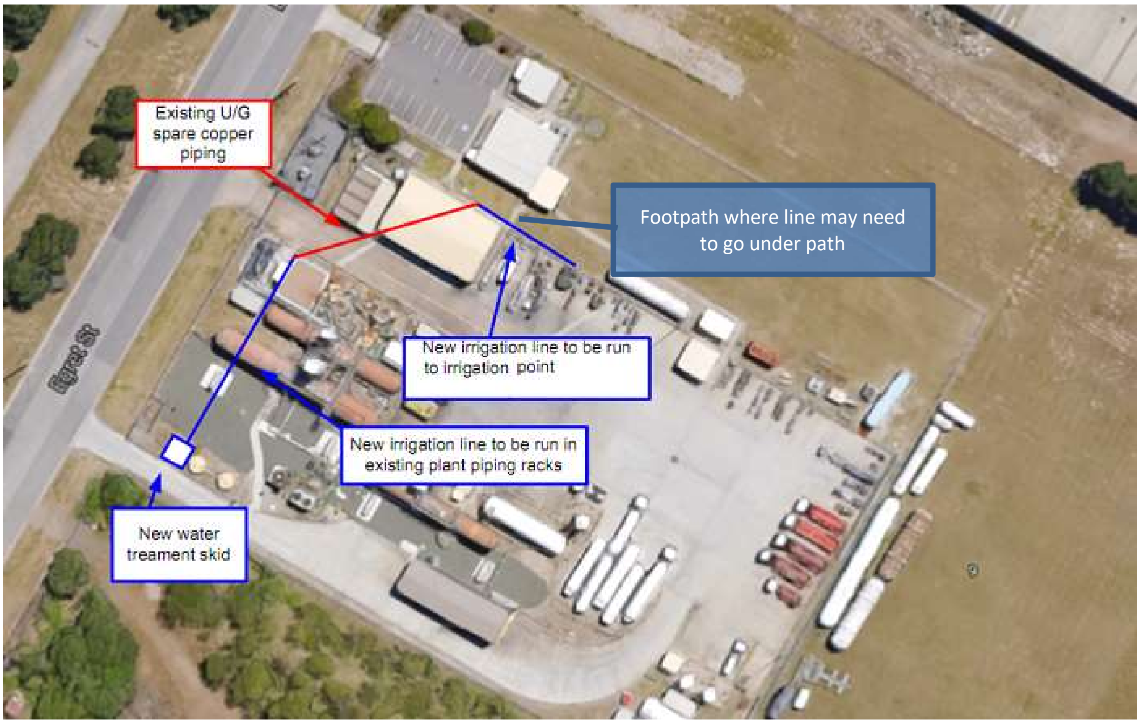

Figure 5-1: Proposed irrigation pipework system diagram

Figure 5-2 shows the proposed filter housing from supplier Polyworld. The filter housing is two (2) polyethylene 1,000 litre tanks.

Figure 5-2: Proposed example of filter housing

Figure 5-3 shows a diagram of the proposed treatment system as taken from the process and instrumentation diagrams and report in Appendix D.

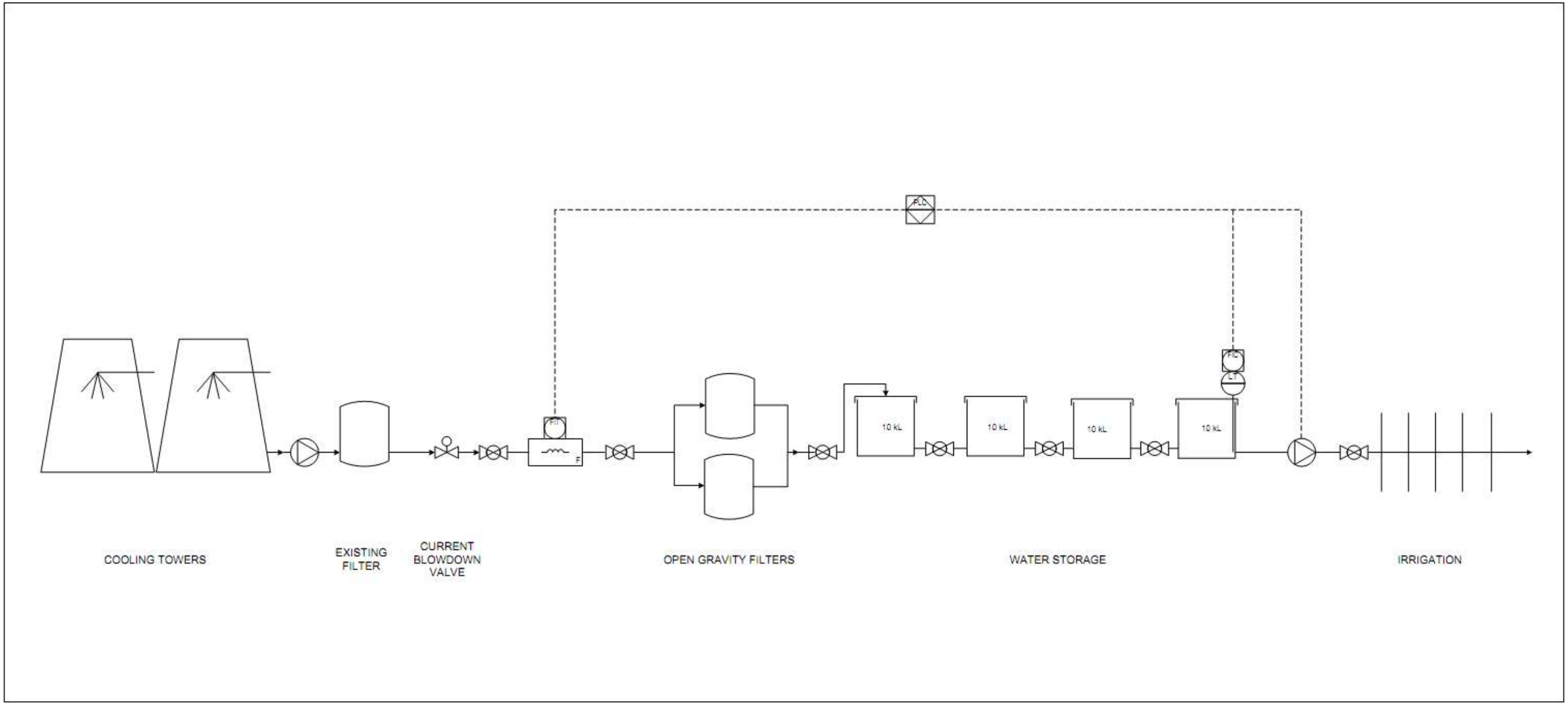

Figure 5-3: Proposed treatment system schematic (not to scale)

A drip irrigation system is proposed to be utilised. Drip irrigation systems provide more operational flexibility and efficiency. Pressurised effluent is discharged through micro-emitters and dripped; this process reduces the risk of aerosol drift and potential odour.

BOC Kooragang will perform a detailed design and construction plan, and perform a Hazard and Operability study (HAZOP) at the concept design stage of the project.

5.2 Wet weather storage

Section 7.4 Wet weather storage showed that the total effluent applied to the land during irrigation is of a volume approximately 1 to 2% of the calculated historical maximum rainfall event. Therefore the volume of effluent is insignificant in comparison to the potential rainfall event.

However wet weather storage has been considered to meet best practice requirements.

The proposed treatment and irrigation system will utilise two (2) additional water storage tank of total capacity 20,000 litres as shown in Figure 5-3. The proposed additional storage capacity allows for an approximate additional week of storage should the need occur.

6 Potential environmental impacts and mitigation

The following section of the report presents the potential environmental impacts of the proposed modifications, and steps to mitigate and/or manage the potential impacts.

6.1 Water quality – expected effluent quality

At the conclusion of the pilot trial, monitoring of the treated water sample was performed to obtain indication of the expected water quality. The analytes monitored were chosen based upon the targeted treatment.

Table 6-1 shows the expected treated water quality to proceed to irrigation from the monitoring of the treated water based upon the results of the pilot trial presented in Appendix C.

