CHALLENGES OF RUNNING HAMILTON ISLAND WATER TREATMENT

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ABSTRACT

Like many Queensland tourist areas, Hamilton Island must cater for a variable population of between 1,500 and up to 4,000 people. Being privately owned and operated, there is a need to produce and continually supply high standard potable water whilst minimising operational costs.

The Island has a number of freshwater collection and storage dams but their capacity is not sufficient to supply water year round. These storages are also susceptible to blue-green algal outbreaks and relatively high Electrical Conductivity (EC) due to evaporation and sea water ingress. The Hamilton Island resort operates a DAFF water treatment plant and a Reverse Osmosis (RO) plant to treat sea water, as a back up during times of limited fresh water availability or when water quality issues require an alternative supply. Unfortunately, the RO plant is expensive to operate and its use must be minimised. Disinfection in the form of Chlorine gas and Ozonation is employed.

There are a number of challenges which the system operators must meet in order to maximise the production of high quality water at a minimal cost. This paper describes some of these challenges and how we are able to achieve a satisfactory outcome.

KEY WORDS

DAFF (Dissolved Air Floatation Filtration), RO (Reverse Osmosis) BAC (Biologically Activated Carbon), EC (Electrical Conductivity).

1.0 INTRODUCTION

Hamilton Island is located half way between Townsville and Mackay; it is one of 74 islands in the Coral Sea. Hamilton Island is operated by Hamilton Island Enterprises and caters for a population of around 1,500 permanent residents and staff and peaks at up to 4000 people including tourists, guests and visitors to the harbour. The island has 4 freshwater collection and storage dams and desalinates seawater for potable use.

Table1: ***Island Storage Capacity***

Storage	Capacity (ML)	Surface Area (m^2)	Usable Capacity (ML)
Terminal Dam	157	17000	149
South Runway Dam	166	88000	117
North Runway Dam	205	109000	184
Palm Valley Dam	74	12500	69

Good rainfalls were recorded early in 2006 and in 2007, which filled all 4 dams to capacity. South Runway and North runway dams are relatively shallow with depths between 2-3 metres.

Their shallow nature combined with the lack of vegetation due to their close proximity to the airport make them susceptible to algal blooms in the warmer months.

2.0 EXISTING TREATMENT PROCESSES

2.1 DAFF Plant.

The DAFF plant is capable of producing 2.0 ML per day but averages 1.3MLto 1.6ML per day. Daily water consumption ranges from 1.2 ML up to 2.4ML during peak times.

The DAFF plant consists of 2 DAFF tanks, fed from a single Flocculation tank. The flocculation tank provides 15-20 minutes detention time depending on flow rate. The DAFF system is very robust and can handle variations in raw water quality reasonably well. Table 2 below outlines the DAFF plant performance during recent rain events where 220 mm fell in 24 hrs and the raw water turbidity went from the usual 15 NTU up to 180 NTU.

Table 2: ***DAFF Plant Performance.***

Date	1-2-2007	2-2-2007	3-2-2007	4-2-2007	5-2-2007	6-2-2007
Conductivity µS/cm	1,236	1,203	970	930	890	860
Final water pH	6.93	6.8	6.61	6.9	6.87	6.94
Final Water Turbidity	0.25	0.2	0.8	0.24	0.51	0.27
Filtered water turbidity	0.33	0.53	1.8	6.35	1.14	2.3
Chlorine residual	1.71	1.88	2.13	1.63	1.57	2.46
Flow rate (l/sec)	24	18	20	20	26	20
Daily Raw water flow	1.242	1.189		1.326	1.657	1.274
Alum residual	0.15			0.15		
Alum Dose (mg/L)	70	70	70	65	75	75

2.2 Ozone Disinfection

Hamilton Island operates an Ozgen ozone generation system. The Ozone generator can produce 400 g/hr of ozone gas. The target residual is between 0.30mg/L to 0.50mg/L, depending on the quality of the raw water and algal counts.

Once the treated water has left the DAFF it is injected with Ozone saturated filtered water where any organic material that has not been taken out by the DAFF process is oxidised by the ozone gas during a 5-minute contact period.

This process is especially important in the treatment of Blue Green Algae as the ozone attacks the cell walls of the blue green algae and destroys the algal toxins that are released by the algae. Ozonation also oxidizes iron and manganese compounds that may be present in the filtered water and this helps improve the taste quality of the treated water.

2.3 BAC (Biologically Activated Carbon)

Once the treated water has been through the Ozone disinfection process it passes through a BAC filter where any toxins or organic compounds are removed by the bacteria and carbon.

