SOLO Water

Water Utility Solutions

Catherine Hill Bay Water Utility

Reverse Osmosis Reject Exportation Pond Water Balance

Montefiore Street, Catherine Hill Bay

October 2014

Water Utility *Solutions*

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1 Introduction

Solo Water has entered into an agreement with the Rose Property Group/Coastal Hamlets to provide an integrated water, sewerage, recycled water and retail service provider solution for the approved residential subdivision at Catherine Hill Bay. The provision of private water services is permitted under the Water Industry Competition (WIC) Act (NSW Government, 2006) and is administered by the NSW Independent Pricing and Regulatory Tribunal (IPART, 2014).

The scheme will be 100% owned, operated and maintained by the Catherine Hill Bay Water Utility (CHBWU) and funding of the scheme will be provided through rating of individual customers in the scheme as is the case with conventional water authorities, e.g. Hunter Water. The CHBWU will take on all risks associated with the scheme and will operate the scheme in accordance with the license issued by IPART.

This Reverse Osmosis (RO) Reject Evaporation Pond Water Balance report has been prepared to demonstrate an effective method for managing RO Reject wastewater from the Stage 2 Advanced Water Treatment Plant (AWTP) using a low energy solution including evaporation ponds. Details of the proposed strategy, modelling and results are outlined in this report.

1.1 Project Scope

The scope of this investigation is to:

- Develop a low energy onsite RO reject waste management strategy using evaporation ponds;
- Undertake water balance modelling to demonstrate the proposed evaporation ponds are appropriately sized to avoid frequent overflow events; and
- Demonstrate through water balance modelling that the proposed strategy will not result in significant environmental impacts or frequent overflow events.

2 Background

2.1 Site Location

The proposed scheme is located inside the approved footprint of the Catherine Hill Bay residential subdivision at Montefiore Street, Catherine Hill Bay in New South Wales. The site is located at the southern end of the Lake Macquarie City Council region. An overview of the approximate site location is provided below in Figure 2.1.

