Australian Water Recycling
Centre of Excellence

Demonstration of robust water recycling: Hazard analysis and critical control point report

A report of a study funded by the
Australian Water Recycling Centre of Excellence

Bartlett, S., Northcott, K., Scales, P.J., Sheehan, D. and Gray, S.
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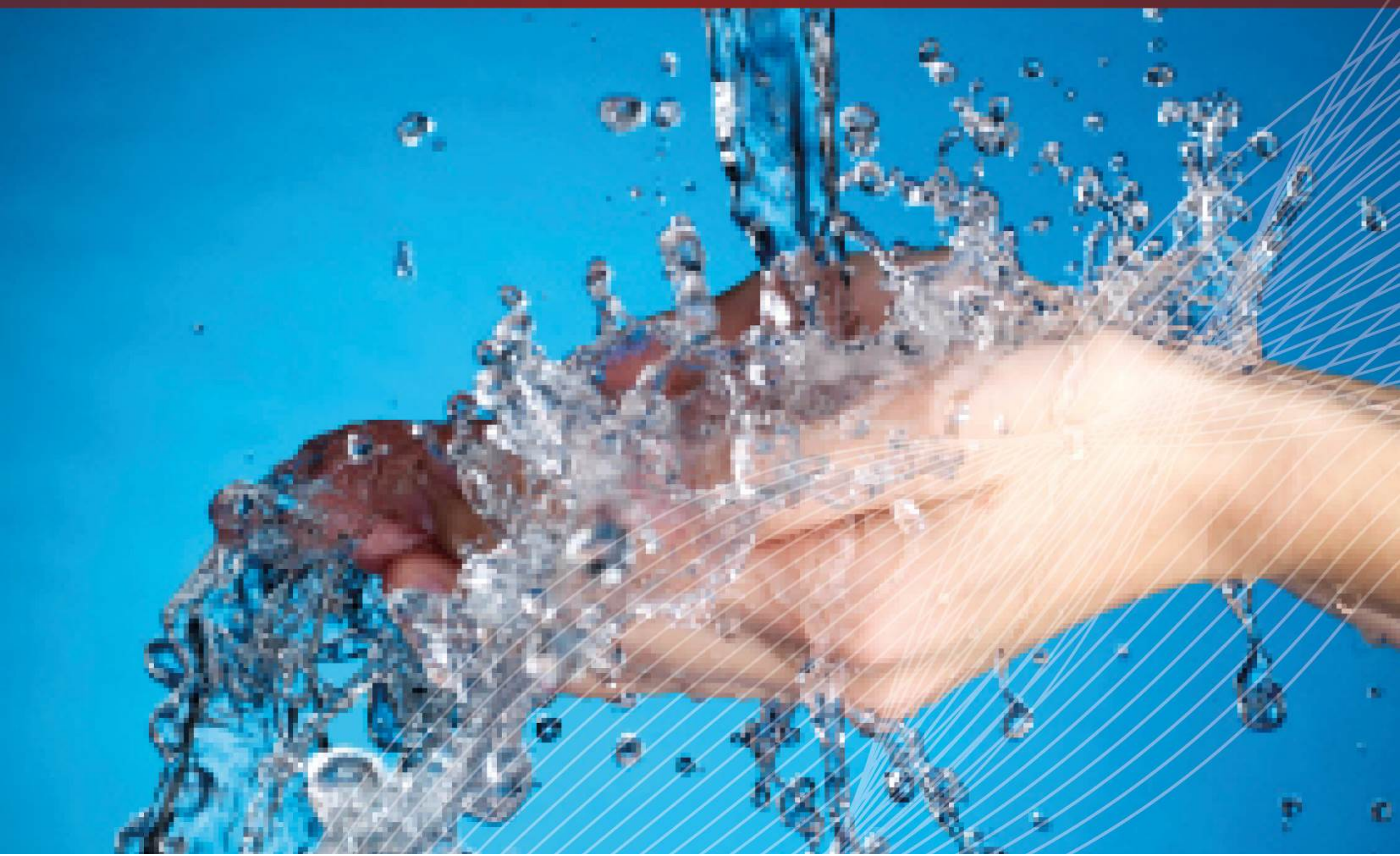

Demonstration of robust water recycling: Hazard analysis and critical control point report

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About the Australian Water Recycling Centre of Excellence

The mission of the Australian Water Recycling Centre of Excellence is to enhance management and use of water recycling through industry partnerships, build capacity and capability within the recycled water industry, and promote water recycling as a socially, environmentally and economically sustainable option for future water security.

The Australian Government has provided $20 million to the Centre through its National Urban Water and Desalination Plan to support applied research and development projects which meet water recycling challenges for Australia's irrigation, urban development, food processing, heavy industry and water utility sectors. This funding has levered an additional $40 million investment from more than 80 private and public organisations, in Australia and overseas.

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Executive Summary

Outcomes from three HACCP workshops are listed below.

- A risk register and decision tree analysis is contained in spreadsheet 'HACCP Workshop Risk Register_30032015.xlsx' outlines the water quality risks for the AWTP that is an appendix in the Recycled Water Quality Management Plan,
- The pathogen CCP tables contained in the RWQMP,
- A chemical risk decision tree analysis and maximum allowable chemical volumes contained in the Risk Assessment of Contaminants of Concern Report. The maximum allowable chemical volumes will inform the purchasing of chemicals and the container sizes that AAD will purchase,
- CCPs for trace organic chemicals contained in the Risk Assessment of Contaminants of Concern Report,
- Bromide and iodide was dosed into the AWTP to determine the ability of the AWTP to remove brominated and iodated disinfection by-products. The AWTP was able to effectively remove disinfection by-products (maximum dosing levels Br^- = 0.693mg/L; I^- = 0.063 mg/L). These results are reported in the Operating Performance and Water Quality Report, Appendix F.
- Formaldehyde concentrations post-ozone, post-BAC and in the RO permeate were below the Australian Drinking Water Guideline (ADWG) maximum allowable concentration of 0.5 mg/L (measured to be <0.1 mg/L).

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Nomenclature

ADWG	Australia Drinking Water Guidelines
AWTP	Advanced water treatment plant
AGWR	Australian Guidelines for Water Recycling
CCP	Critical Control Point
CoC	Chemicals of Concern
HACCP	Hazard Analysis and Critical Control Point
QMRA	Quantitative microbial risk assessment
RWQMP	Recycled water quality management plan

1. Introduction

Three Hazard Analysis and Critical Control Point (HACCP) workshops were undertaken to identify water quality risks and actions to manage the identified risks pertaining to the Advanced Water Treatment Plant (AWTP). The three workshops were held on: 5th and 6th August, 2013 (Workshop 1), 6th May, 2014 (Workshop 2) and 30th March, 2015 (Workshop 3). The first two workshops were led by Sallyanne Bartlett from WaterQPlus and the third by Dr Kathy Northcott from Veolia Water.

2. Workshop Method

The HACCP and risk assessment method was based upon the Australian Drinking Water Guidelines (ADWG) framework element two (assessment of the drinking water supply system) and element three (preventative measures for drinking water quality management). Reference was made to the Australian Guidelines for Water Recycling (AGWR) Phase 2 for specific descriptors for health qualitative measures of likelihood, consequence and impact.

The approach taken during the HACCP workshop was unconventional due to the limited amount of water quality data available for the Davis Station system. A conventional HACCP process is usually supported by a vast array of water quality data generated over a period of time, in some cases decades, for various locations within a water supply system. This was not the case for the Davis Station system. The water quality data that existed was from a few Davis Station sampling events that provided a snapshot of the chemical contaminants that were present in the wastewater at that point in time and a quantitative microbial risk assessment (QMRA) conducted by the University of Melbourne.

In contrast to a conventional water quality system assessment, the physical isolation of the Davis Station system was unique, and because of this the source water inputs were well known to AAD personnel. The AAD is the only source of the contaminants likely to be in the wastewater, as all products that are present at Davis Station are shipped there by the AAD and used by AAD personnel. No other source water inputs exist controlled or uncontrolled. For this reason it was important that the HACCP team assembled consisted of AAD personnel with firsthand operational knowledge regarding the products that are shipped to Davis Station, the application of the products and the potential that these products have to enter the wastewater stream. This enabled a desktop HACCP process to be conducted that did not rely on data from a comprehensive water quality assessment. The team was able to construct a source water input and wastewater stream profile to identify the potential water quality hazards likely to exist in the Davis Station AWTP (DAWTP) feedwater, assess the risks posed by each of these hazards and capability of the DAWTP to manage/control these risks.

Further details of the method and assessment protocols are contained in Appendices A, B and C.

3. Outcomes

The minutes from these workshops are contained in appendices A, B and C. A risk register and decision tree analysis was developed and is contained in a spreadsheet and the final version is named ‘HACCP Workshop Risk Register_30032015.xlsx’. This spreadsheet constitutes part of this HAACP Report and is also an Appendix of the RWQMP.

Critical Control Point (CCP) tables were also developed to specify the critical, alert and target values for each CCP, and the actions to be taken if the alert or critical limits are reached. The CCP tables relating to pathogens were developed in workshops 1 and 2 and are not contained in this report, but are part of the Recycled Water Quality Management Plan (RWQMP)[1].

Workshop 3 focused on unresolved issues pertaining to Chemicals of Concern (CoC). The issues raised during workshop 3 for resolution are listed in Table 1 (page 10), along with the resolution of these items.

1 Demonstration of robust Water Recycling: Recycled Water Quality Management Plan, Australian Water Recycling Centre of Excellence, June 2015.

Areas for further work were identified in the March 2015 Chemical Risk workshop and are listed below along with their status:

1. *Update RWQMP with new information on chemical risk management policies and procedures, specifically around source water management* - Complete.
2. *Identify key chemical risks from AAD chemical manifest via decision tree analysis, and maximum chemical concentrations calculated from volumes on inventory* – Included in Table 10 of the "Risk Assessment for the Removal of Contaminants of Concern Report in the Davis Station Advanced Water Treatment Plant".
3. *Review Selfs Point operational data and bioassay results and prepare validation report for removal of COCs across the process* – Included in the RWQMP and the ""Risk Assessment for the Removal of Contaminants of Concern Report in the Davis Station Advanced Water Treatment Plant".
4. *Identify the ability of the treatment process to treat water with bromide and* iodide – Dosing of the feed water with bromide (≤0.693 mg/L) and iodide (≤0.0.63 mg/L) was undertaken and the report is included in the Operating Performance and Water Quality Report. The AWTP was able to effectively remove disinfection by-products from bromide and iodide, and the product water disinfection by-product values were below the Australian Drinking Water Guideline values.
5. *Finalise work on impact of trace contamination from flame retardants* – no phosphate flame retardants used.
6. *Development of chemical management procedures based on findings of chemical decision tree analysis, such as maximum chemical container volumes purchased* - Risk decision tree and maximum allowable limits contained in the Risk Assessment of Contaminants of Concern Report will allow evaluation of maximum chemical limits and container sizes by AAD.
7. *Follow up on list of generic medical chemicals (ie antiseptics) and general pharmaceuticals (ie antibiotics), as well as biohazard fumigants used by the AAD* - Risk decision tree and maximum allowable limits contained in the Risk Assessment of Contaminants of Concern Report will allow evaluation of chemicals. The fumigants used are pyrethrum and methyl bromide. The boiling point of methyl bromide is 3.5˚C, so it is a gas at normal temperatures and as such is unlikely to be present in significant concentrations by the time ships reach the Antarctic. Pyrethrum is safe for use near humans and breaks down quickly in sunlight and is non-persistent in the environment. Pyrethrum is not mentioned in the ADWG.
8. *Breakage of a UV tube in the UV disinfection system resulting in release of mercury into the product water was identified as a risk*. This risk is included in the updated HACCP risk register, and control of the flowrate is used as a preventative measure. The residual risk was moderate.
9. *Formaldehyde formation during ozonation was identified as a risk*. Formaldehyde concentrations post-ozonation, post-BAC and in the RO permeate were measured during November 2015 and all registered <0.1 mg/L formaldehyde. These concentrations were all less than the ADWG maximum allowable concentration of 0.5 mg/L for formaldehyde.

4. Items still to be addressed

Details of the recommended anti-foam are yet be received from the membrane bioreactor supplies. When details arrive, its chemical composition will be checked against the decision tree in the Risk Assessment of Contaminants of Concern Report. However, effluent sprays may be used instead to break down any foam that might form.

Details of anti-septics used at Davis Station have not been received. Common anti-septics can be compared against the decision tree in the Risk Assessment of Contaminants of Concern Report to determine which are suitable for use at Davis Station.

Table 1: Knowledge gaps identified before workshop 3 (30th March, 2015) and their status.

Knowledge or Information gap	Assumption	Identified follow-up action from initial workshop	Status of action May 2014	Status of action March 2015	Resolution at June 2015
A listing of CoCs (humans) had not been established or water quality data for these types of compounds collected for Davis Station wastewater.	CoCs during the workshop for risk assessment purposes were considered broadly as carcinogens, endocrine disruptors and hormones.	It was suggested a listing of the top 50 compounds tested for by Western Corridor to be used as a guide to test Davis Station wastewater samples. Noted to review products sent down to Davis Station, conduct DALY and screen for these compounds.	New list of CoCs	Split EDCs and hormones from carcinogens in HACCP risk register. Retain the same risk profile for both categories in source water. EDCs to be addressed in ozone and RO CCP. Carcinogens to be addressed in source water QCP (RWQMP, p47).	Carcinogens added to the Risk Register (HACCP Workshop Risk Register_30032015.xlsx) as a separate source water item – row 19, Hazard ID 015a.
Volatile Organic Carbons (VOC) a listing of compounds was not available.	VOCs during the workshop were defined as degreasers, paint thinners, noted paints are water dispersible lighter than hydrocarbon and more water soluble.			Chemical manifest now available from AAD. Uni Melb developing chemical risk decision tree analysis and maximum allowable volumes. To be covered in source water QCP (RWQMP, p47).	VOCs added to the Risk Register (HACCP Workshop Risk Register_30032015.xlsx) as a separate source water item – row 34, Hazard ID 30. Risk decision tree and maximum allowable limits contained in the Risk Assessment of Contaminants of Concern Report.
What types of paints and solvents non water dispersible are used at Davis Station?	Assumed much of the paint is enamel.	Improve understanding of painting and associated products used at Davis Station.		Chemical manifest now available from AAD. Uni of Melbourne developing chemical risk decision tree analysis and maximum allowable volumes. To be covered in source water QCP.	Solvents and paints added to the Risk Register (HACCP Workshop Risk Register_30032015.xlsx) as a separate source water item – row 36, Hazard ID 32. Risk decision tree and maximum allowable limits contained in the Risk Assessment of Contaminants of Concern Report.