Table 6-1: BOC Kooragang expected treated water quality to irrigation

Analyte	Units	Expected quality	Recommended Irrigation Thresholds [1]
pH	pH Unit	7	6 – 9
Electrical conductivity	µS/cm	1,500	-
Sodium Absorption Ratio (SAR)	-	7	-
Alkalinity as calcium carbonate (hardness)	mg/L	71	-
Chloride	mg/L	300	-
Sodium	mg/L	250	-
Fluoride	mg/L	0.2 – 1.0	1.0[2] 2.0[3]
Nitrogen (total)	mg/L	3	25 - 125[2] 5[3]
Phosphorus	mg/L	0.02 - 1	0.8 - 12[2] 0.05[3]
COD	mg/L	~50	-
TSS	mg/L	13	-
Enterococci	CFU/100mL	~5	-
Faecal (thermo tolerant) Coliforms	CFU/100mL	~1	<10,000
Cadmium	mg/L	0.0001	0.01[2] 0.05[3]
Zinc	mg/L	0.020	2.0[2] 5.0[3]
Aluminium	mg/L	0.07	5.0[2] 20[3]
Arsenic	mg/L	0.003	0.1[2]

Analyte	Units	Expected quality	Recommended Irrigation Thresholds [1]
			2.0[3]
Beryllium	mg/L	<0.001	0.1[2] 0.5[3]
Boron	mg/L	0.19	0.5[2] 2 – 4[5]
Chromium VI	mg/L	<0.01	0.1[2] 1.0[3]
Cobalt	mg/L	<0.001	0.05[2] 0.1[3]
Copper	mg/L	0.14	0.2[2] 5.0[3]
Iron	mg/L	0.11	0.2[2] 10[3]
Lead	mg/L	<0.001	2.0[2] 5.0[3]
Lithium	mg/L	0.005	2.5[2] 2.5[3]
Manganese	mg/L	0.006	0.2[2] 10[3]
Mercury	mg/L	<0.0001	0.002[2] 0.002[3]
Molybdenum	mg/L	0.0016	0.01[2] 0.05[3]
Nickel	mg/L	0.005	0.2[2] 2.0[3]
Selenium	mg/L	<0.01	0.02[2] 0.05[3]
Uranium	mg/L	<0.001	0.01[2] 0.1[3]
Vanadium	mg/L	<0.01	0.1[2] 0.5[3]
Herbicides	µg/L	<0.5	1,000[6]
Pesticides	µg/L	<0.5	1,000[6]

[1] Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 guidelines - *Section 4: Primary Industries - 4.2 Water Quality for irrigation and general water use*.

[2] Short-term trigger value (STV) – The STV is the maximum concentration (mg/L) of contaminant in the irrigation water which can be tolerated for a shorter period of time (20 years).

[3] Long-term trigger value (LTV) – The LTV is the maximum concentration (mg/L) of contaminant in the irrigation water which can be tolerated assuming 100 years of irrigation.

[4] Trigger value chosen for areas with restricted public access.

[5] Trigger value chosen for moderately tolerant crops.

[6] General limit set for herbicides for NSW.

It is not expected that the concentrations of the remaining analytes presented in Table 4-2 will be affected by the treatment stage, and all analytes were within the applied irrigation concentration limits.

As per the Effluent Guidelines, the effluent quality is compared to *Table 3.1 Classification of effluent for environmental management*.

Table 6-2: Classification of effluent strength according to the *Effluent Guidelines'* Table 3.1

Analyte	Units	Expected quality	Classification
Total Nitrogen	mg/L	~3	< 50; therefore Low
Total Phosphorus	mg/L	<1	< 10; therefore Low
BOD	mg/L	<50	<50; likely Low
Total dissolved solids (TDS; assumed to be Electrical Conductivity) **	mg/L	820 – 1,500	820 to 1,500 mg/L; therefore likely Medium strength.

Analyte	Units	Expected quality	Classification
Metals	mg/L	Meets ANZECC guidelines	Criteria is that *High strength* effluent is of quality more than 5 times the ANZECC guidelines. All metals are below the threshold limits applied; therefore Low
Oil and Grease	mg/L	Negligible	< 1,500; therefore Low

* COD is always greater than BOD; COD values measured were 50 mg/L therefore BOD will be less than 50 mg/L.
** The Effluent Guideline outlines the relationship of conductivity to TDS. The TDS can be calculated by multiplying the electrical conductivity (EC) in dS/m by an empirical factor from 550 to 900. The average EC is 1,640 µs/cm = 1.6 dS/m. The calculated range of TDS is therefore 820 to 1,500 mg/L.

The effluent can therefore be considered to be a Low Strength Effluent, with the exception of total dissolved solids.

The above information has been used as input to *Section 6.2 Soil and groundwater* and *Section 7 Water Balance, Calculation of proposed irrigation area and storage requirements*.

6.2 Soil and groundwater

A *Geotechnical Investigation* report prepared by Douglas Partners for BOC Kooragang in 2013 is provided in Appendix B. The report outlines the following regarding the BOC Kooragang site:

- The ground surface is near level.
- The surface is mainly grass-covered sand and concrete pavements.
- The site is underlain by quaternary alluvium deposits.
- The site is located in 'disturbed terrain', which is reflective of Kooragang Island being comprised of reclaimed land. The reclaimed portions are dredged sand over natural soils.
- It is not believed that the reclaimed portions of soils (sand) is potential acid sulphate soils (PASS). There is a possibility that the underlying natural soils can be PASS.
- Groundwater is reasonably shallow and is encountered at a depth of 1.2 to 2.2 metres.

Table 6-3 summarises the soil types and conditions from the report prepared by Douglas Partners.

Table 6-3: BOC Kooragang soil and groundwater conditions summary from geotechnical report (Douglas Partners 2013)

Depth from surface (m)	Description
0 (surface)	Sand; loose to medium density
1.2 – 2.2	Groundwater encountered
3.3 – 4.1	Silty clay; soft to firm with sand present
8.0 – 8.3	Sand; dense to very dense
10	End of investigation

A baseline (background, existing) soil and groundwater monitoring program will be performed prior to installation of the proposed system, as detailed in *Section 8 Soil and groundwater baseline monitoring*. The baseline monitoring program would be performed to determine the current soil and groundwater quality at the site.

Soil sodicity is a property to be assessed in accordance with the Effluent Guidelines, and refers to the amount of exchangeable sodium relative to other cations in the soil. Sodic soils can inhibit plant growth and result in a poor soil structure. Sandy soils such as at Kooragang Island have limited ability to exchange sodium and other cations, and therefore have very low exchangeable sodium levels and unlikely to be sodic soils.

This is supported by previous soil investigations and measurements for other industries in the area performed by MJM Environmental with exchangeable sodium results ranging from non-detectable <0.1 mg/L to 0.3 mg/L. It is noted that the baseline soil monitoring program proposed in *8.1.2 Soil baseline monitoring program* can be used to verify these values.

The Effluent Guidelines state that effluent with a Sodium Adsorption Ratio (SAR) above 6 is likely to raise exchangeable sodium percentage in non-sodic soils. The average SAR for the proposed effluent is 7 based upon the results in Table 6-1. It is therefore possible that the SAR may raise the exchangeable sodium percentage in the soil; however the sandy soils possess an initially low sodicity and exchangeable sodium levels therefore is deemed acceptable.

The cation exchange capacity (CEC) of a soil looks at the cations of calcium, magnesium, potassium, sodium and aluminium, and relates to soil structure. Higher CECs result in a good soil structure and nutrient availability. Sandy soils by nature have a low CEC. The soils at Kooragang possess a sandy topsoil with clay present from 3 metres deep. The grassed areas of site show that the soil is capable of providing structure and stability for the existing grasses. Organic matter can be added to soils with a low CEC. The soils at Kooragang possess CECs of around 10 meq/100g for topsoils and 3 to 6 meq/100g for sub-soils.

An indicator of salt (salinity) concentration is electrical conductivity of a soil sample. The Effluent Guidelines state that where the conductivity is less than 2 dS/m, effects on plants are mostly negligible. This is supported by previous soil investigations and measurements for other industries in the area with results ranging from 0.07 to 0.3 dS/m.

Soil pH also affects plant growth and the optimum pH for most plants is between 6 and 7.5. Previous investigations in the Kooragang area show the pH of the soil ranges from 6.5 to 8 with many grassed areas and trees present. It is noted that the baseline soil monitoring program proposed in *8.1.2 Soil baseline monitoring program* can be used to verify these values. The pH of the effluent is expected to be around 7 based upon the results in Table 6-1, which meets the applied irrigation thresholds and is unlikely to cause adverse effects on the soil.

Phosphorus is required for plant growth and Australian soils are able to immobilise phosphorus in soils, therefore many plants require the addition of phosphorus to enable plant growth. Alluvial soils and sandy soils have a relatively low phosphorus sorption capacity, which can result in leaching of phosphorus applied to land to sources such as groundwater. The phosphorus sorption capacity of the soils measured at Kooragang in previous investigations range from <250 mg to 800 mg of phosphorus absorbed per kilogram of soil. The baseline soil monitoring program proposed in *8.1.2 Soil baseline monitoring program* can be used to verify these values. The effluent phosphorus concentration is expected to be approximately 0.02 mg/L based upon the results in Table 6-1. Therefore as the sorption capacity is reasonably low, the addition of low levels of phosphorus through irrigation with the effluent may be advantageous, as it may be taken up by the existing grass and used as a nutrient, and there is unlikely to be excess phosphorus available. Therefore the phosphorus concentrations are not expected to cause adverse effects on the groundwater at Kooragang.

Underground works and excavation activities have the possibility to have the risk of uncovering potential acid sulphate soils (ASS), which are naturally occurring sediments containing iron sulphides that when exposed to air can produce sulphuric acid. Production of sulphuric acid presents a risk to groundwater and surface waters to aquatic life, mobilisation of pollutants such as arsenic, and degradation of infrastructure. The identification of ASS is required to be performed where suspected. Where the soil demonstrates one or more of the following indicators, ASS are likely to be present:

- pH <4
- Existence of shell
- Any pale yellow deposits (jarositic) or considerable iron oxide mottling

The *Geotechnical Investigation* report prepared by Douglas Partners states the following regarding the BOC Kooragang site and ASS:

> *"Reference to the Department of Land and Water Conservation 1:25,000 Acid Sulphate Risk Map for Newcastle indicates the site lies within an area described as 'disturbed terrain', which often includes filled areas, often associated with reclamation of low lying swampland. As such, Acid Sulphate Soil risk is dependent on the origin and properties of the filling material which has been placed on site.*
>
> *Reclaimed portions of Kooragang Island have hydraulically placed dredged sand fill overlying the natural soils. Previous experience has indicated that the dredged sand fill is generally not **Potential Acid Sulphate Soils** (PASS), however the underlying natural soils are PASS and could generate acid if exposed to oxidation."*

A new segment of the irrigation line is to be installed. The pipeline will be run above-ground to the irrigation point above-ground. Where required, such as where there is an existing footpath, it will be run underground for the short distance using directional drilling technique. It is noted here that the report states the dredged sand material extends to a depth of 1.2 metres. It is unlikely the installation of the pipeline will extend past this depth. At this point presence of ASS has not been confirmed. The pipeline installation under a path will not require soil to be removed from site. Therefore it is not believed that the activity will disturb ASS.

