VEOLIA

Long-Term Leachate Treatment Solution Submission Report

Woodlawn Bioreactor

July 2016

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INTRODUCTION

1 Introduction

1.1 Purpose of this Report

This report has been prepared to detail Veolia Australia and New Zealand (Veolia) commitment to delivering a long-term leachate treatment solution for our Woodlawn Bioreactor Facility (the Bioreactor). This report is distributed to NSW Environment Protection Authority (EPA) and NSW Water to:

- Provide detail on current leachate management at the Bioreactor
- Outline the leachate and odour management challenges currently faced
- Provide detail on future leachate management at the Bioreactor.
- Enable comment prior to undertaking a modification to the site development consent

It is intended that once an approved modification to the development consent is obtained for the long-term leachate treatment solution, the Leachate Management Plan would be updated.

This report provides the following information:

- A decision tree for the selection of the proposed solution
- Technical detail on the proposed leachate treatment plant
- The target treated leachate quality for treated leachate
- A timeline for the implementation of the long-term leachate treatment solution
- An project risk assessment and associated mitigation measures
- A preliminary assessment of the environmental impacts and considerations that may result from modifying leachate management measures.

1.2 Background

The Woodlawn Eco-precinct (Woodlawn Site) is owned and operated by Veolia is located approximately 250 kilometres south west of Sydney in the NSW Southern Highlands. The Eco-precinct covers an area of 6000 hectares, which consists of the Woodlawn and Pylara properties. Approved uses at the Eco-Project include:

- Woodlawn Bioreactor (Bioreactor);
- Crisps Creek Intermodal Facility (IMF);
- Woodlawn Farm;
- Woodlawn Wind Farm;
- Woodlawn Mechanical Biological Treatment Facility (MBT) under construction; and
- Woodlawn Fish Farm

In 2012, Veolia received Project Approval (10_0012) from NSW Department of Planning and Environment (DPE) to increase the annual waste input rate to the Woodlawn Bioreactor from 500,000 tonnes per year to 1.13 million tonnes per year. This approval is contingent on approval of an updated Landfill Environmental Management Plan.

In 2016, Veolia submitted a Section 75W application to DPE to modify the Project Approval and Development Consent (DA 31-02-99) to enable:

- Storage of treated leachate in the southern portion of Evaporation Dam 3
- Transfer of stormwater collected from the Bioreactor to Evaporation Dam 2

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DPE are in the final stages of issuing approval for the section 75W application, although the NSW Environment Protection Authority (EPA) have indicated that their approval to this modification is contingent upon Veolia providing additional information on the long-term leachate treatment solution.

1.3 Document Structure

This document has been structured as follows:

- Section 1 – Introduction – Outlines the purpose of this report and presents relevant background context
- Section 2 – Existing environment – Details on existing leachate management measures undertaken at Woodlawn and also clarifies proposed land ownership boundaries with Heron Resources Limited (Heron).
- Section 3 – Proposed Modification – Details the need for modified leachate management practices, the technology selection process, a detailed description and 3D model of the concept design, detail on timeframes for key milestones, the target treated leachate quality for treated leachate and management of treated leachate.
- Section 4 – Potential Impacts – Details a project risk assessment, presents an overview of the key environmental considerations and specialist studies relating to leachate volume and extraction predications, a water balance for the ED1/ED2 system, an odour modelling assessment and an investigation into integrity of the lining system of ED1 and ED2. Sensitivity analysis is also discussed to outline what the impacts may be if actual conditions are different to projection.
- Section 5 – Conclusion – Provides a summary of the justification for the long-term leachate treatment approach selected by Veolia.

2 Existing Environment

2.1 Current Operations

Veolia operate waste filling operations within the Bioreactor, which is located approximately 7 kilometres west of Tarago in New South Wales. Putrescible waste is primarily transported via rail from Sydney to the IMF, which is then transferred onto trucks and hauled via road for the remaining 5 kilometres to the Bioreactor. Additionally, Veolia receive waste from regional Council's and businesses by road.

The bioreactor comprises of:

- a former mine void (converted to the Woodlawn Bioreactor for landfilling activities)
- the bioreactor leachate extraction and treatment infrastructure
- the bioreactor stormwater collection dams and associated infrastructure
- an evaporation dam (split into stormwater and treated leachate evaporation ponds)
- biogas extraction infrastructure
- an onsite power station with 6 landfill gas generators
- an access road, administration offices, facilities and workshop.

Landfilling operations within the Bioreactor generally occur from 7:00am to 5:00pm Monday – Friday. Approximately 10,000 tonnes per week of waste material is received and processed at the Bioreactor. The current waste level is approximately 720RL which is approximately 80m in elevation from the basal liner (640RL). Due to the conical shape of the Bioreactor, the surface area increases as the waste height increases. A 3D model of the Bioreactor from the waste surface to the top bench has been generated using aerial mapping survey (Figure 1).

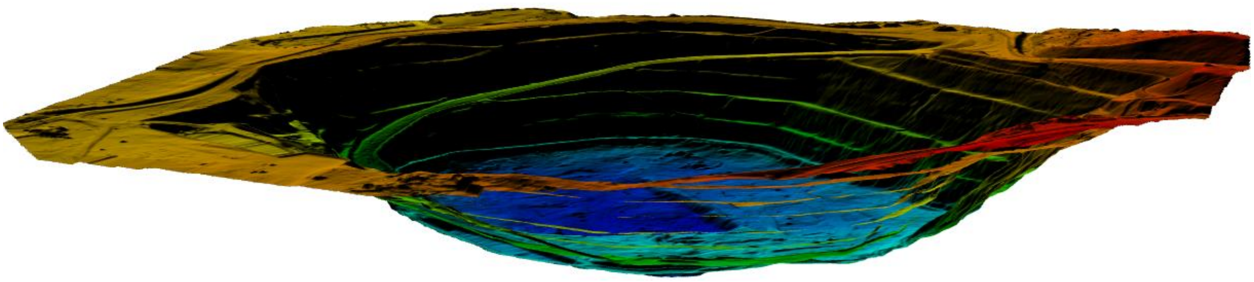


Figure 1: Woodlawn 3D surface model

Within the Bioreactor, the landfill gas extraction network is comprised of:

- 90 steel vertical gas extraction wells which are continually extended as the waste height increases. These wells also enable leachate to be extracted from the Bioreactor.
- Aggregate gas drainage lines to create permeable areas for landfill gas flow to extraction wells
- Manifolds to consolidate the monitoring and flow control locations
- Flow lines for the transfer of collected gas to the power station
- Condensate pots to collect entrained liquid within the gas collection network.

The well field location plan is shown in Figure 2.

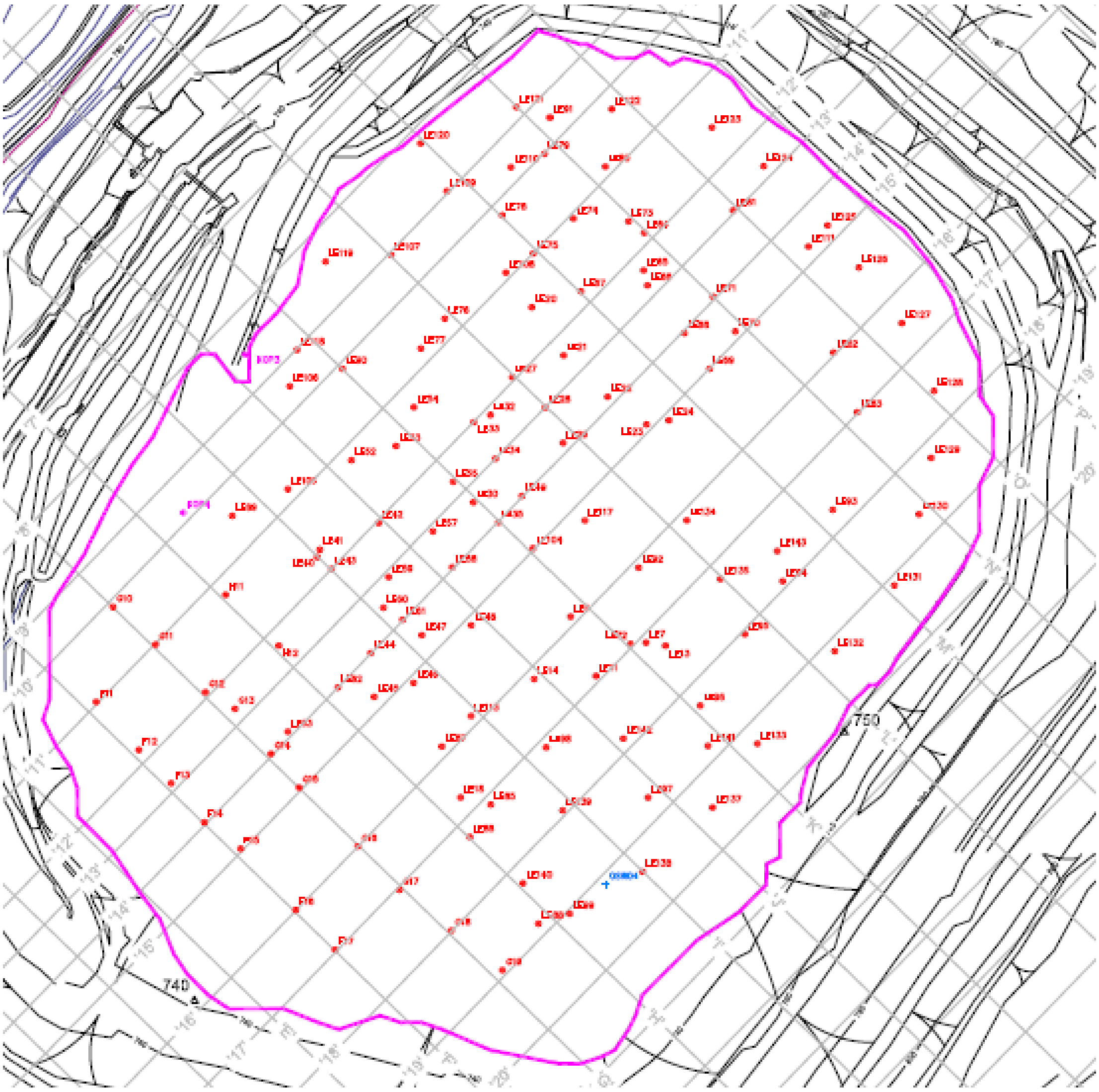


Figure 2: Location of landfill gas collection wells

2.2 Leachate Management

Leachate within the Bioreactor is generated from:

- Groundwater inflow
- Infiltration of stormwater flows
- Retained moisture present within putrescible waste

The following leachate management systems (which include landfill gas condensate) and processes are utilised to operate the Bioreactor. The layout of the current leachate management system is shown in Figure 3.

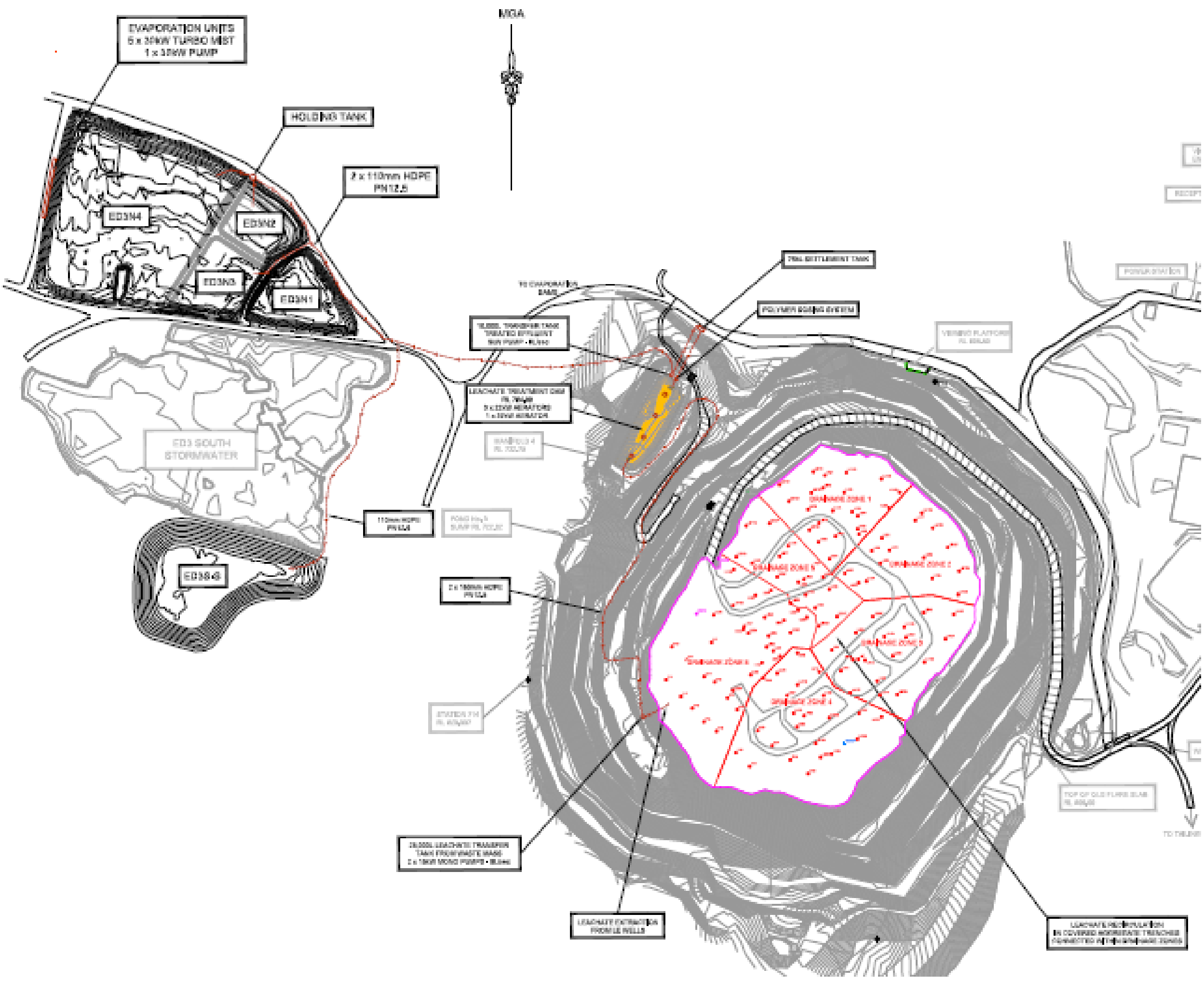


Figure 3: Woodlawn current leachate management layout plan

2.2.1 Leachate Extraction Wells

Leachate extraction wells are an important part of the leachate management on site. The number of extraction wells available determines the ability to extract larger volumes of leachate over shorter periods of time and enables leachate levels within the waste to be reduced or maintained at the desirable level. Leachate extraction wells are steel to ensure that they are able to withstand pressures exerted from waste settlement.

2.2.2 Drainage Infrastructure

Drainage infrastructure installed within the waste mass form a critical function in directed landfill gas and leachate within the Bioreactor. Drainage consists of aggregate trenches strategically placed within the waste to interconnect wells into specific drainage zones. These systems enable access to and control of leachate over larger areas of the waste subsurface and are able to detail. Aggregate drainage lines are used as they are less likely to be impacted by waste settlement than pipelines.

2.2.3 Leachate Recirculation

Leachate recirculation is undertaken to promote even distribution of moisture within the Bioreactor. Leachate is pumped from within the mass at leachate extraction wells and is then reinjected back into waste just below the surface. As the leachate filters through the upper layers of waste, a proportion of the liquid is retained in the

upper layers of waste. Covered reinjection trenches are used to facilitate the infiltration of leachate back through the waste. This process is continuous as part of the operation of the Bioreactor.
Use of uncovered or open spray systems can contribute to the release of odour emissions and are currently not implemented at the Bioreactor.

2.2.4 Leachate Extraction

Leachate extraction is required to manage the volume and level of leachate within the Bioreactor. Excess leachate within the Bioreactor is pumped from leachate extraction wells within the Bioreactor to the leachate aeration dam for treatment. Leachate extracted from the waste mass may be stored in tanks on the waste surface, prior to transfer to the leachate dam.

2.2.5 Leachate Treatment

Leachate treatment is required to manage improve the quality of extracted leachate to enable continuous extraction from the Bioreactor. The current process follows a typical activated sludge treatment process within a 12 Megalitre (ML) leachate aeration dam, which focuses on minimising the organic loading and odour potential, which enables storage of treated leachate in ED3 for evaporation. The leachate treatment process is as follows:

- Raw leachate pumped from the waste is discharged into the leachate aeration dam, as required.
- Aerators with mixing components are operating continuously within the dam to promote mixing and Oxygen transfer.
- Coagulant and flocculant are dosed into the prior to sludge settlement tank. Dosing rate is adjusted based on monitoring of the treatment process.
- Offtake liquid from the dam is passed through a settlement tank to remove suspended solids. The solids are flushed out of the settlement tank and returned back into the dam
- Treated leachate, is transferred to ED3 for storage and evaporation
- Sludge is removed from the dam, as required, and transferred back into the Bioreactor.
- The rate of extraction is limited by the treatment process and storage volumes, although flow rates of up to 4L/s have been achieved.

The current target effluent quality for treated leachate is:

- Biological Oxygen Demand – less than 300 mg/L
- pH – greater than 6.5
- Ammonia – less than 1,500mg/L

This criteria has been demonstrated through annual odour audits to be a satisfactory reduce organic loading and odour potential of treated leachate for long-term storage and evaporation. The odour audit has also endorsed the use of mechanical sprayers to enhance the evaporation rate.

2.2.6 Storage of treated leachate

Storage of treated leachate is managed in Evaporation Dam 3 (ED3). ED3 is split into a series of lagoons to manage treated leachate and stormwater extracted from the void. The northern section of ED3 contains four lagoons, which a have a 500mm thick compacted clay liner. Treated leachate is discharged into the lagoons after passing through the leachate treatment system. All dams/lagoons used for storage of treated leachate will be maintained with a minimum freeboard of 0.5m.

2.2.7 Evaporation of Treated Leachate

Treated leachate stored in onsite dams is managed through evaporation. Natural evaporation at the site is approximately twice the magnitude of rainfall based on historical record. Therefore, liquid loss from large surface area dams is a suitable volume management measure for the site.

Mechanical evaporator units are operated to increase the evaporation potential of liquid within the dam. They are automatically operated based on ambient weather conditions including wind speed and wind direction to ensure that spray is contained back over the source dam.

2.2.8 Existing Control Measures

A summary of the control measures includes:

- Installation of barrier systems, such as clay lining of discontinuous rock areas of the mine void
- Construction of treated leachate storage dams with an engineered liner in accordance with EPA minimum standards
- Maintaining a 0.5m freeboard within storage dams to provide a safeguard against overflow in the event of significant rainfall and waves generated by wind
- Diversion of stormwater and separation of surface water and leachate management systems
- Treatment of excess leachate from the Bioreactor prior to storage in onsite evaporation ponds
- Environmental monitoring of groundwater and surface water systems
- Training of staff involved in the operation of the leachate treatment process

2.3 Challenges

Leachate levels are intrinsically linked with landfill gas capture and odour management at Woodlawn. Data collected as part of the annual odour audits at Woodlawn have identified that the effectiveness of landfill gas capture is the primary management method for odour control. Therefore, as landfill gas collection increase, odour emissions decrease and vice versa.

Veolia is currently experiencing greater than expected leachate volumes within the Bioreactor which is impacting upon the effectiveness of our landfill gas capture system and ability to effectively manage odour with existing systems. The excess leachate has flooded gas collection systems, including aggregate drainage layers and wells which has limited the amount of suction that can be applied within the Bioreactor. Wells that were previously extracting landfill gas have been restricted or rendered inoperative due to the position of the saturated leachate layer within the Bioreactor.

2.4 Interim and Ongoing Management Measures

Veolia have established operational and technical working groups to progress and deliver interim and ongoing management measures to focus on the core objective of increasing landfill gas capture.

Veolia commissioned a hydrogeological study in 2016 to confirm flows into the Bioreactor to refocus efforts in reducing the amount of leachate generated at the site. This study included conceptual models of hydrogeological flows at the Bioreactor the presented following findings:

- Groundwater inflow was rationalised and considered to be equivalent to 1 Litre per second (L/s)
- Infiltration from stormwater has the greatest potential to increase leachate generation
- A modified waste surface profile to drain surface water to designated collection points would reduce the influence of stormwater infiltration on the waste surface as the covered waste surface area increases (with height)
- Moisture content within putrescible waste was equivalent to 30%.
- There was the ability to effectively manage a flow of 1L/s by recirculation of leachate to maximise the absorptive capacity of incoming waste (which is not at field capacity)
- Dewatering leachate was more effective at higher flowrates (i.e. more effective at 2L/s at single extraction points over lesser amounts (0.5L/s) over a number of extraction points)

- An initial volume of leachate is required to be dewatered at an accelerated rate (4 -5L/s) to reactivate landfill gas collection infrastructure
- A long-term sustainable leachate extraction rate of 3-4L/s is reasonable to manage leachate levels in the Bioreactor, provided that leachate recirculation is maximised and stormwater management systems are maintained in an effective state.

2.4.1 Modified waste tipping profile

Veolia have updated the tipping plan for the Bioreactor to enable better drainage and collection of surface water off the covered surface. The tipping plan aim to deliver a new waste profile (refer to Figure 4) which will represent a domes surface. The purpose of this is to drain surface water towards designated c ollection systems located around the edges of the Bioreactor, where it will be extracted through the stormwater management system. It is expected that this profile will be developed over the next 12 months.

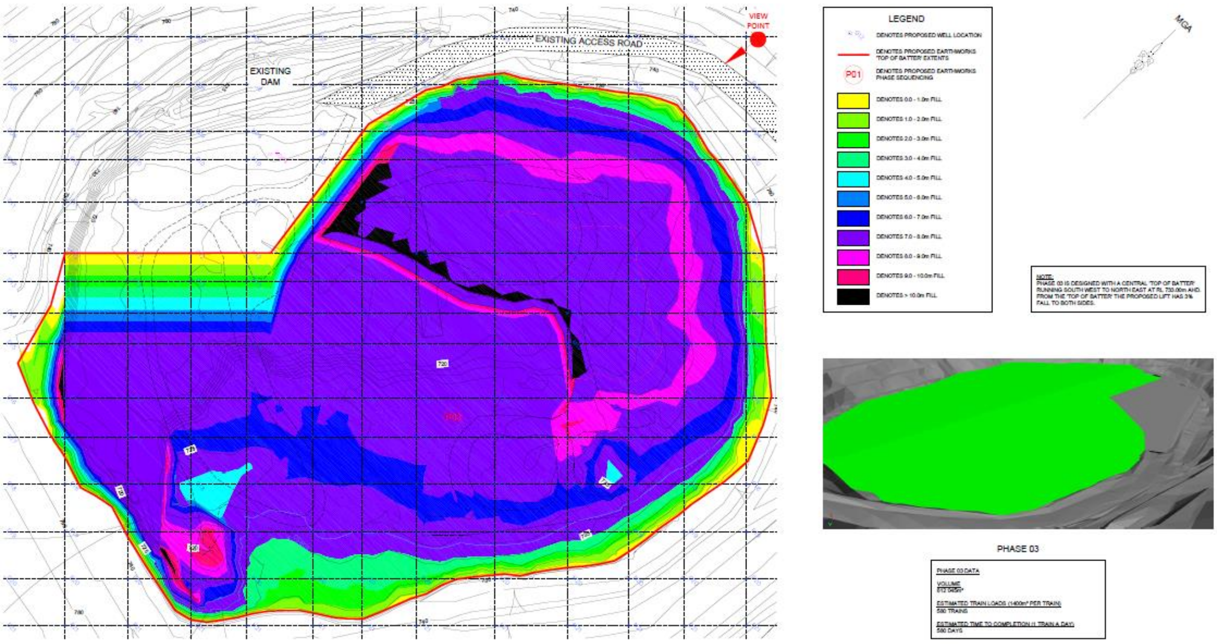


Figure 4: Bioreactor tipping profile

2.4.2 Upgrade to stormwater management systems

Veolia is currently planning / implementing the following upgrades to the stormwater system:

- Installing and upgrading duty standby pumping equipment
- Incorporation of stormwater equipment into landfill SCADA system
- Upgrading diversion structures to increase capture of the walls of the Bioreactor

2.4.3 Modified gas collection well design

Existing gas collection wells are constructed with a 3m solid pipe located from the surface to the perforation zone (where suction is applied to the Bioreactor), which is intended to minimise Oxygen transfer into the landfill gas extraction network. Due to the current leachate levels within the Bioreactor, this has impacted on the performance on many of the wells. As an interim measure, Veolia are installing perforated pipe up the bottom of the covered waste surface in an attempt to maintain suction within the unsaturated zones.

Leachate separation vessels have also been installed at specific wells which are drawing a combined leachate and landfill gas mixture. These vessels provide sufficient capacity to handle higher liquid flows, while allowing continuation of gas collection.

2.4.4 Installation of temporary/sacrificial gas collection infrastructure

In additional to the modified gas collection well design, Veolia is investigating the viability of installing high density polyethylene (HDPE) wells and horizontal extraction wells which are intended to have a short term life. Both methods have the potential to be lost through being crushed or flooded and also have the potential to draw low quality landfill gas. However, the primary purpose of these systems where implemented, is to capture landfill gas that may otherwise be emitted from the surface.

2.4.5 Additional treated leachate storage

Veolia have submitted a modification application to DPE to enable storage of treated leachate within the southern section of ED3. A 111 Megalitre (ML) capacity dam (at 0.5m freeboard) has been constructed to expand the storage capacity of treated leachate for the existing leachate treatment system. During construction additional storage capacity has been generated as the initial survey was not accurate due to water within the dam at the time of survey. Additional capacity was generated through de-silting of the dam and liner construction which included extension of the wall height.

Under the worst case water balance completed for this dam, storage capacity was calculated to be 0.7 years for a 38ML capacity dam. This has now been increased to approximately 1.5 years (or December 2017) based on an increased extraction rate of 4L/s (refer to section 2.4.7). The use of this dam will enable leachate extraction to continue

2.4.6 Modification to existing aeration systems in leachate aeration dam

Veolia has upgraded the existing aerators within the leachate aeration dam to increase the amount of Oxygen transfer to the leachate. Veolia have calculated that we should be able to increase the peak leachate extraction rate to 5L/s, although on average it is expected to be 4L/s. This upgrade has been necessitated to expedite dewatering of leachate from critical landfill gas collection infrastructure.

2.4.7 Leachate level monitoring

Veolia is investigating the ability to install level sensors within dedicated wells to observe leachate level trends over time. The intention is to connect the level sensors to the landfill SCADA so that this data can be viewed by multiple people, on an as required basis. These loggers will be used to obtain data on the performance of leachate extraction from different sections of the Bioreactor. This data will be compared with landfill gas well performance.

2.4.8 Update the Woodlawn Infrastructure Plan

Veolia are updating our Woodlawn Infrastructure Plan, which focuses on the infrastructure within the Bioreactor. This plan contains details of:

- The current infrastructure such as landfill gas, leachate, stormwater and electrical
- How the infrastructure works
- The operational and environmental challenges faced
- The aims of future infrastructure development
- Concept development plans for the next two years

2.5 Land Ownership & Mining

Heron were granted Project Approval (07_0143) on 4 July 2013 to reopen the Woodlawn Mine, which involves extracting and processing up to 1.5 Mt of tailings and underground ore per year to produce 150,000 tonnes of copper, lead and zinc concentrates per year. This concentrate will be trucked to Port Kembla and/or Port Botany for export.

In April 2016, Heron were granted an approved modification to the development consent relating to access to the underground workings via a box cut and decline to the western side of the Bioreactor. The modification was based on improved geotechnical stability of the area.

Veolia and Heron have a number of legal agreements that remain current. These include a Cooperation Agreement, a Deed of Assignment (for SML20) and Deed of Option (to purchase land). The final land ownership boundaries are still being negotiated. The outcome of the modification for Veolia will determine ownership of Evaporation Dam 1 (ED1) and Evaporation Dam 2 (ED2). A draft boundary plan is shown in Figure 5.

Figure 5: Draft boundary plan, Veolia & Heron

It is intended that both Veolia and Heron will utilise these dams for their operations, where water balance modelling suggests this is viable. This includes the use of ED1 and ED2 for the storage of treated leachate and subsequent use by Heron in their processes if the proposed mining operations go ahead.

3 Proposed Modification

3.1 Need for the proposed modification

Due to the landfill gas capture and odour management challenges Veolia are facing with leachate levels in the Bioreactor, a modified approach to leachate management is required. Veolia has been operating an activated sludge leachate treatment system since 2012. This system has been consistently improved in terms of process reliability and treatment efficiency since commissioning. While the quality of the treated leachate has steadily improved since 2012, the treatment capacity of the system is still influenced by ambient conditions, which affects the required residence time within the leachate aeration dam.

Despite this, the current treatment process is not sustainable given the constraints of the existing aeration dam capacity. Storage of treated leachate under the current management system is not sustainable. Despite the low odour profile of the treated leachate, the quality and volume of leachate to be treated is not sustainable for long-term storage and evaporation.

As detailed in Section 2.3, Veolia cannot adequately manage the volume of leachate within the Bioreactor without the integration of an effective long-term leachate treatment solution. Veolia's long-term leachate management solution is comprised of the following:

- Construct a leachate treatment plant to treat leachate to a much higher quality effluent;
- Utilise existing large surface evaporation dams ED1 for storage of treated leachate
- Incorporate mechanical equipment to promote evaporation for treated leachate discharged into the evaporation dams
- Incorporate a strategy for managing treated leachate stores in Evaporation Dam 3 North (ED3N) and Evaporation Dam 3 South (ED3S)
- Develop a program to enable irrigation the application of treated leachate to land (should this option be required)

3.2 Selection Process

Veolia intend on implementing the long-term leachate treatment solution in accordance with the following decision tree. The decision tree (Figure 6) highlights the key points where decisions will need to be made which will dictate which approach is required. A key decision throughout the process is the sustainability of storage volumes.

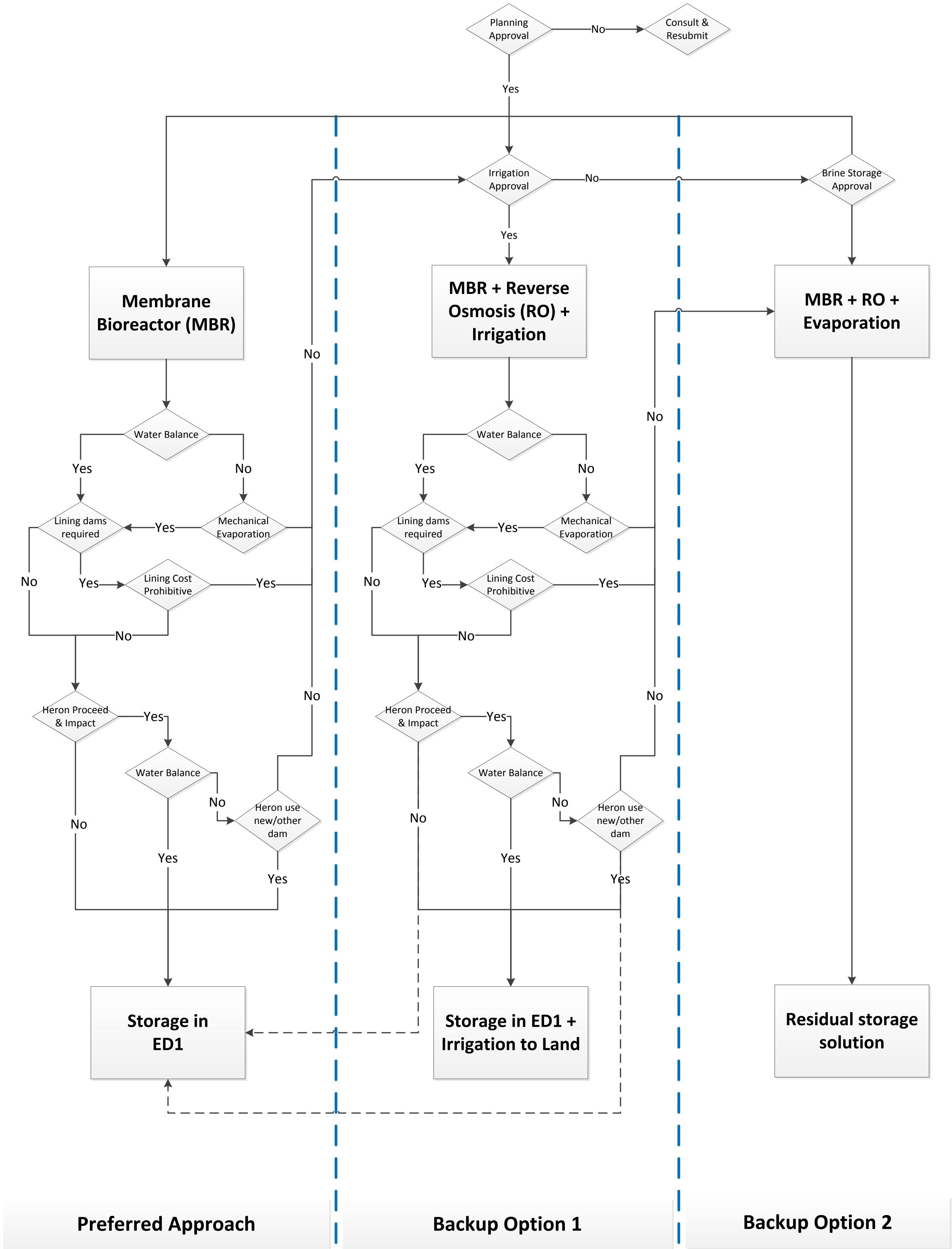


Figure 6: Decision Tree for Woodlawn Long-term Leachate Treatment Solution

3.3 Proposed Modification

Veolia intend to lodge an application (similar to the Section 75W for the short-term modification, but yet to be determined) under the Environmental Planning and Assessment Act, to modify the existing development consent and project approval through DPE. This application is intended to seek approval for the whole approach as shown in the layout plan in Figure 7.