Chemicals that can pass through MBR process (the Davis Station Secondary Wastewater Treatment Plant).	Nil	Further investigation required as to what chemicals can pass through a MBR process – suggested a list from Western Corridor.		Chemical manifest now available from AAD. Uni Melb developing chemical risk decision tree analysis and maximum allowable volumes. To be covered in source water QCP.	Risk decision tree and maximum allowable limits contained in the Risk Assessment of Contaminants of Concern Report.
Formaldehyde is used at Davis Station for laboratory work. Would it be removed by AWTP process barriers, pass through or form by-products?	Formaldehyde is used at Davis Station for laboratory work. Would it be removed by AWTP process barriers, pass through or form by-products?	Formaldehyde is used at Davis Station for laboratory work. Would it be removed by AWTP process barriers, pass through or form by-products?		Chemical manifest now available from AAD. Uni Melb developing chemical risk decision tree analysis and maximum allowable volumes. To be covered in source water QCP. Victoria University investigating formaldehyde DBP formation, in collaboration with AAD.	Formaldehyde added to the Risk Register (HACCP Workshop Risk Register_30032015.xlsx) as a separate source water item – row 39, Hazard ID 35. Formaldehyde concentrations were measured to be <0.1 mg/L, and were significantly below the ADWG maximum concentration of 0.5 mg/L
What dye and other chemicals (e.g. heavy metals) are used in the laboratory?	What dye and other chemicals (e.g. heavy metals) are used in the laboratory?	What dye and other chemicals (e.g. heavy metals) are used in the laboratory?		Chemical manifest now available from AAD. Uni Melb developing chemical risk decision tree analysis and maximum allowable volumes. To be covered in source water QCP.	Dyes added to the Risk Register (HACCP Workshop Risk Register_30032015.xlsx) as a separate source water item – row 40, Hazard ID 36. Risk decision tree and maximum allowable limits contained in the Risk Assessment of Contaminants of Concern Report.
What radiological compounds are likely to be used at Davis Station for laboratory work and could these appear in the wastewater stream?	What radiological compounds are likely to be used at Davis Station for laboratory work and could these appear in the wastewater stream?	What radiological compounds are likely to be used at Davis Station for laboratory work and could these appear in the wastewater stream?		Chemical manifest now available from AAD. Uni Melb developing chemical risk decision tree analysis and maximum allowable volumes. To be covered in source water QCP.	Radioactive compounds added to the Risk Register (HACCP Workshop Risk Register_30032015.xlsx) as a separate source water item – row 72, Hazard ID 68. Risk decision tree and maximum allowable limits contained in the Risk Assessment of Contaminants of Concern Report

No information regarding antifoam product constituents used by MBR process.	No information regarding antifoam product constituents used by MBR process.	No information regarding antifoam product constituents used by MBR process.		Review MBR O&M manual – specifically chemical requirements for operation and associated MSDS.	Antifoam still to be determined and will be checked against the decision tree in the Risk Assessment of Contaminants of Concern Report.
What chemicals can pass through each DAWTP barrier/process?		Improve understanding of what chemicals are likely to pass through each AWTP barrier/process.	Adrian Knight to provide database.	University of Melbourne/RMIT to review operational and bioassay data from Self's Point and prepare validation report for trace organic chemicals.	Risk Assessment of Contaminants of Concern Report contains the rejection and passage of COCs through each treatment barrier.
Chemicals likely to be present onsite at Davis Station each year.	General identification of hydrocarbons, paints, glycol, kitchen and general cleaning products, laboratory chemicals etc.	Review of the chemicals that go to Davis Station and use this information to establish a listing of parameters to be tested in the wastewater.	Michael to obtain AAD chemical manifest.	Chemical manifest now available from AAD. Uni Melb developing chemical risk decision tree analysis and maximum allowable volumes. To be covered in source water QCP.	Risk register (HACCP Workshop Risk Register_30032015.xlsx) was updated to include glycol, hydrocarbons, cleaning chemicals and heavy metals as a separate source water items – rows 64, 65, 66, 73 Hazard IDs 60, 61, 62, 69.
What antiseptics are used at Davis Station?		Review antiseptic use and determine the constituents e.g. hexachlor or iodine based. If iodine based consider in relation to ozonation and the formation of by-products. Curtin University may be able to provide assistance.	AAD medical.	Michael to chase up list of antiseptics used by AAD medical on station.	Anti-septics to be compared against the decision tree in the Risk Assessment of Contaminants of Concern Report.

Impact of a slug dose of cleaning products (impact or ammonia based verses chlorine based) on AWTP.	Considered in a spill situation in impact of cleaning chemicals collectively.	It was suggested to separate a spill situation out into impact of ammonia and chlorine based products separately – consider for future risk register review.		Use Ammonia in MBR CCP – create a new QCP for the MBR for control of chemicals. Chlorine can also be addressed through new MBR QCP.	An ammonia sensor is to be located on the MBR effluent line. A chlorine sensor is not included as it is unlikely free chlorine will pass through the MBR. A large slug of chlorine will kill the bacteria in the MBR and this will be detected by the ammonia, phosphate, nitrate, pH and conductivity sensors on the MBR effluent. RWQMP contains the QCP for control of chemicals.
No water quality data for tarn iodine levels.	Nil	Analysis of tarn water and exist RO product water for iodine concentration.	Requires chasing up.	Victoria University investigating DBP formation, in collaboration with Curtin University.	Disinfection by-product report for iodide and bromide included in the Operating Performance and Water Quality Report. All I and Br disinfection by-products (Br^- <1mg/L; I^-<0.1 mg/L) rejected by the treatment process.
Noted that the ceramic membranes that are proposed for use at the ultra-microfiltration barrier/process step have a catalytic effect across membrane surface.	Nil	Research into what by-products may be formed due to the catalytic effect across the ceramic membranes. Testing to be part of the pilot plant studies.		Victoria University investigating DBP formation, in collaboration with Curtin University.	Disinfection by-product report for iodide and bromide included in the Operating Performance and Water Quality Report. All I and Br disinfection by-products (Br^- <1mg/L; I^-<0.1 mg/L) rejected by the treatment process.

Noted that an ethyl-bromide product is used for everything leaving Australia as a biosecurity measure what impact could this have upon the final treated water produced by the AWTP.	Nil	Investigation biosecurity product and practice further.	AAD biosecurity.	Michael Packer to chase up AAD biosecurity measures – type of fumigant, amounts used. This information to be used to develop maximum concentrations of trace chemical contamination in source water at Davis.	Main fumigants are Pyrethrum and some methyl bromide. The boiling point of methyl bromide is 3.5˚C, so it is a gas at normal temperatures and as such is unlikely to be present in significant concentrations in the Antarctic. Pyrethrum is safe for use near humans and breaks down quickly in sunlight and is non-persistent in the environment. Pyrethrum is not mentioned in the ADWG.
Does the DAWTP RO system require the use of an antiscalant?	Nil	Review the requirement for the use of an antiscalant for the RO system and if required add to the hazard analysis.	Validation trials to cover this.	Team agreed there are no plans to send antiscalant to Antarctica.	No antiscalant to be used a Davis Station.
The impact on the DAWTP of pH fluctuations.	Nil	Pilot plant testing to determine pH fluctuations impacts upon the AWTP.		pH to be managed through MBR, and calcite filter CCPs.	pH fluctuations between 6.5-7.5 during the demonstration trials did not adversely affect the AWTP. QCP on MBR effluent is pH 6.5 - 7.5.
Residual flame retardant used on the building materials could this be present in the wash down water from cleaning activities?	Assumed that if it was the concentration would most likely be in the nanogram range.	Nil		Jianhua has calculated brominated flame retardants are well below ADWG levels. No work yet done on phosphate based flame retardants. Need full list of flame retardants used by AAD to complete validation work. Source water management through recommendation of appropriate flame retardants, as bioassay work indicates they can pass through process barriers.	There are no special flame retardants used on station, apart from those normally included in building materials and furniture etc. Brominated flame retardants are known to be used at Davis Station as they have been detected in the wastewater.

Workshop and maintenance potential spill volumes?	Assumed based on station knowledge that a glycol spill max. 200lts, hydrocarbon 100lts.		Review of AAD procedures.	Chemical manifest now available from AAD. Uni Melb developing chemical risk decision tree analysis and maximum allowable volumes. To be covered in source water QCP.	AAD has strict procedures for spill clean-up, and these are also covered in the RWQMP. RWQMP report contains QCP for source water control.
Bromide pass through AWTP.	Nil	Pilot plant to test bromide pass through.	Validation trials to cover this.	Victoria University investigating anion migration through process, in collaboration with Curtin University.	Disinfection by-product report for iodide and bromide included in the Operating Performance and Water Quality Report. All I and Br disinfection by-products (Br^- <1mg/L; I^-<0.1 mg/L) rejected by the treatment process.
Risk of release of contaminants from BAC filters during plant shutdown.	Assumed that regular runtime would be every 72 hours when AWTP is operating. During extended shutdown periods the filters are to be aerated and DO monitored to prevent anaerobic conditions developing.	No DO maintaining regular aeration. Part of validation trials.	Risk of release of contaminants from BAC filters during plant shutdown.	BAC is a process control. Manage aeration of BAC filters through SCADA programming, regular checks of SCADA trends.	Aeration of BAC is set in SCADA.

5. Conclusions

Three HACCP workshops were held that identified water quality risks and actions to refine the risk profile. Outcomes from the HACCP workshops are listed below:

- A risk register and decision tree analysis is contained in spreadsheet 'HACCP Workshop Risk Register_30032015.xlsx';
- The pathogen CCP tables contained in the RWQMP;
- The chemical risk decision tree analysis and maximum allowable chemical volumes contained in the "Risk Assessment of Contaminants of Concern Report". The maximum allowable chemical volumes will inform the purchasing of chemicals and the container sizes that AAD will purchase;
- CCP for trace organic chemicals contained in the Risk Assessment of Contaminants of Concern Report;
- Bromide and iodide was dosed into the AWTP to determine the ability of the AWTP to remove brominated and iodated disinfection by-products. The AWTP was able to effectively remove disinfection by-products (maximum dosing levels Br^- <1mg/L; I^-<0.1 mg/L). These results are reported in the Operating Performance and Water Quality Report; and
- Formaldehyde concentrations were significantly below the ADWG limit of 0.5 mg/L, with all concentrations measuring <0.1 mg/L.

6. Appendix A: Report from the chemicals workshop – March 2015

Davis Advanced Water Treatment Plant

HACCP WATER QUALITY RISK ASSESSMENT OUTCOMES

CHEMICAL RISK WORKSHOP – MARCH 2015

Document Number: TBD

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1. Introduction

1.1 Purpose

This document details the outcomes of a ½ day chemical risk review workshop that was conducted for the Australian Antarctic Division (AAD) Davis Advanced Water Treatment (DAWTP) Project. This workshop was held to follow up on the findings of the three day water quality Hazard Analysis and Critical Control Point (HACCP) workshop held in August 2013 and May 2014.

1.2 Summary of Key Risk Findings

The first three days of the HACCP workshop indicated that the treatment capability of the DAWTP should be adequate to control the risks posed from pathogenic microorganisms. However, risk determinations associated with the treatment capability of the DAWTP to control other high ranking risks from chemical water quality hazards, such as, chemicals of concern (CoCs), specific contaminants that may be present in the Davis Station wastewater stream (formaldehyde, antiseptics, glycol, biosecurity residuals etc.) was less clear. It was identified during the first HACCP workshop that knowledge gaps existed and further research was required to reduce the uncertainty associated with some of these risk determinations.

The validation and verification phase of the Robust Recycling project provides the opportunity to gather this information and reduce the risk assessment uncertainty. This is through operation of the DAWTP at TasWater's Self's Point WWTP site.

It was also identified that it is imperative to the implementation of the Davis Station Recycled Water Scheme that the AAD establish a Recycled Water Policy and associated documentation that supports the risk assessment determinations e.g. Davis Station approved chemical product inventory and management / operational procedures, such as, waste management, chemical spill management and return to Australia procedures.

In this follow-up workshop, the chemical risk knowledge gaps were reviewed and updated against:

- the latest DAWTP operating and monitoring data,
- the AAD chemical manifests, and
- a review of current industry knowledge regarding validation of treatment processes for removal of trace chemicals.

1.3 Summary Workshop Activities

The HACCP workshop ("the workshop") was conducted over three days. The first two days were held consecutively on the 5 & 6 August 2013 with the third follow-up meeting on the 6 May 2014. The outcomes from the workshop are summarised below:

Day 1 & 2 (5 & 6 August 2013)

- The team defined the intended use statement;
- The DAWTP flow diagram was confirmed;
- Identification of 124 water quality hazards likely to exist in the Davis Station source water, to be present or occur at each of the treatment process steps. Each of these were risk assessed
- Due to the limited amount of Davis Station water quality data available many of the risk assessment outcomes highlighted areas that required further research to fill knowledge gaps and reduce the uncertainty associated with the risk determinations; and;
- Discussion regarding possible Critical Control Points (CCPs) and Quality Control Points (QCPs) to draft for the team to review.