However for the purposes of due diligence, the baseline soil monitoring program proposed in *8.1.2 Soil baseline monitoring program* will be used to verify presence of ASS. Specific analytes have been included in the monitoring program to determine presence of ASS. If ASS is confirmed as present, an Acid Sulphate Soil Management Plan will be drafted and implemented.

Groundwater at Kooragang Island can be encountered at depths of 1.2 to 2.2 metres. Underlying quality of the groundwater must not be reduced to the point that the groundwater cannot support its most beneficial use. Beneficial uses may include for drinking water or a specific ecosystem. The groundwater at Kooragang Island is not used for a current or beneficial purpose such as drinking water. The closest drinking water supply catchment is the Tomago Sandbeds.

The available water holding capacity of sandy soils is usually low due to high permeability. It is noted that the depth of groundwater at the site ranges from 1.2 to 2.2 metres below the surface. The Effluent Guidelines state that a depth of >3 metres is optimal, and a depth of 0.5 to 3 metres is a moderate restriction. High groundwater levels can mean that the soil conditions favour the movement of nutrients from the effluent into groundwater. However it can be seen that the treated effluent stream is relatively low in nutrients, of a low to medium quality with minimal metal concentrations and no detected pesticides or herbicides, therefore is not believed that irrigation using the effluent will result in excessive nutrient loads to the groundwater.

Excavations performed at Kooragang Island are likely to intercept groundwater. Excavations to the depth of the groundwater are not planned for the proposed irrigation project therefore are not expected to intercept and affect groundwater.

Contamination is a consideration for an effluent irrigation system. It has been shown in *Section 6.1 Water quality – expected effluent* quality that the expected effluent quality meets the appropriate guidelines for irrigation. Section *7 Water Balance, Calculation of proposed irrigation area and storage requirements* also shows nitrogen and phosphorus balances.

Following installation and commissioning of the system, it is expected that monitoring programs will be required as part of the EPL. *Section 9.3 EPL monitoring programs* outlines a potential ongoing monitoring program for effluent, soil and groundwater to be performed to monitor trends and potential effects of the irrigation system on the environment.

It is therefore believed that irrigation will not have a negative effect on soil and groundwater at BOC Kooragang, and the abovementioned monitoring programs will assist the operation.

However consideration of the potential effects upon soil and groundwater has been included here. The measures currently in place and recommended to be put in place during operation to ensure mitigation of risks to soil and groundwater include:

- Regular site inspections. These are to include regular site inspections of soil surrounding site structures, especially after rainfall events.
- Spill procedures and pollution incident management plans maintained as per current procedures.
- Review and upkeep of emergency and incident response procedures.
- Spill response and incident response equipment stored onsite.
- Review and upkeep of current operational waste management programs to contain all waste onsite and dispose of appropriately.
- No removal of site vegetation, and regular upkeep of site vegetation.
- Permanent fencing where necessary to mark 'no-go' zones to prevent soil erosion.
- Keep current entry, access and exit for vehicles clearly marked and all roads sealed to minimise soil movement and loss. Regular inspections of access areas and repairs as necessary.
- Regular maintenance of vehicles to avoid oil or fuel spills.
- Spill kits present onsite and maintained.
- All servicing of vehicles to be performed offsite.
- Sediment control devices put in place as determined necessary, and routinely checked. These may include but are not excluded to:
    - Erosion and sediment control equipment

  - Permanent sediment fencing
  - Kerb inlet protection, where applicable
  - Silt traps and associated applicable permanent protective installations

6.3 Climate and flood management

The expected rainfall experienced at the site is included in the report section *7.1 Water Balance and proposed irrigation area.* The BOC Kooragang site does not experience flooding (none or rare). Therefore there is no reason for construction of diversion channels that may be required in areas prone to flooding.

A *Geotechnical Investigation* report prepared by Douglas Partners for BOC Kooragang in 2013 is provided in Appendix B. The report states that the '*ground surface of the site is near-level*'. The site has no surface rock outcrops that may decrease drainage efficiency.

The main methods available for irrigation are:

- Surface
- Sprinkler
- Drip/trickle
- Subsurface

Drip irrigation has been chosen for BOC Kooragang. Advantages of drip irrigation is that the discharge rate of the emitters is low so the irrigation method can be used on most or all soil types. Water can be fed as drops near the root zone of a plant in a dripping motion. Table 2.1 of the *Effluent Guidelines* states that land with a slope <10% such as that at BOC Kooragang has a '*nil or slight*' limitation for trickle (drip) irrigation, therefore is believed to be suitable.

However, an ill-managed irrigation system has the potential to cause adverse impacts upon the environmental, which may include but are not excluded to:

- Pooling and waterlogging of effluent on the irrigated area(s)
- Flooding of effluent on the irrigated area(s)
- Ineffective drainage onsite
- Increased (unsustainable) groundwater recharge and rising water table
- Increased incidence of water-borne diseases (e.g. mosquito-borne illnesses) due to stagnant water
- Reduced downstream river or water source quality (destination such as a river or ocean)

Section 7 Water Balance, Calculation of proposed irrigation area and storage requirements shows that the estimated percolation rate of the proposed effluent irrigated at BOC Kooragang for each month is well below the typical range of percolation rates for the soil type at the facility. The soil type is therefore able to handle the capacity of the effluent applied based upon percolation rates. Therefore the addition of effluent is unlikely to cause ponding or waterlogging of the proposed area at the estimated rate of application, and the effluent is expected to percolate freely through the soil type.

However in order to meet best practice, flood management at the proposed BOC Kooragang system will be performed.

Section 7.4 Wet weather storage showed that the total effluent applied to the land during irrigation is of a volume approximately 1 to 2% of the calculated historical maximum rainfall event. Therefore the volume of effluent is insignificant in comparison to the potential rainfall event. However wet weather storage has been considered to meet best practice requirements.

Flood management will include, but is not excluded to, the following:

- Implementation of an Irrigation Management Plan including explanation(s) of operations during non-standard conditions and the following listed practices:
  - Daily site inspections during irrigation activities.
  - Ceasing irrigation operations during wet weather, rainfall events and other adverse conditions.

- Ability to easily resume disposal of cooling tower effluent offsite with waste contractor if adverse conditions or long term wet weather occurrences do not allow irrigation to land to be performed.
- A contingency plan for if pooling or flooding is noticed despite the above practices, including but not excluded to:
  - Irrigation will immediately be ceased.
  - If pooling appears to be draining offsite or presents a risk of runoff, appropriate bunding will immediately be installed to prevent runoff occurring.
  - Irrigation will only be recommenced once pooling has evaporated and drained.
  - If pooling or flooding is extreme, pumpout and disposal with an appropriate contractor will occur.
  - Consideration of permanent options to decrease risk of offsite draining during adverse conditions, such as installation of an earthen bund surrounding the grassed area.

It is therefore believed that the above actions and management plans will successfully mitigate the possibility of flooding and pooling of effluent onsite.

6.4 Stormwater and surface water

The BOC Kooragang site currently possesses a stormwater management system including stormwater pits located on the hardstand areas of site. The stormwater proceeds to a retention pit, which is then directed to the Hunter Water stormwater drain on the western boundary of the BOC Kooragang site. The stormwater management system is suitable in its current form and will remain in use.

The proposed area of land to be irrigated is grassed and does not contain stormwater pits, therefore it is unlikely to affect stormwater quality.

Contamination of stormwater is usually identified by increased turbidity of the surface waters. This can be due to construction activities where soil has become exposed and uncontrolled. The project does not plan to perform excavations where soil is disturbed thereby effectively eliminating the risk. The additional actions presented in *Section 6.3 Climate and flood management* and *Section 6.5 Sediment, runoff and erosion control* in avoiding flooding and runoff from the irrigation area will also aid in preventing effects upon stormwater and surface water quality from the proposed modifications.

There are no current surface water sources onsite. It is believed that nearby industries possess stormwater or process management systems onsite for their own processes. It is assumed that these existing surface water containment structures, if present, are currently well-managed and do not impact upon BOC Kooragang.

BOC Kooragang’s proposed irrigation system will use drip irrigation, which prevents aerosol drift offsite. No additional surface water sources are planned for the proposed project and all effluent storage is to be in the nominated tanks. Therefore it is not expected that BOC Kooragang’s irrigation practices will impact upon neighbouring businesses’ stormwater or surface management systems.

The South and North channels of the Hunter River run to the south and the east of the site as shown in Figure 7-1.