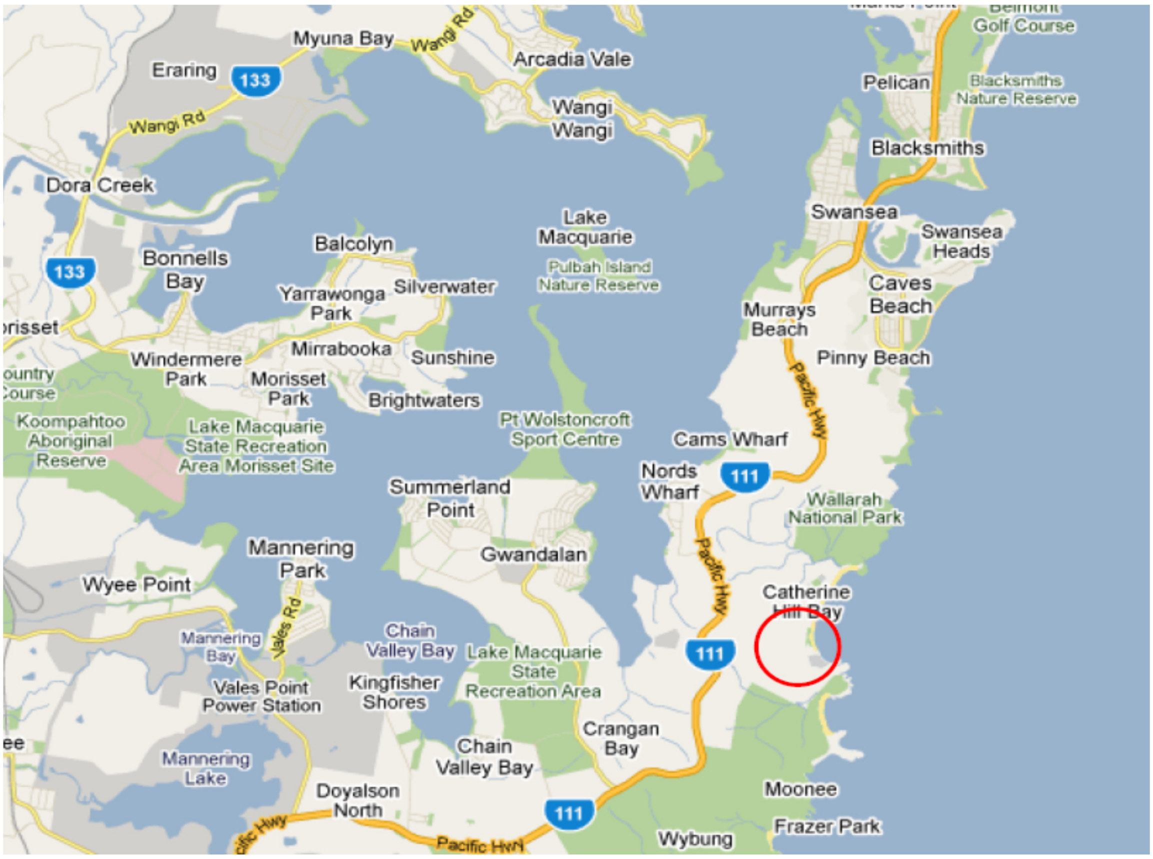

Figure 2.1 Site Location (Source: Google Maps)

2.2 Waste Water Source and Characteristics

The CHBWU will supply potable and recycled water to individual houses in the scheme under a dual reticulation arrangement. The source of recycled water is domestic wastewater generated inside the CHBWU scheme.

All recycled water supplied in the dual reticulation is treated in a Membrane Bioreactor (MBR) followed by treatment in the Advanced Water Treatment Plant (AWTP). The AWTP uses ultrafiltration membranes, ultraviolet disinfection, chlorine contact and salinity control using a side stream reverse osmosis (RO) process.

The RO process for salinity control is required to ensure long term accumulation of salt in the recycled water supply system does not occur. For further information on the AWTP including process flow diagrams and layout plans refer to the Solo Water report *Integrated Water Management Plan* (Rev B, Oct 2014).

The side stream RO process produces a concentrated waste stream that must be managed onsite in a sustainable manner. The production of waste concentrate is proportional to flow through the AWTP and feed water salinity.

The AWTP has a nominal design capacity of approximately 300 kL/day with approximately one-third of the flow treated in the side stream RO process. To minimise reject generation the RO process will be designed with a recovery rate of 85%. At stage 2 capacity of 470 ET, the system is estimated to produce approximately 6.4 kL/day of RO reject with Total Dissolved Solids (TDS) concentration of approximately 5000 mg/L. This corresponds to a salt concentration of approximately one-seventh of sea water strength.

This waste stream will be managed onsite using a low energy system comprising of evaporation ponds with a total surface area of 4870 m^2. The strategy is discussed in the following sections of the report.

3 Overview of Proposed Reverse Osmosis (RO) Reject Management Strategy

RO reject wastewater will be managed with a number of measures that are outlined in the following sections including:

- RO Reject waste minimisation strategy;
- Three Evaporation ponds with total surface area of 4870 m^2; and
- Final disposal of brine concentrate and salt residue to approved landfill facility.

3.1 RO Reject Waste Minimisation Strategy

The volume of RO Reject waste water will be minimised through implementation of waste minimisation measures. Details of the waste minimisation strategy measures are included below in Table 3.1.

Table 3.1 RO Reject Waste Minimisation Strategy Measures

Measure	Description
Residential supply agreements	Mandatory new customer contracts and access agreements that outline the responsibilities of the resident with regard to appropriate water usage, waste and chemical management practices.
Trade waste agreements	Mandatory trade waste agreements for each commercial customer that outline the responsibilities of the commercial tenant with regard to appropriate water usage waste and chemical management practices.
Ongoing monitoring and awareness education	Ongoing monitoring of raw wastewater and effluent flows, salt concentrations and other contaminants. Ongoing awareness and communication with existing customers through additional information provided at each billing cycle.
Maximum recovery rate	A recovery rate of 85% from the reverse osmosis (RO) process has been designed into the system producing a waste stream of approximately 6.4 kL/day with TDS of 5,000 mg/L. This is the maximum recovery rate possible without excessive energy consumption and capital costs.