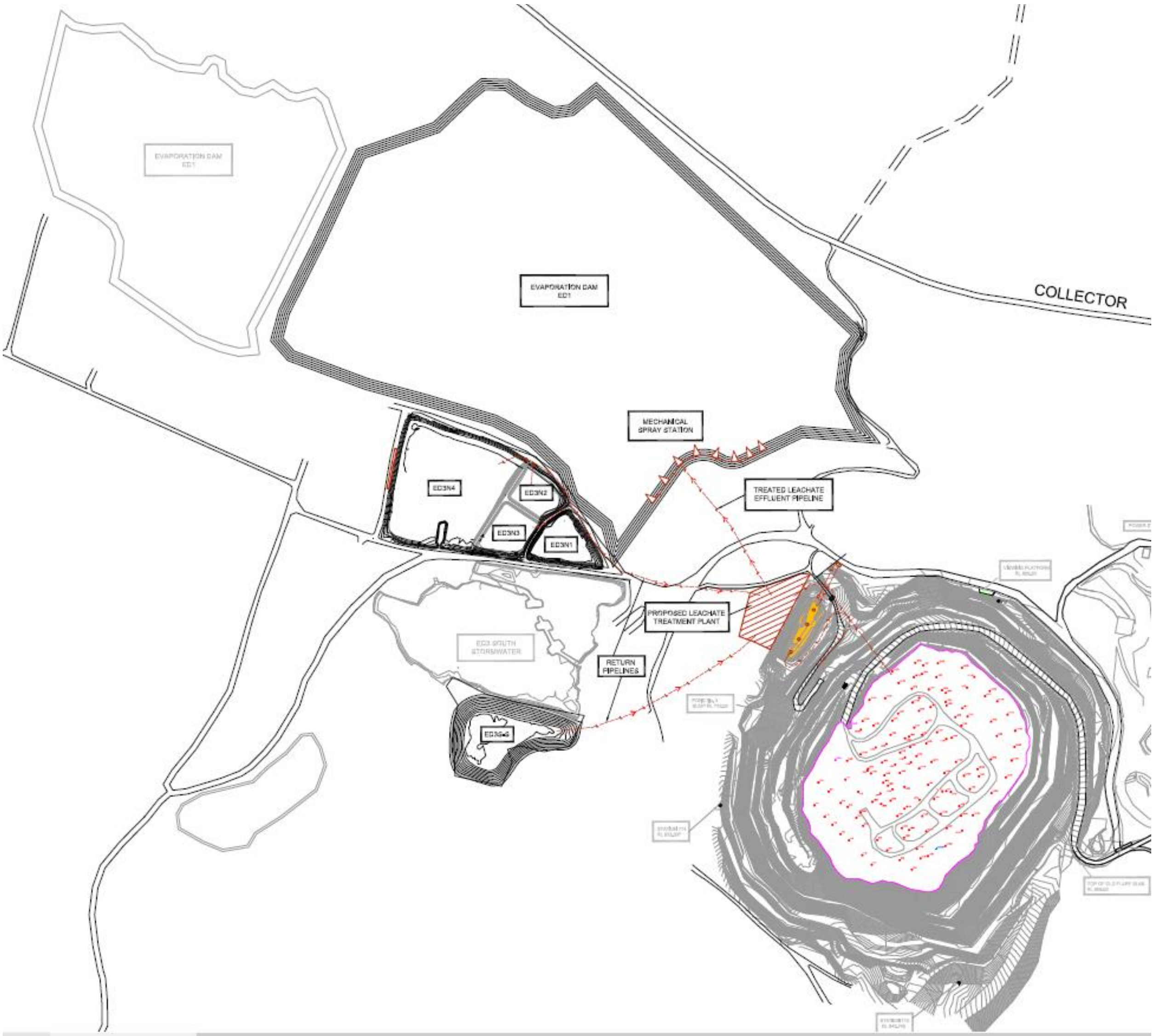


Figure 7: Woodlawn Long-term Leachate Treatment Solution concept layout plan

The modification will cover the following:

- Construction of a membrane bioreactor leachate treatment plant
- Upgrades to the leachate treatment plant consisting of reverse osmosis and evaporator technologies
- Discharge of treated leachate effluent for storage in ED1
- Discharge of treated leachate effluent via an irrigation station, pending approval of a submission which details location and methodology by the EPA and Water NSW
- Use of mechanical equipment and heat to enhance evaporation

The modification works undertaken will be based upon the decision tree (Figure 6) and the project water balance will determine the timeframes for movement to other options.

3.4 Implementation Timeframe

Veolia are prepared to commit to delivering the long-term leachate treatment solution according to the timing of major milestones detailed in Table 1 below:

Table 1: Key milestones and delivery dates

Milestone	Start	Finish
Approval & Consent Modification	July 2016	December 2016 *
Detailed Design	July 2016	December 2016
Placement of order	December 2016	January 2017
Delivery to Site (transport)	January 2017	June 2017
Civil Works and Installation	June 2017	September 2017
Commissioning	September 2017	December 2017
Full Operation	December 2017	

* Approval timeframe is an estimate only and has been used as the basis for other delivery dates

To ensure that Veolia are able to commit to these timeframes, detailed design of the MBR leachate treatment plant will be undertaken prior to approvals.

3.5 MBR Leachate Treatment Plant

3.5.1 MBR Design Development

Biodegradability bench scale tests simulating Sequencing Batch Reactors (SBRs) and MBR systems were operated from 16 October 2015 to 12 December 2015 to determine the efficiency of biological treatment in treating raw leachate from the Bioreactor and also to define design parameters for the proposed leachate treatment system.

The tests results demonstrated that biodegradable organic matter removal expressed as Biological Oxygen Demand (BOD) and biodegradable and soluble Chemical Oxygen Demand (COD), and reliable nitrification can be achieved using SBR and MBR systems.

Final effluent ammonia concentrations fell quickly during the initial stabilisation period and then remained low (< 1 mg/L) for the rest of the trial period.

A large proportion of the COD in the leachate was non-biodegradable, with a residual concentration of 2,500 – 2,800 mg/L achieved in the final treated effluent. The raw leachate COD was 6,000 to 7,000 mg/L with a BOD of 700 to 1,100 mg/L.

The denitrification process was BOD limited and so nitrate levels steadily increased during the trial before reaching a steady state of 3,000-3,500 mg-N/L in the final treated effluent. Since the residual nitrate constitutes a large portion of the effluent Total Dissolved Solids (TDS), which was in the range of 30,000 to 35,000 mg/L and similar to seawater, it was recommended that the design of the biological treatment system should include an anoxic reactor for denitrification with addition of external carbon source.

Sludge settleability was also an issue during the initial SBR when poor or no settling results were achieved. After the system operation was converted to a MBR configuration from 23rd November 2015 to 12th December 2015, there were no further settleability issues.

MBRs are an advanced form of the traditional activated sludge process that uses a membrane to capture the solids in preference to gravitational settlement. The membrane filtration systems replace sedimentation and tertiary filtration systems used in conventional wastewater treatment plants, improving the overall organic matter, nutrients and solids removal in MBRs treatment plants.

MBRs usually provide maximum solids separation with effluent turbidity values typically less than 0.30 Nephelometric Turbidity Units (NTU) and non-detect effluent Total Suspended Solids (TSS) concentrations.

The health and growth of the biomass was monitored by regularly measuring the Mixed Liquor Suspended Solids (MLSS) concentration and examining the sludge conditions under a microscope unit.

Ammonia, nitrate, nitrite, COD and phosphate concentrations were used in conjunction with colour measurement, TSS and TDS concentrations and as an assessment of the final treated effluent quality.

Additional tests considering the effect of a membrane filtration system to improve the final treated effluent were used to determine the treated water quality level (refer to section 3.5.2)

Based on the tests results, reliability and proven technology, Veolia selected a MBR treatment system as the proposed leachate treatment solution for the Woodlawn bioreactor raw leachate.

The MBR system will be designed, built, operated and maintained by Veolia in order to achieve the organic matter, nitrogen, phosphorus and total suspended solids concentrations outlined in Table 1 and commonly associated with odour-producing compounds.

Veolia have extensive experience in designing, building, operating and maintaining MBR plants and aim to achieve the expected removal of odour generally associated with high concentrations of BOD, COD, suspended solids, ammonia and phosphorus as those ones presented in the raw leachate collected from the Woodlawn bioreactor.

Veolia have involved our Technical & Performance Department in Paris, with access to the Group's experience of managing leachate across landfills internationally, to define the most appropriate sustainable solution to leachate treatment at Woodlawn. We are already reviewing offers from our preferred technology providers who are experts in leachate treatment plant design and construction. These include German company Wehrle who built in 2011 with Veolia China, the largest leachate treatment plant in the world.

3.5.2 Technical Design Parameters

Preliminary design drawings are presented in Attachment 1.

Raw leachate characteristics

The MBR treatment plant will be designed to have both flexibility and process control capability to treat the raw leachate characteristic. Average and maximum values have been taken from monitoring results of raw leachate from January 2015 to April 2016.

Design capacity and plant availability

The MBR treatment plant will be designed with some level of redundancy to ensure a plant availability of 90-95%. Veolia will optimise commonality of train capacity and equipment selection for the following design leachate extraction flow rates. The design capacity of the leachate treatment plant will be 350m^3/day (equivalent to 4L/s), although the expected flow rate is 250m^3/day (equivalent to 3L/s).

Design life and materials

Table 2 summarises the design life of key components. The design life for items that do not fall in one of the categories below is to meet or exceed best practice for the water industry in Australia.

Table 2: Design life of key components

Equipment	Design Life (years)
Steel panel tanks	15
Prefabricated concrete tank	15
Steel frames and support	> 25
Pipework, fittings and valves	> 20
Electrical equipment	> 15
Instrumentation and controls	> 15
Chemical storage tanks	> 15
Membrane filtration system	> 4
Protective coatings	> 15

The MBR treatment plant will be constructed with selected, inspected and fit for purpose materials, in compliance with the capacity, reliability and design life requirements specified by Veolia. Corrosion resistance through the use of stainless steel 316 has been allowed for, where required.

Target leachate quality

Veolia are designing the MBR plant to achieve the following target treated leachate quality detailed in Table 3.

Table 3: Target treated leachate quality

Parameter	Units	Average
pH		6.5 – 7.5
COD	mg/L	<3,000
BOD	mg/L	<10
Conductivity	µS/cm	<36,000
TSS	mg/L	<5
TDS	mg/L	~30,000
Ammonia	mg/L	<10
Nitrate	mg/L	<500
Total phosphorus	mg/L	<13
Chloride	mg/L	<5,000

To verify the target treated leachate quality parameters are being met, a Supervisory Control and Data Acquisition (SCADA) system is to be incorporated into the design of the leachate treatment plant.

3.5.3 Proposed location of leachate treatment plant

The leachate treatment plant is planned to be located in either of the areas shown in Figure 8, subject to the geotechnical properties and mining subsidence in the area. An area of 2,500m^2 is being allocated for the construction of the leachate treatment plant.

Figure 8: Proposed locations of the leachate treatment plant

3.5.4 Process Overview

Figure 9 presents an overview of the plant process flow diagram (PFD) including the basic unit operations of the MBR system. The primary purpose of each unit operation is as follows:

- Balance tank: A balance tank will be used to remove potential peak flow events and even the quality that are accepted from the raw leachate collection.
- Biological reactor: A biological reactor configured into anoxic and aerobic zones will be used for biodegradation of the leachate matter (i.e. BOD) and nutrient (i.e. nitrogen) removal. Caustic will be added to control the bioreactor pH. External carbon source will be added to assist in Nitrogen removal.
- Membrane filtration: Membranes will separate the treated leachate from the mixed liquor suspended solids producing a filtrate and act as a primary disinfection barrier.
- Final Treated Leachate Storage: the treated leachate will be stored in a tank. The tank will be used to buffer treated leachate supply.
- Chemical dosing: A variety of chemical dosing systems will be used for process requirements
- Return Activated Sludge (RAS): return activated sludge will be recirculated from the aerobic tank back to the anoxic tank.
- Waste Activated Sludge (WAS): waste activated sludge will be discharged from the MBR (membrane filtration system) back into the void.

Proposed Modification

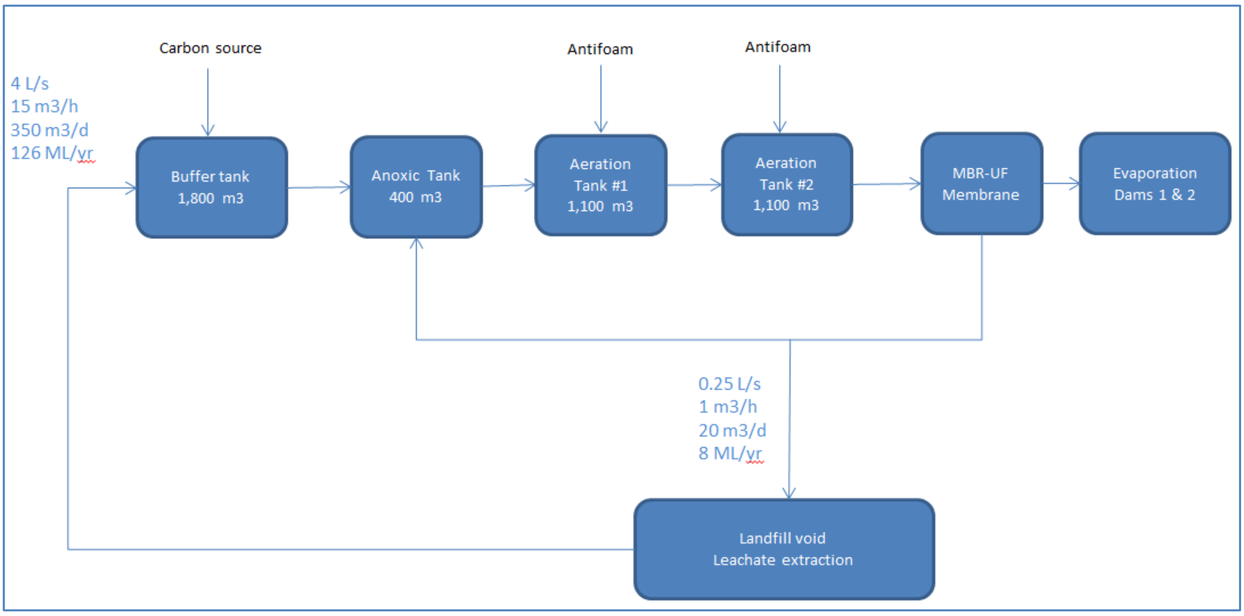


Figure 9: Process flow diagram

<u>Balance Tank</u>

The balance tank will provide a 5 – 7 day buffering storage between the incoming raw leachate average flow rate and the MBR treatment plant capacity.

One balance tank (duty only) will be capable of processing 100% of the ultimate design load including the following equipment:

- raw leachate transfer pumps (duty and standby operations)
- instrumentation and controls to measure, monitor and report tank levels and flow rate (input and output)

<u>Biological Reactor</u>

Biological reactors in activated sludge systems rely on suspended bacteria in solution that consume organic material and nutrients for their growth. The bacteria convert the organic material, expressed as chemical oxygen demand (COD) or biological oxygen demand (BOD), into carbon dioxide and water including bacterial growth in the Mixed Liquor Suspended Solids (MLSS). In doing so, other nutrients such as nitrogen and phosphorus are also taken up to support bacteria growth within MLSS.

The MBR system uses an aerated reactor to oxidise ammonia to nitrate (nitrification) and a primary non-aerated biological reactor to transform nitrate to nitrogen gas (denitrification system).

The biological reactors will be sized in order to achieve BOD and nitrogen reduction and avoid the generation of nuisance odours by the final treated effluent after its discharge into ED1 & ED2.

Overall design of the reactors will take into consideration effective aeration should be maintained to provide efficient organic matter and nitrification removals.

The biology will be a BIOMEMBRAT®-type MBR consisting of:

- a denitrification where up to 90 % of the NO3-N will be removed under optimal usage of BOD5 in the inlet = minimal usage of carbon source

- two aeration basins (nitrification), where COD, BOD5 and NH4-N are removed under optimized oxygen uptake
- ultrafiltration for separation of biomass from treated effluent

An MBR achieves the maximal possible COD reduction of all biological effluent treatment systems; at the same time, an MBR removes reliably all of the BOD5 (>99 %) and all of the NH4 (>99 %)

Caustic addition will be considered, as required, to provide sufficient alkalinity to maintain the pH within acceptable levels and avoid inhibition factor to nitrification. As part of pH adjustment design parameters, H_2SO_4 is not recommended because of the sulfurous bacteria development on membrane. System should be able to keep pH within the MLSS between 6.5 and 7.5.

As a minimum the biological reactors will include:

- Duty submersible mixer in the anoxic tank(s)
- Duty and standby process blowers. Process blowers will be VSD controlled based on Dissolved Oxygen measured in the tanks .Aeration system to keep oxygen levels within the biological reactors above 2 mg/L.
- Air diffuser will not be with pipe-aerators or membrane plate aerators. Veolia will use ejectors (Figure 10) because they are maintenance-free and better suited to leachate treatment.
- Membrane feed pumps to transfer MLSS from the aeration zone to the membrane tank. Pumps will be VSD controlled.
- Internal recycle pumps for the bioreactor to assist in nutrient (nitrogen) removal. Pumps will be VSD controlled.

Figure 10: Typical air ejector

The following instrumentation will control the operation and performance of the biological reactors:

- Dissolved oxygen probe in each biological reactor
- pH probes in each biological reactor
- MLSS (solids content analyser) probe in each biological reactor
- Flow meters (instantaneous & cumulative) on each piped mixed liquor transfer / recycle line
- Pressure indicator on each piped mixed liquor transfer / recycle line
- Flow, pressure and temperature transmitter on air pipe to bioreactor
- Tank levels on each biological reactor to be measured via level transmitter with back up high and low level switches.

In addition, the biological reactors will be designed to keep annual MLSS temperatures varying from 15^{o}C minimum to 35^{o}C maximum. A cooling unit will be provided to accommodate summer temperature.

Monitoring and control of all the above equipment will be accessible from the plant SCADA

Ultra Filtration (Membrane) System

The membrane system will be designed to handle 100% of the ultimate hydraulic load for a 24-hour period.

Membranes can be submerged in the biological reactor or located in a separate stage or compartment external to the biological reactors. As submerged membrane systems can be complex to operate and not so efficient for leachate treatment when compared to external membrane systems, it is then proposed to utilise an external pressurized system. Since the membranes are not required to be removed from the tank for cleaning or maintenance, the external membrane systems are easier to clean, operate and maintain.

Ultrafiltration membranes have a pore size of typically 50nm. The current design allows for a total of 8 membrane modules in 2 loops.

The membrane filtration system will be designed to include the following equipment as minimum operational requirements:

- Membrane modules mounted in skid (refer to Figure 11)
- Automated flushing system
- Chemical cleaning systems
- A fresh water tank for cleaning in place

Figure 11: Berghof Ultra Filtration membrane module

The following instrumentation equipment will be installed to control operation and performance of the membrane filtration system:

- Filtrate flow (instantaneous & cumulative) and back pulse (instantaneous & cumulative) meters
- Instantaneous and cumulative Wasted activated sludge (WAS) flow meters
- Instantaneous and cumulative Wasted activated sludge (RAS) flow meters
- Permeate pH and turbidity sensors
- Trans-membrane pressure (TMP) flux and temperature corrected permeability calculations
- Pressure gauges

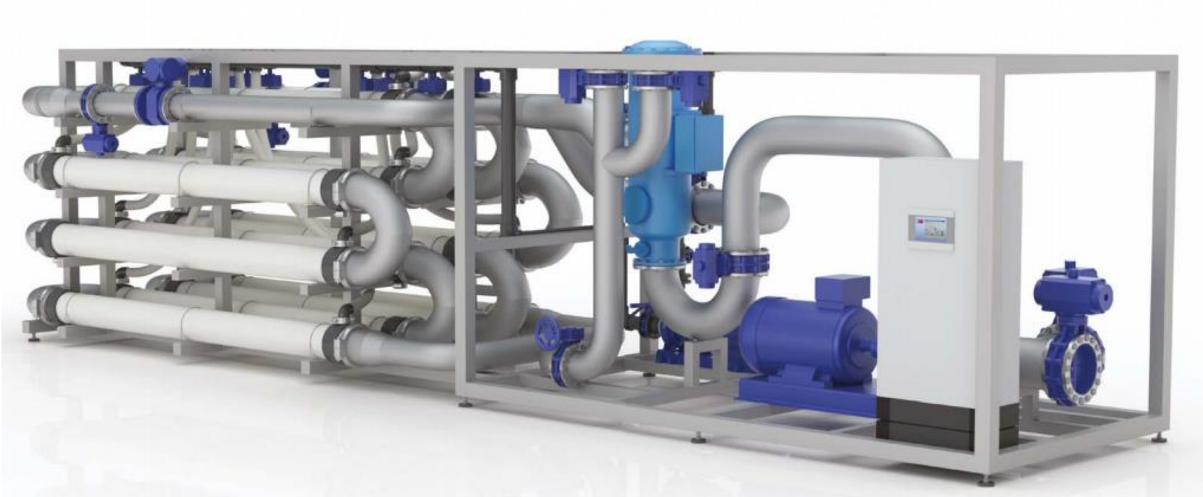


Figure 12: Skid mounted MBR/UF modules

From the UF module, if compliant, the filtrate will be directed into a Filtrate storage tank before to be transferred to ED1 and ED2.

On top of regular manual sampling, if online instrumentation measures that treated leachate quality has started to degrade, then alarm and actions will be generated. Ultimately, treated leachate quality measured to be not compliant, will be automatically diverted from normal discharge to ED1 and ED2 and sent back to the void.

Chemical Storage and Dosing Systems

The following chemical dosing systems will be part of the MBR treatment plant:

- pH correction and adjustment controls alkaline dosages
- Supplementary carbon dosage for nitrogen removal
- Sodium hypochlorite dosage for membrane cleaning
- Citric acid dosage for membrane cleaning

Each chemical dosing system will be capable of processing 100% of the average design loads and equipped with the following minimum operational requirements:

- Minimum of 20 days of storage capacity at the average design load
- Instrumentation to measure and control tank levels and dosage flow rates

Because of the estimated consumption, some chemicals (carbon source / sucrose at least,) will be stored in bulk tank will be delivered by tanker trucks. As required, a safe chemical distribution protocols will be in place to guarantee safety transfer into the storage tanks.

All hazardous chemical storages will comply with Australian standards 3780 and Veolia safety procedures.

SCADA system

A Supervisory Control and Data Acquisition (SCADA) system will be installed to control, monitor and optimise the processes and operation of its treatment plants. The system includes control and communications equipment, cables, monitoring instruments and computers. This system will allow to monitor and optimise processes to improve reliability, improve safety and working conditions, reduce operating costs.

Remote access functionality will be provided. Operational staff will then be able to remotely monitor and control the plant. Critical alarms will be pushed to operator on duty via Text/Email/Call.

Veolia Australia has in-house advanced Control Engineering expertise. This will ensure a high level quality of the project delivery but also a continuous support to the operations via regular visits and tuning.

3.6 Reverse Osmosis & Evaporator Technology

This section presents the detail on additional treatment technology, should circumstances arise where the MBR treatment plant is required to be upgraded (as defined by the Decision Tree in Figure 6). The modifications would be added to the end of the MBR treatment plant process.

It would consist in a Reverse Osmosis (RO) system. RO permeate would then be directed to Evaporation Dams and/or used for irrigation. RO reject (the brine) would go through a 2 stages evaporator/crystalliser process. The distillate will be recovered while the final slurry would be either directed to a specific dam for storage or back to the void. A process flow of this option is included in Figure 13.

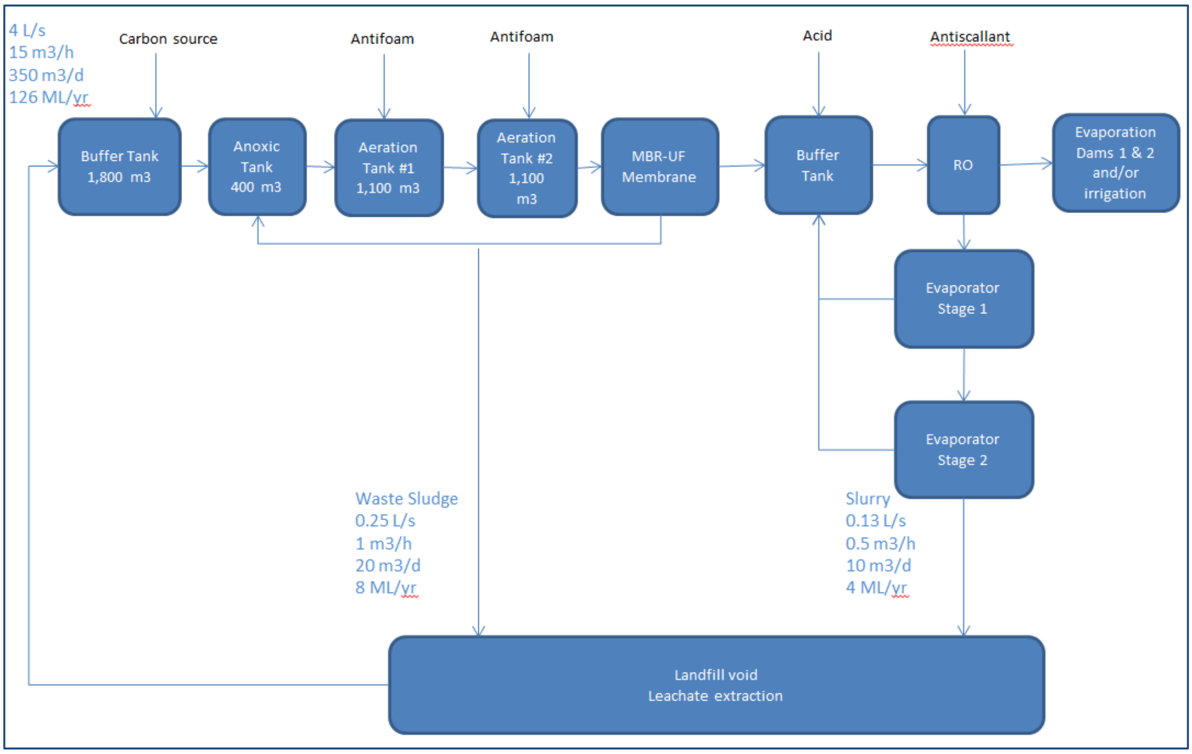


Figure 13: MBR, RO and Evaporator process flow diagram

<u>Acidification</u>

Acidification will be used as a protection barrier before RO and Evapo-concentration systems and will have a dedicated contact tank. The pH target is 5.9 to avoid precipitation of calcium carbonate ($CaCO_3$), silicon dioxide (SiO_2) and Iron (III) oxide-hydroxide ($Fe(OH)_3$).

<u>RO System</u>

The RO system is to be installed and the unit will need to be capable of producing the ultimate flow requirements. Either a single or double pass RO system may be required to meet the treated water quality requirements

Addition of anti-scaling agents can be used to limit fouling. However, the upstream acid dosage must be correct to avoid an increase in ionic load and thus the osmotic pressure.

As a minimum, the Reserve Osmosis system must include:

- Duty / standby low pressure RO feed pumps
- Duty RO skid/s including:
  - Cartridge filters (duty/standby)
  - High pressure pump (duty/standby)
  - Pressure vessel membrane housings
  - RO membranes
  - Instrumentation to measure level, flow, pressure and conductivity
- RO CIP/Flush system including:
  - RO permeate CIP/flush pump (duty only)
  - CIP tank (HDPE)
  - Tank immersion heater
- An automated feed flush action, which is activated whenever the RO system is shutdown. Fresh water is to be used for flushing.

Permeate conductivity and pressure per stage will be continuously measured online. Membrane recovery cleaning will be fully automatic but operator needs to initiate it. The brine will be directed to the Evaporation / Crystallisation system for further treatment.

As a minimum, the reverse osmosis system must include the following instrumentation / performance parameters:

- Feed flow (instantaneous and cumulative), pressure transmitter, pH, ORP and salt level reported as conductivity
- Permeate flow (instantaneous and cumulative), pressure transmitter, pH and salt level reported as conductivity
- If the design allows for a concentrate recycle loop, the flow must be measured online and used to calculate the overall recovery
- Reject water pressure transmitter, pH and salt level reported as conductivity
- CIP tank level via level transmitter come with back-up high-high and low-low level switches
- CIP tank temperature control include high shutdown
- Membrane pressure drop (ΔP) per stage calculated using pressure transmitters and pressure gauge on feed and product side of each major piece of equipment (i.e. pumps, cartridge filter, RO rack, etc)

<u>Evaporation / Crystallisation</u>

The effluent is evaporated in a closed container in order to remove water vapour and concentrate pollutant in a small residual volume.

The process must be sufficiently flexible and have sufficient process control capability to treat the brine composition. This treatment adsorbs the variability of the conductivity and of the COD when occurring.

The Evaporation / Crystallisation system will be designed based on the RO concentrate quality and on the treated leachate quality. Two options available are presented in Figure 14.

When assessing the overall energy requirements of the proposed process, consideration of thermal energy available at the Woodlawn power station will be considered. Appropriate equipment shall be used to recover the available energy.

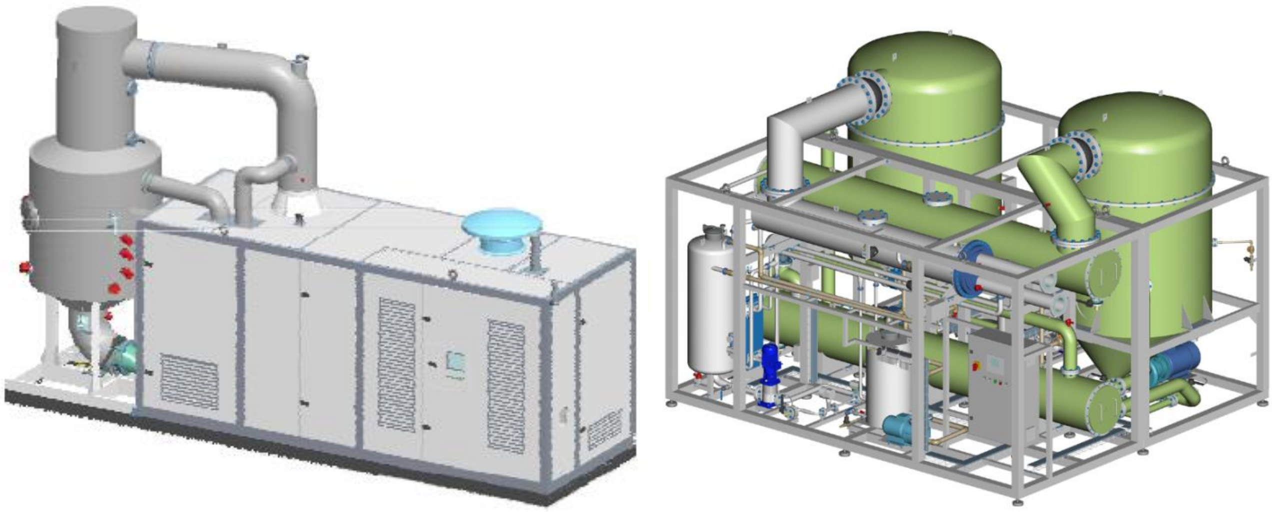


Figure 14: Evaporators – Evaled RV F 60 (left) and Evaled EW 6000 (right)

3.7 Management of Treated Leachate

Management of treated leachate will ultimately depend on what technology has been implemented as part of the decision tree, as detailed in Figure 6. The following systems will be utilised for the management of treated leachate:

3.7.1 Evaporation Dam 1

Evaporation Dam 1 (ED1) is intended to be utilised as the primary storage point for treated leachate effluent from the leachate treatment plant. Effluent will be transferred via a pipeline from the leachate treatment plant to ED1 for storage. Evaporation will be used as the primary measures for volume reduction.

