Beaconsfield Reservoir

Responsible GM: Peter Benazic
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Recommendation(s)

That Council:

1. Note the officers report.
2. Highly commends the work that the Cardinia Environment Coalition has undertaken in managing the reserve and continue to advocate for ongoing recurrent funding for their Park Management activities.
3. Advocate for the State Government to assign the Park Manager role to a State Government Agency.
4. Advocate for the enhancement for recreational assets that creates opportunity for the community to experience the high value natural enviroment.
5. Continue to advocate to DELWP to fund the development of a long-term strategic plan for the reserve.
6. Acknowledge the commuity correspondence received by council supporting the preservation of the dam in its current state.
7. Request that Melbourne Water continue to engage with the community and explain the rationale for the selecting the a partial decommioning option.

Attachments

1. Lowering the Water Level of Beaconsfield Reservoir EIA FINAL Report [**6.2.6.1** - 44 pages]
2. Beaconsfield Reservoir Concept Design Report for CCC [**6.2.6.2** - 154 pages]
3. Beaconsfield Dam Safety Upgrade, Update December 2021, Beaconsfield Online Newsletter [**6.2.6.3** - 4 pages]
4. Sample of letter ODCA [**6.2.6.4** - 2 pages]
5. Sample of form letter received [**6.2.6.5** - 2 pages]

Executive Summary

At the 17 May 2021 Council Meeting, Council resolved to:

1. Note the officers report.
2. Recognises the Beaconsfield reservoir and nature conservation reserve as a place of highly significant environmental, community and cultural importance for our region. A wonderful natural asset that has great potential for community and environmental benefit into the future.
3. Requests that all responsible State Government authorities work together with the local community to develop a long-term strategic plan that delivers the best outcomes for the environment and community interests.
4. Requests that no further works are to be considered or proceed with the reservoir's dam wall until such time this future strategic document is developed and created.
5. Advocate to the relevant State Government departments to undertake a thorough environmental assessment of the reservoir and the greater Beaconsfield Nature Conservation Reserve (BNCR) including a report on the impact that any future developments would have on the environment within.
6. Request that Melbourne Water (MW) make publicly available the safety assessment report which has identified the potential risk of the reservoir wall failing.

7. Acknowledge the petition which is currently before the State Government of Victoria which is requesting the retention of the current reservoir water level.
8. Highly commends the work that the Cardinia Environment Coalition has undertaken in managing the reserve and advocates for ongoing recurrent funding to manage the BNCR into the future.
9. Advocate for the State Government to assign the Park Manager role to a State Government Agency for a significant reserve of regional importance.
10. Indicates support for the improved recreational facilities and greater access to the Reserve for the general public.
11. Is supportive of Melbourne Water taking necessary action to ensure the safety of our community and we ask that thorough community consultation and communication is undertaken regarding any future plans or developments for this site.

The Beaconsfield Reservoir is under the ownership and responsibility of the Victorian Government, but one that is of interest to our community. The purpose of this report is to provide status update of the proposed Beaconsfield Reservoir project and detail what progress has occurred to enact the Council resolutions. Further the report also provides Council with an opportunity to consider correspondence received from community members regarding their preferred outcomes and cultural values that they attach to the existing Melbourne Water assets and reservoir conditions.

The report considers Melbourne Water's proposal to undertake works at the Department of Environment, Land, Water and Planning (DELWP) managed Beaconsfield Nature Conservation Reserve (BNCR). Within the reserve is the Beaconsfield Reservoir. Melbourne Water (MW) is responsible for the infrastructure that supports the reservoir and proposes to decommission the existing reservoir dam wall. Melbourne Waters rationale for the action is driven by safety concerns as the wall allegedly fails to comply with the Australian National Committee on Large Dams (ANCOLD) guidelines. Coupled with the proposed dam wall reduction is the proposed installation of recreational assets and associated landscaping.

The new recreation assets necessitate the assignment of a Park Manager to fund maintenance and ongoing asset care and renewal. MW have advised that if a Park Manager is not assigned that the landscaping work will not form part of the scope for the proposed works according to Melbourne Water project officers.

The current Park Manager for the reserve is The Cardinia Environment Coalition (CEC), they have a direct service provision arrangement with DELWP. The CEC are considered an excellent service provider and have an intimate knowledge of the reserve and are skilled in the provision of environmental services. The Cardinia Environment Coalition is funded through a grant's mechanism for their important environmental services. Any changes to the recreational asset base and visitation volumes would necessitate a review of the funding provision provided by DELWP.

It is evident that there is wide recognition of the environmental value of the reserve. There also appears to be broad support for increased public access to Beaconsfield Nature Conservation Reserve and for improved recreational assets such as, a perimeter walking circuit, BBQs, and picnic facilities. There are however divergent views on Melbourne Waters proposal to decommission the dam wall and lower the current water level in order to address safety concerns.

Melbourne Water (MW) has indicated that they have reached a determination regarding the options that were presented to the community and council in relation to the treatment of the Dam wall.
Their preferred option is Option 1: which is the partial decommission; embankment and reservoir reduction. This option would involve partial demolition of the existing dam wall and

lowering the existing water level of the reservoir. Melbourne Water arrived at the decision using a multi- criteria analysis model. Council officers were not given input into the elements of the model or included in the decision-making processes.

Council officers acknowledges and appreciates that the Melbourne Waters selected option has raised concerns for a sector of the community. The report includes the correspondence received which detail the concerns raised.

Council officers support the community view that BNCR has significant ecological and environmental value for the region. Officers are also in support of enhancement of recreation assets to enable appropriate recreational activities to the reserve for the community.

Council officers support the notion of State Government agencies funding park management cost and asset maintenance activities. Officers assert that the cost for ongoing maintenance and renewal for the State Government managed asset should not be funded from council revenue, and advocate that any cost saving that MW achieves as a result implementing their preferred option should be quarantined and reinvested into the BNCR.

Background

The Beaconsfield Nature Conservation Reserve (BNCR) is an approximately 171 Hectare reserve under the control of the Department of Environment, Land, Water and Planning, see Figure 1. The reserve is fully fenced and is not freely accessible to the general public. Within the reserve is the Beaconsfield Reservoir and associated water retention infrastructure which is managed by Melbourne Water (MW).

Figure 1. Location of Beaconsfield Nature Conservation Reserve

Dating back to 2010, risk assessments and reports have identified the Beaconsfield Reservoir Dam Wall as an area of concern that does not meet current standards. A plan needs to be put in place to address these concerns and a number of proposed works/options have been explored. In February 2021, Melbourne Water Project Officers provided Council officers with a presentation of options, the rationale for the works and identifed a a preferred option. The preferred option presented identified a significant reduction to the existing dam wall and the opportunity for the creation of passive recreation facilities. The Melbourne Water Officers indicated that the main driver for the works was to address risk issues associated with the integrity of the existing dam wall structure.

Specifically, they contended that the dam wall:

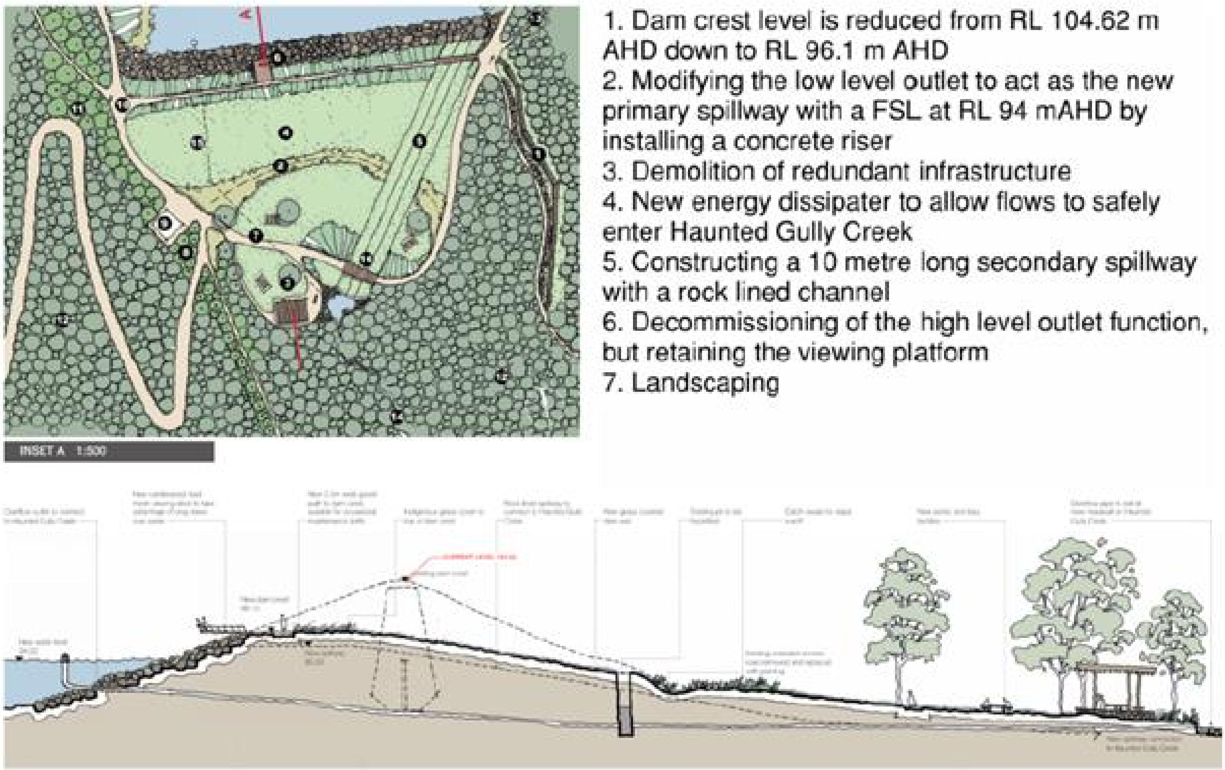
- Does not meet current safety requirements and risk guidelines in terms of stability, internal erosion (piping) protection and general design deficiencies.
- Was built over 100 years ago and does not meet current Australian National Committee on Large Dams (ANCOLD) guidelines.
- Dam managers are required to achieve a level of dam safety which is tolerable and where this is not the case, undertake further measures to reduce the risk.
- Retaining the dam in its current state would not comply with national dam safety regulations.
- The driver of the Beaconsfield Reservoir Dam Safety project is to reduce the risk of Beaconsfield Reservoir failing, protecting properties and community located downstream of the dam.
- While the likelihood of dam failure is low, the consequence is significant.

To address the safety concerns identified, the options considered by Melbourne Water were:
- Option 1: Partial decommission, embankment and reservoir reduction.
- Option 2: Full decommission, removal of all dam infrastructure and a return to previous state before dam was built.
- Option 3: Full dam safety upgrade, this would involve buttressing the dam wall but maintaining the water level.
- Option 4: Do nothing (not considered as a feasible option, because the risk was too High)

These were assessed against four criteria:
- Improve dam safety.
- Cost.
- Community impacts.
- Environmental and conservation impacts.

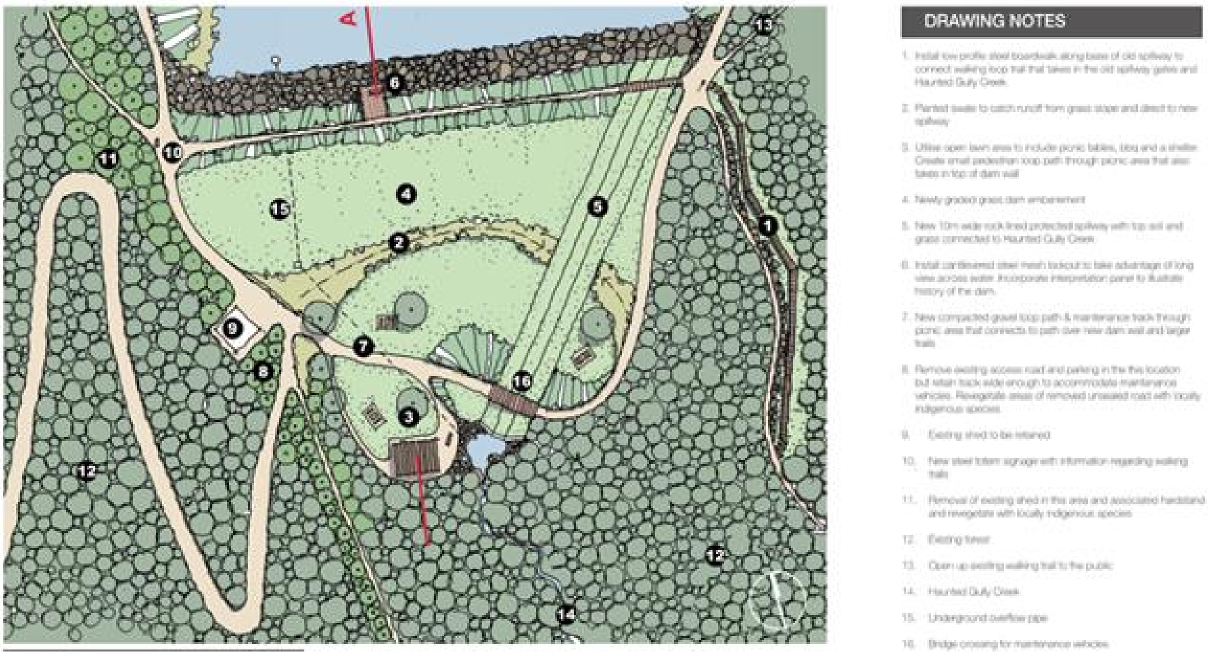
Melbourne Water Officers considered that option 1 to be the most appropriate. The following concept drawings were provided that depict the proposed works see Figure 2 and Figure 3.

Figure 2. Concept drawings



The following concept drawing provides further details of the proposed landscape improvements, see Figure 3. Works include installation boardwalks, planted swale, open lawn area, picnic tables BBQ's and shelter, toilet, viewing platforms, new rock lined spillway to Haunted Gully Creek, path connections and maintenance vehicle access. No parking facilities are proposed.

Figure 3. Concept design with further details



Melbourne Water also identified a number of challenges with the implementation of the project, including:

- Consideration of opening the site up to the public.
- Ongoing maintenance responsibility of recreation infrastructure and role of a Parks Manager.
- Balancing nature conservation with public access.
- Management of community expectations.
- Impact on site during the works.
- Weed management when water levels are drawn down.

Discussion

The following section of the report provides an update on the progress of council's resolutions. Included in response are excerpts from investigative reports conducted by MW. Supplementary information is also included to ensure that issues pertaining to the project are appropriately understood. Further, this section of report includes a sample of the correspondence that Council received, the inclusion of correspondence is to ensure that Council adequately understands the concerns from members of the community pertaining to the MW project.

1 Note the report

The report has been duly noted and has subsequently resulted in a number enquiries to appropriate agencies to inform the content provided in this report.

2. Recognises the Beaconsfield reservoir and nature conservation reserve as a place of highly significant environmental, community and cultural importance for our region. A wonderful natural asset that has great potential for community and environmental benefit into the future.

As previously highlighted the Beaconsfield Nature Conservation Reserve is not currently open for public access or use. Officers acknowledge the high ecological and environmental value of the BNCR and recognize that the proposed additional recreation facilities would benefit the Cardinia Shire community and attract significant regional visitation given the elements that exist in the reserve. There is significant interest and passion for the reserve which is evidenced by the large volume of correspondence that council has received, community meetings and media publicity. Whilst the treatment of the proposed safety action is being debated there appear to be broad support for access and improved recreational facilities in the reserve and increased access to BNCR.

DELWP officers have provided the following comments regarding land use, which reinforces the future intention for the reserve that is consistent with council's expectation. "*BNCR is permanently reserved for Public Purposes (Nature Conservation) and Cardinia Environment Coalition (CEC) is the appointed Committee of Management pursuant to the Crown land (Reserves) Act 1978. Any future use of the reserve will need to be consistent with the reservation*"

3. Requests that all responsible State Government authorities work together with the local community to develop a long-term strategic plan that delivers the best outcomes for the environment and community interests.

Council officers have had discussions with DELWP officers regarding the Council resolution to create a long-term strategic plan for the BNCR. The response that was provided was that there were no immediate plans to fund the development of a long-term strategic plan. It was not clear if DELWP was intending to submit a funding application for a strategic plan in future budget allocations.

The view of MW officers regarding the development of a long-term strategic plan is that "Our position is that whoever the longer-term overarching land manager is should develop the long-term strategic plan"

Council Officers consider that the development of a long-term strategic plan is as an important instrument to clarify and activate the community's vision for the reserve. The development of plan should be multi-faceted and engage a broad array of stakeholders. The plan development should be adequately funded by the Victorian Government, via DELWP. Continued advocacy activities to the appropriate State Agencies is strongly encouraged to ensure they allocate funding for the development of a long-term strategic plan.

4. Requests that no further works are to be considered or proceed with the reservoir's dam wall until such time this future strategic document is developed and created.

Council officers have limited influence on the project times lines. MW in conjunction with DELWP will manage the implementation of the project. Given that council officers have not been given a commitment that a long-term strategic plan will be developed, it will be difficult to meet the resolution. Officers are of the understanding that significant work will not occur until the water levels have been reduced, which is expected to occur over three years. Council officers have not been provided with documentation that outlines the project milestones, however Council has been verbally advised that the water lowering works will commence mid-2022. Information on the MW community portal indicates that infrastructure work will commence in 2025, once the water levels have been lowered.

5. Advocate to the relevant State Government departments to undertake a thorough environmental assessment of the reservoir and the greater BNCR including a report on the impact that any future developments would have on the environment within.

Melbourne Water engaged specialist ecologists from the Arthur Rylah Institute (ARI) to undertake an environmental assessment. The full report is provided as an attachment to the Council report. The report provides nine recommendations including a slow draw down of the water level over a three-year period. The slow draw down reduces potential weed encroachment and will allow the vegetation around the reservoirs edge to adapt to the changing waterline. Melbourne Water have indicated that over the next twelve-month period that further targeted seasonal surveys for both flora and fauna will occur within the Beaconsfield Nature Conservation Reserve. This information will be shared with Department of Environment Land Water and Planning and the Cardinia Environmental Coalition. It should be noted that Melbourne Water has also created a community web-based portal that provides access to the report at the following URL; https://www.melbournewater.com.au/building-and-works/projects/beaconsfield-dam-safety-upgrade-project.

The following excerpts are taken from the "Lowering the water level of Beaconsfield Reservoir A desktop assessment of environmental values and potential impacts", Shelly et al, The executive summary is provided below.

"Context:
Beaconsfield Reservoir is a decommissioned water supply located approximately 45 km southeast of Melbourne in the suburb of Officer. Melbourne Water proposes to reduce the carrying capacity of the reservoir which will result in an overall reduction of waterbody size and depth. The proposed activities will reduce the coverage of shallow water and deep, open water habitat. As the reservoir harbours flora and fauna that are, to varying degrees, reliant on the habitat provided by the waterbody, Melbourne Water engaged the Arthur Rylah Institute for

Environmental Research and Dellbotany to conduct an environmental impact assessment of the proposed activities on these communities.

Aims:
Collate a list of the known flora and fauna directly reliant on the reservoir (waterbirds, herpetofauna, fish, crayfish and mussels) within and close to the reservoir, assess the expected impact of the proposed activities on these communities, and propose ways in which these impacts can be mitigated. Methods: Site visits were completed at Beaconsfield Reservoir on two occasions, on the 8th (flora and waterbirds) and 29th (flora and herpetofauna) of July 2021. Observations made during the site visits were combined with records from various online and literature sources to assess the flora and fauna values of the reservoir so that recommendations could be made as to the impact of the proposed reduction in water holding capacity. The geographic radius of these searches was dependent on the dispersal ability of the organism in question. For example, the search radius for amphibians and reptiles was 5 km, while the search radius for waterbirds, that are highly mobile, was 13 km.

Results:
Few documented surveys have been conducted within the Beaconsfield Reservoir which may be partly due to the lack of public access. However, records from the reservoir, combined with those from the surrounding area, give an indication of the species that are or may be present. In total, 993 plant taxa (655 native and 338 weeds) were identified within 5 km of the reservoir. Of these 38 are listed as threatened. 65 species of waterbirds were identified within 13 km of the reservoir with 11 of these being threatened. 17 species of water-reliant reptiles and nine species of frogs were identified within 5 km of the reservoir. Respectively, one and two of these species were threatened. Finally, 13 species of fish, six species of crayfish and one species of freshwater mussel occur either in the reservoir or the connecting catchments, so may be present.

Conclusions and implications:
A limitation of this study is the general shortage of survey data from the reservoir itself. Based on the data we could find, there are no fundamental issues with the proposed activities, but some species would likely be impacted, especially if the lowering of the water level occurs too quickly. The key to minimising potential disturbance to aquatic and semi-aquatic animals either using or potentially using Beaconsfield Reservoir is to minimise the disturbance to aquatic and terrestrial vegetation that provides them with critical habitat. To achieve this, it is recommended that the draw-down be conducted over at least three years to allow the emergent and submerged vegetation around the edge of the reservoir to migrate with the changing waterline. It is important also that riparian vegetation in stream reaches leading in and out of the reservoir is not significantly impacted by the activity. The EVCs Aquatic Sedgeland, Aquatic Herbland, Riparian Scrub and Swampy Riparian Woodland will undergo changes in their areas of occupancy as a result of the proposed drawdown. The net change in area for each, 5-10 years following drawdown, can be estimated although some uncertainty remains regarding residual losses. The habitat for at least one state listed plant associated with these vegetation types will be impacted by the proposed lowering of the water level. The persistence of this and other species will rely on the persistence of existing conditions, noting that there will be inevitable compositional changes to the vegetation matrix and extent of habitat types."

Council officers note limitations of this study and strongly support ongoing data collection, analysis and monitoring at BNCR to fully understand the impacts on the fauna and flora.

6. Request that Melbourne Water make publicly available the safety assessment report which has identified the potential risk of the reservoir wall failing.

Melbourne Water have provided council officers with a safety assessment report. The report was prepared by GHD, a global company that is renowned for the provision of engineering services. Councils Engineering team have not peer reviewed the content of the report as Council is not equipped with specialist technical skills in relation to significant hydrological infrastructure. The full GHD report is provided as an attachment to the report. Excerpts of the report are included in the sections below. It should be noted that Melbourne Water has also created a community web-based portal that provides access to the report at the following URL; https://www.melbournewater.com.au/building-and-works/projects/beaconsfield-dam-safety-upgrade-project.

The GHD report refers to Australian National Committee of Large Dams (ANCOLD) guidelines. "*Australian National Committee of Large Dams (ANCOLD) guidelines are applicable for water or tailings dams with the potential to cause loss of life or significant environmental or physical damage through operation or failure. Although prepared for dams which would normally be at least 10 to 15m high ANCOLD guidelines can also be used to assist with decisions on smaller dams, particularly where a dam or series or dams creates the potential for loss of life or significant damage.*

ANCOLD guidelines are not a design, construction or operation code and practitioners must apply their own considerations, judgements and professional skills when designing, operating and managing dams".(https://www.ancold.org.au/?page_id=334)

Melbourne Water have supplied the *Beaconsfield Reservoir Concept Design Report* that was prepared by GHD in December 2019. The Executive Summary is provided below.

"*This report presents the concept design to upgrade Beaconsfield Reservoir. The purpose of the upgrade is to reduce the Consequence Category from High A to Low and although not formally assessed, it is expected that this upgrade would largely satisfy ALARP* (As Low as Reasonably Practicable)*.*

Beaconsfield Reservoir is now disconnected from the water supply network. The proposed concept design focuses on reducing the risk profile of the dam as well as reducing any future maintenance and operation requirements for Melbourne Water Corporation.

A previous risk assessment by URS in 2010 identified that Beaconsfield Reservoir lies within an order of magnitude of the ANCOLD (2003) Limit of Tolerability. A dam safety upgrade concept design, which assumed no reduction in reservoir level, was developed by GHD in 2012.The dam safety upgrade was assessed against a partial decommission upgrade; full decommission upgrade and a Do Nothing approach, to determine the preferred way forward. Based on a multi-criteria analysis it was identified that a partial decommissioning option would successfully reduce the Consequence Category to Low whilst still maintaining a permanent water body, and therefore providing a long-term amenity for the public.

Three partial decommissioning concept options were originally considered (labelled 1A to 1C), with different crest and spillway arrangements. The designs were developed by adopting a FSL of RL 94.0 mAHD, which was required to achieve a Low sunny day Consequence Category. However, none of these concept options resulted in a Low Consequence Category for wet day failure. Therefore, an iterative approach was undertaken, in which a fourth concept option (1D) was identified. This option resulted in a Low Consequence Category under both sunny day and wet day failure scenarios. The concept design of Option 1D includes the following key components:

- *Crest at RL 96.10 mAHD, which is 8 m below the current crest level of RL 104.05 mAHD*
- *A downstream embankment slope of 5H:1V*
- *FSL at RL 94.0 mAHD, 4.5 m lower than current restricted FSL of RL 98.5 mAHD*
- *Retrofitting the existing low-level outlet to be utilised as the primary spillway*

- *A secondary spillway at RL 95.5 mAHD located on the left abutment*
- A rock-lined spillway chute and energy dissipator

In addition, the recommended concept design (Option 1D) also includes the landscape design of the site, namely:

- *A re-designed smaller water body including smaller pools extending the visual appearance of the water body*
- *Circuit walking trails including tracks around the water body and along the existing spillway channel*
- *A picnic and passive recreation area located at the downstream toe of the upgraded embankment*

The GHD report highlights safety issues of concern that were identified from a risk assessment that was conducted in 2010. The report states the following concerns:

"The Beaconsfield Reservoir site presents a series of concerns as identified in the risk assessment, which have been actively managed by Melbourne Water. These include:

- *Historical seepage: Most recently observed in August 2018 on the downstream right abutment groin. A reduced operating level of RL 98.85 mAHD has continued to assist limiting risk associated with this deficiency.*
- *Structural instability: Beaconsfield Dam has a factor of safety (FoS) of 1.36, which is below the minimum required FoS of 1.5 for long-term steady state loading.*
- *All other identified deficiencies are related to minor capital works, or operation and maintenance of Beaconsfield Dam".*

In section 5 of the GHD report details are provided of the assessment and the rationale that informed the preferred option that is being proposed by Melbourne Water. The four options considered in the report are as follows:

Option 1 – Partial decommissioning

Partial decommissioning involves a reduction in the Consequence Category to Low or Very Low without an increase in the peak outflow, up to the 1 in 100 AEP, when compared with the existing arrangement. A partial decommissioning upgrade offers the benefit of retaining the ornamental lake for community benefit while minimising risk and cost to Melbourne Water.

Reducing Beaconsfield Reservoir from a High A to Low Consequence Category reduces the ANCOLD (2003a) recommended frequencies of inspections. Comprehensive Dam Safety Inspections are reduced from 5-yearly to 'not required'. Intermediate Dam Safety Inspections are reduced from annual to 5-yearly and routine visual inspections are reduced from daily-triweekly to monthly. Three partial decommissioning options were initially investigated.

The three partial decommissioning options assessed include:

- *Decommissioning the High-Level Outlet including demolishing the outlet tower and valve pit, grouting the pipework with valves to be 'locked out', whilst the Valve House would be retained for storage.*
- *A FSL at RL 94.0 mAHD.*
- *A primary spillway as either a new or retrofitted pipe and inlet structure to pass the*
- *1 in 100 AEP event without changing the current peak outflow.*
- *A secondary spillway to pass the 1 in 1000 AEP event.*
- *The Low-Level Outlet tower superstructure including bridge and hoist house removed and the substructure cut flush with the embankment.*
- *Concrete grouting of the annulus between the Low-Level Outlet cast iron pipe and concrete tunnel.*

- *Erosion protection required at toe, and to be considered for the embankment based on estimated velocities during detailed design.*
- *H:1V downstream slope tied into the natural surface.*
- *Landscaping of the site and wetlands to maximise the quality of community space.*

Option 2 – Full decommissioning
Full Decommissioning eliminates all dam safety risks associated with Beaconsfield Reservoir by removing the water retaining structure and has no ongoing dam maintenance costs. However, there would be no permanent water body, a large construction period, impacts to the flora and fauna within a Nature Conservation Reserve and risks associated with the removal of potentially hazardous silt.

Full decommissioning includes:
- *Removal of the embankment.*
- *Removal of all appurtenant works including the current outlet works (including Valve*
- *House), original outlet works (including those previously abandoned through grouting),*
- *Low Level Outlet and spillway.*
- *Removal and disposal of deposited silt.*
- *Stream bed and bank rehabilitation.*
- *Return stream to pre-dam flows.*

Option 3 – Full Dam Safety Upgrade
A Full Dam Safety Upgrade will address the risks identified by URS (2010) and although not formally assessed, it is expected that this upgrade would largely satisfy ALARP principles. For the purpose of this report, the concept design (GHD, 2012) was considered appropriate. The Full Dam Safety Upgrade would retain the restricted FSL (or higher depending on Melbourne Water's appetite for risk) thereby retaining maximum functionality of the reservoir for community use.

The upgrade is considered to undergo a longer and more costly construction phase than Options 1 and 2, causing disruptions to the community's accessibility to the reservoir. Ongoing dam safety surveillance and maintenance would be required due to an either High C or High B Consequence Category, and therefore it is considered prudent to have the site closed to the public due to public safety issues such as the high embankment and exposed rock faces. The Full Dam Safety Upgrade (GHD, 2012) includes:
- *Full-height filter buttress placed on the downstream batter with weighting fill placed over*
- *the top. The filters are designed to reduce the risk of piping which was a key contributing*
- *risk (URS, 2010).*
- *Restricted FSL becomes the permanent FSL at RL 98.85 mAHD.*
- *Convert the High-Level Outlet to the primary spillway including the removal of all valves,*
- *replacement of the intake screens from a fine screen to a coarse screen. The pipe would*
- *be altered to combine flows (as opposed to running parallel the entire length) and*
- *plugging the unused section of the pipe downstream. A USBR Impact Basin energy*
- *dissipator to retard flows into Haunted Gully Creek would be constructed.*
- *Concrete grouting of the annulus between the cast iron pipe and concrete tunnel in the*
- *Low Level Outlet. This will reduce the risk of piping along and within the outlet and is*
- *considered a prudent measure.*
- *Re-profile the embankment crest where low points exist. Removing any low points will*
- *reduce the risk of overtopping.*
- *Minor capital works as noted in previous Annual Inspections, including works to the*
- *access roads, Valve House and operations and maintenance improvements such as pit*
- *lids, railing and platforms.*

Option 4 – Do Nothing
A 'Do Nothing' option is a control option and used to provide a base case for the options. By doing nothing, the Consequence Category and risk profile remain unchanged. Beaconsfield Reservoir is considered to not currently meeting ALARP, plotting within an order of magnitude of the ANCOLD Limit of Tolerability at the 50% and 80% confidence intervals, and plotting

above the ANCOLD Limit of Tolerability for the 95% confidence interval. Therefore, 'Do Nothing' is not in accordance with ANCOLD guidelines, good practice and precedent or the Strategic Framework for Dam Safety Regulation (DELWP, 2014)."

The options developed were assessed by GHD using Multi Criteria Assessment (MCA) model. The full assessment and weighted scoring are provided on *page 19* of the GHD report in table 5.2. The conclusion of the MCA model was that the partial decommissioning option was the most favourable. The score summary is provided in the table below which was taken from the GHD report.

MCA categories & sub-categories	Category weighting	Sub-category weighting (out of 4)	OPTIONS			
			1	2	3	4
			Partial decom'ing / partial height dam	Full decom'ing / removal of dam	Safety upgrade (full upgrade)	Do nothing / current arrangement
TOTAL SCORE	100		78.3	61.1	65.2	64.6

Melbourne Water advised that interim risk was being actively managed through regular assessments and that the Dam presents no immediate risk to the community. However, they advise that the long term risk needs to be addressed with a plan. They also emphasised that the consequence of failure of the wall could result in significant impact to the community. MW also provided information that demonstrated that the Dam was their highest priority in relation safety compliance in accordance with ANCOLD guidelines.

7. Acknowledges the petition which is currently before the State Government of Victoria which is requesting the retention of the current reservoir water level.

The Officer and District Community Association (ODCA), Save the Beaconsfield Reservoir Action Group, and residents of the Cardinia Shire and surrounding communities submitted the following petition prayer to the Legislative Assembly of Victoria:

"To the Legislative Assembly of Victoria

The Petition of The Officer and District Community Association, Save the Beaconsfield Reservoir Action Group, residents of the Cardinia Shire and surrounding communities draws to the attention of the House that Melbourne Water are proposing to undertake safety works at the Beaconsfield Reservoir Wall by their partial decommissioning option which will reduce the wall height by 6 metres and reduce the water level by about 5 metres The petitioners therefore request that the Legislative Assembly of Victoria ask that Melbourne Water undertake the safety works at the Beaconsfield Reservoir Wall by adopting their Safety Upgrade option which will leave the wall height at its current level and retain the current water level."

The following number of signatures were received at the two community meetings as detailed below according to the ODCA:

- The Public meeting: 85 attendees with 62 signing the petition
- Reservoir Open Day: 300+ attendees with 220 signing the petition

The member for Gembrook in the Victorian Legislative Assembly, Mr. Brad Battin posed the following questions to Minister of Water on 24 November 2021. The responses prepared by MW officers assist to provide further context to this report.

Question 4822 – Mr Battin to ask the Minister for Water
In relation to the redevelopment of Beaconsfield Reservoir, please provide detail of the consultation Melbourne Water undertook with local residents, including providing a timeline.

- *Jacobs were appointed by Melbourne Water to undertake the Community consultation for the project in 2016 and prepared an extensive Communications and engagement plan. However, in initial meetings it was identified that the public were largely unaware of the dam as there was extremely limited public access.*
- *This changed the initial consultation approach.*
- *Melbourne Water decided that the initial consultation (Sept 2016) should be with those with an active interest and responsibility for managing the site. This involved consultation with the Cardinia Environmental Coalition (CEC) (made up of a number of local Landcare and Friends groups) and Cardinia Shire Council.*
- *There was also a meeting with DELWP in Oct 2016 to determine regulatory requirements for any works at the site.*
- *The preliminary concept with the initial Water level reduction was reviewed in Aug 2017 at a Workshop with CEC, Council, DELWP reviewing water levels – use of VR to show the proposed water levels.*
- *February 2018 – Workshop with CEC, Council, DELWP, Friends of Beaconsfield Nature Conservation Reserve (BNCR) to present 92mAHD water level.*
- *February 2018 – Door knocked local residents living downstream and adjacent to the dam to discuss the project and the proposed plans.*
- *June 2018 – we attended the Upper Beaconsfield Association public meeting which had the plans for Beaconsfield Dam on the agenda (as well as other Council initiatives). Community interest in the plans for the Dam were discussed and it became apparent that there was interest from the wider community in the plans.*
- *July 2018 - Open day was held at the at BNCR with a number of locals attending to visit the site for the first time and others who were interested in the plans for the site.*
- *An article appeared in the local Village Bell newsletter in Sept 2018 in which we were invited to provide our response, and this raised public awareness of the site.*
- *At the request of several Community members, a meeting was held in October 2018 with MW and GHD with a number of "technical experts' from the community to go through the proposals and technical aspects of the proposals explaining the water levels and height of the dam wall.*
- *In November 2018, following community concern regarding the use of the dam for firefighting purposes, MW received advice from DELWP's Chief Fire Officer with regards to the potential use of the Beaconsfield dam for firefighting purposes. Advice received stated that while the Dam could potentially be used for firefighting purposes, it was more likely that nearby Lysterfield Lake, Aura Vale Lake and Cardinia Reservoir - all designated with pre-approval as water pickup locations in the cockpit handbook issued to pilots of aerial firefighting aircraft would be considered more appropriate water sources. There was a range of supporting commentary around this.*
- *A meeting with CEC, Council, DELWP, Friends of BNCR to discuss the revised water level of 94mAHD, and landscape drawings was held in March 2019.*
- *Six small community sessions held in Upper Beaconsfield and Officer to discuss project and preferred option were held in April 2019.*
- *Digital engagement with survey and feedback following the sessions – over 30 responses received.*
- *Meeting with CEC, Council and DELWP in June 2019 – to discuss future maintenance of infrastructure.*
- *Melbourne Water has been engaging with the Department of Environment, Land, Water and Planning (DELWP), Cardinia Shire Council, CEC and Friends of Beaconsfield Nature Conservation Reserve about the project since 2016.*

Question 4823 – Mr Battin to ask the Minister for Water
In relation to the redevelopment of Beaconsfield Reservoir, please detail the areas of Cardinia Shire that were sent notification of the proposed redevelopment.

- *Melbourne Water doorknocked the residents immediately downstream and adjacent to the dam to discuss the project and the proposed plans,*
- *Melbourne Water provided these residents and key community groups with information bulletins.*
- *Melbourne Water attended a meeting of the Upper Beaconsfield Association to discuss plans in mid-2018.*
- *Melbourne Water attended an open day at Beaconsfield Reservoir in July 2018 to talk to the wider community about the dam and plans for risk reduction activities*
- *Melbourne Water put notices in the local newspaper (Pakenham Gazette) regarding the community information sessions.*
- *Melbourne Water held six small community sessions in Upper Beaconsfield and Officer to discuss project and preferred option. These were open to the public and were held in April 2019.*

Question 4824 – Mr Battin to ask the Minister for Water
In relation to the redevelopment of Beaconsfield Reservoir, please provide a list of the user and/or community groups that Melbourne Water has engaged with during the consultation and project notification processes.

Melbourne Water undertook engagement with the following groups:
- *Cardinia Environment Coalition (CEC) –made up of 25 local environmental groups*
- *Friends of Beaconsfield Nature Conservation Reserve (BNCR)*
- *Upper Beaconsfield Association (UBA)*
- *Beaconsfield Progress Association*
- *Hughendon Rd Community Fireguard Group*
- *Officer Community Association*

Question 4826 – Mr Battin to ask the Minister for Water
In relation to the redevelopment of Beaconsfield Reservoir, what is Melbourne Water's rationale for undertaking the proposed development?

The design of the dam does not meet current safety requirements and risk guidelines in terms of stability, internal erosion (piping) protection and general design deficiencies.
The dam was built over 100 years ago and does not meet current Australian National Committee on Large Dams (ANCOLD) guidelines.
Australia has a strong emphasis on dam safety management principles set out by these guidelines
As a minimum, dam managers are required to achieve a level of dam safety which is tolerable and where this is not the case, undertake further measures to reduce the risk.

Retaining the dam in its current state, would not comply with national dam safety regulations.
A significant rain event could cause the reservoir to fill, spill and overtop. Without the works occurring at Beaconsfield, these storms could have significant consequences.
The driver of the Beaconsfield Reservoir Dam Safety project is to reduce the risk of Beaconsfield Reservoir failing, protecting properties and community located downstream of the dam.

While the likelihood of dam failure is low, the consequence is significant.

Question 4827 – Mr Battin to ask the Minister for Water
In relation to the redevelopment of Beaconsfield Reservoir, what is the data and/or evidence to support Melbourne Water's claim that the reservoir's wall is unstable.

The dam was built over 100 years ago and does not meet current industry practice for the design of a dam of its size.
Melbourne Water is required to manage the risk associated with our dams to be As Low As Reasonably Practicable (ALARP) due to the hazard posed by the storage of the water.
Beaconsfield Dam has known deficiencies associated with the stability of the embankment and the performance of the spillway and embankment during flood events. In light of our knowledge of the shortcomings in the design, construction and performance of the dam, as well as the consequences of the dam failing, Melbourne Water has a duty of care to reduce the risk of the structure. We understand that the reservoir water body offers amenity value to the community and this has been carefully considered throughout the decision-making and engagement process.

Question 4828 – Mr Battin to ask the Minister for Water
In relation to the redevelopment of Beaconsfield Reservoir, what redevelopment options were considered by Melbourne Water and what are the details of each option

Melbourne Water assessed a range of options for Beaconsfield Reservoir, including:

- *Do nothing – this was not considered as a feasible option, because the risk was too high*
- *Partial decommissioning – this would see a reduction in water level and height of crest*
- *Full decommissioning – this would see the removal of all dam infrastructure and a return to previous state before dam was built*
- *Safety Upgrade – this would involve buttressing the dam wall but maintaining the water level*

Question 4829 – Mr Battin to ask the Minister for Water
In relation to the redevelopment of Beaconsfield Reservoir, what is the cost of Melbourne Water's preferred option for redevelopment, and what are the costs for options that were not selected.

The current estimated cost for the partial decommissioning is approx. $8.9m.
Melbourne Water undertook a multi-criteria analysis (MCA) in choosing a preferred option. Costs are just one component of the assessment – Melbourne Water look to maximise community benefit from our investment and found the option that does that. Detailed cost estimates were only developed for the partial decommissioning, as the preferred option. Initial cost estimates utilised in the MCA indicated the full safety upgrade option to be approximately 50% more expensive than the partial decommissioning option, without taking into consideration ongoing lower maintenance costs.