3.2 Evaporation Ponds

Water from the AWTP RO will be pumped in a controlled manner to three evaporation ponds that will be operated on an alternating fill and dry cycle. Each pond will have a total depth of 1.5 metres and the total surface area of the ponds will be approximately 4870 m^2.

The ponds will be filled one at a time to a maximum depth of 1.2 metres and then rested to allow stored water to evaporate. Filling to 1.2 meters provides a 0.3 metre freeboard to allow for heavy rainfall during the drying out period. Evaporation rates in the pond will be maximised through the use of a spray misting system and black HDPE liner.

Once the pond is dried out, accumulated salt residue and brine concentrate will be transported off site to the nearest accepting waste management facility by licensed Solo Resource Recovery vehicles.

Details of the evaporation ponds are as follows:

- Three evaporation ponds with total surface area of 4870 m^2;
- Total pond depth of 1.5 metres with a fill depth of 1.2 metres and 0.3 metre freeboard;
- Black HDPE liner to avoid seepage to groundwater and to increase the solar absorption and water temperature in the pond;
- Low level sump at one end using a standard stormwater pit to allow emptying of the pond for clean out, salt/brine removal and maintenance; and
- Spray misting system around the perimeter of the pond to increase evaporation rates.

3.3 Operational Management

Under normal operating conditions, the evaporation ponds have been designed so that only one pond receives flow until the level in the pond reaches 1.2 m (0.3 m of freeboard), then the flow is diverted to the second or third pond and the first pond is allowed to dry out via evaporation. Operational management strategies to avoid overflows occurring, to enable removal of concentrated brine and precipitated salt and for monitoring and continuous improvement are described in Table 3.2 below.

Table 3.2 Operational Management Strategies

Component	Description
Normal Pond Cycling	– Only one pond receives inflow at a time. – Each pond receives inflow until the maximum fill level of 1.2 meters is reached, following which the pond is rested to allow stored water to evaporate. – The rested pond does not receive inflow until the water level has reduced sufficiently to allow the pond to be cleaned out with all salt and brine concentrate removed for offsite disposal.
Overflow Management	– If prolonged heavy rain causes pond level to fill within the 0.3 m freeboard and approach overflow level, a high level alarm will be raised to allow the operator appropriate time to undertake the necessary actions required to prevent overflow. – If required Solo Resource Recovery trucks will be used to remove water from the full pond to ensure no overflow occurs. Water will be transported offsite to the nearest accepting licensed waste facility. – Trucks will be notified and appropriate time allowed to avoid any overflow occurring. – In operation decisions can be made to avoid overflows by other means, e.g. transfer of water between ponds, temporarily store water in the free board, turn off the AWTP and use potable water in the recycled water network.

Component	Description
Salt/Brine Management	– Concentrated brine and salt precipitate will be removed from the rested pond once it has sufficiently dried out; – Solo Resource Recovery trucks will be used to remove the final waste products from the ponds and transport it to the nearest accepting licensed waste facility; and – Each pond will be cleaned out and the majority of salt residue removed before bringing the pond back online to receive inflow.
Monitoring	– Continuous online monitoring of water level in each evaporation pond with adjustable alarms will be set at the following pond levels: o Pond empty < 0.1 metres o Pond fill level >1.2 metres o Pond high Level >1.3 metres o Pond overflow imminent >1.4 metres. – Flow meters to measure daily flows into and out of each evaporation pond to refine the site water balance; – Electrical conductivity monitoring of MBR effluent, RO reject water and evaporation pond water; – Records of volumes/weight of brine/salt removed by road tanker for offsite disposal; and – Rainfall monitoring onsite using an automatic weather station.