ED1 has been selected as the most suitable location for storage of treated leachate for the following reasons:

- Climatic conditions at Woodlawn enable evaporation to be utilised as a viable management measure for volume reduction (Evaporation = 1,000 – 1,500mm/annum, Rainfall = 600 – 850mm/annum)
- Large surface area will maximise evaporation loss potential (Dam surface area 47.6 hectares)
- Ability to store large volumes of liquid (Dam volume = 1,345 Megalitres)

Veolia estimate that approximately 150ML of residual liquid is contained within ED1. ED1 currently receives inputs from:

- Direct rainfall
- Runoff from the dolerite stockpile
- Runoff from the former plant area via the Plant Collection Dam

Prior to the implementation of the long-term leachate treatment solution, Veolia will temporarily re-route the plant collection dam to the South Tailings Dam until such time as rehabilitation works for the former plant area are completed. Following this, water from the rehabilitated former plant area would then be treated as clean flow and discharge via natural drainage channels to Crisps Creek.

A detailed survey of ED1 will be completed prior to discharging treated leachate.

3.7.2 Mechanical Sprayers/Atomisers

Mechanical equipment to promote evaporation, such as sprayers or atomisers, will be incorporated into management system at ED1 to enhance evaporation. It is intended that all effluent from the leachate treatment plant shall pass directly through a sprayer or atomiser, as opposed to discharge from an open ended pipe.

Veolia currently operate Turbomist S30P mechanical sprayers which increase the evaporative potential of liquid pumped through these units by approximately 30%. The actual rate is dependent on actual pan evaporation rates and solids content in the liquid.

Veolia is investigating different technologies available to ensure that this process can be maximised and utilised without restriction.

3.7.3 Irrigation Station

Veolia own 6,000 hectares of land at Woodlawn and will investigate a suitable area and methodology to develop an irrigation station, should this option be required. The methodology would be consistent with the EPA *Environmental Guidelines: Use of effluent by Irrigation*, unless agreed otherwise.

3.7.4 Heating

Veolia intend to investigate the use of heat to enhance evaporation rates, if required. Veolia have an abundant source of heat from the onsite power station which could be utilised to heat treated leachate stores to aid in volume reduction.

Further investigation is required to determine if we can effectively transfer the heat from the power station to the treated leachate given the distances involved. An assessment on odour would also be undertaken to demonstrate the effect of any potential odour impacts on heating treated leachate.

3.7.5 ED3N & ED3S volume reduction

Veolia are committed to minimising the volume of treated leachate stored onsite and intend to develop a strategy to outline how this will be achieved.

The treated leachate volume reduction strategy will consider:

- The volume of treated leachate stored in each storage pond
- The effects of natural evaporation and rainfall as a management option
- The odour potential of the treated leachate within the storage ponds
- The length of time Veolia is operating the Bioreactor
- The effects of running mechanical equipment to aid evaporation
- The time taken to empty the storage ponds when applying a constant extraction rate

Volume reduction within the Evaporation Dam 3 North (ED3N) and Evaporation Dam 3 South (ED3S) ponds has been considered within the water balance report (Refer to section 4.3.2).The strategy will be incorporated into the Leachate Management Plan when updated following the modification to the development consent required for the long-term leachate treatment solution.

4 Potential Impacts

4.1 Preliminary Risk Assessment

Veolia have prepared a detailed project risk assessment for the project. A summary of the key delivery, performance and environmental risks identified is included in Table 4.

Table 4: Key delivery, performance and environmental risks for long-term leachate treatment solution

Aspects	Potential Impact	Risk Rating	Mitigation Measures
Project Delays - Delayed implementation - Delayed procurement - Delayed approvals	- Reliance on existing leachate treatment system - Storage dams become full - Reduced leachate extraction rate from Bioreactor - Increase in odour emissions	High	- Progress DPE modification application - ED3SS capacity increased during construction
Approvals - Development approval not granted - Irrigation approval not granted	- Reliance on existing leachate treatment system - Storage dams become full - Reduced leachate extraction rate from Bioreactor - Increase in odour emissions	Medium	- Consultation with stakeholders - Address comments from EPA & Water NSW in modification application - Adequately assess and address risks
Performance - Leachate treatment plant doesn't achieve the target treated leachate quality	- Increase in odour emissions - Reduced leachate extraction rate from Bioreactor	Low	- Ensure design is deliverable - Ensure contracts have performance guarantee clauses - Ensure monitoring systems are in place - Minimise downtime
Leachate volumes - Leachate extraction/treatment more than predicted - Leachate extraction/treatment less than predicted	- Leachate extraction rate from Bioreactor higher than forecasted - Wet climate sequence encountered - Leachate treatment plant may not operate at flow of 1L/s	High	- Complete study into Bioreactor leachate extraction rate over time - Design of leachate treatment plant - Use of existing treatment system to handle peak loads - Consider higher volumes in water balance
Odour - Odour emissions higher than predicted	- Storage of treated leachate - Quality parameters exceed target treated leachate quality - Storage dams turn anoxic	Low	- Complete odour modelling assessment - Monitoring of effluent quality and treatment performance
Surface Water - Contamination of surface	- Overflow of storage dams - Spill from leachate treatment	Medium	- Undertake water balance - Maintain freeboard in

Aspects	Potential Impact	Risk Rating	Mitigation Measures
water systems	plant		storage dams - Leachate treatment plant located in Bioreactor footprint
Groundwater - Contamination of groundwater systems	- Seepage from ED1 liner	Medium	- Heron consent approved to use ED1 for mineral reprocessing and storage of acid mine drainage water - Assess ED1 liner integrity and undertake any works necessary
Community - Community perception and understanding of project	- Complaints received from local community to Veolia - Complaints received from local community to EPA or DPE	High	- Regular communication and attendance at local community group meetings
Mining Operations - Heron commence mining activities - Management of liquid from underground	- Increased water storage in onsite dams - More water than predicted to be extracted for mining operations - Competitive use of ED1 for storage of water	Medium	- Use of treated leachate in mine processing operations - Veolia input into Heron water management plan in to have no net impact for storage of treated leachate in ED1 water balance - Agree with EPA and Heron decline liquid management approach

Potential impacts on aboriginal heritage, ecology, greenhouse gas, noise, dust, socio-economic, road transport or visual impacts were considered to be negligible for this project based on the information available.

4.2 Preliminary Mitigation Measures

Veolia have undertaken a preliminary impact assessment of each aspect identified in Section 4.1

4.2.1 Project Delays

Progress DPE modification application

Veolia intend to engage a consultancy to commence preparing a modification application under Section 75W of the EP&A Act, following the receipt of feedback from this report. The intention is to lodge the application and achieve an approval by December 2016 (i.e. we are allowing approximately 4 months for approval).

ED3SS capacity increased during construction

During construction of the ED3SS dam, Veolia has managed to gain additional capacity within the dam through de-silting and extension of dam walls for liner construction. The additional capacity gained is sufficient increase the minimum life expectancy to the end of 2017 under a wet climate.

4.2.2 Approvals

Consultation with stakeholders
Veolia is providing early communication of the long-term leachate treatment solution through the provision of this report to EPA and Water NSW. This is intended to streamline the modification application process.

Address comments from EPA & Water NSW into modification application
Feedback from this report will be addressed within the modification application to ensure that the approach provided to and distributed by DPE will address potential concerns from these agencies.

Adequately assess and address risks
Veolia has provided a preliminary impact assessment, which includes a number of specialist studies. The intention of these studies is to assess environmental impacts and to validate the effectiveness of the proposed solution. A full impact assessment, utilising information from these specialist studies, will be undertaken during the planning modification process.

4.2.3 Performance

Ensure design is deliverable
Veolia has extensive international experience in delivering wastewater treatment solutions, including leachate treatment plants. Throughout the concept design phase, we have been consulting with our Technical Performance Department in France, to develop a suitable target treated leachate quality, based on minimising odour. The selected target treated leachate quality has been refined with two separate leachate treatment plan contractors prior to the detailed design phase.

Ensure contracts have performance guarantee clauses
Veolia will engage suppliers and designed under specific contracts. These contracts will specify performance guarantees on the performance of the leachate treatment plant, where applicable.

Ensure monitoring systems are in place
The design of the leachate treatment plant will have online monitoring systems as well as sample ports for manual collection for laboratory verification.

Minimise downtime
To minimise downtime, the dual feed train (mentioned above) are being investigated to ensure that we can undertake maintenance and repairs. Maintenance requirements shall be provided by the supplier and integrated into Veolia's computerised maintenance management system so that these works can be planned and recorded.

4.2.4 Leachate Volumes

Complete study into Bioreactor leachate extraction rate
Veolia commissioned Earth2Water to provide a report detailing leachate generation rates and the expected extraction rate required over time. The average leachate extraction rate has been calculated to be 3L/s which decreases to about 2L/s once the waste level exceeds the height of the natural groundwater table. A summary of this report is provided in Section 4.3.

Design of leachate treatment plant
Veolia intend to design a leachate treatment plant capable of treated leachate at a rate of 4L/s. The plant size has been selected based on the best available information on leachate generation and the required extraction rate.

To ensure that the leachate treatment plant can continue to operate at low flows (1L/s), the viability a dual feed treatment system (fed at 2L/s) will be investigated.

Use of existing treatment system to handle peak loads

The existing leachate aeration dam will be kept biologically active to manage potential peak flows that may be required if flows in excess of 4L/s are required. This is contingent on space within the ED3N and ED3S system being available.

Consider higher volumes in water balance

Veolia commissioned Parsons Brinckerhoff to undertake a water balance at 3L/s and 4L/s fill rates into ED1. A summary of the report is included in Section 4.3.

4.2.5 Odour

Complete odour modelling assessment

Veolia engaged The Odour Unit to undertake an odour dispersion model and assessment of the impact of storing treated leachate at the facility. This study considered the effects if odour rates were greater than expected. A summary of the report is provided in Section 4.3.

Monitoring of effluent quality and treatment performance

The design of the leachate treatment plant will have online monitoring systems to detect if key parameters may contribute to treated leachate effluent exceeding the target criteria. Sample ports will be available for manual sample collections for laboratory verification. Sampling of treated leachate stored in ED1 shall also be undertaken.

4.2.6 Surface Water

Undertake water balance

Veolia commissioned Parsons Brinckerhoff to undertake a water balance of the proposed long-term leachate treatment solution. The water balance simulations aimed to demonstrate that ED1 could handle treated leachate flows and the effect of volume reduction activities on stored leachate within ED3N and ED3S. A summary of the report is included in Section 4.3.

Maintain freeboard in storage dams

All treated leachate storage dams are maintained with a freeboard of 0.5m to ensure that there is sufficient freeboard to withhold liquid from a significant rainfall event and prevent wind generated waves contained within the pond. This will also be applied to ED1.

Leachate treatment plant located in Bioreactor footprint

The proposed location of the leachate treatment plant is to be located within the Bioreactor footprint, if the geotechnical stability is suitable. Should the location be outside of the Bioreactor footprint, then bunding or other suitable containment measure shall be adopted

4.2.7 Groundwater

Heron consent approved to use ED1 for mineral reprocessing and storage of acid mine drainage water

Heron's project approval 07_0143 enables the storage of untreated acid mine drainage waters within ED1. The quality of treated leachate effluent will be of a higher quality and therefore it is considered that this is a suitable management system for treated leachate. Based on this Veolia consider that the use of ED1 and ED2 should be sufficient for the storage of treated leachate.

Assess ED1 liner integrity and undertake any works necessary

Veolia commissioned Earth2Water to undertake a desktop assessment of the integrity of the liner of both ED1 and ED2. The report has assessed relevant historical reports to outline further investigation works and advise whether any repairs/maintenance is required to ensure the integrity of the dams as containment structures. A summary of the report is provided in Section 4.3.

4.2.8 Community

Regular communication and attendance at local community group meetings

Veolia intend to provide the community with regular updates through attendance at the Tarago And District Progress Association Incorporated (TADPAI) and Community Liaison Committee groups. These forums provide the opportunity to update the community with upcoming projects, while enabling feedback and questions. The long-term leachate management solution will be discussed within Veolia's allocated time.

4.2.9 Mining Operations

Use of treated leachate in mine processing operations

Heron have indicated that they could use the treated leachate within their processing plant. This process has a requirement for large input of water 500 – 700ML per annum which is substantially greater than the Bioreactor extraction rate. The treated leachate will be of a higher quality than acid mine drainage waters extracted from underground.

Veolia input into Heron water management plan in to have no net impact for storage of treated leachate in ED1 water balance

Under Heron's project approval, Heron must consult with Veolia in relation to the development of a water management plan. While Heron's mining operations are yet to be confirmed, if it does proceed, the mining operation must have no net impact on the water balance for the storage of treated leachate it ED1 and no net impact generally on Veolia's operation of the Bioreactor or other activities on site. Veolia also have a Cooperation Agreement with Heron where these requirements will be reinforced.

Agree with EPA decline liquid management approach

Veolia will continue discussions with the EPA and other relevant agencies and stakeholders as to the most appropriate measures for dealing with the liquid within the decline.

4.3 Specialist Studies

Veolia has commissioned a number of specialist studies to validate the proposed long-term leachate treatment solution.

4.3.1 Bioreactor Leachate Extraction / Treatment Rate

Veolia engaged Earth2Water to better understand future leachate extraction rates from the Bioreactor with consideration of reduced inward hydraulic gradients, increased rate of waste deposition (absorptive capacity), variable climate and water control measures. This was a follow on report to a detailed hydrogeological study at Woodlawn presented to Veolia in March 2016. The report is included as Attachment 2.

This report presents the expected leachate extraction rate of as a function of waste depth (Table 4), which is initially 3L/s. This decreases by 10% for every 10m in height of waste placed from a height of 750RL. A constant extraction rate of 2.7L/s has been calculated once the waste height reached 780RL. The leachate extraction rate has been calculated based on:

- Groundwater inputs;
- Absorptive capacity of the waste
- Waste moisture inputs; and

The leachate extraction rates are presented in this report consider that the stormwater management measures identified in section 2.4.1 and 2.4.2 are completed.

Table 5 shows the leachate extraction rate from the Bioreactor as presented in the report.

Table 5: Leachate extraction rate based on waste height and volume

Estimated Leachate Treatment Rate (L/sec)	Estimate Year and Waste Level RL	RL of Waste	Thickness of Waste (m)	Waste Volume (m3)	volume of waste (m3) per Lift	Cumulative Volume (m3) per Lift
	2004	640	0	-	0	
		650	10	123,846		
		660	20	328,419		
		670	30	637,175		
		680	40	1,047,573		
		690	50	1,615,971		
		700	60	2,384,881		
		710	70	3,314,900		
		720	80	4,396,653		
		722	82	4,633,951		
3	waste RL June 2016	724	84	4,878,353	0	0
		726	86	5,129,313	250961	250,961
		728	88	5,386,647	257334	508,294.63
	mid 2017	730	90	5,650,796	264148	772,443.06
	end 2017	732	92	5,929,884	279089	1,051,531.59
3	start 2018 (commence treatment)	734	94	6,218,790	0	
3		736	96	6,514,538	295748	295748
3		738	98	6,816,999	302461	598210
3		740	100	7,126,244	309245	907455
2.7	mid 2020 (10% reduction predicted in gw inflow)	750	110	8,821,558	1695313	2602768
2.43	2023	760	120	10,748,276	1926718	4529486
2.187	mid 2025	770	130	12,995,733	2247458	6776943
1.7	2029	780	140	15,494,825	2499092	9276035
		790				

4.3.2 Water Balance

Veolia engaged Parsons Brinckerhoff to complete a water balance (Attachment 3) for the preferred approach for the long-term leachate management solution.

The scope of the water balance model was to:

- Carry out a water balance model with a discharge rate of 3L/s and 4L/s
- Model the effects of an increased evaporation rate
- Incorporate mechanical sprayer data into water balance to determine the number of mechanical sprayers that may need to be employed.
-

Water balances were modelled for a range of scenarios to assess whether ED1 and ED2 can provide storage required for Veolia's leachate and stormwater management during the next 40 years of projected operation from 2018. The peak leachate rate of 3L/s for the best case scenario and 4L/s for the worst case scenario were used in the assessments. The leachate production schedule was provided by Veolia for 40 years commencing from 2018. The best case leachate production schedule suggest a declining trend from the peak value of 3L/s for the first two years to 1.7 L/s for the last 22 years of the operation. The worst case leachate production schedule was constructed by adding 1 L/s to the time series of the best case leachate production.

If ED1 and ED2 are exclusively used for Veolia's bioreactor operation then there is a good chance that these ponds may serve well to manage the leachate and stormwater without any assisted mechanical evaporation, if the pan factor of 0.85 could be applicable and the best case leachate production being maintained.

For any other additional water transfer into ED1 and ED2 further water loss is required to contain water within ED1. Veolia is proposing to use mechanical evaporators for boosting evaporation from ED1 and ED2. A range of scenarios presented here suggests that 3 units for ED1, 0.5 units for ED2, 0.5 units for ED3S and 0.25 units for ED3N may be required for the worst case leachate production under the wet climate sequence similar to 1947 to 2015 with a pan factor of 0.6, when water is transferred from ED3 cells at 1 L/s.

If Heron also uses ED1 for storage of mine dewatering, then overflows from ED1 and ED2 can only be prevented if Herron Resources uses water from ED1 at 14.5 L/s without the use of mechanical evaporator, and 9.5 L/s with the mechanical evaporators during the worst case leachate production under the wet climate sequence similar to 1947 to 2015 with a pan factor of 0.6, when water is transferred from ED3 cells at 1 L/s. Even under the dry climate sequence similar to 1976 to 2015, Herron Resources might have to reuse the water from ED1 at a rate of 13.5 L/s without mechanical evaporator, and at 8.5 L/s with mechanical evaporators operating at ED1 and ED2.

Veolia currently uses ED3S for the void generated stormwater storage and ED3N cells (1, 2, 3 and 4) for the bioreactor leachate storage. Once Veolia starts using ED1 and ED2 ponds for leachate and stormwater management respectively, ED3S and ED3N ponds will not receive any water except direct rainfall and local catchment runoffs. Modelled simulations under these conditions were undertaken to assess how long it might take for these ponds to become nearly empty.

The cells of ED3S and ED3N ponds will evaporate and eventually become empty at the end of:

- 25 years if water is transferred from these ponds to ED1 at a rate of 1 L/s during the wet climate sequence similar to the climate from 1947 to 1986.
- 8 years if water is transferred from these ponds to ED1 at a rate of 1 L/s during the dry climate sequence similar to the climate from 1976 to 2015.
- 34 years if water is not transferred from these ponds to ED1 during the dry climate sequence similar to the climate from 1976 to 2015.

ED3S and ED3N ponds may not become empty by natural evaporation during the next 40 years if the wet sequence similar to the climate from 1947 to 1986 repeats even if the water is transferred to ED1 at a rate of 1 L/s. The pond volumes may frequently exceed their capacities during the wet climate sequence and mechanical evaporators may be required even for ED3N and ED3S cells.

4.3.3 Odour Dispersion Modelling Assessment

Veolia engaged The Odour Unit to undertaken an odour modelling assessment for the proposed long-term leachate treatment solution (Attachment 4). The purpose of the assessment was to determine the potential odour impact through continuous treatment of leachate through the MBR facility and storage in ED1.

The scope of works for the odour dispersion model study consisted of:

- Sourcing and setting up the original odour dispersion model used in the Environmental Assessment Woodlawn Expansion Report dated August 2010 (EA). Some meteorology-based revisions to this model were necessary given the year that the model was completed (see Section **Error! Reference source not found.** for details);

- Inclusion of the proposed ED1 System into the EA odour dispersion model;
- Undertaking of a regression analysis for the purposes of developing a mathematical function that can project the expected specific odour emission rate (SOER) based on the final treated leachate quality generated by the proposed MBR Treatment Plant. This analysis was based on an extensive dataset pertaining to leachate quality and odour emissions from the LMS obtained during the previous four odour audits, conducted annually, at the Woodlawn Bioreactor Facility since 2012; and
- Odour dispersion modelling projection of the individual off-site odour impact from the inclusion of the proposed ED1 System. In addition, the cumulative off-site odour impact with the other modelled emission sources in the EA were undertaken to assess site-wide compliance with the relevant NSW EPA odour performance criterion.

The results of the odour assessment were:

- The modelling projection results demonstrate compliance with the 6 ou odour performance criterion ground level concentration based on 1-hour averaging at the 99.0th percentile frequency at the nearest sensitive receptor
- There is minimal sensitivity to variations in leachate quality of 2, 5 and 10 times above the target design treated leachate quality parameters.
- Veolia is targeting a high quality treated leachate effluent for storage in ED1.
- Veolia's long-term leachate treatment solution (MBR treatment plant option) will not result in any significant increase to off-site odour impacts and will have negligible change on the existing surrounding off-site amenity

The odour contour plot is presented in Figure 15.

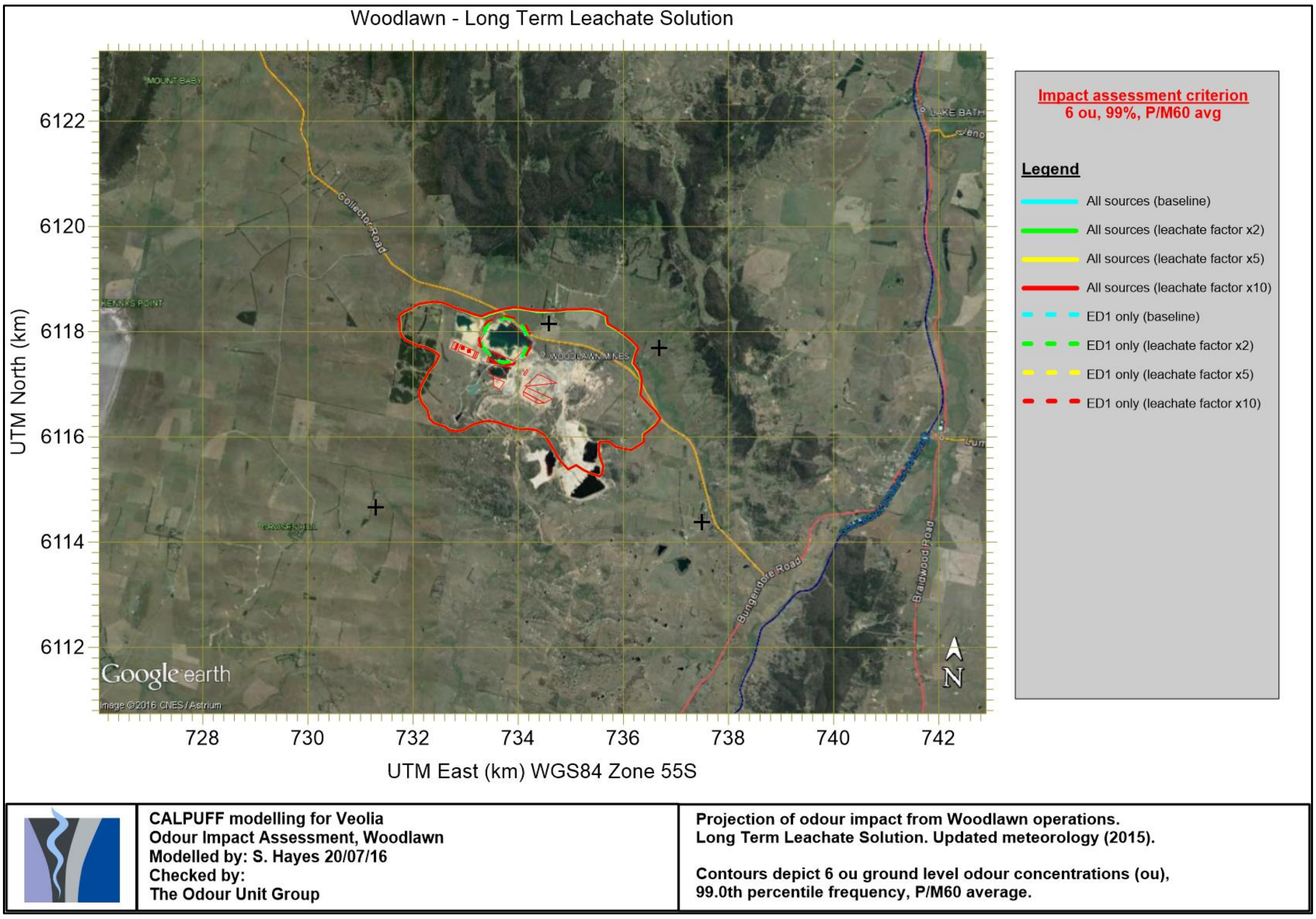


Figure 15: Woodlawn long term leachate treatment solution odour contour map

4.3.4 ED1 and ED2 Liner Integrity Desktop Study

Veolia engaged Earth2Water to undertake a desktop assessment of the integrity of the current lining systems of ED1 and ED2 (Attachment 5). The assessment was a multifaceted approach of current and historical information sourced from Veolia, E2W and previous mining activities. The assessment includes; site inspection and surveillance reports, review of available monitoring data, review of available geotechnical, geological, and hydrogeological information.

The integrity assessment indicates leakage of acid mine water from ED1 and ED2 based on results of adjacent monitoring wells. The nature and extent of the leachate plume is not well known due to the limited monitoring network.

Higher water levels in ED1 and ED2 are expected with the additional inputs from the proposed leachate treatment plant or from re-activated mining activities. Increase storage and hydraulic pressures in ED1 and ED2 may increase or enhance the migration of contaminated water into the underlying fractured rock or alluvium and potentially impact nearby Crisps Creek and/or Allianoyonyiga Creek. Imperfect containment of ED1 and ED2 is evident from historical and current water quality trends.

The report recommends further investigations to address data gaps:

- A geophysical survey (EM-34) to better characterise preferential migration pathways
- Additional monitoring wells (shallow/deep) to delineate the extent of contaminated groundwater,
- Additional surface water samples at key locations

- Geological mapping in the vicinity of ED1, ED2 and Allianoyonyiga Creek.

Control measures that have been identified which may improve the integrity of ED1 and ED2 include:

- Impervious subsurface barriers (cut-off walls)
- Controlled groundwater extraction locations; and/or
- Targeted sealing of the dams (e.g. bentonite slurry, or repairs to liner systems).

5 Conclusion

5.1 Alternatives considered

Veolia have considered a number of alternatives related to the leachate treatment plant (outlined within the decision tree in Figure 6). Veolia intends to seek approval which includes each of the alternate solutions identified within the decision tree. The preferred approach is for an MBR treatment plant with storage of treated leachate effluent in ED1 and the use of mechanical sprayers/atomisers to enhance evaporation.

5.1.1 Do Nothing

This option involves relaying on the existing leachate treatment system and continual construction of treated leachate storage dams. Both the EPA and Veolia do not consider this a sustainable or effective long –term management method for leachate at Woodlawn.

If odour was not considered a current issue, Veolia would consider the Do Nothing as a potentially viable approach.

5.1.2 MBR, RO and Irrigation

This option will be guided by:

- Water balance modelling suggests that storage capacity in ED1 is limited and mechanical sprayers/atomisers are unsustainable
- A wet climate and/or leachate extraction volumes are higher than expected
- Lining of ED1 and ED2 is required and then cost prohibitive
- Regulatory approval for the irrigation of treated effluent (meeting current treated effluent quality guidelines) to land.

5.1.3 MBR, RO, Evaporation and Brine Storage

This option will be guided by:

- Approvals for irrigation to land are not granted
- Water balance modelling suggests that storage capacity in ED1 is limited and mechanical sprayers/atomisers combined with irrigation is unsustainable
- A wet climate and/or leachate extraction volumes are higher than expected

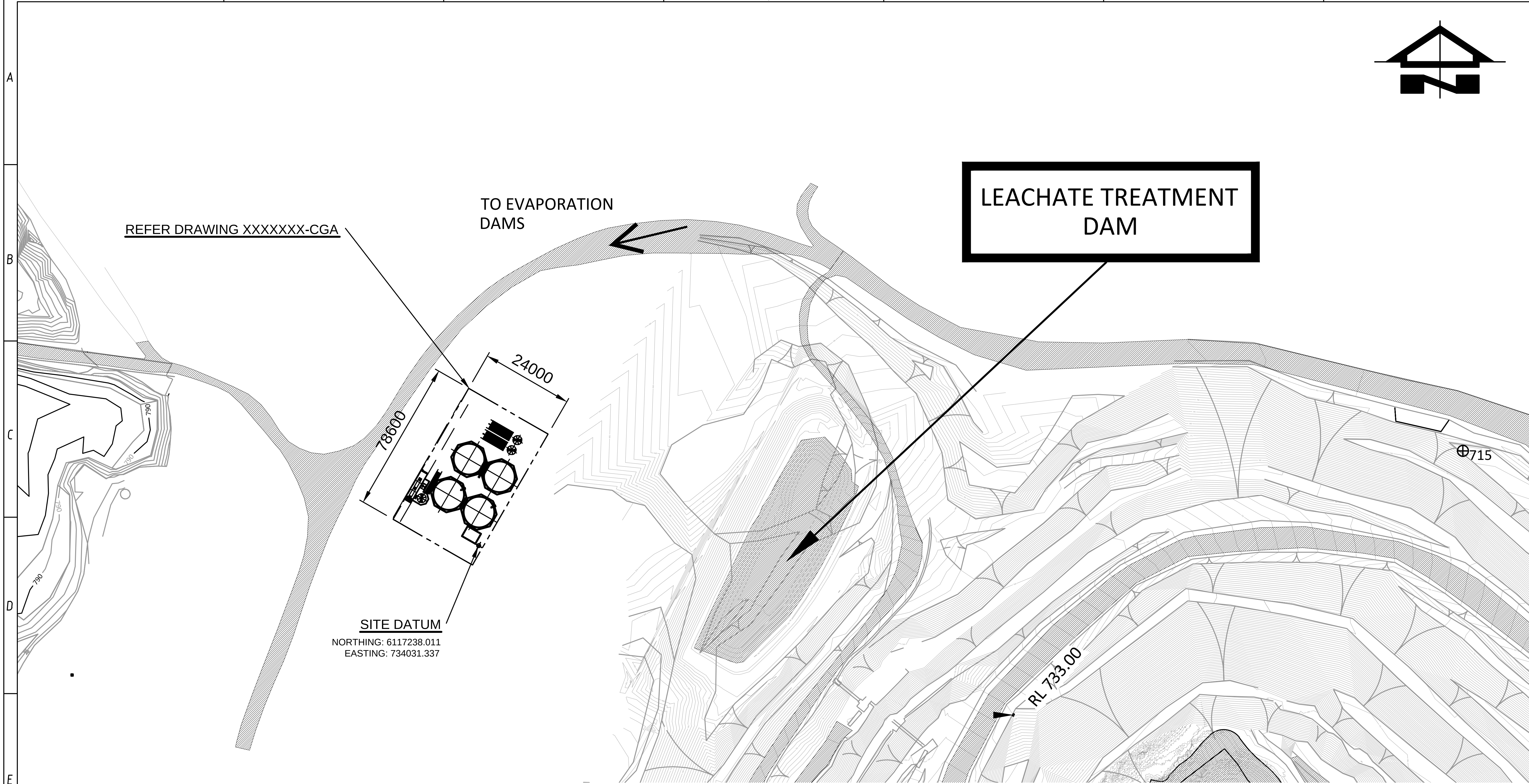
5.2 Conclusion

Due to the uncertainty of future conditions at Woodlawn (such as climate, leachate volumes and mining operations), Veolia has provided a modular solution that is adaptable to change, if required. The MBR is considered the most cost effective and sustainable long-term leachate management solution approach based on what is currently known.

If circumstances require a different approach, Veolia will look at modifying the MBR plant with RO and evaporator technology. This will ensure that Veolia's long-term leachate management solution remains viable and sustainable into the future.