Question 4830 – Mr Battin to ask the Minister for Water
In relation to the redevelopment of Beaconsfield Reservoir, why does Melbourne Water does not consider the reservoir to be suitable to refurbish and provide potable water to the South-East growth corridor.
Beaconsfield Dam has not been connected to the water distribution network since 1988, following the connection of Cardinia Reservoir and upgrades to the water transfer network allowing water supply to the Mornington Peninsula.

The dam has a very small catchment, and the reservoir water level stays relatively constant, which indicates that losses due to evaporation match inflows in most years and so the dam would not provide any yield.
This site is not required as part of Melbourne Water's plans for water supply.

Question 4831 – Mr Battin to ask the Minister for Water
In relation to the redevelopment of Beaconsfield Reservoir, what plans are in place to open the precinct to the public for tourism and public visits?

Melbourne Water is committed to working collaboratively with Council and residents to enhance the environmental aspects of the Beaconsfield Dam and surrounding Reserve for all the community to enjoy.

Future engagement around the site is planned in stages. Stage 2 will see opportunities for engagement with the community on the amenity and liveability improvements to the site. This is yet to be determined and will be subject to ongoing funding being made available to CEC/Council (as the Committee of Management) for the site.
The planned work is necessary to allow community access for all to enjoy the area as a recreation space. The only way the site can be opened to the public is if the risk profile is reduced, which these works will achieve.
Background for DELWP:
This is Crown Land with a Committee of Management, so the decisions around opening it up are not made by Melbourne Water.
Melbourne Water have met with various stakeholders and will continue to work towards and push for outcomes of opening it.

Question 4832 – Mr Battin to ask the Minister for Water
In relation to Beaconsfield Reservoir, why has there been only one public open day since 2018.
Melbourne Water are not the Land managers. The Cardinia Environment Coalition manage the site and who can access or attend Open Days.
Background for DELWP
While the reservoir itself is an MW asset, the surrounding space is Crown Land managed through a COM.

Question 4833 – Mr Battin to ask the Minister for Water
In relation to the redevelopment of Beaconsfield Reservoir, what study or modelling was undertaken to support Melbourne Water's claim that the town of Officer would be flooded in the even that a 1 in 10,000-year storm event would occur.

The dam currently stores a large volume of water which poses a high hazard to the downstream population. Risk associated with the current dam is not considered to be As Low As Reasonably Practicable.
MW's preferred option is to lower the water level to reduce the hazard posed to the downstream population. The aim of the works is to ensure that, if the dam were to fail in the future under any circumstance, there would be no loss of life and minimal damage to property.
Melbourne Water have previously indicated that the current total likelihood of failure is 1 in 10,000 AEP (Annual Exceedance Probability). AEP is a detailed technical measure used in flood management. The likelihood was calculated as the sum of all of the probability of all of the different failure modes considered by Melbourne Water.
While the likelihood of dam failure is low, the consequence is significant.

8. Highly commends the work that the Cardinia Environment Coalition has undertaken in managing the reserve and advocates for ongoing recurrent funding to manage the BNCR into the future.

The reserve is currently managed by the CEC in a direct relationship with DELWP. The CEC is a highly respected organisation and the work conducted by the CEC and volunteers is of immense public value. The CEC provide numerous services and achieve high standards of delivery which are evident by the condition of the reserve. The environmental services provided by the CEC are funded through the provision of State Government grants. It is the council officers' understanding that no recurrent funding budgets exist in the State Departments and the CEC ongoing relationship is contingent on grants being made available annually and successful applications. Council officers would prefer that DELWP consider the establishment of recurrent budget allocation and consider a longer-term service agreement with the CEC for this important regional reserve. Council understand that the CEC is continually in constructive dialogue with DELWP to progress the matter of recurrent funding.

9. Advocate for the State Government to assign the Park Manager role to a State Government Agency for a significant reserve of regional importance.

Council officers have raised the matter with MW of assigning the Park Manager role to a State Government Agency given BNCR is a significant reserve of regional importance. Melbourne Water understands that DELWP sees their role as facilitating others to manage the site rather than actively managing the site as a Park Manager. Melbourne Water states that their role within BNCR is limited to the management of the dam embankment.

The following correspondence was received from DELWP in relation to the appointment of a Park Manager, *"BNCR is permanently reserved for Public Purposes (Nature Conservation) and Cardinia Environment Coalition (CEC) is the appointed Committee of Management pursuant to the Crown land (Reserves) Act 1978. Any future use of the reserve will need to be consistent with the reservation. DELWP recognises that the Dam Safety Upgrade Project may offer opportunities for improved biodiversity/environmental outcomes and potentially improved public access, while needing to be cognisant of the maintenance capacity/resources of the appointed land manager and known safety issues within the reserve (e.g. unmarked mine shafts).*

I have confirmed that DELWP (LBE Port Phillip Region) are not activity pursing the appointment of a Park Manager (e.g. transfer of management responsibilities to Parks Victoria). There is an appointed land manager for BNCR, and we do not foresee that changing

Council Officers understand that the additional recreational assets proposed a part of the MW option will only occur if a Park Manager is assigned. The CEC provide excellent service to the site in its current configuration. However, the installation of the asset would necessitate an increase in resources, asset management and long-term recurrent funding. In the view of council officers, Parks Victoria would better equipment to manage the recreation assets for a park of regional significance.

10. Indicates support for the improved recreational facilities and greater access to the Reserve for the general public.

MW and DELWP have indicated the requirement to assign a "Park Manager" to assume the ongoing service provision and asset management responsibility for the recreational asset proposed as part of the partial decommissioning option. The Park Manager would assume the cost of providing services to the community users and for surveillance, maintenance, repair of assets and renewal. The initial capital installation cost for the creation of the recreational assets and associated landscaping would be borne by MW as part of the dam wall reduction project. The Park Manager would be required to enter into an ongoing agreement with DELWP and accept the legal committee of the management status.

Council officers are generally supportive of the proposal to create additional recreational assets and access for the general public. Officers are of the view that the Cardinia Shire rate revenue should not be used to fund the ongoing asset and service cost for the reserve. The State agencies such as Parks Victoria would be better equipped and resourced to assume the Park Manager role for the State-owned reserve. Officers are however fully supportive of an ongoing and longer-term relationship for CEC at the BNCR. The CEC are competent and efficient service providers for matters and projects pertaining to fauna and flora. It is the view of the officers that they are not currently resourced to manage and service the proposed new recreational assets. This view is consistent with the correspondence received from the Cardinia Environment Coalition (CEC).

11. Is supportive of Melbourne Water taking necessary action to ensure the safety of our community and we ask that thorough community consultation and communication is undertaken regarding any future plans or developments for this site.

Officers consider that community safety is imperative, and Council would expect that the community are consulted by Melbourne Water regarding the decision-making process for their preferred option. Council officers are cognisant that MW are dealing with multiple competing interests and achieving community consensus is a difficult task. Balancing risk, environmental impacts, community interest and project cost is a highly complex process. Council officers are reliant on the technical expertise of the Melbourne Water asset managers to assess the appropriate solution, consequences and risk appetite for their assets.

Whilst Council is aware that residents in the vicinity of the Dam received a newsletter providing an update and details of a web page, there is a view that additional public community sessions are also required. A public meeting forum would allow meaningful dialogue to take place. The provision of factual information and the rationale process may assist to build community trust for the project. This advice was provided directly to MW officers by Council. The MW officers acknowledged the Councils view and indicated that additional engagement will occur with the community around March–April 2022.

Fire Fighting Concerns

There have been concerns expressed about the reduced opportunity for use of the site for fire fighting purposes should the water level reduce. MW indicated that advice provided by the DELWP Chief Fire officer stated that “while the Dam could potentially be used for firefighting purposes, it was more likely that nearby Lysterfield Lake, Aura Vale Lake and Cardinia Reservoir - all designated with pre-approval as water pickup locations in the cockpit handbook issued to pilots of aerial firefighting aircraft would be considered more appropriate water sources”. Further, the dam was not precluded from use but required the aviation operators to undertake a risk assessment on a case by case basis.

In correspondence supplied to council officers, The Hon Lisa Neville MP, Minster for Water provided the following advice “*Although the water level will be lowered, the additional grassland created is not anticipated to pose additional fire risk. The preferred option retains a body of water on the land while improving safety, accessibility, and improving environmental outcomes. Beaconsfield Dam is not a preferred water storage area for firefighting helicopters, which generally consider Cardinia Reservoir rather than Beaconsfield.”*

It is understood that through the consultation process undertaken in 2018 by MW, the community raised concerns regarding the use of the dam for firefighting purposes. MW indicated that their advice provided by the DELWP Chief Fire officer stated that *“while the Dam could potentially be used for firefighting purposes, it was more likely that nearby Lysterfield Lake, Aura Vale Lake and Cardinia Reservoir - all designated with pre-approval as water pickup locations in the cockpit handbook issued to pilots of aerial firefighting aircraft would be considered more appropriate water sources”*.
Further, the dam was not precluded from use but required the aviation operators to undertake a risk assessment on a case by case basis.

Biolink Impact

In April 2021, Council published the Draft Biolink Plan for consultation. This plan identifies the BNCR as a ‘node’, defined as ‘a cluster of patches of vegetation considered to be crucial to supporting biodiversity and maintain landscape connectivity for a broad range of animal types’.

The purpose for Melbourne Water’s proposed reservoir wall works is to improve the safety of the wall and manage the regular maintenance obligations. Based on an assessment of the project information provided by Melbourne Water to date (including the proposed reduction of the water level in the reservoir), there is no indication that there will be a detrimental environmental impact as a result of the proposed works. The terrestrial values of the surrounding BNCR and its classification as a Biolink node will not be negatively impacted. Council officers will work closely with the Cardinia Environment Coalition for activities required to support the Biolink plan

Correspondence:
Council officers acknowledge the recent correspondence received from community members regarding the MW project. Officers have provided the correspondence as an attachment to the report. In correspondence received from Officer and District Community Association's (ODCA), they have clearly stated their preference regarding the proposed MW option as indicated in the following statement *"The Officer and District Community Association's (ODCA) position on the Melbourne Water refurbishment of the reservoir is for the Safety Upgrade option instead of the proposed Partial Decommissioning"*

The ODCA are supportive of the installation of recreational assets such as walking tracks that provide greater connection to Council's trail network.

Council also recently received also received 59 submissions over a one-week period in January 2022 in response to an article that appeared in the Star News on January 5. The submissions clearly stated the following position *"We are opposed to MW's decision to demolish a substantial amount of the historically significant 103-year-old, formerly Heritage Listed, Beaconsfield Reservoir wall. It is absolutely unacceptable that Melbourne Water plan to drain and waste 440 Megalitres of vital water from the reservoir, beginning mid-2022. A significant need exists to retain this wall and water, both historically and for current and future community needs and safety reasons, which has been expressed to Council and MW numerous times"*

It should be noted that representation in media article was not intended to infer that Council officers or Councillors had a endorsed the option selected by the MW Officers, but rather intended to reinforce that public safety is important and ongoing consultation is necessary.

Consultation with Traditional Owners

The following statement is provided on the MW community portal "Melbourne Water has held an initial project briefing with the Bunurong Land Council Aboriginal Corporation (BLCAC). Further engagement to develop a Cultural Heritage Management Plan will occur when we are closer to planning the upgrade." Council officers are appreciative that MW has commenced the process of communication with the Bunurong people as the issue was raised by the community as a matter of concern. Also, it is reassuring that the project will be subject to the rigour of a Cultural Heritage Management Plan as legislatively required.

Heritage Considerations

There continues to be concern amongst the community regarding the heritage status of the dam wall. As previously stated, Council officers have been in contact with Heritage Victoria to understand the status of the dam wall. Heritage Victoria have advised that the site was previously listed on the Victorian Heritage Inventory. The Victorian Heritage Inventory (VHI) contains places which have the potential to contain artefacts of archaeological significance related to the former use of the site and are protected by State legislation in the Heritage Act 2017.

In the late 90's and early 2000's many places that have some form of heritage value were listed on the Heritage Inventory. Subsequently Heritage Victoria undertook a review of the

Heritage Inventory, and it was determined that sites that do not demonstrate archaeological potential should be removed or de-listed from the Heritage Inventory. It was determined the Beaconsfield Reservoir did not contain strong enough archaeological potential to justify a listing on the Heritage Inventory and hence, was delisted. This does not necessarily mean that there are no other heritage values at the site. This only relates to the sites potential to contain archaeological features, deposits, or artefacts. There is currently no local heritage overlay on the site.

Policy Implications

Open Space Asset Management Plan:
If Council were to assume the Park Manager responsibility the assets would need to be included on council's asset register for the provision of funds for future maintenance renewal.

Relevance to Council Plan

3.3 Our Environment - Enhanced natural environment
3.3.8 Preserve and improve our bushland and natural environment by implementing weed management programs and continuing work on high conservation bushland reserves and roadsides.

Consultation/Communication

Council Officers consider that the communication and consultation responsibilities for project is the obligation of the project leader, Melbourne Water.

Financial and Resource Implications

Should Council consider the entering into an agreement to assume the Park Manager role, the Council would need to consider a financial budget allocation for the required management resources. As the project scope has not been fully ratified it is difficult to provide accurate costings. A very preliminary budget estimate for maintenance activities would require an estimated allocation of $90,000.00 per annum as a minimum for the maintenance of the proposed asset. Council would also need to consider the ongoing renewal that will be required to retain the recreation base in serviceable condition. The budget estimate would need to be reviewed on the confirmation of the project scope and may result in additional cost. The estimate does not account for the works provided by the CEC. It would be preferable if MW, DELWP or another State Government agency fully funded the required resources. It should be noted that currently there is no budget allocation in Councils 10-year draft budget for the BNCR. Allocation of a budget will place further pressure on the existing rate capped revenue base.
It is the view of Officers that the appropriate State Government Agency should fund maintenance and renewal costs for this significant regional public reserve.

Conclusion

Council officers are supportive of works that protects the community from unnecessary risks. It is acknowledged there are several options that can achieve the desired safety outcome. Council officers are reliant on the technical expertise of the Melbourne Water asset managers to assess the appropriate solution, consequences and risk appetite for their assets. Council also supports the notion of ongoing consultation and engagement by MW with the community to ensure community concern are fully understood and addressed.

There are clearly divergent and passionate views regarding what the vision should be for the BNCR, which only strengthens the Council's perspective for the need for the development of a long-term strategic plan by DELWP. There is also appears to be strong support for enhanced recreational facilities to be delivered to enable greater access to reserve and provide connection to Council trails.

Given the prominence of the BNCR as a potential regional destination, officers believe that a State Government agency should assume the responsibility for the recreational assets and continue the arrangement with CEC to provide environmental services. The BNCR is of immense public value and should be afforded the appropriate status by DELWP to ensure that the community can have access to its beauty.

Lowering the water level of Beaconsfield Reservoir

A desktop assessment of environmental values and potential impacts

J.J. Shelley, M. Dell, K.M. Howard, P.V. Macak and G.W. Brown

August 2021

Arthur Rylah Institute for Environmental Research
Unpublish Client Report

Arthur Rylah Institute for environmental research
dellbotany
VICTORIA State Government | Environment, Land, Water and Planning

Acknowledgment

We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and deep spiritual connection to it. We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

We are committed to genuinely partner, and meaningfully engage, with Victoria's Traditional Owners and Aboriginal communities to support the protection of Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond.

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Front cover photo: Beaconsfield Reservoir and its wall in the distance (Phoebe Macak).

Lowering the water level of Beaconsfield Reservoir

A desktop assessment of environmental values and potential impacts

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Arthur Rylah Institute for Environmental Research
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Summary

Context: Beaconsfield Reservoir is a decommissioned water supply located approximately 45 km southeast of Melbourne in the suburb of Officer. Melbourne Water proposes to reduce the carrying capacity of the reservoir which will result in an overall reduction of waterbody size and depth. The proposed activities will reduce the coverage of shallow water and deep, open water habitat. As the reservoir harbours flora and fauna that are, to varying degrees, reliant on the habitat provided by the waterbody, Melbourne Water engaged the Arthur Rylah Institute for Environmental Research and Dellbotany to conduct an environmental impact assessment of the proposed activities on these communities.

Aims: Collate a list of the known flora and fauna directly reliant on the reservoir (waterbirds, herpetofauna, fish, crayfish and mussels) within and close to the reservoir, assess the expected impact of the proposed activities on these communities, and propose ways in which these impacts can be mitigated.

Methods: Site visits were completed at Beaconsfield Reservoir on two occasions, on the 8th (flora and waterbirds) and 29th (flora and herpetofauna) of July 2021. Observations made during the site visits were combined with records from various online and literature sources to assess the flora and fauna values of the reservoir so that recommendations could be made as to the impact of the proposed reduction in water holding capacity. The geographic radius of these searches was dependent on the dispersal ability of the organism in question. For example, the search radius for amphibians and reptiles was 5 km, while the search radius for waterbirds, that are highly mobile, was 13 km.

Results: Few documented surveys have been conducted within the Beaconsfield Reservoir which may be partly due to the lack of public access. However, records from the reservoir, combined with those from the surrounding area, give an indication of the species that are or may be present. In total, 993 plant taxa (655 native and 338 weeds) were identified within 5 km of the reservoir. Of these 38 are listed as threatened. 65 species of waterbirds were identified within 13 km of the reservoir with 11 of these being threatened. 17 species of water-reliant reptiles and nine species of frogs were identified within 5 km of the reservoir. Respectively, one and two of these species were threatened. Finally, 13 species of fish, six species of crayfish and one species of freshwater mussel occur either in the reservoir or the connecting catchments, so may be present.

Conclusions and implications: A limitation of this study is the general shortage of survey data from the reservoir itself. Based on the data we could find, there are no fundamental issues with the proposed activities, but some species would likely be impacted, especially if the lowering of the water level occurs too quickly. The key to minimising potential disturbance to aquatic and semi-aquatic animals either using or potentially using Beaconsfield Reservoir is to minimise the disturbance to aquatic and terrestrial vegetation that provides them with critical habitat. To achieve this, it is recommended that the draw-down be conducted over at least three years to allow the emergent and submerged vegetation around the edge of the reservoir to migrate with the changing waterline. It is important also that riparian vegetation in stream reaches leading in and out of the reservoir is not significantly impacted by the activity.

The EVCs Aquatic Sedgeland, Aquatic Herbland, Riparian Scrub and Swampy Riparian Woodland will undergo changes in their areas of occupancy as a result of the proposed drawdown. The net change in area for each, 5-10 years following drawdown, can be estimated although some uncertainty remains regarding residual losses. The habitat for at least one state listed plant associated with these vegetation types will be impacted by the proposed lowering of the water level. The persistence of this and other species will rely on the persistence of existing conditions, noting that there will be inevitable compositional changes to the vegetation matrix and extent of habitat types.

We finish by providing nine recommendations to minimise the risk of impacting flora and fauna, including conducting formal surveys to increase the information available on which species are using the area.

1 Introduction

Melbourne Water proposes to reduce the carrying capacity of Beaconsfield Reservoir which will result in an overall reduction of waterbody size and depth (Table 1). Total waterbody area will decline from 70,000 m^2 to 31,000 m^2. Water depths over 1.5 m will experience the highest reduction, declining from 51,500 m^2 to 19,700 m^2 (61%). The proposed activities will also reduce the coverage of shallow water depths (< 1.5 m) from 18,500 m^2 to 11,300 m^2 (39%), although shallow waters will account for a higher proportion of the proposed reservoir. The reservoir lies within the Beaconsfield Nature Conservation Reserve (BNCR), which harbours flora and fauna that are, to varying degrees, reliant on the habitat provided by the waterbody. As such, Melbourne Water engaged the Arthur Rylah Institute for Environmental Research and Dellbotany to conduct an assessment of potential environmental impacts of the proposed activities on these communities. This report details the known flora and fauna that are dependent on the reservoir (waterbirds, herpetofauna, fish, crayfish and mussels) within the area of the BRNR, assesses the expected impact of the proposed activities on these communities, and proposes ways in which these impacts can be mitigated.

Table 1. The area and proportion of the Beaconsfield Reservoir that will have water depths greater than and less than 1.5 m, before and after the proposed lowering of the reservoir's carrying capacity. ahd = above height datum.

	Water depth less than 1.5m (m^2)	Water depth greater than 1.5m (m^2)	Total water area (m^2)	Percentage of shallow water
Current (98.5 m ahd)	18,500	51,500	70,000	26%
Proposed (94 m ahd)	11,300	19,700	31,000	36%
Total reduction (m^2)	7,200	31,800	39,000	
Percentage reduction	39%	61%	56%	

2 Methods

2.1 Study site

Beaconsfield Reservoir is located on Haunted Gully Creek, approximately 45 km southeast of Melbourne in the suburb of Officer. The reservoir is an on-stream storage, with a local catchment area of approximately 334 ha. It was constructed in 1918 as part of a new water supply scheme for the Mornington Peninsula. Water was harvested from the Bunyip River and conveyed to Beaconsfield Reservoir by the Bunyip Main Race, which was later supplemented by the construction of the Tarago Main Race. However, the reservoir was permanently disconnected from Melbourne's water supply and distribution network in 1988 and now serves as an ornamental lake. Cardinia Reservoir replaced Beaconsfield Reservoir as the regions water supply and lies approximately 6 km to the north.

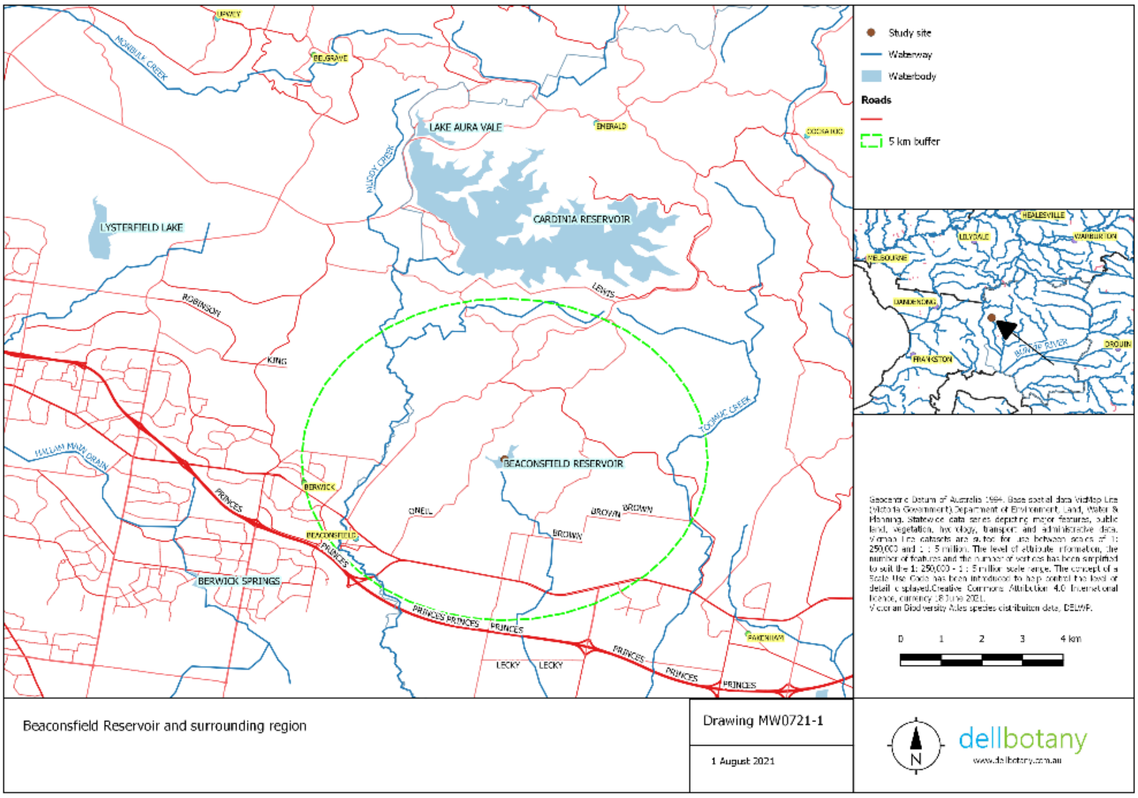

Figure 1. Beaconsfield Reservoir and the surrounding area.

2.2 Field and desktop surveys of flora and fauna

Site visits were completed at BNCR on two occasions: the 8th (flora and waterbirds) and 29th (flora and herpetofauna) of July 2021. Observations made during the site visits were combined with records from various online and literature sources to assess the flora and fauna values of the BNCR, so that recommendations could be made as to the impact of the proposed reduction in water holding capacity. The geographic radius of the desktop searches was dependant on the dispersal ability of the organism in question. For example, the search radius for amphibians and reptiles was 5 km, while the search radius for waterbirds, that are highly mobile, was 13 km to encompass two large nearby water bodies (section 2.2.2). The literature review for fish focussed on the wider stream catchment.

2.2.1 Flora

A brief inspection of vegetation and habitats within approximately 50 m of the reservoir bank was undertaken on foot. Notes were made on vegetation fringing the bank and how this may change with changes to the average water level. General notes were taken on the vegetation downstream of the reservoir wall and further upslope within BNCR, to describe its floristic composition and habitats for threatened species and communities. A list of dominant or characteristic plant species was recorded for each Ecological Vegetation Class (EVC) and these were provisionally mapped including the extent of habitat types within 30 m of the edge of the water (Figure 2; Figure 3).

The Victorian Biodiversity Atlas (VBA) was searched for records of threatened plant species which have been previously recorded within 2 km of the BNCR. Threatened species are those listed as state threatened under the *Flora and Fauna Guarantee Act 1988* and nationally threatened under the *Environment Protection and Biodiversity Conservation Act 1999*. A separate 5 km search was undertaken to identify any addition taxa previously recorded within the broader landscape, that may have habitat within BNCR. These taxa were then assessed for their likelihood of occurrence (low, medium, high) within BNCR, based on inference of habitat types and current understanding of extent and status of populations more broadly.

An EPBC Act Protected Matters Report (DAWE 2021) was generated for the same 5 km search area. This report identifies listed species, communities and other matters of national environmental significance which may occur within the search area.

Mapping of vegetation polygons was drafted in the field using QField v.1.9.6. Map figures were produced with QGIS v3.6.

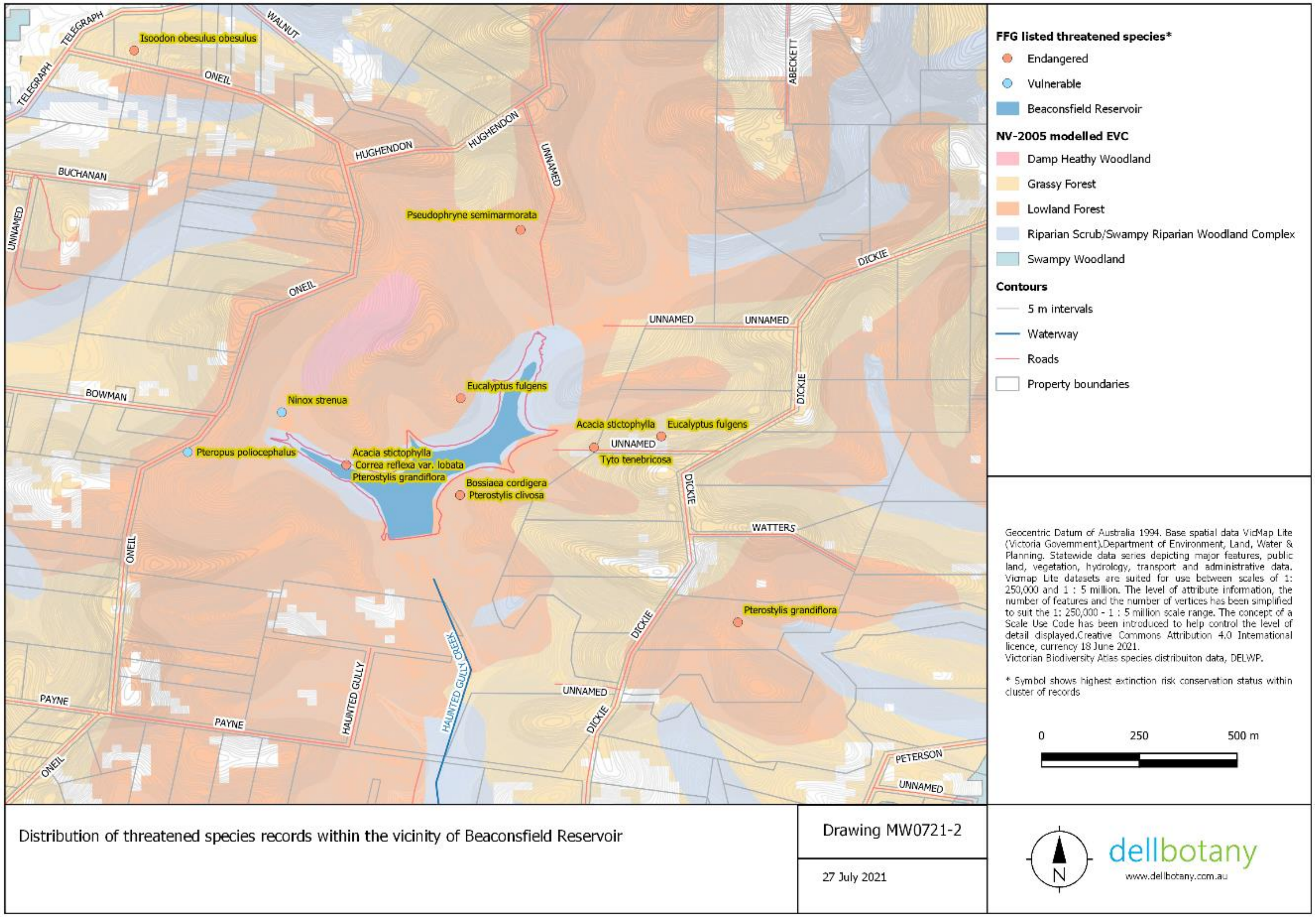

Figure 2. A map of Beaconsfield Reservoir and the immediate area showing Flora and Fauna Guarantee (FFG) Act listed species and modelled EVCs.

2.2.2 Waterbirds

During the site visit (8 July 2021) a portion of the perimeter (at the dam wall, and from the western tip along the northern edge) was explored by foot by one observer to inspect potential waterbird habitat. While slowly walking along the water's edge, binoculars and a telescope were used to opportunistically scan the band of emergent vegetation around the edge of the reservoir, including the opposite side, as well as the open waters. This was sufficient to observe the whole area of the reservoir. During the subsequent site visit (29 July 2021), opportunistic waterbird observations were noted. No formal waterbird counts were undertaken.

To form a more complete picture of waterbird species potentially using the reservoir, the Victorian Biodiversity Atlas (VBA) (DELWP 2021a) was interrogated for previous records. This included the area immediately adjacent to the reservoir to establish local use, and an area approximately 13 km within the vicinity of the reservoir that encompassed the largest waterbodies nearby (Lysterfield Lake 12 km to the north-west and Cardinia Reservoir 6 km to the north). Records from the immediate BNCR area were combined with those from a previous assessment at the site (Mueck et al. 2002) and eBird, a citizen science database (eBird 2021).

2.2.3 Herpetofauna

A site visit was conducted on 29 July 2021 and the entire perimeter of the reservoir was explored on foot to assess habitat, listen for calling frogs and opportunistically search for reptiles and frogs. As well as the main reservoir itself, the ephemeral gully lines were inspected to provide a complete overview of the site and the habitats available. Calling frogs were recorded opportunistically during the waterbird site visit on 8 July and during the site assessment on 29 July.

Records of herpetofauna within the immediate region surrounding BNCR were acquired from desktop searches of NatureKit Victoria (which displays records from the VBA), the Atlas of Living Australia (ALA), and a previous assessment by Mueck et al. (2002). The VBA and ALA search included 1 km and 5 km search radiuses to provide a list of species known to the immediate area of the BNCR and identify local species that may occupy the site. Regional species record searches in the ALA along with relevant literature reviews informed what additional species may occur at BNCR. Nomenclature follows Cogger (2018).

2.2.4 Fish, crayfish and mussels

Existing data on the distribution of aquatic vertebrates and selected invertebrates was obtained from the VBA, a fish survey of Beaconsfield Reservoir conducted by Mueck et al. (2002), a survey of Cardinia, Gum Scrub, Toomuc and Deep creeks by Close et al. (2001), and an overview of burrowing crayfish and spiny crayfish distributions produced by Horwitz (1990) and McCormack (2012) respectively. The reservoir is situated at the headwaters of Haunted Gully Creek which ultimately joins Gum Scrub Creek before flowing out into Western Port. Gum Scrub Creek likely experiences temporary surface water connectivity with Cardinia, Toomuc and Deep creeks as they run immediately parallel to each other in the lower catchment where they have been channelised for the purposes of flood mitigation. As such, we included those catchments in our literature search as they likely share fish communities, and it is possible that some of these species are in Beaconsfield Reservoir but haven't been detected.

Results

2.3 Flora

Database searches revealed 993 plant taxa that have been previously recorded within 5 km of the BNCR. This comprises 655 native taxa and 338 weed taxa. Of these 38 are listed as threatened and seven state listed taxa are regarded as being present within BNCR (Table 2).

The vegetation within the littoral zone comprises two wetland Ecological Vegetation Classes (EVCs); Aquatic Herbland and Aquatic Sedgeland. All fringing vegetation is regarded as having developed since the reservoir was constructed. The northeast arm of the reservoir was likely occupied by Swampy Riparian Woodland prior to construction but the flood zone has possibly since widened due to impeded draining around the inflow point. This area is mapped as Riparian Scrub for the purpose of the assessment, on the basis that the canopy is dominated by myrtaceous shrubs rather than eucalypts. This littoral zone nearest the northeast arm has the greatest extent of shallow water and is contiguous with riparian areas upstream that would be subject to periodic flooding. Around much of the remaining perimeter, the bank of the reservoir is steeper and there is a shorter gradient between wetland vegetation and various communities of dry foothill forest. The relevant EVCs are described below including their landscape context.

Modelled EVC mapping by DELWP (Figure 2igure 2, Figure 3) indicates that most of BNCR is occupied by Lowland Forest. A patch of Damp Heathy Woodland is modelled to occur on the western side of the reservoir and Grassy Forest is modelled on parts of the eastern and northern side. Riparian Scrub/Swampy Riparian Woodland Complex is modelled around much of the edge of the reservoir. The site assessment revealed that the composition of EVCs is generally consistent with modelling while the distributions of each EVC varies from that of the modelling. Swampy vegetation which would fall within the abovementioned complex could be placed in either Riparian Scrub or Swampy Riparian Woodland depending on interpretation. The observed structure and composition fit the benchmark of Riparian Scrub for the purpose of habitat interpretation and planning. Emergent eucalypts occur within this area. Grassy Forest examples within the reserve generally fit the benchmark description for the bioregion, while noting that drier aspects and ridges have a more drought-tolerant component of the understory vegetation compared with other examples in the bioregion.

2.3.1 Aquatic Herbland

Aquatic Herbland occurs in very narrow zones on the edge of some parts of the reservoir. Only larger patches have been mapped during this assessment. In the northeastern arm, this EVC extends to cover a broader zone where there is a larger area of shallow water. The shallow water is accessed by deer and associated soil disturbance was observed. The most developed example of Aquatic Herbland comprises a moderate–high cover of aquatic herbs amongst less dominant tussocks of sedges and rushes. Characteristic species include Swamp Club-sedge (*Isolepis inundata*), Small River Buttercup (*Ranunculus amphitrichus*), Lesser Joyweed (*Alternanthera denticulata* s.s.), Centella (*Centella cordifolia*), Swamp Crassula (*Crassula helmsii*), Common Spike-sedge (*Eleocharis acuta*), Austral Brooklime (*Gratiola peruviana*), Common Bog-sedge (*Schoenus apogon*), Australian Lilaeopsis (*Lilaeopsis polyantha*), Small Loosestrife (*Lythrum hyssopifolia*), Upright Water-milfoil (*Myriophyllum crispatum*), Streaked Arrowgrass (*Triglochin striata*), Wing Pennywort (*Hydrocotyle pterocarpa*), Weeping Grass (*Microlaena stipoides* var. *stipoides*), Joint-leaf Rush (*Juncus holoschoenus*), Finger Rush (*Juncus subsecundus*), Broad-leaf Rush (*Juncus planifolius*), with less common elements Tall Sedge (*Carex appressa*), Common Water-ribbons (*Cycnogeton procerum* s.s.), Hollow Rush (*Juncus amabilis*), Green Rush (*Juncus gregiflorus*) and Knotweed (*Persicaria* spp.). The FFG Act listed species Floodplain Fireweed (*Senecio campylocarpus*) was recorded within this EVC during the current assessment. Typical weeds include Drain Flat-sedge (**Cyperus eragrostis*), Common Feather-moss (**Eurhynchium praelongum*), Jointed Rush (**Juncus articulatus* subsp. *Articulates*) and Self-heal (**Prunella vulgaris*).

Bioregional conservation status – This EVC is not listed for the Highlands - Southern Fall bioregion but is certainly threatened given its rarity in the bioregion. DSE (2012) notes that this EVC is widespread but rare in mountains and the north-west. It is listed as endangered in six out of seven of its occupied bioregions.

2.3.2 Aquatic Sedgeland

This EVC occupies deeper water near the edge of the reservoir banks (Figure 3). There is often open shallow water between Aquatic Sedgeland and the bank, which may comprise Aquatic Herbland or a mix of ubiquitous native and weed species that are suited to regularly wet or shallow inundated clay soil. The dominant sedge is Tall Spike-sedge (*Eleocharis sphacelata*) and few other species occupy examples of this EVC at BNCR.

Bioregional conservation status – this EVC is not listed for the Highlands - Southern Fall bioregion. It is moderately common in wetlands and larger dams.

2.3.3 Riparian Scrub

Riparian Scrub at BNCR may be derived from other vegetation types or expanded since changes to hydrology following the dam construction. The rare occurrence of Swamp Gum (*Eucalyptus ovata*) on the margins of the scrub area indicates that Swampy Riparian Woodland may have once occupied the gully. Mature eucalypts are virtually absent from the mapped area (Figure 3). The EVC is otherwise dominated by medium to tall shrubs including Woolly Tea-tree (*Leptospermum lanigerum*), Manuka (*Leptospermum scoparium*), Swamp Paperbark (*Melaleuca ericifolia*), Scented Paperbark (*Melaleuca squarrosa*), Common Cassinia (*Cassinia aculeata* subsp. *aculeata*), Prickly Currant-bush (*Coprosma quadrifida*), Silver Wattle (*Acacia dealbata*), Snowy Daisy-bush (*Olearia lirata*) and Hazel Pomaderris (*Pomaderris aspera*). Patches with lower canopy cover are dominated by ferns and large graminoids including Soft Water-fern (*Blechnum minus*), Fishbone Water-fern (*Blechnum nudum*), Rough Tree-fern (*Cyathea australis*), Ground Fern (*Hypolepis* sp.), Austral King-fern (*Todea barbara*), Variable Sword-sedge (*Lepidosperma laterale* var. *majus*), Pale Rush (*Juncus pallidus*), Tall Rush (*Juncus procerus*), Sword Tussock-grass (*Poa ensiformis*) and Spiny-headed Mat-rush (*Lomandra longifolia* subsp. *longifolia*). Several forb species also occupy this EVC. Weeping Grass (*Microleana stipoides*) and bryophytes are dominant on the ground in many areas including Golden Weft-moss (*Thuidiopsis furfurosa*). Weed cover is generally low and includes Neat Feather-moss (**Pseudoscleropodium purum*), Common Blackberry (**Rubus anglocandicans*) and Ragwort (**Senecio jacobaea*).

Bioregional conservation status – Vulnerable.