Figure 6-1: Hunter River and BOC Kooragang location

The effluent quality has been shown to be of a low to medium quality with minimal metal concentrations and no detected pesticides or herbicides. Therefore it is not expected that the effluent will have a negative effect on the Hunter River.

Based upon the above information, it is therefore believed that the proposed project will not have adverse effects on stormwater or surface waters at Kooragang. However for due diligence the measures in place and recommended to be put in place to ensure mitigation of risks to surface water and stormwater include:

- Spill kits present onsite and maintained as per current procedures.
- Regular site inspections maintained. These are to include regular site inspections of soil surrounding site structures, especially after rainfall events.
- Spill procedures and pollution incident management plans maintained as per current procedures.
- All substances stored appropriately.
- All servicing of vehicles to be performed offsite.
- Roof water and stormwater control to remain in place as part of the current development.

6.5 Sediment, runoff and erosion control

An effluent irrigation system should not result in deterioration of land quality resulting in soil erosion or sedimentation. The *Effluent Guidelines* states that the potential for erosion of the site should be considered in terms of both stormwater runoff and effluent application rates. In this case, it is assumed that potential erosion is due to water application. Water erosion occurs when soil particles are displaced by rain or flowing water.

Potential for soil erosion is based upon slope of land, climate and soil type. The percolation and infiltration rates of a soil surface affects the likelihood of surface runoff and hence erosion potential from heavy rain or irrigation. For instance when rainfall is greater than soil infiltration, runoff and erosion is likely to occur. In general, construction, excavation and stockpiling activities can result in sedimentation migration offsite, and erosion.

Table 2.1 of the *Effluent Guidelines* states that certain types of irrigation such as flood and underground irrigation possess an excess runoff and erosion risk. Drip irrigation has been chosen for BOC Kooragang which does not possess an excess runoff risk. Sites with slopes >12% may have an increased erosion and runoff risk, appear to Table 2.1 of the *Effluent Guidelines* also states that land with a slope >12% may be suitable irrigation provided erosion is managed. BOC Kooragang's site is flat therefore has a low risk of erosion.

Sodic soils are highly susceptible to erosion. Sandy soils such as at Kooragang Island have limited ability to exchange sodium and other cations, and therefore have very low exchangeable sodium levels and unlikely to be sodic soils.

As described previously, a new segment of the irrigation line is to be installed. The pipeline will be run above-ground to the irrigation point above-ground. Where required, such as where there is an existing footpath, it will be run underground for the short distance using directional drilling technique. The pipeline installation under a path will not require soil to be removed from site. Therefore it is not believed that the activity will result in disturbed areas, sediment runoff or erosion.

For best practice, prior to commencement of the line installation, BOC Kooragang and contractors will prepare an operating procedure and project plan to ensure surface runoff will not occur, which may include:

- Installation of bunding and other protection measures where necessary
- Installation is performed in a manner that does not mix different soil types
- Exposure of soil will be limited to a specific area that is located in the centre of site that is not near the boundary, therefore unlikely to cause runoff offsite.
- Any nearby stormwater pits will be bunded for the duration of excavation to avoid potential runoff.

6.6 Flora and fauna

The BOC Kooragang site is developed and well established. The direct land zone surrounding the lot is RE1 Public Recreation. Vegetation at the site such as trees also provide a natural habitat for fauna species.

The site is in an established industrial area and there are no animals present that will use the grass for grazing purposes. Irrigation is planned to be performed on grassed areas only. The grassed areas do not possess trees that may be used as habitat and nesting. The grassed areas are likely to have birds and other fauna that may be present sporadically in the area. No vegetation is to be cleared as part of the proposed project therefore will not remove existing habitat.

The drip irrigation system is unlikely to cause spray drift to other sites where fauna may be present.

It is believed that nearby industries possess stormwater or process management systems onsite for their own processes. It is assumed that these existing surface water containment structures may provide habitat for particular species. It has been shown previously that the irrigation project is unlikely to impact upon the neighbouring surface water containment structures.

A desktop review of flora and fauna species using the EPA's *Wildlife ATLAS* database was performed over a 10-kilometre square area surrounding Kooragang and including the Hunter River. The desktop survey showed over 1,300 species of flora and fauna sighted in the chosen area, including aquatic life and fish species. Records of sightings of endangered populations of fauna appeared in the ATLAS search, including:

- Green and golden bell frog
- Wandering albatross
- Black-necked stork
- Australasian bittern
- Bush Stone-curlew
- Pied Oystercatcher
- Australian Painted Snipe
- Curlew Sandpiper
- Little Tern
- White-flowered Wax Plant
- Swift Parrot

The *Wildlife ATLAS* provides a minimum search area of 10 square kilometres. It is expected that such a range of wildlife would be present in a coastal area which includes waterways, beaches and the Hunter River.

It is reasonable to assume that the final destination of the drip irrigated effluent will be the irrigated grassed area within the boundary of BOC Kooragang Island. The closest flora and fauna sensitive environment to the boundary of BOC Kooragang Island is the Hunter River.

The Hunter River is positioned approximately 377 metres north of BOC's irrigation boundary. The distance of 377 metres contains the Port of Newcastle's coal unloading terminal, a main road called Cormorant Road, and the facility Sims Metal.

The Hunter River contains fauna such as fish which are sensitive to changes in water quality from high strength effluents, including increased turbidity, ammonia, heavy metals and pesticides. The treated BOC effluent quality has been shown to be of a low to medium quality with minimal metal concentrations and no detected pesticides or herbicides.

Therefore due to the low volume of treated effluent to be irrigated, it is not expected that the drip irrigated treated effluent will exit the boundary of the BOC facility. If for natural disaster reasons unforeseen that the drip irrigation treated effluent was introduced to Hunter River, it is highly unlikely to have a negative effect on the Hunter River as a final destination, due to the treated water's quality. Finally, the volume of the treated effluent is relatively small compared to the volume of Hunter River.

The drip irrigation system is therefore considered unlikely to cause disturbance to any existing native fauna onsite or offsite.

The potential risks to flora has been covered in the previous sections regarding irrigation effluent quality.

As a result it is not expected that a specific endangered flora and fauna study or a species impact statement is required for the SEE. However consideration of the potential effects of activities to affect terrestrial (land) and aquatic (water) flora and fauna has been included here. The measures currently in place and recommended to be put in place during operation to ensure mitigation of risks to flora and fauna include:

- No removal of site vegetation. Regular upkeep of site vegetation to be performed to enable prevention of loss of habitat.
- Any work areas will be clearly marked through permanent fencing. This will ensure no trespassing and disturbance of native fauna.
- Site inspection to include checks for weed infestation. Weeds are to be treated at the earliest stage.
- Vehicles arriving onsite from known and potential weed infested area must undergo vehicle checks and/or washdown procedures.
- To avoid potential pests, all food waste is to be placed into designated waste bins and secured.
- No animals are to be brought onto the site.
- Operational noise is expected to be the same as current practices, therefore no additional disturbance to flora and fauna is expected.
- If threatened or endangered flora and/or fauna species are identified during operation, an ecologist or similar specialist is to be contacted.
- If planting of additional vegetation is planned, the flora must be native to the area.
- Mitigation of sediment runoff and potential spills to waterways as detailed in *Section 6.5 Sediment, runoff and erosion control*.
- Spill response and incident response equipment stored onsite.

6.7 Land use and amenity

It is important to assess the potential risks to people, land usages and community when considering effluent for irrigation.

The vicinity of BOC Kooragang's site is industrial, reasonably flat, and contains grassed land areas. The proposed irrigation area at BOC Kooragang is a grassed area, and does not possess crops intended for harvest or human consumption. The grassed areas are not open to the general public and are fenced, and entry to the site is by a locked automatic gate only. The BOC Kooragang site is not located near residences or public services such as recreation areas or parks. Therefore the use of the proposed irrigation area will not negatively affect local amenity or cause unreasonable interference.

Drip irrigation has been chosen for BOC Kooragang. An advantage of drip irrigation is that the discharge rate of the emitters is low and water can be fed as drops near the root zone of a plant. Therefore the visual impact of the sprinkler process is lessened when compared to other more visible types of irrigation.

As an example, sprinkler irrigation systems are located at adjacent properties. These types of sprinklers are more visible than the proposed drip irrigation as they are located above ground, and the water is sprayed into the air and onto the ground. Therefore it is not believed that the irrigation process proposed for BOC Kooragang's will affect visual amenity due to the type of sprinklers proposed.

The proposed irrigation project will not affect or alter the land usage type. Operating hours of the facility will remain the same. Operating hours of the proposed irrigation system will be limited to two to three hours during the daytime period.

The grassed areas do not possess trees and no vegetation is to be cleared as part of the proposed project therefore will not affect visual amenity.

The site has frontage onto Egret Street, and the remaining site boundaries are surrounded by industrial sites. The Egret Street boundary is fenced, and the office, buildings and storage vessels are directly visible to pedestrians and traffic. It is very unlikely that the proposed modifications will overshadow any part of the existing visible development.

No additional signage is planned as part of the proposed development.

The proposed water treatment filters will be a suitable colour in order to blend in with the current BOC Kooragang facility. The size of the filters is much smaller than current vessels onsite, therefore it is not believed the filters will negatively affect visual amenity at the site.