4 Water Balance Modelling

A daily time step water balance model using 100 years of local rainfall and evaporation data was setup in Microsoft Excel to simulate the water and salt balance in the evaporation ponds. The performance of a number of different scenarios was investigated in the modelling exercise, however only details of the adopted option have been included below.

4.1 Modelling Inputs & Assumptions

A summary of the adopted input parameters and assumptions used in the modelling is presented below in Table 4.1.

Table 4.1 Model Input Parameters & Assumptions

Parameter	Value Adopted	Description
Pond Inflow characteristics	6.4 kL/day @5000 mg/L TDS 3.2 kL/day @5000 mg/L TDS (wet days)	On days with more than 3 mm of rain, pond inflow was halved to account for the reduction in recycled water generation that would occur on these days due to reduced irrigation demand.
Pond Area	Total surface area: 4870 m^2	Pond area is the maximum surface area when the pond is full at a depth of 1.5 metres. Water surface area was calculated each day based on the volume of water in the pond.
Pond Levels	Total depth: 1.5 m Fill depth: 1.2 m Freeboard: 0.3 m	Each pond is filled to a maximum depth of 1.2 meters before being rested to allow stored water to evaporate, thus leaving a 0.3 metre freeboard. Overflow occurs when pond level is above the maximum depth of 1.5 m.
Climate Data^	Daily rainfall data	100 years of daily Rainfall data * Station: Newcastle Nobbys Signal Station, BOM station # 61055 * Mean annual rainfall = 1123.5 mm * Modelling Period: 01/01/1912 to 31/12/2013 * Average monthly rainfall data can be found in Appendix A.
	Average monthly evaporation data	Mean Class A Pan Evaporation data * Station: Williamtown RAAF, BOM station # 61078 * Mean annual evaporation = 1716.7 mm * Mean Monthly Evaporation data for period: 1974 to 2012 * Average monthly evaporation data can be found in Appendix A.
Pond Factor	0.9	A pond evaporation factor of 0.9 was adopted to account for the reduction in evaporation that would occur from a shallow HDPE lined pond compared with a standard Class A evaporation pan.
Misting Factor	1.3	A misting factor of 1.3 was adopted to account for the increase in evaporation that would occur with the use of a spray misting system that effectively increases the water surface area for evaporation to occur.

Parameter	Value Adopted	Description
Salinity Evaporation Factor	1.00 – 0.56	The salinity evaporation factors outlined below (Kokya & Kokya, 2006) were used to account for the reduction in evaporation that occurs with increasing salinity. **Salinity**: 0-0.2 g/L / 40 g/L / 80 g/L / 160 g/L / 350 g/L **Salinity Evapo Factor**: 1.00 / 0.94 / 0.81 / 0.69 / 0.56 Salinity in the model is calculated daily after inflow and rainfall to determine the appropriate Salinity Evaporation Factor for that day based on interpolation of the above data.
Total Evaporation	Calculated daily	Evaporation was calculated each day in the model after rainfall and inflow was added to the pond. Pond Evaporation = Pan Evaporation x Pond Factor x Misting Factor x Salinity Factor
Removal of brine/salt residue	40 kL	The modelling assumed that the pond was cleaned out and all brine and salt residue removed when the volume in the pond fell below 40 kL.

Salinity	0-0.2 g/L	40 g/L	80 g/L	160 g/L	350 g/L
Salinity Evapo Factor	1.00	0.94	0.81	0.69	0.56

^Climate Data retrieved from Climate Data Online (Australian Government Bureau of Meteorology, 2013).

Daily water balance modelling was undertaken based on the data presented above in Table 4.1, modelling results are presented below in Section 4.2.

4.2 Modelling Results

A summary of the average water balance results over the 100-year modelling period for the evaporation ponds is outlined below in Table 4.2.