Note due to time constraints during the initial two day workshop there was no decision made regarding exactly what CCP/QCP plans would be applicable or the detail required e.g. locations, alert/critical limits and monitoring procedures. Following the initial workshop a draft document was issued to the AAD project manager in September 2013 for distribution to attendees for review with a set of potential CCP/QCP Plans for consideration.

Day 3 (May 6 2014)

- Collation of comments from a review of the draft workshop document including the draft CCP/QCP Plans;
- The inclusion of the BAC filter as a QCP or a process control point is still be decided and the associated management strategies required

Day 4 (March 30th 2015)

- Review of the HACCP Water Quality Risk Assessment Outcomes , Section 4.3 (Overall Findings, Hazardous Events, Treatment Capability and Risk Assessment Uncertainty).
- Review of Section 4.4 of HACCP Water Quality Risk Assessment Outcomes document, and recommendations for existing and new CCPs and QCPs.
- Review latest operational and water quality analysis data from the Self's Point DAWTP operations, to address knowledge gaps for various trace chemical contaminants.
- Review AAD chemical manifest and discuss development of Quantitative Chemical Risk Assessment (QCRA), including chemical risk decision tree.

- Review Appendix D (Appendix A of this document) of HACCP Water Quality Risk Assessment Outcomes document and update knowledge gaps and action plan.

1.4 Workshop Attendees

The chemical risk review workshop was held on the 30th March 2015 at the University of Melbourne. The table below provides a listing of the attendees.

Table 1.1: Workshop Attendees 30th March 2015.

Name	Organisation
Kathy Northcott	Veolia
David Sheehan	Coliban Water
Stephen Gray	Victoria University
Peter Scales	The University of Melbourne
Michael Packer	Australian Antarctic Division
Graham Allinson	RMIT
Mayumi Allinson	The University of Melbourne
Jianhua Zhang	Victoria University
Adrian Knight	The University of Melbourne

2. Workshop outcomes

2.1 Risk Assessment Outcomes

At the original HACCP risk workshop there were a total of one hundred and twenty four water quality hazards identified for the Davis Station system that were likely to exist in the DAWTP feedwater. A number of these hazards were identified as being chemical in nature. However, at the time many it was considered there was insufficient knowledge or operating data available to fully quantify the level of risk. The chemical risk workshop on the 30th March 2015 was intended to address these knowledge gaps. The outcome of this workshop is detailed in the following sections.

Overall Findings – Chemical Risks

High ranking water quality risks likely to pass through the MBR process and be present in the DAWTP feedwater during normal routine station operations are from:

- Brominated flame retardant compounds;
- TOC/DOC;
- Colour;
- Pharmaceutical products and metabolites;
- Chemicals of Concern (CoCs) the team considered CoCs broadly as carcinogens, endocrine disruptors and hormones;
- Antiseptics;
- Volatile Organic Carbon (VOCs) water dispersible; and;
- Cleaning products from disposal of field waste.

COCs were originally defined in the first HACCP workshop as being carcinogens, EDCs and hormones. In the March 30th workshop it was agreed that carcinogens would be listed and assessed separately from the other COCs, to enable a more effective risk assessment and management method. Hence the HACCP risk register will be updated to reflect this

Source water risks to pass through the MBR process and pose a moderate risk in the DAWTP feedwater during normal station operations are from:

- Residual cleaning chemicals – ammonia based (all buildings);
- Nutrients (nitrogen and phosphorous) human waste from station, field trip waste disposal and kitchen activities);
- Turbidity;
- Personal hygiene products - surfactants;
- Colour (kitchen activities);

The original Appendix D of the HACCP Water Quality Risk Assessment Outcomes has been included in this document (Appendix A), with the addition of a new column with status of each item as of March 2015.

Hazardous Events Identified

The hazardous events (or abnormal operating conditions) identified contributing to elevated source water or process water chemical risks are:

A station spill event that is not adequately contained or is washed into a drain resulting in the following water quality hazards (contaminants) to enter the wastewater stream:

- Glycol;
- Hydrocarbons from a fuel or oil spill;
- Cleaning products (all products);
- Radioactive material and heavy metals from the science building; and;
- Iron and manganese from a treatment chemical spill.

Bulk disposal via the wastewater stream of unusable food products i.e. out of date or rotten resulting in a slug dose to the system elevating the risk posed by the following water quality hazards:

- Nutrients (nitrogen and phosphorous);
- TOC/DOC;
- Turbidity;
- Colour; and;
- TDS.

Failure of existing RO system providing potable water to the station resulting in an elevated risk from the following water quality hazards:

- Bromide;
- Silica; and;
- Chloride.

Equipment or process failure or suboptimal operating performance resulting in chemical under/dose situation or inadequate/reduced treatment capability e.g. MBR, membrane or disinfection failure.

A further risk identified under the equipment or process failure was breakage of a UV tube in the UV disinfection system, resulting in release of mercury into the product water. This risk will be included and assessed in the updated HACCP risk register.

Treatment Capability

The risk assessment outcome indicated that the DAWTP treatment barriers should adequately control the health risk derived from physical, chemical and radiological source water hazards that pass through the MBR process to the DAWTP feedwater or that may occur at a treatment step. However, in the first HACCP workshop, the team made assumptions regarding some of the risk determinations documented and that further research will be required to fill the knowledge gaps. The updated knowledge gaps and action plan is shown in Appendix A.

The following water quality hazards were identified as occurring during the treatment process.

- The formation of bromate during the ozonation process from bromide in DAWTP feedwater posing a very high risk; and;
- The formation of formaldehyde from aldehyde in the DAWTP feedwater posing a moderate risk.

Risk Assessment Uncertainty

While the source water input and wastewater stream profile was based on firsthand working station knowledge, there remains a degree of uncertainty concerning the dispatch of chemical products, the use of certain products and the disposal or return to Australia policy.

It is imperative to the implementation of the Davis Station Recycled Water Scheme that a Recycled Water Policy is developed by the AAD and is supported by management and operational procedures that are aligned with certain risk determinations. For example,

managing source water inputs through a controlled approved Davis Station chemical/products inventory,

chemical management procedure, such as, onsite storage, handling and use, spill response/containment,

waste management procedures, and,

products for return to Australia procedures.

The establishment of the above and the communication of this information to the DAWTP demonstration operations validation and verification team will assist with reducing the uncertainty associated with certain risk determinations.

The latest version of the AAD chemical inventory was provided to the team for the purpose of the chemical risk workshop. It was agreed that Peter Scales and his team at the University of Melbourne would use this inventory to develop a "QCRA", by:

Preparation of a chemical risk decision tree (or matrix) that can identify chemicals likely to pass through key process barriers, based on typical characteristics (ie molecular weight, charge, solubility etc.)

Calculation of maximum concentrations, based on chemical volumes purchased by the AAD.

Review of COC's, disinfection by-products and other relevant trace organic chemicals against the Self's Point operational data and bioassay results and preparation of chemical removal validation report.

2.2 Identification of CCPs and QCPs

The DAWTP treatment barriers that provide the required removal to guarantee the minimum water quality criteria have all been identified as CCPs. Those barriers in place that are considered crucial to achieving the minimum water quality criteria but did not meet the criteria for a CCP were identified as a QCP. Each of these points within the Davis System are listed below:

CCP – the performance of the MBR process i.e. DAWTP feedwater quality.

CCP - Ozonation – for oxidation and disinfection. It has been recommended this CCP be updated for COCs. In order to do this a validation report needs to be created to provide the relationship between ozone dose relative to removal of trace organic chemicals.

CCP - Microfiltration – for removal of solids and larger microorganisms.

CCP - Reverse Osmosis – for removal of Total Dissolved Solids (TDS) and further removal of organic matter and contaminants e.g. pharmaceuticals, personal hygiene products, chemicals of concern (CoCs) and microorganisms. This CCP will be updated to better demonstrate management of chemical removal.

CCP Ultraviolet radiation – for deactivation and/or kill of pathogenic microorganisms (particularly protozoa);

CCP - Calcite filter – for treated water ion balance and pH adjustment.

CCP - Chlorination – for deactivation and/or kill of pathogen microorganisms.

QCP – The management of source water inputs such as chemicals and other substances (e.g. pharmaceuticals, cleaning products, laboratory chemicals, operation and maintenance products) that are likely to be present and used at the station, kitchen, laboratory, workshop/operations and medical clinic waste management practices, incident and emergency management practices in the event of a spill and the training of staff in the correct use of chemicals/other substances and appropriate station waste management practices;

QCP (New) – Performance of MBR for chemical removal. This would essentially use the same criteria as for the MBR CCP to validate MBR process health. This in turn ensures maximum chemical removal efficacy across the MBR process.

QCP to become Process Control Point: Biologically Activated Carbon filtration – for removal of organic matter and contaminants e.g. pharmaceuticals, personal hygiene products, chemicals of concern (CoCs) – NOTE during the workshop held on the 6 May 2014 the team recommended removing this QCP.

New Process Control Point – MF process management and monitoring to optimise chemical removal potential.

2.3 CCP and QCP Plans

The CCP and QCP Plans for each of the above points are listed below.

CCP – 1: DAWTP Feedwater Quality

CCP – 2: Oxidation Control

CCP – 3: Filtration Control

CCP – 4: Reverse osmosis

CCP – 5: UV disinfection

CCP – 6: Final pH Correction Control

CCP – 7: Chlorination Control

QCP – 1: Source Water Management

QCP – 2: MBR effluent quality management

3. Summary of action plan

The following further work was identified and agreed to in the March 2015 Chemical Risk workshop:

Update HACCP risk register with new items identified in workshop and circulate to team for comment (KN)

Update CCPs and QCPs and circulate for comment (KN)

Update RWQMP with new information on chemical risk management policies and procedures, specifically around source water management (DS)

Identify key chemical risks from AAD chemical manifest via decision tree analysis, and maximum chemical concentrations calculated from volumes on inventory (PJS, AK)

Review Self's Point operational data and bioassay results and prepare validation report for removal of COCs across the process (PJS, GA, MA)

Follow up on disinfection by-product analysis and findings (SG)

Finalise work on impact of trace contamination from flame retardants (JZ)

Development of chemical management procedures based on findings of chemical decision tree analysis, such as maximum chemical container volumes purchased (MP)

Follow up on list of generic medical chemicals (ie antiseptics) and general pharmaceuticals (ie antibiotics), as well as biohazard fumigants used by the AAD (MP)

APPENDIX A

Identified knowledge gaps, risk assumption and additional data/information requirements

Knowledge or Information gap	Assumption	Identified follow-up action from initial workshop	Status of action May 2014	Status of action March 2015
A listing of CoCs (humans) had not been established or water quality data for these types of compounds collected for Davis Station wastewater.	CoCs during the workshop for risk assessment purposes were considered broadly as carcinogens, endocrine disruptors and hormones.	It was suggested a listing of the top 50 compounds tested for by Western Corridor to be used as a guide to test Davis Station wastewater samples. Noted to review products sent down to Davis Station, conduct DALY and screen for these compounds.	New list of CoCs	Split EDCs and hormones from carcinogens in HACCP risk register. Retain the same risk profile for both categories in source water. EDCs to be addressed in ozone and RO CCP. Carcinogens to be addressed in source water QCP.
Volatile Organic Carbons (VOC) a listing of compounds was not available.	VOCs during the workshop were defined as degreasers, paint thinners, noted paints are water dispersible lighter than hydrocarbon and more water soluble.			Chemical manifest now available from AAD. Uni Melb developing chemical risk decision tree analysis and maximum allowable volumes. To be covered in source water QCP.
What types of paints and solvents non water dispersible are used at Davis Station?	Assumed much of the paint is enamel.	Improve understanding of painting and associated products used at Davis Station.		Chemical manifest now available from AAD. Uni Melb developing chemical risk decision tree analysis and maximum allowable volumes. To be covered in source water QCP.
Chemicals that can pass through MBR process (the Davis Station Secondary Wastewater Treatment Plant).	Nil	Further investigation required as to what chemicals can pass through a MBR process – suggested a list from Western Corridor.		Chemical manifest now available from AAD. Uni Melb developing chemical risk decision tree analysis and maximum allowable volumes. To be covered in source water QCP.

Formaldehyde is used at Davis Station for laboratory work would it be removed by AWTP process barriers, pass through or form by-products?	Formaldehyde is used at Davis Station for laboratory work would it be removed by AWTP process barriers, pass through or form by-products?	Formaldehyde is used at Davis Station for laboratory work would it be removed by AWTP process barriers, pass through or form by-products?		Chemical manifest now available from AAD. Uni Melb developing chemical risk decision tree analysis and maximum allowable volumes. To be covered in source water QCP. Victoria University investigating formaldehyde DBP formation, in collaboration with Curtin University.
What dye and other chemicals (e.g. heavy metals) are used in the laboratory?	What dye and other chemicals (e.g. heavy metals) are used in the laboratory?	What dye and other chemicals (e.g. heavy metals) are used in the laboratory?		Chemical manifest now available from AAD. Uni Melb developing chemical risk decision tree analysis and maximum allowable volumes. To be covered in source water QCP.
What radiological compounds are likely to be used at Davis Station for laboratory work and could these appear in the wastewater stream?	What radiological compounds are likely to be used at Davis Station for laboratory work and could these appear in the wastewater stream?	What radiological compounds are likely to be used at Davis Station for laboratory work and could these appear in the wastewater stream?		Chemical manifest now available from AAD. Uni Melb developing chemical risk decision tree analysis and maximum allowable volumes. To be covered in source water QCP.
No information regarding antifoam product constituents used by MBR process.	No information regarding antifoam product constituents used by MBR process.	No information regarding antifoam product constituents used by MBR process.		Review MBR O&M manual – specifically chemical requirements for operation and associated MSDS.
What chemicals can pass through each DAWTP barrier/process?		Improve understanding of what chemicals are likely to pass through each AWTP barrier/process.	Adrian Knight to provide database	University of Melbourne/RMIT to review operational and bioassay data from Self's Point and prepare validation report for trace organic chemicals.