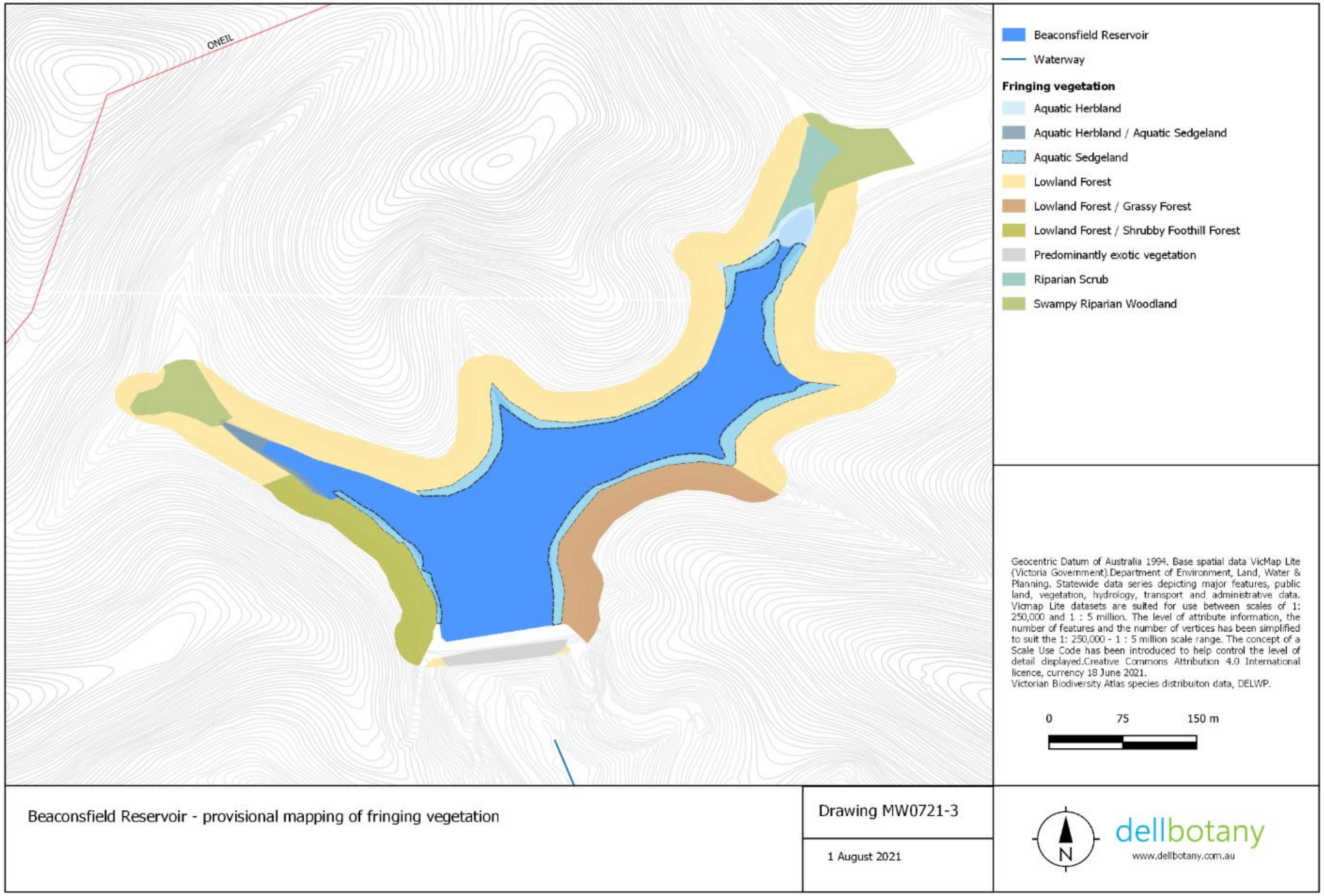

Figure 3. Ecological Vegetation Classes around Beaconsfield Reservoir.

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2.3.4 Lowland Forest

Lowland Forest is the most widespread EVC which adjoins fringing vegetation around the reservoir. Its canopy is dominated by Messmate Stringybark (*Eucalyptus obliqua*), Narrow-leaf Peppermint (*Eucalyptus radiata* subsp. *radiata*) with other species variably including Mealy Stringybark (*Eucalyptus cephalocarpa* s.s.), Broad-leaf Peppermint (*Eucalyptus dives*), Green Scentbark (*Eucalyptus fulgens*) (FFG Act endangered), Bundy (*Eucalyptus goniocalyx* s.s.), with rare occurrences of Swamp Gum (*Eucalyptus ovata*). Understorey vegetation is open and shrubby including Narrow-leaf Wattle (*Acacia mucronata* subsp. *longifolia*), Prickly Moses (*Acacia verticillata* subsp. *verticillata*), Black Wattle (*Acacia mearnsii*), Silver Banksia (*Banksia marginata*), Common Heath (*Epacris impressa*), Yarra Burgan (*Kunzea leptospermoides*), Dusty Miller (*Spyridium parvifolium*), Golden Bush-pea (*Pultenaea gunnii*), Holly Lomatia (*Lomatia ilicifolia*), Trailing Ground-berry (*Acrotriche prostrata*), Forest Wire-grass (*Tetrarrhena juncea*), Thatch Saw-sedge (*Gahnia radula*), Small Grass-tree (*Xanthorrhoea minor* subsp. *lutea*), Common Tussock-grass (*Poa labillardierei*) and a suite of forb species. Weeds have low average cover and include Early Black-wattle (**Acacia decurrens*), Spanish Heath (**Erica lusitanica*), Sweet Pittosporum (**Pittosporum undulatum*), Gorse (**Ulex europaeus*) and Neat Feather-moss.

Bioregional conservation status – Least concern.

2.3.5 Grassy Forest

This EVC generally occupies west- or north-facing slopes and some ridgelines. It has a lower canopy height compared with Lowland Forest and a higher abundance of Bundy (*Eucalyptus goniocalyx* s.s.) and Broad-leaf Peppermint (*Eucalyptus dives*). The understorey vegetation is conspicuously grassy with Silvertop Wallaby-grass (*Rytidosperma pallidum*), Kangaroo Grass (*Themeda triandra*), spear grasses (*Austrostipa* spp.) and other grasses. It is otherwise moderately rich in forbs and small shrubs.

Bioregional conservation status – Vulnerable.

2.3.6 Other EVCs

Areas modelled as Damp Heathy Woodland have characteristics of that EVC yet their landscape context and plant composition also fit Lowland Forest. Mueck et al. (2002) did not consider Damp Heathy Woodland to occupy BNCR. The vegetation in question is likely too far from the reservoir bank to be considered for a more detailed impact assessment. Some areas of forest on the south-eastern side of the reservoir have a very high shrub cover and notably different composition compared with other foothill forests observed. It includes high cover-abundances of Dusty Miller, Rusty Bush-pea (*Pultenaea hispidula*) and other shrubs, while Black Sheoak (*Allocasuarina littoralis*) appears more abundant than elsewhere. There are affinities with this vegetation and Lowland Forest, but it is distinct enough that it may represent Shrubby Foothill Forest, which occurs nearby to the north at Cardinia Reservoir. The area has also been recently burnt and the high cover of some shrub species may be product of this. This shrubby community is noted here mainly for the different habitat types it provides, with consideration to a more detailed assessment of threatened species. Damp Heathy Woodland has a bioregional conservation status of Depleted and Shrubby Foothill Forest as a bioregional conservation status of Least Concern.

2.3.7 Threatened plants

Threatened plants recorded within 2 km of the reservoir body (Table 2) comprise seven state listed taxa (all endangered under the *Flora and Fauna Guarantee Act 1988*). These taxa should be considered present within BNCR for planning purposes. No EBPC Act listed plant taxa have been previously recorded within this 2 km zone. Thirty-one additional threatened taxa have been recorded or, for some EPBC taxa, are predicted to occur within a radius up to 5 km from the reservoir body. These include three EPBC Act listed taxa; Maroon Leek-orchid (*Prasophyllum frenchii*), Matted Flax-lily (*Dianella amoena*) and Clover Glycine (*Glycine latrobeana*). One EPBC Act listed taxon and six FFG Act listed taxa previously recorded from within 5 km of the reservoir have been determined as having medium or high likelihood of occurrence within habitat types found at BNCR. These are briefly discussed:

Wine-lipped Spider-orchid (*Caladenia oenochila*). This orchid has six records from the search, between 1939–2003 (DELWP 2021a). It typically occupies moist grassy foothill forests around central Victoria (VicFlora 2021). There are extensive areas of suitable habitat within BNCR, including some forest areas on lower slopes near the edge of the reservoir.

Forest Sedge (*Carex alsophila*). This sedge has one 1980 record near Officer (DELWP 2021a). It is an over-looked species which typically occupies mountain gullies, including around Gembrook, and can be locally common (VicFlora 2021). Areas of Riparian Scrub or Swampy Riparian Woodland provide suitable habitat for this species.

Austral Crane's-bill (*Geranium solanderi* var. *solanderi* s.s.). This taxon has one 2004 record to the east of Officer. Its habitat requirements are unclear due to taxonomic uncertainty involving several other related *Geranium* species. It appears to typically occupy damp areas of grassy woodland, along drainage lines or seepage areas (VicFlora 2021). This species may occupy drainage lines surrounding Beaconsfield Reservoir.

Rough Daisy-bush (*Olearia asterotricha*). This shrub has one 1980 record from Beaconsfield Upper (DELWP 2021a). This record would likely represent (*Olearia asterotricha* subsp. *lobata*) which typically occupies moist forest and swampy heathland (VicFlora 2021). Areas of Riparian Scrub at BNCR provide somewhat suitable habitat.

Long Pink-bells (*Tetratheca stenocarpa*). This shrub has one 1935 record from near Beaconsfield, however its largest population and most of its total area of occupancy occurs in forests between Emerald, Powelltown and Tarago Reservoir. It typically occupies open forests and tall mountain forests (VicFlora 2021), and there are areas of suitable habitat within BNCR. If present it is likely associated with slopes of surrounding forest rather than riparian areas.

There are a small number of other EPBC Act listed plant taxa that should be considered further, but do not appear in database searches. Round-leaf Pomaderris (*Pomaderris vacciniifolia*) is a critically endangered shrub which occupies moist forests and scrubs between Healesville, Marysville and Whittlesea, and across to Tyers-Walhalla area (VicFlora 2021). It is often associated with riparian vegetation (Patykowski et al. 2014). It has recently been re-discovered in areas of historical records between West Gippsland and Central Highlands, including Rokeby Flora and Fauna Reserve and Bunyip River Crossing Reserve. Smaller individuals can be somewhat inconspicuous in forests, and it is vulnerable to deer browsing. It is plausible that this species may occupy BNCR due to the considerable areas of suitable habitat. The orchid Green-striped Greenhood (*Pterostylis chlorogramma*) (vulnerable) typically occurs in moist areas of heathy and shrubby forest, on well drained soils (VicFlora 2021). There is ample habitat for this species at BNCR. Another orchid of similar general appearance, Tall Greenhood (*Pterostylis melagramma)*, was observed during the current site assessment. There is need to consider that if Green-striped Greenhood is present at BNCR then it may have been misidentified as Tall Greenhood. Database records of greenhoods in this group are strongly confounded by the misapplication and names and concepts. The nearest vouchered and recent records are from the southern end of Bunyip State Park (DELWP 2021a). Given the potential for Green-striped Greenhood to grow in forest near the edge of the reservoir, a targeted survey should be undertaken during its flowering period and prior to commencing work.

Mueck et al. (2003) note that habitat for two other EPBC Act listed plant taxa—River Swamp Wallaby-grass (*Amphibromus fluitans*) and Swamp Everlasting (*Xerochrysum palustre*)—occurs within BNCR and that these species might occur. River Swamp Wallaby-grass is associated with permanent swamps (VicFlora 2021) and can occupy farm dams, shallow wetlands, rivers and other waterbodies. It is recorded from a number of isolated wetlands where it may be dispersed by waterbirds, or in flood water. There is a low likelihood that it occupies such habitats in BNCR. It is generally associated with lowland areas and largely absent from the Central Highlands. The nearest records are from Lysterfield Lake area where last recorded in 1994 (DELWP 2021a). While there is some likelihood that it may occur on the fringes of Beaconsfield Reservoir, it has been determined as low predominantly due to lack of records in the bioregion. Swamp Everlasting is similarly absent from the Central Highlands (DELWP 2021a); it is unlikely to occur at BNCR due to a lack of suitable habitat and supporting records.

Table 2. Threatened plant taxa recorded within 5 km of the waterbody of Beaconsfield Reservoir.

Hydrological group: **1** – occupies riparian areas, swamps or other areas where there is permanent or periodic inundation (seasonal or other) e.g. flood zones, dam edges and similar. **2** – terrestrial areas which are subject to rainwater runoff or drainage, but without accumulating surface water. FFG and EPBC statuses – Cr – Critically endangered, En – Endangered, Vu – Vulnerable. Source VBA – Victorian Biodiversity Atlas, PMST – EPBC Protected Matters Search Tool. *Modelled likelihood of occurrence from the PMST applies to *Pterostylis cucullata*. The two subspecies in Victoria occupy quite different habitats (one coastal and the other in mountains) and as such modelling used to generate the PMST has uncertainty in this regard and given low weight in consideration of factors contributing to the likelihood assessment. **Some taxa are awaiting assessment and listing under the FFG Act due to the transitional provisions of the Act.

Common Name	Scientific Name	Year of last record	Occupancy likelihood	Search radius	Source	Hydrological group	EPBC Act status	FFG Act status
Dandenong Wattle	*Acacia stictophylla*	2006	Present	2 km	VBA	2		En
Wiry Bossiaea	*Bossiaea cordigera*	2011	Present	2 km	VBA	1,2		En
Powelltown Correa	*Correa reflexa* var. *lobata*	2006	Present	2 km	VBA	2		En
Green Scentbark	*Eucalyptus fulgens*	2006	Present	2 km	VBA	2		En
Red-tip Greenhood	*Pterostylis clivosa*	2011	Present	2 km	VBA	2		En
Cobra Greenhood	*Pterostylis grandiflora*	2006	Present	2 km	VBA	2		En
Floodplain Fireweed	*Senecio campylocarpus*	2021	Present	2 km	VBA	1		En
Round-leaf Pomaderris	*Pomaderris vacciniifolia*	-	Medium	5 km	PMST	2	Cr	Cr
Maroon Leek-orchid	*Prasophyllum frenchii*	2019	Low	5 km	VBA,PMST	1,2	En	En
Matted Flax-lily	*Dianella amoena*	2019	Low	5 km	VBA,PMST	2	En	Cr
Eastern Spider-orchid	*Caladenia orientalis*	-	Low	5 km	PMST	2	En	En
Basalt Peppercress	*Lepidium hyssopifolium*	-	Low	5 km	PMST	2	En	En

Clover Glycine	*Glycine latrobeana*	2003	Low	5 km	VBA,PMST	2	Vu	Vu
Strzelecki Gum	*Eucalyptus strzeleckii*	-	Low	5 km	PMST	2	Vu	Cr
Dense Leek-orchid	*Prasophyllum spicatum*	-	Low	5 km	PMST	2	Vu	Cr
Green-striped Greenhood	*Pterostylis chlorogramma*	-	Medium	5 km	PMST	2	Vu	En
Leafy Greenhood	*Pterostylis cucullata*	-	Low	5 km	PMST	2	Vu	En*
Swamp Fireweed	*Senecio psilocarpus*	-	Low	5 km	PMST	1	Vu	Not assessed**
White Star-bush	*Asterolasia asteriscophora* subsp. *albiflora*	1933	Low	5 km	VBA	2		Cr
Angahook Pink-fingers	*Caladenia maritima*	2000	Low	5 km	VBA	2		Cr
Wine-lipped Spider-orchid	*Caladenia oenochila*	2003	Medium	5 km	VBA	2		Cr
Winter Sun-orchid	*Thelymitra hiemalis*	2012	Low	5 km	VBA	2		Cr
Veined Spear-grass	*Austrostipa rudis subsp. australis*	2003	High	5 km	VBA	2		En
Lizard Orchid	*Burnettia cuneata*	1900	Low	5 km	VBA	1		En
Forest Sedge	*Carex alsophila*	1980	Medium	5 km	VBA	1		En
Powelltown Correa	*Correa reflexa* var. *lobata*	2014	High	5 km	VBA	2		En
Spurred Helmet-orchid	*Corybas aconitiflorus*	2008	Low	5 km	VBA	2		En
Purple Diuris	*Diuris punctata* var. *punctata*	1986	Low	5 km	VBA	2		En

Austral Crane's-bill	*Geranium solanderi* var. *solanderi* s.s.	2004	Medium	5 km	VBA	2	En
Tufted Club-sedge	*Isolepis wakefieldiana*	2004	High	5 km	VBA	1	En
Rough Daisy-bush	*Olearia asterotricha*	1980	Medium	5 km	VBA	1,2	En
Inland Red-tip Greenhood	*Pterostylis rubescens*	2003	Low	5 km	VBA	2	En
Mentone Greenhood	*Pterostylis* X *toveyana*	1900	Low	5 km	VBA	2	En
Spreading Knawel	*Scleranthus fasciculatus*	1999	Low	5 km	VBA	2	En
Long Pink-bells	*Tetratheca stenocarpa*	1935	Medium	5 km	VBA	2	En
Crested Sun-orchid	*Thelymitra* X *irregularis*	1900	Low	5 km	VBA	2	En
Slender Pink-fingers	*Caladenia vulgaris*	2004	Low	5 km	VBA	2	Vu
Sharp Greenhood	*Pterostylis* X *ingens*	1900	Low	5 km	VBA	2	Vu

2.4 Waterbirds

Waterbird habitat at the BNCR comprised small areas of exposed mud and shallow water (<30 cm deep) mainly along the western gully line of the reservoir, with waters close to the reservoir bank observed to be around 30 cm deep then dropping away. A band of Tall Spike-sedge extended around most of the perimeter (Figure 4), beyond which there was an extensive area of deep open water. Submerged aquatic vegetation was also present within the shallower waters.

Figure 4. An example of thick Tall Spike-sedge at the perimeter of Beaconsfield Reservoir

Four waterbird species were seen during the two separate site visits in 2021: one individual Little Pied Cormorant (*Microcarbo melanoleucos*) and two Australian Shelduck (*Tadorna tadornoides*) observed flying at a low height above the reservoir, an individual White-faced Heron (*Ardea pacifica*) amongst reeds close to the shore and three Hoary-headed Grebes (*Poliocephalus poliocephalus*) in the open water.

A total of 17 waterbird species have been recorded from the immediate study area (DELWP 2021a, Mueck 2002) and 65 from the wider search area (DELWP 2021a, Table 3). Seventeen of the overall number of species are listed under the Flora and Fauna Guarantee Act 1988 (DELWP 2021b), with one of these species also recorded from the study area itself (Eastern Great Egret *Ardea alba modesta*). A number of species, including several of those listed as threatened, had been recorded only a few times, many years ago (Table 3). Apart from the Eastern Great Egret, all other species recorded from the study site are relatively common.

Table 3. Waterbird species recorded from Beaconsfield Reservoir and up to 13 km within the surrounding area.

Species observed during the site visit in 2021 are marked with an ^

Common Name	Scientific Name	Recorded within study site	Number of records	Most recent record	EPBC Act Status	FFG Act Status
Lewin's Rail	*Lewinia pectoralis*		7	2019		
Buff-banded Rail	*Hypotaenidia philippensis*		19	2018		
Australian Spotted Crake	*Porzana fluminea*		20	2018		
Baillon's Crake	*Porzana pusilla*		31	2019		
Spotless Crake	*Porzana tabuensis*		24	2019		
Black-tailed Native-hen	*Tribonyx ventralis*		3	2009		
Dusky Moorhen	*Gallinula tenebrosa*	X	416	2021		
Australasian Swamphen	*Porphyrio melanotus*	X	427	2019		
Eurasian Coot	*Fulica atra*	X	401	2021		
Great Crested Grebe	*Podiceps cristatus*		28	2010		
Australasian Grebe	*Tachybaptus novaehollandiae*	X	275	2019		
Hoary-headed Grebe	*Poliocephalus poliocephalus*	X^	174	2021		
Great Cormorant	*Phalacrocorax carbo*	X	120	2019		
Little Black Cormorant	*Phalacrocorax sulcirostris*	X	193	2019		
Pied Cormorant	*Phalacrocorax varius*		28	2019		
Little Pied Cormorant	*Microcarbo melanoleucos*	X^	377	2021		
Australasian Darter	*Anhinga novaehollandiae*	X	149	2019		
Australian Pelican	*Pelecanus conspicillatus*		153	2020		
Whiskered Tern	*Chlidonias hybrida*		5	2018		
Australian Gull-billed Tern	*Gelochelidon macrotarsa*		1	2017		
Caspian Tern	*Hydroprogne caspia*		8	2018		Vu
Crested Tern	*Thalasseus bergii*		1	1975		
Silver Gull	*Chroicocephalus novaehollandiae*		243	2019		
Red-kneed Dotterel	*Erythrogonys cinctus*		23	2018		
Masked Lapwing	*Vanellus miles*	X	435	2019		
Banded Lapwing	*Vanellus tricolor*		1	1987		
Double-banded Plover	*Charadrius bicinctus*		2	2010		

Black-fronted Dotterel	*Elseyornis melanops*		122	2018		
Red-necked Avocet	*Recurvirostra novaehollandiae*		1	1972		
Common Sandpiper	*Actitis hypoleucos*		2	1998		Vu
Marsh Sandpiper	*Tringa stagnatilis*		1	2004		En
Red-necked Stint	*Calidris ruficollis*		1	2005		
Sharp-tailed Sandpiper	*Calidris acuminata*		13	2018		
Latham's Snipe	*Gallinago hardwickii*		141	2019		
Glossy Ibis	*Plegadis falcinellus*		2	2017		
Australian White Ibis	*Threskiornis molucca*		400	2019		
Straw-necked Ibis	*Threskiornis spinicollis*		318	2020		
Royal Spoonbill	*Platalea regia*		108	2019		
Yellow-billed Spoonbill	*Platalea flavipes*		42	2019		
Little Egret	*Egretta garzetta*		14	2019		
Plumed Egret	*Ardea intermedia plumifera*		3	2019		
Eastern Great Egret	*Ardea alba modesta*	X	163	2019		Vu
White-faced Heron	*Egretta novaehollandiae*	X^	468	2019		
White-necked Heron	*Ardea pacifica*		66	2021		
Nankeen Night-Heron	*Nycticorax caledonicus*	X	40	2019		
Australian Little Bittern	*Ixobrychus dubius*		6	2006		En
Australasian Bittern	*Botaurus poiciloptilus*		17	2018	En	CE
Cape Barren Goose	*Cereopsis novaehollandiae*		2	2006		
Magpie Goose	*Anseranas semipalmata*		1	1987		
Australian Wood Duck	*Chenonetta jubata*	X	501	2020		
Black Swan	*Cygnus atratus*	X^	263	2020		
Australian Shelduck	*Tadorna tadornoides*	X	33	2021		
Pacific Black Duck	*Anas superciliosa*	X	751	2021		
Chestnut Teal	*Anas castanea*		272	2019		
Grey Teal	*Anas gracilis*		181	2019		
Australasian Shoveler	*Spatula rhynchotis*		80	2019		Vu
Pink-eared Duck	*Malacorhynchus membranaceus*		26	2019		
Freckled Duck	*Stictonetta naevosa*		4	2019		En
Hardhead	*Aythya australis*		217	2019		Vu
Blue-billed Duck	*Oxyura australis*		133	2019		Vu

Musk Duck	*Biziura lobata*	91	2019	Vu
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	14	2017	En
Mallard	*Anas platyrhynchos*	20	2019	
Eastern Cattle Egret	*Bubulcus coromandus*	36	2019	
Pectoral Sandpiper	*Calidris melanotos*	1	1998	

2.5 Herpetofauna

2.5.1 Frogs

Withing the BNCR, the reservoir contains near-continuous fringing vegetation that provides suitable habitat for frogs and includes sedges, floating and submerged vegetation. The eastern arm of the reservoir also contains Aquatic Herbland and Riparian Scrub/Swampy Riparian Woodland. Shallow depressions and low-lying flood areas were located along the main gully line entering the eastern side of the reservoir, as well as a drainage line running alongside the eastern arm of the reservoir (Figure 5). These areas provide suitable breeding habitat for the Southern Toadlet (*Pseudophryne semimarmorata*). There was damage observed on the wetland fringes caused by deer in multiple locations, including pugging and wallows (Figure 6). During the two site visits only one frog species was heard calling, the Common Froglet (*Crinia signifera*), with large numbers heard near the dam wall on the western side and along the eastern arm of the reservoir.

The VBA and the ALA yielded records of seven frog species within the immediate study area (1 km) and an additional two species within 5 km (Table 4). Of the nine species, seven are common, having broad distributions throughout south-eastern Australia (Anstis 2013). The Growling Grass Frog (*Litoria raniformis*) is listed as Vulnerable nationally (EPBC Act 1999) and Threatened in Victoria under the *Flora and Fauna Guarantee Act* 1988 (DELWP 2021b). The Growling Grass Frog has been recorded at wetlands at Officer, located just within the 5 km radius from Beaconsfield NCR. The Southern Toadlet is listed as Endangered under the *Flora and Fauna Guarantee Act* 1988 (DELWP 2021b) and was last recorded at Beaconsfield in 1981 (Table 4). The majority of frog species have been recorded in the area during the last ten years. Additional anuran species that may occur in the area include Peron's Tree Frog (*Litoria peronii*) and Haswell's Frog (*Paracrinia haswelli*). Peron's Tree Frog is widespread throughout coastal and inland areas of Queensland, New South Wales and Victoria, and Haswell's Frog occurs along the New South Wales and eastern Victorian coastal areas and adjacent plateaux's (Anstis 2013). Neither species is listed as threatened within Victoria.

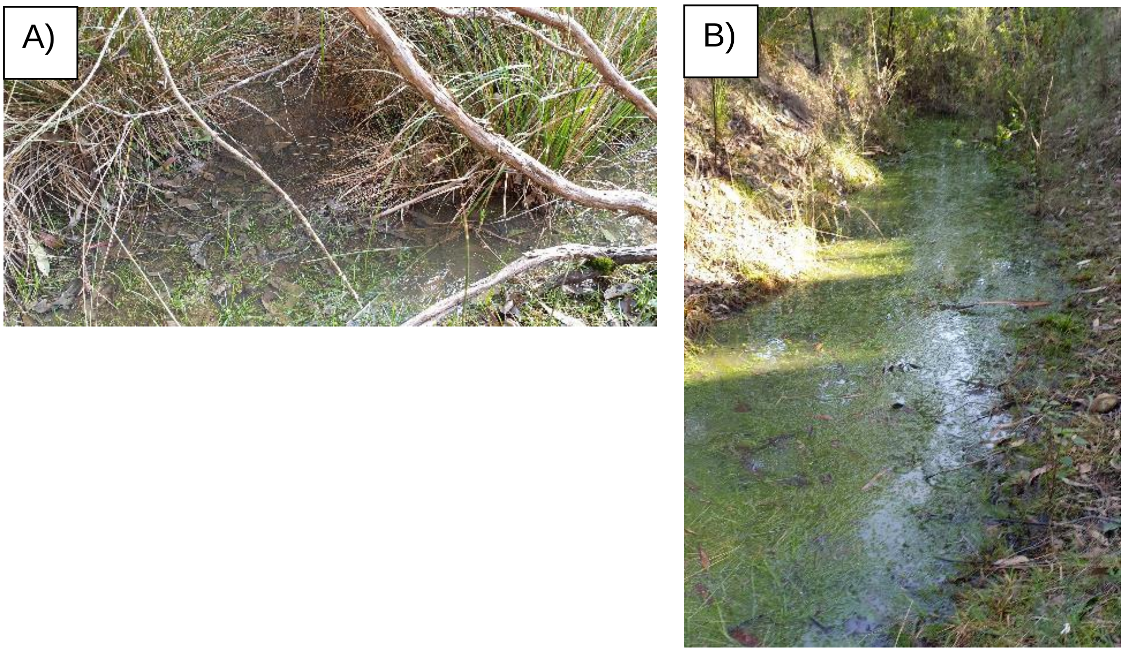

Figure 5. Shallow, inundated depression on the eastern gully line (A) and a shallowly, inundated drainage line located alongside the eastern side of the reservoir (B).

Figure 6. Damage to wetland fringes and habitat caused by deer wallowing and pugging.

2.5.2 Reptiles

Beaconsfield NCR provides a range of habitats that are suitable for reptiles, including Aquatic Herbland, Aquatic Sedgeland, Riparian Scrub, Lowland Forest and Grassy Forest.

The Victorian Biodiversity Atlas (VBA, DELWP) yielded 16 species of terrestrial reptiles and one aquatic species within a 5 km radius of the BNCR, comprising 10 skink species, two dragon species, one goanna species and four species of elapid snakes (Table 4). With the exception of the Swamp Skink (*Lissolepis coventryi*), all are typical of lowland forest (sensu lato) or riparian environments that cover the southern slopes of the GDR in southern Victoria and all have broad distributions throughout temperate south-eastern Australia (Cogger 2019, Robertson and Coventry 2019).

The aquatic Eastern Long-necked Turtle (*Chelodina longicollis*) has been recorded within 5 km of the BNCR. This species was not trapped during aquatic surveys in 2002 (Mueck 2002), although, these surveys were conducted in August when this species is relatively inactive (Chessman 1988). Given its propensity for overland migration (Chessman 1984) and movement between multiple wetlands within its home range (Roe and Georges 2007), this species may be found at Beaconsfield.

Other reptile species that may occur in the area yet are not listed in VBA records include Black Rock Skink (*Egernia saxatilis intermedia*), Red-bellied Black Snake (*Pseudechis porphyriacus*) and possibly Mountain Dragon (*Rankinia diemensis*). These species are similarly common and widespread in south-eastern Australia and have been recorded from the area around Cardinia Reservoir, approximately 6 km north of the BNCR.

Table 4. Reptile and frog species recorded within a 5 km radius of Beaconsfield Reservoir (Atlas of Living Australia) and in the immediate are (1 km).

Common name	Scientific name	Within 1 km	No. of records	Most recent record	EPBC Act Status	FFG Act Status
Reptiles						
Blotched Blue-tongued Lizard	*Tiliqua nigrolutea*		5	2014		
Eastern Blue-tongued Lizard	*Tiliqua scincoides*		2	2020		
Dark-flecked Garden Sunskink	*Lampropholis delicata*		8	2018		
Pale-flecked Garden Sunskink	*Lampropholis guichenoti*	X	18	2014		
Swamp Skink	*Lissolepis coventryi*		1	2017		En
Eastern Three-lined Skink	*Acritoscincus deperreyi*		2	1964		
Highlands Forest Skink	*Anepischetosia maccoyi*		3	1967		
Metallic Cool-skink	*Carinascincus metallicus*		2	1977		
Weasel Skink	*Saproscincus mustelinus*		8	2002		
Southern Water Skink	*Eulamprus tympanum*		3	1988		
Jacky Lizard	*Amphibolurus muricatus*		3	1988		
Lace Monitor	*Varanus varius*		1	2018		
Tiger Snake	*Notechis scutatus*		1	1988		
Eastern Small-eyed Snake	*Cryptophis nigrescens*	X	4	1988		
White-lipped Snake	*Drysdalia coronoides*		5	2008		
Lowland Copperhead	*Austrelaps superbus*		4	2014		
Eastern Long-necked Turtle	*Chelodina longicollis*		3	2010		
Amphibians						
Southern Brown Tree Frog	*Litoria ewingii*	X	132	2020		
Growling Grass Frog	*Litoria raniformis*		9	2011	Vul	Vul
Striped Marsh Frog	*Limnodynastes peronii*		44	2019		
Spotted Marsh Frog	*Limnodynastes tasmaniensis*	X	20	2018		
Eastern Banjo Frog	*Limnodynastes dumerilii*	X	15	2019		

Common Froglet	*Crinia signifera*	X	67	2021	
Victorian Smooth Froglet	*Geocrinia victoriana*	X	14	2013	
Southern Toadlet	*Pseudophryne semimarmorata*	X	21	1981	En
Verreaux's Tree Frog	*Litoria verreauxii verreauxii*	X	37	2016	

2.6 Fish, crayfish and mussels

Mueck et al. (2002) conducted the only known survey of Beaconsfield Reservoir. Over two days they conducted a range of survey techniques including fyke and gill netting, light trapping, electrofishing, and angling. As such the species list is considered reasonably comprehensive. They found seven fish species in total. These included the native Short-finned Eel (*Anguilla australis*), Spotted Galaxias (*Galaxias truttaceus*) and Southern Pygmy Perch (*Nannoperca australis*), and the exotic Eastern Gambusia (*Gambusia holbrooki*) and Goldfish (*Carassius auratus*).

The native Common Yabby (*Cherax destructor*) and Balonne Freshwater mussel (*Velesunio ambiguus*) was also observed. Shrimp (*Paratya* sp.) were common. Further to this, the authors observed active burrows belonging to burrowing crayfish during a site visit in July 2021, that could belong to the Foothill Burrowing Crayfish (*Engaeus victoriensis*), Lowland Burrowing Crayfish (*Engaeus quadrimanus*), or Granular Burrowing Crayfish (*Engaeus cunicularius*) that occur in the area.

In the surrounding catchments, native fish including Long-finned Eel (*Anguilla reinhardtii*), River Blackfish (*Gadopsis marmaratus*), Climbing Galaxias (*Galaxias brevipinnis*), Common galaxias (*Galaxias maculatus*), Dwarf galaxias (*Galaxiella pusilla*) have been observed. Also, exotic fish including Rainbow trout (*Oncorhychus mykiss*), Roach (*Rutilis rutilis*), and Brown Trout (*Salmo trutta*). Regarding crayfish, Granular Burrowing Crayfish (*Engaeus cunicularius*), Lowland Burrowing Crayfish (*Engaeus quadrimanus*), Foothill Burrowing Crayfish (*Engaeus victoriensis*), Gippsland Spiny Crayfish (*Euastacus kershawi*), Woiwuru Spiny Crayfish (*Euastacus woiwuru*), and Yarra Spiny Crayfish (*Euastacus yarraensis*). Of these the Dwarf Galaxias (*Galaxiella pusilla*) is listed as 'Endangered' under Flora and Fauna Grantee Act (FFG Act) and 'Vulnerable' under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

While efforts were made to stock Brown Trout (*Salmo trutta*) in the reservoir in 1921 and 1923 (Barnham 2000), they do not appear to have established a self-sustaining population.

Table 5. Fish, crayfish and mussel species recorded from Beaconsfield Reservoir and the broader Cardinia Creek and Deep Creek catchments.

Migratory species that cannot form landlocked populations are not included as they would not be able to access the isolated reservoir. Species recorded within Beaconsfield Reservoir are marked with an 'X'. Burrowing crayfish are present within the study site, but the exact species is unknown, so they are marked with a question mark (?). Exotic species are indicated by an asterisk (*). Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) list of threatened fauna and Flora and Fauna Guarantee Act 1988 - Threatened List.

Common Name	Scientific Name	Recorded within study site	EPBC Act Status	FFG Act Status
Fish				
Short-finned Eel	*Anguilla australis*	X		
Long-finned Eel	*Anguilla reinhardtii*			
Goldfish*	*Carassius auratus*	X		
River Blackfish	*Gadopsis marmaratus*			
Climbing Galaxias	*Galaxias brevipinnis*			
Common Galaxias	*Galaxias maculatus*			
Spotted Galaxias	*Galaxias truttaceus*	X		
Dwarf Galaxias	*Galaxiella pusilla*		Vu	En
Eastern Gambusia*	*Gambusia holbrooki*	X		
Southern Pygmy Perch	*Nannoperca australis*	X		
Rainbow Trout*	*Oncorhychus mykiss*			
Roach*	*Rutilis rutilis*			
Brown Trout*	*Salmo trutta*			
Crayfish				
Granular Burrowing Crayfish	*Engaeus cunicularius*	?		
Lowland Burrowing Crayfish	*Engaeus quadrimanus*	?		
Foothill Burrowing Crayfish	*Engaeus victoriensis*	?		
Gippsland Spiny Crayfish	*Euastacus kershawi*			
Woiwuru Spiny Crayfish	*Euastacus woiwuru*			
Yarra Spiny Crayfish	*Euastacus yarraensis*			
Mussels				
Balonne Freshwater Mussel	*Velesunio ambiguus*	X		

3 Discussion

3.1 Plants

3.1.1 Listed communities

The Protected Matter Search Tool identified two EPBC Act listed ecological communities which may occur within the search area. These are:

- Natural Damp Grassland of the Victorian Coastal Plains
- White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland

Neither listed community is considered likely to occur, based on the definition criteria of each (DoE 2015, TSSC 2006) and observations of communities during the site assessment for this report. The BNCR does not fall within the landscape context of the former community, which is typically lowland plains. None of the characteristic eucalypt species occur for the latter community.

There were no FFG Act listed communities observed during the site inspection. The area of Riparian Scrub (Figure 2) has affinities with the FFG Act listed community Sedge-rich *Eucalyptus camphora* Swamp, currently known only from Yellingbo Nature Conservation Reserve. Many of the flora species observed at BNCR are common to this community however the Riparian Scrub example has a different hydrology and therefore does not develop the same composition and cover of sedges and other swamp species which prefer longer intervals of inundation. It also lacks Mountain Swamp-gum based on this preliminary assessment however this species has the potential to occur in and around BNCR. Despite this, the swampy areas at the BNCR still have ecological significance for their rarity in the landscape and associated fauna habitats. It is also habitat for at least one threatened species (Floodplain Fireweed) and potentially contains others.

This preliminary assessment concludes that there are no listed ecological communities which are likely to be impacted by the proposed action.

3.1.2 Ecological Vegetation Classes (EVCs) and canopy trees

Aquatic Herbland has very limited extent on the margins of the reservoir and is the most threatened EVC with regard to the proposed lowering of the water level. It is possible that newly created areas of shallow water will provide replacement habitat for this EVC, however it should not be assumed that it will naturally establish in such areas. The depth of water is important for this EVC to establish and persist within suitable waterbodies.

Riparian Scrub also will be impacted by lowering the water level. Many of the shrub species which dominate this EVC are common and readily recruit in areas of suitable habitat. Once the dam is lowered, the creation of new areas of Riparian Scrub will likely follow. Flooding and waterlogging of soils on the inflow side of the dam will persist and will likely increase in extent if the margins have a lower gradient than previous. There is a moderate diversity of understory plants in Riparian Scrub, some of which including several fern species may be slower to colonise new areas of habitat.

Dry foothill EVCs on lower slopes, including Lowland Forest, fringe most of the waterbody. It is expected that these vegetation types will recruit into areas of exposed earth following permanent lowering of the water level, however monitoring would be required to determine the compositional changes which occur as a result. Some dieback of eucalypts may occur near the current high water level due to the rate of change to hydrological regimes. Seed dispersal and germination however is not expected to be limited due to an abundance of fertile material near the bank. There are also several species which occupy the zone nearest the edge of the bank including Messmate Stringybark, Silver-leaf Stringybark, Green Scentbark, Narrow-leaf Peppermint and Swamp Gum. This offers a level of redundancy in any one species' role to provide a tree canopy between the current and future high-water mark. Similarly, it is expected that a suite of understorey species will be suited to recruit in this space; either by vegetative spread or by seed. Regarding longer-lived perennials, it is also expected that early successional species or those which are advantaged by disturbance will be dominant over the 10 years following, including Burgan, Manuka and cassinias (*Cassinia* spp.).

Implications for impacts to trees warrant separate discussion due to their multiple ecological roles including habitat for fauna. Impacts should be considered in terms of changes to soil conditions, ambient humidity and related changes over a 3–5 year period as the water level is lowered. It is not implied that this will lead to a water deficit in mature trees as most of these species are abundant also further upslope, away from the edge of the reservoir. Stress due to hydrological changes rather than water deficit may make some tree more susceptible to other pressures which can cause dieback. The wider influence of drought (seasonal and long-term) is also a consideration and planning may take into account how these two factors interact. Other factors such as soil instability may contribute to windthrow. There is capacity for eucalypt species to vary physiological traits in response to drought and season. Such observations have been made for Messmate Stringybark with plasticity in traits attributed to some level of resilience against drought (Pritzkow et al. 2020). Messmate Stringybark has the capacity to adapt to long-term drought by changing morphological traits (Pritzkow et al. 2021). It is conceivable that trees closer to the reservoir edge are less resilient to future long-term drought, and that the combined effects of lowering the water level and regional climate cycles may result in higher incidence of dieback in this zone. An analysis of stomatal conductance of six eucalypt species in central Victoria revealed that each species had a unique response to seasonal variation in climate, with Yellow Box (*Eucalyptus melliodora*) having the lowest level of photosynthesis rate relative to stomatal conductance and transpiration, and Bundy having the highest across all seasons (Patykowski et al. 2019). As such, the responses of trees to lowering the water level will likely vary depending on the species. Tree recruitment in the zone between new and old high-water levels has its own considerations. Eucalypt seedlings will need to compete with other species including several woody weed species which occur around the reservoir. They will also need to endure summer conditions while still at seedling stage and with limited shade.

3.1.3 Potential threats to significant flora

The following applies to significant plant species which currently occupy BNCR.

Dandenong Range Cinnamon Wattle – There are numerous reliable records of this species in the local area. It typically occupies riparian zones on hillsides in tall forest and open woodland (VicFlora 2021). Targeted searches would be required to provide further mitigation of impacts to this species' habitat, associated with lowering the water level.

Wiry Bossiaea – The habitat requirements of this shrub are varied although it is usually associated with moist drainage lines or floodplains. It occurs in heathland, heathy woodland and open forest (VicFlora 2021). Lowering of the water level may result in some sections of drainage line drying out. While habitat may be replaced over time there is high uncertainty around this. It is often very rare at a site and the BNCR population should be monitored as part of impact mitigation.