Care must be taken with the Ozone disinfection as a residual that is too high can sterilise the BAC bed and turn it into an activated carbon filter. Backwashing of the filter must also be monitored to ensure over washing does not reduce the bacteria to an extent where it is not effective at removing organic compounds produced by the ozonation process. A monthly monitoring regime provides cell counts for both Pre and Post BAC Ozone treatment to ensure the process is operating correctly.

2.4 Reverse Osmosis Plant

The dictionary definition of osmosis is; transfer of liquid solvent through a semi permeable membrane that does not allow dissolved solids to pass. External pressure exerted on the side containing the solute can stop or reverse the osmosis effect. Reverse Osmosis (RO) is used to convert seawater into safe drinking water.

The RO plant at Hamilton Island is capable of producing 1.4ML per day but it is currently operated at around 50% to 75% of its capacity to compliment the DAFF process

Raw water pumps deliver seawater with an EC of around 54,000 µs/cm to the RO plant where the raw water passes through a series of filters. The first are the spinklin filters which remove larger inorganic compounds such as shell, sand and grit. Water is filtered by sand and carbon filters, split into 2 banks each bank consists of 4 sand and 4 carbon filters, 1 micron filters further filter the water where it is stored in 2 x 20,000 L tanks.

These tanks are the supply for the high-pressure pumps that feed the four RO Banks. Each RO bank consists of 5 pressure vessels each vessel contains 6 membranes. One bank is capable of producing 4.2 L/sec of permeate flow from a feed rate of 12 L/sec with a final average EC reading of 500µs/cm. The water left over by the process, which has an EC of around 72,000 µs/cm, is returned to the ocean via an outfall pipeline.

2.5 Chlorine Dosing

The final step in the treatment process is the addition of Chlorine. The final water is directed to a 1.5ML treated water storage which is chlorinated to around 1.2-2 mg/L to ensure a residual in the reticulation network 0.5 to 0.7mg/L in the dead ends.

3.0 CHALLENGES IN RUNNING THE TREATMENT SYSTEM

The main challenges fall into 3 areas

- Ensuring all barriers are in place when treating algal blooms
- Reducing the EC of the potable water
- Minimising maintenance and operational costs of Reverse Osmosis.

3.1 Managing and Treating Algal Blooms

Algal blooms are an inevitable part of the annual weather cycle. The algal counts from Hamilton island storages for the period August 06 through to December 06 are represented in Table 3.

Nth runway dam is the primary raw water source for supply to the DAFF plant. Algal counts increase as temperatures rise. High numbers of algae are transported to the Terminal dam from Nth Runway dam. It is at this point increased monitoring checks are made at the plant to ensure all barriers in place to remove any algal toxins are functioning correctly.

Palm Valley dam is used to blend with the other 2 storages when algal counts become too high. It is also used as a stand-alone water supply when Nth and Sth runway dams become unusable. Algal counts in Palm Valley are significantly lower than the other three storages.

Table 3: ***Storage Algal counts Aug 06 – Dec 06***

Cells/ mL	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06
Palm Valley Blue Green	0	0	0	68,833	30,400
Palm Valley Total	43,000	45,000	250,000	150,000	170,000
Terminal Dam Blue green	8,185	54,899	126,000	42,000	135,000
Terminal Dam Total	290,000	4,800,000	3,700,000	330,000	780,000
Nth Runway Blue green	910	12,343	10,467	530	70,143
Nth Runway Total	3,400,000	7,100,000	2,100,000	1,500,000	4,700,000
Sth Runway Blue green	13,725	50,000	99,800	216,667	17,767
Sth Runway Total	740,000	2,800,000	4,100,000	2,200,000	1,500,000

An interesting point is that of the 4 storages, Palm Valley is the most protected from human impact and has a relatively untouched catchment area. These algal counts show how important it is to protect catchments and the benefits this can have on water quality. A program of bank restoration incorporating fencing and re-vegetation to help reduce nutrients in sediment runoff is under way.

When Algal blooms do occur, there are several barriers in place to ensure safe drinking water including:

- The DAFF plant where the bulk of the algae is removed,
- Ozonation to destroy any cells that have made it through the DAFF process.
- Biologically activated carbon removes any compounds created by the ozone process
- Monthly sampling of Pre and Post ozone treatment.

3.2 Reducing EC

All the storages exhibit high EC readings due largely to the geographical nature of the island and they are occasionally infiltrated by King tides. Reducing the EC of the final water to less than 1,000µs/cm is crucial to reduce corrosion damage to pumps, impellors, treatment plant assets and the metal components of the reticulation network.

Both North and South Runway dams were formed from what was formerly a natural bay before the present day airport was constructed.