Chemicals likely to be present onsite at Davis Station each year.	General identification of hydrocarbons, paints, glycol, kitchen and general cleaning products, laboratory chemicals etc.	Review of the chemicals that go to Davis Station and use this information to establish a listing of parameters to be tested in the wastewater.	Michael to obtain AAD chemical manifest	Chemical manifest now available from AAD. Uni Melb developing chemical risk decision tree analysis and maximum allowable volumes. To be covered in source water QCP
What antiseptics are used at Davis Station?		Review antiseptic use and determine the constituents e.g. hexachlor or iodine based. If iodine based consider in relation to ozonation and the formation of by-products. Curtin University may be able to provide assistance.	AAD medical	Michael to chase up list of antiseptics used by AAD medical on station
Impact of a slug dose of cleaning products (impact or ammonia based verses chlorine based) on AWTP.	Considered in a spill situation in impact of cleaning chemicals collectively.	It was suggested to separate a spill situation out into impact of ammonia and chlorine based products separately – consider for future risk register review.		Use Ammonia in MBR CCP – create a new QCP for the MBR for control of chemicals. Chlorine can also be addressed through new MBR QCP.
No water quality data for tarn iodine levels.	Nil	Analysis of tarn water and exist RO product water for iodine concentration.	Requires chasing up	Victoria University investigating DBP formation, in collaboration with Curtin University.
Noted that the ceramic membranes that are proposed for use at the ultra-microfiltration barrier/process step have a catalytic effect across membrane surface.	Nil	Research into what by-products may be formed due to the catalytic effect across the ceramic membranes. Testing to be part of the pilot plant studies.		Victoria University investigating DBP formation, in collaboration with Curtin University.
Noted that an ethyl-bromide product is used for everything leaving Australia as a biosecurity measure what impact could this have upon the final treated water produced by the AWTP.	Nil	Investigation biosecurity product and practice further.	AAD biosecurity	Michael Packer to chase up AAD biosecurity measures – type of fumigant, amounts used. This information to be used to develop maximum concentrations of trace chemical contamination in source water at Davis.

Does the DAWTP RO system require the use of an antiscalant?	Nil	Review the requirement for the use of an antiscalant for the RO system and if required add to the hazard analysis.	Validation trials to cover this	Team agreed there are no plans to send antiscalant to Antarctica
The impact on the DAWTP of pH fluctuations.	Nil	Pilot plant testing to determine pH fluctuations impacts upon the AWTP.		pH to be managed through MBR, and calcite filter CCPs.
Residual flame retardant used on the building materials could this be present in the wash down water from cleaning activities?	Assumed that if it was the concentration would most likely be in the nanogram range.	Nil		Jianhua has calculated brominated flame retardants are well below ADWG levels. No work yet done on phosphate based flame retardants. Need full list of flame retardants used by AAD to complete validation work. Source water management through recommendation of appropriate flame retardants, as bioassay work indicates they can pass through process barriers.
Workshop and maintenance potential spill volumes?	Assumed based on station knowledge that a glycol spill max. 200lts, hydrocarbon 100lts.		Review of AAD procedures	Chemical manifest now available from AAD. Uni Melb developing chemical risk decision tree analysis and maximum allowable volumes. To be covered in source water QCP.
Bromide pass through AWTP.	Nil	Pilot plant to test bromide pass through.	Validation trials to cover this.	Victoria University investigating anion migration through process, in collaboration with Curtin University.

Risk of release of contaminants from BAC filters during plant shutdown.	Assumed that regular runtime would be every 72 hours when AWTP is operating. During extended shutdown periods the filters are to be aerated and DO monitored to prevent anaerobic conditions developing.	No DO maintaining regular aeration. Part of validation trials	Risk of release of contaminants from BAC filters during plant shutdown.	BAC is a process control. Manage aeration of BAC filters through SCADA programming, regular checks of SCADA trends.

7. Appendix B: HACCP Meeting 2 Notes

Davis Advanced Water Treatment Plant

HACCP WATER QUALITY RISK ASSESSMENT OUTCOMES

INTERNAL

Document Number: TBD

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<u>Electronic files provided with this document</u> HACCP

workshop risk register_06052014 (excel file) Workshop

Briefing Paper (Final) (PDF file)

CCP-1-1 DAWPT Self's Point Feedwater Quality (PDF file) CCP-

1 DAWTP Feedwater Quality (Davis Station) (PDF file) CCP-2

Oxidation Control (PDF file)

CCP-3 Filtration Control (PDF file)

CCP-4 Primary Disinfection Control (PDF file)

CCP-5 Reverse Osmosis Control (PDF file) CCP-6

Final pH Correction Control (PDF file)

CCP-7 Distribution Chlorine Residual Control (PDF file)

QCP-1 Source Water Input Management (Davis Station) (PDF file)

QCP-2 BAC Filter Performance Management (PDF file)

1 INTRODUCTION

1.1 Purpose

This document details the outcomes of a three day water quality Hazard Analysis and Critical Control Point (HACCP) workshop that was conducted for the Australian Antarctic Division (AAD) Davis Advanced Water Treatment (DAWTP) project.

1.2 Summary of Key Risk Findings

Overall, the HACCP workshop indicated that the treatment capability of the DAWTP should be adequate to control the risks posed from pathogenic microorganisms. However, risk determinations associated with the treatment capability of the DAWTP to control other high ranking risks from chemical water quality hazards, such as, chemicals of concern (CoCs), specific contaminants that may be present in the Davis Station wastewater stream (formaldehyde, antiseptics, glycol, biosecurity residuals etc.) was less clear. It was identified during the workshop that knowledge gaps existed and further research was required to reduce the uncertainty associated with some of these risk determinations. The validation and verification phase provides the opportunity to gather this information and reduce the risk assessment uncertainty through running trials to simulate the Davis Station wastewater stream profile for both normal and abnormal operation conditions. It was also identified that it is imperative to the implementation of the Davis Station Recycled Water Scheme that the AAD establish a Recycled Water Policy and associated documentation that supports the risk assessment determinations e.g. Davis Station approved chemical product inventory and management / operational procedures, such as, waste management, chemical spill management and return to Australia procedures.

1.3 Summary of Workshop Activities

The HACCP workshop (“the workshop”) was conducted over three days. The first two days were held consecutively on the 5 & 6 August 2013 with the third follow-up meeting on the 6 May 2014. The outcomes from the workshop are summarised below:

Day 1 & 2 (5 & 6 August 2013)

- The team defined the intended use statement;
- The DAWTP flow diagram was confirmed;
- Identification of 124 water quality hazards likely to exist in the Davis Station source water, to be present or occur at each of the treatment process steps. Each of these were risk assessed;
- Due to the limited amount of Davis Station water quality data available many of the risk assessment outcomes highlighted areas that required further research to fill knowledge gaps and reduce the uncertainty associated with the risk determinations; and;
- Discussion regarding possible Critical Control Points (CCPs) and Quality Control Points
- (QCPs) to draft for the team to review.

Note due to time constraints during the initial two day workshop there was no decision made regarding exactly what CCP/QCP plans would be applicable or the detail required e.g. locations, alert/critical limits and monitoring procedures. Following the initial workshop a draft document was issued to the AAD project manager in September 2013 for distribution to attendees for review with a set of potential CCP/QCP Plans for consideration.

Day 3 (May 6 2014)

- Collation of comments from a review of the draft workshop document including the draft
- CCP/QCP Plans;
- The inclusion of the BAC filter as a QCP or a process control point is still be decided and the associated management strategies required;

- Limits proposed for the draft CCP Plans;
- A review of process monitoring;
- Discussion concerning the risk assumptions made, the knowledge gaps and the follow-up actions identified in the initial two day workshop; and;
- TasWater's Self's Point wastewater treatment plant (SPWWTP) was identified as the location for the DAWTP demonstration operation site and a point of difference comparison against the Davis Station identified water quality hazards and risk was conducted.

1.4 Workshop Attendees

The initial workshop was held at the University of Melbourne on the 6 and 7 August 2013. The table below provides a listing of the workshop attendees over the two days. The attendance record has been provided Appendix A of this document.

Table 1.1: Workshop Attendees 5 & 6 August 2013.

Name	Organisation Represented	Day of Attendance
Tony Foy	AAD	Day 1
David Waterhouse	AAD	Day 1 & 2
Joe Brennan	AAD	Day 1 & 2
Tim Price	AAD	Day 1 & 2
Peter Scales	University of Melbourne	Day 1 & 2
Michael Packer	AAD	Day 1 & 2
Kathryn Mumford	University of Melbourne	Day 1 & 2
Stephen Gray	University of Victoria	Day 1 & 2
Jianhua Zhang	University of Victoria	Day 1 & 2
Kathy Northcott	Veolia Water Australia	Day 2

The follow up workshop was held on the 6 May 2014 at the AAD Hobart. The table below provides a listing of the attendees.

Table 1.2: Workshop Attendees 6 May 2014.

Name	Organisation Represented
Kathy Northcott	Veolia Water Australia
Adrian Knight	University of Melbourne
Jianhua Zhang	University of Victoria
Stephen Gray	University of Victoria
Michael Packer	AAD
Nicholas Milne	University of Victoria
Colin Ellett	Veolia Water Australia

2 REGULATORY REQUIREMENTS AND OTHER REQUIREMENTS

2.1 Regulatory Environment

For the purpose of this workshop the legal jurisdiction for the DAWTP project falls under the Australian Capital Territory (ACT) government as Antarctica is an Australian Territory. It is noted that the AAD is a Commonwealth Agency and doesn't fall under this jurisdiction. However, should the AAD outsource the operation of the AWTP to a third party (e.g. private water business) the applicable jurisdiction would be that of the ACT government.

2.2 Applicable Drinking Water Legislation

- Australian Capital Territory Public Health Act 1997 Drinking Water Code of Practice 2007

2.3 Reference Legislation

- Victorian Safe Drinking Water Act (2003)
- Victorian Safe Drinking Water Regulations (2005)

2.4 Australian Guidelines

- Australian Drinking Water Guidelines 2011(ADWG)
- Australian Guidelines for Recycled Water: Phase 2 Augmentation of Drinking Water Supplies 2008 (AGRW)

2.5 Intended Use Statement

The intended use of the water produced by the DAWTP is to provide an optional/supplementary potable water supply for the purposes described below.

General Use – potable water quality for station usage e.g. kitchen, personal hygiene (washing, showering, laundry), laboratory work, medical purposes, workshop (operations and maintenance) and hydroponics.

Consumption – potable water quality for consumption by the station population and for the preparation of food.

3 WORKSHOP METHOD

The HACCP and risk assessment method was based upon the ADWG Framework element two (assessment of the drinking water supply system) and element three (preventative measures for drinking water quality management). Reference was made to the AGRW Phase 2 for specific descriptors for health qualitative measures of likelihood, consequence and impact.

The approach taken during the HACCP workshop was unconventional due to the limited amount of water quality data available for the Davis Station system. A conventional HACCP process is usually supported by a vast array of water quality data generated over a period of time, in some cases decades, for various locations within a water supply system. This was not the case for the Davis Station system. The water quality data that existed was from a few Davis Station sampling events that provided a snapshot of the chemical contaminants that were present in the wastewater at that point in time and a quantitative microbial risk assessment (QMRA) conducted by the University of Melbourne.

In contrast to a conventional water quality system assessment, the physical isolation of the Davis Station system was unique and because of this the source water inputs were well known to AAD personnel. The AAD is the only source of the contaminants likely to be in the wastewater, as all products that are present at the station are shipped there by the AAD and used by AAD personnel. No other source water inputs exist controlled or uncontrolled. For this reason it was important that the HACCP team assembled consisted of AAD personnel with firsthand operational knowledge regarding the products that are shipped to Davis Station, the application of the products and the potential that these products have to enter the wastewater stream. This enabled a desktop HACCP process to be conducted that did not rely on data from a comprehensive water quality assessment. The team was able to construct a source water input and wastewater stream profile to identify the potential water quality hazards likely to exist in the DAWTP feedwater, assess the risks posed by each of these hazards and capability of the DAWTP to manage/control these risks.

The HACCP workshop source water input and wastewater stream profile was used to select an equivalent mainland location to commission, validate and verify the performance of the DAWTP.

3.1 Workshop Key Definitions

The following is a list of key definitions used during the workshop.

Hazard – A hazard is a biological, chemical, physical or radiological agent that has the potential to cause harm (ADWG, 2011).

Hazardous Event – A hazardous event is an incident or situation that can lead to the presence of a hazard (what can happen and how) (ADWG, 2011).

Risk – is the likelihood of identified hazards causing harm in exposed populations in a specified timeframe, including the severity of the consequences (ADWG, 2011).

Maximum Risk – risk in the absence of preventative (control) measures (AGRW, 2008).

Residual Risk – risk remaining after consideration of existing preventative (control) measures (AGRW, 2008).

Critical Control Point (CCP) – is defined as an activity, procedure or process at which control can be applied and which is essential to prevent a hazard or reduce it to an acceptable level (ADWG, 2011).

Quality Control Point (QCP) – is defined as a management process or step rather than operational control or it may be an operational process/step that has limited capacity to be monitored and/or corrective action to be taken in a timely manner.

3.2 Hazard Identification

The identification of the hazards likely to exist for the source water and to occur or be present at each of the system process steps was based upon the use of the following information:

- The quantitative microbial risk assessment (QMRA) that was undertaken to determine the pathogen reduction requirements for direct potable reuse at Davis Station (Baker et al 2012);
- The water quality data from samples collected at Davis Station – refer to workshop briefing paper Appendix B of this document.
- The firsthand working station knowledge provided by the AAD personnel attending the workshop.
- The expert opinion and knowledge provided by the scientific and technical workshop attendees experienced in the fields of water treatment and water quality.

3.3 Risk Assessment

The following tables were used during the workshop to conduct a qualitative risk assessment to determine maximum (or inherent) and residual risk. Due to small scale of the Davis Station AWTP system and population served the workshop attendees agreed that when attributing consequence catastrophic equated to one death and a major impact was greater than one third of the population affected.