Attachments

Attachment 1 – MBR Treatment Plan Preliminary Drawings



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CUSTOMER: WOODLAND LEACHATE TREATMENT FEED

TITLE: FRONT END ENGINEERING DESIGN
GENERAL ARRANGEMENT
OVERALL PLAN

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LOCATION:

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ESTIMATE No.:
AREA:
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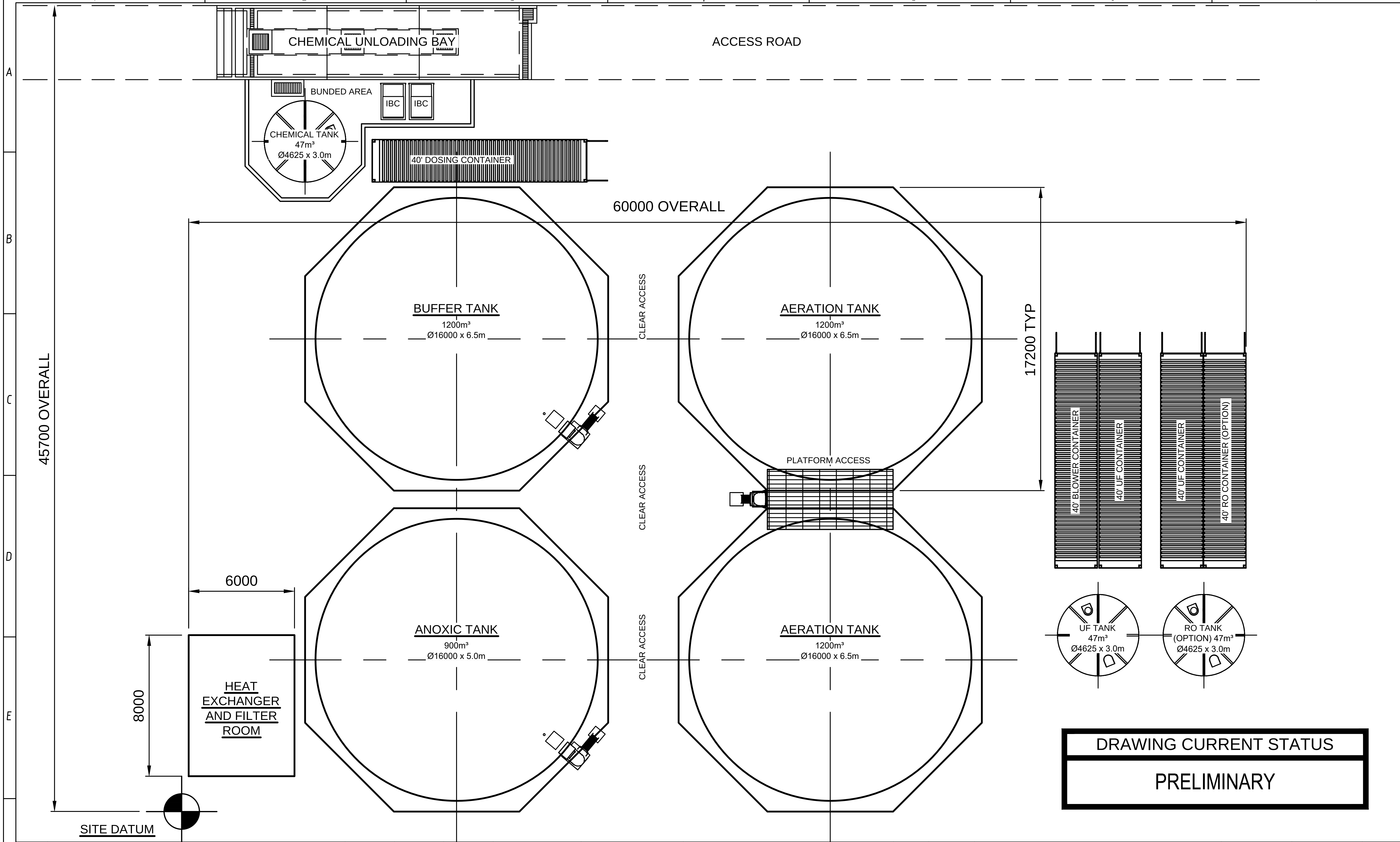

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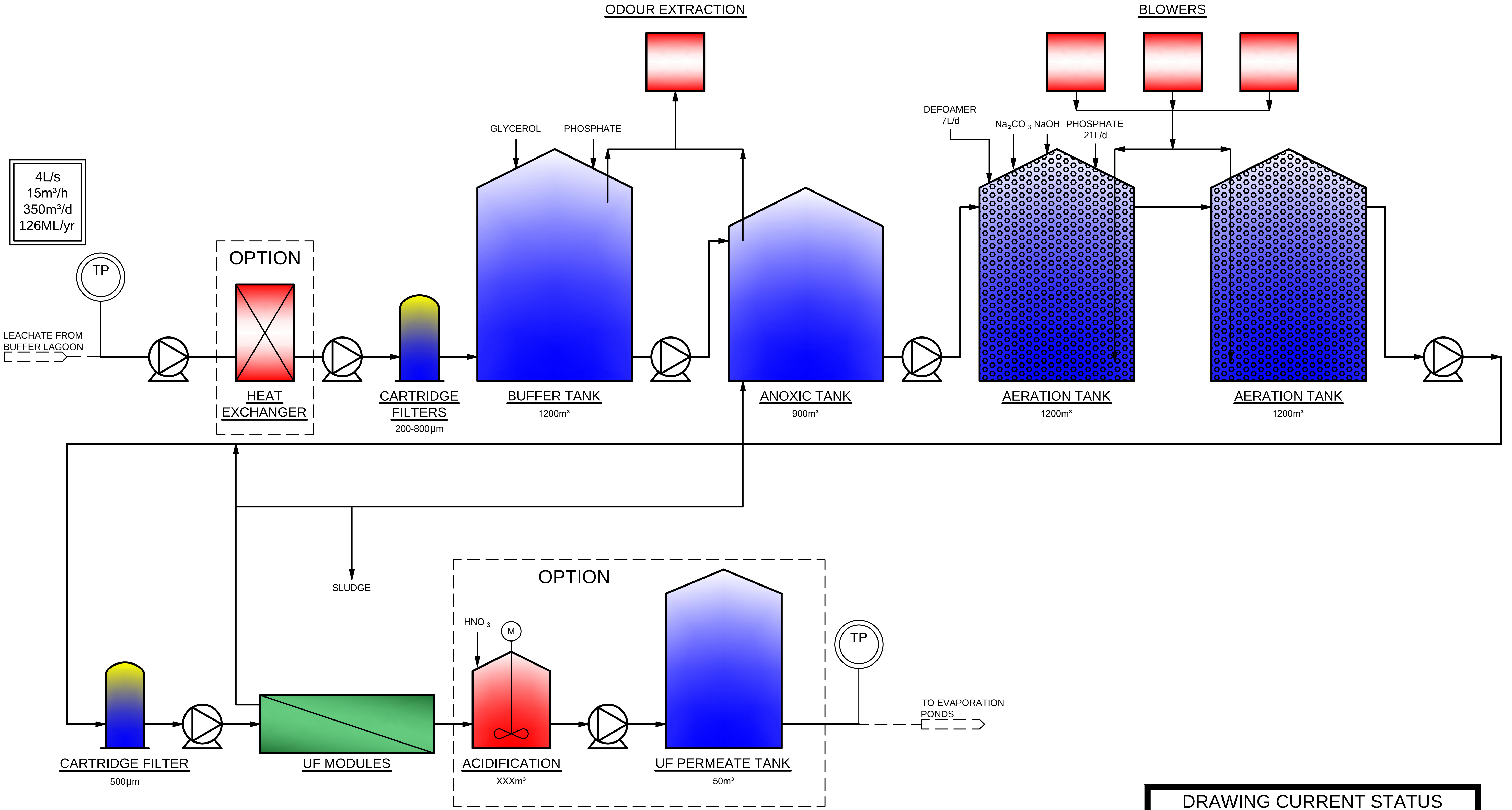

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REVISION	A

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Attachments

Attachment 2 – Bioreactor Leachate Extraction / Treatment Report

Environmental & Groundwater Consulting
ABN 64 100 859 238
175 Fern Street Gerringong NSW 2534
Phone: (02) 4234 0829 Fax: (02) 4236 1824

Ref: E2W-243 L001a (V2)
1 July 2016

Shaun Rainford.
Veolia Environmental Services (Australia & NZ) Pty Ltd
619 Collector Road
Tarago, NSW, 2580.

Re: Hydrogeological Study at Woodlawn Bioreactor- Summary of Water Balance & Leachate Treatment Predictions

1 Introduction

Earth2Water Pty Ltd (E2W) was engaged by Veolia Australia and New Zealand (Veolia) to undertake a hydrogeological study at the Woodlawn Site (E2W-0243 R001-V dated 26 March 2016). This letter follows Veolia request to better understand potential future leachate treatment extraction rates with consideration of reduced inward hydraulic gradients, increased rate of waste deposition (absorptive capacity), variable climate and water control measures (sealing of seeps etc, Figure 1 and Plates 1,2 &3).

Based on current information, leachate levels in the Void are shallow (<5m below waste) and extraction is required to assist with landfill gas production. The target leachate extraction rate to address storm water and groundwater inflows is estimated at ~3 L/sec on an annual basis. Water control measures (e.g. multiple pump stations, Pond 3 overflows and containment, clay bunds/groundwater-surface water extraction) are required to address heavy storm water events to enable better management and prediction of leachate treatment over time.

Refinement and prediction of the target leachate extraction rate over the landfill life (15 + years) is to assist Veolia manage the storage capacity of ED1 & ED2. Potential for enhanced groundwater ingress is interpreted from 700 to approximately 740 RL (i.e. presence of horizontal bores and likely fracture & rock slip systems). Near the top of the Void (<50 m), decreased groundwater inflows are expected due to merging of leachate level and surrounding water table (which is subject to long term recovery period). Mitigation of localized groundwater inflows can be achieved by clay bunds, sumps and or extraction works during progressive filling of the Void.

The purpose of this letter is to provide guidance on likely future groundwater inflow rates and consequently leachate treatment rates as the Void is filled over the next 15+ years[1]. Based on E2W current understanding, the extraction rate (3 L/sec) is based on approximate measurements and variable climatic conditions. The leachate treatment volumes (~3 L/sec) are anticipated to be similar (700 to ~ 740 RL) for the next ~40 m rise in waste levels based on the balance of water contributions (such as reduced evaporation loss/more permeable fracture/seeps "versus" the increased waste absorption/reduced gradient).

[1] *The filling rate over time (RL vs date) and relative position of the water table are presented in Tables 1A & 1B. The groundwater table is approx 20m bgl.*

2 Objectives and Background Information

- Refinement and prediction of the target leachate extraction rate over the landfill life (15 + years) to assist manage storage capacity at ED1 & ED2. Future variable parameters include increased waste inputs over time, wet climate, and potential reduction in groundwater ingress due to lower hydraulic gradients.

The open cut mine void where landfilling is proposed has a volume of approximately 25 million m^3 and a depth of about 200 m (630 RL to 800 RL). The landfill site lies in a regional geological setting of volcanic rocks which form part of the Lachlan Fold Belt of south eastern NSW. The hydrogeology of the site is dominated by the hard rock geology and mine/landfill activities.

The rock mass is generally of low permeability but fractures and joints, where interconnected, create minor storage and some secondary permeability. Rock permeability (E-08 to E-09 m/sec) is due almost entirely to fractures. The groundwater flow is via diffusion through bulk bedrock matrix, with preferential flow paths (fractures) with minor inter-granular flow associated with the rocks effective porosity (<5%).

Packer tests conducted within selected piezometers (constructed within the pit wall) produce a mean permeability value of 3.8x10-3 m/day (Woodward Clyde, 1997). Assuming the aquifer has a thickness of 150 m, transmissivity was assessed at approximately 0.6 m^2/day (very low). E2W understand that fracture openings and permeability decrease with depth (>100m, Appendix A, Fetter, 1994. Applied Hydrogeology) due to overburden pressure from bedrock.

Observation indicate the seepages from the base of the Void, occurs primarily through two fault/fracture zones (the 690, 750/790) located on opposite ends of the pit. Seepage is also known to occur via old exploration drill holes, and horizontal drain holes (i.e. 730 bench on north wall, Plates 1,2,3) which were designed to relive hydraulic pressures from the pit walls. Flows in mine workings are noted and up to 3.7 L/sec (northern portal in mine tunnel). Above the 730 m bench the Void surface area is large (>15 ha) relative to its base, and potential exists for enhanced seepage associated with rock slips, shear zones as water levels rise (Plates 1-3).

In late 2015, the groundwater levels in some piezometers (P44A/P44B and 100A/B) situated along fracture zones have rapidly equilibrated and stabilized with the waste level (~700 RL). This information indicates that groundwater ingress is keeping up with the rise of waste/landfill operations which causes leachate generation.

Dewatering associated with mining operations has created a steep cone of depression in the void area. The steep hydraulic gradients into the void are indicative of the impervious bedrock characteristics and slow seepage velocities in the bedrock, except where open fractures/bores linked to surface recharge areas (Figure 1). The influence from mine works (decline 1.4GL) is not well understood, however represents a large storage which may connect with the Void due to exploration boreholes/mine shafts (> 100 penetrations present around the Void).

2.1 Groundwater Inflows

Stormwater accumulation is a major component (~60%, groundwater ~30%, direct rain ~10%) of the water balance and cause of leachate generation.

Groundwater inflow potential for the Void is based Darcy Law (Q=kiA[2]). The geometry of the Void creates a substantial increase in surface area/perimeter with the incremental rise in the waste level (e.g. 2004 = 0.5 Ha, and 2016 = 11 ha waste and 2 km perimeter). The shape and geometry of influences the Voids ground inflow potential to intersect new fracture systems (especially unsaturated-natural and artificial, Figure 1).

E2W consider that in fractured impervious bedrock settings, the influence of hydraulic conductivity (k) dominates over the hydraulic gradient (i) due to the order of magnitude differences which occur with K (10 to 1,000) relative to "i" (e.g. less than 5). Therefore, the location and depth of fractures/seeps are key aspects of assessing future groundwater inflows and leachate treatment volumes.

The diminishing potential for evaporation of seeps/moisture on the rock faces decreases with the rise of waste in the Void. Although not quantified, the diminishing of evaporation losses would tend to balance the reduced hydraulic gradient with the enlarging and filling of the Void. The contribution of multiple small seeps (e.g. <0.1 L/sec) over large and previously evaporated sections would contribute water together with diffusion/moisture from the saturated bedrock (especially weathered material).

Groundwater inflows and (short medium term) seep responses are considered to reflect the recharges events associated with dry and wet seasons (e.g. rainfall varies from 500 mm to 750mm /annum rainfall). Temporary and rapidly flowing seeps (interflow from waste rock dump area etc) following wet weather are expected to be diverted into Pond 3 or other capture structures.

2.2 Leachate Reduction/Water Uptake

The potential increases to the groundwater inflow rates are balanced by the unsaturated waste properties.

- Hydraulic gradient decreases as the waste level rises and also from the absorptive capacity of the waste which is increasing over time (2014 @ 400,000 tonnes/annum to 2015@ 580,000 tonnes/annum, 2016 @ 650,000 tonnes/annum, 2017 @ 800,000 tonnes/annum, 2018 @ 850,000 tonnes/annum). Refer to Tables 1A and 1B.

The absorptive capacity of the increased waste deposition rate is as follows (assuming ~12 % moisture changes from waste disposal and saturation)

- 2016: 500,000 t equivalent to 1.5 to 2 L/sec (averaged over 1 year)

[2] **K= hydraulic conductivity (m/day), i= hydraulic gradient, A=area (m2), Q=flow m3/day**

- 2018: 800,000 t equivalent to ~3 L/sec (averaged over 1 year)

It is noted that any benefits associated with the increased waste deposition (100,000 t) from 2014 to 2016 was over ridden by the wet weather cycle and potentially leakage from the mine decline (1.4 GL). The absorptive capacity of the waste (may be negligible in wet periods) is subjected to seasonal wet weather and Veolia prevailing stormwater management practices (i.e. ponded water or leachate on waste surface should be removed to enable absorptive capacity to be utilised in the buried waste).

An initial increase in leachate extraction adjustments/circulation/pumping is recommended in short term to appropriately manage the shallow leachate levels and to improve gas rates (extraction, evaporation dam capacity, re-circulation and seepage works). Lowering of leachate levels will take time and can be addressed by the absorptive capacity of new waste, stormwater management measures and a consistent leachate extraction regime (demonstrated from February to May 2016).

Mitigation of localized groundwater inflows (i.e. via construction of clay bunds and sumps against the rock/waste interface to extract the groundwater and surface water/interflow which commenced in 2015/ 2016) can reduce amount of leachate being generated.

E2W interpret that target leachate treatment volumes of 3 L/sec could be reduced in future (15+ yrs) due to the implementation of engineered water control measures. The influence of the reduced groundwater inflow due to lessening of hydraulic gradient is considered to be marginal for the next 40m rise of waste level (e.g. 700 to 740 RL) due to upcoming fractures/seepage areas (i.e. 730 RL bench, Plates 1-2). Refer to Table 1A.

2.3 Leachate Prediction Summary

The lessening of groundwater inflow above 700 RL due to hydraulic gradient changes are interpreted to be balanced by the following:

- Higher flows/permeability of shallower (<100 m) more open fracture systems that are activated as the water level rises (i.e. permeability of rock mass can vary by order of magnitude due to fractures).
- Diminishing groundwater inflows is expected with clay lining/sealing of rock walls and as leachate levels begin to merge with the surrounding water levels (<50 m below top of Void).
- Diminished evaporative effects on the rock walls as they are covered by waste.

Lowering of the leachate levels (relative to waste surface) can be achieved from the additional absorptive capacity of the waste and leachate extraction and treatment (~3 L/sec per annum).

Variations in the groundwater inflow rates are likely to be linked to recharge events associated with wet seasons and localized fracture/seepages. Localised fracture seepages may be reduced/diverted from the waste with engineered solutions such as sealing, capping or extraction.

The leachate treatment volumes (~3 L/sec) are anticipated to be similar (700 to ~ 740 RL) for the next ~40 m rise in waste levels based on the balance of water contributions (evaporation loss/opening of fracture/seeps ~730 RL "versus" the increased waste absorption/reduced hydraulic gradient). The lessening of hydraulic gradient is considered to be balanced and marginal for the next 40 m rise of waste level (e.g. 700 to 740 RL) due to upcoming known fractures/seepage areas (i.e. 730 RL bench, Plates 1-2).

The potential for significant fractures/groundwater inflow potential from 740 to 800 RL is not well known. The groundwater recovery time for the pre-mining water table is predicted to be long term (decades) for the upper section (top 20m to 50m) of the Void and may potentially fall behind (lower) than the rate of leachate level rises.

A consistent groundwater flow (~1 L/sec at ~770 RL) was observed just above the leachate treatment pond since December 2015 to May 2016 and inferred to relate to surface drainage, pipe leaks, and or leakage from evaporation dams. Reduction of groundwater inflows (<50m from top of Void) and installing a clay wall liner would benefit by reducing leachate treatment volumes and contribute to landfill closure and rehabilitation works.

The predicted leachate treatment volumes based on annual waste deposition rates and levels is presented in Tables 1A and 1B. A gradual decrease in groundwater inflow contributions is predicted over the fractured rock aquifer from approximately 740 RL to 780 RL. The groundwater inflow decreases are estimated at 10% per 10m rise in waste level above 740 RL.

The groundwater inflow contribution is predicted to cease above 780 RL due to the merging and slow equilibration with regional hydraulic levels. The leachate treatment volumes above 780 RL are interpreted to correspond to direct rainfall recharge over an increase waste surface area.

Leachate treatment predictions above 780 RL are as follows,

- 30 ha (300,000 m^2) waste surface catchment area and 20% infiltration/recharge over waste surface from 900mm rainfall (wet season).
- Water infiltration equivalent to 53,100 m^3/year or 1.7 L/sec averaged over 1 year.

Surface water management will be on ongoing strategy to reduce and divert stormwater out of the Void and also away from the buried waste where enhanced leachate generation events can occur rapidly (e.g. 4 & 5 June 2016 of 150mm rainfall, and 29 March 1999 of 161 mm).

Yours sincerely,
Earth2Water Pty Ltd
ABN: 64100 859 238

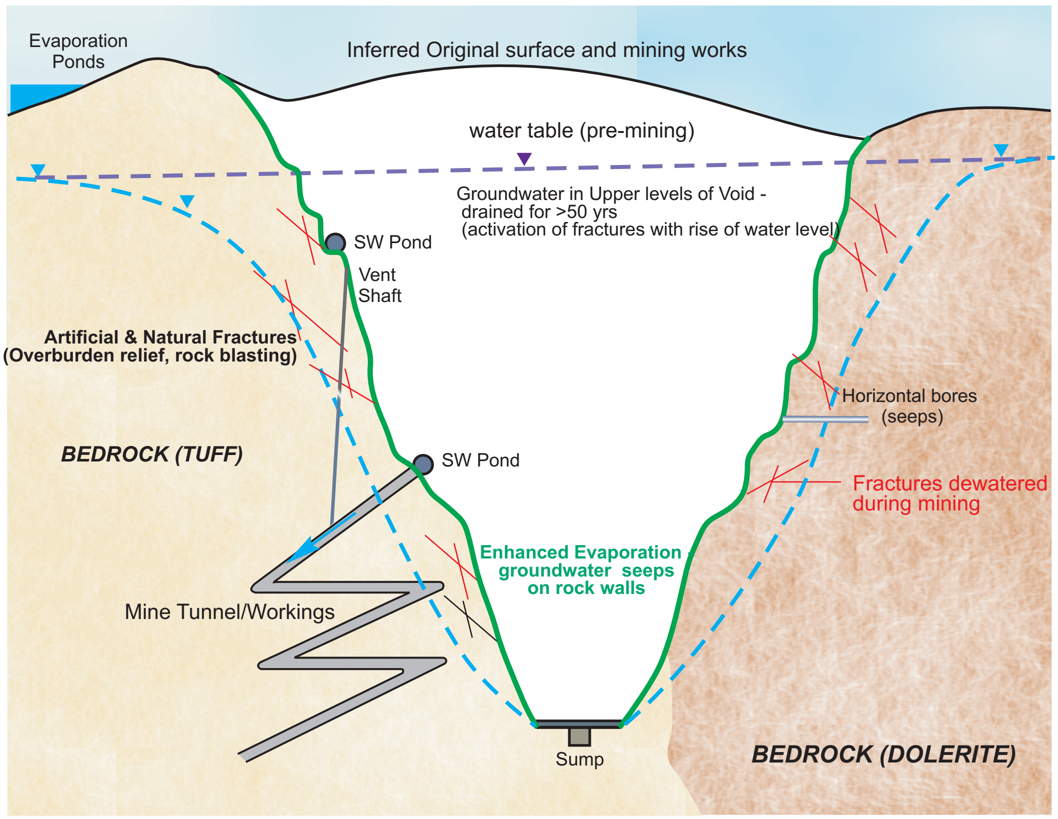
Dino Parisotto (Managing Director)
BAppSc - Geology (Hons); MAppSc – Groundwater; Driller C3(DL1977)

Mobile 0422 334102

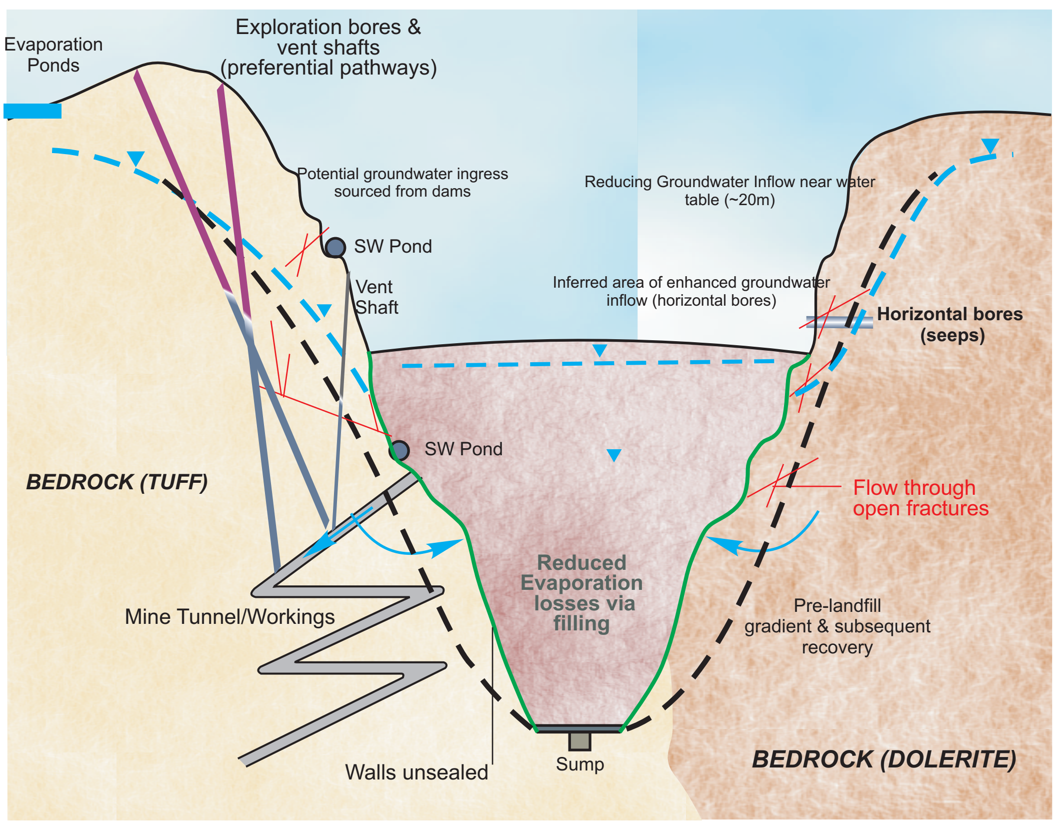
Attachments

Figure 1	Conceptual Site Model- Void Hydraulics (June 2016)
Plates	1,2, 3 Seepage Pathways in Void (December 2015)
Table 1A	Void Volume and Filling Predictions
Table 1B	Woodlawn Estimated Waste Tonnes Forecast
Appendix A	Groundwater Yields vs Depth (Fetter, 1994. Applied Hydrogeology)

Figure & Plates



1. Mining Operations



2. Void/Landfill Operations

Conceptual Site Model- Void Hydraulics (V1, June 2016)

Date: 21 June 2016

Reference: E2W_243_03.cdr

Woodlawn Bioreactor - Hydrogeological Study

Figure 1

Plates 1 & 2 (15 December 2015) Void- eastern wall (720 m bench). Plates showing the horizontal bores and plumbing used to control the seepage & hydraulic pressures. The frequency (10m spaced bores ~12) and staining on the rock walls indicate long term active seepage. (*clay bund walls and drainage to pits recommended for managing/plugging groundwater inflows and stormwater diversion & management- flow rate from seepage ports not known & likely activation by rainfall*).

Plate 3 (15 December 2015) Void- northern wall showing rock slip/fault line and possible zone of seepage activation with rising of water levels.

Tables

Table 1A: Void Volume and Filling Predictions

Estimated Leachate Treatment Rate (L/sec)	Estimate Year and Waste Level RL	RL of Waste	Thickness of Waste (m)	Waste Volume (m3)	volume of waste (m3) per Lift	Cumulative Volume (m3) per Lift
	2004	640	0	-	0	
		650	10	123,846		
		660	20	328,419		
		670	30	637,175		
		680	40	1,047,573		
		690	50	1,615,971		
		700	60	2,384,881		
		710	70	3,314,900		
		720	80	4,396,653		
		722	82	4,633,951		
3	waste RL June 2016	724	84	4,878,353	0	0
		726	86	5,129,313	250961	250,961
		728	88	5,386,647	257334	508,294.63
	mid 2017	730	90	5,650,796	264148	772,443.06
	end 2017	732	92	5,929,884	279089	1,051,531.59
3	start 2018 (commence treatment)	734	94	6,218,790	0	
3		736	96	6,514,538	295748	295748
3		738	98	6,816,999	302461	598210
3		740	100	7,126,244	309245	907455
2.7	mid 2020 (10% reduction predicted in gw inflow)	750	110	8,821,558	1695313	2602768
2.43	2023	760	120	10,748,276	1926718	4529486
2.187	mid 2025	770	130	12,995,733	2247458	6776943
1.7	2029	780	140	15,494,825	2499092	9276035
		790				

Notes: 1. Direct rainfall only (above 780 RL) - 295,000m2 catchment *20% infiltration*900mm rainfall expressed as L/sec= 53,100 m3/yr or 1.7 L/sec
2. Groundwater inflow ceasing above 780 RL due to equilibration with surrounding water table. Void walls sealed/capped above 780m RL
3. Leachate levels relative to waste level is not well known, however approx 10m from waste surface

Table 1B: Woodlawn Estimated Waste Tonnes Forecast

Tonnes per year forecast (ex MT)		
start year	waste per annum	cumulative tonnes per annum
2017		-
2018	850,000	850,000
2019	900,000	1,750,000
2020	900,000	2,650,000
2021	900,000	3,550,000
2022	900,000	4,450,000
2023	900,000	5,350,000
2024	900,000	6,250,000
2025	900,000	7,150,000
2026	900,000	8,050,000
2027	900,000	8,950,000
2028	900,000	9,850,000
2029	900,000	10,750,000
2030	900,000	11,650,000
2031	900,000	12,550,000
2032	900,000	13,450,000
2033	900,000	14,350,000
2034	900,000	15,250,000
2035	900,000	16,150,000
2036	900,000	17,050,000
2037	900,000	17,950,000
2038	900,000	18,850,000
2039	900,000	19,750,000
2040	900,000	20,650,000
2041	900,000	21,550,000
2042	900,000	22,450,000
2043	900,000	23,350,000
2044	900,000	24,250,000
2045	900,000	25,150,000
2046	900,000	26,050,000
2047	900,000	26,950,000

Appendix A

IGNEOUS AND METAMORPHIC ROCKS 357

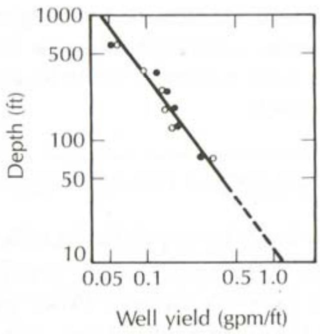


FIGURE 9.26 Yields of wells in crystalline rock in the eastern United States. Open circles represent grouped mean yields of granite rock wells and black dots represent grouped mean yields for schist wells. Source: S. N. Davis & L. J. Turk, *Ground Water* 2 (1964): 6–11.

Attachments

Attachment 3 – Water Balance Report

Our ref: 2269623B-RES-LTR-03 Rev0 - ED1 Water Balance Assessment Report.docx

Your ref: Email dated 1 June 2016

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22 July 2016

Stephen Bernhart
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Dear Stephen

ED1 water balance assessment for treated leachate management

1. INTRODUCTION

Veolia Australia and New Zealand (Veolia) is considering upgrading their leachate treatment plant that is likely to output at a peak rate in between 3 L/s and 4 L/s. The quality of required treatment will depend on whether the treated leachate can be managed by storing in Evaporation Dam 1 (ED1) and subsequent evaporation from it.

Veolia undertook a leachate modelling and provided the following proposed schedule of leachate rate that is likely to generate from the mine void bioreactor from 2016 to 2057. The leachate treatment plant is planned to commence from 2018 and Veolia would like to use ED1 for its storage and subsequent evaporative disposal for 40 years.

Table 1.1 Schedule of leachate rate from Veolia's mine void bioreactor

DATE	FILL LEVEL IN THE MINE VOID (M, RL)	LEACHATE RATE (L/S)
[illegible]1[illegible]	71[illegible]	[illegible]
[illegible]17	7[illegible]	[illegible]
D[illegible]17	7[illegible]	[illegible]
[illegible]1[illegible] [illegible] r[illegible]	7[illegible]	[illegible]
[illegible]	75[illegible]	[illegible]7[illegible]
[illegible]	7[illegible]	[illegible]
[illegible]5	77[illegible]	[illegible]1[illegible]7
[illegible]	7[illegible]	1[illegible]7[illegible]
[illegible]57	7[illegible]	1[illegible]7[illegible]

ED1 is also a primary dam that Herron Resources is likely to use when they commence mining. Hence a water balance assessments were required to evaluate the viability of options for the treated leachate disposal in ED1.

WSP|Parsons Brinckerhoff was commissioned by Veolia on Wednesday 1 June 2016 to undertake water balance simulations using the GOLDSIM based water balance model that was used previously in the assessment of Evaporation Dam 3 South (ED3S) for a licensing application.

The main objective of the Veolia nominated scenarios was to assess whether ED1 (refer to Figure 1.1 for its location) will overflow over a period of 40 years, if the treated leachate is discharged as per projected schedule (refer to Figure 1.2 or Table 1.1) under the following three scenarios:

- Scenario A – ED1 does not receive runoff from the Plant Containment Dam (PCD) catchment and groundwater from pit dewatering
- Scenario B – Condition of Scenario A and water transfer from ED3N and ED3S cells at 1L/s
- Scenario C –Condition of Scenario B and groundwater transfer from pit dewatering with concurrent water use by Herron Resources for mineral processing

Additional objective of the water balance modelling was to demonstrate how long it might take for ED3S and ED3N cells to empty by evaporation alone if water is not transferred to ED1.