Powelltown Correa – This shrub has been recorded within BNCR and there are three records elsewhere near Cardinia Reservoir from 2006–2014. It typically occupies moist open forests which are often heathy (VicFlora 2021). Such forest types occur within BNCR including vegetation within or on fringes of riparian zones.

Green Scentbark – There are few related threats to this species as most mature individuals are well away from the bank of the reservoir. This species is not typically dependent on riparian zones or margins of waterbodies.

Red-tip Greenhood – This orchid occurs on well-drained soils, on slopes and ridges in drier open forests and woodland (VicFlora 2021). It is determined as present based on at least two reliable records from the local area. Due to its preference for drier habitats, it is unlikely to be impacted from the proposed action.

Cobra Orchid – This orchid occurs on moist, shady slopes in open forest on well-drained soils (VicFlora 2021). It is determined as present based on one reliable 2006 record within BNCR and may occupy lower slopes near the edge of the reservoir.

Floodplain Fireweed – One plant of this species was observed during a general inspection of habitats. Additional plants may be found following a targeted survey. The main threat to this species is changes to hydrology. Such changes may alter habitat conditions and make existing area of habitat uninhabitable or more prone to weed invasion. Another significant threat to this species is deer trampling, as it grows in sites which are often used for wallows.

Apart from impacts associated with lowering the water level, the next two greater threats with direct management intervention options are weed invasions and impacts from deer. Both will require a suitable level of investment in control and monitoring during and after lowering the reservoir. A detailed ecological assessment should make a determine on potential losses and gains in threatened species populations, based on a better understanding of the distribution of each within BNCR.

3.2 Waterbirds

The suitability of wetland waterbird habitat for different species is largely driven by the depth of water, and the gradient of water depth extending away from the shoreline. This influences the presence of submerged and emergent vegetation, which is used by waterbirds for foraging, either on the vegetation itself or the invertebrates that reside there, and/or shelter, and the extent of deep open water, used by species that dive (Halse et al. 1993, Marchant and Higgins 1990). Open water is the most extensive waterbird habitat present at Beaconsfield Reservoir which would suit species that forage in deep water (e.g. diving ducks). It is also likely to be used as a refuge or roosting area by waterbird species that forage in shallow water but swim further from shore when disturbed (e.g. Pacific Black Duck, Dusky Moorhen). The narrow band around the perimeter that includes the Spike-sedge would suit species that forage in relatively shallow water if <30 cm deep (shorebirds, large waders and some filter feeders). However, these species appear to be poorly represented at Beaconsfield Reservoir, perhaps because much of the shallow water is occupied by Spike-sedge, and many shorebird and waterbird species tend to avoid such tall vegetation, though it is favoured by some marsh-dwelling species such as Australasian Swamphen. The proposed draw-down of the reservoir water level, and predicted decrease in the area of shallow and deep water, may impact waterbird species that use shallow habitats, with 'winners' and 'losers' being determined by the response of vegetation to decreasing water levels. Precise impacts are therefore difficult to predict, but given the relatively steep shorelines of the reservoir, the relative area of shallow water is likely to remain small.

Species that forage in deep water include grebes, ducks and cormorants, and also the Black Swan which reaches down under the water with its long neck, all of which have been recorded at the reservoir. Only three duck species (Pacific Black Duck, Australian Wood Duck and Australian Shelduck) have been recorded at the study site, but others such as Grey Teal, Chestnut Teal and Hardhead, which represent the more commonly recorded species in the surrounding area, may also use the reservoir.

Bitterns are found in swamps and wetlands amongst tall dense vegetation such as reeds, rushes and sedges. Similarly, crakes frequent wetland areas that provide dense cover, though also forage along muddy edges (Menkhorst et al. 2019). The Tall Spike-sedge at the BNCR may provide suitable habitat for such birds, and although none of these species have been recorded on site, a small number have been recorded in the wider area.

Large waders such as ibis, spoonbills, herons and egrets forage for invertebrates such as insects, molluscs and fish in surface or shallow waters, probing mud (ibis), sweeping their bills from side to side (spoonbills), or grabbing (herons and egrets) (Marchant and Higgins 1990). Of these waders, the White-faced Heron, Nankeen Night-Heron and Eastern Great Egret have been recorded at the BNCR. There appears to be little habitat for ibis at BCNR as they largely prefer shallower water less than 30 cm deep (Pallisson et al. 2002, Rogers et al. 2019) and Beaconsfield Reservoir provides limited areas like this.

For many of the other species recorded within the wider area, Beaconsfield Reservoir does not provide suitable habitat. For example, for there is minimal habitat for shorebird species that prefer mud flats or very shallow water to forage, such as plovers, avocets and sandpipers (Marchant and Higgins 1993a), there is minimal habitat of this type.

One of the more wide-ranging species present in the area, the White-bellied Sea-eagle (not strictly a waterbird), utilises open water to hunt over the surface (Marchant and Higgins 1993b). Although this species (listed as Endangered under the FFG Act) has not been recorded from Beaconsfield Reservoir, individuals may include this site if within their foraging territory. It has been recorded at Lysterfield Lake, Cardinia Reservoir and most recently at River Gum Creek Reserve, Hampton (12 km to the east of the study area) and would likely use several of these larger bodies of water in the wider area to forage.

The restricted public access to the BNCR has likely contributed to the lack of formal records from the site; it is possible that a more diverse waterbird community uses the reservoir, particularly ducks. Other more cryptic species such as bitterns and crakes may also be present. In addition, the site visits for this current assessment took place during winter when waterbird numbers in southern Victoria are at their lowest (Rogers et al. 2019). Conducting formal waterbird surveys, particularly during spring (to capture any breeding) and late summer (to capture the highest numbers), would provide more information in this regard. The unusually wet year may also mean there is abundant waterbird habitat further inland providing more attractive foraging.

Potential adverse impacts of lowering the water level on waterbird habitat includes a loss of the area of Spike-sedge, which is particularly thick within some of the narrower arms e.g. the north-east tip, and submerged vegetation. A very slow lowering of the water level such that there is minimal loss of emergent and submerged vegetation would provide the best outcome for waterbirds that use this habitat. This is particularly the case if the area is utilised during breeding. The area of shallow and open deep water is predicted to decrease, however will still be reasonably extensive. There is the potential for areas of water <

30 cm deep e.g. along drainage lines, which would particularly benefit waders. Currently there is little evidence that large numbers of waterbirds use the reservoir, although it may be locally important, particularly during dry periods, as there are few natural wetlands in the immediate area.

There are two key large waterbodies close to the BNCR that also provide waterbird habitat: Cardinia Reservoir and Lysterfield Lake. All the species recorded using Beaconsfield Reservoir, or are likely to use it, would be able to utilise these and other local areas and it is anticipated that their habitat needs could be met outside of the study site. However, if formal surveys revealed e.g. large numbers of threatened ducks utilising the reservoir, this may warrant further consideration of how the proposed lowering of the water level could cause impacts via a reduction in available habitat or disturbance during the dam wall works. Further actions might involve ongoing monitoring or minimising disturbance during works.

3.3 Herpetofauna

3.3.1 Frogs

Frogs utilise the marginal habitats in large wetlands and reservoirs. The emergent, floating and submergent vegetation which provides habitat for both frogs and tadpoles is largely restricted to the shallower sections of Beaconsfield. Biofilm production is higher in more complex habitats such as those with aquatic plants (Gagnon et al. 2007) and tadpole diets, although they vary depending on food availability, typically consist of biofilm, with microcrustaceans and algae consumed when abundant (Ocock et al. 2018). Snags, as well as providing important habitat, also serve as a base for biofilm production (Johnson et al. 2003). Lowering the water level at Beaconsfield Reservoir, increasing the proportion of shallow water habitat whilst maintaining habitat complexity is likely to benefit the local frog community.

Two conservation listed frog species have been recorded within a 5 km vicinity of Beaconsfield NCR: the Growling Grass Frog and the Southern Toadlet. Growling Grass Frogs have been recorded on the southern side of the Princes Highway (VBA) and may not have been recorded at Beaconsfield for a variety of reasons. Firstly, although this species is highly mobile and there are numerous waterbodies between Officer and Beaconsfield NCR, Growling Grass Frogs are susceptible to population fragmentation due to urbanisation (Hale et al. 2013). Detection probabilities for Growling Grass Frogs during diurnal and nocturnal surveys vary greatly and can be quite low (0.1 and 0.696 respectively, Heard et al. 2006) and reliance on single-site visits for this species is likely to severely underestimate site occupancy (Heard et al. 2006). The two survey days conducted in August, when the species is not active, are less likely to have detected them. Lastly, in 2002 the reservoir was described as having ‘extensive areas of open water, few shallow margins, no emergent aquatic vegetation and limited fringing aquatic vegetation’ making the reservoir marginal habitat at that time (Mueck et al. 2002). Reductions in the carrying capacity of the reservoir since 2002 has lowered water levels and created more complex habitat. Growling Grass Frogs typically prefer wetlands with a range of emergent, floating and submergent vegetation (Heard et al. 2008) and it is possible, if a resident population is located nearby, that the site could be colonised. Although not detected at the site previously, the Growling Grass Frog is listed as Threatened (DELWP 2021b) so it is recommended that appropriate surveys are undertaken to determine whether the species is present.

The Southern Toadlet is listed as Endangered in Victoria (DELWP Threatened List June 2021) and was last recorded at Beaconsfield NCR in 1981. This species can be more difficult to detect and typically requires targeted surveys. The Southern Toadlet is the only species of the nine detected that lays its eggs on the ground (Anstis 2013). Unlike most spring and summer calling species, the Southern Toadlet calls in Autumn from shallow depressions in low lying flood-areas (Anstis 2013). This species is a pool breeding amphibian, reliant on damp gullies, basins and depressions that inundate in Autumn and Winter (De Angelis and Cleeland 2019). Reducing the extent of the reservoir may increase the availability of low-lying flood-areas that would have previously been permanently inundated. The proposed works will expose over 300 m of gully line that feed into the waterbody and will return sections of the gully back to its original state as an ephemeral creek line, potentially providing additional breeding habitat for the Southern Toadlet. Southern Toadlets were detected along the eastern gully line in 1981, 420 m from the current water extent. Although the habitat is still favourable for this species, impacts from feral deer were observed in the gully lines and it is recommended that this is managed irrespective of proposed changes to the reservoir water-level. Given the recent population declines and losses recorded for this species (Heatwole and Rowley 2018), it is recommended that targeted surveys are undertaken to determine if populations still persist at the NCR to ensure any potential impacts are mitigated.

3.3.2 Reptiles

The proposed works will have little impact on most of the reptile species recorded at Beaconsfield NCR as the surrounding habitat will not be disturbed. Reptile species commonly associated with watercourses include Swamp Skink, Tiger Snake and Red-bellied Black Snake, the elapid snakes because of their predilection for frog prey (Shea et al. 1993, Aubret et al. 2006, Robertson and Coventry 2019). The diet of another elapid snake, the Lowland Copperhead, is also known to include a substantial proportion of frogs (Shine 1987). The only aquatic species recorded locally was the Eastern Long-necked Turtle and, being an opportunistic carnivore that primarily eat crustaceans, invertebrates and carrion (Chessman 1984), is typically captured in the shallower margins of wetlands (Howard et al. 2020). Given its capacity for overland migration it is likely to be recorded at the reservoir at some stage. Reductions in the water level are unlikely to impact this species.

The Swamp Skink, threatened in Victoria and categorised as Endangered under the *Flora and Fauna Guarantee Act* 1988, has been located at Cardinia Reservoir and also 3 km north west of Beaconsfield in 2017 (ALA). This species is restricted to swampy habitats that are often dominated by sedges, reeds or *Melaleuca* species (Chapple 2003, Robertson and Coventry 2019). These habitat types are represented at Beaconsfield NCR however, as stated in Mueck et al. (2002), the cover of overstorey vegetation may be too high as the forest closely abuts the reservoir edge. Riparian Scrub located at the end of the eastern arm of the reservoir is situated in a broader gully line with less canopy cover, providing more suitable habitat for Swamp Skinks. Reducing the water level may also extend the Riparian Scrub and provide additional habitat for this species.

Few terrestrial reptile species will be affected if the water level in the Beaconsfield Reservoir is lowered. Indeed, the few species that are associated with waterbodies and thus likely to be affected may benefit from (1) a likely increase in the abundance of frogs, due to a larger proportion of shallow water or damp gullies – that the resident frog assemblage is known to prefer, and (2) a potential increase in the availability of Swamp Skink habitat if water levels and fringing vegetation are managed appropriately. If the Beaconsfield Dam wall is lowered or modified then activities associated with this need to minimise any impacts to known taxa and, in particular, exclude or minimise disturbance to known and potential Swamp Skink habitat.

3.4 Fish, crayfish and mussels

Each of the fish, crayfish and mussel species occurring in the reservoir and surrounding catchment exhibit a general preference for shallow waters with abundant and diverse aquatic and terrestrial vegetation (Allen et al. 2002; Ault and White 1994; Woodward and Malone 2002; Schultz et al. 2009; McCormack 2012; Broadhurst et al. 2012). Fallen timber from terrestrial vegetation and the presence of aquatic vegetation provide refuge from predators, harbour prey items, and in the case of these native fish species (excluding eels), they are where females deposit their eggs (McCormack 2012; Humphries and Walker 2013). The diets of the local fish and crayfish populations are broad, including detritus (e.g. fallen leaves), algae, macrophytes, invertebrates, fish and fish eggs (Horwitz 1990; McDowall and Lagahetau 2001; McCormack 2012; Humphries and Walker 2013; Raadik 2014). Short-finned Eel are an exception, being predominantly carnivorous (Allen et al. 2002). So, vegetation provides habitat and supports important components of the food chain that are critical for all species and life-history stages.

Eastern Gambusia and Goldfish also occupy these habitats and compete with native species for resources (Hutchison 1991; Jones et al. 2008; Macdonald et al. 2012). Furthermore, Eastern Gambusia are highly aggressive and there is evidence that they negatively impact on several small-bodied, sedentary species such as Spotted Galaxias, Dwarf Galaxias, and Southern Pygmy Perch (Ault et al. 1994; Jones et al. 2008; Coleman et al. 2016). However, aquatic vegetation would help mediate these aggressive interactions (Ling 2004; Macdonald et al. 2012).

The proposed change in water height at Beaconsfield Reservoir is most likely to impact on fish, crayfish and freshwater mussels by changing the amount and distribution of shallow (< 1.5 m), vegetated edge habitat. While there are many other factors that may influence habitat suitability for each given species (e.g. physiochemical properties of the water, sediment type), these are not expected to change due to the proposed actions. While the reduction in water level will reduce the amount of this vegetated edge habitat, there will still be a large amount (11,300 m^2) in a continuous band around the reservoir. It is logical that a reduction in the amount of habitat will reduced the number of animals that can occupy it, but it is unknow how close to capacity current populations are. The worst-case scenario is that the species will persist in lower abundance relative to current levels due to density dependant processes, but there will still be sufficient habitat to support large numbers of each species that are easily sufficient to avoid the negative genetic implications of having small populations (e.g. Kriesner et al. 2020).

A further important consideration is the ability for these animals to move with the changing water line as the reservoir water level is reduced. If the rate at which the water level is lowered exceeds an aquatic animal's ability to move with it, they will become stranded leading to death. This would not pose a problem for fish and spiny crayfish that are highly mobile. However, fish eggs attached to vegetation would be impacted. In this instance, the galaxiids, River Blackfish, and Southern Pygmy Perch each spawn in vegetation and on woody debris during spring and would likely be affected (Allen et al. 2002). As such, water reductions during spring that would completely expose aquatic vegetation and woody debris should be avoided. *Engaeus* spend most of their life underground in deep (> 1 m) burrows that intersect with the water table (Horwitz and Richardson 1986). While the lowering of the water height may change the current water table height surrounding the reservoir, the crayfish are still quite mobile and able to travel across land to relocate. Freshwater mussels have some ability to move horizontally to track changing water levels, but their response would be slow given they have no appendages (Lymbery et al. 2020). We anticipate a reduction of over months, rather than days, would allow for freshwater mussels to successfully migrate with the moving water line.

If the BNCR is to be opened to the public there is a serious risk that exotic species such as Carp (*Cyprinus carpio*), Roach (*Rutilis rutilis*), and trout will be illegally introduced for the purpose of recreational fishing. Such introductions would be to the detriment of the native species present, except the eels and mussels. In particular, the introduction of Rainbow Trout or Brown Trout (*Salmo trutta*) would likely eliminate any galaxiid populations present (Jones and Closs 2018; Lintermans et al. 2020). We propose three ways in which this risk can be reduced. First, educate the public on the natural values of the BNCR through the public consultation stages of this project and by placing informational signs around the BNCR on walking trails, at picnic grounds and other sites that are visible to the public. Second, restrict access to the reservoir to the daytime (i.e. by locking the gate) to deter illegal activities. Third, deter the introduction of exotic angling species (e.g. trout) by introducing a native fish put-and-take recreational fishery in conjunction with the Victoria Fisheries Authority.

3.5 Legislation and policy

3.5.1 Permitted Clearing Guidelines

Losses and gains in biodiversity values in a statewide context may be quantified using methods in the permitted clearing guidelines (DELWP 2017), including impacts to modelled threatened species habitats. This can be achieved by mapping the areas proposed to be impacted as well as areas which are likely to be gained (new areas covered by native vegetation). The net difference in parameters may assist in reporting the potential benefits to biodiversity by lowering the water level.

Planning permit requirements of Melbourne Water (e.g. Clause 52.17) or equivalent consideration for the proposed action have not been considered for this assessment, but should be undertaken for a detailed assessment.

3.5.2 Flora and Fauna Guarantee Act (FFG Act) 1988

The purpose of the FFG Act is to 'establish a legal and administrative structure to enable and promote the conservation of Victoria's native flora and fauna and to provide for a choice of procedures which can be used for the conservation, management or control of flora and fauna and the management of potentially threatening processes'.

At least one FFG Act listed (Threatened) species of plant will be likely impacted by the proposed activity. However, the impact of the proposed activities on FFG listed fauna that may be present, is considered negligible. Impacts to protected flora will be required with consideration of generally protected flora (Section 46 of the FFG Act). Melbourne Water's obligation under the Act will be determined by a public authority management agreement and in relation to the proposed activity. Melbourne Water must determine and document their obligations to consider potential biodiversity impacts under their public authority duty, Section 4B of the FFG Act.

3.5.3 Environment Protection and Biodiversity Conservation Act (EPBC Act) 1999

The EPBC Act provides for the listing, promotion, protection and management of matters of national environmental significance. This includes nationally listed species and communities.

The current assessment has not identified any EPBC Act listed plant species or ecological communities which have been previously recorded within the BNCR. Two plant species— Round-leaf Pomaderris and Green-striped Greenhood—have a medium likelihood of occurring based on suitability of habitats and an understanding of the current extent of occurrence for these species in Victoria. It is recommended that targeted searches are undertaken for these species within 20 m of the water edge and to within 100 m of riparian corridors (or other areas proposed to be impacted by the activity). If any EPBC Act listed species are located on site following further investigations, a decision must be made as to whether the proposed action will need to be referred to the Commonwealth. A referral may result in an action being determined a controlled action.

4 Conclusions and Recommendations

Based on the available data, there are no fundamental issues with the proposed activities at Beaconsfield Reservoir, but some species would likely be impacted, especially if the lowering of the water level occurs too quickly. The key to minimising potential disturbance to aquatic and semi-aquatic biota is to minimise the disturbance to aquatic and terrestrial vegetation that provides them with critical habitat. To achieve this, it is recommended that the draw-down be conducted over three years to allow the emergent and submerged vegetation around the edge of the reservoir to migrate with the changing waterline. A slow draw-down would also help prevent the establishment of terrestrial weed species that may impact on some amphibian and skink species.

The reduction in water-level will lead to a reduction in the overall amount of vegetated edge habitat that would intuitively reduce the carrying capacity of the reservoir for all species reliant on that vegetation. This may lead to an increase in density dependent processes such as predation and competition that would reduce the overall abundance of the resident species. However, it is beyond the scope of this report to say if this will happen and by how much. It is expected that there will still be a large, continuous ring of vegetation around the reservoir that would likely support sufficient numbers of animals to avoid negative genetic implications and reduced resilience associated with small populations. If density dependent processes were to place pressure on more mobile animals such as waterbirds, and to a lesser extent frogs, skinks and crayfish, they would be expected to relocate to nearby waterbodies. A general limitation of this report is the lack of detailed information on the species present in the BNCR. With all this in mind we make the following recommendations.

Overall:

1. Prior to commencing works, formal flora, waterbird and frogs surveys should be undertaken, including detailed mapping of EVCs and targeted surveys for species which are known or likely to occupy the site, particularly during breeding seasons or when seasonal peaks are expected. This will better inform an assessment of species that may be sensitive to degradation (flora) or habitat loss (fauna) due to a drop of water level, during earth works related to the wall, or if public amenities are developed around the BNCR. An assessment of the results of any further surveys should resolve and set out all legislative requirements relating to biodiversity, specifically in relation to the proposed activity.
2. Lowering the water level should occur over a minimum of three years. There is no reference standard for this practice, and consideration must be given to the ecological requirements of many species and communities. The three-year timeframe provides a precautionary approach and allows Melbourne Water to monitor the process and its effects on biodiversity.

Flora:

3. Undertake monitoring of impacts to flora:
    - Monitor the composition of recruiting vegetation on newly exposed earth, caused by lowering the water level.
    - Develop a design to monitor changes in native plant and weed cover-abundance over time, along a lateral gradient between the adjacent foothill vegetation and riparian zones. Changes in number of eucalypt recruits should also be included.
    - Monitor Riparian Scrub / Swampy Riparian Woodland areas for recruitment of Floodplain Fireweed and other threatened species.
    - Monitor tree canopy condition and cover using hemispherical photography or other suitable method.
4. Collect seed from Swamp Gum and Green Scentbark in the first year of lowering the water level. Store seed for propagation and use in revegetation where required.
5. Prior to any ancillary works (e.g. walking track installation), undertake spring targeted surveys for threatened species in Table 2 which are present or have a medium to high likelihood of occurrence. During the survey, map and record any new observations of threatened species (FFG Act and EPBC Act).
6. Control all woody weeds to negligible levels within 30 m of the current high-water level. Monitor for high threat aquatic weeds.
7. Repair the perimeter fence and undertake intensive deer control over the duration of lowering the water level (3–5 years) and maintain management of deer numbers. The management of deer is critical for the re-establishment and protection of native vegetation and for it to be resilient to climate and other pressures. If effective deer control is not possible, alternate measures should be taken to

protect new plants that have established long the changing waterline, such as placing guards around seedlings.

Herpetofauna:

8. If the wall is reduced, it should be assumed that frogs and skinks may be present in the rock wall and appropriate care taken when moving the rocks as part of the deconstruction.

Fish:

9. If BNCR is to be opened to the public undertake actions to reduce the likelihood of exotic fish species being introduced to the reservoir.

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Melbourne Water Corporation

Beaconsfield Reservoir
Concept Design Report – FINAL

December 2019

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

Executive Summary

This report presents the concept design to upgrade Beaconsfield Reservoir. The purpose of the upgrade is to reduce the Consequence Category from High A to Low and although not formally assessed, it is expected that this upgrade would largely satisfy ALARP.

Beaconsfield Reservoir is now disconnected from the water supply network. The proposed concept design focuses on reducing the risk profile of the dam as well as reducing any future maintenance and operation requirements for Melbourne Water Corporation.

A previous risk assessment by URS in 2010 identified that Beaconsfield Reservoir lies within an order of magnitude of the ANCOLD (2003) Limit of Tolerability. A dam safety upgrade concept design, which assumed no reduction in reservoir level, was developed by GHD in 2012.

The dam safety upgrade was assessed against a partial decommission upgrade; full decommission upgrade and a Do Nothing approach, to determine the preferred way forward. Based on a multi-criteria analysis it was identified that a partial decommissioning option would successfully reduce the Consequence Category to Low whilst still maintaining a permanent water body, and therefore providing a long-term amenity for the public.

Three partial decommissioning concept options were originally considered (labelled 1A to 1C), with different crest and spillway arrangements. The designs were developed by adopting a FSL of RL 94.0 mAHD, which was required to achieve a Low sunny day Consequence Category. However, none of these concept options resulted in a Low Consequence Category for wet day failure. Therefore, an iterative approach was undertaken, in which a fourth concept option (1D) was identified. This option resulted in a Low Consequence Category under both sunny day and wet day failure scenarios. The concept design of Option 1D includes the following key components:

- Crest at RL 96.10 mAHD, which is 8 m below the current crest level of RL 104.05 mAHD
- A downstream embankment slope of 5H:1V
- FSL at RL 94.0 mAHD, 4.5 m lower than current restricted FSL of RL 98.5 mAHD
- Retrofitting the existing low-level outlet to be utilised as the primary spillway
- A secondary spillway at RL 95.5 mAHD located on the left abutment
- A rock-lined spillway chute and energy dissipator

In addition, the recommended concept design (Option 1D) also includes the landscape design of the site, namely:

- A re-designed smaller water body including smaller pools extending the visual appearance of the water body
- Circuit walking trails including tracks around the water body and along the existing spillway channel
- A picnic and passive recreation area located at the downstream toe of the upgraded embankment

A RANE analysis was completed for the four concept designs, with a summary of outputs shown in the table below.

Table E-1 RANE analysis output

	RANE Output ($M)			
	Option 1A	Option 1B	Option 1C	Option 1D
Base Project Cost				
Low Expected Project Cost, P5				
Expected Project Cost, P50				
High Expected Project Cost, P95				
Contingency (P95 – P50)				
(P95-P50)/P50				
(P95 – Base Cost) / Base Cost				

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1. Introduction

1.1 Purpose of this report

GHD was engaged by Melbourne Water Corporation (MWC) on 24 July 2018 to undertake a Comprehensive Inspection and Concept Design for Beaconsfield Reservoir. This Report describes the Concept Design developed for the dam.

The key purpose of the concept design is to provide guidance to MWC on options to achieve a Consequence Category of Low and reduce risks associated with the storage, which were identified through a risk assessment undertaken by URS (now AECOM) in 2010. The main failure modes identified as key contributors to the existing risk are:

- Piping along the spillway interface (47%)
- Downstream instability (42%)

The results of the risk assessment indicated Beaconsfield Dam plots below the ANCOLD Limit of Tolerability (LoT) under the 50% and 80% confidence levels and above the LoT at the 95% confidence level. The risks at Beaconsfield Dam were assessed as not satisfying the As Low As Reasonably Practicable (ALARP) principle, predominantly on the basis that the "…dam has inadequate factor of safety for embankment stability." and the "…dam has no filters." (MWC, 2015e). Potential failure modes are further discussed in Sections 1.2.2 and 6.4.

This report, Beaconsfield Reservoir Concept Design Report, follows the Preliminary Concept Design undertaken by Jacobs (2018) and utilises current industry practice for updating the hydrology and dambreak assessment using ARR (2016/2019) and RCEM (2014) guidance. This report details the process undertaken to achieve the following criteria:

- Reduction of the Consequence Category from High to Low
- Minimise ongoing operation and maintenance requirements for MWC, and
- Maintain or improve amenity for key stakeholders

This report provides recommendations on the preferred option to progress to the detailed design phase, in line with the design criteria identified in this report. This report summarises the following:

- Background information on the storage
- Design criteria used in the development of concept upgrade options
- Key input information, including hydrology, dambreak and consequence assessments
- Preliminary option assessment, including the multi-criteria assessment for high level options
- Initial concept design development - based on sunny day failure, including landscape design
- Final concept design development - based on wet day failure, including landscape design
- Cost estimates and RANE estimates, and
- Conclusions and recommendations

Supporting information is provided in the Appendices to this report.

1.2 Background Information

1.2.1 Safety Review (GHD, 1999)

MWC engaged GHD to undertake a Safety Review of Beaconsfield Reservoir in 1999. During the review, GHD arrived at a number of key conclusions including:

- The left side of the embankment is unstable and requires remedial works
- The existing spillway capacity is adequate when the reservoir is operated 4 m below the spillway crest level, but is insufficient if the FSL is maintained at the spillway crest level
- The existing outlet works should be modified to operate as a primary spillway *
- The scour control valve should be repaired and operated at regular intervals to ensure its continuing serviceability *
- Erosion control works are required in the Haunted Gully Creek near the outlet of the scour and the return channel from the (proposed) primary spillway *
- Rainfall runoff from the catchment is needed to sustain the reservoir level, and the diversion drain should be breached with provision made to discharge into the reservoir *
- The indicative costs of the above remedial works were in the order of $500,000

** Items have been actioned by MWC and DELWP/CEC*

1.2.2 Detailed Risk Assessment (URS, 2010)

Following the Safety Review in 1999, MWC engaged URS (now AECOM) to undertake a detailed risk assessment of Beaconsfield Reservoir. The report involved the identification, screening and quantification of the risks associated with Beaconsfield Reservoir. A Monte Carlo simulation was undertaken to assess confidence intervals to further understand the sensitivity around the estimates of some of the risks. The outcomes of the risk assessment were:

- The main contributors to risk were piping along the spillway interface (47%) and downstream instability (42%).
- The three highest ranked failure modes in terms of annual failure probability were piping along the spillway interface (5.5 x 10^{-4}), downstream instability (6.5 x 10^{-5}) and flood overtopping (4.1 x 10^{-5}).
- Slope stability analyses should be undertaken using undrained strengths.
- Simplified deformation analyses, such as the method described by Khalili, should be undertaken.
- Remedial works at the embankment spillway interface, as recommended in GHD's 1999 Safety Review report, should be undertaken.
- The spillway wall low point (RL 104.05 mAHD) should be raised.
- Lowering of the spillway crest level should be considered to ensure the water level restriction (i.e. 4 m below FSL) is achieved.
- Grouting up of the annulus of the original outlet works should be considered. Works should also include removal of the upstream gate and installation of an additional downstream gate valve.
- Hydrology and dambreak modelling should be updated to current best practice.

1.2.3 Remedial Works Design and Revised Hydrology and Dambreak Assessment (GHD, 2012)

Following the risk assessment, GHD was engaged in 2012 to undertake an upgrade options assessment. The preferred option, which was progressed to concept design included:

- Full height filter buttress with a stabilising berm
- Outlet works modified to act as a primary spillway

The scope of works was established from recommendations arising from the URS (2010) risk assessment and included the following criteria:

Scope item	Conclusion / Outcome
Stability assessment using undrained shear strengths (and additional geotech investigations)	$FOS_{undrained}$ = 1.89 $FOS_{drained}$ = 1.45
Simplified deformation analysis	8.8-11.0 m along circular failure surface equivalent to 2.5-5.4 m vertical displacement. The proposed freeboard (at the time) was 5.77 m.
Proposed remedial works for the preferred option	• Full height filters • DCF varies – RL 104.00-104.62 mAHD • Berm at RL 95 mAHD • Spillway interface works • Energy dissipator and rock-lined channel • Modification to valves, pipework, valve house and valve pit • Replacing outlet tower screens
Cost estimate	RANE P50 = $3.1 million
Revised hydrology and hydraulics	FSL = RL 98.95 mAHD DCF = RL 104.02 mAHD • Spillway only – 1 in 280,000 AEP • Spillway and 1 outlet pipe – 1 in 500,000 AEP • Spillway and 2 outlet pipes – 1 in 700,000 AEP DCF = RL 104.62 mAHD • Spillway only – 1 in 200,000 AEP • Spillway and 1 outlet pipe – 1 in 1,600,000 AEP • Spillway and 2 outlet pipes – 1 in 2,000,000 AEP
Dambreak and consequence assessment	PAR_{day} = 1451 and PAR_{night} = 235 (incremental) PLL_{day} = 4 and PLL_{night} = 4 (incremental) Sunny Day Failure = High C Consequence Category Wet Day Failure = High C Consequence Category

1.2.4 Modelling for Removal of Beaconsfield Reservoir Part 1 (MWC, 2015a)

In 2015, modelling of the proposed decommissioning options was undertaken to better understand the full range of options (from decommissioning to full upgrade) available to MWC. The purpose of the study was to assess the impact to downstream properties due to full decommissioning of the dam. The conclusions of the study were:

- Flows increased (as expected) – at the Urban Growth Boundary (Brown Road) the peak flows increased in Haunted Gully Creek by 13 m^3/s.

- Depth of flooding was estimated to increase on all properties currently subjected to flooding.
- The removal of the dam led to three (3) additional properties within the inundation zone for the 1 in 100 AEP flood.
- The average increase of flood depths was 0.42 m with two (2) properties increasing by over 1 m.
- If a more accurate flow path and/or depth was required, it was recommended that a 2D model of the floods be undertaken.

1.2.5 Modelling for Removal of Beaconsfield Reservoir Part 2 (MWC, 2015b)

Part 2 of the decommissioning modelling noted that "…complete removal of Beaconsfield Reservoir will lead to unacceptable increases in flood levels along Haunted Gully Creek…". In response, MWC modelled further scenarios, including operating the reservoir via the lower outlet pipe, to reduce the water level in Beaconsfield Reservoir while limiting any increases in water levels downstream, during a storm with an AEP of 1 in 100. The modelled scenarios included:

- Lower outlet pipe current set up
- Lower outlet pipe size increased to 1050 mm diameter pipe
- Lower outlet pipe size increased to 1200 mm diameter pipe
- Installation of a 1050 mm diameter pipe at the base of the reservoir
- Installation of a 1200 mm diameter pipe at the base of the reservoir

The results of the study found were:

- Peak discharges up to 2.8 m^3/s were "acceptable" for changes in flood levels along Haunted Gully Creek.
- All modelled scenarios were deemed to be "acceptable" based on the 2.8 m^3/s threshold, except for full decommissioning.
- The "recommended solution" was determined to be operating Beaconsfield Reservoir via the Lower Outlet given it would reduce flood levels at each parcel.

1.2.6 Beaconsfield Reservoir Consequence Assessment (GHD, 2016)

GHD was engaged to reassess the Consequence Category of the existing dam and investigate two possible future scenarios, which could reduce the Consequence Category. The scenarios included:

- Current conditions
- Reduce FSL to half of existing FSL
- Reduce FSL to one quarter of existing FSL.

The results of the study concluded that:

- Current conditions had a High C Consequence Category for Sunny Day Failure (SDF), and a Significant Consequence Category for Wet Day Failure (for the DCF), respectively.
- At half FSL, failures for the SDF and DCF both had a Consequence Category of Significant.
- At quarter FSL, failures for the SDF and DCF both had a Very Low Consequence Category.

1.2.7 Dam Consequence Assessment Review – Stage 2 (HARC, 2016)

MWC engaged Jacobs and HARC in 2015 to "address the perceived inconsistencies in PLL estimates across MWC's portfolio of water supply dams and retarding basins (RBs)". To rectify this, MWC commissioned a project (Stage 1 – Jacobs and HARC) to review the data, methods and assumptions used to estimate PLL, and to consider recently emerged methods for estimating PLL. Stage 2 (HARC, 2016) involved using the Reclamation Consequence Estimating Methodology (RCEM) to estimate the PLL from failure of five dams - Beaconsfield, Frankston, Tarago, Thomson and Yan Yean. The results for Beaconsfield Reservoir were:

- SDF: PLL of 3.2
- DCF: PLL of 0.4
- Medium Severity of Damage and Loss
- The DCF had a 'Significant' Consequence Category
- The SDF was assessed as 'High A'.

1.2.8 Beaconsfield Dam Decommissioning Basis of Design Report (Jacobs, 2018)

Jacobs was engaged to develop a Basis of Design Report to further progress the state of the partial decommissioning:

- Preliminary concept design
- Discussion of the basis of design for each parameter and design references
- Stakeholder engagement
- Identification, assessment and proposed mitigation of data gaps and associated risks

At the commencement of the project, MWC indicated that they wished to decommission Beaconsfield Dam. In consultation with stakeholders as part of the project, it was found that maintaining a permanent water body was an important requirement. Therefore, the approach was changed to that of reducing the Consequence Category of the dam to a level where MWC would be able to safely handover the dam to the local council. It was determined that, under the Water Act 1989, this would require reducing the current Consequence Category of High C to Low or Very Low.

The Jacobs preliminary concept design involved the following design criteria:

- Lowering FSL to RL 92.0 mAHD by converting the existing scour to the primary spillway.
- Installing a hardened earth secondary spillway on the embankment, approximately 20 m wide down the centre of the crest at RL 97.0 mAHD.
- Lowering the dam crest level to RL 98.0 mAHD.
- Wetlands rehabilitation and stabilisation.

1.2.9 Beaconsfield Reservoir – Additional Hydrology, Dambreak and Consequence Assessment (GHD, 2018b)

GHD was engaged to develop Sunny Day Failure (SDF) and Wet Day Failure (WDF) consequence assessments of each of the three (3) options (A, B and C) proposed in the Jacobs concept design. GHD (2018) followed the general method undertaken in GHD (2016). The key difference was GHD (2018) used the revised stage-storage relationship determined from updated bathymetric survey undertaken by Taylors in 2017, which reduced the storage volume at all levels.

Using the updated stage-storage relationship, GHD arrived at the following:

- Option A, FSL RL 92.0 mAHD – Low Consequence Category
- Option B, FSL RL 93.0 mAHD – Low Consequence Category
- Option C, FSL RL 94.0 mAHD – Significant Consequence Category.

2. Background

2.1 Description of storage

Beaconsfield Reservoir is located on Haunted Gully Creek, approximately 45 km southeast of Melbourne in the suburb of Officer. The reservoir is an on-stream storage, with a local catchment area of approximately 334 ha. It was constructed by the State Rivers and Water Supply Commission in 1918 as part of a new water supply scheme for the Mornington Peninsula. Water was harvested from the Bunyip River and conveyed to Beaconsfield Reservoir by the Bunyip Main Race (BMR), which was later supplemented by the construction of the Tarago Main Race (TMR). The reservoir was permanently disconnected from Melbourne's water supply and distribution network in 1988 and now serves as an ornamental lake.

The site consists of a 24 m high earthfill embankment, a spillway on the left abutment, a low-level outlet passing through the foundation beneath the embankment, and a high-level outlet. During an upgrade in 1970, the original high-level outlet was decommissioned and grouted up, and a new high-level outlet was installed.

At the original Full Supply Level (FSL) of RL 103.08 mAHD, Beaconsfield Reservoir has a total storage capacity of 912 ML and a surface area of 14.6 ha. The reservoir is currently operated at a restricted level of 4.23 m below FSL at RL 98.85 mAHD, and has a capacity of approximately 410 ML.

Key information is summarised in Table 2-1 below with a comprehensive table shown in Appendix A.

Beaconsfield Reservoir is operated by Melbourne Water, but is located on Crown Land managed by the Department of Environment, Land, Water and Planning (DELWP). The Cardinia Environment Coalition (CEC) manage the surrounding Beaconsfield Nature Conservation Reserve under an agreement with the Minister for Water.

Table 2-1 Key information

Component	Description
Name	Beaconsfield Reservoir
Watercourse	Haunted Gully Creek is directly downstream of the reservoir
Location	Access from O'Neil Rd, Officer
Current Purpose	Ornamental lake
Upgrades	1970, 1988, 2014 (See Appendix A for details)
Population at Risk (PAR)	Sunny Day Failure: 334-408 Incremental Wet Day Failure: 1372-1676
Potential Loss of Life (PLL)	Sunny Day Failure: 2.2-2.8 Incremental Wet Day Failure: 8.9-11.6
Severity of Damage and Loss	Sunny Day Failure: Medium Incremental Wet Day Failure: Medium
Sunny Day Failure Consequence Category (ANCOLD 2012)	High C (based on PLL)
Incremental Wet Day Failure Consequence Category (ANCOLD 2012)	High A (based on PLL)

Component	Description
Type	On-stream storage
Full Supply Level (FSL)	RL 103.08 mAHD
Reduced Maximum Operating Level (MOL)	RL 98.85 mAHD
Minimum Operating Level	RL 90.86 mAHD
Total Storage Capacity at FSL	912 ML
Storage Capacity at restricted MOL	320 ML (revised by Taylors 2017)
Catchment area	334 ha
Reservoir surface area at FSL	14.6 ha
Type	Earthfill with (puddle) clay core and partial concrete cut-off
Crest level	RL 104.62 mAHD (nominal crest level) Sags by up to 0.6 m (to RL 104.02 mAHD)
Crest length	174 m
Crest width	1.8 m
Normal freeboard	1.54 m (FSL to nominal crest level) 5.77 m / 5.17 m (restricted MOL to nominal crest level / restricted MOL to lowest crest level)
Embankment Height	24.0 m
Upstream slope	2H:1V (above FSL) 3H:1V (below FSL)
Downstream slope	2H:1V Berm at RL 93.0 mAHD (approx.)
Type	Ogee crest with concrete channel at left abutment (Note: High Level Outlet now acts as the primary spillway, and the left abutment spillway as a secondary spillway)
Invert level	RL 103.08 mAHD
Length	17.8 m
Capacity	See Appendix A for further details.
Dam Crest Flood AEP	See Appendix A for further details.
High Level outlet works (current Primary Spillway)	Twin 1050 mm dia. nominal (42”) MSCL pipes. See Appendix A for further details.
Low Level outlet works & tunnel	Circular tower with intake at RL 90.87 mAHD and 450 mm or 500 mm (18”) nominal diameter pipeline (varies depending on source) through embankment within a tear drop culvert. Upstream and downstream valve control. See Appendix A for further details.
Abandoned structures	See Appendix A for further details.
Valves	See Appendix A for further details.
Outlet works capacity	See Appendix A for further details.
Inlet works	See Appendix A for further details.