Table 3.1 Qualitative measures of likelihood (ADWG, 2011)

Level	Descriptor	Example description
A	Almost certain	Is expected to occur in most circumstances *(Is expected to occur, with a probability of multiple occurrences within a year)*
B	Likely	Will probably occur in most circumstances *(Will occur within a 1-5 year period)*
C	Possible	Might occur or should occur at sometime *(Might occur or should be expected to occur within a 5-10 year period)*
D	Unlikely	Could occur at sometime *(Could occur within 20 years or in unusual circumstances)*
E	Rare	May occur in exceptional circumstances *(May occur only in exceptional circumstances; may occur once in 100 years)*

Parenthesis contains information from the ARWG Phase 2 (2008) for qualitative measures of likelihood.

Table 3.2 Qualitative measures of consequence or impact (ADWG, 2011)

Level	Descriptor	Example description
1	Insignificant	Insignificant impact, little disruption to normal operation, low increase in normal operational costs (Insignificant impact or not detectable)
2	Minor	Minor impact for small population, some manageable operation disruption, some increase in operational costs (Health – minor impact for small population)
3	Moderate	Minor impact for large population, significant modification to normal operation but manageable, operation costs increased, increased monitoring (Health – minor impact for large population)
4	Major	Major impact for small population, systems significantly compromised and abnormal operation if at all, high level of monitoring required (Health – major impact for small population)
5	Catastrophic	Major impact for large population, complete failure or systems (Health – major impact for large population)

Parenthesis contains information from the ARWG Phase 2 (2008) for health qualitative measures of consequence or impact.

Table 3.3 Qualitative risk analysis matrix: level of risk classification (ADWG, 2011)

Likelihood	Consequences				
	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
A (almost certain)	Moderate	High	Very High	Very High	Very High
B (likely	Moderate	High	High	Very High	Very High
C (possible)	Low	Moderate	High	Very High	Very High
D (unlikely)	Low	Low	Moderate	High	Very High
E (rare)	Low	Low	Moderate	High	High

3.3.1 *Determining CCPs and QCPs*

The ADWG details the criteria that a preventative measure must meet for selection as a CCP. A CCP has several operational requirements, including:

- Operational parameters that can be measured and for which critical limits can be set to define the operational effectiveness of the activity (e.g. chlorine residuals for disinfection)
- Operational parameters that can be monitored frequently enough to reveal any failures in a timely manner (online and continuous monitoring is preferable)
- Procedures for corrective action that can be implemented in response to deviation from critical limits.

The ADWG provides a critical control point decision tree this was used to determine the potential CPPs applicable to the operation of the Davis Station AWTP.

Where preventative (control) measures do not meet the criteria for CCP, however, were still considered important operational/process steps to ensuring the quality of the final product these points were termed Quality Control Points (QCPs).

4 WORKSHOP OUTCOMES

4.1 System Flow Diagram

A simplified flow diagram taken from drawing 271202-04R3 was tabled at the initial workshop (5 & 6 August 2013) for confirmation prior to commencing the hazard identification and risk assessment process. There were several changes and additions made to the diagram. The follow up workshop (6 May 2014) reviewed an amended the system flow diagram once again to accommodate the demonstration operation site at Self's Point. A system flow diagram for both the Davis Station system and the Self's Point system has been included as Appendix C of this document.

4.2 Water Quality Characteristics

The HACCP workshop held on the 6 May 2014 reviewed the water quality characteristics presented in the workshop briefing paper for the Davis Station system with additional information supplied and comments provided from team members. The revised water quality characteristics tables are presented in the sections below. A comprehensive water quality assessment will be required for the selected demonstration operation water system and this will occur during the commissioning, validation and verification phase.

4.2.1 *DAWTP Feedwater Quality*

The table below presents the minimum standard MBR effluent quality required as DAWTP feedwater. The parameters marked * are expected values and the parameters marked # are the DAWTP design feedwater quality specifications, and therefore, the MBR effluent must meet this criteria.

Table 4.1: DAWTP Feedwater Quality (minimum standard MBR effluent requirements)

Parameter	Value
Biochemical Oxygen Demand (BOD5)*	<20mg/L
Suspended Solids (SS)*	<10mg/L
*E.coli**	>3 log reduction (drawing 271201-04R3 states 1 log reduction)
Total Nitrogen (TN)*	<10mg/L
Turbidity#	Max: 1NTU
pH#	Min: 6 Max: 8
Ammonia#	<5mg/L
Phosphorous#	<5mg/L
Bromide#	Upper limit for bromide to be calculated
True colour#	<10NTU
TOC / DOC#	<10mg/L

*extracted from the AAD document titled *"User Requirements Specification Davis Waste Water (Secondary) Treatment Plant Project"*.
#extracted from the AAD document titled "Davis Advanced Water Treatment Plant – Functional Description"

4.2.2 *DAWTP Final Treated Water Quality*

The table below presents the DAWTP final treated water quality specifications reviewed by the team during the HACCP workshop. This information was sourced from the AAD document titled Davis Advanced Water Treatment Functional Description.

Table 4.2: DAWTP final treated water quality specification

Parameter	Minimum Value	Maximum Value	Units
Turbidity	-	0.05	NTU
pH	6	8	Units
Chlorine residual (free)	0.05	-	mg/L
Alkalinity	40	-	Mg/LCaCO 3
Total Dissolved Solids (TDS)		500	mg/L
Iron	-	0.05	mg/L
Manganese	-	0.02	mg/L
Aluminium	-	0.1	mg/L
Ammonia	-	0.1	mg/L
Bromate	-	0.02	mg/L
Colour	-	5	HU
Taste and Odour	-	Acceptable	N/A
Total coliforms	-	0	orgs/100mL
E.coli	-	0	org/100mL
THMs	-	0.2	mg/L

The table below presents the minimum pathogen LRV required for the DAWTP final treated water to control the health risks derived from pathogenic microorganisms.

Table 4.3: Required minimum pathogen LRV for DAWTP final treated water

Pathogen	Minimum pathogen LRV	Comment
Viruses	13	Required LRV for norovirus from study by Baker et al. 2012
Bacteria	13	Required LRV 8.1 for Campylobacter from ARWG Phase 2 (2008)
Protozoa	10.5	Required 10.2 for Giardia from study by Baker et al. 2012
Helminths	6	Required LRV for helminths for augmented drinking water supplies at the Western Corridor Recycled Water Scheme

4.3 Risk Assessment Outcomes

There were a total of one hundred and twenty four water quality hazards identified for the Davis Station system that were likely to exist in the DAWTP feedwater, to be present at or to occur at each treatment step. These are discussed further in each of the sections below.

4.3.1 *Overall findings*

During normal routine station operations the highest ranking source water risks to pass through the MBR process into the DAWTP feedwater is from pathogenic microorganisms - bacteria, viruses, protozoa and helminths. Identification of specific target pathogens was not part of the HACCP workshop this is expected to occur during the validation and verification phase.

Other **high** ranking water quality risks likely to pass through the MBR process and be present in the DAWTP feedwater during normal routine station operations are from:

- Brominated flame retardant compounds;
- TOC/DOC;
- Colour;
- Pharmaceutical products and metabolites;
- Chemicals of Concern (CoCs) the team considered CoCs broadly as carcinogens, endocrine disruptors and hormones;
- Antiseptics;
- Volatile Organic Carbon (VOCs) water dispersible; and;
- Cleaning products from disposal of field waste.

Source water risks to pass through the MBR process and pose a **moderate** risk in the DAWTP feedwater during normal station operations are from:

- Residual cleaning chemicals – ammonia based (all buildings);
- Nutrients (nitrogen and phosphorous) human waste from station, field trip waste disposal and kitchen activities);
- Turbidity;
- Personal hygiene products - surfactants;
- Colour (kitchen activities);

- Antibiotics – including penicillin as an allergen;
- Bacteria from yeast cultures;
- Formaldehyde;
- Dye residual and chemical products; and;
- Bromine – release of spa water to wastewater stream.

4.3.2 *Hazardous Events Identified*

The hazardous events (or abnormal operating conditions) identified contributing to elevated source water or process water risks are:

- A gastrointestinal disease outbreak at the station resulting in the wastewater stream having an elevated pathogenic microorganism loading;
- A station spill event that is not adequately contained or is washed into a drain resulting in the following water quality hazards (contaminants) to enter the wastewater stream:
  - Glycol;
  - Hydrocarbons from a fuel or oil spill;
  - Cleaning products (all products);
  - Radioactive material and heavy metals from the science building; and;
  - Iron and manganese from a treatment chemical spill.
- Bulk disposal via the wastewater stream of unusable food products i.e. out of date or rotten resulting in a slug dose to the system elevating the risk posed by the following water quality hazards:
  - Nutrients (nitrogen and phosphorous);
  - TOC/DOC;
  - Turbidity;
  - Colour; and;
  - TDS.
- Failure of existing RO system providing potable water to the station resulting in an elevated risk from the following water quality hazards:
  - Microorganisms;
  - Bromide;
  - Silica; and;
  - Chloride.
- Equipment or process failure or suboptimal operating performance resulting in chemical under/dose situation or inadequate/reduced treatment capability e.g. MBR, membrane or disinfection failure.

4.3.3 *Treatment Capability*

The outcome of the risk assessment indicated that the DAWTP treatment barriers will adequately control the health risk derived from the microorganism risks present under normal station operations and during a gastrointestinal disease outbreak at the station affecting a third of the population. The table below is a revised LRV listing for the DAWTP current as of 6 May 2014.

Table 4.4: Required minimum pathogen LRV for DAWTP final treated water

Barrier	Pathogen	LRV Required	
Whole Plant	Viruses	13	
	Bacteria	13	
	Protozoa	10.5	
		LRV Attainable	LRV Claimed
Barrier 1 - Ozonation	Viruses	> 4	4
	Bacteria	> 4	4
	Protozoa	> 2	0.5
Barrier 2 - CM	Viruses	> 4	0
	Bacteria	> 4	0
	Protozoa	> 4	4
Barrier 4 - RO	Viruses	> 4	1
	Bacteria	> 4	1
	Protozoa	> 4	2
Barrier 5 - UVD	Viruses	> 4	4
	Bacteria	> 4	4
	Protozoa	> 4	4
Barrier 6 - Chlorination	Viruses	> 4	4
	Bacteria	> 4	4
	Protozoa	0	0

Note: The MBR system is used prior to the current plant and will provide 2 LRV. It is not tested as part of this system. Barrier 3 (BAC) provides no LRV credits.

The risk assessment outcome indicated that the DAWTP treatment barriers should adequately control the health risk derived from physical, chemical and radiological source water hazards that pass through the MBR process to the DAWTP feedwater or that may occur at a treatment step. However, it must be noted that the team made assumptions regarding some of the risk determinations documented and that further research will be required to fill the knowledge gaps and reduce the risk assessment uncertainty (refer to section 4.3.4).

The following water quality hazards were identified as occurring during the treatment process.

- The formation of bromate during the ozonation process from bromide in DAWTP
- feedwater posing a very high risk; and;
- The formation of formaldehyde from aldehyde in the DAWTP feedwater posing a moderate risk.

4.3.4 *Risk Assessment Uncertainty*

Due to the limited water quality data available for the Davis Station system assumptions were made for some of the risk determinations. In some cases, the risk was yet to be determined due to knowledge gaps and the need for additional research. This has created varying degrees of uncertainty associated with the risk assessment outcomes and this is expected to be addressed during the validation and verification process. The risk assumptions, knowledge gaps and follow up actions required are highlighted on the final risk register against the related hazard/risk and a listing has been provided as Appendix D of this document.

While the source water input and wastewater stream profile was based on firsthand working station knowledge, there remains a degree of uncertainty concerning the dispatch of chemical products, the use of certain products and the disposal or return to Australia policy. It is imperative to the implementation of the Davis Station Recycled Water Scheme that a Recycled Water Policy is developed by the AAD and is supported by management and operational procedures that are aligned with certain risk determinations. For example,

- managing source water inputs through a controlled approved Davis Station chemical/products inventory,
- chemical management procedure, such as, onsite storage, handling and use, spill response/containment,
- waste management procedures, and,
- products for return to Australia procedures.

The establishment of the above and the communication of this information to the DAWTP demonstration operations validation and verification team will assist with reducing the uncertainty associated with certain risk determinations.

4.4 Identification of CCPs and QCPs

The DAWTP treatment barriers that provide the required removal to guarantee the minimum water quality criteria have all been identified as CCPs. Those barriers in place that are considered crucial to achieving the minimum water quality criteria but did not meet the criteria for a CCP were identified as a QCP. Each of these points within the Davis System are listed below:

- **CCP** – the performance of the MBR process i.e. DAWTP feedwater quality;
- **CCP** - Ozonation – for oxidation and disinfection;
- **CCP** - Microfiltration – for removal of solids and larger microorganisms;
- **CCP** - Reverse Osmosis – for removal of Total Dissolved Solids (TDS) and further removal of organic matter and contaminants e.g. pharmaceuticals, personal hygiene products, chemicals of concern (CoCs) and microorganisms;
- **CCP** Ultraviolet radiation – for deactivation and/or kill of pathogenic microorganisms (particularly protozoa);
- **CCP** - Calcite filter – for treated water ion balance and pH adjustment.
- **CCP** - Chlorination – for deactivation and/or kill of pathogen microorganisms and provision of disinfection residual to prevent/control regrowth or recontamination of the final treated water in storage or in the distribution.
- **QCP** – The management of source water inputs such as chemicals and other substances (e.g. pharmaceuticals, cleaning products, laboratory chemicals, operation and maintenance products) that are likely to be present and used at the station, kitchen, laboratory, workshop/operations and medical clinic waste management practices, incident and emergency management practices in the event of a spill and the training of staff in the correct use of chemicals/other substances and appropriate station waste management practices; and;
- **QCP** - Biologically Activated Carbon filtration – for removal of organic matter and contaminants e.g. pharmaceuticals, personal hygiene products, chemicals of concern (CoCs) – **NOTE** during the workshop held on the 6 May 2014 the team recommended removing this QCP.