The findings presented in this letter is subject to the data set and model parameters as detailed in WSP|Parsons Brinckerhoff report 2269623A-WAT-REP-001 RevA (November,2015).

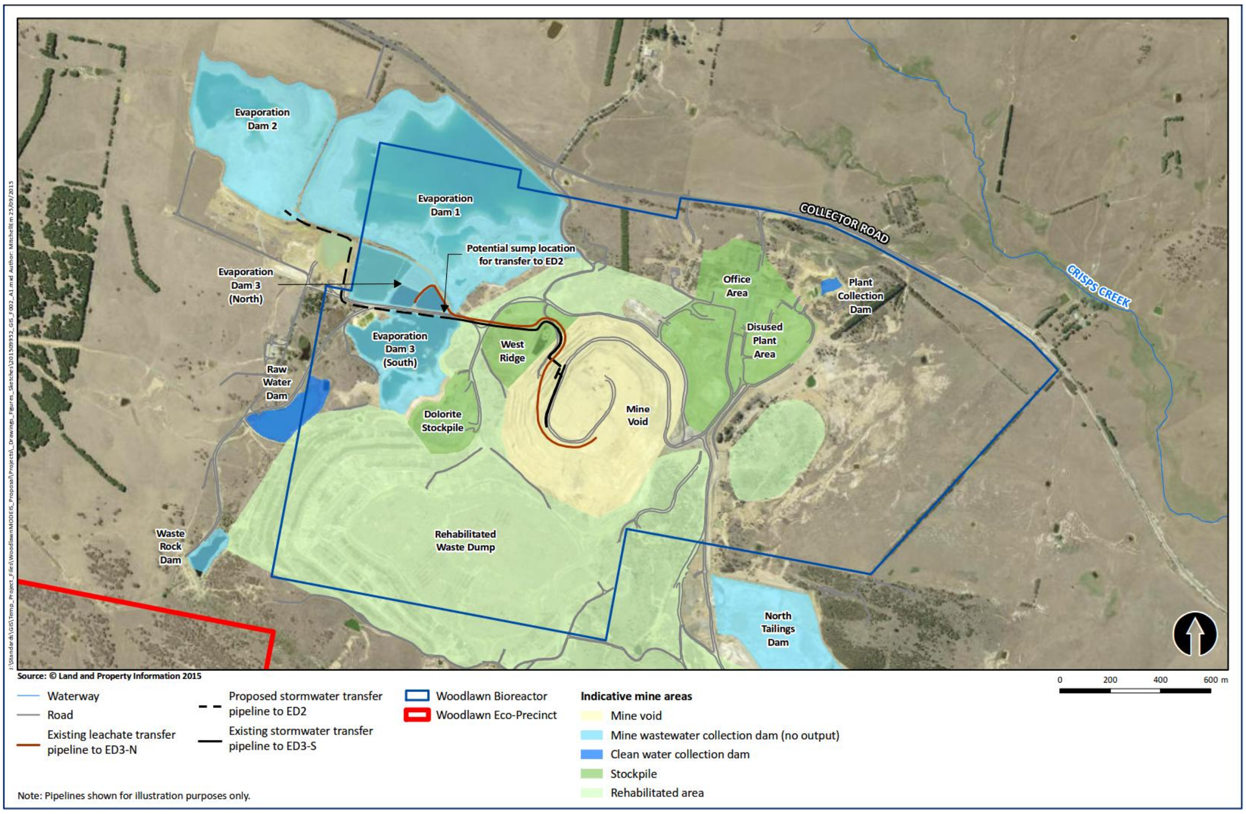

Figure 1.1 Location of evaporation dams and Veolia's mine void

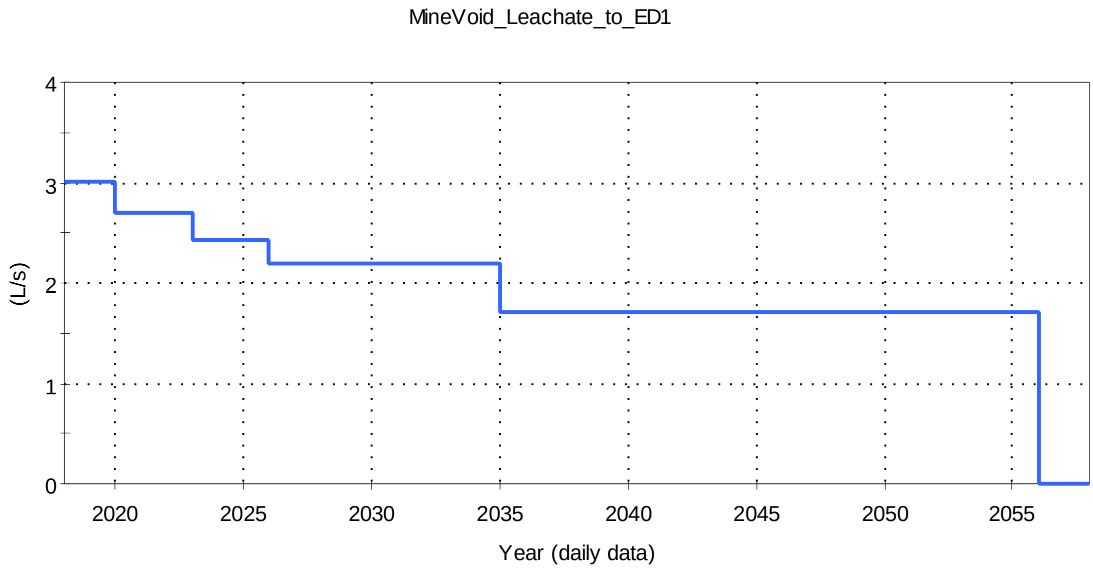

Figure 1.2 Schedule of treated leachate used in the modelling for the base case

2. CLIMATE

The GOLDSIM based water balance model was simulated for two sets of climate sequences as presented in Figure 2.1 (refer to chapter 3 of 2269623A-WAT-REP-001 RevA for details):

1. 1947 to 1986 (sequence containing annual rainfalls greater than 1000 mm)
2. 1976 to 2015 (recent sequence with less than 1000 mm of annual rainfalls)

The climate sequence from 1947 to 1986 was termed as the wet sequence as it contains five years with more than 1,000 mm of annual rainfall and 22 years with more than 680 mm of annual rainfall, which is a long term average from 1932 to 2015.

The climate sequence from 1976 to 2015 does not contain any year with more than 1,000 mm of annual rainfall and has 18 years exceeding the long term annual average. The highest annual rainfall recorded in this period was 980 mm in 1984.

Both series starts with above average annual rainfall, however, the wet sequence contains the first six consecutive years of above annual average rainfalls. The dry sequence also contains a period of seven consecutive years of above average annual rainfalls but towards the middle of the sequence from 1987 to 1993.

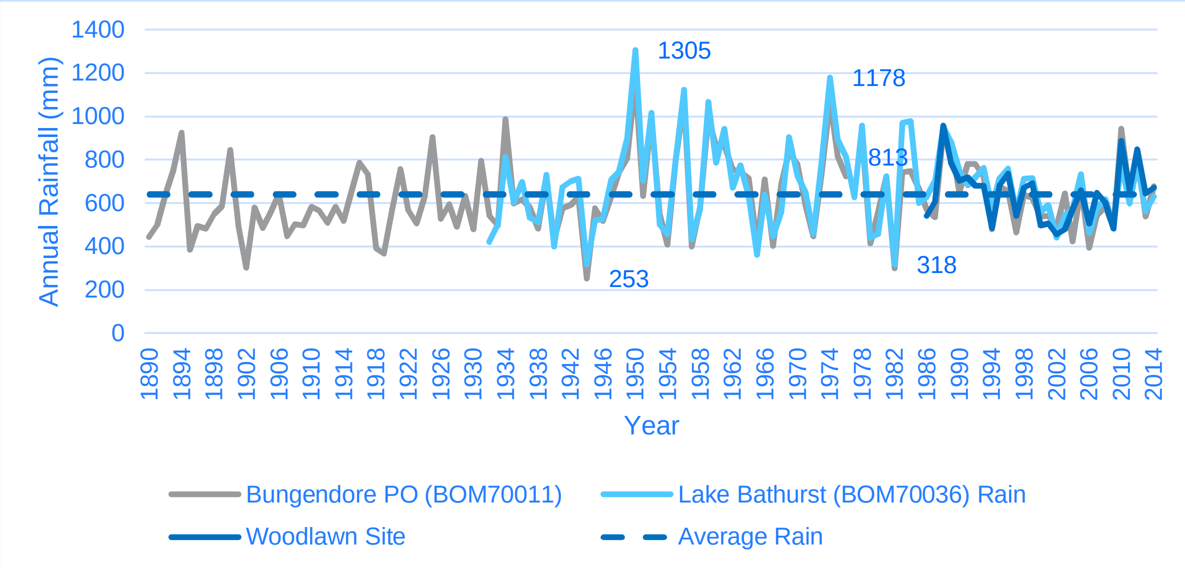

Figure 2.1 Rainfall sequences from 1890 to 2014

3. MODELLING APPROACH

The Goldsim based water balance model was calibrated to the existing condition for ED1 and ED2 (refer to Figure 3.1 for a flow chart). Future additional volumes of water to ED1 and ED2 were then applied to the water balance system as per Scenario A, Scenario B and Scenario C (refer to Figure 3.2 for a flow chart). The model was run on a daily basis for the two climate sequences: 1976 to 2015 (referred to as the dry sequence) and 1947 to 1965 (refer to as the wet sequence). The modelling approach assumes that similar climate sequences would occur in future.

The model calibration parameters were:

- pan evaporation coefficient =0.7 (recommended by Veolia)
- seepage losses from dams= 0.6 mm/day (refer to Section A.1 of 2269623A-WAT-REP-001 RevA)
- runoffs from PCD catchment=37% of rainfalls (refer to Section A.1 of 2269623A-WAT-REP-001 RevA)
- runoffs from Veolia's pit stormwater = 0.000148 x annual rainfalls (refer to Section 8.3 of 2269623A-WAT-REP-001 RevA)
- runoffs from remainder of catchments for ED1 and ED2= 10% of rainfalls (refer to Section 8.3 of 2269623A-WAT-REP-001 RevA)

For future scenarios, the seepage rates from ED1, ED2 and ED3 ponds were set to zero. Veolia is planning on undertaking required works to minimise seepage from the ponds that will receive leachate from the mine void.

The stormwater runoffs generated from the plant containment dam (PCD) catchment will not be pumped into ED1. Veolia is considering progressively rehabilitating the catchment for external release. Until that happens, Veolia plans to utilise tailings storage facility ponds for storage of the PCD catchment runoffs.

Future scenario modelling assumes that PCD catchment runoffs will not enter ED1 directly or in the form of overflow transfer from the tailings dams.

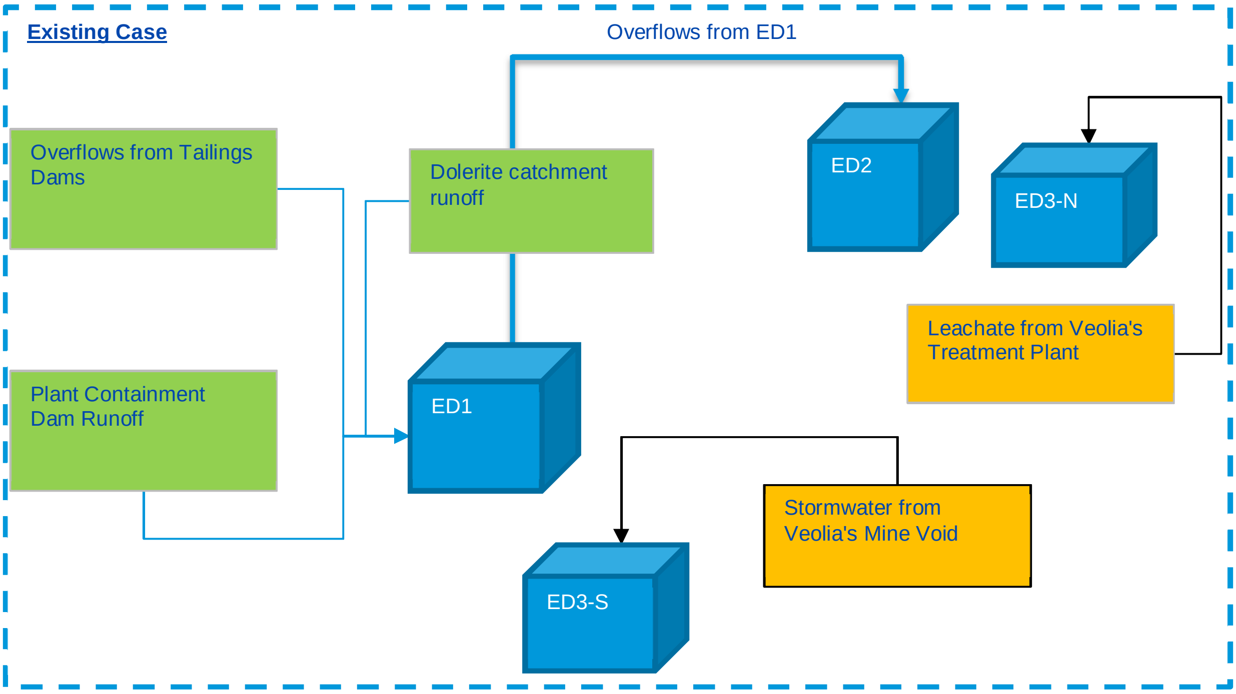

Figure 3.1 Modelling flow chart for the existing case

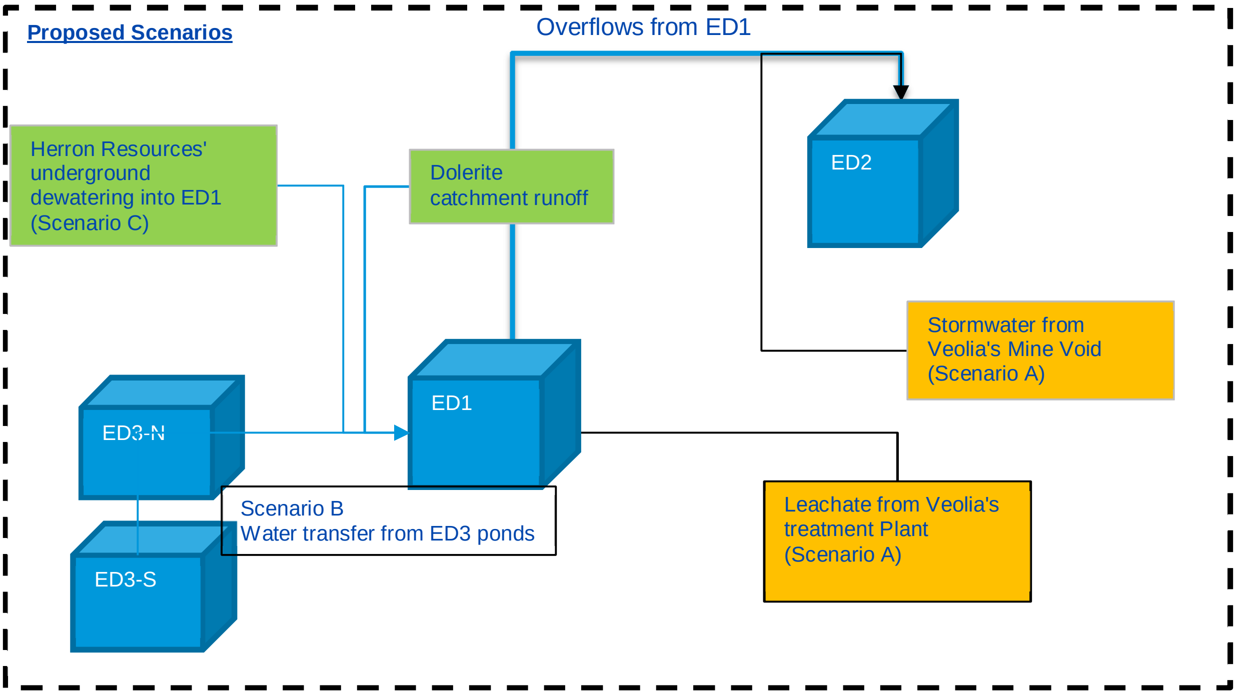

Figure 3.2 Modelling flow chart for future scenarios

4. RESULTS

4.1 Model calibration for the climate sequence from 1997 to 2014

Figure 4.1 for ED1 and Figure 4.2 for ED2 presents simulated water levels and volumes for the model calibration from 1997 to 2014. Comparisons with the measured water levels for the dams suggest the model is calibrated. Note that the initial volumes in the dams for the calibration were at 725 ML for ED1 and 480 ML for ED2. The start-up volume before future additional volumes are added will have impact on how and when the dams may overflow.

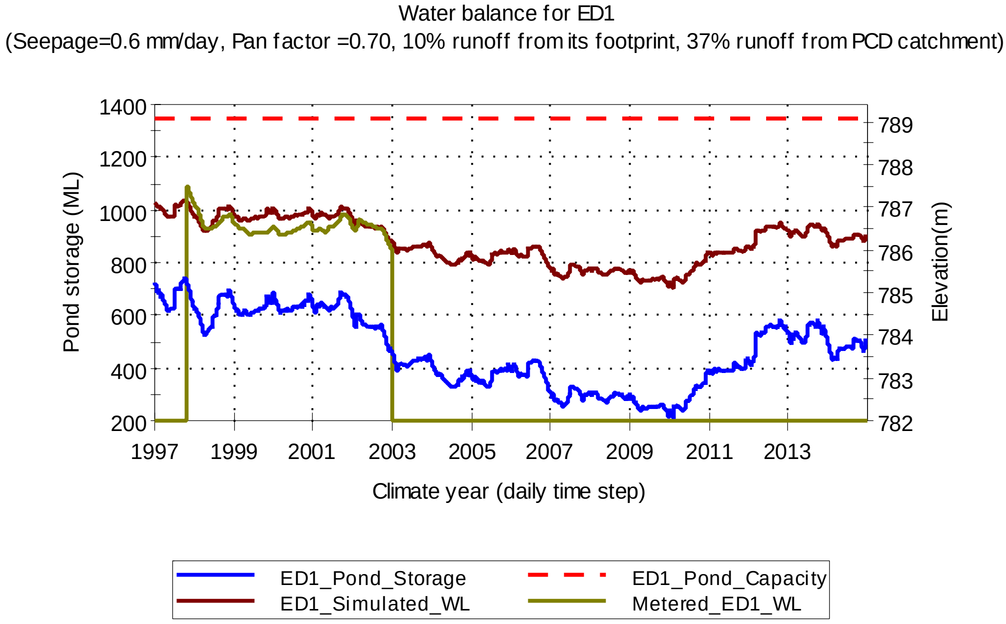

Figure 4.1 ED1 simulated results for the calibration case

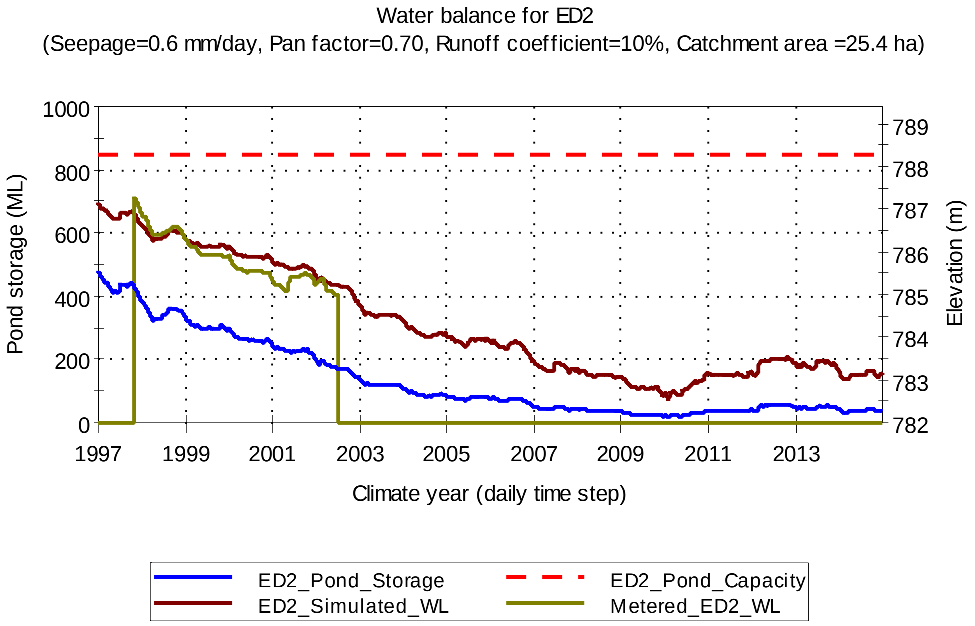

Figure 4.2 ED2 simulated results for the calibration case

4.2 Scenario A – ED1 and ED2 are exclusively used by Veolia

In this scenario, Veolia will use ED1 exclusively for storage of treated leachate from 2018. The mine void stormwater will also be diverted to ED2 pond via a sump (a portion of the current northern cell of ED3-S). If ED1 becomes full before ED2, the overflows will enter ED2. ED1 will continue to receive the stormwater runoff or leachate from the dolerite catchment as it happens currently. ED1 will not receive any stormwater runoff from the PCD or the tailings storage facility. The initial volumes at the start of simulation for Scenarios A and B were kept at 150ML and 100ML respectively (current volumes as of July 2016).

4.3 Scenario A1-Scenario A under 1947 to 1986 climate

The future Scenario A was simulated under the wet climate sequence.

4.3.1 Base case Scenario A1

The leachate schedule and parameters assumed to represent the base case Scenario A1 were:

- pan factor=0.7
- seepage from pond floors=0.0 mm/day
- treated leachate schedule shown in Figure 1.2

Simulated results for ED1 in Figure 4.3 suggest the dam would become full in 2027 (within 10 years, commencing from 2018) due to rainfall-runoff and the scheduled future discharges of treated leachate. Note that the secondary y-axis in Figure 4.3 has been deliberately limited to 1 ML/day to show leachate rate time series.

Simulated results for ED2 in Figure 4.4 also shows that ED2 would also fill up and spill in 2027 primarily due to excess water received from ED1 as well as mine void stormwater.

Initial increase in volumes in both ponds are due to six consecutive years of above average rainfall condition (1947 to 1952). Also the leachate rates for the first two years are expected to be 3L/s. Once the annual rainfalls drops below the long term annual average rainfall of 680 mm for four consecutive years, the storage in both ponds steadily reduces due to natural evaporation. The storage rises again triggered by above average rainfall.

4.3.2 Sensitivity to pan factor

The base case simulation was repeated with increased pan factor to estimate additional evaporation that may be required from the surface of ED1 dam to lose excess water via evaporation in order to prevent ED1 from overflowing into ED2.

The leachate schedule and parameters assumed to represent the base case Scenario A1 sensitivity to pan factor were:

- pan factor=0.85
- seepage from pond floors=0.0 mm/day
- treated leachate schedule shown in Figure 1.2

Figure 4.5 for ED1 and Figure 4.6 for ED2 demonstrates that if the evaporation were to occur at 85% of the pan evaporation from these ponds, the proposed leachate schedule could be managed by exclusive use the ED1.

Given that the salinity of the leachate is likely to increase over time due to evaporation, the pan factor is also likely to reduce over time rather than increase.

The leachate schedule presented in Figure 1.2 is the best case leachate production schedule. The rates could increase due to uncertainty in moisture content, groundwater and climate.

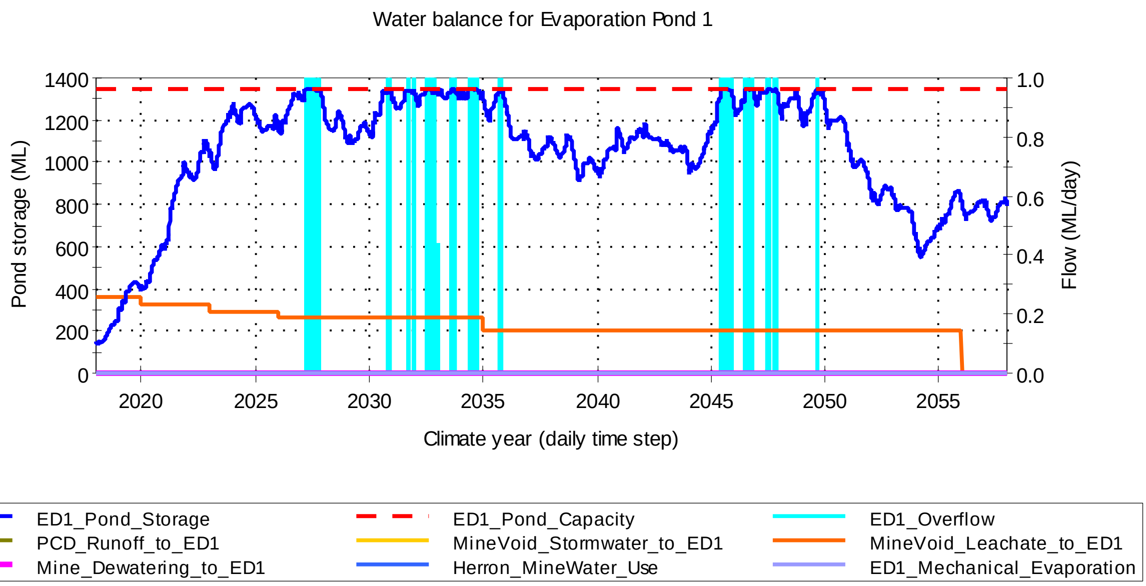

Figure 4.3 ED1 simulated results for the base case Scenario A1

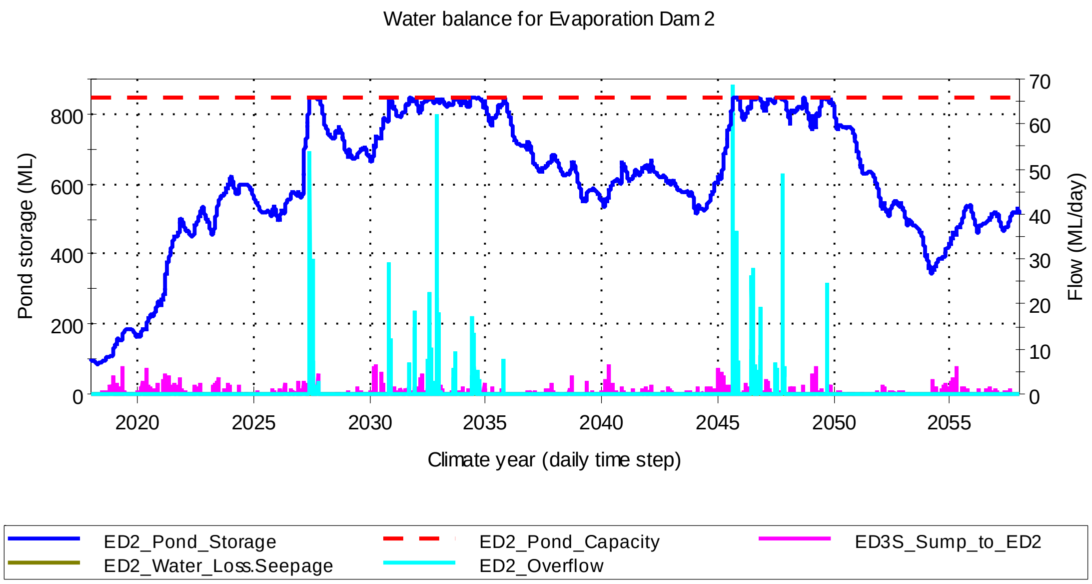

Figure 4.4 ED2 simulated results for the base case Scenario A1

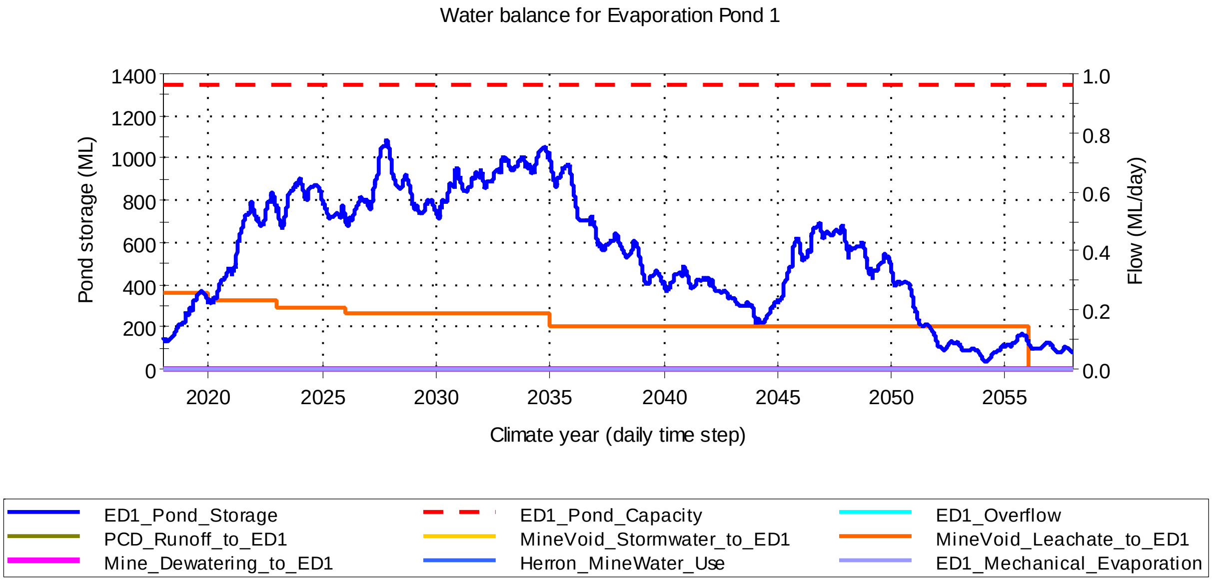

Figure 4.5 ED1 simulated results for the base case Scenario A1 with a pan factor of 0.85

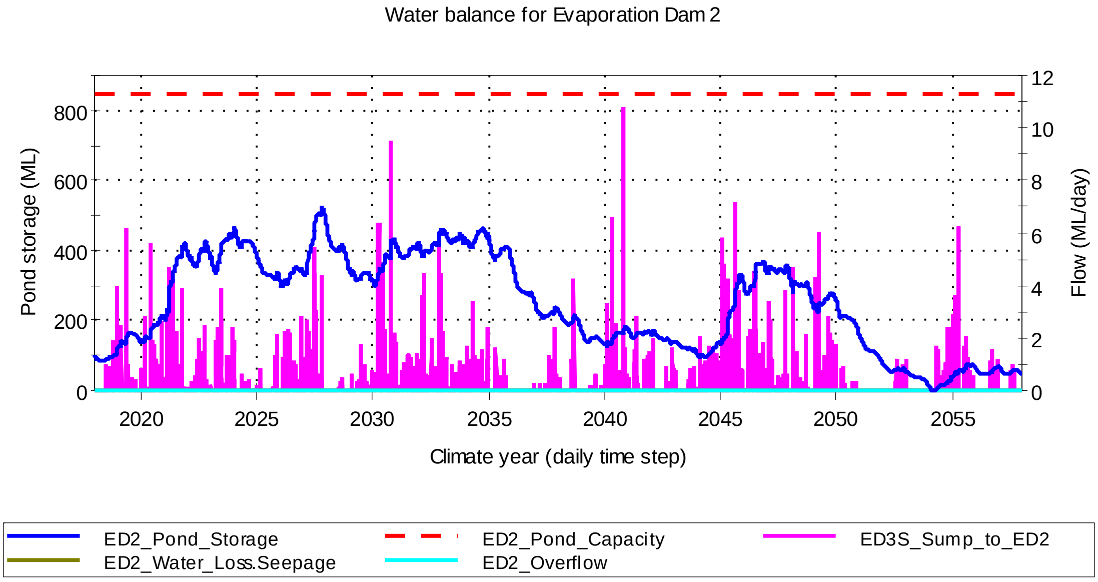

Figure 4.6 ED2 simulated results for the base case Scenario A1 with a pan factor of 0.85

4.3.3 Sensitivity to increase in leachate production

To simulate what happens when the leachate production increases by 1L/s over the life of the bioreactor operation (40 years), the following input and parameters were adopted.

- pan factor=0.85
- seepage from pond floors=0.0 mm/day
- treated leachate schedule shown in Figure 1.2 increased by 1L/s

Figure 4.7 shows that even with the pan factor of 0.85, overflows from ED1 to ED2 would occur when the leachate production is increased by 1L/s. Figure 4.8 indicates that ED2 would contain the overflows from ED1.