Component	Description
Instrumentation	• 2 gauge boards • Electronic reservoir and rainfall monitoring • 9 standpipe piezometers • 11 movement markers

2.2 Identified risks

In 2010, URS (now AECOM) undertook a risk assessment of Beaconsfield Reservoir. The risk assessment identified a number of credible failure modes, which are presented below in Table 2-2, together with the annual probability of failure for each of the failure modes.

Table 2-2 Annual probabilities of failure (URS, 2010)

Failure mode	Condition	Annual Pr(f)
Downstream instability	Sunny Day	6.45E-05
Piping along spillway interface	Flood	5.50E-05
Piping through embankment	Sunny Day	8.18E-06
Flood overtopping	Flood	3.86E-06
Overtopping of spillway channel	Flood	2.18E-06
Downstream instability	Flood	8.10E-07
Piping through embankment	Flood	2.75E-07
Piping along outlet works	Flood	2.48E-09

The Beaconsfield Reservoir site presents a series of concerns as identified in the risk assessment, which have been actively managed by Melbourne Water. These include:

- Historical seepage: Most recently observed in August 2018 on the downstream right abutment groin. A reduced operating level of RL 98.85 mAHD has continued to assist limiting risk associated with this deficiency.
- Structural instability: Beaconsfield Dam has a factor of safety (FoS) of 1.36, which is below the minimum required FoS of 1.5 for long-term steady state loading.
- All other identified deficiencies are related to minor capital works, or operation and maintenance of Beaconsfield Dam.

2.3 Unit conversion

There are three different level datums referred to in the available drawings and documents relating to Beaconsfield Reservoir. The crest level of the spillway (the FSL) has been used as a reference point for unit conversions on the level datum. Equation 2-1 has been used for imperial to metric unit conversion.

Equation 2-1 Conversion

$$RL\ mAHD = RL\ (imperial) \times 0.3048 - 0.552$$

2.4 Reference drawings

A list of reference drawings for Beaconsfield Reservoir is provided in Appendix B.

3. Design criteria

3.1 General

The design criteria for this project have been developed to guide the concept design. It is noted that the design criteria for this project are focused on partial decommissioning of the dam. Additional design criteria will need to be developed if it is decided to completely decommission the dam, or retain the current FSL and fully upgrade the dam.

The key inputs used in the development of the design options include:

- Original design drawings – A list of reference drawings is provided in Appendix B
- Storage-elevation curve – The storage-elevation curve used in the analysis is provided in Appendix G
- Hydrology – The inflow hydrology used in the development of concept design is discussed in Appendix C
- Community and stakeholder input

3.2 Key design criteria

The key design criteria for the partially decommissioned storage include:

- The Consequence Category is reduced to Low. Based on the preliminary dambreak and consequence assessment, the following is noted:
  – Dambreak modelling described in Section 4 showed that an FSL of RL 94.0 mAHD was required to achieve a Low sunny day failure Consequence Category
- The key hydraulic criteria:
  – The partially decommissioned dam should not exceed the existing peak outflow for up to the 1 in 100 AEP flood event. The existing peak outflow is approximately 3.4 m^3/s for the 1 in 100 AEP flood.
  – The ANCOLD fallback criteria for flood capacity for a 'Low' Consequence Category dam is between 1 in 100 to 1 in 1000 AEP (ANCOLD Draft, 2016). For the purposes of this concept design, it has been assumed that the upgraded dam will be required to safely pass the 1 in 1000 AEP.
- Any upgrade works should be accordance with current industry practice.

Other design criteria, specific to each option, are discussed as required in the relevant sections of this report.

4. Full Supply Levels for Sunny Day Low Consequence Category

Sunny Day Failure breach modelling was undertaken with three different FSL scenarios, RL 95.0 mAHD, RL 94.0 mAHD and RL 93.0 mAHD, to confirm the design FSL that would result in a 'Low' Consequence Category. For all three scenarios, an embankment crest level of RL 97.0 mAHD was assumed for Sunny Day Failure modelling.

The details of the breach parameter estimation and modelling are provided in Appendix D.

The breach parameters adopted and resulting peak breach flows are summarised in Table 4-1.

Table 4-1 Adopted breach parameters

Scenario	Basis	Breach base width (m)	Breach development time (min)	Peak flow (m^3/s)
Sunny Day FSL = RL 93.0 mAHD (upper bound sensitivity)	Bureau of Reclamation	16	12	196
Sunny Day FSL = RL 93.0 mAHD (most likely)	**Froehlich (2008)**	**3.2**	**8**	**120**
Sunny Day FSL = RL 93.0 mAHD (lower bound sensitivity)	Min. Singh and Scarlatos breach base width with adjusted MacDonald Langridge Monopolis (after Wahl) breach time	5.4	22	84
Sunny Day FSL = RL 94.0 mAHD (upper bound sensitivity)	Bureau of Reclamation	19.2	14	273
Sunny Day FSL = RL 94.0 mAHD (most likely)	**Froehlich (2008)**	**4.5**	**10**	**184**
Sunny Day FSL = RL 94.0 mAHD (lower bound sensitivity)	Min. Singh and Scarlatos breach base width with adjusted MacDonald Langridge Monopolis (after Wahl) breach time	5.4	22	114
Sunny Day FSL = RL 95.0 mAHD (upper bound sensitivity)	Bureau of Reclamation	22	16	368
Sunny Day FSL = RL 95.0 mAHD (most likely)	**Froehlich (2008)**	**5.9**	**12**	**256**
Sunny Day FSL = RL 95.0 AHD (lower bound sensitivity)	Min. Singh and Scarlatos breach base width with adjusted MacDonald Langridge Monopolis (after Wahl) breach time	5.4	22	147

4.1 Downstream hydraulic modelling

A two dimensional model (TUFLOW) was used to model the floodplain flows below Beaconsfield Reservoir. The model extent is shown in Figure 4-1.

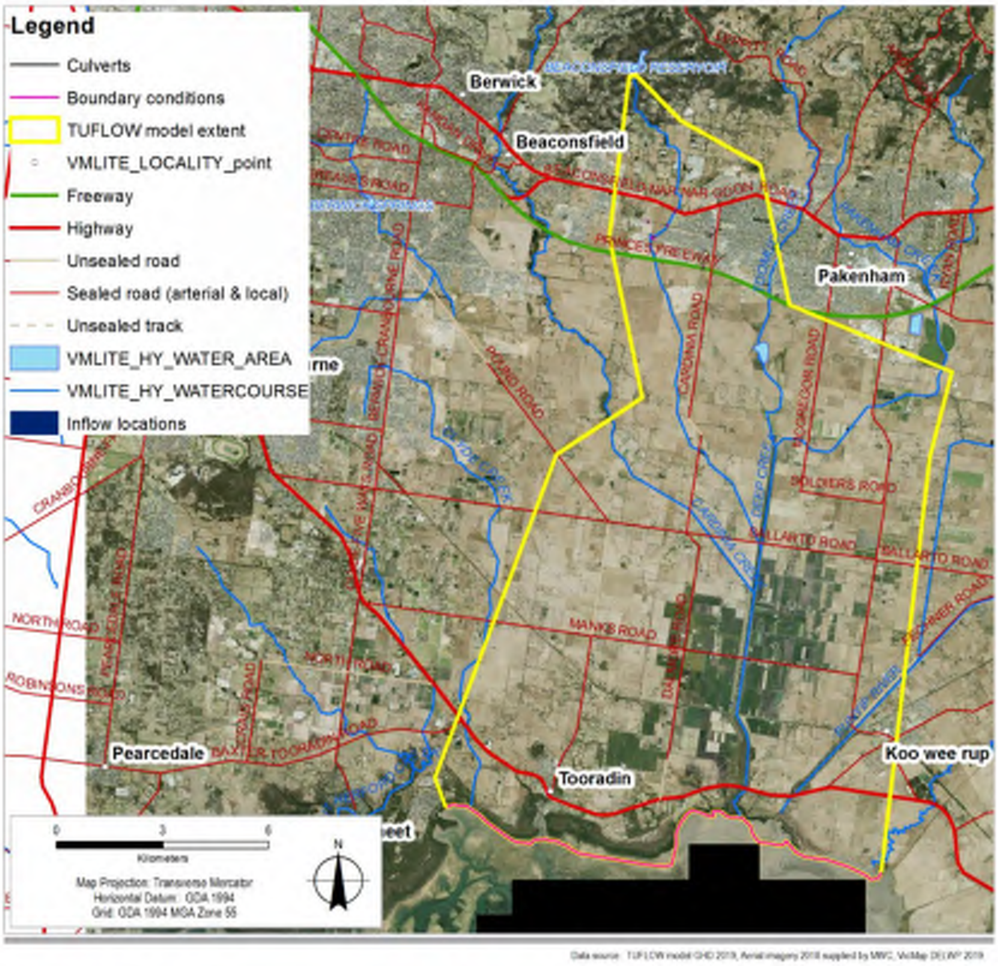

Figure 4-1 TUFLOW model extent

The reservoir outflow hydrographs generated using FLDWAV were used as input flows to the TUFLOW model.

The flood level and hazard (velocity depth product) results from the TUFLOW model were subsequently used to determine the Population at Risk (PAR) and the Potential Loss of Life (PLL).

Further details on the TUFLOW model may be found in the “Beaconsfield Comprehensive Inspection” and “Design-Hydrology and Consequence Category update” reports (GHD, 2019).

4.2 Population at Risk (PAR)

In accordance with the “Guidelines on the Consequence Categories for Dams” (ANCOLD, 2012), the Consequence Category is determined by assessing either the PAR or PLL, together with the Severity of Damage and Loss arising from downstream inundation caused by a dambreak.

According to ANCOLD (2012), the definition of PAR includes all persons who would be directly exposed to flood waters within a dambreak-affected zone at the onset of the dambreak if they took no action to evacuate. The dambreak-affected zone is defined as the zone of flooding where the changes in depth and velocity of flooding due to dambreak are such that there is potential for undesirable consequences. Although not specified in ANCOLD (2012), industry practice is to generally limit the count to those areas where the dambreak causes a rise in level of floodwaters greater than 300 mm.

The PAR downstream of Beaconsfield Reservoir may originate from a number of sources:

- Scout camp (Camping ground, nature walk, canoe area)
- Boon Roses
- Dwellings
- Princes Highway

GIS procedures were used to calculate the number of buildings and length of major roads inundated. Two distinct time periods were assumed for estimating the PAR:

- Day time (10 hours)
- Night time (14 hours)

4.3 PLL summary for Sunny Day Failure

The Sunny Day Failure PLL from each main source is summarised in Table 4-2.

Table 4-2 Summary of Sunny Day PLL estimates

Scenario	PLL buildings floor level – night UK RARS	PLL buildings floor level – night USBR suggested median	Scout Park – USBR overall upper	Boon Roses – USBR suggested upper (day only)	Princes Highway	Total day	Total night (using USBR suggested median for dwellings)
FSL=93 mAHD (2-3 buildings affected above floor)	0.007 – 0.02	0.03-0.04	0.01 (day)	0.04	0	**0.06 - 0.07**	0.03-0.04
FSL=94 mAHD (3-4 buildings affected above floor)	0.02-0.05	0.04-0.06	0.011-0.02(day) 0-0.02 (night)	0.04	0	**0.07 - 0.09**	0.04-0.08
FSL=95 mAHD (3-4 buildings affected above floor)	0.03-0.11	0.04-0.06	0.03-0.06 (day) 0.02- (night)	0.04	0.01 (day and night)	**0.10 - 0.15**	0.05-0.09

The ANCOLD (2012) Guidelines for Consequence Categories states that a PLL of <0.1 is required to achieve a Low consequence. The estimated PLL during a Sunny Day Failure for the FSL of either RL 93.0 mAHD or RL 94.0 mAHD achieves a Low Consequence Category in accordance with ANCOLD (2012). A FSL of RL 95.0 mAHD shows an estimated PLL of >0.1. The Severity of Damage and Loss is estimated to be Medium, the basis for which is included in Appendix E . Due to the community desire to keep the water level in the reservoir as high as possible, the RL 94.0 mAHD FSL option has been progressed.

5. Options assessment

5.1 General

As part of the assignment, a wide range of upgrade options were considered. The reason for this initial phase was to demonstrate that partial decommissioning was the most appropriate for dam safety, stakeholders and MWC.

The options considered for Beaconsfield Reservoir included three partially decommissioned options (refer Options 1A to 1C), and one fully decommissioned option (refer Option 2). These were compared with a full dam safety upgrade as per GHD's 2012 concept design (refer Option 3).

Table 5-1 below summarises the key changes to Beaconsfield Reservoir based on the upgrade options initially considered.

Table 5-1 Summary of concept options as initially considered

Component	Option	Partial decommissioning			Full decom'ing	Full dam safety upgrade
		1A	1B	1C	2	3
N/A	Retain Current FSL (Crest raising, increase spillway, full-height filters)					✓
Low Level Outlet Modifications	Modify Low Level Outlet to Primary Spillway	✓	✓			
	Decommission Low level Outlet			✓		
High Level Outlet Modifications	Decommissioning High Level Outlet	✓	✓	✓		
Embankment Modifications	Lowered embankment crest – Partial section overtops (secondary spillway) – Concrete with rock-lined chute	✓				
	Lowered embankment crest – Full length overtops (secondary spillway)		✓			
	Lowered embankment crest – Partial section overtops (secondary spillway) – Culverts			✓		
	Complete removal of embankment and structures				✓	

Preliminary details of the scope of work of these options, and preliminary hydraulics, are provided in the following sub-sections.

5.2 Option 1 – Partial decommissioning

Partial Decommissioning involves a reduction in the Consequence Category to Low or Very Low without an increase in the peak outflow, up to the 1 in 100 AEP, when compared with the existing arrangement. A partial decommissioning upgrade offers the benefit of retaining the ornamental lake for community benefit while minimising risk and cost to Melbourne Water. Reducing Beaconsfield Reservoir from a High A to Low Consequence Category reduces the ANCOLD (2003a) recommended frequencies of inspections. Comprehensive Dam Safety Inspections are reduced from 5-yearly to 'not required'. Intermediate Dam Safety Inspections are reduced from annual to 5-yearly and routine visual inspections are reduced from daily-tri-weekly to monthly. Three partial decommissioning options were initially investigated.

The three partial decommissioning options assessed include:

- Decommissioning the High Level Outlet including demolishing the outlet tower and valve pit, grouting the pipework with valves to be 'locked out', whilst the Valve House would be retained for storage.
- A FSL at RL 94.0 mAHD.
- A primary spillway as either a new or retrofitted pipe and inlet structure to pass the 1 in 100 AEP event without changing the current peak outflow.
- A secondary spillway to pass the 1 in 1000 AEP event.
- The Low Level Outlet tower superstructure including bridge and hoist house removed and the substructure cut flush with the embankment.
- Concrete grouting of the annulus between the Low Level Outlet cast iron pipe and concrete tunnel.
- Erosion protection required at toe, and to be considered for the embankment based on estimated velocities during detailed design.
- 5H:1V downstream slope tied into the natural surface.
- Landscaping of the site and wetlands to maximise the quality of community space.

5.3 Option 2 – Full decommissioning

Full Decommissioning eliminates all dam safety risks associated with Beaconsfield Reservoir by removing the water retaining structure, and has no ongoing dam maintenance costs.

However, there would be no permanent water body, a large construction period, impacts to the flora and fauna within a Nature Conservation Reserve and risks associated with the removal of potentially hazardous silt.

Full decommissioning includes:

- Removal of the embankment.
- Removal of all appurtenant works including the current outlet works (including Valve House), original outlet works (including those previously abandoned through grouting), Low Level Outlet and spillway.
- Removal and disposal of deposited silt.
- Stream bed and bank rehabilitation.
- Return stream to pre-dam flows.

5.4 Option 3 – Full Dam Safety Upgrade

A Full Dam Safety Upgrade will address the risks identified by URS (2010) and although not formally assessed, it is expected that this upgrade would largely satisfy ALARP principles. For the purpose of this report, the concept design (GHD, 2012) was considered appropriate.

The Full Dam Safety Upgrade would retain the restricted FSL (or higher depending on Melbourne Water's appetite for risk) thereby retaining maximum functionality of the reservoir for community use.

The upgrade is considered to undergo a longer and more costly construction phase than Options 1 and 2, causing disruptions to the community's accessibility to the reservoir. Ongoing dam safety surveillance and maintenance would be required due to an either High C or High B Consequence Category, and therefore it is considered prudent to have the site closed to the public due to public safety issues such as the high embankment and exposed rock faces.

The Full Dam Safety Upgrade (GHD, 2012) includes:

- Full-height filter buttress placed on the downstream batter with weighting fill placed over the top. The filters are designed to reduce the risk of piping which was a key contributing risk (URS, 2010).
- Restricted FSL becomes the permanent FSL at RL 98.85 mAHD.
- Convert the High Level Outlet to the primary spillway including the removal of all valves, replacement of the intake screens from a fine screen to a coarse screen. The pipe would be altered to combine flows (as opposed to running parallel the entire length) and plugging the unused section of the pipe downstream. A USBR Impact Basin energy dissipator to retard flows into Haunted Gully Creek would be constructed.
- Concrete grouting of the annulus between the cast iron pipe and concrete tunnel in the Low Level Outlet. This will reduce the risk of piping along and within the outlet and is considered a prudent measure.
- Re-profile the embankment crest where low points exist. Removing any low points will reduce the risk of overtopping.
- Minor capital works as noted in previous Annual Inspections, including works to the access roads, Valve House and operations and maintenance improvements such as pit lids, railing and platforms.

5.5 Option 4 – 'Do Nothing'

A 'Do Nothing' option is a control option and used to provide a base case for the options. By doing nothing, the Consequence Category and risk profile remain unchanged. Beaconsfield Reservoir is considered to not currently meet ALARP, plotting within an order of magnitude of the ANCOLD Limit of Tolerability at the 50% and 80% confidence intervals, and plotting above the ANCOLD Limit of Tolerability for the 95% confidence interval. Therefore, 'Do Nothing' is not in accordance with ANCOLD guidelines, good practice and precedent or the Strategic Framework for Dam Safety Regulation (DELWP, 2014).

5.6 Multi-criteria analysis on options

Following discussions with stakeholders in September 2018, a multi-criteria analysis was requested by a select group of community representatives to explain the more technical aspects of the project be undertaken on the four options provided above. The purpose of a multi-criteria analysis is to undertake a complimentary approach, in order to identify the best method to achieving a series goals set out by stakeholders directly and indirectly involved with this reservoir.

The analysis was undertaken initially by determining a set of categories and weightings. This was then presented to MWC where updates were made as a group. Finally, the analysis was presented to the public where additional opinions and suggestions were received and updated where appropriate.

The analysis considered cost and dam safety as equally weighted categories and contributing 60% to the total score. Community impacts and environment and conservation impacts were equally weighted and made up the remaining score.

Each of the four categories contained a number of sub-categories each with weighting as well.

The MCA results from Table 5-2 illustrate that a Partial Decommissioning option is the most appropriate strategy for Melbourne Water. Partial Decommissioning addresses community interest in the reservoir while minimising construction cost and lowering ongoing maintenance costs. Commentary on the Category, Sub-category and Options weightings are provided in Appendix F.

Table 5-2 Multi-criteria analysis

MCA categories & sub-categories		Category weighting	Sub-category weighting (out of 4)	OPTIONS			
				1	2	3	4
				Partial decom'ing / partial height dam	Full decom'ing / removal of dam	Safety upgrade (full upgrade)	Do nothing / current arrangement
1	**Cost**	**30**		21.3	15.6	17.3	23.1
1.1	Construction cost		4	3	1	2	4
1.2	Ongoing maintenance cost		4	3	4	2	1
1.3	Cost of public amenity operations and maintenance		1	3	3	4	4
1.4	Approvals, public engagement costs		2	2	1	3	4
1.5	Design, engineering costs		2	3	1	2	4
2	**Satisfying ALARP**	**30**		25.7	30.0	21.4	7.5
2.1	F-N Position / Life safety risk		4	3	4	2	1

MCA categories & sub-categories		Category weighting	Sub-category weighting (out of 4)	OPTIONS			
				1	2	3	4
				Partial decom'ing / partial height dam	Full decom'ing / removal of dam	Safety upgrade (full upgrade)	Do nothing / current arrangement
2.2	Compliance with good practice		3	4	4	4	1
3	**Community impacts**	**20**		16.3	10.5	16.5	16.5
3.1	Provision of public amenities and safe access		3	4	4	3	2
3.2	Visual appearance of landscape		4	4	4	3	2
3.3	Visual appearance of lake/retained water		3	2	1	4	4
3.4	Retention/incorporation of heritage & 'past infrastructure' elements		1	4	2	3	4
3.5	Impact on community by construction activity, vehicle movements, etc		3	3	1	2	4

MCA categories & sub-categories		Category weighting	Sub-category weighting (out of 4)	OPTIONS			
				1	2	3	4
				Partial decom'ing / partial height dam	Full decom'ing / removal of dam	Safety upgrade (full upgrade)	Do nothing / current arrangement
3.6	Fire		3	3	1	4	4
3.7	Flood mitigation		3	3	1	4	4
4	**Environmental and conservation impacts**	**20**		15.0	5.0	10.0	17.5
4.1	Construction and rehabilitation period		3	2	1	2	4
4.2	Long-term impacts on flora & fauna communities		3	4	1	2	3
	TOTAL SCORE	**100**		**78.3**	**61.1**	**65.2**	**64.6**

6. Partial decommissioning options assessment

6.1 General

Following the MCA, three partial decommissioning options were further developed. The key design criteria for the partial decommissioning options were:

- The dam must have a Low Consequence Category as per the ANCOLD Guidelines on the Consequences Categories for Dams (2012).
- No increase in flows up to the 1 in 100 AEP outflow. The current peak outflow at Beaconsfield Reservoir is 3.4 m^3/s and should not increase as part of the upgrade, so as to not increase downstream flooding during frequent flood events.
- Safely pass the 1 in 1000 AEP flood event. The ANCOLD Guidelines on Selection of Acceptable Flood Capacity for Dams (Draft, 2016) recommends that dams with a Consequence Category of Low or Very Low should safely pass floods between 1 in 100 AEP (for Low and Very Low Consequence Category) and 1 in 1 1000 AEP (Low Consequence Category).

Three options were initially considered in terms of partial decommissioning, namely:

- Option 1A - Allowing discharges greater than the 1 in 100 AEP to pass through a wide channel through part of the embankment section on the abutment.
- Option 1B - Allowing discharges greater the 1 in 100 AEP to overtop the full length of the embankment.
- Option 1C - Allowing discharges greater than the 1 in 100 AEP to pass through box culverts, which are narrower and taller than the channel in Option 1A.

Appendix I contains drawings showing key details of concept options 1A to 1C.

6.2 Concept Design Options 1A to 1C

Table 6-1 Detailed of Concept Options 1A to 1C

Component	Option 1A	Option 1B	Option 1C
Description	Modify low level outlet to primary spillway and broad crested weir secondary spillway	Modify low level outlet to primary spillway and overtoppable embankment as secondary spillway	Decommission low level outlet and install new pipe as primary spillway and concrete culverts as secondary spillway
FSL	RL 94.0 mAHD	RL 94.0 mAHD	RL 94.0 mAHD
Embankment	• Dam crest at RL 96.80 mAHD • 37 m (approx.) crest width – to improve stability and reduce piping risk • 5H:1V downstream batter grade – to improve downstream slope stability and reduce piping risk • Fill from crest lowering to be placed on downstream embankment • Topsoil and plants per landscape design – to improve public amenity	• Overtoppable dam crest at RL 96.30 mAHD • 110 m (approx.) overtoppable embankment length • Hardened surface of either concrete or hardened earthfill to control dam crest level • 39 m (approx.) crest width – to improve stability and reduce piping risk • Reno mattress approx. 250 mm thick where overtoppable with topsoil and plants per landscape design – to provide erosion protection • 5H:1V downstream batter grade – to improve downstream slope stability and reduce piping risk • Fill from crest lowering to be placed on downstream embankment • Swale drain at toe to prevent pooling of water	• Dam crest at RL 97.00 mAHD • 36 m (approx.) crest width – to improve stability and reduce piping risk • 5H:1V downstream batter grade and tied into natural surface – to improve downstream slope stability and reduce piping risk • Fill from crest lowering to be placed on downstream embankment • Topsoil and plants per landscape design – to improve public amenity

Component	Option 1A	Option 1B	Option 1C
Secondary Spillway	• Spillway crest at RL 96.0 m – to not increase the peak flows for the 1 in 100 AEP event • 40 m (approx.) spillway width through crest • An earthen approach channel leading to the concrete structure – to improve the efficiency of the spillway, minimising the required size to safely pass the 1 in 1000 AEP event • Spillway founded on good quality rock – to minimise scour • Cut-offs at the upstream and downstream ends of the structure – to minimise piping along the spillway interface • Downstream chute; rock-lined channel and able to be covered by topsoil and grass – to maximise public amenity	See *Embankment* for details	• Twin concrete culverts at RL 95.8 mAHD – to not increase the peak flows for the 1 in 100 AEP event • Twin concrete box culverts approximately 1.7 m in width with internal dimensions of 1.5 m wide and 1.2 m high • 40 m (approx.) spillway width through crest • An earthen approach channel leading to the concrete structure – to improve the efficiency of the spillway, minimising the required size to safely pass the 1 in 1000 AEP event • Spillway founded on good quality rock – to minimise scour • Cut-offs at the upstream and downstream ends of the structure – to minimise potential for piping along the spillway interface • Downstream chute -rock-lined channel
Primary Spillway	See *Low Level Outlet* for details		• New DN 600 pipe installed at RL 94.0 mAHD • Concrete encased under the secondary spillway to prevent piping • Discharge into the secondary spillway downstream chute

<table>
<tr><th>Component</th><th>Option 1A</th><th>Option 1B</th><th>Option 1C</th></tr>
<tr><td>Low Level Outlet</td><td colspan="2">• Install concrete riser to raise low level outlet to RL 94.0 mAHD at upstream toe of dam with coarse trashrack on top – to maximise water level for community while maintaining Low or Very Low Consequence Category
• Low level outlet Tower Bridge flush with the embankment crest. Removal of hoist house and top section of the tower. Bulkhead facility to be retained in case isolation is required – for public safety
• Downstream valve pit to be decommissioned by removing valves and installing a manhole cover for public safety while retaining accessibility
• Concrete backfill the annulus between the cast iron pipe and the concrete tunnel to reduce the risk of bursting of the cast iron pipe – to reduce the risk of piping
• Consideration should be given to the installation of a filter collar around the downstream end of the modified Low Level Outlet – to reduce the risk of piping
• Consideration should be given to sleeving the section of pipe between the upstream intake and the tower with a DN 450 pipe and grouting the annulus given the potential risk of piping (currently unknown condition of pipe and joints) – to reduce the risk of piping</td><td>Decommissioning of the Low Level Outlet. Works include:
• Pipework – Concrete backfilling or grouting of the complete section of pipe from the concrete core wall to the upstream intake shaft
• Tower – The existing Low Level Outlet tower bridge to be removed and the top of the tower flush with the revised embankment crest level. The remaining ‘stub’ section of the tower would be backfilled with concrete
• Consideration should be given to concrete backfilling the annulus between the cast iron pipe and the concrete tunnel to reduce the risk of bursting of the cast iron pipe – to reduce the risk of piping
• Consideration should be given to the installation of a filter collar around the downstream end of the modified Low Level Outlet – to reduce the risk of piping</td></tr>
<tr><td>High Level Outlet</td><td colspan="3">• Grouting – The full length of the twin pipes would be grouted
• Consideration of a downstream filter collar
• Consideration of public safety and the demolition of the outlet tower – it is noted that demolition of the tower is not a dam safety requirement
• Downstream valve house – The structure would be retained with valves locked out and ladder removed
It is noted that the extent of decommissioning on many of the High Level Outlet features is likely to be a risk-based decision in terms of both dam and public safety aspects.</td></tr>
</table>

6.3 Check of dambreak results for Option 1A

6.3.1 Determination of the AEP of the DCF

The preferred concept design Option 1A was configured in a RORB model. A range of very rare to extreme floods were routed through the reservoir. The AEP of the DCF estimated to be 1 in 1000 AEP, with the 12 hour GSAM duration being critical. The flood frequency (assuming glass walling) is shown in Figure 6-1 below.

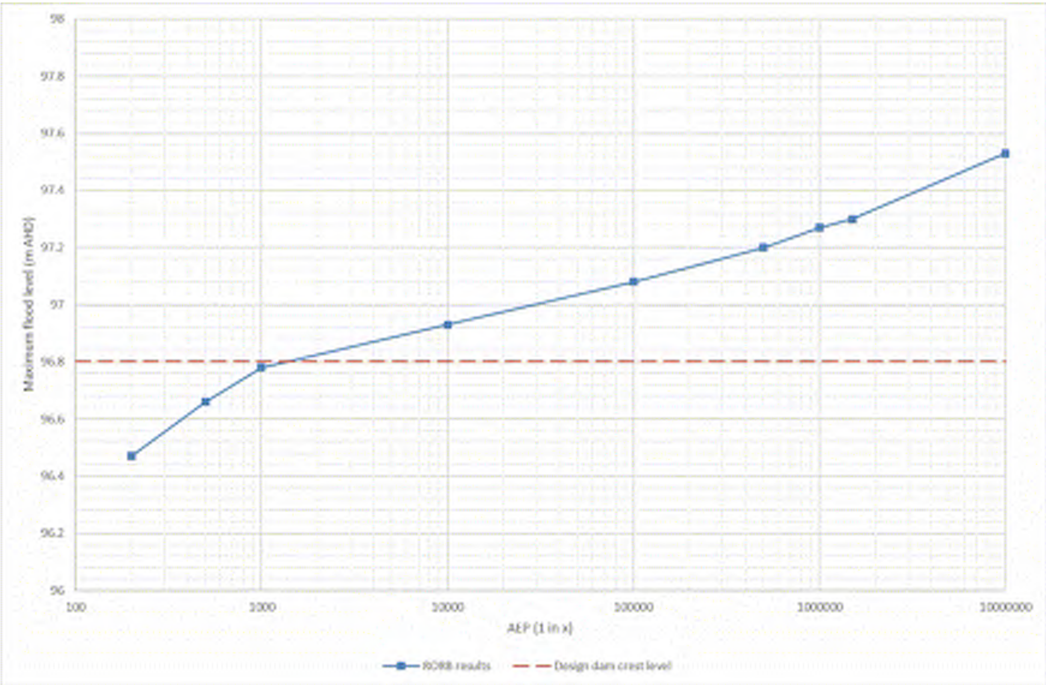

Figure 6-1 Concept Option 1A flood frequency (glass-walled)

6.3.2 Breach parameters

The range of breach parameters estimated from empirical equations is given in Table 6-2.

Table 6-2 Breach parameters from empirical equations for Option 1A DCF

Empirical equation	Side slope	Option 1A DCF breach base width (m)	Option 1A DCF breach development time (min)
MacDonald Langridge Monopolis (Wahl)[1]	0.2	1.2	17
Bureau of Reclamation	0.2	27.4	19
Froehlich (2008)[2]	0.7	8.2	16
Von Thun Gillette (1990)	1	20.8	47
Singh and Scarlatos minimum breach base width	0.2	5.4	22 (applying Wahl earthfill equation to volume of embankment eroded)

These breaches were simulated in FLDWAV, with the resulting breach hydrographs shown in Figure 6-2 following.

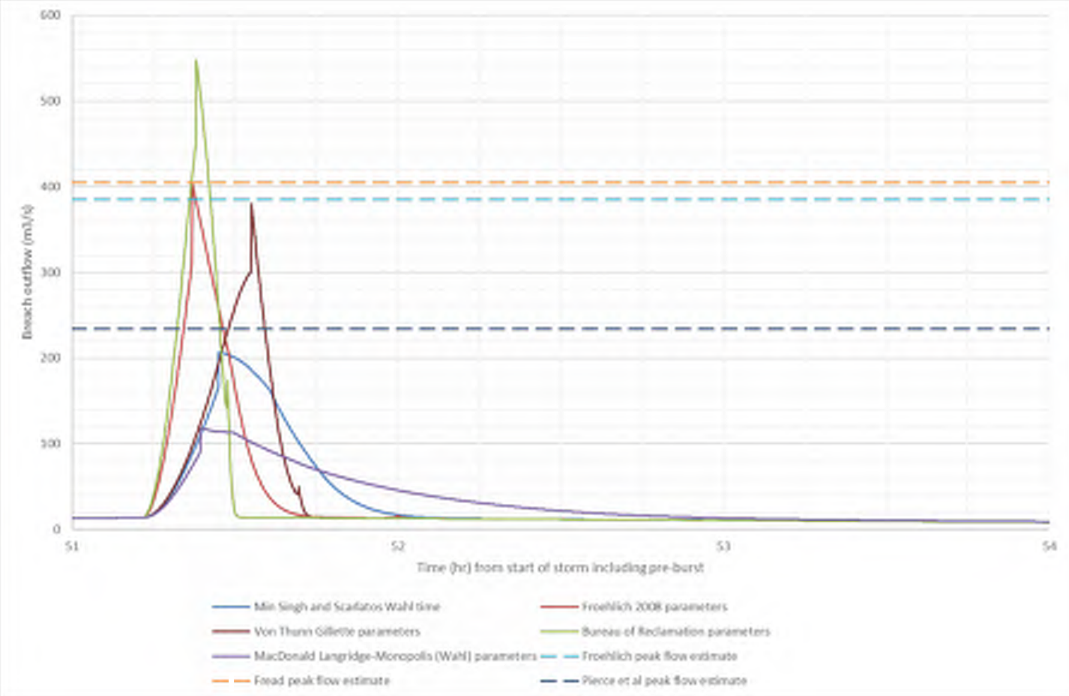

Figure 6-2 Concept design Option 1A – DCF breach hydrographs

Following inspection of the breach hydrographs the breach parameters shown in Table 6-3 were selected, with the respective hydrographs simulated in the TUFLOW model to inform the Consequence Category Assessment.

Table 6-3 Adopted breach parameters for Option 1A

Scenario	Basis	Breach base width (m)	Breach development time (min)	Peak flow (m^3/s)
No breach		NA	NA	14
Upper bound sensitivity	Bureau of Reclamation	27.4	19	547
Most likely	**Froehlich (2008)**	**8.2**	**16**	**403**
Lower bound sensitivity	Min Singh and Scarlatos breach base width with adjusted MacDonald Langridge Monopolis (after Wahl) breach time	5.3	23	207

6.3.3 PAR and PLL estimation for Option 1A

The area of 300 mm incremental depth extends to the Princes Freeway, as shown in Figure 6-3 below. The flood maps for a dambreak following upgrade in accordance with Option 1A can be found in Appendix D.

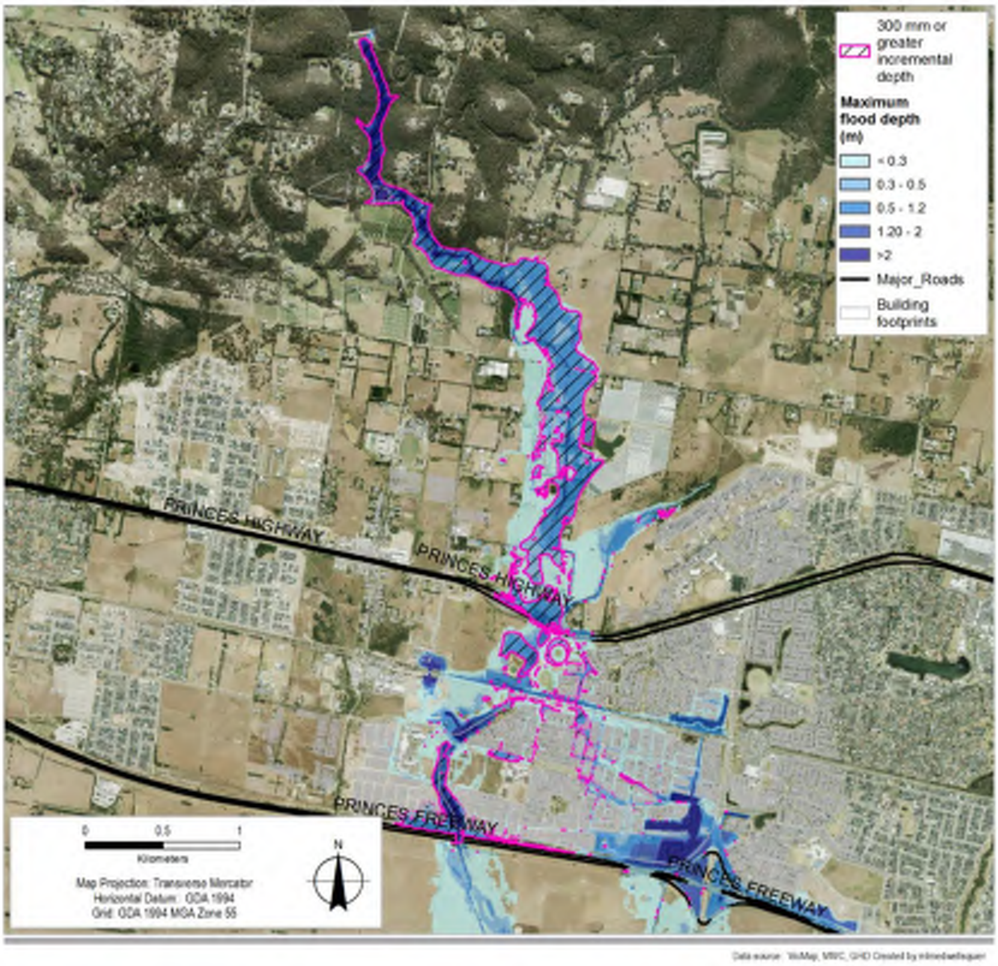

Figure 6-3 Area of greater than 300 mm incremental depth for Concept Design Option 1A (DCF breach)

6.3.4 No breach fatality rates for Option 1A

The fatality rates previously discussed for dambreaks in relation to the Sunny Day Failure are not directly applicable to the estimation of loss of life in non-dam failure flood situations. Hill et al. (2007) where the Graham fatality factors were compared to large historical floods undertook an investigation. In the 2007 investigation, it was recommended that for a low flood severity a fatality rate of 0.0002 be adopted. For a medium flood severity with a warning time greater than 60 minutes, a fatality rate of 0.005 (vague) to 0.002 (precise) was recommended.

6.3.5 Dwelling summary for Option 1A

The PAR and PLL from dwellings relating to a DCF breach, assuming upgrade in accordance with Option 1A, are shown in Table 6-4. The Scout Camp is assumed not to be occupied during extreme weather.

Table 6-4 Option 1A concept PAR and PLL for DCF failure

Parameter	Day	Night	Day/Night	Day	Night	Day/Night
Scenario	No Breach			DCF piping breach		
Number affected buildings - Floor Level	3			103-128		
PAR Buildings (USBR, 2014) - Floor Level	4	8	7	144-179	288-358	228-284
PLL Buildings (USBR, 2014) - Floor Level	0.000	0.001	0.001	0.728-0.905	1.456-1.810	1.153-1.433
PLL Buildings (UK RARS, 2013) - Floor Level	0.000	0.001	0.001	0.262-0.411	0.524-0.822	0.414-0.650

As they are greater than 0.1, these PLL estimates do not satisfy the requirements of a “Low” or “Very Low” Consequence Category. Therefore, the design was iterated as discussed in Section 6.4 in order to arrive at an upgrade solution that results in a “Low” Consequence Category for both sunny day and wet day failure scenarios.

6.4 Additional Concept Design (Option 1D)

6.4.1 Development of Option 1D

The initial concept options (Options 1A to 1C) were developed on the assumption that the sunny day failure was the critical scenario with a wet day scenario to only be considered as a ‘final check’. However, based on the revised hydrology and consequence assessment (refer to Section 6.3), it was apparent that the wet day failure scenario is more critical. The concept design was further developed (Option 1D) to achieve a Low Consequence Category under both sunny day failure and wet day failure scenarios.

The recommended concept design (Option 1D) maintains modifying the Low Level Outlet (LLO) to act as the primary spillway and installs a secondary spillway through the embankment. However, the embankment crest and spillway invert levels were both lowered. This was to reduce the volume of water stored under DCF loading and ultimately reduce the PLL to below 0.1 for DCF dambreak. This arrangement achieved a Low Consequence Category under both wet and sunny day scenarios.