In general, it is unlikely that the proposed development will As part of The measures recommended to be put in place during operation to ensure minimisation of visual impacts include:

- Regular site inspections.
- The existing trees and garden located onsite will be able to provide reduction in visual impact. No vegetation is to be removed, and weed control to be performed regularly.
- Proposed filters will be a suitable colour and small footprint, therefore not believed to increase visual disturbance.
- No public access to work areas.
- Storage of machinery and equipment onsite is to be tidy and all equipment to be placed in appropriate stored locations.
- Routine site inspections to ensure site tidiness and enforcing of waste management plan.
- Option of re-vegetation to enhance visual impact if complaints are received.

6.8 Traffic and access

Once in operation, the proposed modification will decrease regular traffic at the site, as the disposal of cooling tower water with a waste contractor truck and vacuum pump will no longer be performed on a weekly basis. If rain events occur that prevent irrigation, the waste contractor truck may resume operations, which does not increase the frequency of cooling tower wastewater pumpout operations currently occurring.

Deliveries of filter media will occur approximately annually during daylight hours, which will result in a truck onsite once per year.

Disposal of spent filter media will occur approximately annually during daylight hours, which will result in a truck onsite once per year utilising a vacuum.

Therefore the proposed modification is not expected to adversely affect traffic onsite or on Egret Street. For the purposes of due diligence the following measures are put in place during operation to minimise traffic management risks are:

- Only authorised vehicles and mobile plant to enter the site.
- Access (entry and exit) to be clearly marked.
- Speed limits to be set and observed.
- Idling to be avoided.
- Internal traffic routes are clearly marked and have hardstand present.
- Avoid parking in areas that are not covered with hardstand.
- Onsite parking areas remain clearly marked.
- All fences to remain locked and secured when applicable.

6.9 Air quality

Depending on the source of the effluent, such as a particular process generating wastewater, may introduce sources of odour during irrigation. Industries such as dairy and amenities wastewater are known for generating odours.

A cooling tower wastewater stream is not considered an odorous stream, as the operation of the cooling tower involves recirculating supplied town water and make-up for evaporation with additional water.

An additional control is that the proposed irrigation system is recommended to be drip irrigation. Drip irrigation systems involve discharging effluent through micro-emitters and dripped; this process reduces the risk of aerosol drift and potential odour.

6.10 Noise and vibration

The BOC Kooragang site is located in an industrial setting and is developed. Direct neighbours are industrial in nature, therefore it can be assumed that the industrial area produces industrial noise emissions.

Sources of noise may include waste contractor trucks and vacuums collecting spent filter media and potentially the cooling tower wastewater during conditions where irrigation is not optimal. Once in operation, the proposed modification does not increase the frequency of cooling tower wastewater pumpout operations currently occurring – the number of pumpouts will be reduced.

Vibration occurs in buildings from external sources, and can be continuous (uninterrupted for a defined period), impulsive (cyclical with peak-and-decay), or intermittent. Due to the distance of the receptors and the nature of the construction activities, vibration in nearby buildings is expected to occur only if blasting operations are used during excavation, which is not planned to occur.

Disposal of spent filter media will occur approximately annually during daylight hours, which will result in a truck onsite utilising a vacuum. The activity will occur approximately once per year.

There is likely to be background noise in the industrial area that may be required to take into account for cumulative noise assessments. If noise and/or vibration complaints are received, BOC Kooragang are to identify the noise levels through an environmental noise and vibration assessment at site and noise receiver(s) and compare to the NSW Industrial Noise Policy 2000 (INP).

Due to the nature of the nearby industrial properties it is not expected that noise generated will have an adverse effect, and the proposed modification will not introduce sources of intrusive noise or vibrations that would increase the existing noise emissions from site. However for the purposes of due diligence, the measures in place and recommended to be put in place to ensure mitigation of noise and vibration include:

- Site is in a known industrial area and the site is not open to the public.
- Control of noise and/or vibration at the source in first instance is preferred practice, such as the use of low noise power tools and fitting machines with exhaust silencers where applicable. This includes control of noise and/or vibration at the source of any non-standard equipment used onsite.
- Repairs and related noise-generating work onsite to be completed with the minimum delay.
- Traffic movements to adhere to marked access areas, with no machine idling where possible.
- If noise and/or vibration complaints are received, BOC Kooragang are to identify the noise levels through an environmental noise and vibration assessment at site and noise receiver(s) and compare to the NSW Industrial Noise Policy 2000 (INP).
- All personnel onsite to adhere to WH&S policies when in the vicinity of noise generating equipment.
- If nuisance noise and/or vibrations are generated from the above operations, BOC Kooragang are to identify noise mitigation methods and install.

6.11 Heritage

There are no non-Aboriginal heritage considerations identified for the purposes of the assessment as the BOC Kooragang site and majority of the surrounding land is zoned *SP1 Special Activities*.

The site is not identified as a heritage conservation area. The site is not identified as an Aboriginal place of heritage significance.

Therefore it is not expected that the proposed irrigation project will affect Aboriginal and non-Aboriginal heritage significance.

6.12 Trees and vegetation

No trees are required to be removed for the project. Therefore it is not expected that the proposed irrigation project will affect trees currently existing onsite.

The site is in an industrial area and there are no animals present that will use the grass for grazing purposes. The grassed areas do not possess trees that may be used as habitat. No vegetation is to be cleared as part of the proposed project.

6.13 Interaction with current facility regarding hazards and risk

The current cooling tower process at BOC Kooragang produces cooling tower blowdown water, which is directed to two (2) storage tanks, and disposed offsite with a licensed waste contractor.

The proposed change to cooling tower operations involves cooling tower wastewater to be pumped from the outlet of the cooling towers directly to the filtration units through a new pipeline. Once treated through gravity filtration, the treated water proceeds directly to the current and additional storage tanks. From the storage tanks, the treated water is then pumped to the drip irrigation system through a combination of existing and new pipelines to the proposed grassed area.

BOC Kooragang's gas operations utilise a large number of pipelines above and below ground, therefore the operation of additional pipelines is unlikely to be an issue for the site regarding hazards and risk.

There will be no additional chemical usages or chemical storages required for the proposed project. Footprint for treated water storage and for the filters will increase, however the site has room available for the additional storage and filter units.

Filter media is required, which arrives at site in insert solid granular form. The filter media is not a hazardous substance. If media is required to be stored onsite prior to installation in the filter, the media will be stored in an appropriately bunded area.

Therefore the proposed process is not believed to have interaction with the existing facility regarding hazards and risk such as dangerous goods and chemical storage.

For due diligence and good engineering practice BOC Kooragang will perform a detailed design and construction plan, and perform a Hazard and Operability study (HAZOP) at the concept design stage of the project. Completion of a HAZOP Study is standard engineering practice when looking to complete a detailed design and or install a new operation. The idea of the HAZOP is to undertake a structured and systematic examination of a complex planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment.

The intention of performing a HAZOP is to review the design to pick up design and engineering issues that may otherwise not have been found. It is carried out by a suitably experienced multi-disciplinary team during a meeting or a series of meetings, depending on the complexity of the process. The international standards call for team members to display 'intuition and good judgement' and for the meetings to be held in 'a climate of positive thinking and frank discussion'. It is important to note here that a HAZOP is required at each new facility, and that it is a safety, process, and legal safeguard for all companies involved.

6.14 Waste management

One (1) additional waste stream will be produced as part of the proposed modification. The proposed pre-treatment system is as described in the report and Appendices C and D. The proposed process includes use of activated alumina as a filter media in an open gravity filter. Once spent, the filter media will require disposal as a waste in accordance with the NSW EPA's *Waste Classification Guidelines* (2014). There are no additional waste streams expected to be produced as a result of the modification.

Appendix C contains results of a preliminary classification analysis on filter media used in a pilot-scale trial for the contaminant of concern, which is Fluoride. The results of the preliminary classification analysis showed that the media would be classified as General Solid Waste and could therefore be taken to a landfill for disposal. It is stated here that the preliminary classification analysis was not intended to be a Waste Classification Report for the purposes of disposal, and should not be treated as such at this time, as the trial filter media was able to be reused and was not disposed offsite at the time of writing.

There is a likelihood that elevated fluoride levels will occur after 12 months of operation, therefore the spent filter media used in the proposed filters will require sampling and analysis to determine the waste classification and disposal options according to the Waste Classification Guidelines.

The filter has been designed for a media life of 12 months, and therefore the media will likely be replaced on a 12-month basis. The site's existing computerised maintenance management system (CMMS) will be utilised for this purpose.

Once the media is analysed and classified, the waste will be taken offsite to an appropriate destination using an appropriately licensed waste contractor if required.

As best practice, BOC Kooragang will update and implement the site's Waste Management Plan (WMP). The WMP will be updated to include, but will not be excluded to, the following:

- Addition of filter media as an identified waste stream at BOC Kooragang.
- Reference to the appropriate waste guidelines, being the EPA's *Waste Classification Guidelines* at time of writing.
- Standard operating procedures for the waste type, including but not excluded to:
    - Monitoring requirements for waste classification
    - Procedures for appropriate waste classification of the media waste utilising an independent third-party consultant and NATA-accredited laboratory.
    - Procedures for disposal of waste following waste classification report, including preferred waste contractor(s) as applicable.

The above waste management procedures are appropriate for the waste stream generated by the proposed modification, and it is not believed the

6.15 Work health and safety

BOC Kooragang operates a safety management system to work health and safety regulations.