Readings of above 3,000µs/cm for South Runway dam are not uncommon, which makes reducing the EC level difficult. Secondly, to utilise South Runway water is pumped into Nth Runway thereby increasing the EC in Nth Runway. At present South runway dam is used as a back up water supply.

North runway dam is the main dam that feeds to the Terminal dam at the DAFF plant. The EC level in Nth runway dam can reach 2,900 µs/cm, generally in the warmer months and as the storage levels decrease.

Palm valley dam has the lowest of all the storage EC's with readings of around 250µs/cm, however it has a very limited capacity of 74ML.
Palm Valley is used to blend with Nth runway and Terminal dam to help reduce the EC. Blending from Palm Valley generally reduces the EC to a level of between 1100µs/cm and 1350µs/cm with a practical target > 1200µs/cm achieved.

Terminal dam, which is located directly opposite the airport terminal and directly behind the DAF and RO plants, has its own catchment area and is topped up by annual rainfall. Both Palm Valley dam and Nth runway dam are pumped to the Terminal dam before treatment at the DAF plant.

<u>Table 4:</u> ***Hamilton Island Storage Conductivity (µs/cm)***

Date	Palm Valley	Nth runway	Sth Runway	Terminal Dam	DAF Final Water
01-Nov-06	260	2110	2420	1430	1284
16-Nov-06	270	2250	2470	1640	1254
08-Dec-06	280	2520	2670	1820	1120
20-Dec-06	300	2640	2800	2020	1342
27-Dec-06	310	2850	2900	2070	1740
03-Jan-07	280	2680	2890	1760	1441
18-Jan-07	310	2960	3030	1390	1138
24-Jan-07	240	1670	2630	1320	1225
02-Feb-07	190	360	1900	930	970

Early rainfall in the past 2 years has reduced the overall EC readings of all the Island storages. As the storage levels fall, generally the EC readings increase and two management options are available:
Option 1 - Pump from Palm valley dam to the Terminal dam. By blending from Palm Valley, which has a generally low EC, the EC readings in terminal dam storage are able to be reduced.
Option 2 - is to reduce the flow rate from the DAF and increase the flow rate from the RO. This is very effective at lowering the EC readings however the reverse osmosis process requires large amounts of power and is a very expensive exercise as depicted in Table 5.

<u>Table 5:</u> ***RO/DAFF Power Usage V's Flow Rate***

Date	Number RO Banks running	Power Kilowatt Hrs	RO Flow rate (L/sec)	DAFF Flow Rate (L/sec)	Power Kilowatt Hrs
12/12/2006	3	39	12	20	8
13/12/2006	3	40	12	20	7
14/12/2006	3	37	12	20	7
15/12/2006	3	41	12	20	9
16/12/2006	2	29	8	25	5
17/12/2006	2	27	8	25	9
18/12/2006	2	28	8	18	8
19/12/2006	3	35	12	25	7
20/12/2006	2	31	8	25	8

3.3 RO Maintenance and Operational Costs

Due to the corrosive nature of seawater, the RO is both costly from maintenance and an operating perspective. Table 5 shows the comparison between the power usage for water production between the DAFF and the RO plants. The RO uses nearly 5 times as much power to produce generally less than half the water of the DAF plant.

Seawater corrodes everything in the RO plant, even the shed that houses the plant. There is a constant program of painting and replacement of non-stainless parts. A full time fitter and turner is employed to run and maintain the RO plant because of the constant repairs and maintenance required.

The membranes used in the RO plant have a life span of 4-5 years provided they remain free from mechanical failure. The cost involved in replacing membranes in somewhere in the range of $1,600 each and there are 4 banks each with 30 membranes. The total cost of the membranes is around $190,000. There are 2 banks of 1-micron filters each bank houses 32-filter cartridges at a replacement cost of $21.00 each. One micron filters need to be replaced about every 3-4 weeks depending on the quality of the carbon in the filter banks. The activated carbon in the filters has deteriorated and is due to be replaced; hopefully this will increase the life of the 1-micron filters.

4.0 CONCLUSION

Hamilton Island is experiencing a development boom at present with a new resort, staff accommodation and a new yacht club presently being constructed as well numerous private residences being built.
The current challenges are being met by

- Constant testing and calibrating of all our monitoring equipment;
- Protecting our storages and catchments from the effects of all the new development by constructing silt traps;
- Revegetating areas susceptible to erosion;
- Rationalising the use of the Reverse Osmosis plant.

The new challenge will be to ensure current infrastructure is sufficient to meet the demands of these future developments and implementing new technology to minimise impacts on the very special environment in which we live work and play.

5.0 ACKNOWLEDGEMENTS

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