Further details based on the recommended concept design (Option 1D) are discussed in Sections 6.4.2 to 6.4.5, with a comparison between Option 1A and 1D key design features presented below in Table 6-5.

Table 6-5 Comparison of key design features - Options 1A and 1D

Key Component	Option 1A	Option 1D
Primary Spillway	Existing LLO converted to primary spillway at RL 94.0 mAHD	
Dam Crest Level	RL 96.8 mAHD	RL 96.1 mAHD
Secondary Spillway type	Constructed on good quality natural rock through crest with concrete sill discharging into downstream rock beaching-lined channel	
Secondary Spillway level	RL 96.00 mAHD	RL 95.50 mAHD
Secondary Spillway length	10 m	
Existing HLO	Decommissioned	

6.4.2 Embankment details for Option 1D

The proposed concept design (Option 1D) involves lowering the embankment crest level from RL 104.03 mAHD (existing) to RL 96.1 mAHD. The excavated material would be used to construct the downstream batter at a slope of 5H:1V. This would assist in addressing key failure modes identified in the risk assessment by URS in 2010:

- Improving downstream stability through re-profiling the embankment.
- Reducing piping risk via an increased flow path and reducing the maximum hydraulic gradient.

The reduced dam crest level reduces the dam crest flood (DCF) given a smaller storage volume, reducing the consequences of failure. The embankment crest will be graded towards the downstream side at 3%, for approximately 37 m. The new downstream batter will have a 5H:1V slope and will be tied into the natural surface at the downstream toe with the top 150 mm (confirmed in future designs) stripped to provide good connection between the existing embankment and new weighting fill.

A number of erosion protection products have been discussed for the embankment downstream batter during the concept design including rock, reno mattress, GeoWeb and grass. For the purposes of this concept design and associated cost estimates, the crest and downstream batter of the embankment were assumed to be grassed (potentially planted with native grasses) to provide some degree erosion protection during overtopping of the embankment. The requirements for erosion protection of the downstream batter should be confirmed in the detailed design, when velocities are further assessed. The toe of the downstream batter will have a spoon drain to provide drainage, with specific reno mattress or rock erosion protection.

A typical cross section of the lowered embankment can be seen in Figure 6-4.

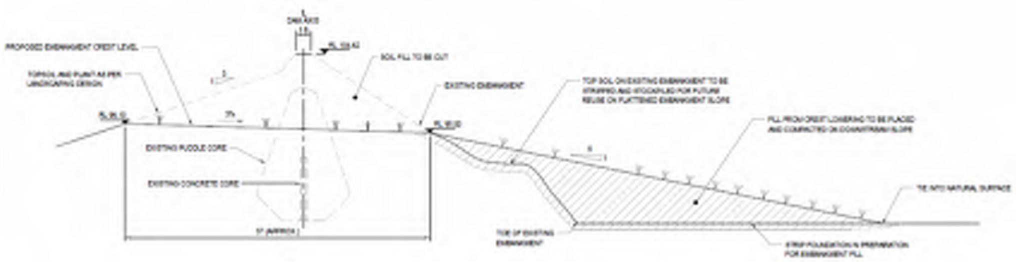

Figure 6-4 typical cross section of lowered embankment – Option 1D

6.4.3 Secondary spillway design for Option 1D

A new secondary spillway would be constructed at RL 95.50 m and be 10 m long. It is preferable to found the structure on rock wherever possible, to minimise differential settlement and foundation related issues. This means that the structure would be located on one of the abutments as opposed to the centre of the embankment section, as seen in Figure 6-5 following. The spillway would extend the width of the crest (approximately 40 m) directing flows into a rock-lined channel to discharge flows into the downstream creek. The spillway chute would need to be modelled as part of the detailed design. The key components of the new secondary spillway include:

- Approach channel – an earthen approach channel leading to the concrete sill.
- Excavation into rock – the structure would be founded on quality rock with local demolition of the core wall to accommodate the concrete sill structure being founded on rock (refer to Figure 6-6).

- It is also likely that cut-offs will be required at the upstream and downstream ends of the structure to minimise seepage and erosion beneath the spillway floor.
- Downstream chute – the chute would extend from the downstream shoulder of the crest to approximately the toe of the dam as seen in Figure 6-7 following. At the toe, the chute would direct flows into a rock-lined stilling basin, discharging into the downstream creek.

The secondary spillway design is set at RL 95.50 mAHD, which together with the primary spillway (refer to Section 6.4.4) does not increase peak flows downstream during frequent floods, up to and including the 1 in 100 AEP event. The corresponding peak flow was found to be approximately 5.5 m^3/s. The relatively wide spillway also provides greater discharge capacity, thereby increasing the discharge capacity at all levels above the spillway crest, enabling the 1 in 1000 AEP event to be safely passed.

The decommissioning of the previous broad crested spillway reduces all probability associated with piping along the spillway interface which represented 47% of total risk at Beaconsfield Reservoir. The setting of the new secondary spillway in good quality rock will help to mitigate any potential for piping risks along the spillway interface.

A key requirement of the scope was to maintain and improve public amenity of the space. Landscaping the rock-lined channel, stilling basin and decommissioned broad crested spillway, as discussed in Section 8, will improve public space and contribute towards stakeholder satisfaction.

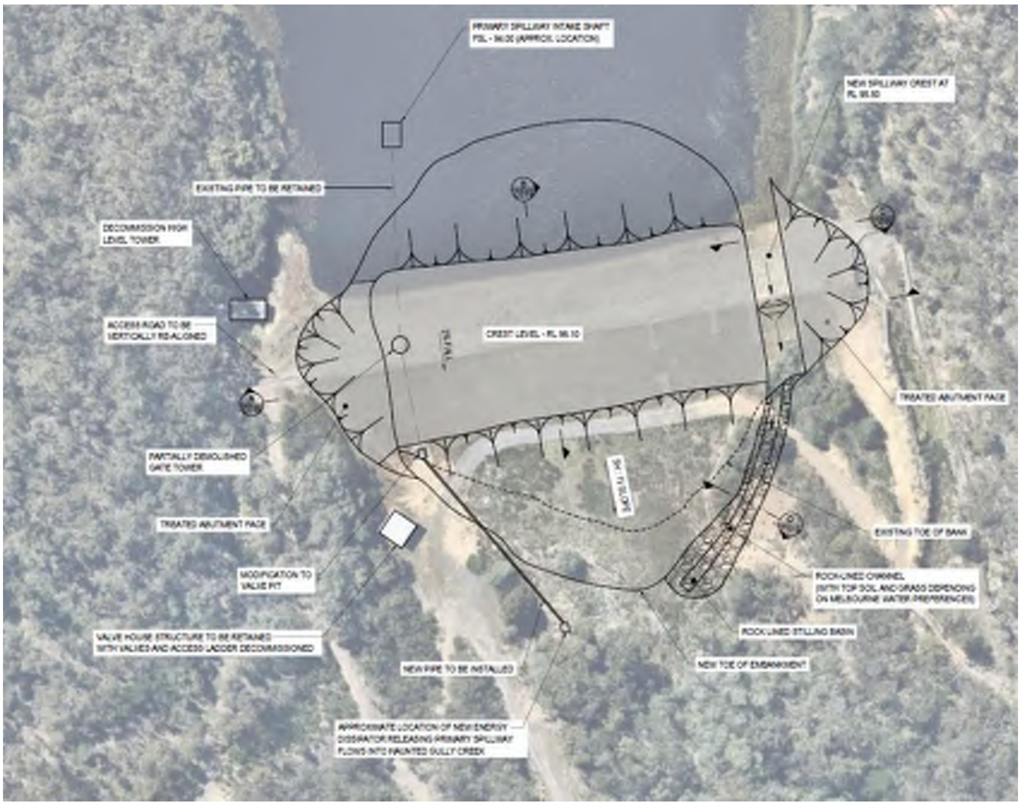

Figure 6-5 Arrangement of spillway and downstream chute – Option 1D

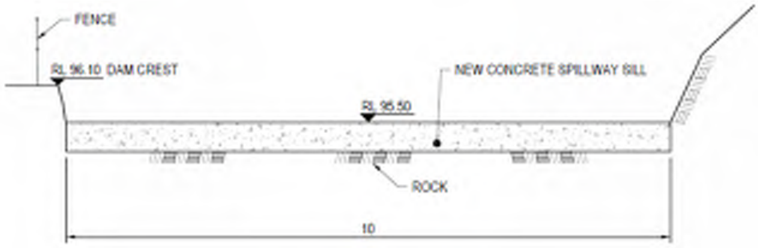

Figure 6-6 Cross section of concrete spillway crest – Option 1D

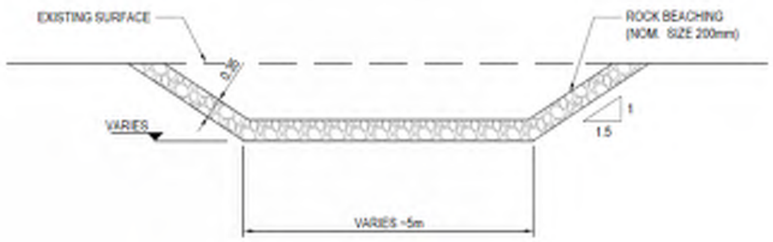

Figure 6-7 Typical section of rock-lined channel – Option 1D

6.4.4 Low Level Outlet converted to primary spillway for Option 1D

Under the proposed concept design, the current Low Level Outlet would be converted to the primary spillway with an invert level of RL 94.0 m. Included in this package of work are:

- Intake shaft – The concrete intake shaft at the upstream toe of the embankment would be raised to the revised Full Supply Level (RL 94.0 m) by breaking back the existing concrete to expose the existing reinforcement, splicing new reinforcement and forming a new vertical shaft. A coarse trashrack (birdcage) would be constructed over the intake shaft. Refer to Figure 6-8 and Figure 6-9 for details.

Figure 6-8 'Birdcage' trashrack (1)

Figure 6-9 'Birdcage' trashrack (2)

- Tower – The existing low-level outlet tower bridge would be removed, and the hoist house and top section of the tower would be demolished down to the revised embankment crest level. Minor works would be required at the top of the partially demolished tower to prevent public access to the tower. It is proposed that the bulkhead facility be retained in case isolation of the outlet downstream of the tower is required (for maintenance and inspection purposes). Refer to Figure 6-10 following for details.
- Cast iron pipework – Concrete backfilling the annulus between the cast iron pipe and the concrete tunnel should be undertaken to reduce the risk of bursting of the cast iron pipe
- Valve pit and outlet – The downstream valve pit would be partially removed to eliminate the confined space. The downstream valve would be removed and replaced with a manhole cover in case access is required for CCTV inspection of the pipe. Minor modifications would be made to the downstream pipework to enable uncontrolled discharges to the downstream creek including installing new pipework downstream of the valve pit and excavating (if required) the abandoned pipework. Refer to Figure 6-11 following for details.
- New energy dissipator – At the downstream end of the primary spillway pipework, the pipe would discharge into an Impact Energy Dissipating Basin. This basin has been successfully implemented on other projects with similar flow velocities. However, depending on MWC's preferences, there is flexibility in design. Downstream of the impact basin is rock beaching, which allows discharges to safely enter into Haunted Gully Creek. Refer to Figure 6-11 and Figure 6-12 following for details.
- Filter collar – Consideration should be given to installing a filter collar around the downstream end of the modified Low Level Outlet (i.e. Figure 6-11)
- Upstream concrete pipework – The section of waterway pipe between the upstream intake and the tower is currently a concrete section (refer Figure 6-10). The condition of this pipe is not known. If the structural condition of the pipe or the joints has deteriorated, there is a risk of collapse or piping failure through the joints. While it is considered unlikely that piping issues associated with this section of pipe could lead to complete breach of the dam due to the presence of the core wall, the design should consider sleeving this section of the pipe with a 450 mm pipe and grouting the annulus.

Retaining the Low Level Outlet and converting it to the primary spillway provides the most cost effective solution for not increasing peak flows up to the 1 in 100 AEP event (in combination with the secondary spillway for events less frequent than approx. 1 in 200 to 1 in 500 AEP events).

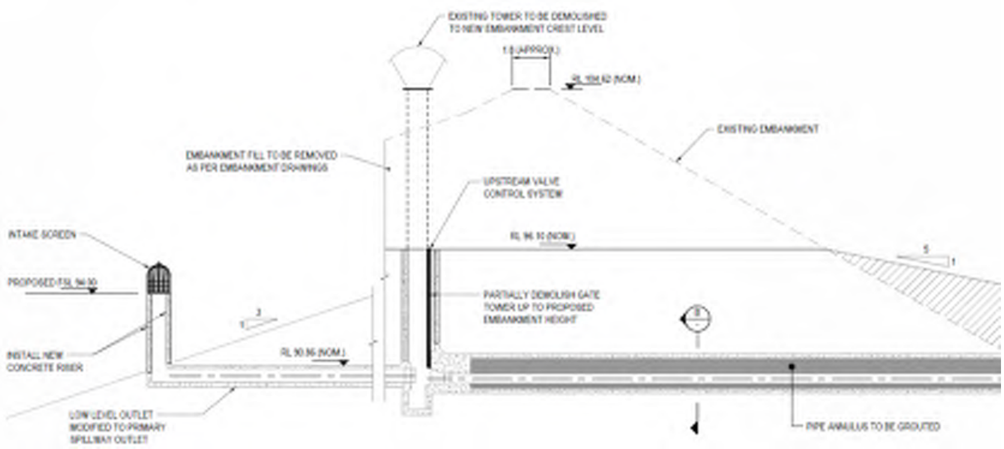

Figure 6-10 Typical section for Low Level Outlet and Tower modifications – Option 1D

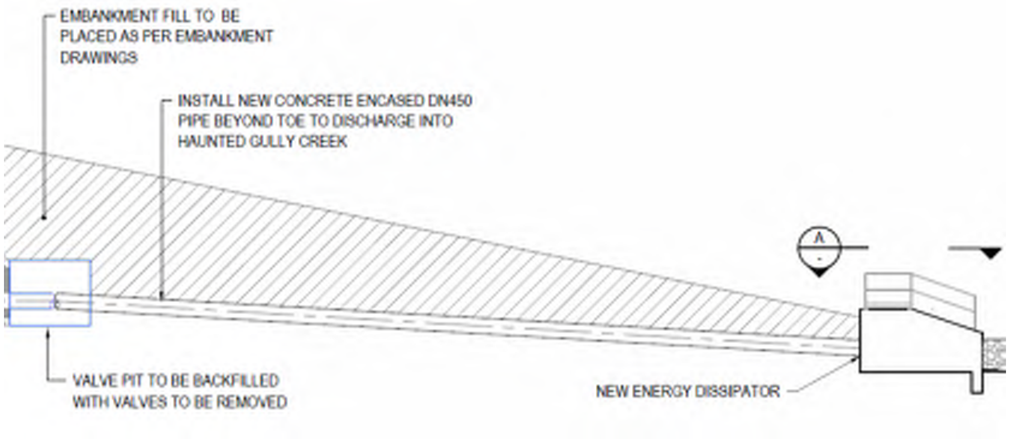

Figure 6-11 Section through Low Level Outlet – Option 1D

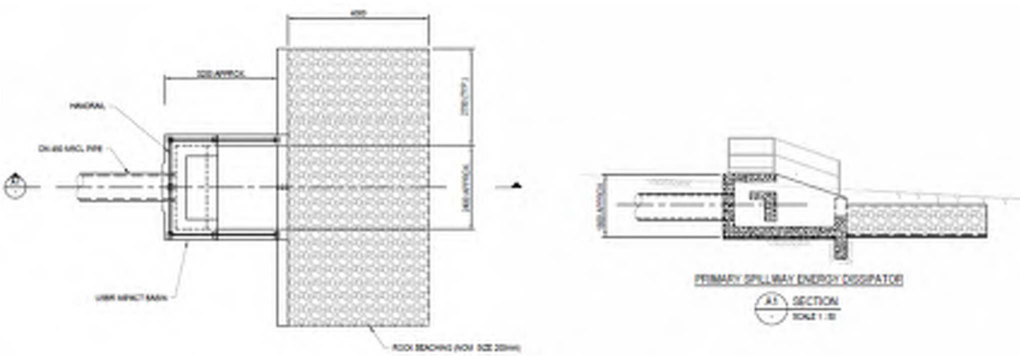

Figure 6-12 Plan (left) and section (right) of Energy Dissipator

6.4.5 Decommissioning of High Level Outlet – Option 1D

The invert of the High Level Outlet is currently set at approximately RL 97.9 mAHD, which is higher than the proposed reduced water level, although potentially lower than the expected design flood level. As such, concept design Option 1D requires that the High Level Outlet be fully decommissioned. The following works would be required:

- Grouting – the full length of the twin pipes would be grouted (or backfilled with concrete) from the upstream outlet tower to the downstream valve house.
- Filter collar – consideration should be given to installing a filter collar around the downstream end of the decommissioned outlet pipes.
- Demolition of outlet tower – consideration should be given to long-term public safety around the high-level outlet tower, including removal or treatment of the four asbestos cement columns (refer to Rec 2015/03 from 2015 Annual Dam Safety Inspection). Where considered to present a safety risk, partial demolition of this structure could be undertaken. It is noted that demolition of the tower is not a dam safety requirement. For details refer to Figure 6-13.
- Downstream valve house – The structure is proposed to be retained for use by Cardinia Environmental Coalition (CEC). Valves contained within the valve house will be locked out and the access ladder removed. A solid lid is proposed to be placed over the floor to hide the locked out valves beneath to prevent any untoward actions. It is noted that the proposed minor works to the valve house are subject to change following discussions with CEC.

It is noted that the extent of decommissioning on many of the High Level Outlet features is likely to be a risk-based decision, in terms of both dam safety and public safety. The design focuses on maintaining infrastructure for continued use for stakeholders, while safely passing peak flows up to and including the 1 in 100 AEP event, solely by the two spillways proposed for option 1D. Rarer floods pass over the overtoppable embankment to safely pass events rarer than the standards based 1 in 1000 AEP requirement. This minimises ongoing costs associated with inspection of the pipe and addresses piping risks along the interface of the conduits with the embankment.

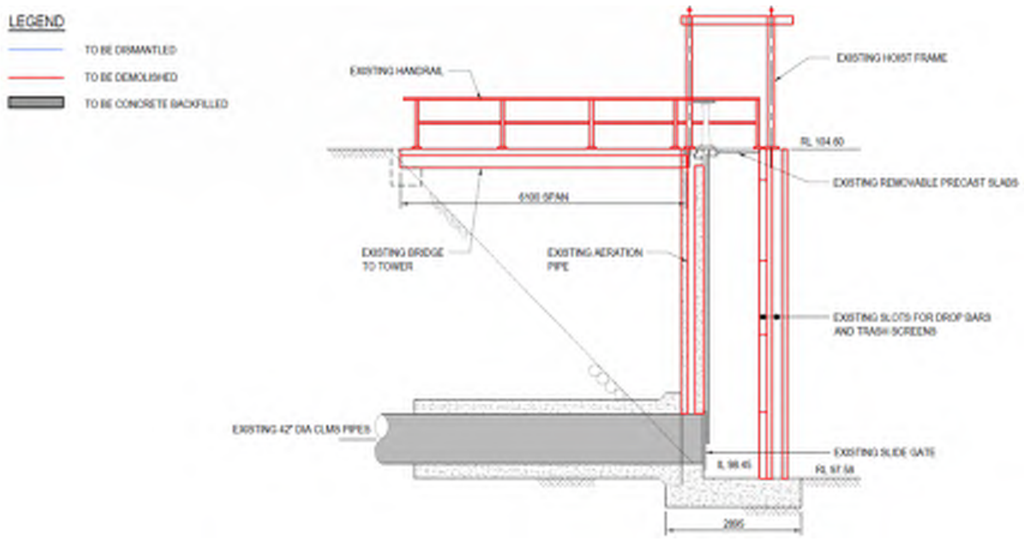

Figure 6-13 Typical section through High Level Outlet Tower – Option 1D

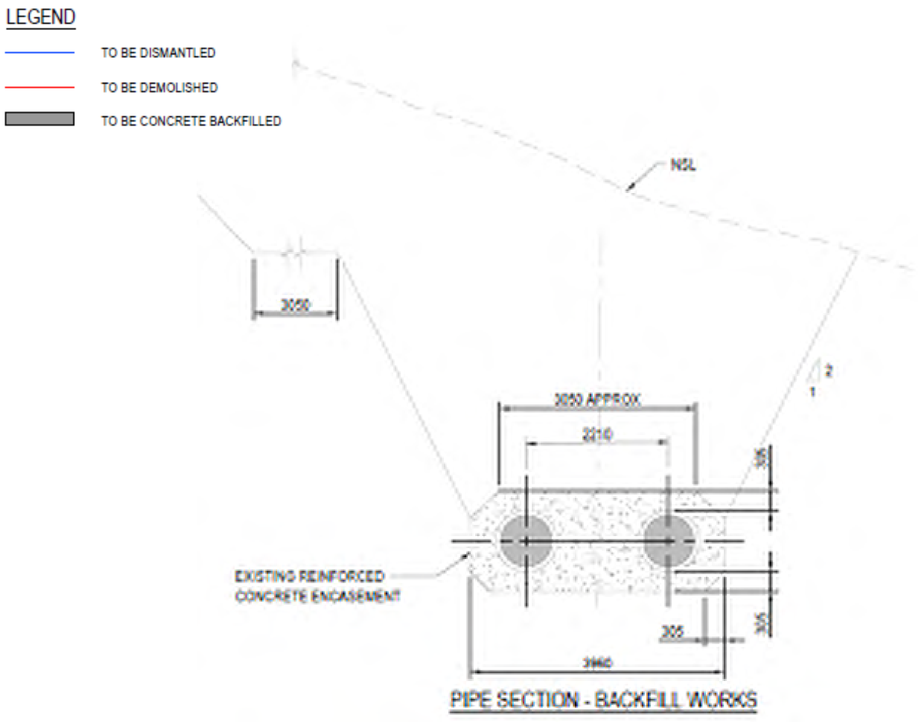

Figure 6-14 Typical cross section of High Level Outlet Pipes – Option 1D

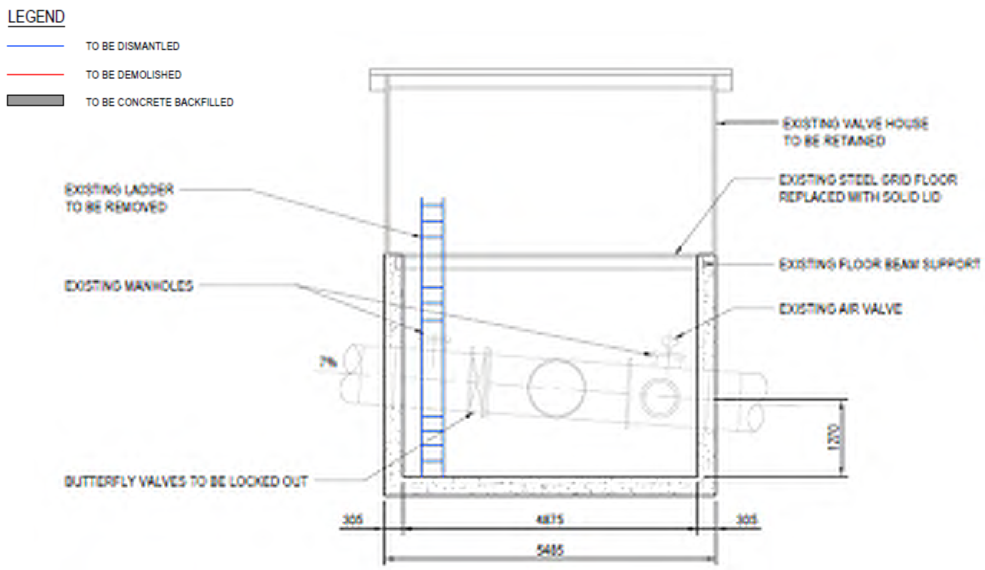

Figure 6-15 Typical cross section of High Level Outlet Pipes – Option 1D

7. Partial decommissioning concept design

7.1 Concept design Option 1D spillway configuration

The design was iterated with various secondary spillway configurations to approach but not exceed the peak outflows from existing conditions, over a range of events up to and including the 1 in 100 AEP.

7.1.1 Baseline "existing" conditions

A key consideration was how 'existing' conditions should be defined – either the original design, or the Restricted FSL case. The Developer Services group at MWC was consulted with regards to how the planning levels and design criteria were being set for new developments downstream of Beaconsfield Reservoir. The flows being used for planning purposes were compared to both the original FSL and Restricted FSL cases, as summarised in Table 7-1.

It should be noted that the Developer Services RORB model assumes significant development between Browns Road and the Princes Highway, and accordingly has increased impervious fractions in this area.

The Developer Services model includes three subareas upstream of the dam, and an approximation of the reservoir, which has a different storage discharge relationship to either the original FSL or the RFSL configurations. It represents a 150 m long spillway at RL 104.25 mAHD, which results in much higher peak flows from the reservoir. The impact of including a more accurate representation of the reservoir is shown in Line References 5 and 6 of Table 7-1 below.

With reference to Table 7-1 below it can be seen that:

- The flows being used for planning purposes are slightly lower (within 1.0 m^3/s) compared to those generated by adopting ARR 2016 data and an ensemble approach. The same catchment file and k_c value were adopted.
- Representing the correct spillway level and length (original FSL) in the Developer Services model produces equivalent flows at Browns Road, and a reduction in peak flows at the Princes Highway, when adopting ARR 2016 data and an ensemble approach.

The FSL scenario was adopted as the existing case on this basis – refer to Line Reference 4 in Table 7-1 below.

Table 7-1 RORB model to Princes Highway – comparison with flows used for development planning/approvals

Line reference	Scenario	Kc	Number of subareas upstream of dam	Rainfall and losses	Cease to flow elevation (RL mAHD)	1% Beaconsfield Reservoir peak outflow (m^3/s)	1% Browns Rd peak flow	1% Princes Hwy peak flow
1	MWC Developer Services planning flows (using ARR 1987 methodologies/parameters). k_c=5.6	5.6	3	ARR 1987	104.25	7.5	17.7	23.7
2	MWC Developer Services RORB model using ARR 2016 data and methodologies (ensemble approach). k_c=5.6	5.6	3	ARR 2016 (ensemble approach)	104.25	8.0	18.2	24.4
3	Extended Beaconsfield Reservoir RORB model for RFSL storage representation with k_c/d_{av} ratio of Reservoir model maintained	10.05	9	ARR 2016 (ensemble approach)	98.85	3.2	no print out	21.0
4	**Extended Beaconsfield Reservoir RORB model for original FSL storage representation with k_c/d_{av} ratio of Reservoir model maintained**	**10.05**	**9**	**ARR 2016 (ensemble approach)**	**103.08**	**5.0**	**no print out**	**21.3**
5	MWC Developer Services RORB model using ARR 2016 data and methodologies (ensemble approach). k_c=5.6. Storage representing Restricted FSL	5.6	3	ARR 2016 (ensemble approach)	98.85	3.6	17.4	21.5
6	**MWC Developer Services RORB model using ARR 2016 data and methodologies (ensemble approach). K_c=5.6. Storage representing original FSL**	**5.6**	**3**	**ARR 2016 (ensemble approach)**	**103.08**	**5.6**	**18.2**	**23.1**

7.1.2 Concept design flows for events as frequent as 1% AEP (up to 100-year ARI)

The concept design was configured in the catchment file, with the discharge curve combining:

- Primary spillway at RL 94.0 mAHD (Low Level Outlet)
- Secondary spillway at RL 95.5 mAHD (10 m wide broad-crested weir, C_d=2)

Both ensemble and Monte Carlo approaches have been used to check outflows are not increased between the existing (original FSL) and the concept design conditions. The ensemble approach uses median burst losses and assumes AEP neutrality (that 1% AEP rainfall produces a 1% AEP flood), whereas the Monte Carlo approach samples combinations of initial loss and rainfall depth. This is in recognition of the fact that a smaller rainfall event on a wet catchment may produce a greater flood peak than a larger rainfall event on a dry catchment.

The outflows are summarised in Table 7-2 and Table 7-3 below for the ensemble and Monte Carlo approaches respectively. The two approaches yield results, which are between 0-0.4 m^3/s different, with the Monte Carlo results generally slightly smaller.

Table 7-2 Ensemble outflows (data hub losses and median pre-burst depths)

AEP	Existing (original FSL) peak outflow	Critical duration	Concept design peak outflow	Critical duration	Comment
1 in 10	2.3	9 hour	1.1	9 hour	Design secondary spillway not activated
1 in 20	3.3	9 hour	1.1	9 hour	Design secondary spillway not activated
1 in 50	4.5	9 hour	3.9	12 hour	
1 in 100	5.8	12 hour	5.5	9 hour	Developer Services assumed 7.5 m^3/s for planning/design purposes

Table 7-3 Monte Carlo outflows (no pre-burst adjustment)

AEP	Existing (original FSL) peak outflow	Critical duration	Concept design peak outflow	Critical duration	Comment
1 in 10	2.2	9 hour	1.1	9 hour	Design secondary spillway not activated
1 in 20	3.1	9 hour	1.1	12 hour	Design secondary spillway not activated
1 in 50	4.4	12 hour	3.5	12 hour	
1 in 100	6.1	12 hour	5.5	12 hour	Developer Services assumed 7.5 m^3/s for planning/design purposes

A range of continuing loss values were also tested for sensitivity. As shown in Figure 7-1 and Figure 7-2 following, the ensemble approach outflows are sensitive to the continuing loss assumption. For the 1% AEP, if the continuing loss value was reduced to 2.6 mm/hr or less, a slight adjustment would need to be made to the design for Option 1D to match the original FSL outflows for the 1% AEP.

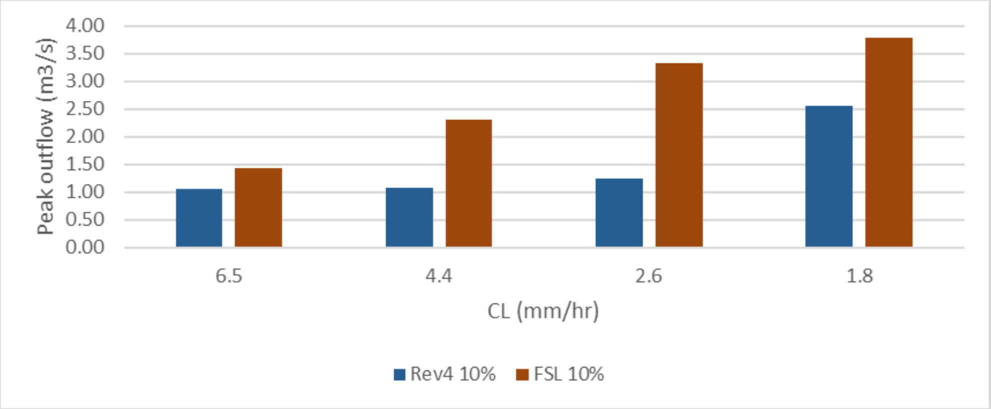

Figure 7-1 FSL and concept design Option 1D outflow comparison (10% AEP)

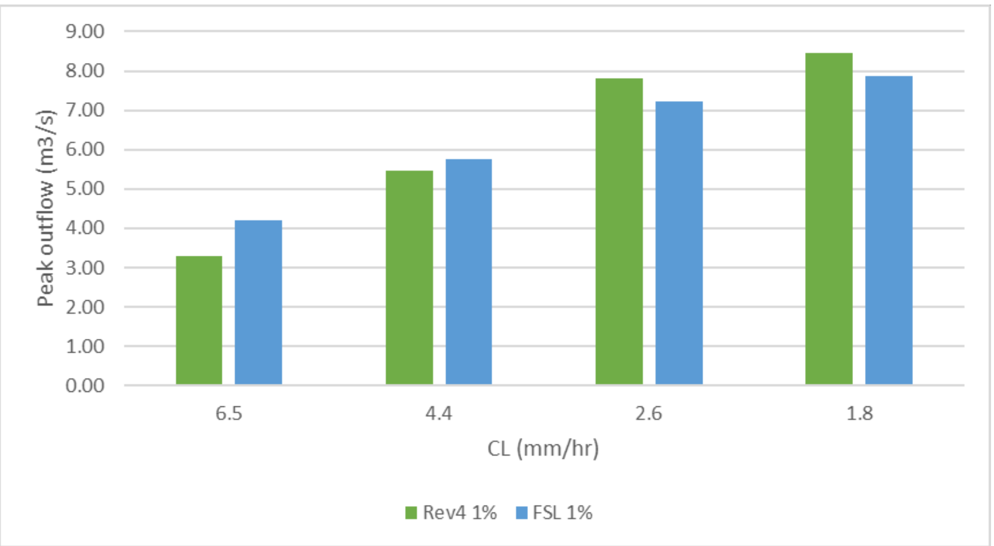

Figure 7-2 FSL and concept design Option 1D outflow comparison (1% AEP)

As a final check, the Developer Services RORB model was updated to reflect the Concept Design for Option 1D and rerun. As can be seen in Table 7-4 below, the design flows at Browns Road and the Princes Highway were not increased by this change.

Table 7-4 Comparison with flows used for development planning/approvals

Line reference	Scenario	1% Beaconsfield Reservoir peak outflow (m^3/s)	1% Browns Rd peak flow	1% Princes Hwy peak flow
1	MWC Developer Services planning flows (using ARR 1987 methodologies/ parameters). k_c=5.6	7.5	17.7	23.7
2	MWC Developer Services RORB model using ARR 2016 data and methodologies (ensemble approach). k_c=5.6. Storage representing restricted FSL RL 98.85 mAHD.	8.0	18.2	24.4
3	MWC Developer Services RORB model using ARR 2016 data and methodologies (ensemble approach). k_c=5.6. Storage representing original FSL RL 103.08 mAHD.	5.6	18.2	23.1
4	MWC Developer Services RORB model including Concept Design for Option 1D using ARR 2016 data and methodologies (ensemble approach). k_c=5.6	5.4	17.4	21.4

Scenario 2 and 3 are similar, however scenario 3 uses a storage representing the original FSL of RL 103.08 mAHD, whereas scenario 2 adopts the restricted FSL of RL 98.85 mAHD.

7.2 Concept design Option 1D dam crest level

Following discussions with MWC, the embankment crest level was set at approximately the 1 in 200 AEP level, with some allowance for changes in continuing loss and/or Low Level Outlet blockage. The embankment crest level has been set at RL 96.1 mAHD, which allows approximately 10.4 m^3/s through the primary and secondary spillways combined. This makes the DCF between the 1 in 200 AEP and 1 in 500 AEP events for various modelling sensitivity analyses undertaken. Critical duration outflows for different scenarios are given for comparison in Table 7-5 following. Given that a combination of data hub and GSDM/GSAM temporal patterns may be required to smooth the transition between the 1% AEP and the very rare events, both have been simulated to assess the impact of temporal patterns and pre-burst depth assumptions. Due to the storage, the critical outflow duration is 9-12 hours, however, the critical inflow duration is much shorter.

Table 7-5 Ensemble and Monte Carlo flow comparisons for 1 in 200 and 1 in 500 AEP events (assuming glass wall)

Scenario	Critical duration 1 in 200 AEP design outflow (m^3/s)	Critical duration 1 in 500 AEP design outflow (m^3/s)
Ensemble (base k_c and losses) data hub temporal patterns	8.6 (9 hour)	
Ensemble (base k_c and losses) GSDM/GSAM temporal patterns	8.2 (12 hour GSAM)	11.5 (12 hour GSAM)
Monte Carlo (base k_c, no pre-burst adjustment) data hub patterns	8.1 (12 hour)	12.8 (12 hour)
Ensemble (base k_c, 2.6 mm/hr CL)	10.1 (12 hour)	
Ensemble (base k_c, 2.6 mm/hr CL) GSDM/ GSAM temporal patterns	10.4 (12 hour GSAM)	13.3 (12 hour GSAM)

7.3 Concept design Option 1D – design overtopping event

It was agreed that given the widened crest and reduced embankment height a credible wet day failure is likely to occur only after a continuous overtopping of in excess of 300 mm for at least 6 hours occurred.

A range of events were simulated to estimate the AEP at which approximately overtopping failure of the embankment would occur for a period of approximately 6 hours or more. GSDM and GSAM patterns (with pre-burst) were used from the 1 in 200 AEP event.

As per Figure 7-3 the estimated AEP for an overtopping depth of 300 mm (RL 96.4 mAHD) is approximately 1 in 1,000,000 AEP (12 hour GSDM).

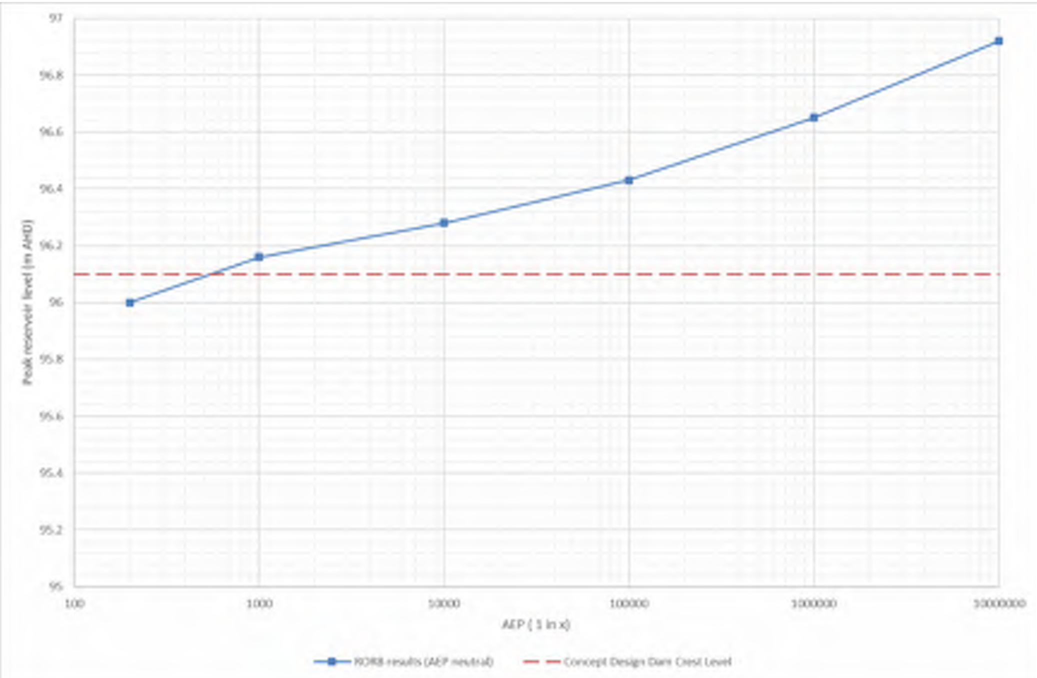

Figure 7-3 Beaconsfield Reservoir Concept Design Flood Frequency – Option 1D

7.4 Concept design Option 1D – wet day overtopping dambreak and consequences

7.4.1 Breach parameters

The range of empirical breach parameters for the 1 in 1,000,000 AEP overtopping breach are shown in Table 7-6 below.

Table 7-6 Empirical breach parameters for 1 in 1,000,000 overtopping breach (Option 1D)

Empirical equation	Side slope	Concept design overtopping breach base width (m)	Concept design overtopping breach development time (min)
MacDonald Langridge Monopolis (Wahl)[1]	0.2	1.2	16
Bureau of Reclamation	0.2	26.3	19
Froehlich (2008)	1	9.8	16
Von Thun Gillette (assuming erosion resistant)	1	20.5	47
Singh and Scarlatos minimum breach base width	0.2	4.9	22 (applying Wahl earthfill equation to volume of embankment eroded)
Singh and Scarlatos minimum breach base width	0.2	4.9	45 (applying Wahl earthfill equation to volume of embankment eroded)

The FLDWAV model was adapted to represent a breach triggering at the time of approximately 6 hours of overtopping by approximately 300 mm, and the different sets of breach parameters simulated. The resulting breach hydrographs are shown in Figure 7-4 following. Both the Bureau of Reclamation (1988) and Froehlich (2008) parameters produce very similar breach hydrographs. In this instance, it was not expected that these would show appreciable differences in flood behaviour at the location of the first dwelling (the Scout Park caretaker's residence). For the third breach simulated, the lower bound sensitivity was taken to be the minimum Singh and Scarlatos breach base width, with the time derived from the volume of embankment eroded, using the MacDonald Langridge-Monopolis development time equation from DERM (relationship shown in ANCOLD Bulletin 97).