The expected water quality of the effluent is not expected to provide additional work health and safety risks to employees. The microbiological parameters (coliforms) concentrations in the expected water quality are also very low, as shown previously in Table 6-1.

The proposed grassed areas onsite are not in frequent use by BOC Kooragang employees. The employees and visitors utilise the carpark, main office administration building, and the hardstand plant area.

Therefore it is not expected that the use of the cooling tower effluent for irrigation will present a work health and safety issue for employees or visitors onsite.

7 Water Balance, Calculation of proposed irrigation area and storage requirements

7.1 Water Balance and proposed irrigation area

BOC Kooragang proposed to utilise a full-reuse scheme; that is, to fully utilise the effluent from the cooling towers where possible during normal operations and conditions.

It is noted first that in times of adverse weather or process conditions, mitigation includes that the wastewater can be disposed offsite with a licensed waste contractor as is currently performed.

As per the Effluent Guidelines, in a full reuse scheme the limiting factor is the largest land area required to satisfy any single nutrient or pollutant balance to ensure a sustainable scheme.

A water balance is required to calculate the amount of water and nutrients that can be applied to meet crop requirements, while avoiding runoff and percolation. As per the Effluent Guidelines, the water balance is comprised of:

Precipitation + effluent applied = evapotranspiration + percolation + runoff

Rainfall data was obtained from the Bureau of Meteorology's (BOM) Automated Weather Station 61055 – Nobby's Signal Station approximately 6 kilometres from the BOC Kooragang site.

Table 7-1: BOC Kooragang water flows

Item	Units	Value	Note / Description
Maximum amount of water generated by cooling tower	L/week	18,200	Cooling tower operation is constant and is not seasonal, therefore the maximum amount generated per week can be assumed to be constant for the full year.
	L/day	2,600	
Irrigation area	m^2	1,314	Shown in Figure 7-1; approximately 73 by 18 metres.

Figure 7-1: Proposed irrigation area

Table 7-2 shows the calculations performed for the water balance at BOC Kooragang. The water balance calculations use the following data as input:

- Proposed irrigation area.
- Rainfall data. The availability of effluent to be used as irrigation varies with rainfall events.
- Expected effluent flow per day from press as shown in Table 7-1.
- Expected runoff volumes.
- Evaporation data. The availability of effluent to be used as irrigation water varies with amount of water evaporated to atmosphere.
- Evaporation data is used as input to estimate evapotranspiration, and applies a crop factor based upon plant productivity. Evapotranspiration is a more accurate estimation of evaporation from land surface where vegetation is present.

The above data sources are used to estimate the *percolation* at BOC Kooragang in the water balance. Percolation is the '*movement of water down through the soil profile*' as per the Effluent Guidelines, and occurs naturally through rainfall. Percolation also occurs from irrigation in addition to rainfall.

Table 7-2: BOC Kooragang water balance to obtain percolation volumes

Mth	Rainfall averaged from monthly data (mm/day)	Precipitation over irrigation area, averaged[1] (L/day)	Evaporation at irrigation area (mm/month)[2]	Evapotranspiration at irrigation area (mm/day)[2]	Evapotranspiration at irrigation area (L/day)[2]	Runoff (L/day)[3]	Effluent applied over irrigation area (L/day)	Percolation over irrigation area (L/day)[4]	Percolation per m^2 of area (L/m^2.day)[4]
Jan	2.9	3,819	200	4.52	5,934	0	2,600	485	0.4
Feb	3.8	5,016	150	3.75	4,928	0	2,600	2,688	2.0
Mar	3.8	5,044	150	3.39	4,451	0	2,600	3,193	2.4
Apr	3.9	5,135	100	2.00	2,628	0	2,600	5,107	3.9
May	3.8	4,937	80	1.29	1,695	0	2,600	5,841	4.4
Jun	3.9	5,174	50	0.75	9,86	0	2,600	6,788	5.2
Jul	3.0	3,969	80	1.03	1,356	0	2,600	5,213	4.0
Aug	2.4	3,118	100	1.45	1,907	0	2,600	3,811	2.9
Sep	2.4	3,160	125	2.29	3,011	0	2,600	2,749	2.1
Oct	2.3	3,077	175	3.67	4,822	0	2,600	856	0.7
Nov	2.4	3,134	200	4.67	6,132	0	2,600	-398	-0.3
Dec	2.6	3,439	200	4.52	5,934	0	2,600	105	0.1

[1] Rainfall data was obtained from the Bureau of Meteorology's (BOM) Automated Weather Station 61055 – Nobby's Signal Station approximately 6 kilometres from the BOC Kooragang site for all available years of rainfall data (1862 to 2015). The values were obtained from the average of the daily rainfall values for each month.

[2] Evapotranspiration was calculated using the BOM's Evaporation Maps for each month available at http://www.bom.gov.au/jsp/ncc/climate_averages/evaporation/index.jsp. The maps are based upon data from 1975 to 2005. Evapotranspiration was calculated as per the Effluent Guidelines Table 4.1 assuming a crop factor for *Pasture* of 0.7.

[3] For a full reuse scheme the runoff is to be zero.

[4] *Percolation = (precipitation + effluent applied) – (evapotranspiration) – (runoff)*

The water balance in Table 7-2 shows the amount of water expected each month to proceed to percolation at BOC Kooragang.

It can be seen that during November, the average evapotranspiration is greater than the sum of precipitation and effluent applied which results in a negative percolation value.

Table 7-3 uses the percolation obtained from Table 7-2 to estimate the approximate rate of percolation through the soil in centimetres per hour.

The percolation rate is based upon utilising the proposed irrigation system for a conservative estimate of two (2) hours per day. It is likely the irrigation will be performed and operated during daylight hours for approximately 2 hours, over which time the system will discharge the daily rate of effluent to the irrigation area. Therefore the system will not be operating over 24 hours.

The estimated rate of percolation is then compared to the soil type's permeability rates based on literature data.

Table 7-3: BOC Kooragang percolation assessment

Mth	Percolation per m^2 of area ($L/m^2.day$)[4]	Irrigation hours per day (h)	Estimated Rate of irrigation percolation (cm/h)	Rate of percolation for typical soil type (cm/h)[1]
Jan	0.4	2	0.02	2 – 5
Feb	2.0	2	0.10	2 – 5
Mar	2.4	2	0.12	2 – 5
Apr	3.9	2	0.19	2 – 5
May	4.4	2	0.22	2 – 5
Jun	5.2	2	0.26	2 – 5
Jul	4.0	2	0.20	2 – 5
Aug	2.9	2	0.15	2 – 5
Sep	2.1	2	0.10	2 – 5
Oct	0.7	2	0.03	2 – 5
Nov	-0.3	2	-0.02	2 – 5
Dec	0.1	2	0.004	2 – 5

[1] Soil permeability and therefore percolation rates for sandy soils can range from 2.5 to 5 cm/h; it is considered a 'moderate' speed permeability class.

It can be seen that the estimated percolation rate of the proposed effluent irrigated at BOC Kooragang for each month is well below the typical range of percolation rates for the soil type at the facility.

The soil type is therefore able to handle the capacity of the effluent applied based upon percolation rates.

Therefore the addition of effluent is unlikely to cause ponding or waterlogging of the proposed area at the estimated rate of application, and the effluent is expected to percolate freely through the soil type.

7.2 Nitrogen assessment and balance

Nitrogen can be added through effluent and fertiliser. It is not intended to utilise additional fertiliser at BOC Kooragang therefore the added nitrogen is assumed to be from effluent only.

Nitrogen behaviour in plants and soils can be a limiting factor based upon the uptake of nitrogen by the plant, and the nitrogen losses. A nitrogen balance can be performed to compare total nitrogen usage of each plant with the amount of total nitrogen available.

A nitrogen balance was performed as per the Effluent Guidelines' *Equation 6 Nitrogen-limiting loading*. Equation 6 is shown below.

$$R_y = \frac{U}{TNE_y}$$

where R_y = annual effluent loading in year y in ML/ha/yr
U = annual crop uptake of nitrogen in kg/ha/yr
TNE_y = total plant-available nitrogen in year y in kg/ML

Table 7-4: BOC Kooragang nitrogen balance

Item	Value / Calculation	Note / Description
TNE	3 kg/ML	The TNE for plant uptake was assumed to be the Total Nitrogen concentration measured in the treated water in order to be conservative.
U	= 14,000 kg/ha/yr * 2.4% = 336 kg/ha/yr	Using Table 4.2 of Effluent Guidelines for an appropriate crop *Fescue* (a species of grass) which is in season all year. Fescue has: - a yield of 14 tonnes per hectare (14,000 kg/ha) - nitrogen uptake of 2.4%
R_y	= 336 kg/ha/yr ÷ 3 kg/ML = 112 ML/ha/y	
Proposed effluent flow	= 18,200 L/wk = 0.95 ML/y	Based on constant flow.
Proposed effluent irrigation area	1,314 m^2 = 0.13 ha	
Actual effluent loading	= 0.95 ML/year ÷ 0.13 ha = 7.2 ML/ha/y	

The actual effluent loading of 7.9 ML/ha/y is much lower than the annual limiting effluent nitrogen loading of 112 ML/ha/y. The actual load therefore comprises only 7% of the limiting load for nitrogen.