4.5 CCP and QCP Plans

The CCP and QCP Plans for each of the above points are listed below and provided as electronic files with this document.

- CCP – 1: DAWTP Feedwater Quality
- CCP – 2: Oxidation Control
- CCP – 3: Filtration Control
- CCP – 4: Primary Disinfection Control
- CCP – 5: Reserve Osmosis Control

- CCP – 6: Final pH Correction Control
- CCP – 7: Distribution Control
- QCP – 1: Source Water Management
- QCP – 2: Biologically Activated Carbon Filter Performance (this may not be required)

The CCP Plan alert and critical limits have been derived from the DAWTP functional specification and recommended ADWG values. These are to be trialled during the validation and verification process. The version of the CCP Plans issued with this document contain references for some of the limits proposed, this was to ensure the knowledge related to the basis of each of the values was retained.

5 DAWTP DEMONSTRATION OPERATIONS

The one day follow up workshop held on the 6 May 2014 confirmed the selection Self's Point Wastewater Treatment (SPWWTP), Newtown, Hobart, as the site for the demonstration operations location. The other locations reviewed earlier (in December 2013 and January 2014) were Cambridge and Macquarie Point Wastewater Treatment Plants. The objective was to select a mainland location (Hobart) with a wastewater stream that best fit the Davis Station source water characteristics. That being predominately domestic in composition with some form chemical composition that would undergo secondary treatment (to simulate the MBR process stage at Davis Station) prior to feeding the DAWTP. The team selected SPWWTP, as the catchment is predominately domestic with one tradewaste customer a diary manufacturer and a hospital. A point of difference comparison was undertaken by the team on the 6 May 2014 to compare the source water hazards identified for the Davis Station system and the likely occurrence of similar hazards and risk scoring at Self's Point. This comparison has been provided electronically with this document (refer to excel workbook titled HACCP workshop risk register_06052014.xlsx). The team concluded that a similar water quality hazard and risk profile existed and that SPWWTP would be a suitable site for the DAWTP demonstration operation. A comprehensive water quality assessment will be conducted as part of the validation and verification of the plant performance.

During demonstration operations the DAWTP feedwater will be SPWWTP effluent that has undergone secondary treatment and clarification. The DAWTP feedwater will be pumped from the effluent channel pre- UV disinfection. The intake to the DAWTP will be fitted with a screen that is able to be backwashed, removing some of the larger materials that may be still present in the water.

A CPP Plan for the Self's Point Feedwater Quality is required for the demonstration operations period. This has been provided as an electronic file with this document. All the other DAWTP CCP Plans remain applicable to the demonstration operations period.

The DAWTP demonstration operations phase at Self's Point is expected to provide the data and information required to fill the identified knowledge gaps, confirm assumptions made by the team during the risk assessment process and reduce the uncertainty associated with some of the risk determinations. It is expected that this will occur through a series of experimental trials to simulate scenarios that may occur at Davis Station and potentially pose a significant risk to the DAWTP final treated water quality produced. Some examples are given below,

- Understanding the fate through the DAWTP and health implications of CoCs, VOCs, formaldehyde, bromide, antiseptics and any antifoaming product that maybe used.
- Understanding of the chemicals that may pass through the MBR into the DAWTP feedwater;
- Understanding of the chemicals or the by-products that may pass through the DAWTP and be present in the final treated water; and;
- Simulation of hazardous events, such as, station chemical spills or poor waste management practices to understand the risk posed to the DAWTP final treated water quality.

6 CONCLUSION

In summary, the desktop HACCP workshop provided a good knowledge base concerning the Davis Station source water inputs and wastewater stream profile given the limited water quality data that was available.

However, there was a degree of uncertainty associated with certain risk determinations and it is expected that the DAWTP demonstration operations validation and verification phase will address the identified knowledge gaps with further research and simulation of Davis Station scenarios. The outcomes of the validation and verification phase and the development by the AAD a Davis Station Recycled Water Policy that is supported by a set of detailed management and operational procedures should provide the required information to build a robust final Davis Station water system risk assessment. Therefore, it is recommended that the risk assessment is reviewed again by the team during a one to two day workshop following the completion of the validation and verification phase.

7 REFERENCE

Australian Antarctic Division (2012), User Requirements Specification Davis Waste Water (Secondary) Treatment Plant Project. Version 1.0.

Australian Antarctic Division (2013), Davis Advanced Water Treatment Plant Functional Description. Version 0.5.

Baker SF, Packer M, Scales PJ, Gray S, Snape I and Hamilton AJ (2012), Manuscript for publication titled Pathogen reduction requirements for direct potable reuse in Antarctica: evaluating human health risks in small communities.

NHMRC (2011), Australian Drinking Water Guidelines. Canberra, ACT, National Health and Medical Research Council, Natural Resource Management Ministerial Council.

NRMMC, EPHC, NHMRC (2008), Australian Guidelines for Water Recycling: managing health and environmental risks (Phase 2): Augmentation of drinking water supplies. National Water Quality Management Strategy. Natural Resource Management Ministerial Council, Environment Protection and Heritage Council, National Health and Medical Research Council, Canberra.

APPENDIX A

Risk assessment team attendance record (5 & 6 August 2013)

Record of Attendees

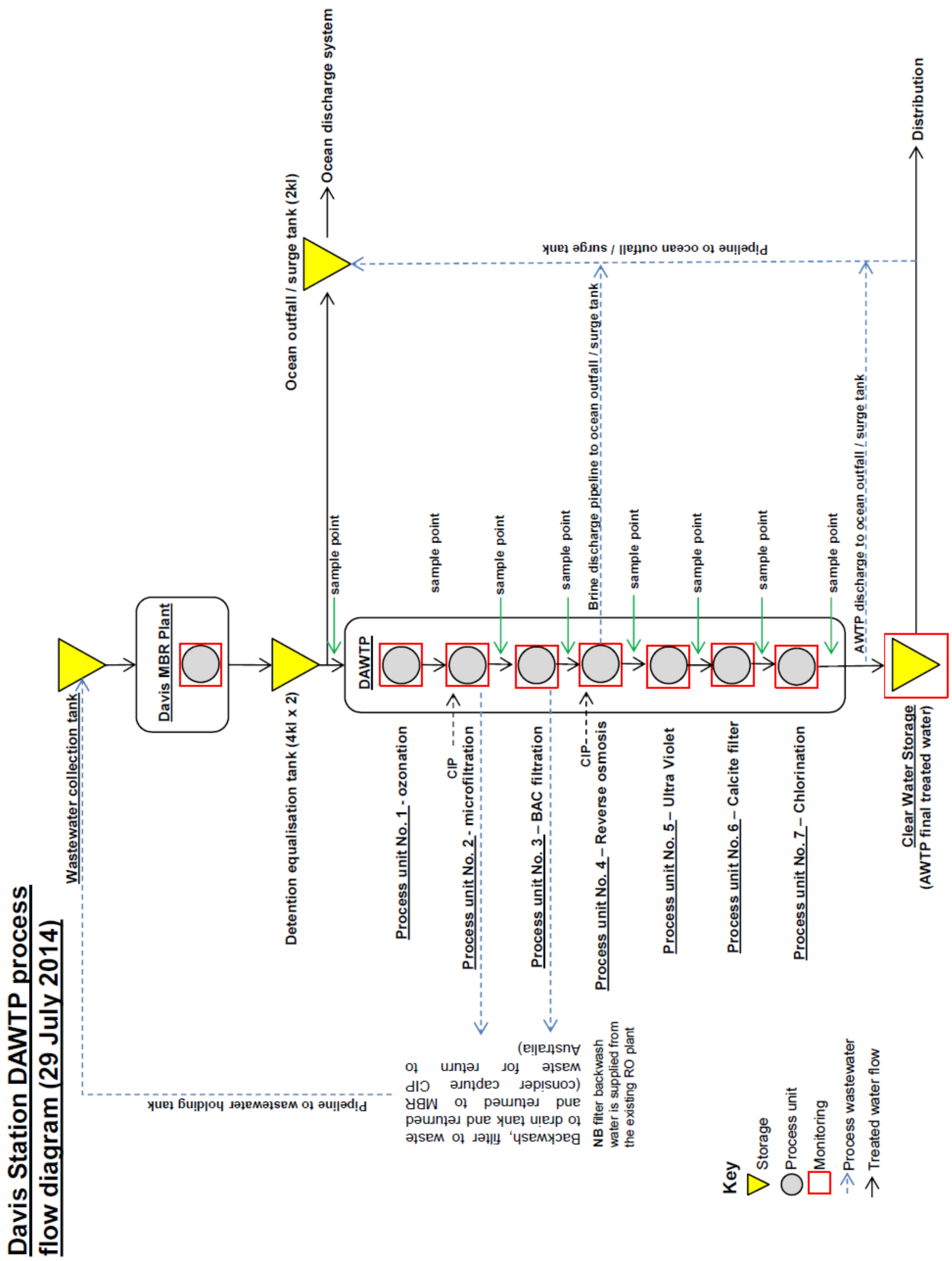
Full Name	Organisation	Signature	
1. Tony Fox.	AAD	[signature]	Day 1
2. David Waterhouse	AAD	[signature]	1+2
3. JOE BRENNAN	AAD	[signature]	1+2
4. Tim PRICE	AAD	[signature]	1+2
5. Peter Scales	Uni Melb	[signature]	1+2
6. Michael Packer	AAD	[signature]	1+2
7. Kathryn Mumford	Uni Melb	[signature]	1+2
8. Stephen Gray	Vic Uni	[signature]	1+2
9. Jianhua Zhang	Vic Uni		1+2
10. Day 2			
11.			
12. KATHY Duthcott	UWA.	[signature]	Day 2
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			

APPENDIX B

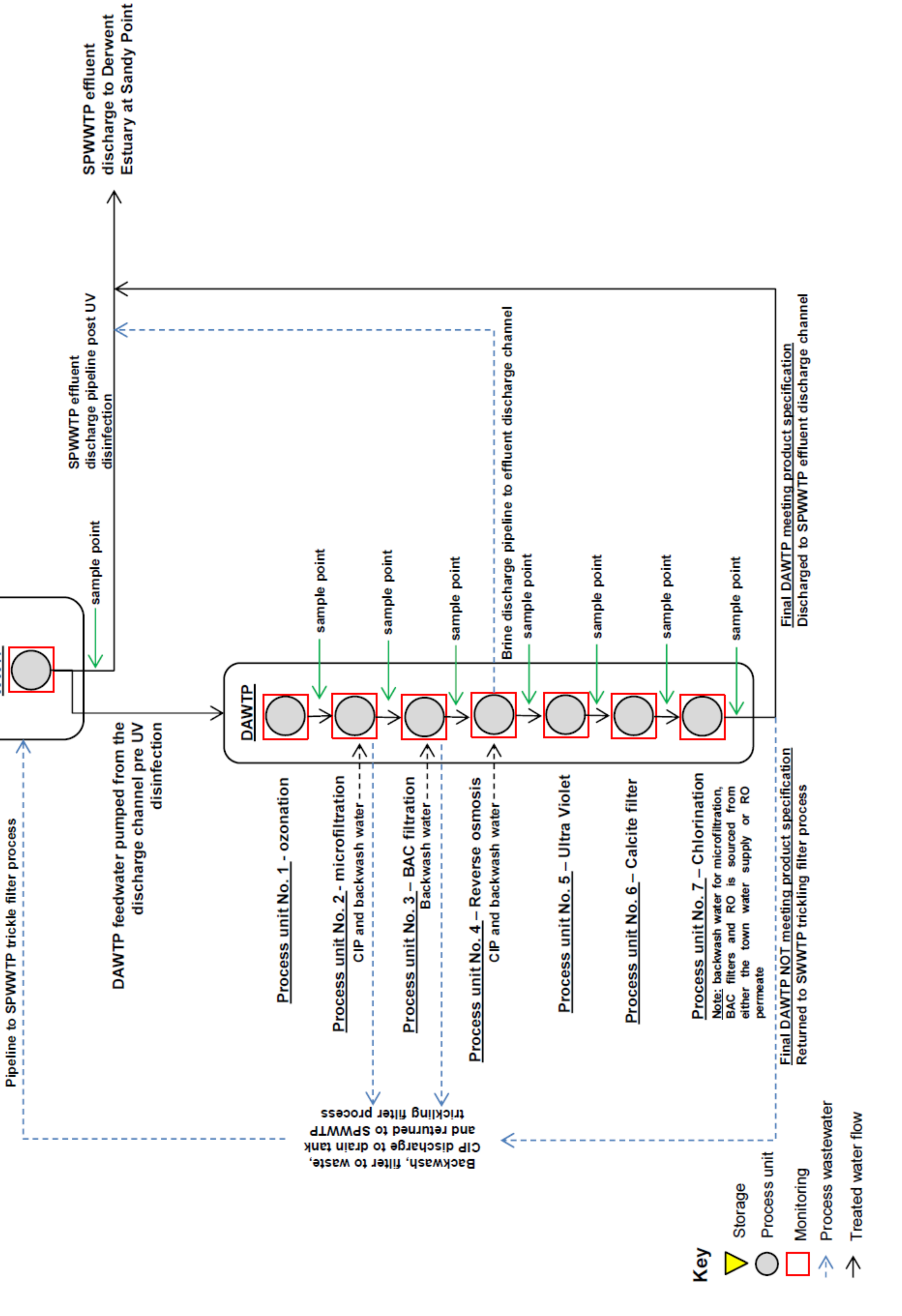
HACCP Briefing Paper

APPENDIX C

System Flow Diagrams



Self's Point DAWTP demonstration operations process flow diagram



APPENDIX D

Identified knowledge gaps, risk assumption and additional data/ information requirements