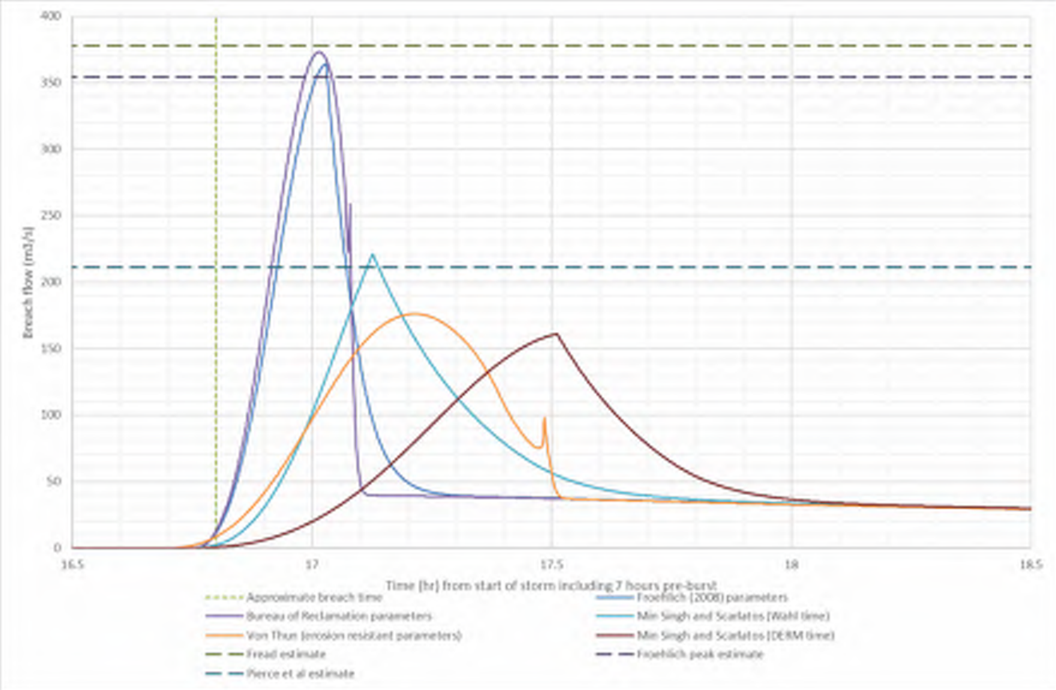

Figure 7-4 Wet day (overtopping failure) breach hydrographs – Option 1D

The adopted breach parameters are given in Table 7-7 below.

Table 7-7 Adopted overtopping breach parameters – Option 1D

Scenario	Basis	Breach base width (m)	Breach development time (min)	Peak flow (m3/s)
No breach		NA	NA	41
Upper bound sensitivity	Bureau of Reclamation	26.3	19	373
Most likely	**Min Singh and Scarlatos breach base width with adjusted MacDonald Langridge Monopolis (after Wahl) breach time**	**4.9**	**22**	**222**
Lower bound sensitivity	Min Singh and Scarlatos breach base width with adjusted MacDonald Langridge Monopolis (after DERM) breach time	4.9	45	161

7.4.2 PAR and PLL estimates – Option 1D

The area impacted by the breach as defined by 300 mm or greater incremental depth extends to the Princes Highway, as shown in Figure 7-5 below.

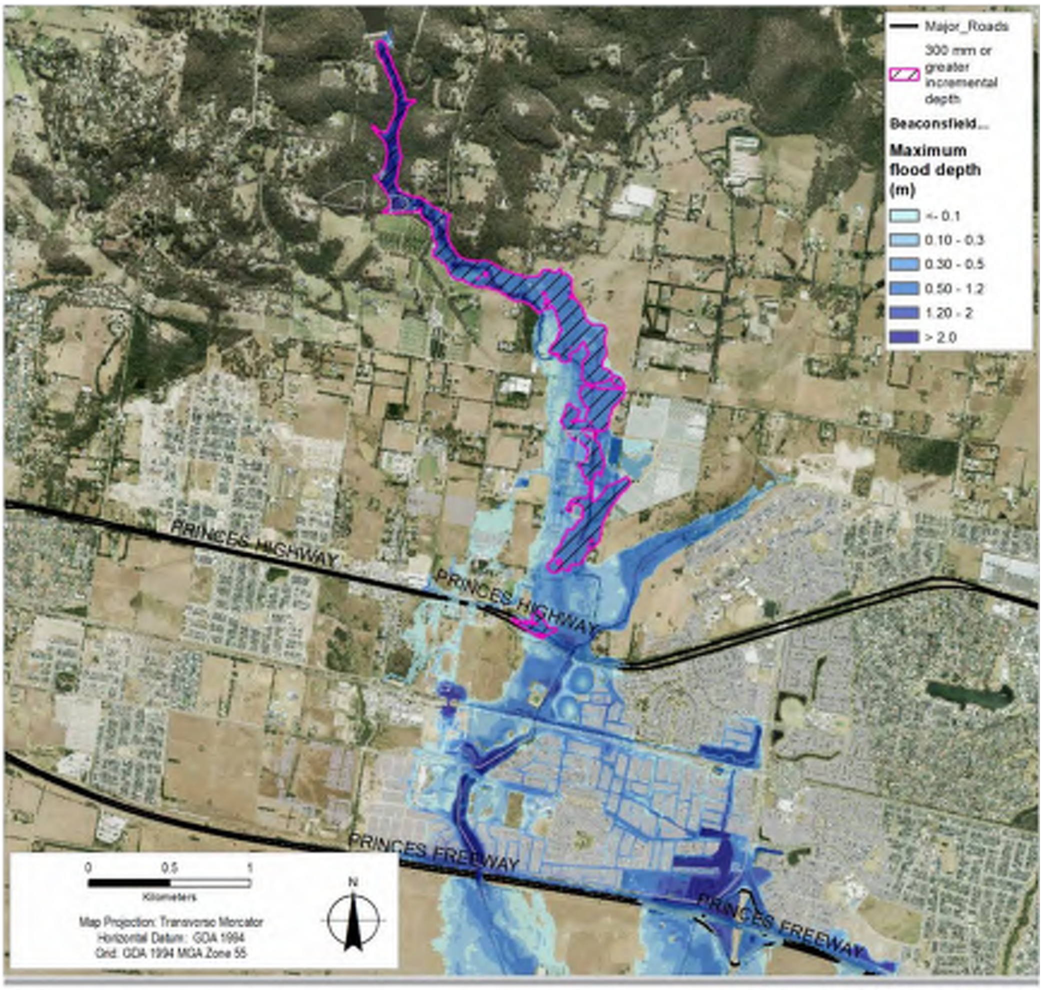

Figure 7-5 Overtopping breach affected zone – concept design Option 1D

Existing development in the breach-affected zone includes:

- Four dwellings, including the Scout Park caretaker's residence
- Glass houses and packing sheds at Boon Roses (assume four staff for eight hours during the day and none at night)

Apart from the caretaker's residence, it has been assumed that no one would be present at the Scout Park during such an extreme flood event.

It has been assumed that no traffic would be attempting to pass the Princes Highway in such a rare flooding event. As demonstrated by Figure 7-6 following, the road will have been inundated by more than 300 mm for an extended period of time prior to the arrival of the breach flood wave.

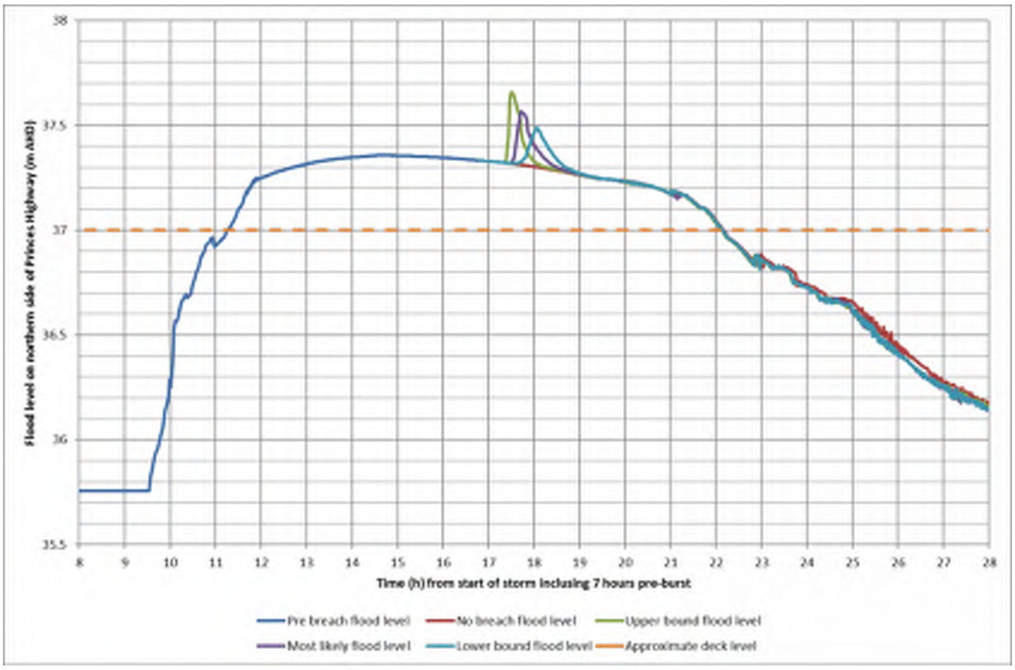

Figure 7-6 Flood level hydrographs at the Princes Highway during 1 in 1,000,000 AEP overtopping design event

Inspection of the pre-breach flood results shows that prior to the breach occurring, the dwellings would not have been inundated significantly, however the glasshouses and sheds at Boon Roses would have been inundated by between 0.1-0.5 m. The PAR at Boon Roses has still been considered, on the grounds that staff may still attempt to salvage plants and equipment under these conditions. This is considered a conservative assumption, as it is likely that workers would not have travelled to work in flooded conditions.

The resulting PAR and PLL estimates for the overtopping failure associated with concept design Option 1D are summarised in Table 7-8 following.

Table 7-8 PAR and PLL summary for Option 1D overtopping failure

Parameter	Day	Night	Day/ Night weighted average	Day	Night	Day/ Night weighted average	Day	Night	Day/ Night weighted average
	Overtopping failure			No breach (within 300 mm incremental depth boundary for respective breach)			Incremental		
Number of buildings flooded above floor	2-5			1-2			1-3		
PAR at floor level	3-9	6-11	4-10	1-5	3-6	2-4	2-4	3-5	2-6
PLL at floor level (USBR suggested median)	0.01-0.06	0.03-0.08	0.02-0.07	0.000-0.001	0.000-0.001	0.000-0.001	0.01-0.06	0.03-0.08	0.02-0.07

The application of the 300 mm incremental depth threshold means that Boon Roses is included in the no-breach numbers for the upper bound breach, but not for the lower bound and most likely breach (as it does not experience a 300 mm increase in flood levels over no breach conditions for these scenarios).

The weighted PLL under a Wet Day Failure is less than 0.1 and therefore achieves a Consequence Category of Low as per the design criteria.

8. Landscape design

8.1 General

A critical part of the concept design is to provide an indication of possible treatments of the upgraded site including:

- Improved access and connectivity
- Equitable use of site
- Cultural connections
- Quality open space
- Passive and active recreation space balance
- Enhancing connections to nature
- Access and safety
- Shade structures

The design is focused on providing details on proposed infrastructure such as walking trails, site furniture, shelters, boardwalks, lookouts, and potential bunding to the upstream area of the reservoir for improving biodiversity and habitat for the upstream area.

Landscape architecture concept designs have been developed for the three initial concept options (Options 1A to 1C) and the final concept design (Option 1D). Each design includes a masterplan and detailed section of the dam. Refer to Appendix I for drawings.

The overall landscape masterplan outcome for the partial decommissioning of Beaconsfield Reservoir can be broken down into three key elements. These include:

- The re-designed smaller water body
- Circuit walking trails
- The picnic and passive recreation area

8.2 Landscape elements

8.2.1 Smaller water body

The revised and smaller open water body provides opportunity to convert the remaining extent into a functioning wetland, to ensure the original footprint of the dam is utilised to its full potential. Characteristics of this wetland shall include and consider:

- A planting palette and profile of indigenous species that is consistent with MWC's preferred planting zones highlighted in their Constructed Wetlands Design Manual (Ephemeral Planting Zone, Shallow Marsh Zone, and Deep Marsh Zone, etc.).
- Species selected will be indigenous to the local area.
- Rock, earth bunding, and trees removed because of future works will be used to create pool and riffle elements that will aerate water within the wetland, as well as create opportunity for native flora and fauna habitat, helping biodiversity.
- Facilitate the migration and population of indigenous flora and fauna species through the reintroduction of conditions best suited to their cultivation and prosperity.

8.2.2 Circuit walking trails

Walking trails within the site extent are separated into a series of concentric circuit paths, providing options for users of varying walking abilities to navigate the site as well as several different experiential qualities. These will be clearly denoted by trail signage at regular intervals. The path networks include:

- Opening an existing walking trail to the public that meanders through the existing bushland immediately surrounding the wetland. The circuit path will be punctuated with picnic and seating opportunities to serve as respite areas for walkers, as well as capture key vistas and views of the waterbody. The path also extends to use parts of the spillway channel and decommissioned Bunyip Main Race.
- A new internal track around the current water level will service users who wish to experience the site at a more leisurely pace. New low profile steel bridges crossing the smaller tributaries to the north will allow for uninhibited views of the open water body and the tributaries upstream. This internal track and its structures will be robust enough to allow for it be utilised as periodical maintenance access.
- A new compacted gravel all access loop path that allows for pedestrian mobility in and around the old dam wall to the south and the amenities that service the passive recreation area. This will also serve as periodical maintenance access due to the location of the existing shed.

8.2.3 Picnic and passive recreation area

The picnic and passive recreation area will provide amenity for respite and end of trip facilities, as well as brief experiential landscape interventions. Elements of this area include:

- A new-cantilevered steel mesh viewing deck to the north to take advantage of the long views over the water.
- A low profile steel boardwalk along the base of the old spillway to the east to connect with the walking loop trail that takes in the old spillway and Haunted Gully Creek.
- Newly graded grass dam embankment to provide informal seating and passive recreation opportunities.
- Utilising this new open lawn area further to the south to include picnic tables, barbecue and a shelter, facilitated by a small pedestrian access path.

9. Cost estimates

9.1 General

Estimates of the project costs has been developed for the concept design (Options 1A to 1D). This section describes the assumptions, limitations and accuracy of these costs, selection of unit rates, and percentages assigned to overheads.

9.2 Key assumptions, limitations and accuracy

The level of project definition and the accuracy of the inputs influences the accuracy of the cost estimates. In this regard, the following should be considered for the cost estimate:

- The design has been developed at a 'concept' level of design, and the accuracy of the cost estimates, and in particular the adopted Very High and Very Low Variances, are based on this level of project definition.
- The cost estimates covers the extent of works as detailed in Section 6 for each of the initial Concept Options 1A, 1B, 1C and adopted Concept Option 1D, including Landscape Works as detailed in Section 8.
- A nominal allowance is included in the cost estimates for a number of items, which are unique to this project. These estimates were developed through engineering judgement.
- The cost estimates do not include any costs associated downstream of the Landscape Works (i.e. of the stilling basin and/or headwall discharging into Haunted Gully Creek).
- Estimates of foundation conditions have been based on interpreting the existing geotechnical information.
- It is assumed that the contractor will have relatively open access to the work site, and will not be restricted by limited hours of operation.
- Optimisation of the embankment width and slope should be investigated in future stages of design. The current cost estimates are based on a 5H:1V profile with disposal of spoil onsite. If this is not feasible, a revised downstream batter slope should be considered and costs should be re-calculated based on the new design. Likewise, if excess embankment material is required to be disposed offsite, costs should be re-evaluated.
- It is assumed that no extensive environmental permits will be required.
- It is assumed that drawdown of the reservoir can be achieved during the construction phase to allow for dry conditions when undertaking embankment works.

It is considered that the cost estimates have a -30% / +100% level of accuracy. This is comparable with:

- The Association for the Advancement of Cost Engineering International (AACEI) recommended ranges for 'Class 4' – Order of Magnitude/Concept Study (i.e. -30%/+100%), which was considered appropriate in this case where a large risk workshop involving experienced GHD and MWC personnel was not undertaken.

9.3 Unit rates and percentage items

9.3.1 General

Rates have been selected for items where the quantity of work is measurable in terms of units or lump sums. For other items, such as establishment/disestablishment costs, minor items and contingencies, where the quantity of work is more difficult to measure, allowances have been included in the cost estimates as percentage-based items. The selection of these unit rates and percentages is discussed in the following sections.

9.3.2 Unit rates

Unit rates for various components of the work were selected with reference to rates used on recent previous construction projects. Reference was also made to the following documents:

- Rawlinsons, Australian Construction Handbook, 2013
- Information provided by Alan Rae Consulting as part of the 2012 Remedial Works Design for Beaconsfield Reservoir
- Estimates of MWC internal time and resources (pro rata where necessary) from Maroondah Reservoir New Outlet Concept Design (GHD, 2018a).

Unit cost rates for each item are all inclusive. For instance, unit rates for reinforced concrete includes labour, preparation, formwork, jointing, sealant, compaction, admixtures, reinforcing steel, bar bending and fixing, and surface treatment. Unit rates adopted for earthfill includes supply, placement and compaction with testing separately priced.

9.3.3 Percentage items

General costs for items including establishment, miscellaneous items, contingencies, and design and construction management have been taken as a percentage of the total construction costs, and are based on an assessment of recent project percentages as well as typically accepted values. In terms of contingency percentages, it is acknowledged that uncertainties exist in some of the quantities and unit rates, including material sources and foundation conditions.

The percentages adopted in the cost estimates are:

- SP Project Management– 15% of Direct Cost
- SP Detailed Design – 14% of Direct Cost
- SP Risk – 12% of Total Cost
- SP Margin – 15% of Total Cost
- Program Management Allocation – 7.5%

9.4 Summary of project costs (CAPEX)

Cost estimates for the Concept Design options are provided in Appendix J. GHD's cost estimate (base project cost) for each of the partial decommissioning designs (including landscaping) will cost in the order of $6 M (range of $5.8-6.9 M).

9.5 RANE analysis

RANE analysis was undertaken using the base cost (CAPEX) inputs and the risk register inputs. The RANE inputs (costs and risks) for are included in Appendix K and in Appendix L respectively.

A summary of the RANE outputs is provided in Table 9-1 below.

Table 9-1 Summary of RANE outputs

	RANE output ($M)			
	Option 1A	Option 1B	Option 1C	Option 1D
Base Project Cost				
Low Expected Project Cost, P5				
Expected Project Cost, P50				
High Expected Project Cost, P95				
Contingency (P95 – P50)				
(P95-P50)/P50				
(P95 – Base Cost) / Base Cost				

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10. Next steps

10.1 Overall Beaconsfield Reservoir concept design strategy

The next steps for the project are largely associated with MWC's assessment of the options for Beaconsfield Reservoir Concept Design. Based on earlier strategy work (MCA), MWC identified that the focus of this Concept Design Report should be on partial decommissioning options. As such, the three main options to review as part of the overall strategy were as follows:

1. **Option 1A:** Modify the Low Level Outlet to act as a Primary Spillway and install a wide concrete structure as the Secondary Spillway.
2. **Option 1B:** Modify the Low Level Outlet to act as a Primary Spillway and make the embankment overtoppable to act as the Secondary Spillway.
3. **Option 1C:** Decommission the Low Level Outlet and install a new pipe to function as the Primary Spillway and concrete culverts as the Secondary Spillway.

The key differences between Options 1A and 1C are the outflow channel in Option 1C would be narrower and taller and concrete would be visible, while Option 1A has the potential to have topsoil and grasses covering the rock-lined channel. As described in Section 8 within the Landscape Drawings, there exists the potential to improve the aesthetics of the rock-lined channel to cascade, thereby creating a "natural" rock stream with pools.

Option 1B would be able to be overtopped for the entire length of the crest. This would engage at floods larger than 1 in 100 AEP, which would erode the topsoil and grass in the event of significant overtopping. The Primary Spillway would remain the same as in Option 1A, with the current Low Level Outlet modified to act as the Primary Spillway. Options 1A through to 1C all satisfied the design criteria for a Sunny Day Failure (PLL<0.1) but did not satisfy the criteria during a Wet Day Failure.

Option 1D was developed to meet the design criteria under both Sunny Day Failure and Wet Day Failure scenarios to have an estimated PLL of less 0.1. The key design components for Option 1D are outlined in Table 10-1.

Table 10-1 Key design features of Option 1D

Key Component	Detail
FSL	RL 94.0 mAHD
Dam crest level	RL 96.1 mAHD
Secondary Spillway Type	Constructed on good quality natural rock through crest with concrete sill discharging into downstream rock beaching-lined channel
Secondary Spillway Level	RL 95.50 mAHD
Secondary Spillway Length	10 m

10.2 Requirements for future stages

10.2.1 General

A Detailed Design (and a Functional Design prior if deemed necessary) would be undertaken in future stage(s) before the construction phase to confirm reduction of the Consequence Category to ‘Low’. This section, “Requirements for Future Stages”, outlines aspects which future designers, MWC and eventually construction contractors should consider, which are a function of the assessments made and designs undertaken as reported herein, subject to the assumptions and limitations associated with this Report.

10.2.2 Future stages

Requirements during future stages relate to scope and information limitations and assumptions made in this Report, which must be considered as part of any future stage scopes. These include:

- The scope of the current study did not include any supporting studies to identify environmental, cultural or heritage issues that might affect the identified options. All information reviewed in this regard was provided by MWC. Consideration should be given to the investigation regarding environmental, cultural and heritage issues if deemed necessary by MWC or future designers.
- No seismic assessment was undertaken and no inherent defects were assumed at the site, apart from the already known issues with seepage originating on the downstream right abutment groin and dam instability.
- It is anticipated that during Detailed Design (and prior Functional Design if undertaken) that further site investigations will be undertaken as deemed required, such as boreholes, UCS testing of rock (pending confirmation of option selection) and other tests deemed necessary by future designers.
- The cost estimates are based on simplified estimates of quantities and rates and should only be relied on for the purposes as set out in the Project Brief. The conditions required high-level concept designs and cost estimates of the upgrade options for planning purposes. A more detailed cost estimate should be undertaken following future stages to confirm initial cost estimates.
- The current study was undertaken at a feasibility level, which is a preliminary study typically undertaken to determine, analyse, and select the best business scenarios. This level of study is required where there is more than one business scenario, and it is necessary to determine which one is the best, both technically and financially.
- The LiDAR survey undertaken in 2017 terminates marginally downstream of the berm on the downstream batter of the embankment. This is short of the proposed new toe of embankment and hence there exists some uncertainty in the levels and earthworks quantities.
- The dambreak modelling and Consequence Category Assessment has been undertaken based on existing conditions. Development occurring downstream (between Browns Road and the Princes Highway in particular) will alter the terrain, drainage features (and in turn the flood behaviour), and locations and types of PAR in some areas. These changes have the potential to affect the outcomes of the Consequence Category Assessment. Updated survey and building footprints will need to be incorporated into the assessment at Detailed Design phase.

- Construction support and supervision is anticipated to be required by the designers engaged for the Detailed Design. This will include but not be limited to the construction of critical dam safety structures including any modification, decommissioning or installation of existing or a new Primary Spillway. Similarly, Secondary Spillway structures will require supervision during the construction of critical components.
- The Concept Design Drawings as presented as part of this report in Appendix I are not suitable for construction tendering purposes and should not be relied on. A suitable designer should be engaged to further examine site conditions and obtain more accurate estimates and information to develop Detailed Design Drawings before the construction tender process.

Future requirements can also relate to key risks identified in this Report, which should be considered as part of following stages. These include:

- There is strong community interest in Beaconsfield Reservoir. It is critical to manage risks associated with fauna, flora and water quality (upstream, downstream and bore) to prevent project delays and poor public relations

11. Conclusions and recommendations

11.1 Conclusions

The multi-criteria analysis undertaken suggests that the most appropriate option is to partially decommission Beaconsfield Dam. The analysis was weighted to reflect the relative importance of each criterion. The criteria included:

- Cost
- Satisfying ALARP
- Community impacts
- Environmental and conservation impacts

Hydrological analysis of Beaconsfield Reservoir found that a Low Consequence Category is achieved for a Sunny Day Failure scenario at a lowered FSL of RL 94 mAHD (primary spillway level). The secondary spillway and crest design was then further iterated to also achieve a Low Consequence Category for the Wet Day Failure scenario. To achieve a Very Low Consequence Category, the reservoir level may need to be further lowered so that the Severity of Damage and Loss becomes 'Minor'.

With a target Low Consequence Category, Beaconsfield Reservoir required:

- No increase in the peak outflows for the 1 in 100 AEP flood event (in the order of 5 m^3/s)
- To safely pass the 1 in 1000 AEP flood event

There are four Partial Decommissioning Options presented as part of this Report. It is noted there exists the potential for variations to design based on community feedback, an internal review, and in compliance with dam safety regulations and ANCOLD. The four options include:

1. **Option 1A:** Modify the Low Level Outlet to act as the Primary Spillway and construct a Secondary Spillway by excavating into good quality rock, with invert controlled by a concrete sill.
2. **Option 1B:** Modify the Low Level Outlet to act as the Primary Spillway and make the embankment overtoppable to act as the Secondary Spillway.
3. **Option 1C:** Decommission the Low Level Outlet and install a new pipe to function as the Primary Spillway and concrete culverts as the Secondary Spillway.
4. **Option 1D:** Modify the Low Level Outlet to act as the Primary Spillway and construct a Secondary Spillway by excavating into good quality rock, with invert controlled by a concrete sill. Same as Option 1A but crest and spillway at lower relative levels to achieve a Low Consequence Category for both Sunny Day and Wet Day failures.

11.1.1 Comparison of Options 1A to 1C

Options 1A and 1B would modify the current Low Level Outlet to act as the new Primary Spillway. Option 1A would construct a Secondary Spillway on one of the abutments comprised of a wide concrete structure for the control sill and good quality rock for the chute, whereas Option 1B would have the embankment crest as overtoppable for the full length of the crest. Option 1C would decommission the current Low Level Outlet and construct a new Primary Spillway and Secondary Spillway on the abutment, with new pipe and concrete culverts. Option 1C would have the Primary Spillway discharging into the Secondary Spillway chute and therefore would require a rock-lined channel without topsoil, whereas the Secondary Spillway chute for Option 1A could be topsoiled and grassed (over the channel), noting this would erode away during sizeable floods above the 1 in 100 AEP event.

Options 1A through 1C satisfied the design criteria under a Sunny Day Failure where the PLL is less than 0.1. However, under a Wet Day Failure all three options did not achieve this target. An iterative approach was undertaken to determine the option that would not only achieve a PLL<0.1 during a Sunny Day Failure but also under a Wet Day Failure (Option 1D).

11.1.2 Option 1D

Option 1D was developed via an iterative approach, to achieve a Low Consequence Category for both Sunny Day and Wet failure scenarios. Although it has similarities to the initial options proposed, the modified geometry and elevations in Option 1D have resulted in a PLL of less than 0.1 under both Sunny Day and Wet Day failure scenarios.

Option 1D would involve modifying the Low Level Outlet to act as the new Primary Spillway, with a FSL at RL 94.0 mAHD. A Secondary Spillway, 10 m long, would be excavated into good quality rock on one of the abutments, with the unlined rock channel forming the spillway chute. A concrete sill would fix the invert level of the spillway, designed at RL 95.5 mAHD, with an earthen approach channel. The natural rock chute through the crest would be tied into a fabricated rock beaching-lined channel. The dam crest is RL 96.1 mAHD, with overtopping commencing in events rarer than 1 in 200 AEP. The rock beaching-lined channel and/or spillway chute could be topsoiled and grassed, as landscape drawings depict.

Landscaping Designs have been prepared with a focus on promoting to the picnic area and wetlands. These designs have the flexibility to be altered with other suggested options of design possible, as noted in Section 8, depending on MWC's preferences following internal and stakeholder reviews.

GHD's cost estimate (base project cost) for each of the designs is in the order of $6 M (range of $5.8-6.9 M). A summary of the RANE estimate for each of the options is given in Table 11-1.

Table 11-1 RANE estimates

	RANE Output ($M)			
	Option 1A	Option 1B	Option 1C	Option 1D
Base Project Cost				
Low Expected Project Cost, P5				
Expected Project Cost, P50				
High Expected Project Cost, P95				
Contingency (P95 – P50)				
(P95-P50)/P50				
(P95 – Base Cost) / Base Cost				

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11.2 Recommendations

If the works to reduce Beaconsfield Reservoir to a Low Consequence Category are not intended to be undertaken soon, interim actions should include:

- Visually monitor seepage – especially that originating from the downstream right abutment groin.
- Visually monitor the dam for signs of instability.

- Plan and undertake recommended actions developed in 2018 Beaconsfield Comprehensive Inspection (GHD, 2019). It is noted that those actions are independent of any major capital works.

There exists some uncertainty around cost estimates for the construction of the partial decommissioning based on the simplified geometries assumed given the stage of the assessment and finite amount of information. To better understand the costs of each option, further site works should be undertaken to reduce uncertainty. Future investigations could include:

- Boreholes to assess foundation level.
- Further investigation of the Low Level Outlet condition, including full-length external tunnel inspection and an internal pipe inspection to reduce uncertainty around the condition and cost estimate for works associated with the pipe.
- Obtain/request LiDAR data from the Capacity Survey (Taylors, 2017) extending beyond the berm on the downstream embankment to reduce uncertainty in quantity estimates. If the data does not exist, consider commissioning new survey, which captures the downstream toe area of the new embankment.
- If an option that includes a Secondary Spillway on the abutments is the preferred option, consider laboratory testing to confirm rock strength.

12. References

Various Drawings (refer to Appendix B).

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Appendices

Appendix A – Dam information

Component	Description	Reference
General		
Name	Beaconsfield Reservoir	
Watercourse	Haunted Gully Creek is directly downstream of the reservoir	MWC 2015
Location	Access from O'Neil Rd, Officer	SMEC 2012
Purpose	*Original purpose* Water supply (no longer connected to supply) by Tarago Reservoir via the Tarago Main Race and a series of small diversion weirs via the Bunyip Main Race. *Since 1988* Ornamental lake	MWC 2015
Coordinates (Map Grid of Australia)	Zone 55, 5789728 N 360403 E	MWC 2015
Map Reference	Melway Map 212 H 7	MWC 2016 sketch plan
Year of original construction	1918	SMEC 2012
Original designer and constructor	State Rivers & Water Supply Commission	SMEC 2012
Operator	Melbourne Water Corporation	MWC 2015
Imperial datum conversion (for old drawings)	RL (m AHD) = { RL (ft.) * 0.3048 m/ft. } – 0.552 m	GHD 2012
Upgrades and remedial works		
1970	• New Outlet constructed • Old high level outlet "abandoned" by c. 1972	SMEC 2012 Dwg 113610C
1988	• Old Outlet converted to scour outlet • Old scour pipe and base of old tower grouted • Old Tower cut down flush with upstream face of embankment • Toe area cleared, and stabilising fill placed to construct stabilising berm.	SMEC 2012
2014	• Obstructions removed from spillway including the outlet pipe • Training wall constructed on RHS of spillway • DN 225 Scour replaced by DN 450 scour with baffle, rock chute and a DN 100 bypass for low flows. • New reservoir level sensor and rain gauge connected to SCADA	MWC 2015
2016 (unconfirmed but planned)	• Works to seal around perimeter of new penstock gate.	MWC 2015
Consequences of dam failure		
Population at Risk (PAR)	Sunny Day Failure: 334-408 Incremental Wet Day Failure: 1372-1676	GHD 2019

Component	Description	Reference
Potential Loss of Life (PLL)	Sunny Day Failure: 2.2-2.8 Incremental Wet Day Failure: 8.9-11.6	GHD 2019
Severity of Damage and Loss	Sunny Day Failure: Medium Incremental Wet Day Failure: Medium	GHD 2019
Sunny Day Failure Consequence Category (ANCOLD 2012)	High C (based on PLL)	GHD 2019
Incremental Wet Day Failure Consequence Category (ANCOLD 2012)	High A (based on PLL)	GHD 2019
Reservoir		
Type	On-stream storage	SMEC 2012
Full Supply Level (FSL)	RL 103.08 mAHD	SMEC 2012
Reduced Maximum Operating Level (MOL)	RL 98.85 mAHD (4.23 m below FSL, sill level of high level inlet) Restriction due to possible core leakage near FSL, and inadequate stability and flood handling capacity	MWC 2015 SMEC 2012
Minimum Operating Level	RL 90.86 mAHD	SMEC 2012 & MWC 2016 sketch plan
Minimum RL upstream of dam	RL 87 mAHD	GHD 2016
Total Storage Capacity at FSL	912 ML	SMEC 2012
Storage Capacity at restricted MOL	320 ML (revised by Jacobs, 2018)	Jacobs 2018
Catchment area	334 ha	SMEC 2012
Reservoir surface area at FSL	14.6 ha	SMEC 2012
Dam wall		
Type	Earthfill with (puddle) clay core and partial concrete cut-off	SMEC 2012
Crest level	RL 104.62 mAHD (nominal crest level) Sags by up to 0.6 m (to RL 104.02 mAHD)	MWC 2015
Crest length	174 m	SMEC 2012
Crest width	1.8 m	SMEC 2012
Normal freeboard	1.54 m (FSL to nominal crest level) 5.77 m / 5.17 m (restricted MOL to nominal crest level / restricted MOL to lowest crest level)	Re-calculated from MWC 2015
Embankment Height	24.0 m	SMEC 2012
Upstream slope	2H:1V (above FSL) 3H:1V (below FSL)	SMEC 2012
Downstream slope	2H:1V Berm at RL 93.0 mAHD (approx.)	SMEC 2012

Component	Description	Reference
Spillway		
Type	Ogee crest with concrete channel at left abutment (Note: High Level Outlet now acts as the primary spillway, and the left abutment spillway as a secondary spillway)	SMEC 2012
Crest level	RL 103.08 mAHD	SMEC 2012
Crest length	17.8 m	SMEC 2012
Capacity	25 m^3/s (left abutment spillway only at lowest DCF) Approx. 30 m^3/s (left abutment spillway & one 1050 mm outlet pipe at lowest DCF) Approx. 33 m /s (left abutment spillway & two 1050 mm outlet pipes at lowest DCF)	GHD 2012
Dam Crest Flood AEP	Spillway only: 1 in 280,000 (to crest low) / 1 in 1,200,000 (to nominal crest level) Spillway & twin 1050 mm diameter outlet pipes: 1 in 700,000 (to crest low) / 1 in 2,000,000 (nominal crest level)	GHD 2012
Outlet works		
High Level outlet works	Constructed c. 1970	
Concrete tower & access deck	13.7 m (45 ft.) high, 4.6 m (15 ft.) wide, 2.3 m (7 ft. 5”) deep concrete tower (inc. 0.75 m / 2.5 ft. thick base/foundation as per original design drawings). Foundation level on drawings approx. RL 97.0 mAHD (RL 320 ft.). Tower top grated platform at RL 104.6-104.8 mAHD (from survey). Walkway supported by four (4) asbestos cement pipe columns. Concrete sill at tower entrance controlling lowest drawdown level to RL 98.85 mAHD (RL 323 ft.). Invert level of twin 1050 mm (42”) outlet pipes approx. RL 97.9 mAHD. Twin 1750 mm (69”) wide inlet trash screens and opening into tower for full-face height of tower.	Drawings, photographs, survey
Concrete tower slide gates	Twin 1050 mm (42”) slide gates (crank operated, left open for reduced FSL).	MWC 2015
High level outlet pipes	Twin 1050 mm dia. nominal (42”) MSCL pipes from High Level Outlet Tower to Valve House. Pipe capacity nominally 4.2 m^3/s for DCF head (GHD 2012)	MWC 2015 GHD 2012
Valve house	Twin 1050 mm diameter nominal (42”) butterfly valves on twin outlet pipelines, with third 1050 mm diameter nominal (42”) butterfly valve on cross connection within valve house. Eastern outlet pipeline blanked off downstream of butterfly valve. 1050 mm diameter RC pipeline downstream abandoned. Western outlet pipeline (1050 mm dia. MSCL) continues to riparian scour works; blanked off and abandoned beyond.	MWC 2015 MWC 2016 sketch plan

Component	Description	Reference
Low Level outlet works & tunnel	Original construction c. 1918 Converted to scour works c. 1988	
Upstream intake	Intake approx. RL 90.87 mAHD (RL 299.92 ft.)	
Concrete tower/shaft & access deck	Circular tower, 1700 mm outer diameter, 1250 mm inner diameter, 12.5 m internal depth (tower extending to embankment foundation). Located on upstream face of embankment, upstream of concrete core wall. Steel superstructure (installed c. 2012) incorporating access hatch and walkway deck.	Drawings MWC 2015 1994 survey
Penstock gate	500 mm nominal penstock gate at base of low-level outlet tower (installed c. 2012, replaced previous slide gate). Reportedly commissioned c. 2016.	MWC 2015
Low level outlet pipeline	18” nominal diameter (given as 450 mm or 500 mm nominal diameter in various sources) CI pipe within low-level culvert. (Original pipeline c. 1918)	MWC 2015
Low level outlet tunnel/ culvert	‘Upside down’ teardrop-shaped ‘ovoid’ culvert at foundation level through base of concrete core wall. Culvert dimensions 1.37 m (4 ft. 6”) tall by 1.09 m (3 ft. 7”) wide.	MWC 2015
Low level outlet isolation valve & valve pit	Outlet valve pit at downstream end of tunnel/culvert. 18” CI gate valve within downstream isolation valve pit. Downstream connection to 1050 mm RC old outlet pipeline abandoned. Downstream connection to 1050 mm MSCL outlet pipeline.	MWC 2015 MWC 2016 sketch plan
Abandoned old high level outlet	Decommissioned c. 1972	
Old high level intake pit	Decommissioned high-level outlet pit within reservoir near right abutment, intake RL 99.42 mAHD (RL 328 ft.), plugged with concrete.	Drawings (Dwg 113610C)
Old high level pipeline	Decommissioned 600 mm nominal diameter (24”) concrete pipeline passing through right abutment foundation at RL 99.42 mAHD (RL 328 ft.), with concrete cut-off wall at embankment centreline. Current presence/demolition unknown.	Drawings (Dwg 113610C, Dwg 26210)
Abandoned scour works	Original construction c. 1918 Decommissioned c. 1988	
Original scour tower and conduit through embankment	Tower cut down flush with embankment, outlet conduit and base of old tower grouted c. 1988. Original 18” (450 mm) nominal diameter CI scour pipe upstream invert RL 85.94 mAHD (RL 283.75 ft.). Control point RL 86.0 mAHD. Pipe invert at concrete core wall RL 85.94 mAHD (RL 283.75 ft.). Concrete encased through embankment.	SMEC 2012 Drawings (Dwg 26206)
Downstream scour works	Original 225 mm nominal dia. scour works downstream of embankment decommissioned c. 2014.	MWC 2015

Component	Description	Reference
Scour & riparian release	Constructed c. 2014	
Outlet pipeline	450 mm nominal diameter MSCL pipeline tee off 1050 mm MSCL pipeline downstream of High Level Outlet Valve House. 1050 mm pipeline blanked off beyond tee, abandoned downstream.	MWC 2015
New DN450 scour valve	450 mm nominal diameter butterfly valve on scour through line. Valve left closed except during scour operation.	MWC 2015
New DN100 bypass valve	100 mm nominal diameter butterfly valve on 100 mm bypass line for environmental flows. Valve left open.	MWC 2015
Scour pipeline & riparian discharge	450 mm nominal diameter MSCL pipe from scour valves to riparian discharge flow diffuser and baffle, discharging into rock-lined channel into Haunted Gully Creek approx. 100 m downstream of embankment.	MWC 2015
Outlet works capacity	Reported capacity of 450 mm scour: 80 ML/day (not verified) Reported capacity of 100 mm environmental bypass: 8 ML/day (not verified)	MWC 2015c (DSEP data sheet)
Inlet works		
Bunyip Main Race channel	Abandoned inlet channel on east side of reservoir (adjacent to spillway). Channel penstock gates still in position.	MWC 2015
Cardinia 'Siphon' transfer pipeline	Inlet structure on west side of reservoir upstream no longer in use. Structure reportedly in 'satisfactory' condition c. 2012.	MWC 2011
Catch drain	Catch drain around reservoir (for previous water quality management purposes) broken out, abandoned.	MWC 2011
Monitoring instrumentation		
Reservoir water level gauge boards	Two (2) gauge boards: One mounted to High Level Outlet Tower eastern wall. Another on upstream batter between the High Level and Low Level outlet towers.	
Reservoir water level sensor	Commissioned c. 2015. Automatic electronic sensor with telemetry. Mounted on High Level Outlet Tower.	MWC 2015
Local rain gauge sensor	Commissioned c. 2015. Automatic electronic sensor with telemetry.	MWC 2015
Piezometers	Nine (9) standpipe piezometers on downstream batter and berm. Instruments WH090PIBA-P1 to P9. Six (6) installed c. 1988, three (3) installed c. 1999.	SMEC 2012