Table 4.2 Summary of Average Water Balance Results

	Measure	Units	Total
Pond Water Balance	RO Reject Inflow Volume	kL/Year	2,123.3
	Rain Volume	kL/Year	4,192.1
	Evaporation Volume	kL/Year	6,253.9
	Overflow Volume removed	kL/Year	38.2
	Concentrated Brine removed	kL/Year	11.5
	Change in Pond Volume	kL	11.8
Overflow Statistics	Volumetric overflow percentage	% of inflow	1.8%
	No. of overflow days per 100 years	Days/100yrs	124
	% Overflow Days	% of days	0.34%
	No. of overflow years per 100 years	Years/100yrs	6
	% Overflow Years	% of yrs	6%
	Average salinity of overflows	mg/L	7,777
Brine removal	No. of days where salt residue/brine concentrate removed from pond	Days/100yrs	32

As shown above in Table 4.1 the proposed evaporation ponds are predicted to overflow approximately 38 kL per year on average, which represents 1.8% of total pond inflow. This could be managed with an average of 2 x 20 kL road tankers per year. Average salinity of overflow water was shown to be approximately 7,777 mg/L, or around ¼ of sea water strength.

In reality the overflow events do not occur every year but are concentrated to periods of heavy rainfall approximately every 10-20 years. During the 100-year modelling period there were 6 years (6% of years) when overflows occurred spread across 124 days. A plot of overflow volume per year is shown below in Figure 4.1.

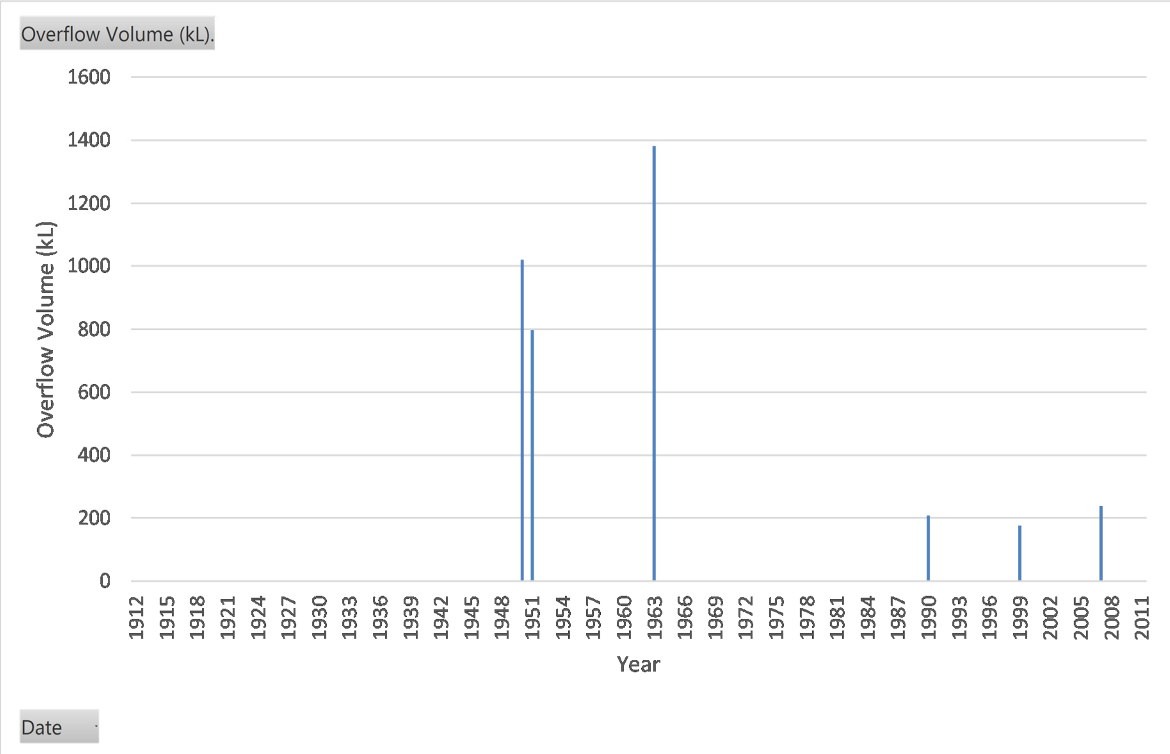

Figure 4.1 Overflow Volume for the 100-year Modelling Period

The years when overflows occurred as shown above in Figure 4.1 correspond to years with above average rainfall with the worst overflows occurring in 1950 and 1963 when annual rainfall was above the 95th percentile wet year (see Appendix A for BOM rainfall data).