Knowledge or information gap	Assumption	Identified follow up action from initial workshop	Status of action 6 May 2014
A listing of CoCs (humans) had not been established or water quality data for these types of compounds collected for Davis Station wastewater.	CoCs during the workshop for risk assessment purposes were considered broadly as carcinogens, endocrine disruptors and hormones.	It was suggested a listing of the top 50 compounds tested for by Western Corridor to be used as a guide to test Davis Station wastewater samples. Noted to review products sent down to Davis Station, conduct DALY and screen for these compounds.	New list of CoCs
Volatile Organic Carbons (VOC) a listing of compounds was not available.	VOCs during the workshop were defined as degreasers, paint thinners, noted paints are water dispersible lighter than hydrocarbon and more water soluble.		AAD Engineer
What types of paints and solvents non water dispersible are used at Davis Station?	Assumed much of the paint is enamel.	Improve understanding of painting and associated products used at Davis Station.	Adrian Knight to provide a list
Chemicals that can pass through MBR process (the Davis Station Secondary Wastewater Treatment Plant).	Nil	Further investigation required as to what chemicals can pass through a MBR process – suggested a list from Western Corridor.	AAD Science
Formaldehyde is used at Davis Station for laboratory work would it be removed by AWTP process barriers, pass through or form by-products?	During workshop assumed it would be processed by MBR, ozonation and BAC process barriers.	It was suggested confirmation of assumption through literature review and Davis Station wastewater sample analysis to understand if formaldehyde is a source water input or if it is managed within the laboratory through collection and return to Australia practices. Melbourne Water may be able to assist with further information.	AAD Science

Knowledge or information gap	Assumption	Identified follow up action from initial workshop	Status of action 6 May 2014
What dye and other chemicals (e.g. heavy metals) are used in the laboratory?	Nil	Suggested further investigation of the laboratory chemicals and consider including in the Waste Management Plan both environmental and human health impacts of compounds (particularly those to be disposed of via the wastewater stream).	AAD Science
What radiological compounds are likely to be used at Davis Station for laboratory work and could these appear in the wastewater stream?	Assumed laboratory practices would prevent entry into wastewater stream.	It was suggested further investigation into what radiological compounds are used for laboratory work at Davis Station and what management policy and practice used.	AAD Science
No information regarding antifoam product constituents used by MBR process.	The risk ratings for this hazard is blank and will be populated once the product is further investigated.	Investigate MBR antifoaming product and determine constituents and impact upon AWTP processes and final treated water.	Michael ????
What chemicals can pass through each DAWTP barrier/process?		Improve understanding of what chemicals are likely to pass through each AWTP barrier/process.	Adrian Knight to provide database
Chemicals likely to be present onsite at Davis Station each year.	General identification of hydrocarbons, paints, glycol, kitchen and general cleaning products, laboratory chemicals etc.	Review of the chemicals that go to Davis Station and use this information to establish a listing of parameters to be tested in the wastewater.	Michael to obtain AAD chemical manifest

Knowledge or information gap	Assumption	Identified follow up action from initial workshop	Status of action 6 May 2014
What antiseptics are used at Davis Station?		Review antiseptic use and determine the constituents e.g. hexachlor or iodine based. If iodine based consider in relation to ozonation and the formation of by-products. Curtin University may be able to provide assistance.	AAD medical
Impact of a slug dose of cleaning products (impact or ammonia based verses chlorine based) on AWTP.	Considered in a spill situation in impact of cleaning chemicals collectively.	It was suggested to separate a spill situation out into impact of ammonia and chlorine based products separately – consider for future risk register review.	
No water quality data for tarn iodine levels.	Nil	Analysis of tarn water and exist RO product water for iodine concentration.	Requires chasing up
Noted that the ceramic membranes that are proposed for use at the ultra-microfiltration barrier/process step have a catalytic effect across membrane surface.	Nil	Research into what by-products may be formed due to the catalytic effect across the ceramic membranes. Testing to be part of the pilot plant studies.	
Noted that an ethyl-bromide product is used for everything leaving Australia as a biosecurity measure what impact could this have upon the final treated water produced by the AWTP.	Nil	Investigation biosecurity product and practice further.	AAD biosecurity
Does the DAWTP RO system require the use of an antiscalant?	Nil	Review the requirement for the use of an antiscalant for the RO system and if required add to the hazard analysis.	Validation trials to cover this
The impact on the DAWTP of pH fluctuations.	Nil	Pilot plant testing to determine pH fluctuations impacts upon the AWTP.	

Knowledge or information gap	Assumption	Identified follow up action from initial workshop	Status of action 6 May 2014
Residual flame retardant used on the building materials could this be present in the wash down water from cleaning activities?	Assumed that if it was the concentration would most likely be in the nanogram range.	Nil	
Workshop and maintenance potential spill volumes?	Assumed based on station knowledge that a glycol spill max. 200lts, hydrocarbon 100lts.		Review of AAD procedures
Bromide pass through AWTP.	Nil	Pilot plant to test bromide pass through.	Validation trials to cover this.
Risk of release of contaminants from BAC filters during plant shutdown.	Assumed that regular runtime would be every 72 hours when AWTP is operating. During extended shutdown periods the filters are to be aerated and DO monitored to prevent anaerobic conditions developing.		No DO maintaining regular aeration. Part of validation trials

8. Appendix C: HACCP meeting 1

HACCP Workshop Outcomes Report

Davis Station Advanced Water Treatment Plant

Workshop dates 6 and 7 August 2013

Prepared for

Australian Antarctic Division

HACCP Workshop Outcomes Report

Davis Station Advanced Water Treatment Plant

Prepared for

Australian Antarctic Division

Prepared by

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Issued

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Document version

DRAFT

Electronic files provided with this report

HACCP Workshop Risk Register_FINAL (excel file)

CCP-1 AWTP Feedwater Quality (word and PDF file)

CCP-2 Oxidation Control (word and PDF file)

CCP-3 Filtration Control (word and PDF file)

CCP-4 Primary Disinfection Control (word and PDF file)

CCP-6 Final pH Correction Control (word and PDF file)

CCP-7 Distribution Chlorine Residual Control (word and PDF file)

QCP-1 Source Water Input Management (word and PDF file)

QCP-2 BAC Filter Performance Management (word and PDF file)

Contents

ABBREVIATIONS

AAD	Australian Antarctic Division
ACT	Australian Capital Territory
ADWG	Australian Drinking Water Guidelines
AGRW	Australian Guidelines for Recycled Water
AWTP	Advanced Water Treatment Plant
BAC	Biologically Activated Carbon
BOD_5	Biological Oxygen Demand (five day test)
CCP	Critical Control Point
CoCs	Chemicals of Concern
CT	Contact Time or expressed as *Ct*
DOC	Dissolved Organic Carbon
DPR	Direct Potable Reuse
HACCP	Hazard Analysis Critical Control Point
LRV	Log Reduction Value
LQ	Living Quarters
OPS	Operations
PBDE	Polybrominanted diphenyl ethers
PDT	Pressure Decay Test
QCP	Quality Control Point
QMRA	Quantitative Microbiological Risk Assessment
RO	Reverse Osmosis
SCI	Science Quarters
SS	Suspended Solids
SWWTP	Secondary Waste Water Treatment Plant
TDS	Total Dissolved Solids
TN	Total Nitrogen
TOC	Total Organic Carbon
UF	Ultrafiltration
UV	Ultra Violet
UVT	Ultra Violet Transmittance

EXECUTIVE SUMMARY

A two day water quality Hazard Analysis Critical Control (HACCP) workshop was held on the 6 and 7 August 2013 at the University of Melbourne for the Australian Antarctic Division Davis Station direct potable reuse system Advance Water Treatment Plant (AWTP). The workshop identified in total one hundred and twenty four water quality hazards that are likely to exist in the source water and to occur or be present at each of the system process steps. For each of the hazards the maximum risk was assessed and after consideration of the preventative or control measures to be implemented at each point within the system the residual risk was then determined. Based on the output of the hazard identification and risk assessment process the following Quality Control Point (QCP) and Critical Control Point (CCP) Plans are proposed:

- QCP-1: Source Water Management
- QCP-2: BAC Filter Performance Management
- CCP-1: AWTP Feedwater Quality
- CCP-2: Oxidation Control
- CCP-3: Filtration Control
- CCP-4: Primary Disinfection Control
- CCP-5: Reverse Osmosis Control
- CCP-6: Final pH Correction Control
- CCP-7: Distribution Disinfection Control

Draft QCP and CCP Plans have been created in a tabular format that require further population with information once the AWTP has been constructed and operational pilot studies conducted. The pilot study process verification and validation data will provide the input necessary to establish the correct process performance target criteria, alert and critical limits, monitoring system details and corrective action requirements.

1. INTRODUCTION

1.1 Purpose

This report details the water quality Hazard Analysis and Critical Control Point (HACCP) workshop outcomes for the Australian Antarctic Division (AAD) direct potable reuse Advanced Water Treatment Plant (AWTP) to be implemented at Davis Station in Antarctica.

1.2 Summary of Workshop Outcomes

The outcomes of the workshop are summarised below and are discussed further within this report.

- The intended use statement was redefined;
- A review, modification and confirmation of the direct potable reuse system flow diagram;
- Identification of one hundred and twenty four water quality hazards that are likely to exist for the source water and to occur or by present at each of the system process steps;
- Areas highlighted for further investigation or data collection to reduce the uncertainty
- associated with some risk determinations;
- Identification of Quality Control Points (QCP) and Critical Control Points (CCP)); and;
- Draft QCP and CCP Plans.

Over the scheduled two days the water quality hazard identification and risk assessment process was completed and possible QCP and CCP were discussed. There was no decisions or consideration regarding what plans may be applicable or any of the specific details due to time constraints.

1.3 Workshop Attendees

The workshop was held at the University of Melbourne on the 6 and 7 August 2013. The table below provides a listing of the workshop attendees over the two days. The attendance record has been provided Appendix A of this report.

Table 1.1 Workshop Attendees

Name	Organisation Represented	Day of Attendance
Tony Foy	AAD	Day 1
David Waterhouse	AAD	Day 1 & 2
Joe Brennan	AAD	Day 1 & 2
Tim Price	AAD	Day 1 & 2
Peter Scales	University of Melbourne	Day 1 & 2
Michael Packer	AAD	Day 1 & 2
Kathryn Mumford	University of Melbourne	Day 1 & 2
Stephen Gray	Victoria University	Day 1 & 2
Jianhua Zhang	Victoria University	Day 1 & 2
Kathy Northcott	Veolia Water Australia	Day 2

2. LEGAL AND OTHER REQUIREMENTS

2.1 Regulatory Environment

For the purpose of this workshop the legal jurisdiction for the AWTP project falls under the Australian Capital Territory (ACT) government as Antarctica is an Australian Territory. It is noted that the AAD is a Commonwealth Agency and doesn't fall under this jurisdiction. However, should the AAD outsource the operation of the AWTP to a third party (e.g. private water business) the applicable jurisdiction would be that of the ACT government.

2.2 Applicable Drinking Water Legislation

- Australian Capital Territory Public Health Act 1997 Drinking Water Code of Practice 2007

2.3 Reference Legislation

- Victorian Safe Drinking Water Act (2003)
- Victorian Safe Drinking Water Regulations (2005)

2.4 Australian Guidelines

- Australian Drinking Water Guidelines 2011(ADWG)
- Australian Guidelines for Recycled Water: Phase 2 Augmentation of Drinking Water Supplies 2008 (AGRW)

2.5 Intended Use Statement

The intended use of the water produced by the AWTP is to provide an optional/supplementary potable water supply for the purposes described below.

General Use – potable water quality for station usage e.g. kitchen, personal hygiene (washing, showering, laundry), laboratory work, medical purposes, workshop (operations and maintenance) and hydroponics.

Consumption – potable water quality for consumption by the station population and for the preparation of food.

3. WORKSHOP METHODOLOGY

The workshop methodology used was based upon that described by the Australian Drinking Water Guidelines 2011 (ADWG) and the Australian Recycled Water Guidelines 2008 (ARWG).

3.1 Workshop Key Definitions

The following is a list of key definitions used during the workshop.

Hazard – A hazard is a biological, chemical, physical or radiological agent that has the potential to cause harm (ADWG, 2011).

Hazardous Event – A hazardous event is an incident or situation that can lead to the presence of a hazard (what can happen and how) (ADWG, 2011).

Risk – is the likelihood of identified hazards causing harm in exposed populations in a specified timeframe, including the severity of the consequences (ADWG, 2011).

Maximum Risk – risk in the absence of preventative (control) measures (AGRW, 2008).

Residual Risk – risk remaining after consideration of existing preventative (control) measures (AGRW, 2008).

Critical Control Point – is defined as an activity, procedure or process at which control can be applied and which is essential to prevent a hazard or reduce it to an acceptable level (ADWG, 2011).

Quality Control Point – is defined as a management process or step rather than operational control or it may be an operational process/step that has limited capacity to be monitored and/or corrective action to be taken in a timely manner.

3.2 ADWG Framework for Management of Drinking Water

The ADWG (2011) Framework for Management of Drinking Water (the Framework) approach was used to identify water quality hazards, assess the risks posed and establish critical control points and quality control points.

3.2.1 Hazard Identification

The identification of the hazards likely to exist for the source water and to occur or be present at each of the system process steps was based upon the use of the following information:

- The quantitative microbial risk assessment (QMRA) that was undertaken to determine the pathogen reduction requirements for direct potable reuse at Davis Station (Baker et al 2012);
- The water quality data from samples collected at Davis Station – refer to workshop briefing paper.
- The station knowledge provided by the AAD staff attending the workshop.
- The expert opinion and knowledge provided by workshop attendees experienced in the fields of water treatment and water quality.

3.2.2 Risk Assessment

The following tables were used during the workshop to conduct a qualitative risk assessment to determine maximum (or inherent) and residual risk. Due to small scale of the Davis Station AWTP system and population served the workshop attendees agreed that when attributing consequence catastrophic equated to one death and a major impact was greater than one third of the population affected.