4.3.4 Use of mechanical evaporator Scenario A1

To manage uncertainty in leachate production and pan factor, Veolia would like to use mechanical evaporators to increase evaporation from the ponds. Mechanical evaporators such as TurboMist (http://www.turbomist.com/products) may be able to increase evaporation by pumping water from the pond into air as a mist. The surface area increased in vertical air space above the pond as well as fine size mist particles of water staying longer in the air are two main factors that may lead to additional evaporation. The manufacturer's data as provided by Veolia (refer to Table 4.1) were used in assessing how many evaporator units may be required to evaporate additional water that otherwise cannot be contained within ED1 pond. Each mechanical evaporator is expected to provide a water loss of at least 28% of volume pumped through it.

Table 4.1 Performance of Mechanical Sprayers (Technical Data)

EVAPORATION RATE ON-SITE (INCHES/MONTH)	EVAPORATION RATE ON-SITE (MM/YEAR)	EVAPORATION AS A PERCENTAGE OF VOLUME PUMPED (%)	EVAPORATION BY MECHANICAL SPRAYERS (ML/YEAR)
2	610	28	402.2
3	914	30	430.9
4	1219	34	488.4
5	1524	36	517.1

This scenario adopted the following inputs and parameters:

- pan factor=0.6
- seepage from pond floors=0.0 mm/day
- treated leachate schedule shown in Figure 1.2 increased by 1L/s
- 2.5 units of mechanical evaporators operating at ED1, 0.7 unit at ED2

Note that a mechanical evaporator unit is capable of pumping at 350L/min operating 24-hours at 95% capacity.

Figure 4.9 illustrates that mechanical evaporators can control volume build up in ED1 and ED2. These results were obtained with 2 units of mechanical evaporators operating continuously and 1 unit operating at half capacity at ED1. Figure 4.10 also illustrates that the volume in ED2 is contained within the dam spillway level. This result was obtained with 1 unit of mechanical evaporator operating at half capacity at ED2.

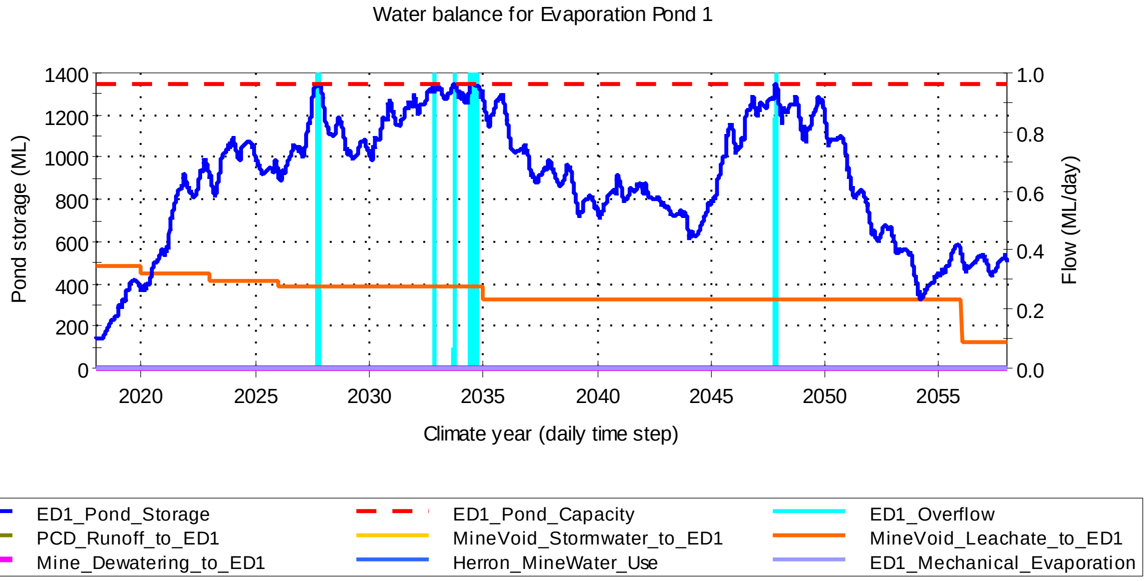

Figure 4.7 ED1 simulated results for the base case Scenario A1 with a pan factor of 0.85 and increased leachate production by 1L/s

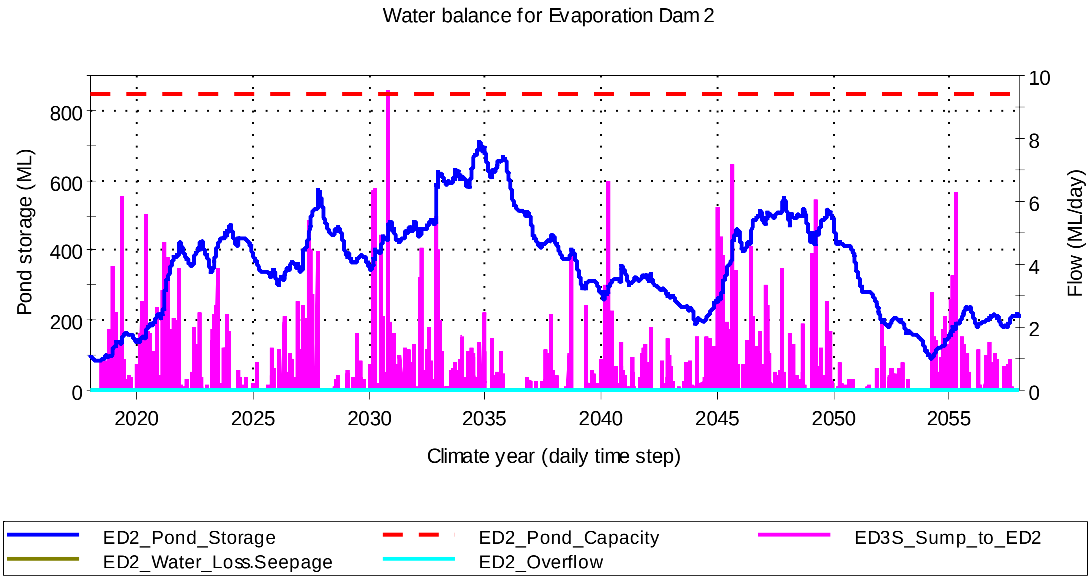

Figure 4.8 ED2 simulated results for the base case Scenario A1 with a pan factor of 0.85 and increased leachate production by 1L/s

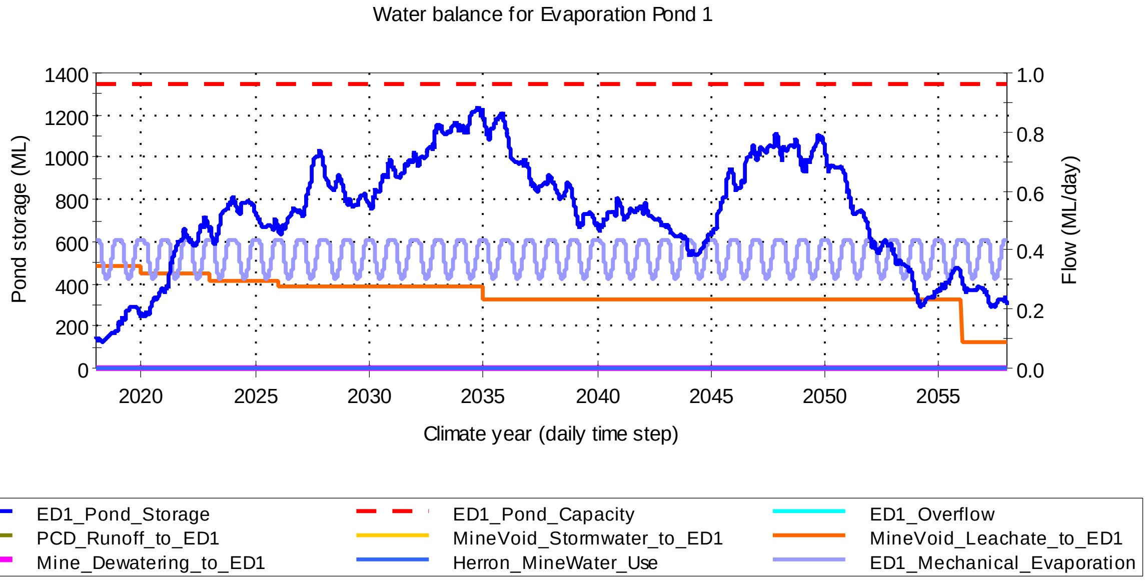

Figure 4.9 ED1 simulated results for the base case Scenario A1 with a pan factor of 0.6, mechanical evaporators and increased leachate production by 1L/s

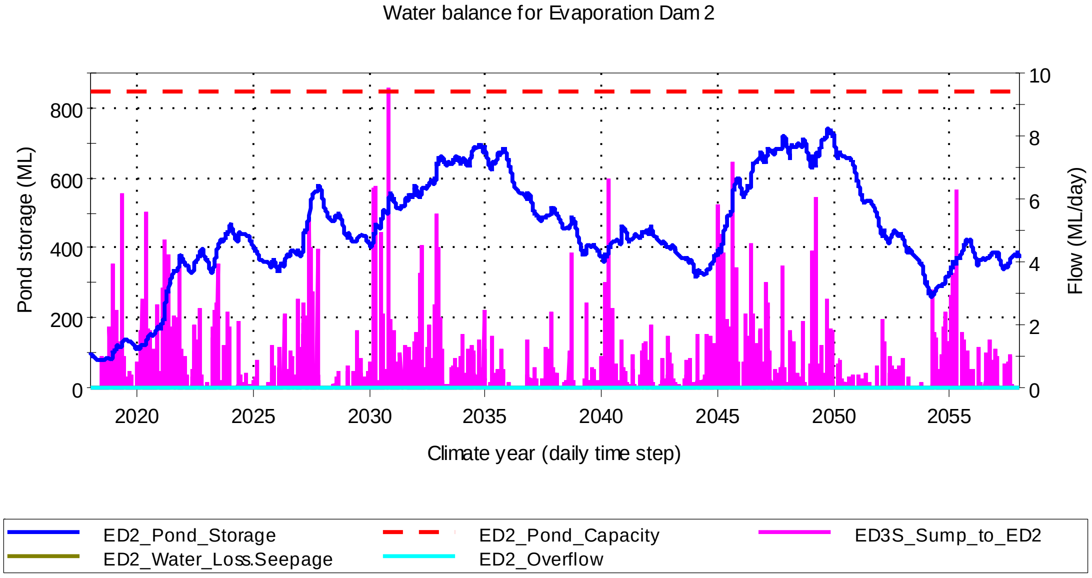

Figure 4.10 ED2 simulated results for the base case Scenario A1 with a pan factor of 0.6, mechanical evaporators and increased leachate production by 1L/s

4.4 Scenario A2-Scenario A under 1976 to 2015 climate

This section presents results for the same sub-set of scenarios as presented in Section 4.3 but under the dry climate sequence.

4.4.1 Base case Scenario A2

The leachate schedule and parameters assumed to represent the base case Scenario A1 were:

- pan factor=0.7
- seepage from pond floors=0.0 mm/day
- treated leachate schedule shown in Figure 1.2

The simulated results presented in Figure 4.11(for ED1) and Figure 4.12 (for ED2) suggest that even under the dry climate sequence from 1976 to 2015, ED1 is expected to become full and the overflows from ED1 leads to ED2 overflowing as well. The overflows occur when seven consecutive years of above average annual rainfall occur from (1987 to 1993).

4.4.2 Scenario A2 sensitivity to pan factor

The base case simulation was repeated with reduced pan factor to simulate the impact of reduced evaporation from concentration of salt content in ED1.

The leachate schedule and parameters assumed to represent the base case Scenario A1 to test the impact of reduced evaporation on ED1 volumes were:

- pan factor=0.6
- seepage from pond floors=0.0 mm/day
- treated leachate schedule shown in Figure 1.2

The simulated results presented in Figure 4.13 (for ED1) and Figure 4.14 (ED2) indicate that even ED2 is likely overflow multiple times if the pan factor reduces in future from 0.7 to 0.6 due to increased salt content in the dams.

4.4.3 Scenario A2 sensitivity to increased leachate production

Knowing that ED1 and ED2 may overflow due to addition of treated leachate as per the schedule presented in Figure 1.2 when the pan factor is reduces to 0.6, this scenario was developed to assess whether an increase in evaporation can counteract additional leachate production of 1L/s and yet contain leachate within ED1. The following input and parameters were adopted:

- pan factor=0.85
- seepage from pond floors=0.0 mm/day
- treated leachate schedule shown in Figure 1.2 increased by 1L/s

The simulated results presented in Figure 4.15 (for ED1) and Figure 4.16 (for ED2) indicate that no leachate will leave ED1 and the pond volume in ED1 may remain less than 1000 ML. The maximum volume in ED2 was simulated to be less than its 50% capacity.

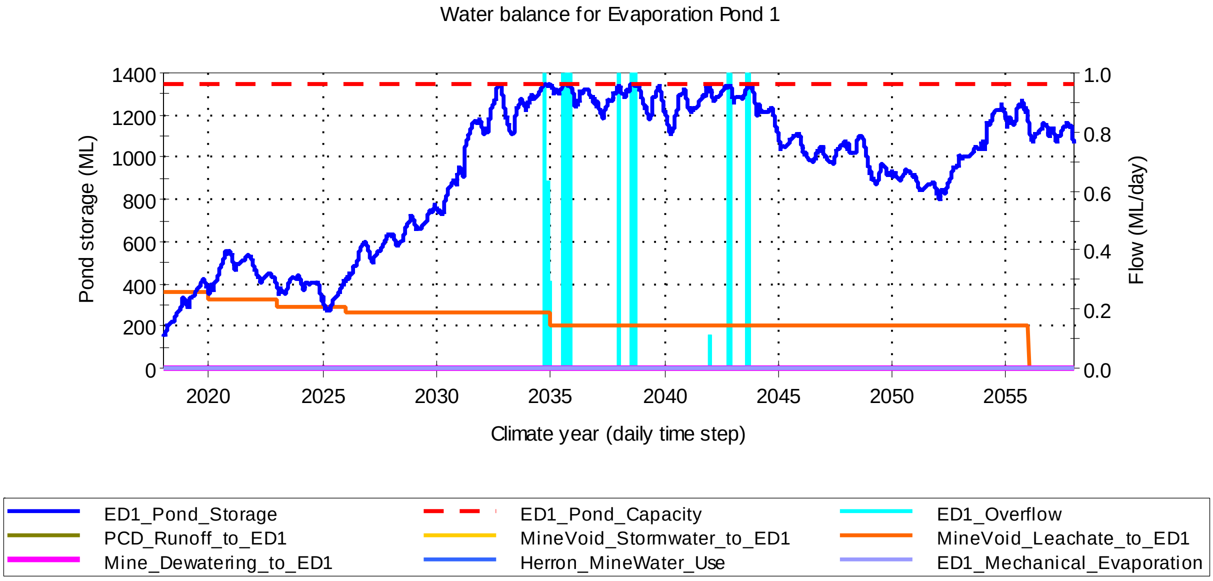

Figure 4.11 ED1 simulated results for the base case Scenario A2 under 1976 to 2015 climate

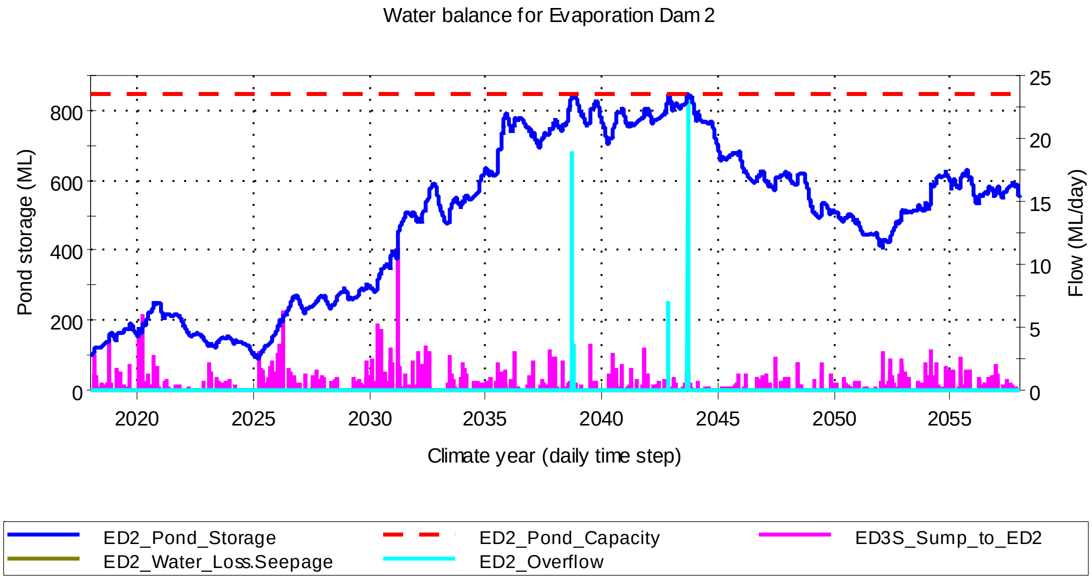

Figure 4.12 ED2 simulated results for the base case Scenario A2 under 1976 to 2015 climate

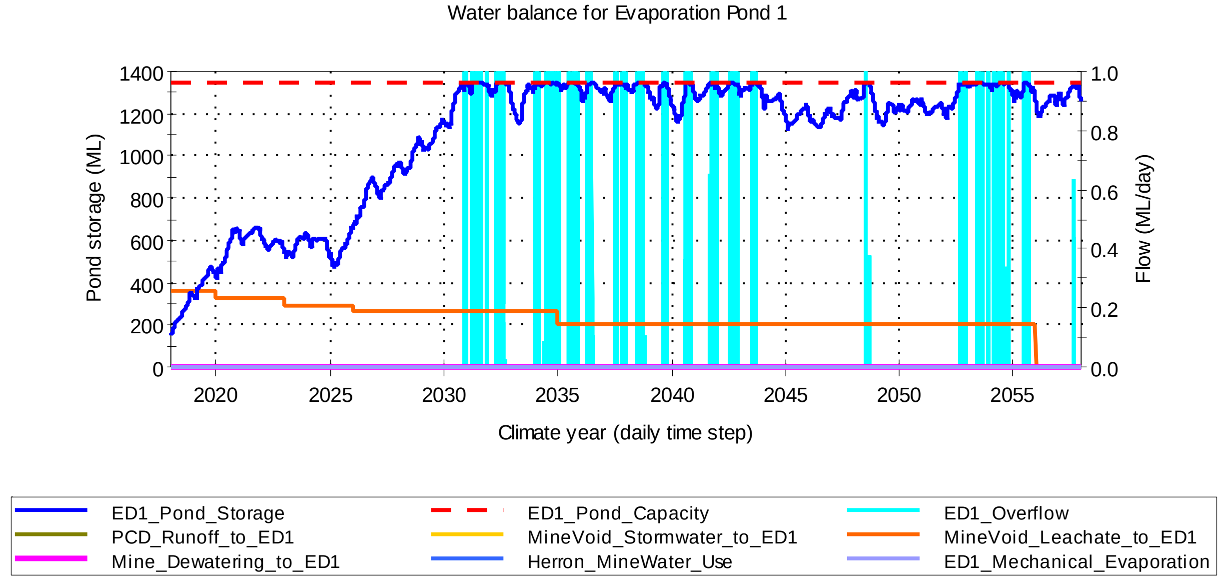

Figure 4.13 ED1 simulated results for the base case Scenario A2 with a pan factor of 0.60

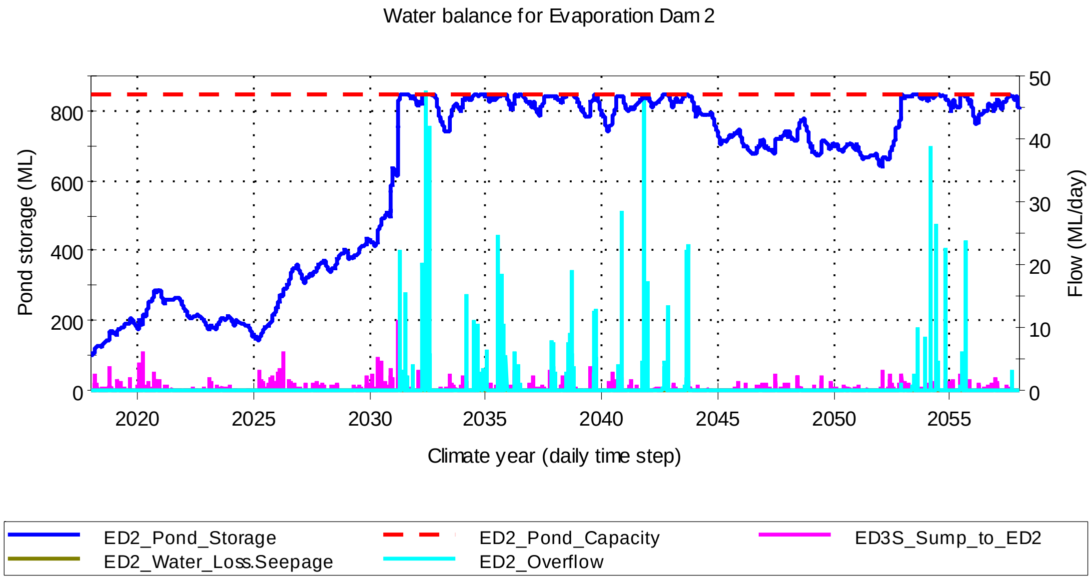

Figure 4.14 ED2 simulated results for the base case Scenario A2 with a pan factor of 0.60

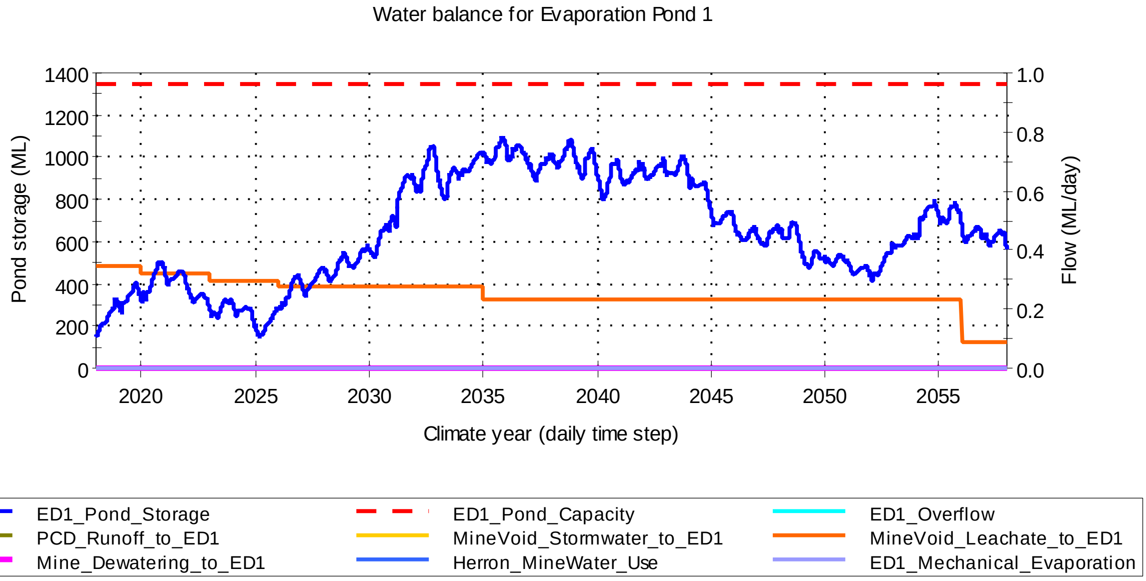

Figure 4.15 ED1 simulated results for the base case Scenario A2 with a pan factor of 0.85 and increased leachate production by 1L/s

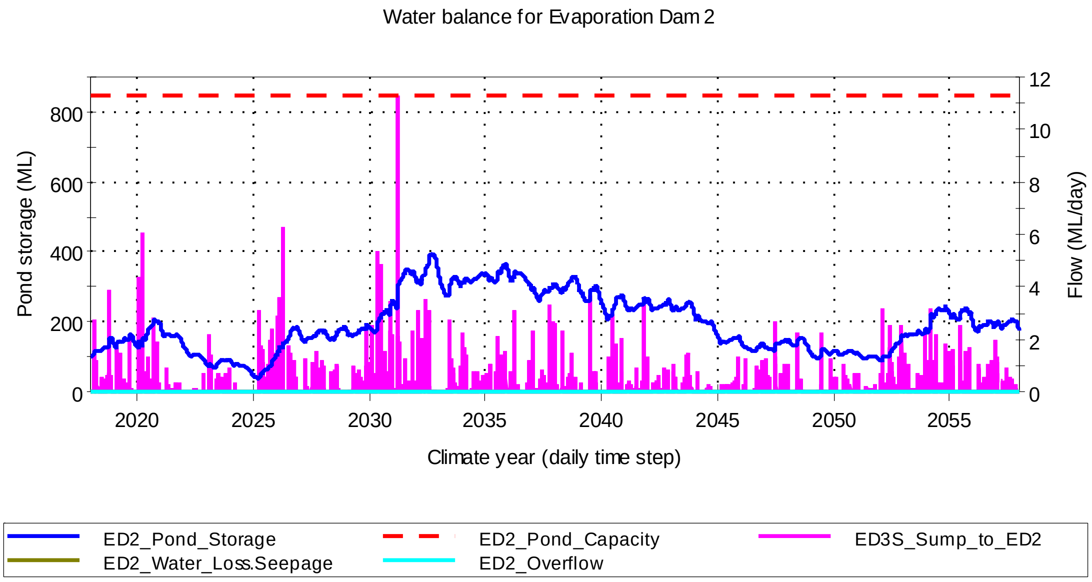

Figure 4.16 ED2 simulated results for the base case Scenario A2 with a pan factor of 0.85 and increased leachate production by 1L/s

4.4.4 Use of mechanical evaporator Scenario A2

This scenario was simulated to estimate the number of mechanical evaporator units that may be required under the dry climate sequence for Scenario A2. The following parameters and inputs were adopted for this scenario:

- pan factor=0.6
- seepage from pond floors=0.0 mm/day
- treated leachate schedule shown in Figure 1.2 increased by 1L/s
- 2.5 units of mechanical evaporators operating at ED1, 0.5 unit at ED2

A mechanical evaporator unit is capable of pumping at 350L/min operating 24-hours at 95% capacity.

Simulated results presented in Figure 4.17 (for ED1) and Figure 4.18 (for ED2) suggest that a total of three evaporator units will be required for ED1, one of the units may operate only half the time. ED2 will also require a unit operating for half the time.

4.5 Scenario B – ED1 receives water from ED3S and ED3N cells

This scenario was undertaken to identify mechanical evaporator requirements for the wet and dry climate sequences when additional water transfers were to be made from ED3N and ED3S cells. Note that current operation utilises ED3S for Veolia's mine void stormwater management and ED3N for Veolia's leachate management. The ED3S and ED3N cells are expected to be full at the current freeboard levels. The spillways will be closed off and neither void stormwater nor leachate will be transferred to these ponds until they become dry either by natural evaporation or by water transfer to ED1.

The parameter and inputs for this scenarios were:

- pan factor=0.6
- seepage from pond floors=0.0 mm/day
- treated leachate schedule shown in Figure 1.2 increased by 1L/s
- total water transfer rate from ED3S and ED3N cells at 1L/s
- 3.0 units of mechanical evaporators operating at ED1, 0.5 unit at ED2

A mechanical evaporator unit is capable of pumping at 350L/min operating 24-hours at 95% capacity.

Note that in this simulation, water was first pumped from ED3S cell until it no longer could supply water to ED1. Water was next drawn from the first cell of ED3N (ED3N1) then from the second and so on until all cells of ED3N became dry.

Simulated results for the wet climate (Figure 4.19) suggests three units of mechanical evaporators need to run full time at ED1 and 1 unit of mechanical evaporator at half capacity at ED2 to contain the leachate in ED1.

Simulated results for the dry climate (Figure 4.20) suggests two units of mechanical evaporators need to run full time and one unit of mechanical evaporator at half capacity full time at ED1. The result for ED2 is unchanged requiring one full time unit of mechanical evaporator at half capacity to contain the leachate in ED1.

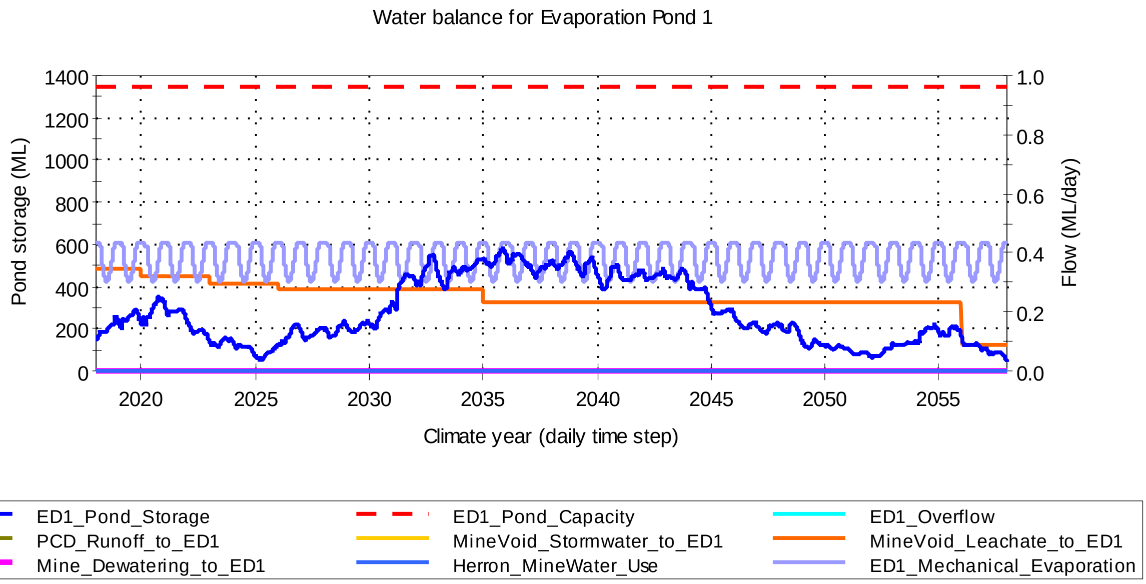

Figure 4.17 ED1 simulated results for the base case Scenario A2 with a pan factor of 0.6, mechanical evaporators and increased leachate production by 1L/s

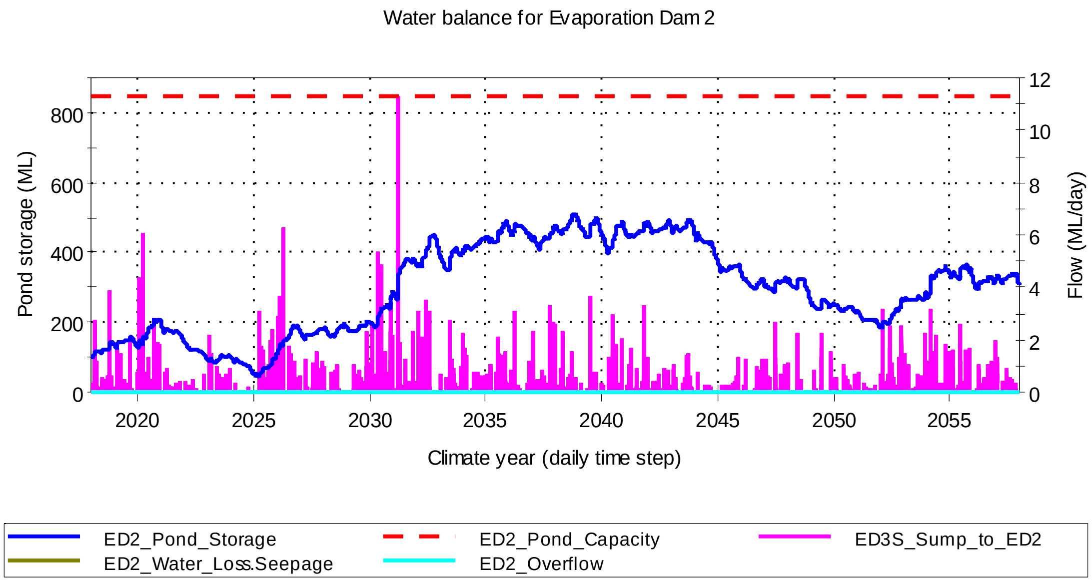

Figure 4.18 ED2 simulated results for the base case Scenario A2 with a pan factor of 0.6, mechanical evaporators and increased leachate production by 1L/s

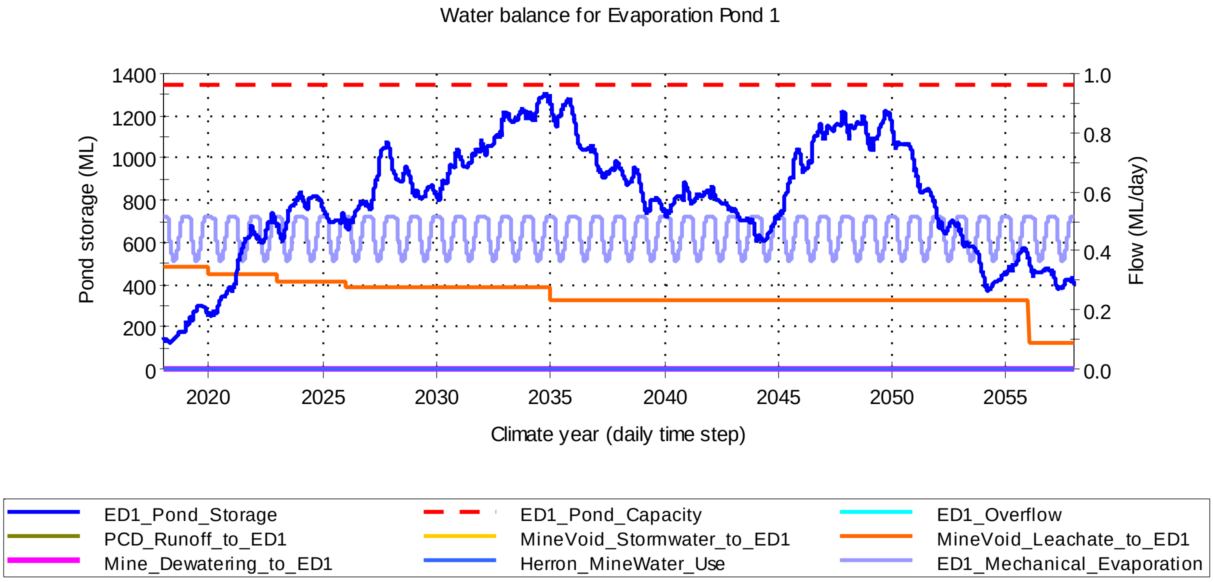

Figure 4.19 ED1 simulated results for the Scenario B with 3.0 units of mechanical evaporators under the wet climate sequence from 1947 to 1986

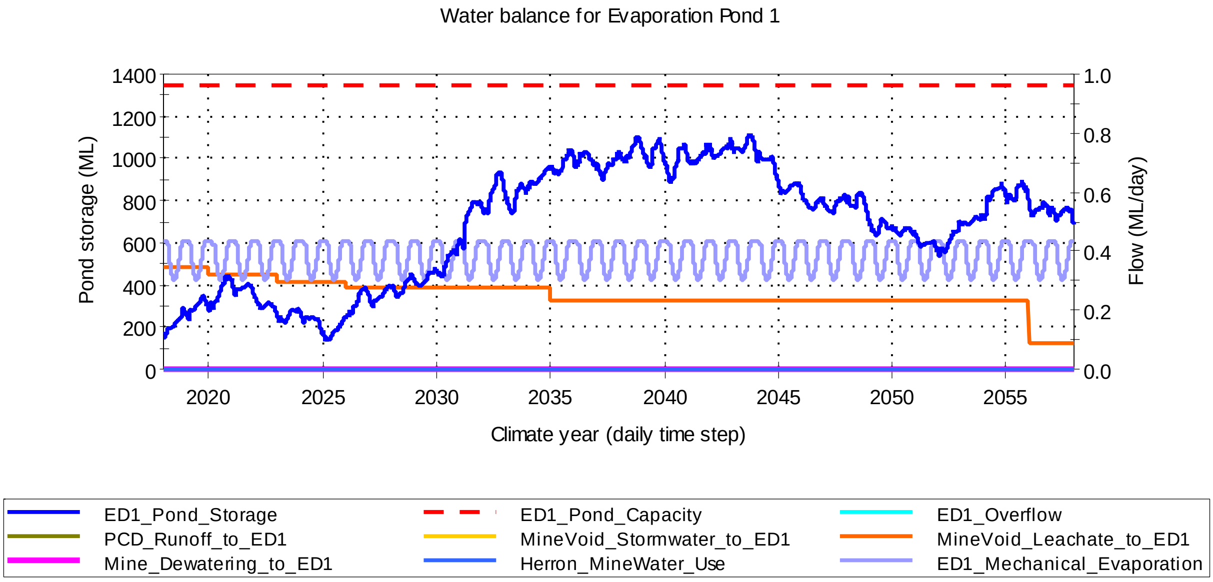

Figure 4.20 ED1 simulated results for the Scenario B with 2.5 units of mechanical evaporators under the dry climate sequence from 1976 to 2015

4.6 Scenario C- ED1 receives groundwater from pit dewatering

Scenario C was developed to assess the impact of dewatering entering ED1 from the underground workings to facilitate mining by Herron Resources' future mine re-development.