As the nitrogen limiting value of 112 ML/ha/y was significantly above the actual load of 7.9 ML/ha/y while assuming conservative nitrogen uptake values, it was not deemed necessary to perform further calculations.

7.3 Phosphorus sustainability balance

Phosphorus is removed from effluent through processes in the soil, and can be determined through the phosphorus sorption capacity of the soil. Take-up of phosphorus in the soil can prevent leaching of phosphorus to other water sources such as groundwater; the sorption capacity can assist in determining how much phosphorus can be taken up before the site is saturated.

A phosphorus sustainability calculation was performed as per the Effluent Guidelines based upon expected effluent quality.

Table 7-5: BOC Kooragang phosphorus balance

Item	Value / Calculation	Note / Description
Phosphorus sorption capacity of soil	750 mg/kg	From previous investigations at Kooragang Island. It is noted that the baseline soil monitoring program proposed in *8.1.2 Soil baseline monitoring program* can be used to verify this value.
Critical phosphorus sorption capacity of soil	= 750 mg/kg ÷ 10 = 75 mg/kg	Conservative value that one-tenth of the total sorption capacity can be used before leaching occurs. Most soils have a low to moderate P sorption where one-third of the capacity can be used.
Soil depth	1 metre	From geotechnical report
Soil density	1,600 kg/m^3	General guidelines for sandy soil
Irrigation area	0.13 ha	-
Total P in effluent	0.02 mg/L	-
Volume effluent applied per year	0.95 ML/y	-
Total P adsorbed before leaching	= (P sorption capacity (critical) * depth * density * area m^2) = (75 mg/kg) * 1m * (1,600 kg/m^3) * (1.04 ha*10,000 m^2) * (1e-6 mg/kg) = 158 kg	-
Total P applied in effluent per year	= 0.02 mg/L * 0.95 ML/yr = 0.019 kg	-
Total P removed by crop per year	0	Used 0 as a conservative figure, therefore assumes all P removed by soil
Site irrigation period	= (158 kg) / (0.019 kg/yr – 0 kg removed) = 8,308 years	-

Therefore when looking at the phosphorus concentration in the effluent, it can be seen that the phosphorus concentration is low enough to allow irrigation for a long period of time.

7.4 Wet weather storage

The Effluent Guidelines state that appropriate wet weather storage be calculated for the use of effluent in irrigation.

Table 7-6 shows the calculations performed for the wet weather storage assessment. The maximum recorded daily rainfall event for each month from the historical data was utilised as a worst-case scenario.

Table 7-6: BOC Kooragang wet weather storage assessment

Mth	Maximum recorded daily rain (mm)	Precipitation over irrigation area, averaged[2] (L/day)	Effluent applied over irrigation area (L/day)	Effluent volume as % of rainfall event (%)
Jan	201	263,588	2,600	1.0
Feb	253	332,048	2,600	0.8
Mar	284	372,782	2,600	0.7
Apr	231	303,665	2,600	0.9
May	182	239,017	2,600	1.1
Jun	210	275,677	2,600	0.9
Jul	119	155,840	2,600	1.7
Aug	169	221,935	2,600	1.2
Sep	158	206,955	2,600	1.3
Oct	97	126,801	2,600	2.1
Nov	124	162,936	2,600	1.6
Dec	178	233,235	2,600	1.1

[1] Rainfall data was obtained from the Bureau of Meteorology's (BOM) Automated Weather Station 61055 – Nobby's Signal Station approximately 6 kilometres from the BOC Kooragang site for all available years of rainfall data (1862 to 2015). The values were obtained from the maximum of the daily rainfall values for each month.

It can be seen from Table 7-6 that the total effluent applied to the land during irrigation is of a volume approximately 1 to 2% of the calculated historical maximum rainfall event. Therefore the volume of effluent is insignificant in comparison to the potential maximum rainfall event.

Section *5.1 Water treatment system* outlines that the proposed irrigation system will utilise two (2) additional wastewater storage tank of capacity 10,000 litres each. This totals 20,000 litres of extra storage which therefore allows for an approximate additional week of storage should the need occur.

Section *9 Operation and maintenance* also describes an irrigation management plan that will be utilised at BOC Kooragang. The irrigation management plant will include mitigations in times of wet weather or adverse conditions, irrigation will cease being performed. Additional mitigation includes that the wastewater can continue to be disposed offsite with a licensed waste contractor.

8 Soil and groundwater baseline monitoring

8.1 Baseline monitoring program

An effluent irrigation system should be sustainable, and management of the system should reduce risks to environment, health and flora. The use of effluent to irrigation at BOC Kooragang should therefore consider potential risks to the soil and groundwater at the site.

A baseline monitoring program will be implemented for BOC Kooragang prior to installation of the irrigation system. The baseline monitoring program would be performed to determine the current soil and groundwater quality at the site.

It is proposed to perform the following baseline monitoring programs.

8.1.1 Groundwater baseline monitoring program

It is proposed that BOC Kooragang will install groundwater monitoring bores for the purposes of obtaining baseline groundwater monitoring data, that is, the current groundwater quality at the site.

The data obtained will be used as baseline data for the proposed operational monitoring program to compare with groundwater quality after the proposed irrigation process is installed.

It is proposed the analytes outlined in Table 8-1 will be monitored during the baseline monitoring program.

Table 8-1: BOC Kooragang baseline groundwater monitoring program

Analytes	Unit	Analytes	Unit
Fluoride	mg/L	Sodium	mg/L
pH	-	Nitrogen (total)	mg/L
Standing water level	m	Total Kjeldahl Nitrogen	mg/L
Electrical conductivity	µS/cm	Sulphate	mg/L
Sodium Absorption Ratio	-	Phosphorus	mg/L
Alkalinity as calcium carbonate (hardness)	mg/L	Total dissolved solids	mg/L
Chloride	mg/L	Metals suite (As, CD, Cr, Cu, Ni, Pb, Zn, Hg)	mg/L

Enquiries have been made with Water NSW (previously under the functions of Department of Primary Industries [DPI] Water) to determine whether BOC Kooragang is required to apply for a groundwater licence to construct and use the proposed monitoring bores. It was confirmed via email on 1 November 2016 that an interim position for the regulation of monitoring bores has been established, whereby a *Water Act 1912* licence is no longer required for monitoring bores that are located outside of the Great Artesian Basin and are less than 40 metres deep.

As the groundwater at Kooragang Island has been shown to be encountered at a depth of approximately 1.2 metres it is therefore believed that BOC Kooragang will not be required to obtain a groundwater licence for the monitoring bores. The bores will be installed and constructed to the *Minimum Construction Requirements for Water Bores in Australia 2012*.

At the time of writing BOC Kooragang has three (3) groundwater bores in existence at the site. It is proposed that:

- Three (3) existing bores be utilised.
- One (1) bore be installed at the proposed irrigation area.
- Two (2) additional bores installed outside the irrigation area to enable maximum interception of potentially affected groundwater during monitoring.

Therefore the total number of monitoring bores is proposed to be six (6) as shown in Figure 8-1.

Figure 8-1: Existing and proposed location of BOC Kooragang's groundwater bores (marked with crosses)

8.1.2 Soil baseline monitoring program

Soil sampling will be completed using the sampling grid guidelines advised by NSW EPA *Soil Sampling guidelines* and *AS4482.1-2005 – Guide to the Investigation and Sampling of Sites with Potentially Contaminated Soil.*

It is proposed the analytes outlined in Table 8-2 will be monitored during the baseline monitoring program. It can be seen that the baseline monitoring program also includes analytes for Acid Sulphate Soils.

Table 8-2: BOC Kooragang soil baseline monitoring program

Pollutant	Units
Fluoride	mg/kg
Bray Phosphorus (as Fluoride Extractable Phosphorus)	mg/kg
Collwell Phosphorus (as Bicarbonate Extractable Phosphorus)	mg/kg
Cation Exchange Capacity	meq/100g
Chloride	mg/kg
Conductivity	dS/m
Exchangeable Calcium	meq/100g
Exchangeable Magnesium	meq/100g
Exchangeable Potassium	meq/100g
Exchangeable Sodium	meq/100g
pH	-
Moisture	%
Nitrate	mg/kg
Nitrogen (total)	mg/kg

Pollutant	Units
Nitrogen Oxides	mg/kg
Phosphorus (total)	mg/kg
Phosphorus Sorption Capacity	mg/kg
Total Kjeldahl Nitrogen (TKN)	mg/kg
Peroxide Oxidation Combined Acidity and Sulphate (POCAS) for Acid Sulphate Soils	
The POCAS method may include the following analytes:	
pH_{KCL} TAA	pH Unit
KCL Extractable Sulphur	%
TAA Extractable S	%
p_{HOX} TPA	pH Unit
Peroxide Sulphur	%
TPA and Peroxide Sulphur	%
ANC_E (Neutralising Capacity)	%
S_{NAS} (Retained Acidity)	%
Lead	mg/kg
Volatile Organic Compounds (VOCs)	ppm
Polycyclic Aromatic Hydrocarbons (PAHs) (sum)	mg/kg

Soil sampling will be performed at the following locations:

- Sampling grid in the proposed irrigation area.
- Three (3) background samples in the immediate surroundings of non-irrigated areas.

For the irrigation area sampling grid, composite samples will be taken for:

- Top soils; and
- Sub-surface soils.