During the worst overflow period in 1963 (one of the wettest years on record) there was a total overflow volume of approximately 1,382 kL over a 38 day period. In operation this would require approximately 70 x 20 kL trucks visits over the 38-day overflow event or around 1 truck visit every 1-2 days.

When a pond is being rested the modelling assumed all concentrated brine and salt residue would be removed when the volume of water in the pond falls below 40 kL. This occurred 32 times through the modelling period, which equates to approximately one 20 kL tanker approximately every 3 years, or 11.5 kL/year as indicated in Table 4.2.

5 Conclusions

Solo Water has developed a strategy for the sustainable onsite management of RO Reject wastewater from the proposed Advanced Water Treatment Plant that will supply Class A+ recycled water to customers in the Catherine Hill Bay Water Utility scheme.

The proposed waste management strategy includes waste minimisation processes and evaporation ponds with a total surface area of 4870 m^2. The evaporation ponds were sized to minimise the potential for overflows so that any required offsite management during extreme wet weather would be infrequent and manageable using Solo Resource Recovery licensed waste vehicles.

Water balance modelling of the proposed RO reject management system has indicated that the overflow volume accounts for approximately 1.8% of the inflow volume and these overflows occur in 6% of years (less than 1% of days) during periods of high rainfall approximately every 10-20 years.

The proposed RO reject waste management system is therefore considered sustainable and unlikely to result in significant environmental impacts or risks to the local environment.

6 References

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Appendix A

BOM Average Monthly Climate Data

BOM Average Monthly Climate Data

Rainfall Data all years (1862-2013) Station: Newcastle Nobbys Signal Station, BOM station # 61055													
Statistic	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Mean	88.4	107.9	119.6	116.0	117.3	117.1	94.6	73.6	72.5	72.9	70.5	81.1	1123.5
Lowest	2.0	0.5	2.8	0.0	2.1	0.8	0.0	0.0	0.8	4.6	2.4	4.6	596.9
5th %ile	15.9	11.5	23.9	17.0	15.5	17.1	11.4	6.1	9.9	10.7	9.1	15.7	765.1
10th %ile	24.4	19.6	29.9	26.3	23.5	22.1	15.9	12.6	16.5	17.1	14.8	21.0	794.2
Median	70.3	88.0	94.8	91.7	103.4	93.2	80.4	57.7	57.2	63.8	65.1	62.8	1048.4
90th %ile	174.6	213.9	242.4	235.4	228.9	245.6	198.3	139.5	146.4	141.1	135.0	155.1	1541.6
95th %ile	228.2	273.0	336.1	296.3	301.5	300.0	244.8	191.8	188.2	173.9	173.0	200.8	1625.6
Highest	404.0	559.2	544.4	546.4	441.3	495.8	351.1	545.3	283.1	277.5	203.9	326.5	1919.4
Evaporation Data for period: 1974 to 2012 Station: Williamtown RAAF, BOM station # 61078													
Mean	213.9	175.2	151.9	114.0	83.7	75.0	80.6	111.6	141.0	170.5	189.0	223.2	1716.7
Monthly Rainfall – Evaporation Deficit													
Mean deficit	-125.5	-67.3	-32.3	2.0	33.6	42.1	14.0	-38.0	-68.5	-97.6	-118.5	-142.1	-593.2
90th %ile deficit	-39.3	38.8	90.5	121.4	145.2	170.6	117.7	27.9	5.4	-29.4	-54.0	-68.1	-175.1

Note: Daily rainfall data was used in the modelling exercise; monthly data is presented above for information only.

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