The rate at which Herron Resources is likely to dewater the underground workings are as follows:

- 215 ML in first 6 months
- 300 ML per annum thereafter

The modelling assumed that Herron Resources will use the water stored in ED1 for its mining purposes.

The purpose of this scenario was to demonstrate rate at which Herron Resources needs to use the water to avoid spillage of water from ED1 to ED2.

For this scenario the initial water volumes were increased in ED1 from 150ML to 327ML and in ED2 from 100 ML to 132 ML to account for initial storage of 6-month dewatering, rainfall runoff and stormwater.

A total of 4 sub-scenarios were assessed as summarised in section from 4.6.1 through to 4.6.4.

4.6.1 Wet climate sequence assessment without mechanical evaporator

- pan factor=0.6
- seepage from pond floors=0.0 mm/day
- treated leachate schedule shown in Figure 1.2 increased by 1L/s
- water transfer from ED3S and ED3N to ED1 at 1L/s
- without any mechanical evaporator
- wet climate sequence from 1947 to 1986
- Herron's daily water use at 15.0 L/s

4.6.2 Wet climate sequence assessment with mechanical evaporator

- pan factor=0.6
- seepage from pond floors=0.0 mm/day
- treated leachate schedule shown in Figure 1.2 increased by 1L/s
- water transfer from ED3S and ED3N to ED1 at 1L/s
- wet climate sequence from 1947 to 1986
- 3.0 units of mechanical evaporators operating at ED1, 0.5 unit at ED2
- Herron's daily water use at 10.0 L/s

4.6.3 Dry climate sequence assessment without mechanical evaporator

- pan factor=0.6
- seepage from pond floors=0.0 mm/day
- treated leachate schedule shown in Figure 1.2 increased by 1L/s
- water transfer from ED3S and ED3N to ED1 at 1L/s
- dry climate sequence from 1976 to 2015
- Herron's daily water use at 14.0 L/s

4.6.4 Dry climate sequence assessment with mechanical evaporator

- pan factor=0.6
- seepage from pond floors=0.0 mm/day
- treated leachate schedule shown in Figure 1.2 increased by 1L/s
- water transfer from ED3S and ED3N to ED1 at 1L/s

→ dry climate sequence from 1976 to 2015

→ 3.0 units of mechanical evaporators operating at ED1, 0.5 unit at ED2

→ Herron's daily water use at 8.5L/s

Results presented for ED1 in Figure 4.21 (wet climate and without mechanical evaporators), Figure 4.22 (wet climate and with mechanical evaporators), Figure 4.23 (dry climate and without mechanical evaporators) and Figure 4.24 (dry climate and with mechanical evaporators) demonstrate that three units of mechanical evaporators may be required to operate at ED1.

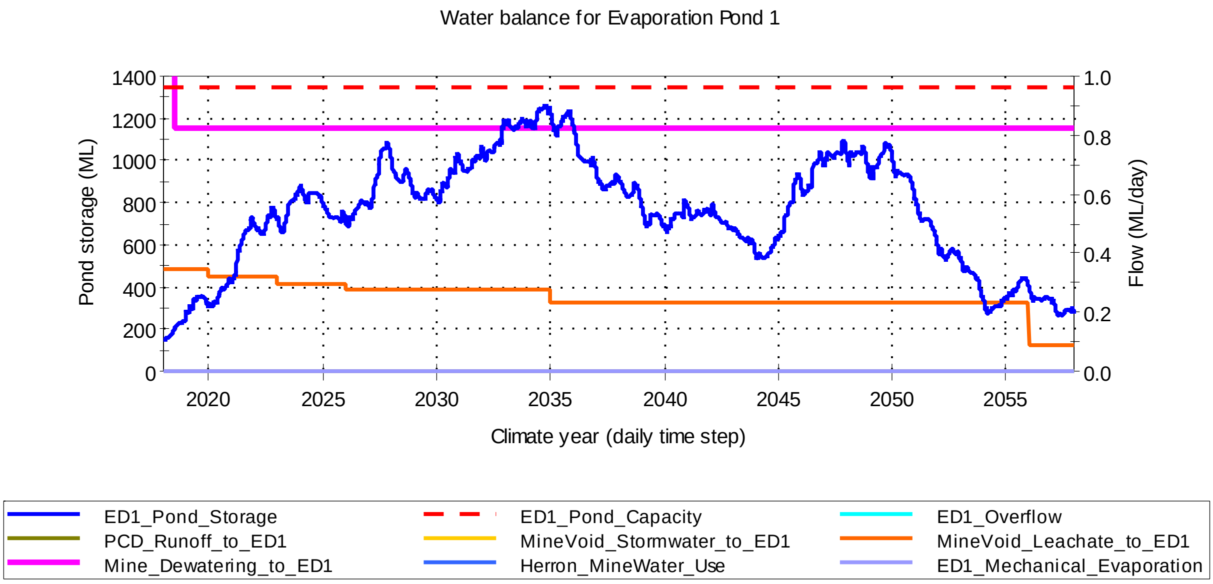

Figure 4.21 ED1 simulated results for the Scenario C without mechanical evaporators under the wet climate sequence from 1947 to 1986

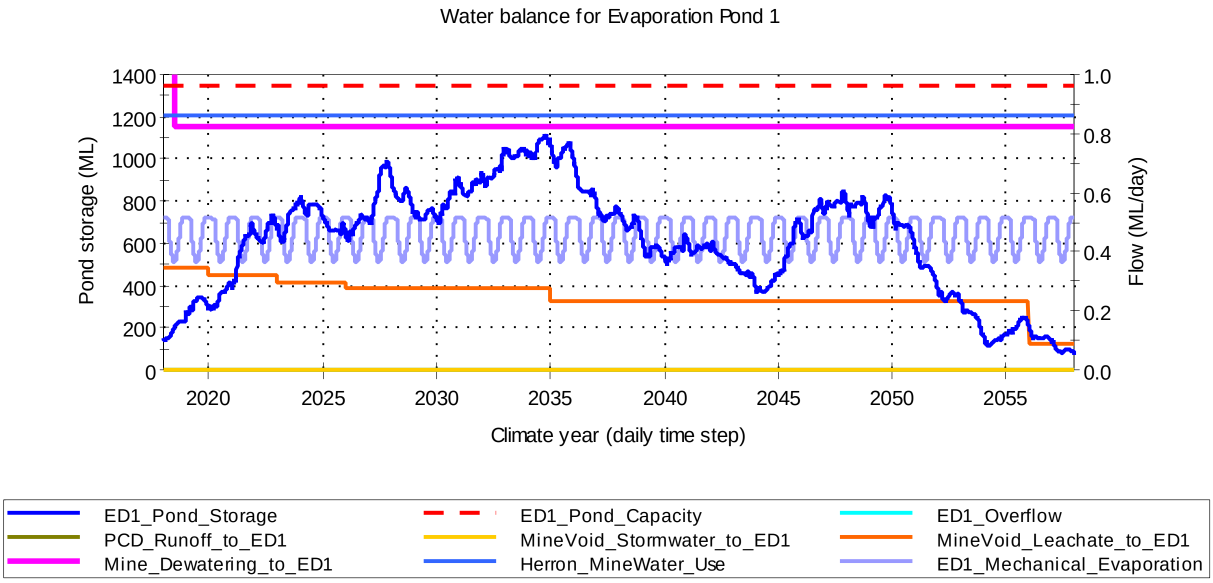

Figure 4.22 ED1 simulated results for the Scenario C with mechanical evaporators under the wet climate sequence from 1947 to 1986

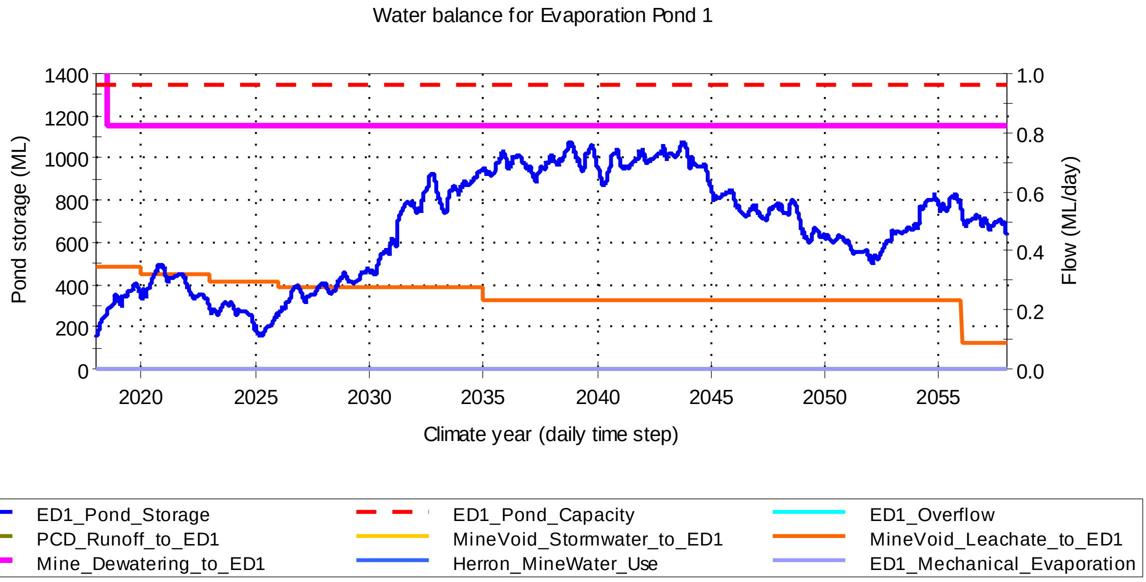

Figure 4.23 ED1 simulated results for the Scenario C without mechanical evaporators under the dry climate sequence from 1976 to 2015

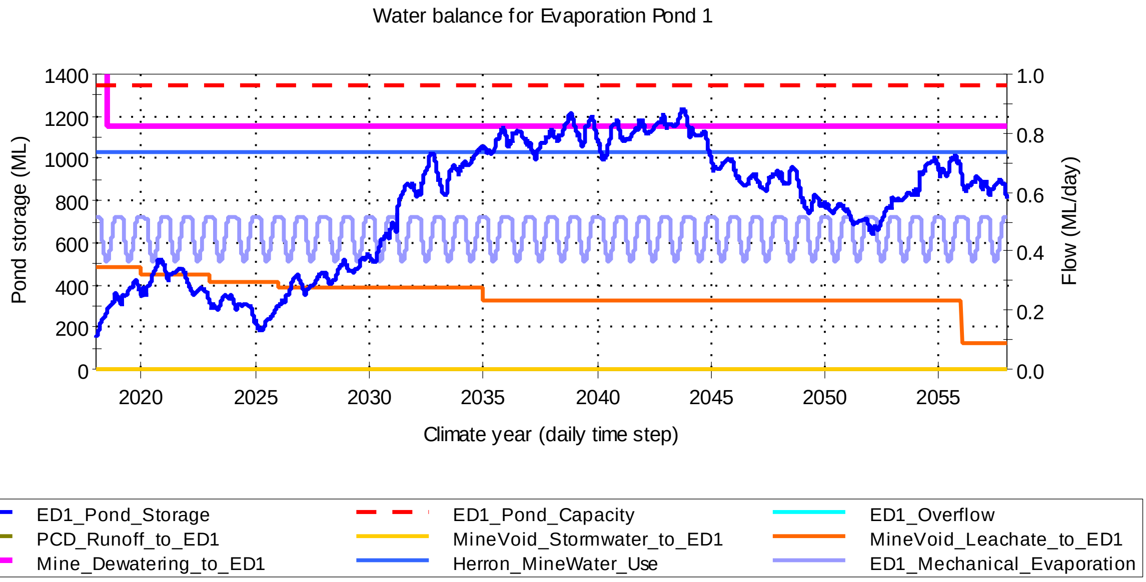

Figure 4.24 ED1 simulated results for the Scenario C with mechanical evaporators under the dry climate sequence from 1976 to 2015

4.7 Simulated declining water storage in ED3S and ED3N cells

This section presents results for declining water storage in ED3S and ED3N with and without water transfer to ED1 under the wet and dry sequences.

In the model, any potential overflows from ED3S was transferred to ED3N-1. Subsequent spillway runoffs from ED3N-1 was transferred to ED3N-2, to ED3N-3 and finally to ED3N-4 until all cells became full.

Common parameters were:

- pan factor=0.6
- seepage from pond floors=0.0 mm/day
- water transfer from ED3S and ED3N to ED1 at 1L/s
- dry climate sequence from 1976 to 2015
- wet climate sequence from 1947 to 1986

4.7.1 Decline of ED3S and ED3N pond storage under dry climate sequence without transfer

Results for this scenario as presented in Figure 4.25 (for ED3S), Figure 4.26 (for ED3N1), Figure 4.27 (for ED3N2), Figure 4.28 (for ED3N3) and Figure 4.29 (for ED3N4) illustrate that the ED3S and ED3N cells will achieve the lowest volumes in 2025 and 2051 (after 8 and 34 years since 2018).

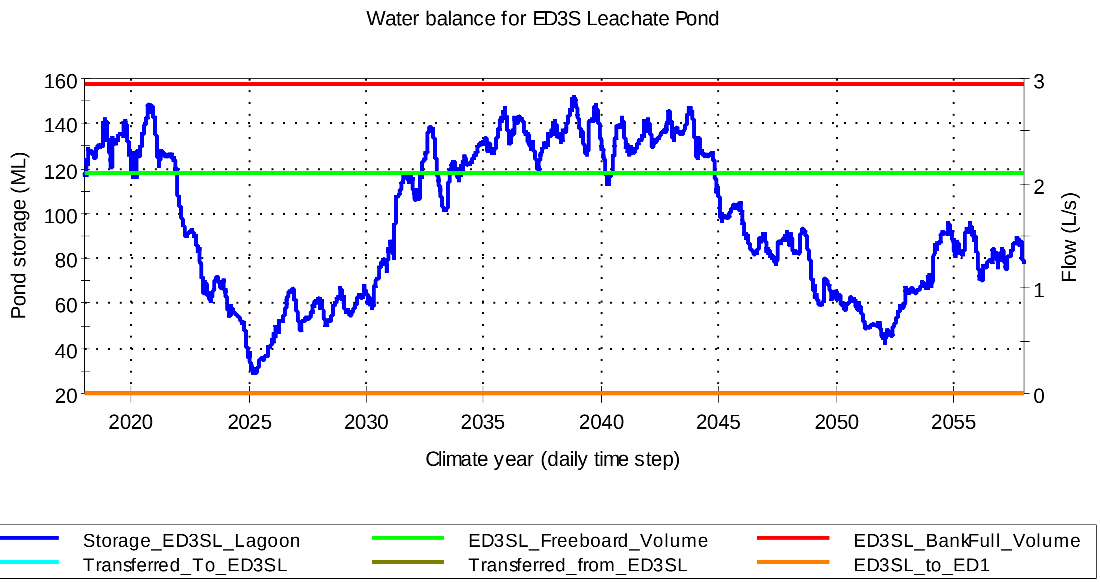

Figure 4.25 ED3S simulated results without water transfer to ED1 under the dry climate sequence from 1976 to 2015

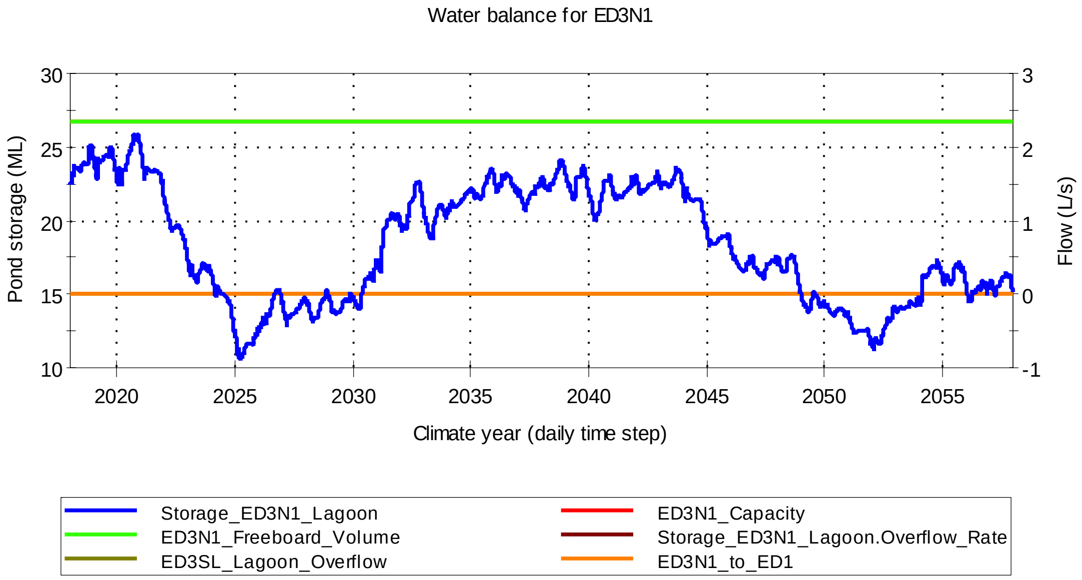

Figure 4.26 ED3N1 simulated results without water transfer to ED1 under the dry climate sequence from 1976 to 2015

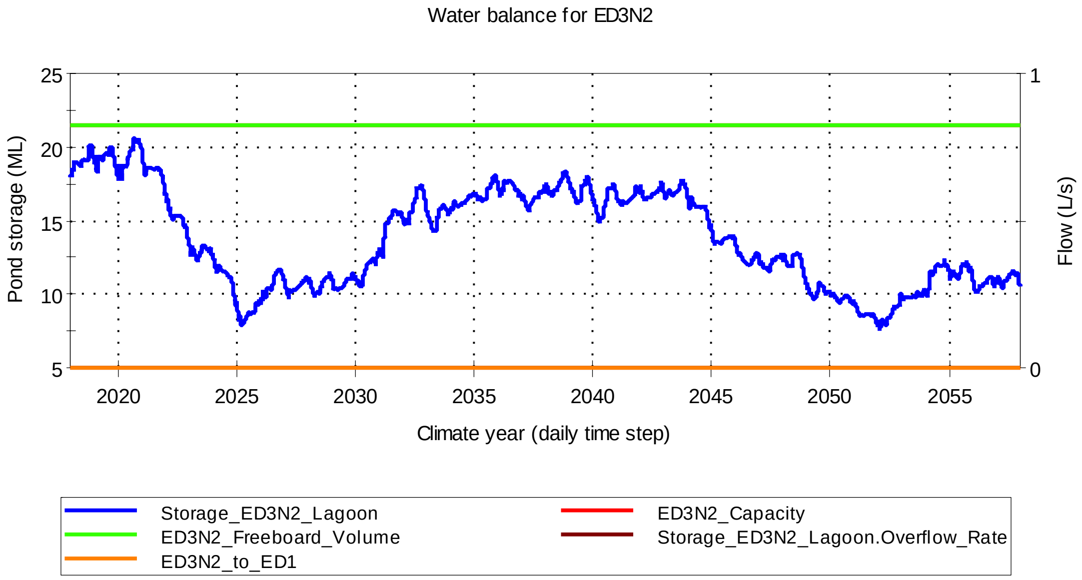

Figure 4.27 ED3N2 simulated results without water transfer to ED1 under the dry climate sequence from 1976 to 2015

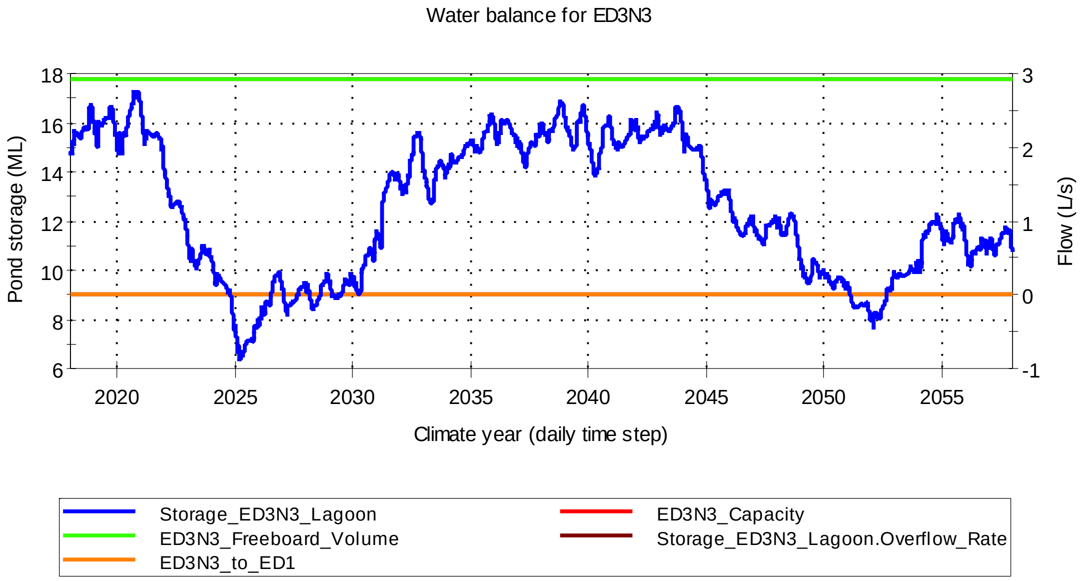

Figure 4.28 ED3N3 simulated results without water transfer to ED1 under the dry climate sequence from 1976 to 2015

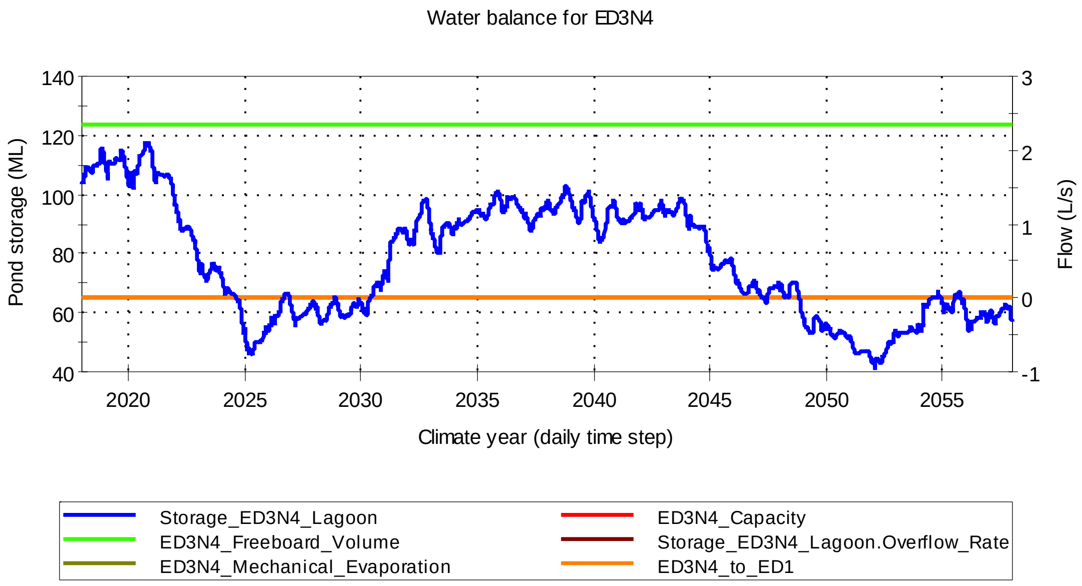

Figure 4.29 ED3N4 simulated results without water transfer to ED1 under the dry climate sequence from 1976 to 2015

4.7.2 Decline of ED3S and ED3N pond storage under wet climate sequence without transfer

Results for this scenario as presented in Figure 4.30 (for ED3S), Figure 4.31 (for ED3N1), Figure 4.32 (for ED3N2), Figure 4.33 (for ED3N3) and Figure 4.34 (for ED3N4) illustrate that the ED3S and ED3N cells will exceed the volume at dam wall level during the first 18 years (between 2021 and 2035). The rainfall – runoff generated from local hill slope towards ED3S will be sufficient to generate enough volume to reach the top of the dam wall if the starting volume in these cells were to be at freeboard level from 2018.