9 Operation and maintenance

9.1 Operation of system

The proposed installation will be operated in accordance with best management practices and the applicable approvals.

The proposed irrigation system will include, but not be excluded to, the following controls:

- Automated operation using a timer for operation during permitted times of the day. The proposed system has been designed for 2 hours of irrigation per day.
- Supervisory Control and Data Acquisition (SCADA) control system in place on irrigation system with appropriate feedback systems.
- High and low level alarms and appropriate valves and pipework for all tanks, including existing cooling tower storage tanks.
- Installation of fencing and signage as necessary for irrigation areas.
- Installation of a flow meter.

9.2 Effluent Irrigation Management Plan

As part of best practice, BOC Kooragang will prepare and implement an *Effluent Irrigation Management Plan*. The management plan will include, but will not be excluded to, the following:

- Description of processes.
- Diagrams of irrigation system and identification of permitted storage, flows, and irrigation areas.

- Start-up and shut-down procedures.
- Internal monitoring programs, including site inspections of the processes and irrigation areas. The irrigation system and irrigated areas will undergo regular inspections, especially after wet weather.
- Description of irrigation system maintenance required, such as inspection, cleaning and replacement of lines and nozzles.
- Explanation(s) of operations during non-standard conditions, which will include the following:
  - Ceasing operations during wet weather, rainfall events and other adverse conditions.
  - Ability to send offsite with waste contractor if adverse conditions or long term wet weather occurrences deem necessary.
- Details of internal and external monitoring programs.
- Development of internal programs and standard operating procedures (SOPs) for all of the above topics.

9.3 EPL monitoring programs

BOC Kooragang propose to include monitoring points in EPL 20165 for the operation of the irrigation system. The following sections outline the proposed monitoring points and additional monitoring programs for EPA's consideration to place in EPL 20165 for:

- Cooling tower wastewater (effluent)
- Groundwater
- Soil

9.3.1 Effluent water monitoring program

It is proposed that the outlet of the irrigation system balance/ buffer tank be included as a monitoring point for effluent monitoring.

The cooling tower blowdown water used for irrigation will be monitored for the analytes outlined in Table 9-1. It is proposed that the wastewater will be monitored quarterly for the first year of operation. After the first year of operation, the monitoring program may be reviewed to ensure suitability for subsequent years.

The site's existing computerised maintenance management system (CMMS) will be utilised for this purpose as required.

BOC Kooragang will have installed a flow meter as part of the treatment process, which will enable measurement of volume of flows proceeding to the irrigation area.

Table 9-1: Cooling tower wastewater monitoring analytes

Analytes	Unit
pH	-
Electrical conductivity	µS/cm
Sodium Absorption Ratio	-
Alkalinity as calcium carbonate (hardness)	mg/L
Chloride	mg/L
Sodium	mg/L
Fluoride	mg/L
Nitrogen (total)	mg/L
Total Kjeldahl Nitrogen	mg/L
Sulphate	mg/L
Total dissolved solids	mg/L
Phosphorus	mg/L
Metals suite (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg)	mg/L
Volume	kL/year

9.3.2 Groundwater monitoring program

It is proposed that the bores installed for baseline monitoring be included as monitoring points for groundwater monitoring.

It is proposed the analytes outlined in Table 9-2 will be monitored for the stated frequencies on the first year and subsequent years of operation. After the first year of operation, BOC Kooragang proposes the monitoring program can be reviewed to ensure suitability for subsequent years.

The site's existing CMMS will be utilised for this purpose as required.

Table 9-2: BOC Kooragang proposed groundwater monitoring program

Analytes	Unit	Frequency 1st year	Frequency subsequent years
Fluoride	mg/L	Quarterly	6-monthly
pH	-	Quarterly	6-monthly
Standing water level	m	Quarterly	6-monthly
Electrical conductivity	µS/cm	Quarterly	6-monthly
Sodium Absorption Ratio	-	Quarterly	6-monthly
Alkalinity as calcium carbonate (hardness)	mg/L	Quarterly	6-monthly
Chloride	mg/L	Quarterly	6-monthly
Sodium	mg/L	Quarterly	6-monthly
Nitrogen (total)	mg/L	Quarterly	6-monthly
Total Kjeldahl Nitrogen	mg/L	Quarterly	6-monthly
Sulphate	mg/L	Quarterly	6-monthly
Phosphorus	mg/L	Quarterly	6-monthly
Total dissolved solids	mg/L	Quarterly	6-monthly
Metals suite (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg)	mg/L	Quarterly	Annually

9.3.3 Soil monitoring program

It is proposed that the irrigation area be included as a monitoring point for soil monitoring. It is proposed the analytes outlined in Table 9-3 will be monitored for the stated frequencies.

Soil sampling will be performed at the following locations:

- Sampling grid in the proposed irrigation area.
- Three (3) background samples in the immediate surroundings of non-irrigated areas.

For the irrigation area sampling grid, composite samples will be taken for:

- Top soils; and
- Sub-surface soils.

The site's existing CMMS will be utilised for this purpose as required.

Table 9-3: BOC Kooragang proposed soil monitoring program

Pollutant	Units	Frequency
Fluoride	mg/kg	Annually
Bray Phosphorus (as Fluoride Extractable Phosphorus)	mg/kg	Annually
Collwell Phosphorus (as Bicarbonate Extractable Phosphorus)	mg/kg	Annually
Cation Exchange Capacity	meq/100g	Annually
Chloride	mg/kg	Annually
Conductivity	dS/m	Annually
Exchangeable Calcium	meq/100g	Annually
Exchangeable Magnesium	meq/100g	Annually
Exchangeable Potassium	meq/100g	Annually
Exchangeable Sodium	meq/100g	Annually
pH	-	Annually
Moisture	%	Annually
Nitrate	mg/kg	Every 3 years
Nitrogen (total)	mg/kg	Every 3 years
Nitrogen Oxides	mg/kg	Every 3 years
Phosphorus (total)	mg/kg	Every 3 years
Phosphorus Sorption Capacity	mg/kg	Every 3 years
Total Kjeldahl Nitrogen (TKN)	mg/kg	Every 3 years

10 Conclusion

BOC Kooragang owns and operates a gas facility for the production and supply of gas products located at 9 Egret Street Kooragang, NSW and holds NSW Environmental Protection Authority (EPA) Environmental Protection Licence (EPL) 20165.

BOC Kooragang currently possess two (2) cooling towers onsite. The wastewater is collected by an approved waste contractor approximately once per week. BOC Kooragang have performed internal investigations regarding the feasibility of utilising the cooling tower wastewater for irrigation purposes in grassed areas of the site. Therefore BOC Kooragang wishes to obtain consent from the Department of Planning and EPA to utilise the cooling tower blowdown stream as effluent to irrigate a selected area of land at the site, as a full reuse scheme.

The cooling tower wastewater was found to contain levels of fluoride above the ANZECC irrigation guidelines. MJM performed a pilot plant trial for the removal of fluoride using activated alumina, which was found to successfully remove fluoride to acceptable levels. The report has outlined the proposed system for treatment of the cooling tower wastewater to irrigation.

It is believed that the proposed irrigation system at BOC Kooragang is feasible for the following reasons:

- The water balance shows that the estimated percolation rate of the proposed is well below the typical range of percolation rates for the soil type at the facility. When managed appropriately at the estimated rate of application, is it believed the soil type is therefore able to handle the capacity of the effluent applied based upon percolation rates, and is unlikely to cause ponding.
- Nitrogen and phosphorus balances performed show that the concentration of these analytes are not limiting factors for irrigation purposes.
- The review of potential environmental factors shows that the proposed facility is not expected to adversely impact upon the environment.

As best practice, BOC Kooragang propose to implement the following practices and procedures to ensure the proposed system is managed sustainably and appropriately:

- Automated operation during permitted times of the day, including Supervisory Control and Data Acquisition (SCADA) control system in place on irrigation system with appropriate feedback systems.

- An effluent irrigation management plan, which will include but is not excluded to the following:
  - Internal monitoring programs, including site inspections of the processes and irrigation areas.
  - Description of irrigation system maintenance required.
  - Details of operation and mitigation during non-standard conditions, such as wet weather events.
- Implementation of regular soil, groundwater and effluent monitoring as part of EPL 20165.
- Update of waste management plan for filter media.

It is believed that the proposed irrigation system at BOC Kooragang is beneficial for the following reasons:

- No reliance on town-supplied water for irrigation of the proposed grassed area.
- Removal of 18,200 litres per week that would be directed to a waste contractor, and ultimately to Hunter Water's sewer.
- Financial benefits to BOC Kooragang due to decreased operational costs and wastewater sent offsite.

11 References

EPA Atlas Search; accessed 02/02/2017
http://www.environment.nsw.gov.au/atlaspublicapp/UI_Modules/ATLAS_/AtlasSearch.aspx

State Environmental Planning Policy (Three Ports) 2013
http://www.legislation.nsw.gov.au/#/view/EPI/2013/228

NSW EPA Environmental Guidelines: Use of effluent by irrigation (2004).

Appendix A – NATA Laboratory Results Reports

Appendix B – Geotechnical report 2013 Douglas Partners

Appendix C – Treated water results report

Appendix D – Irrigation system design report

Appendix E – Current site plan

Appendix F – Proposed site plan

Appendix G – Dangerous Goods certificate from SafeWork NSW