Table 3.1 Qualitative measures of likelihood (ADWG, 2011)

Level	Descriptor	Example description
A	Almost certain	Is expected to occur in most circumstances *(Is expected to occur, with a probability of multiple occurrences within a year)*
B	Likely	Will probably occur in most circumstances *(Will occur within a 1-5 year period)*
C	Possible	Might occur or should occur at sometime *(Might occur or should be expected to occur within a 5-10 year period)*
D	Unlikely	Could occur at sometime *(Could occur within 20 years or in unusual circumstances)*
E	Rare	May occur in exceptional circumstances *(May occur only in exceptional circumstances; may occur once in 100 years)*

Parenthesis contains information from the ARWG (2008) for qualitative measures of likelihood.

Table 3.2 Qualitative measures of consequence or impact (ADWG, 2011)

Level	Descriptor	Example description
1	Insignificant	Insignificant impact, little disruption to normal operation, low increase in normal operational costs *(Insignificant impact or not detectable)*
2	Minor	Minor impact for small population, some manageable operation disruption, some increase in operational costs *(Health – minor impact for small population)*
3	Moderate	Minor impact for large population, significant modification to normal operation but manageable, operation costs increased, increased monitoring *(Health – minor impact for large population)*
4	Major	Major impact for small population, systems significantly compromised and abnormal operation if at all, high level of monitoring required *(Health – major impact for small population)*
5	Catastrophic	Major impact for large population, complete failure or systems *(Health – major impact for large population)*

Parenthesis contains information from the ARWG (2008) for qualitative measures of likelihood consequence or impact.

Table 3.3 Qualitative risk analysis matrix: level of risk classification (ADWG, 2011)

Likelihood	Consequences				
	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
A (almost certain)	Moderate	High	Very High	Very High	Very High
B (likely	Moderate	High	High	Very High	Very High
C (possible)	Low	Moderate	High	Very High	Very High
D (unlikely)	Low	Low	Moderate	High	Very High
E (rare)	Low	Low	Moderate	High	High

3.2.3 Determining CCPs and QCPs

The ADWG details the criteria that a preventative measure must meet for selection as a CCP. A CCP has several operational requirements, including:

- Operational parameters that can be measured and for which critical limits can be set to define the operational effectiveness of the activity (e.g. chlorine residuals for disinfection)
- Operational parameters that can be monitored frequently enough to reveal any failures in a timely manner (online and continuous monitoring is preferable)
- Procedures for corrective action that can be implemented in response to deviation from critical limits.

The ADWG provides a critical control point decision tree this was used to determine the potential CPPs applicable to the operation of the Davis Station AWTP.

Where preventative (control) measures do not meet the criteria for CCP, however, were still considered important operational/process steps to ensuring the quality of the final product these points were termed Quality Control Points (QCPs).

1. WORKSHOP OUTCOMES

4.1 System Flow Diagram

A simplified flow diagram taken from drawing 271202-04R3 was tabled at the workshop for confirmation prior to commencing the hazard identification and risk assessment process. There were several changes and additions made to the diagram. The amended version of the flow diagram used during the workshop is included as Appendix B of this report.

4.1 Hazard Identification and Risk Assessment Outcomes

A total of one hundred and twenty four hazards were identified for the Davis Station direct potable water reuse system. Refer to Davis Station Direct Potable Reuse System Risk Register provided with this report as an electronic excel file titled HACCP Workshop Risk Register_FINAL.

The water quality data provided by AAD and detailed in the workshop briefing paper was used to assist with the hazard identification and risk assessment process. It must be noted that the water quality data available was limited and assumptions were made that may have caused varying degrees of uncertainty associated with some of the risk determinations. Where knowledge was limited and assumptions were made or where gaps remain on the risk register, further actions were identified to address the information / data gap. The assumptions, knowledge gaps and follow up actions are detailed on the risk register against the related hazard/risk. Table 4.1.1 below provides a listing.

Table 4.1.1 Summary of knowledge gaps, assumptions and follow up actions.

Knowledge or information gap	Assumption	Identified follow-up actions
A listing of CoCs (humans) had not been established or water quality data for these types of compounds collected for Davis Station wastewater.	CoCs during the workshop for risk assessment purposes were considered broadly as carcinogens, endocrine disruptors and hormones.	It was suggested a listing of the top 50 compounds tested for by Western Corridor to be used as a guide to test Davis Station wastewater samples. Noted to review products sent down to Davis Station, conduct DALY and screen for these compounds.
Volatile Organic Carbons (VOC) a listing of compounds was not available.	VOCs during the workshop were defined as degreasers, paint thinners, noted paints are water dispersible lighter than hydrocarbon and more water soluble.	
What types of paints and solvents non water dispersible are used at Davis Station?	Assumed much of the paint is enamel.	Improve understanding of painting and associated products used at Davis Station.
Chemicals that can pass through MBR process (the Davis Station Secondary Wastewater Treatment Plant).	Nil	Further investigation required as to what chemicals can pass through a MBR process – suggested a list from Western Corridor.
Formaldehyde is used at Davis Station for laboratory work would it be removed by AWTP process barriers, pass through or form by-products?	During workshop assumed it would be processed by MBR, ozonation and BAC process barriers.	It was suggested confirmation of assumption through literature review and Davis Station wastewater sample analysis to understand if formaldehyde is a source water input or if it is managed within the laboratory through collection and return to Australia practices. Melbourne Water may be able to assist with further information.
What dye and other chemicals (e.g. heavy metals) are used in the laboratory?	Nil	Suggested further investigation of the laboratory chemicals and consider including in the Waste Management Plan both environmental and human health impacts of compounds (particularly those to be disposed

Knowledge or information gap	Assumption	Identified follow-up actions
		of via the wastewater stream).
What radiological compounds are likely to be used at Davis Station for laboratory work and could these appear in the wastewater stream?	Assumed laboratory practices would prevent entry into wastewater stream.	It was suggested further investigation into what radiological compounds are used for laboratory work at Davis Station and what management policy and practice used.
No information regarding antifoam product constituents used by MBR process.	The risk ratings for this hazard is blank and will be populated once the product is further investigated.	Investigate MBR antifoaming product and determine constituents and impact upon AWTP processes and final treated water.
What chemicals can pass through each AWTP barrier/process?		Improve understanding of what chemicals are likely to pass through each AWTP barrier/process.
Chemicals likely to be present onsite at Davis Station each year.	General identification of hydrocarbons, paints, glycol, kitchen and general cleaning products, laboratory chemicals etc.	Review of the chemicals that go to Davis Station and use this information to establish a listing of parameters to be tested in the wastewater.
What antiseptics are used at Davis Station?		Review antiseptic use and determine the constituents e.g. hexachlor or iodine based. If iodine based consider in relation to ozonation and the formation of by-products. Curtin University may be able to provide assistance.
Impact of a slug dose of cleaning products (impact or ammonia based verses chlorine based) on AWTP.	Considered in a spill situation in impact of cleaning chemicals collectively.	It was suggested to separate a spill situation out into impact of ammonia and chlorine based products separately – consider for future risk register review.
No water quality data for tarn iodine levels.	Nil	Analysis of tarn water and exist RO product water for iodine concentration.
Noted that the ceramic membranes that are proposed for use at the ultra-microfiltration barrier/process step have a catalytic effect across membrane surface.	Nil	Research into what by-products may be formed due to the catalytic effect across the ceramic membranes. Testing to be part of the pilot plant studies.
Noted that an ethyl-bromide product is used for everything leaving Australia as a biosecurity measure what impact could this have upon the final treated water produced by the AWTP.	Nil	Investigation biosecurity product and practice further.
Does the AWTP RO system require the use of an antiscalant?	Nil	Review the requirement for the use of an antiscalant for the RO system and if required add to the hazard analysis.
The impact on the AWTP of pH fluctuations.	Nil	Pilot plant testing to determine pH fluctuations impacts upon the AWTP.
Residual flame retardant used on the building materials could this be present in the wash down	Assumed that if it was the concentration would most likely be in the nanogram range.	Nil

Knowledge or information gap	Assumption	Identified follow-up actions
water from cleaning activities?		
Workshop and maintain potential spill volumes?	Assumed based on station knowledge that a glycol spill max. 200lts, hydrocarbon 100lts.	
Bromide pass through AWTP.	Nil	Pilot plant to test bromide pass through.
Risk of release of contaminants from BAC filters during plant shutdown.	Assumed that regular runtime would be every 72 hours when AWTP is operating. During extended shutdown periods the filters are to be aerated and DO monitored to prevent anaerobic conditions developing.	

4.2 Quality and Critical Control Points

4.2.1 Identification of the Quality and Critical Control Points

Based on the output from the hazard identification and risk assessment process the following points in the system were identified as important for the prevention and/or control of hazards and have been defined as a QCP or a CCP:

- **CCP** – the performance of the Secondary Wastewater Treatment Plant (SWWTP);
- **CCP** - Ozonation – for oxidation and disinfection;
- **CCP** - Microfiltration – for removal of solids and larger microorganisms;
- **CCP** - Reverse Osmosis – for removal of Total Dissolved Solids (TDS) and further removal of organic matter and contaminants e.g. pharmaceuticals, personal hygiene products, chemicals of concern (CoCs) and microorganisms;
- **CCP** Ultraviolet radiation – for deactivation and/or kill of pathogenic microorganisms (particularly protozoa);
- **CCP** - Calcite filter – for treated water ion balance and pH adjustment.
- **CCP** - Chlorination – for deactivation and/or kill of pathogen microorganisms and provision of disinfection residual to prevent/control regrowth or recontamination of the final treated water in storage or in the distribution.
- **QCP** – The management of source water inputs such as chemicals and other substances (e.g. pharmaceuticals, cleaning products, laboratory chemicals, operation and maintenance products) that are likely to be present and used at the station, kitchen, laboratory, workshop/operations and medical clinic waste management practices, incident and emergency management practices in the event of a spill and the training of staff in the correct use of chemicals/other substances and appropriate station waste management practices;
- **QCP** - Biologically Activated Carbon filtration – for removal of organic matter and contaminants e.g. pharmaceuticals, personal hygiene products, chemicals of concern (CoCs);

4.2.2 Quality and Critical Control Point Plans

WaterQPlus Pty Ltd has proposed the following QCP and CPP Plans for application at the Davis Station direct potable water reuse system:

- **QCP – 1:** Source Water Management
- **QCP – 2:** Biologically Activated Carbon Filter Performance
- **CCP – 1:** AWTP Feedwater Quality
- **CCP – 2:** Oxidation Control
- **CCP – 3:** Filtration Control
- **CCP – 4:** Primary Disinfection Control
- **CCP – 5:** Reverse Osmosis Control

- **CCP – 6:** Final pH Correction Control
- **CCP – 7:** Distribution Disinfection Control (may not be applicable if AWTP final treated water is to be stored for a long period of time and used as an option/supplementary potable water supply)

Draft QCP and CCP Plans have been created in a tabular format and have been provided with this report as individual electronic word and PDF files. Note that the HACCP workshop did not progress to the stage of defining exactly QPC and CCP Plans may be required or the specific details of each plan due to time constraints, therefore, the plans are draft proposals for consideration. The text that has been inserted into the plans is only an example of what may be applicable (particularly the text highlighted yellow). One of these examples is for CCP-4 Primary Disinfection Control, where a plant log inactivation calculation could be programed into the control system as actual ct over required ct as a measure to monitor the performance of each of the disinfection process units. These types of examples and the pilot study process verification and validation data will provide the input necessary to establish the correct process performance target criteria, alert and critical limits, monitoring system details and corrective action requirements. It is recommended that a further workshop is held to discuss and confirm the details of each plan.

5. Conclusion

The output from the HACCP workshop produced an initial risk register for the Davis Station Direct Potable Reuse System that identified one hundred and twenty four hazards. It highlighted areas of the system where additional knowledge and data is required to provide more certainty associated with risk determinations. The suggested follow up actions in conjunction with the operational data from the pilot studies will provide valuable input to the review of the risk register and finalisation of the QCP and CCP Plans.

6. REFERENCES

Australian Antarctic Division (2012), User Requirements Specification Davis Waste Water (Secondary) Treatment Plant Project. Version 1.0.

Australian Antarctic Division (2013), Davis Advanced Water Treatment Plant Functional Description. Version 0.5.

Australian Antarctic Division (2013), HACCP Workshop Briefing Paper – Davis Station Advanced Water Treatment. Version Final.

Baker SF, Packer M, Scales PJ, Gray S, Snape I and Hamilton AJ (2012), Manuscript for publication titled Pathogen reduction requirements for direct potable reuse in Antarctica: evaluating human health risks in small communities.

NHMRC (2011), Australian Drinking Water Guidelines. Canberra, ACT, National Health and Medical Research Council, Natural Resource Management Ministerial Council.

NRMMC, EPHC, NHMRC (2008), Australian Guidelines for Water Recycling: managing health and environmental risks (Phase 2): Augmentation of drinking water supplies. National Water Quality Management Strategy. Natural Resource Management Ministerial Council, Environment Protection and Heritage Council, National Health and Medical Research Council, Canberra.

APPENDIX A – Attendance Record

Record of Attendees

Full Name	Organisation	Signature	
1. Tony Fox.	AAD	[signature]	Day 1
2. David Waterhouse	AAD	[signature]	1+2
3. JOE BRENNAN	AAD	[signature]	1+2
4. Tim PRICE	AAD	[signature]	1+2
5. Peter Scales	Uni Melb	[signature]	1+2
6. Michael Packer	AAD	[signature]	1+2
7. Kathryn Mumford	Uni Melb	[signature]	1+2
8. Stephen Grey	Vic Uni	[signature]	1+2
9. Jianhua Zhang	Vic Uni	[signature]	1+2
10. Day 2			
11.			
12. KATHY Northcott	UWA.	[signature]	Day 2
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			

APPENDIX 8- AWTP Flow Diagram

(as reviewed, modified and confirmed during the workshop)