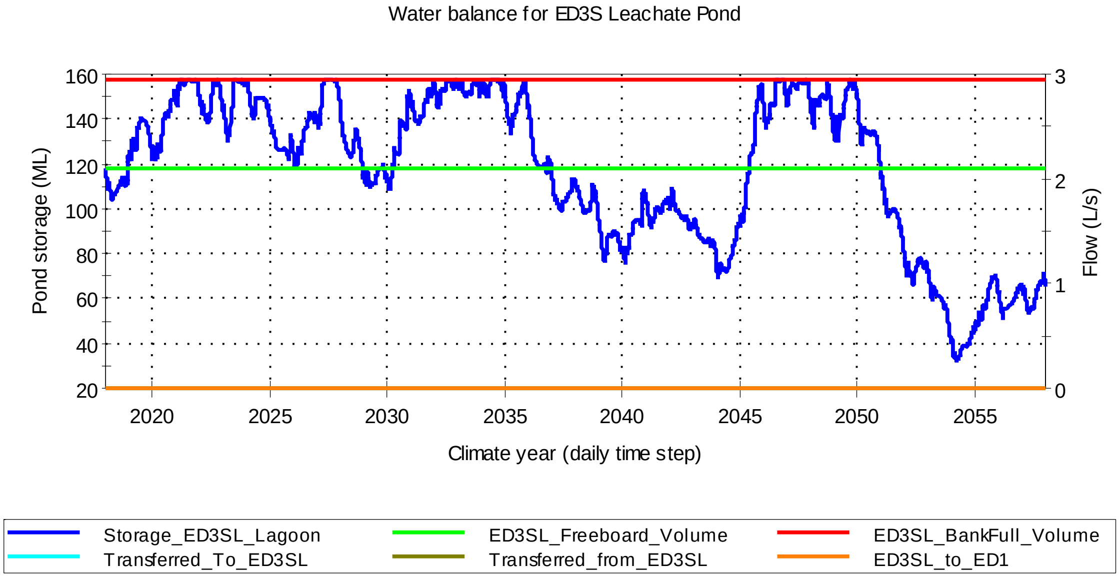

Figure 4.30 ED3S simulated results without water transfer to ED1 under the wet climate sequence from 1947 to 1986

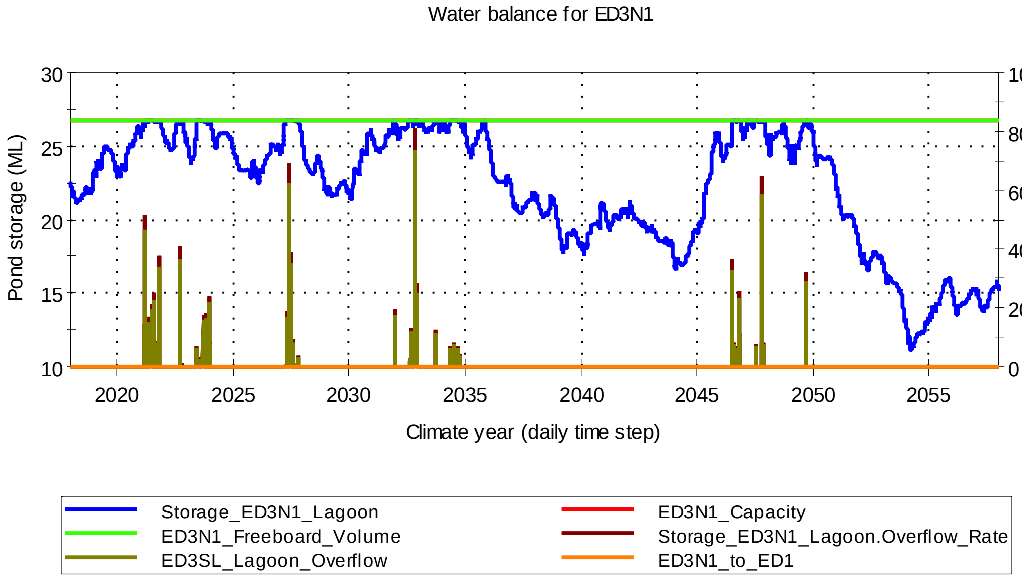

Figure 4.31 ED3N-1 simulated results without water transfer to ED1 under the wet climate sequence from 1947 to 1986

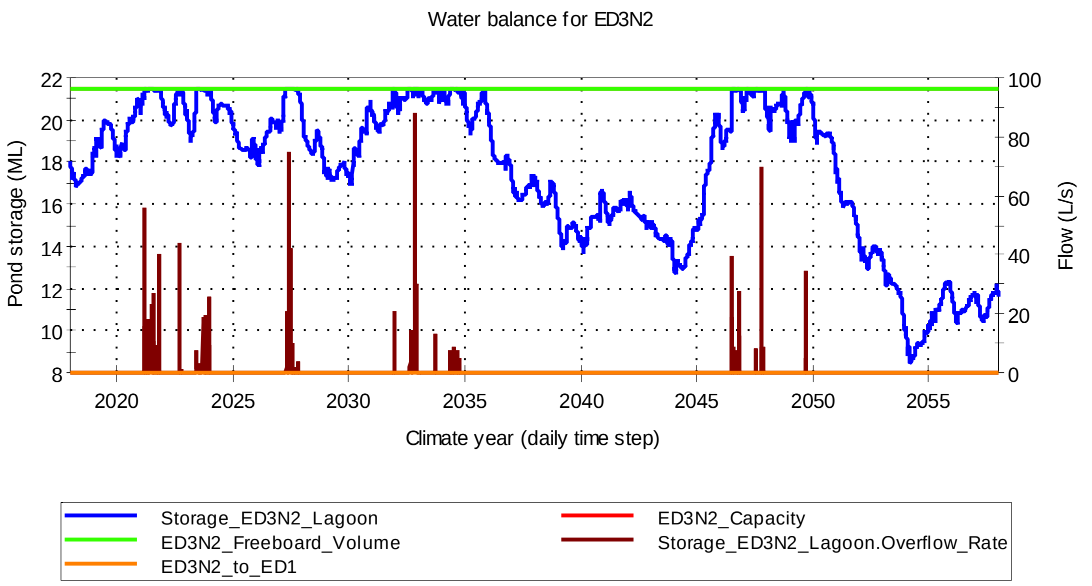

Figure 4.32 ED3N-2 simulated results without water transfer to ED1 under the wet climate sequence from 1947 to 1986

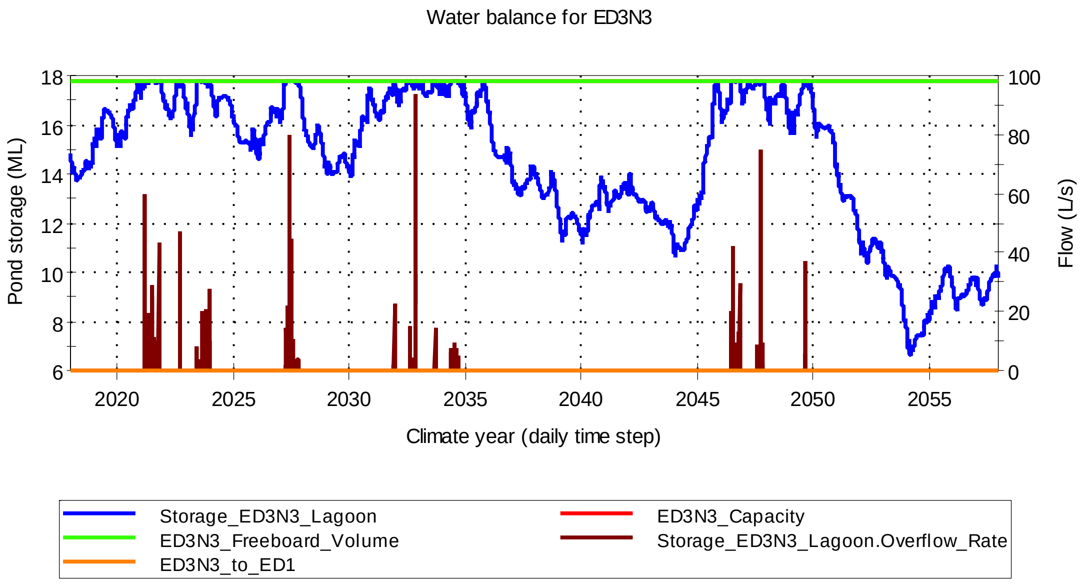

Figure 4.33 ED3N-3 simulated results without water transfer to ED1 under the wet climate sequence from 1947 to 1986

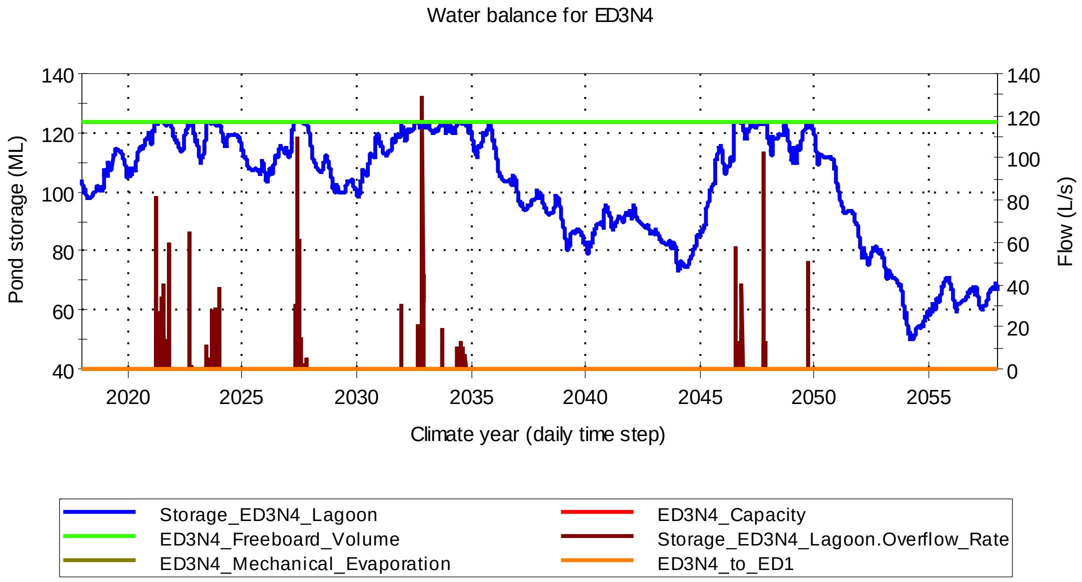

Figure 4.34 ED3N-4 simulated results without water transfer to ED1 under the wet climate sequence from 1947 to 1986

4.7.3 Decline of ED3S and ED3N pond storage under dry climate sequence with transfer

Results for this scenario as presented in Figure 4.35 (for ED3S), Figure 4.36 (for ED3N1), Figure 4.37 (for ED3N2), Figure 4.38 (for ED3N3) and Figure 4.39 (for ED3N4) illustrate that the ED3S and ED3N cells are expected to become empty within 8 years. Note that in this simulation, the water was first drawn from ED3S until it became empty within 4 years. Subsequently the water was pumped from the cells of ED3N in the following order: ED3N1, ED3N2, ED3N3 and ED3N4.

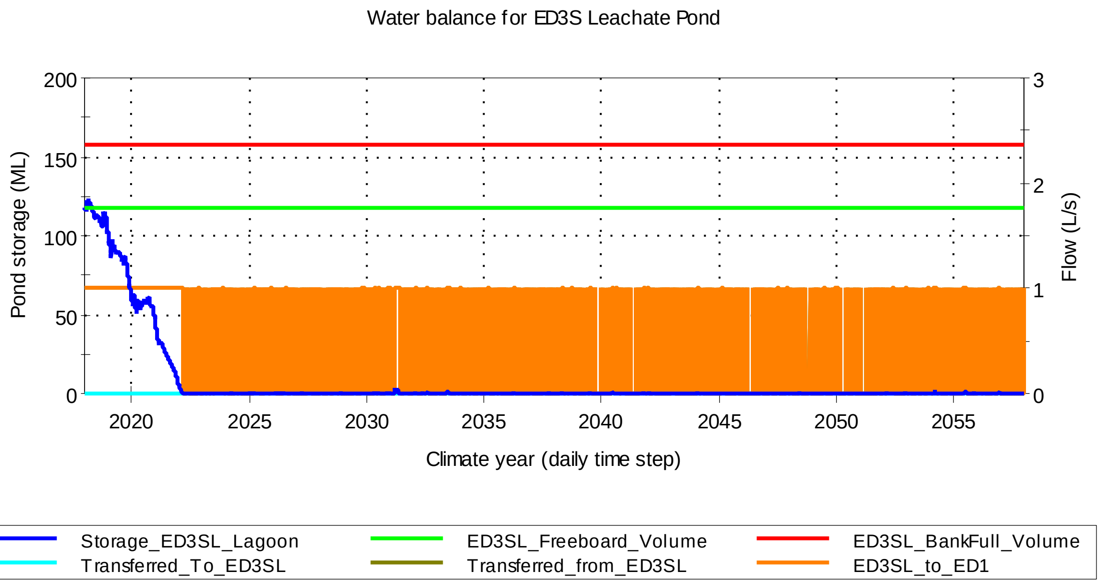

Figure 4.35 ED3S simulated results with water transfer to ED1 under the dry climate sequence from 1976 to 2015

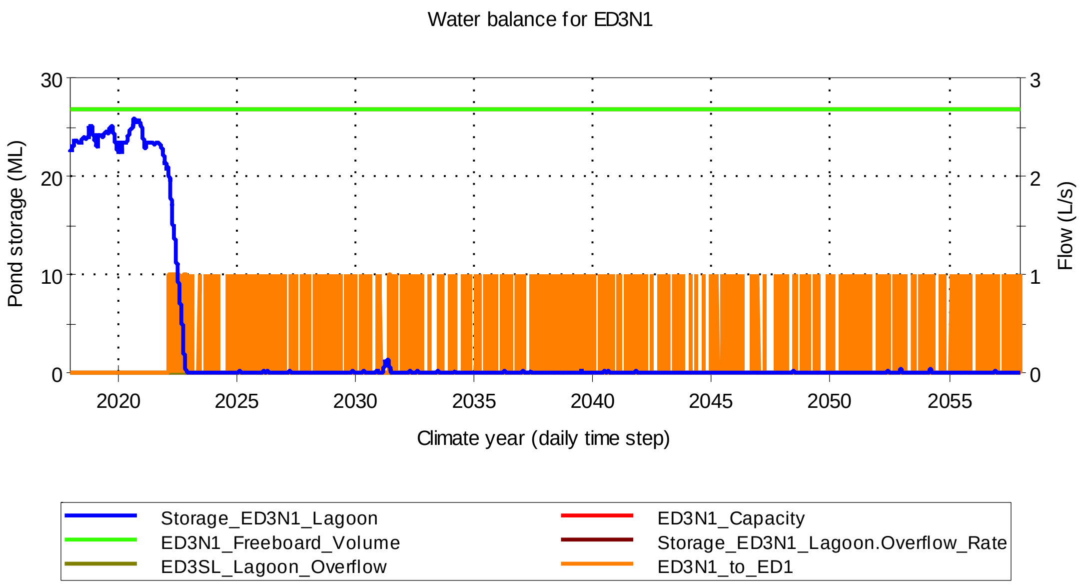

Figure 4.36 ED3N-1 simulated results with water transfer to ED1 under the dry climate sequence from 1976 to 2015

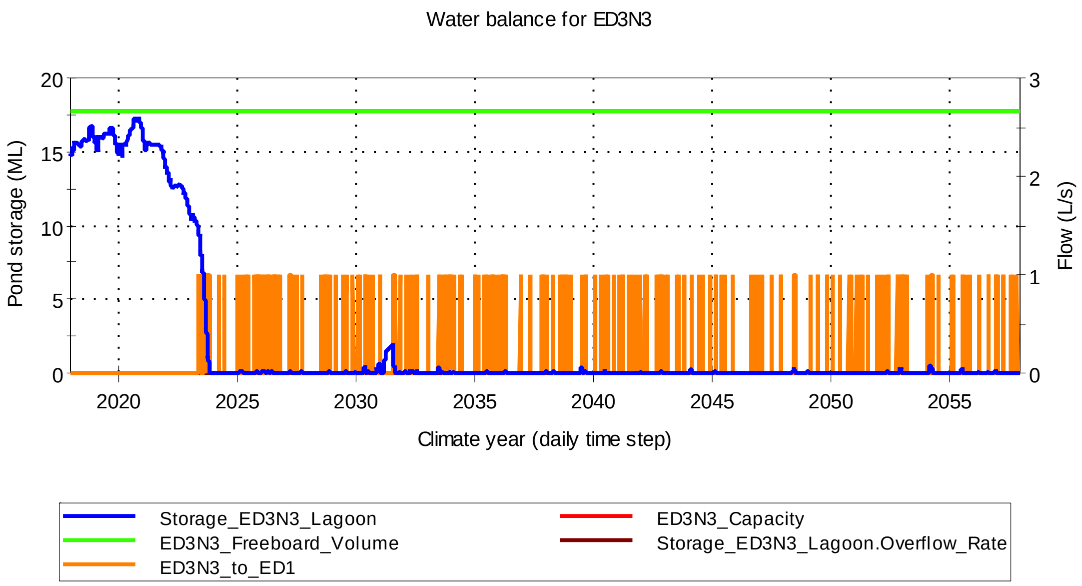

Figure 4.37 ED3N-2 simulated results with water transfer to ED1 under the dry climate sequence from 1976 to 2015

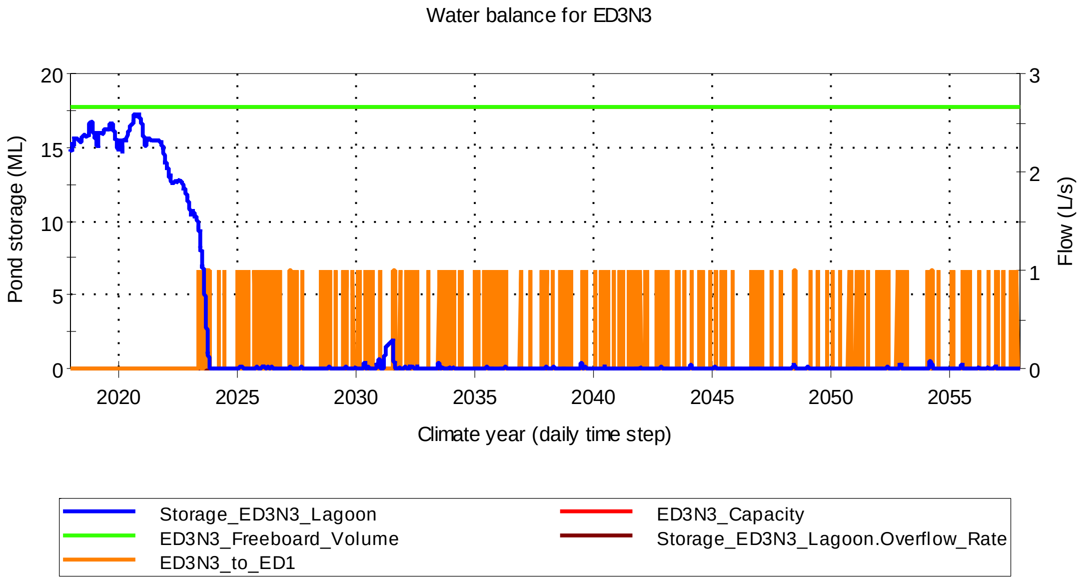

Figure 4.38 ED3N-3 simulated results with water transfer to ED1 under the dry climate sequence from 1976 to 2015

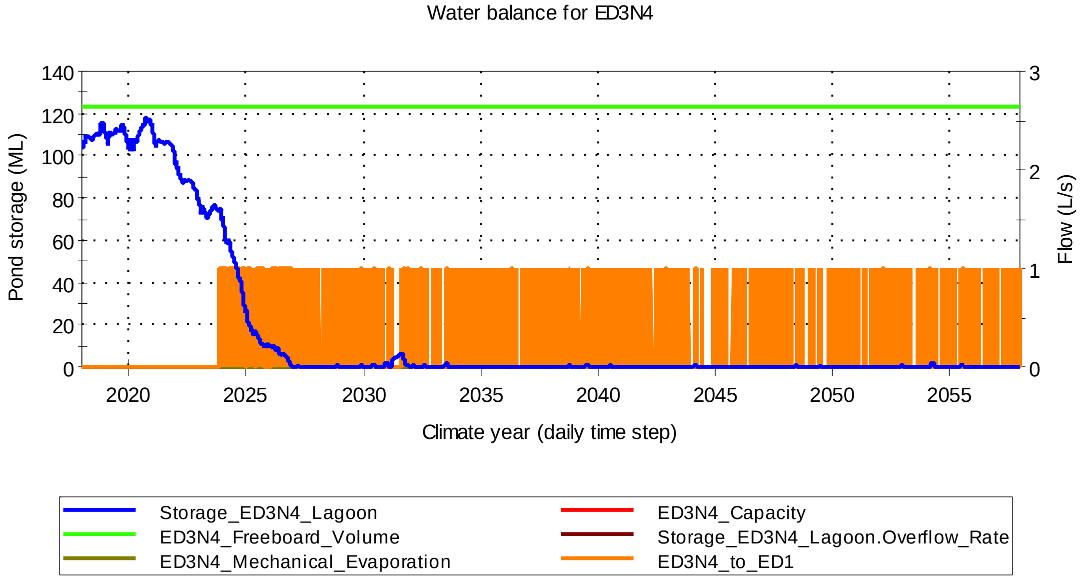

Figure 4.39 ED3N-4 simulated results with water transfer to ED1 under the dry climate sequence from 1976 to 2015

4.7.4 Decline of ED3S and ED3N pond storage under wet climate sequence with transfer

For the wet sequence it was found that pumping water from all the cells at the same time will be required to lower the water levels below the current freeboard levels (0.5 m below the top of the dams).

Results for this scenario as presented in Figure 4.40 (for ED3S), Figure 4.41 (for ED3N1), Figure 4.42 (for ED3N2), Figure 4.43 (for ED3N3) and Figure 4.44 (for ED3N4) illustrate that the ED3S is expected to become empty by 2054 (within 37 years from 2018). It would take 14 years for ED3N1, 8 years for ED3N2, 4 years for ED3N3 and 28 years for ED3N4 to become empty

Some overflows from ED3S to ED3N1 is expected during the first 13 years due to multiple occurrences of more than 1,000 mm annual rainfall. However, the overflows will be fully contained within ED3N1.

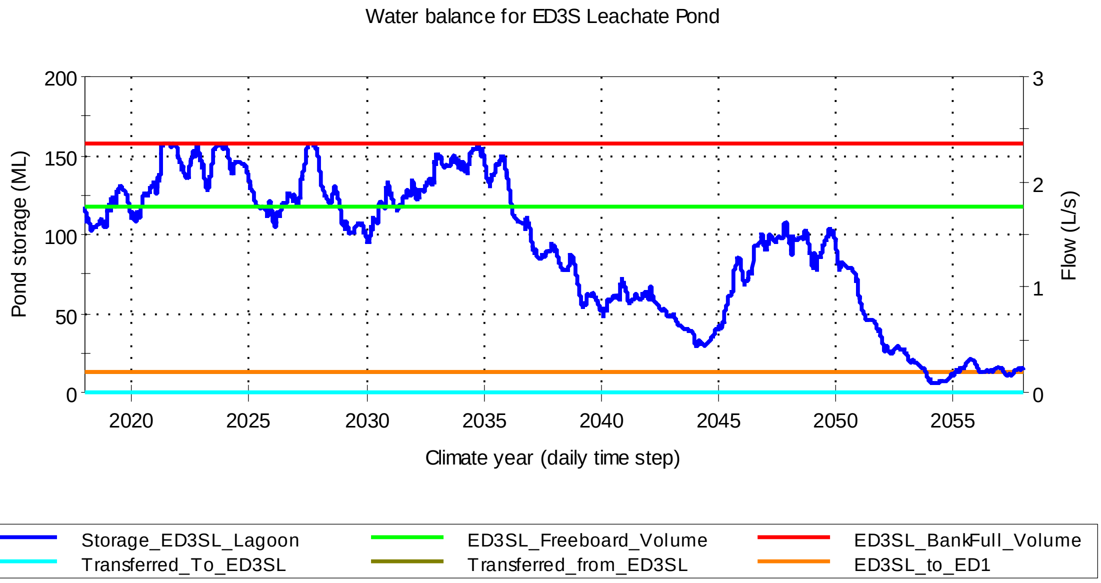

Figure 4.40 ED3S simulated results with water transfer to ED1 under the wet climate sequence from 1947 to 1986

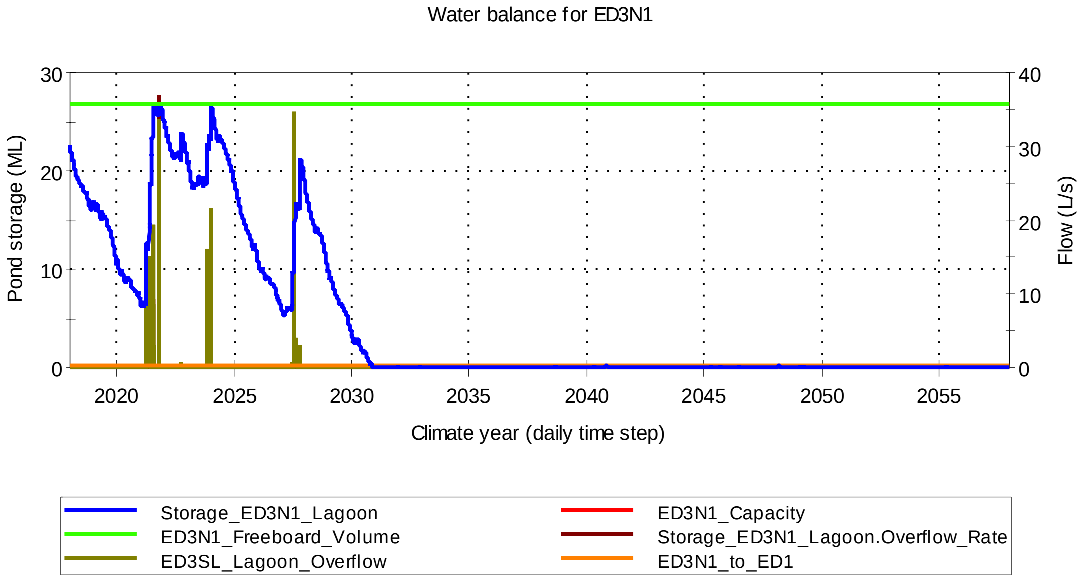

Figure 4.41 ED3N-1 simulated results with water transfer to ED1 under the wet climate sequence from 1947 to 1986

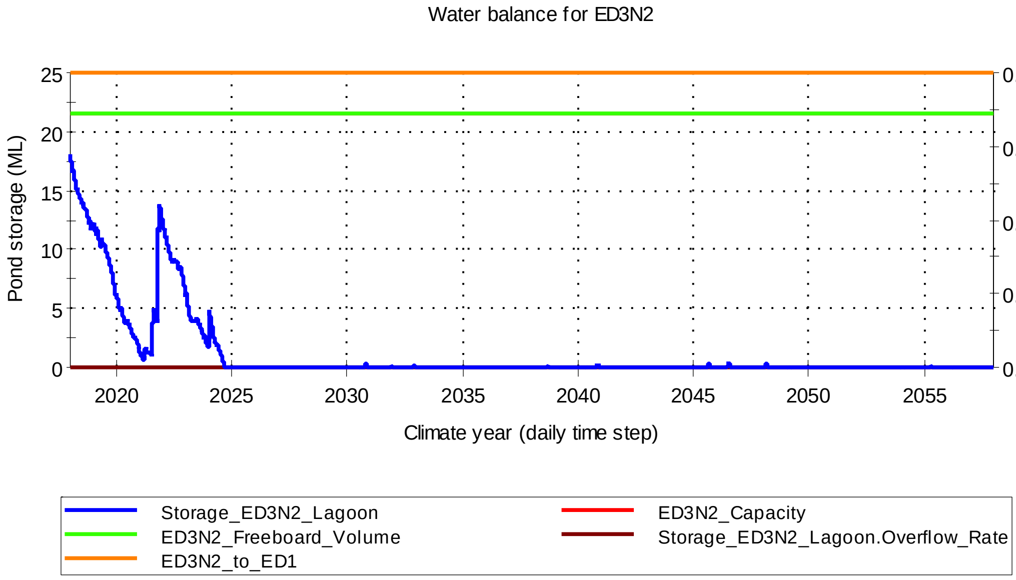

Figure 4.42 ED3N-2 simulated results with water transfer to ED1 under the wet climate sequence from 1947 to 1986

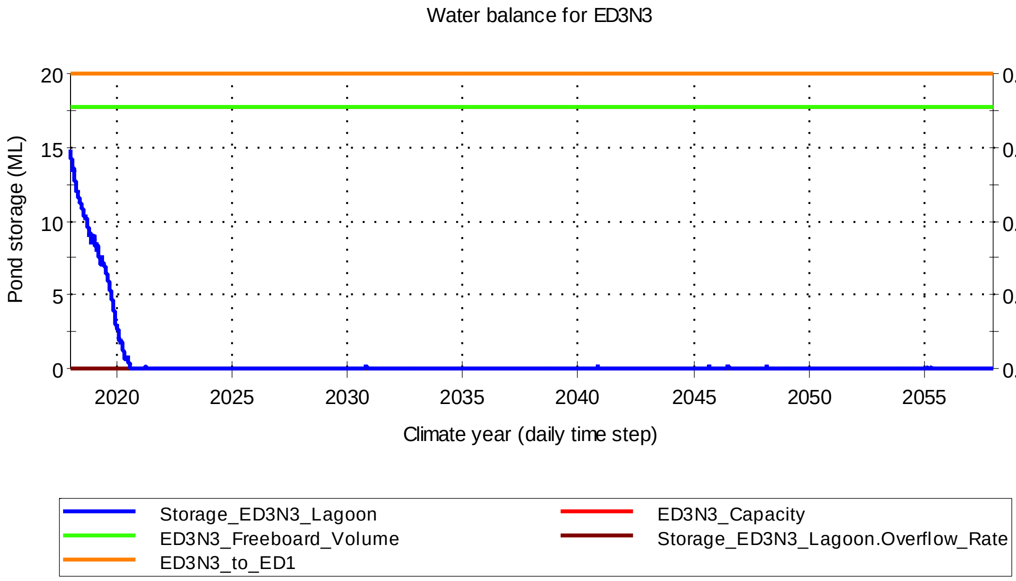

Figure 4.43 ED3N-3 simulated results with water transfer to ED1 under the wet climate sequence from 1947 to 1986

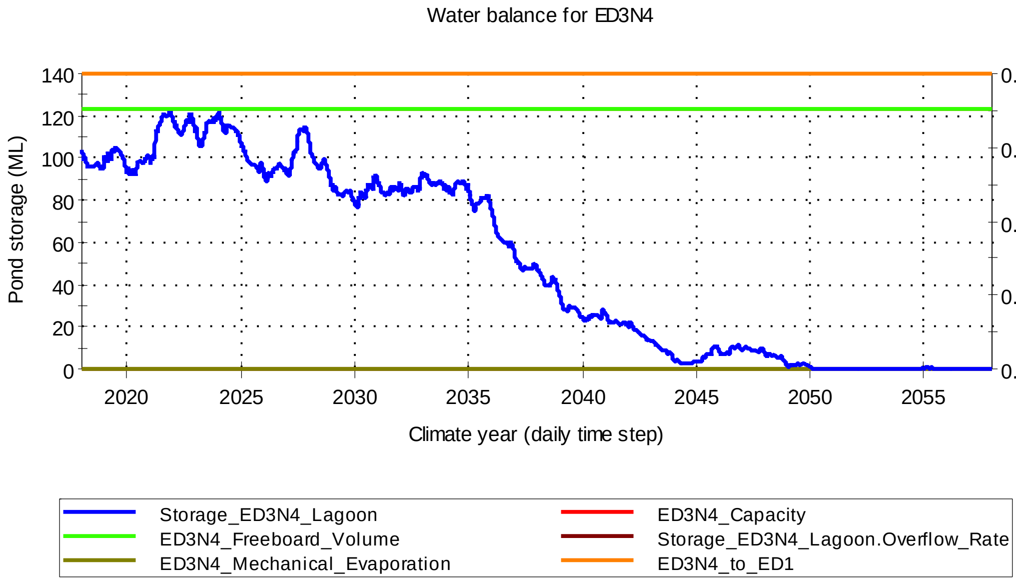

Figure 4.44 ED3N-4 simulated results with water transfer to ED1 under the wet climate sequence from 1947 to 1986

5. SUMMARY

Water balances were modelled for a range of scenarios to assess whether ED1 and ED2 can provide storage required for Veolia's leachate and stormwater management during the next 40 years of projected operation from 2018. The peak leachate rate of 3L/s for the best case scenario and 4L/s for the worst case scenario were used in the assessments. The leachate production schedule was provided by Veolia for 40 years commencing from 2018. The best case leachate production schedule suggest a declining trend from the peak value of 3L/s for the first two years to 1.7 L/s for the last 22 years of the operation. The worst case leachate production schedule was constructed by adding 1 L/s to the time series of the best case leachate production.

If ED1 and ED2 are exclusively used for Veolia's bioreactor operation then there is a good chance that these ponds may serve well to manage the leachate and stormwater without any assisted mechanical evaporation, if the pan factor of 0.85 could be applicable and the best case leachate production being maintained.

For any other additional water transfer into ED1 and ED2 further water loss is required to contain water within ED1. Veolia is proposing to use mechanical evaporators for boosting evaporation from ED1 and ED2. A range of scenarios presented here suggests that 3 units for ED1, 0.5 units for ED2, 0.5 units for ED3S and 0.25 units for ED3N may be required for the worst case leachate production under the wet climate sequence similar to 1947 to 2015 with a pan factor of 0.6, when water is transferred from ED3 cells at 1 L/s. Note that a mechanical evaporator unit is capable of pumping at 350L/min operating 24-hours at 95% capacity.

If Herron Resources also uses ED1 for storage of mine dewatering, then overflows from ED1 and ED2 can only be prevented if Herron Resources uses water from ED1 at 15 L/s without the use of mechanical evaporator, and 10 L/s with the mechanical evaporators during the worst case leachate production under the wet climate sequence similar to 1947 to 2015 with a pan factor of 0.6, when water is transferred from ED3 cells at 1 L/s. Even under the dry climate sequence similar to 1976 to 2015, Herron Resources might have to reuse the water from ED1 at a rate of 14 L/s without mechanical evaporator, and at 8.5 L/s with mechanical evaporators operating at ED1 and ED2.

Veolia currently uses ED3S for the void generated stormwater storage and ED3N cells (1, 2, 3 and 4) for the bioreactor leachate storage. Once Veolia starts using ED1 and ED2 ponds for leachate and stormwater management respectively, ED3S and ED3N ponds will not receive any water except direct rainfall and local catchment runoffs. Modelled simulations under this conditions were undertaken to assess how long it might take for these ponds to become nearly empty.

The cells of ED3S and ED3N ponds will evaporate and eventually become empty at the end of:

- 37 years if water is transferred from these ponds to ED1 at a rate of 1 L/s during the wet climate sequence similar to the climate from 1947 to 1986. It would take 37 years for ED3S, 14 years for ED3N1, 8 years for ED3N2, 4 years for ED3N3 and 28 years for ED3N4 to become empty.
- 8 years if water is transferred from these ponds to ED1 at a rate of 1 L/s during the dry climate sequence similar to the climate from 1976 to 2015.
- Minimum volume is reached at 8 and 34 years if water is not transferred from these ponds to ED1 during the dry climate sequence similar to the climate from 1976 to 2015.

The cells of ED3S and ED3N ponds may not become empty by natural evaporation during the next 40 years if the wet sequence similar to the climate from 1947 to 1986 repeats even if the water is transferred to ED1 at a rate of 1 L/s. The pond volumes may frequently exceed their capacities during the wet climate sequence and mechanical evaporators may be required even for ED3N and ED3S cells.

Yours sincerely

Aditya Jha
Principal Water Resources Engineer

Carl Kopke
General Manager, Resources West

Attachments

Attachment 4 – Odour Modelling Assessment Report

Veolia Australia & New Zealand

Woodlawn Bioreactor Facility Odour Modelling Study

Long-term Treated Leachate Solution

July 2016

Final Report

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Project Number: N1806L.06

Report Revision		
Revision Number	**Date**	**Description**
Draft report	21.07.2016	Internal review
Final report (unsigned)	22.07.2016	Issued to client for review
Final Report (signed)	22.07.2016	Final report issued
Report Preparation		
Report Prepared By: M. Assal & S. Hayes	**Approved By:** M. Assal	
Report Title: Veolia Australia & New Zealand Woodlawn Bioreactor Facility Odour Modelling Study – Long-term Treated Leachate Solution		

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