Component	Description	Reference
Survey markers	Eleven (11) survey markers measuring settlement and movement offset. Five (5) located on crest, instruments WH090SUR-CS01 to CS05. Three (3) located on upper slope of downstream batter, instruments WH090SUR-ES06 to ES08. Three (3) located on downstream berm, instruments WH090SUR-ES09-ES11.	SMEC 2012
Gauge board	Gauge Board (in poor condition) mounted on eastern (embankment) side of High Level Outlet Tower	

Appendix B – Drawing list

No.	Title/ Description	Drawing No.	Year	Authority
1	Beaconsfield Reservoir – General Layout	5016_20.1	1972	SR&WSC
2	Beaconsfield Reservoir – Capacity Chart	5016_20.2	-	SR&WSC
3	Beaconsfield Reservoir – Locality Plan	5016_20.3	1988	SR&WSC
4	Beaconsfield Reservoir – Capacity Chart	5016_20.4	-	SR&WSC
5	Beaconsfield Reservoir – Contour and Capacity Plan	5016_20.5	-	SR&WSC
6	Beaconsfield Reservoir – Contour Plan of Site of Dam	5016_20.6	-	SR&WSC
7	Beaconsfield Reservoir – Contour Plan	5016_20.7	-	SR&WSC
8	Beaconsfield Reservoir – Contour and Capacity Plan	5016_20.8	-	SR&WSC
9	Beaconsfield Reservoir – Clay Core Wall Depth Below Natural Surface	5016_20.9	1987	SR&WSC
10	Beaconsfield Reservoir – Sections of Dam	5016_21.1	-	SR&WSC
11	Beaconsfield Reservoir – Section Showing Fill Required to Raise Crest to RL 347.00	5016_21.2	1956	SR&WSC
12	Beaconsfield Reservoir – Locality and Cross Sections Outer Batter of Bank	5016_21.3	1986	SR&WSC
13	Beaconsfield Reservoir – Locality & Cross Sections	5016_21.4	-	SR&WSC
14	Beaconsfield Reservoir – Waste Weir & By Wash	5016_21.5	-	SR&WSC
15	Beaconsfield Reservoir – Contour and Inlet Channel	5016_24.1	-	SR&WSC
16	Beaconsfield Reservoir – Remodelled Outlet Works - Arrangement	5016_25.1	1969	SR&WSC
17	Beaconsfield Reservoir – Outlet	5016_25.2	-	SR&WSC
18	Beaconsfield Reservoir – Outlet & Scour Pipe	5016_25.3	-	SR&WSC
19	Beaconsfield Reservoir – Outlet Tunnel Lining	5016_25.4	-	SR&WSC
20	Beaconsfield Reservoir – Outlet Tunnel Lining	5016_25.5	-	SR&WSC
21	Beaconsfield Reservoir – Outlet Pit to Tunnel	5016_25.6	-	SR&WSC
22	Beaconsfield Reservoir – Longitudinal Section of Scour Pipe	5016_25.7	1954	SR&WSC
23	Beaconsfield Reservoir – Groundwater Boreholes	5016_3.1	1994	SR&WSC
24	Beaconsfield Reservoir – Outlet Tower – Critical Path Network	112923	1970	SR&WSC
25	Beaconsfield Reservoir – Fencing Around Outlet Tower	114252	1972	SR&WSC
26	Beaconsfield Reservoir – Fencing Around Outlet Tower	27750	1972	SR&WSC
27	Beaconsfield Reservoir – Outlet Tower Grill Floor	91296A	1973	SR&WSC
28	Beaconsfield Reservoir – 1.5 Ton Crane Class 2	91439	1978	SR&WSC

No.	Title/ Description	Drawing No.	Year	Authority
29	Beaconsfield Reservoir – Outlet Tower – Reinforcement Details Sheet 1	97543	1970	SR&WSC
30	Beaconsfield Reservoir – Outlet Tower – Reinforcement Details Sheet 2	97544C	1970	SR&WSC
31	Beaconsfield Reservoir – Outlet Works Remodelling Outlet Tower – Hoist Frame Details	97620A	1970	SR&WSC
32	Beaconsfield Reservoir – Outlet Tower Drop Bar Arrangement & Details	97628	1970	SR&WSC
33	Beaconsfield Reservoir – Construction Program	112922	1970	SR&WSC
34	Beaconsfield Reservoir – Outlet Works - Feature Survey	94945	1968	SR&WSC
35	Beaconsfield Reservoir – Outlet Works Long Section of 42_Dia.	97441	1970	SR&WSC
36	Beaconsfield Reservoir – Outlet Works	97443	1970	SR&WSC
37	Beaconsfield Reservoir – Outlet Works 42_dia. Pipeline – 24 Dia. Offtake	97444	1970	SR&WSC
38	Beaconsfield Reservoir – Outlet Works - 42_ Dia. Conduit 3_ Dia. And 6_ Dia. Offtakes	97445	1970	SR&WSC
39	Beaconsfield Reservoir – Outlet Works 42_ Dia. Pipeline Dismantling Joint	97446	1970	SR&WSC
40	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline Arrangement	97520	1970	SR&WSC
41	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline	97521	1970	SR&WSC
42	Beaconsfield Reservoir – Outlet Works 42_dia. Pipeline-Barrel Mk No.2	97522	1970	SR&WSC
43	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline	97523	1970	SR&WSC
44	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline	97524	1970	SR&WSC
45	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline	97525	1970	SR&WSC
46	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline	97527	1970	SR&WSC
47	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline	97529	1970	SR&WSC
48	Beaconsfield Reservoir – Outlet Works Remodelling Valve House	97530	1970	SR&WSC
49	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline	97531	1970	SR&WSC
50	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline	97532	1970	SR&WSC
51	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline	97533	1970	SR&WSC

No.	Title/ Description	Drawing No.	Year	Authority
52	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline	97534	1970	SR&WSC
53	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline	97535	1970	SR&WSC
54	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline	97536	1970	SR&WSC
55	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline	97537	1970	SR&WSC
56	Beaconsfield Reservoir – Outlet Works Remodelling Faucet - Lead To Existing Pipe	97538	1970	SR&WSC
57	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline	97539	1970	SR&WSC
58	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline	97540	1970	SR&WSC
59	Beaconsfield Reservoir – Outlet Works Remodelling Connection To Existing Pipeline	97541	1970	SR&WSC
60	Beaconsfield Reservoir – Outlet Works Remodelling 42_Dia. Pipeline Thrust Block, Cut-off Wall	97542	1970	SR&WSC
61	Beaconsfield Reservoir – Outlet Works Remodelling - Valve House	97548	1970	SR&WSC
62	Beaconsfield Reservoir – Outlet Works Valve House Handrail Details	97624	1970	SR&WSC
63	Beaconsfield Reservoir – Outlet Works Trash Screens - Arrangement & Details	97625	1970	SR&WSC
64	Beaconsfield Reservoir – Outlet Works Removable PC Planks	97626	1970	SR&WSC
65	Beaconsfield Reservoir – Outlet Works Remodelling Footbridge Deck Planks	97627	1970	SR&WSC
66	Beaconsfield Reservoir – Outlet Works Remodelling Valve House Removable Roof Details	97629	1970	SR&WSC
67	Beaconsfield Reservoir – Outlet Works - Valve House – A-Frame Arrangement 2 Ton Capacity	98120	1971	SR&WSC
68	Beaconsfield Reservoir – Outlet Works - Valve House Grid Flooring & Access Ladder Rl 305-5	98121	1971	SR&WSC
69	Beaconsfield Reservoir – Outlet Works - Valve House Concrete Apron	98122	1971	SR&WSC
70	Beaconsfield Reservoir – Spillway – Erosion Control	113559	1971	SR&WSC
71	Beaconsfield Reservoir –Showing Capacity	110132	-	SR&WSC
72	Beaconsfield Reservoir – Link Up At High Level Outlet At Beaconsfield Reservoir	110543	1957	SR&WSC
73	Beaconsfield Reservoir – Outlet	110575	-	SR&WSC

No.	Title/ Description	Drawing No.	Year	Authority
74	Beaconsfield Reservoir – Locality Plan	111851	1965	SR&WSC
75	Beaconsfield Reservoir – Inlet Pipe Conc. Pipe Supports	112438	1968	SR&WSC
76	Beaconsfield Reservoir – Longitudinal Section	112439	1968	SR&WSC
77	Beaconsfield Reservoir – Longitudinal Section	112440	1968	SR&WSC
78	Beaconsfield Reservoir – Locality Plan	112441	1968	SR&WSC
79	Beaconsfield Reservoir – Graph Of Flow Upstream Of Beaconsfield Reservoir	112533	1968	SR&WSC
80	Beaconsfield Reservoir – Graph Of Flow Upstream Of Beaconsfield Reservoir	112534	1968	SR&WSC
81	Beaconsfield Reservoir – Drainage Easement CA 142	112677	1969	SR&WSC
82	Beaconsfield Reservoir – Feature Survey - West End Of Bank Street	112895	1969	SR&WSC
83	Beaconsfield Reservoir – Feature Survey - West End Of Bank Street	112896	1969	SR&WSC
84	Beaconsfield Reservoir – Western Access Road - Locality Plan	112973	1970	SR&WSC
85	Beaconsfield Reservoir – Western Access Road - Longitudinal & Cross Sections	112974	1970	SR&WSC
86	Beaconsfield Reservoir – Capacity Table	113035	-	SR&WSC
87	Beaconsfield Reservoir – Water Levels Gauge	113129	1970	SR&WSC
88	Beaconsfield Reservoir – Valve House Pit - Beaconsfield Reservoir	113148	1971	SR&WSC
89	Beaconsfield Reservoir – General Layout	113610	1971	SR&WSC
90	Beaconsfield Reservoir – Cardinia Syphon Offtake	113701	-	SR&WSC
91	Beaconsfield Reservoir – Contents Chart	114087	1972	SR&WSC
92	Beaconsfield Reservoir – Contents Chart	114672	1977	SR&WSC
93	Beaconsfield Reservoir – Western Outlet - Steel Grating Pit Covers	115289	1976	SR&WSC
94	Beaconsfield Reservoir – Contour & Capacity Plan	115914	-	SR&WSC
95	Beaconsfield Reservoir – Western Outlet, Screen Cleaning Arrangement	116037	1980	SR&WSC
96	Beaconsfield Reservoir – Screen Cleansing Arrangement MS Grate	116086	1980	SR&WSC
97	Beaconsfield Reservoir – Locality Sections (Outer Batter)	117172	1986	SR&WSC
98	Beaconsfield Reservoir – (Long Section) Clay Core Wall Depth Below Natural Surface	117627	1987	SR&WSC
99	Beaconsfield Reservoir – Range Road Chlorinator Building - Chain Hoist	117977	1988	SR&WSC

No.	Title/ Description	Drawing No.	Year	Authority
100	Beaconsfield Reservoir – Feature Record	118989	1991	SR&WSC
101	Beaconsfield Reservoir – Widening Of Bridge (Access)	136099	1983	SR&WSC
102	Beaconsfield Reservoir – Contour Plan	19633	-	SR&WSC
103	Beaconsfield Reservoir – Locality Plan Showing FSL	19634	-	SR&WSC
104	Beaconsfield Reservoir – Contours	25059	1942	SR&WSC
105	Beaconsfield Reservoir – Sections Of Dam	26010	1917	SR&WSC
106	Beaconsfield Reservoir – Outlet & Scour Pipes	26201	-	SR&WSC
107	Beaconsfield Reservoir – Outlet Tunnel Lining	26202	1954	SR&WSC
108	Beaconsfield Reservoir – Outlet Pit To Tunnel	26203	-	SR&WSC
109	Beaconsfield Reservoir – Section Showing Fill Required To Raise Crest To RL347	26205	1954	SR&WSC
110	Beaconsfield Reservoir – Long. Section Of Scour Pipe	26206	1954	SR&WSC
111	Beaconsfield Reservoir – Lifting Gear - Outlet	26207	-	SR&WSC
112	Beaconsfield Reservoir – Lifting Gear - Scour Gates	26208	1954	SR&WSC
113	Beaconsfield Reservoir – Contour Plan of Site Of Dam	26209	-	SR&WSC
114	Beaconsfield Reservoir – Offtake At RL 328	26210	-	SR&WSC
115	Beaconsfield Reservoir – Scour & Offtake	26211	1917	SR&WSC
116	Beaconsfield Reservoir – Waste Weir & By wash	26212	-	SR&WSC
117	Beaconsfield Reservoir – Contour Inlet Channel	26213	-	SR&WSC
118	Beaconsfield Reservoir – Additional Grids	26228	1954	SR&WSC
119	Beaconsfield Reservoir – Discharge Curve - Main Race	26232	1923	SR&WSC
120	Beaconsfield Reservoir – Discharge Of Main Race	26233	1923	SR&WSC
121	Beaconsfield Reservoir – Contours Around Haunted Gully	26234	1954	SR&WSC
122	Beaconsfield Reservoir – Embankment Site - Haunted Gully	26238	1954	SR&WSC
123	Beaconsfield Reservoir – Details Of Trash And Crest Angle For Inlet Measuring Weir	27334	1968	SR&WSC
124	Beaconsfield Reservoir – 42_ CLMS Field Welding Details	27510	-	SR&WSC
125	Beaconsfield Reservoir – Proposed Enlargement Of Inlet Works	27624	-	SR&WSC
126	Beaconsfield Reservoir – Inlet Control Structure & Measuring Weir	27630	1968	SR&WSC

No.	Title/ Description	Drawing No.	Year	Authority
127	Beaconsfield Reservoir – Inlet Control Structure Gate Support Beams	27631	1968	SR&WSC
128	Beaconsfield Reservoir – Outlet Connections To New Supply Main (24_Dia.)	29044	1965	SR&WSC
129	Beaconsfield Reservoir – Connection To New 42_Dia. RC Pipe Details Of 45dg Branch	29051	-	SR&WSC
130	Beaconsfield Reservoir – Beaconsfield-Langwarrin Pipe Line	29061	-	SR&WSC
131	Beaconsfield Reservoir – Commission Occupied Land	77404	1966	SR&WSC
132	Beaconsfield Reservoir – West Outlet Temporary Pumps Wiring Diagram	91387	1973	SR&WSC
133	Beaconsfield Reservoir – West Outlet Temporary Panel & Elec. Layout	91388	1973	SR&WSC
134	Beaconsfield Reservoir – Cranbourne Pipelines No. 2 & No. 3 Automatic Chlorinator Building	92715	1973	SR&WSC
135	Beaconsfield Reservoir – Cranbourne Pipelines No. 2 & No.3 Automatic Chlorinator Monorail Steel	92716	1979	SR&WSC
136	Beaconsfield Reservoir – Cranbourne Pipelines No. 2 & No. 3 Automatic Chlorinator Building	92717	1979	SR&WSC
137	Beaconsfield Reservoir – Feature Survey At Exit Tunnel - July 1968	94948	1968	SR&WSC
138	Beaconsfield Reservoir – Feature Survey West End Of Bank	95293	1969	SR&WSC
139	Beaconsfield Reservoir – Tower Access Bridge	97545	1970	SR&WSC
140	Beaconsfield Reservoir – 42_Dia. Pipeline - Blank Flange For 24_Dia. Offtake	97546	1970	SR&WSC
141	Beaconsfield Reservoir – 42_Dia. Pipeline - Blank Flange	97547	1970	SR&WSC
142	Beaconsfield Reservoir – Valve House Arrangement Of Grid Flooring At RL 306.0ft	97621	1970	SR&WSC
143	Beaconsfield Reservoir – Valve House - Grid Flooring	97622	1970	SR&WSC
144	Beaconsfield Reservoir – Valve House - Access Ladder	97623	1970	SR&WSC
145	Beaconsfield Reservoir – Brick Valve House	99291	1971	SR&WSC
146	Beaconsfield Reservoir – Mits Telemetry Terminal Connections Wiring Diagram	WD016_002	1999	SR&WSC
147	Beaconsfield Reservoir – Detail Survey	WD016_031	1994	SR&WSC
148	Beaconsfield Reservoir – Beaconsfield Reservoir, Detail Survey Enlargement Plan	WD016_032	1995	SR&WSC
149	Beaconsfield Reservoir – Detail Survey	WD016_033	1995	SR&WSC

Appendix C – Hydrology

C.1 Existing hydrology

C.1.1 ARR 2016 revision of existing hydrology

The hydrology for Beaconsfield Reservoir was updated to be in line with the revised Australian Rainfall and Runoff guidelines (ARR, 2016) using an ensemble approach (taking the representative result of ten temporal patterns for each duration). The stage storage relationship was also updated based on bathymetric survey undertaken in 2017. The RORB layout for the dam catchment is shown in Figure C-1 below.

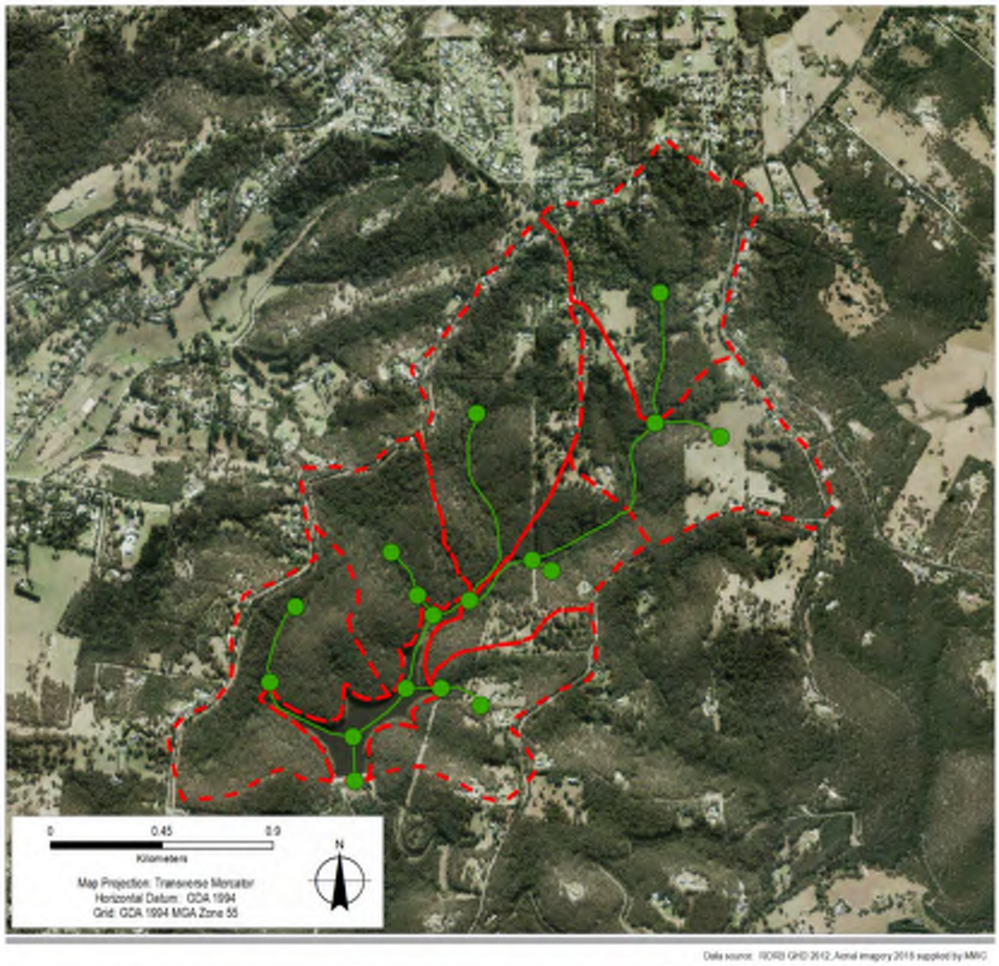

Figure C-1 Dam catchment RORB layout

C.1.2 Regional kc estimates

A number of different empirical equations exist for estimating an appropriate storage routing parameter (which affects the amount of attenuation when routing through a reach). Some of the equations commonly used in the Melbourne area are given in Table C-1.

The Beaconsfield Reservoir catchment area is 3.3 km^2, and the d_{av} (average flow distance in the channel network of all the sub-area inflows) for the reservoir catchment is 1.62 km. The Mean Annual Rainfall (MAR) for the Beaconsfield Reservoir catchment is in excess of 800 mm, according to the Bureau of Meteorology gridded mean annual rainfall data.

Table C-1 kc equations and values for Beaconsfield Reservoir

Equation	Source	k_c value for Beaconsfield Reservoir
$k_c = 0.49 \times A^{0.65}$ (MAR < 800 mm)	Australian Rainfall and Runoff	1.06
$k_c = 2.57 \times A^{0.45}$ (MAR > 800 mm)	Australian Rainfall and Runoff	4.40
$k_c = 2.2 \times A^{0.5}$	RORB Manual	4.00
$k_c = 1.25 \times d_{av}$	Pierce et al. (2010)	2.03
$k_c = 1.53 \times A^{0.55}$ (South East ("DVA") area)	MWC	2.95
$k_c = 1.19 \times A^{0.56}$ (Melbourne Metropolitan Board of Works area)	MWC	2.32

For Beaconsfield Reservoir, the applicable regional equation given in ARR (2016) is the second equation, which yields a suggested k_c value of 4.4. Sensitivity analysis on the k_c value is shown as part of the validation and verification process in Section C.1.4.

C.1.3 Losses

Rainfall losses were downloaded from the ARR Data Hub. These are shown in Table C-2 below, along with the previously adopted values for comparison.

Table C-2 Data Hub losses for Beaconsfield Reservoir

Loss type	Data Hub Value	Previous Cardinia Reservoir calibration values (using ARR, 1987)
Storm initial loss (IL_s)	25	26.3
Continuing loss (CL)	4.4	2.6

The storm initial loss is slightly lower than previously adopted. The way in which the burst loss is calculated has changed, with median pre-burst depths now available from the data hub.

Prior to ARR (2016), losses were derived in accordance with the equations from the Cooperative Research Centre for Catchment Hydrology (CRCCH, 1996), using a base flow index (BFI) as shown below:

$IL_S = -25.8\ BFI + 33.8$

$CL = 7.97\ BFI + 0.00659\ PET – 6.0$

The data hub pre-burst depth is now subtracted from the storm loss to calculate the burst loss applicable to the AEP and duration for ensemble modelling. The data hub continuing loss value is larger than obtained in the Cardinia Reservoir calibration previously, using ARR (1987) methodologies.

C.1.4 Verification

For a given catchment within RORB, the hydrograph peak, shape and volume are influenced by both the k_c value and rainfall losses. The k_c value is a non-linear storage routing factor applied to reaches. The larger the k_c value the higher the attenuation. Losses affect the peak of the hydrograph, and the volume of the hydrograph, with larger losses reducing the volume.

Where there is simultaneous rainfall and streamflow gauging, both the k_c value and the losses may be adjusted to provide a good match between the modelled and observed hydrographs.

Catchment files

A number of different catchment files were run using the ARR (2016) IFD, the data hub losses, median pre-burst depths and ensemble temporal patterns. The catchment files and purpose are summarised in Table C-3 below.

Table C-3 Summary of catchment files and purpose

Catchment file	Purpose	Comment
Natural (i.e. no reservoir)	For comparison to Regional Flood Frequency Estimation	Validation for ungauged catchment. There is no rainfall or streamflow gauge within catchment.
Reservoir catchment model (at original FSL)	Estimating existing flows	N/A
Reservoir at original FSL (model extended to Princes Highway)	Verifying against flood frequency at Officer gauge	Low impervious fractions, representative of conditions for most of the gauge record. No rainfall gauge within catchment. Rainfall gauge is located at same location as streamflow gauge.
MWC Developer Services planning model	Comparison of flows used for planning purposes, including verifying against flood frequency at Officer gauge	Represents almost full development of area between Browns Road and Princes Highway. Stage storage and storage discharge curve for reservoir updated (to correctly represent original FSL).

Gauge data

The nearest gauge is located on Gum Scrub Creek at the Princes Highway in Officer (228365A). Beaconsfield Reservoir is located within the catchment of the Officer gauge. Key information on the gauge is summarised in Table C-4 following.

Table C-4 – Officer Gauge – key information

Parameter	Value	Comment
Period of record	26 Jun 1980 - present	Significant development has occurred in parts of the catchment during the gauging period. The creek profile downstream of the gauge has also changed recently.
Catchment size	41 km^2	At 3.3 km^2, the Beaconsfield Reservoir catchment is a small proportion of this catchment.
Largest actual gauging	6.2 m^3/s	Occurred 29/07/1987 (prior to restricted FSL). Catchment would have been almost entirely rural in those days.
Largest estimated flow		Occurred Converted from level to flow using rating curve.
BoM Flood frequency 1% AEP estimate	18-23	LP3/ GEV-L moments

Flood frequency analysis was undertaken on the annual maximum series using the FLIKE analysis package. FLIKE offers fitting using a number of different distributions. Of these, the LP3 (no prior information) and Gumbel distributions appeared to have the best “goodness of fit” as data points were not outside of the confidence limits, and the confidence limits were narrowest. The FLIKE plots are included below.

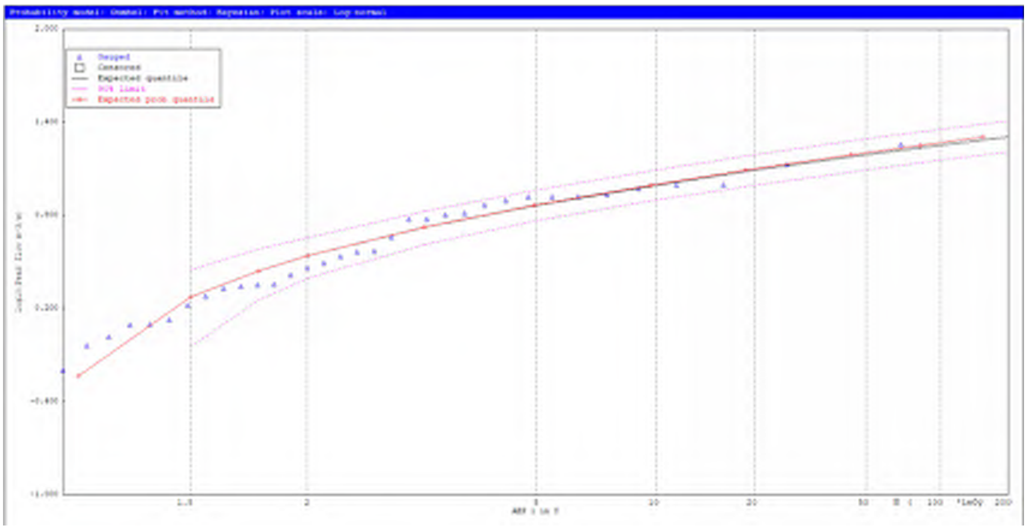

Figure C-2 Gumbel probability model on Log normal scale

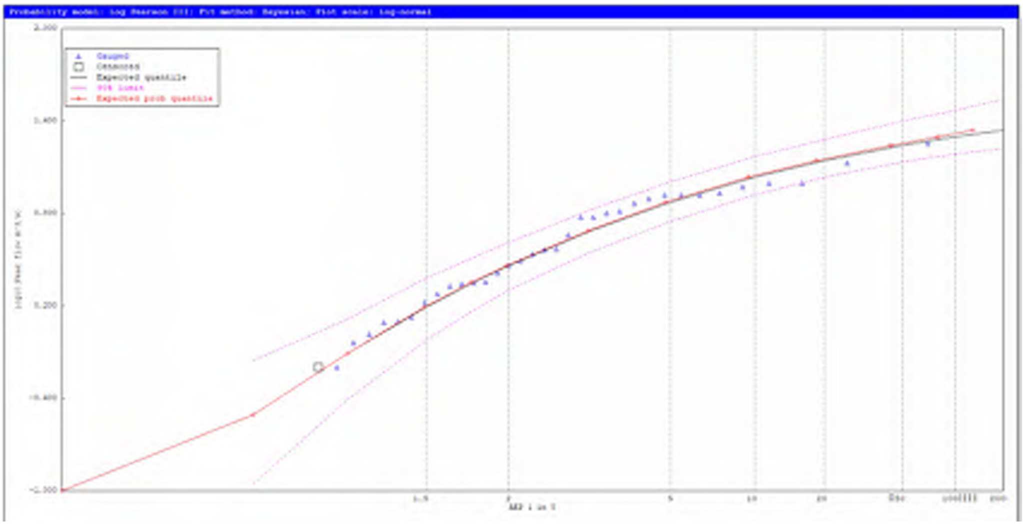

Figure C-3 LP3 no prior info probability model on Log normal scale

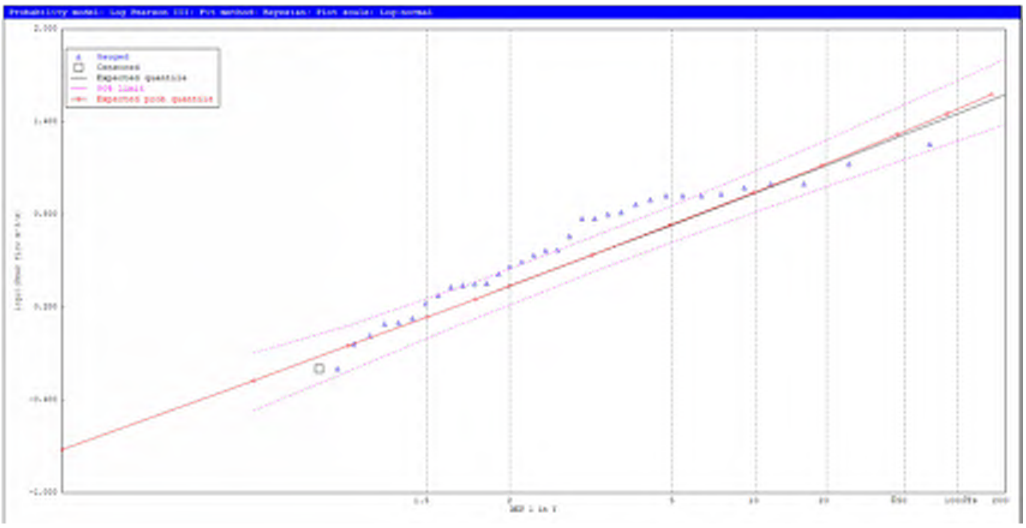

Figure C-4 LP3 regional probability model on Log normal scale

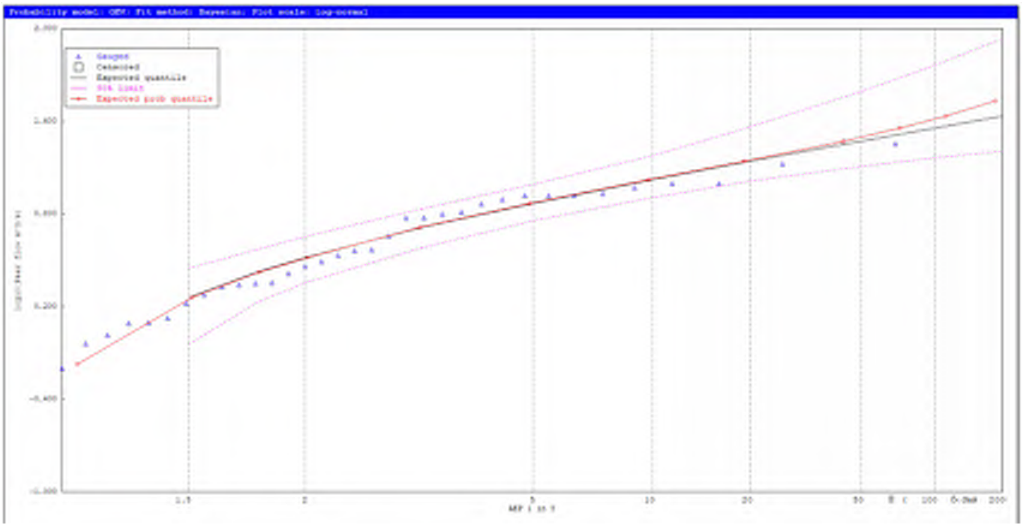

Figure C-5 GEV probability model on log normal scale

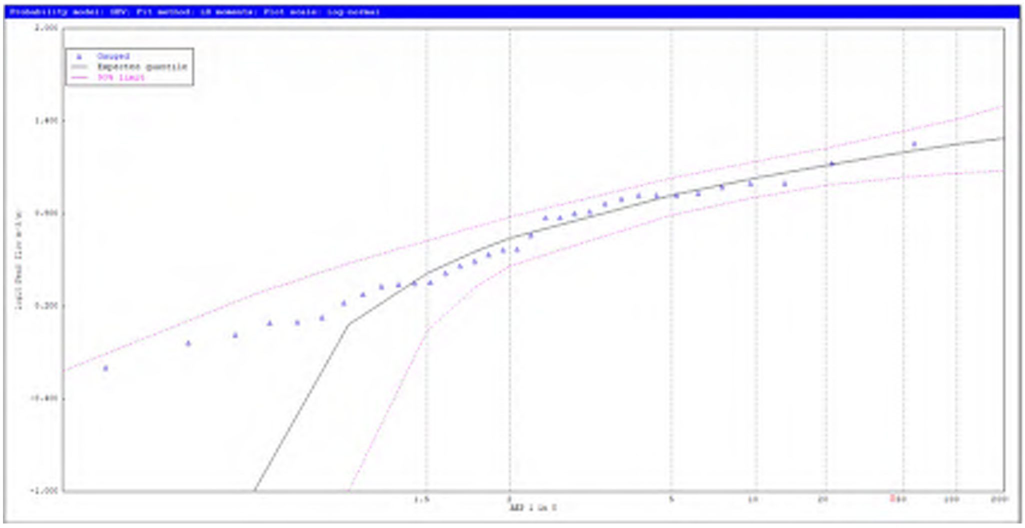

Figure C-6 GEV probability model with optimised LH moments on log normal scale

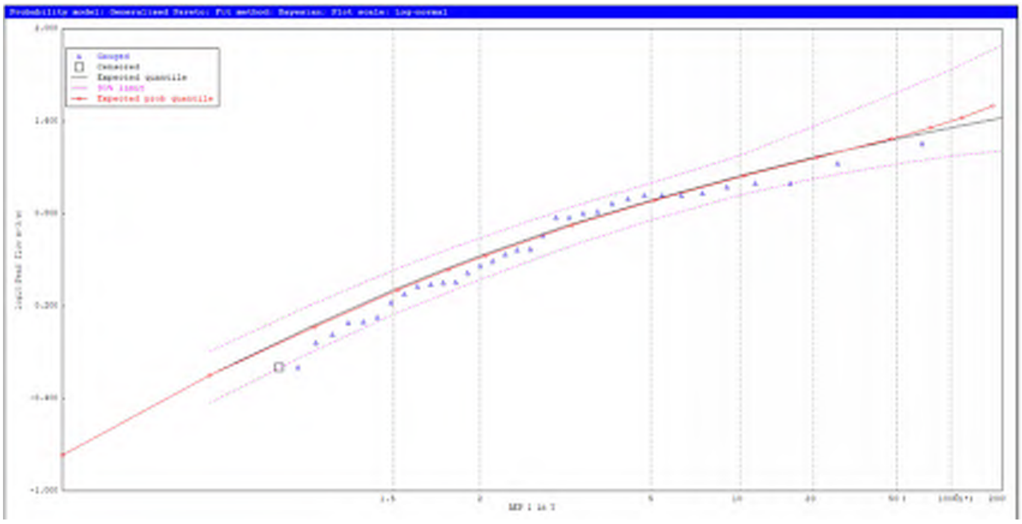

Figure C-7 Generalised Pareto probability model on Log normal scale

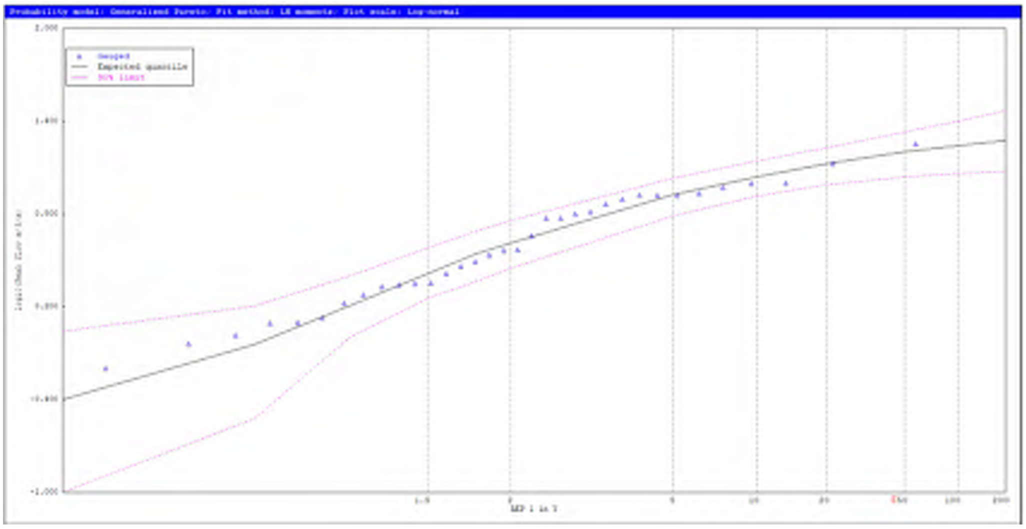

Figure C-8 Generalised Pareto probability model with optimised LH moments on Log normal scale

An extended RORB model for the larger catchment area to the Princes Highway was compiled and undeveloped fraction impervious values were applied (accounting for conditions throughout most of the gauge record). The Areal Reduction Factor (ARF) applied was for the catchment area upstream of the Princes Highway, and a k_c value, which maintains the kc/dav ratio of the reservoir catchment only model, was adopted.

With reference to Figure C-9 following, the 1 in 100 AEP peak design flows derived from ARR (2016) ensembles, and the data hub losses accounting for median pre-burst, are within the ranges of the gauge Flood Frequency Analysis, being slightly above the expected quantile for LP3 (no prior information) and Gumbel fits.

The flood frequency analysis results support both the k_c and loss values adopted for the reservoir catchment.

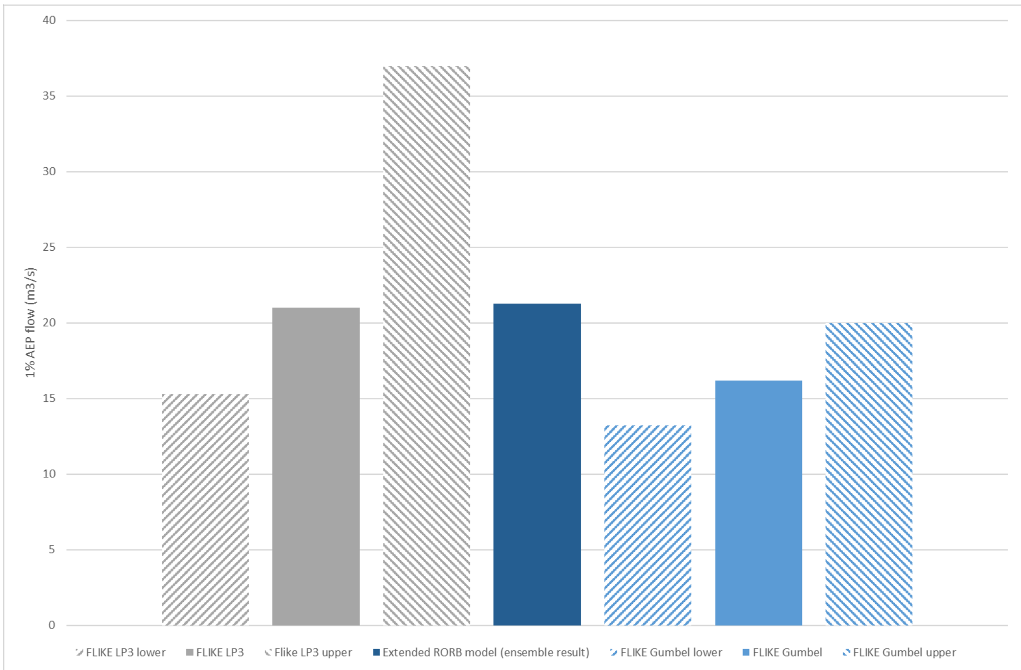

Figure C-9 FLIKE and RORB model results for Gum Scrub Creek at Officer

Regional Flood Frequency Estimation (RFFE)

As part of the ARR revision, a Regional Flood Frequency Estimate software tool has been developed to estimate flows for ungauged catchments. The software to infer flow estimates from nearby gauged catchments uses the location of the catchment centroid, catchment outlet location and catchment size. The Rational Method is no longer recommended for estimating peak flows from ungauged catchments.

The natural catchment RORB model was simulated for the 1 in 100 AEP using an ensemble simulation with data hub losses and median pre-burst depths; the resulting peak flows for the various k_c equations are compared in Figure C-10 following. Both the RORB equation and MAR>800 mm k_c values provide a good match to the RFFE expected quantile using the data hub losses in an ensemble approach.

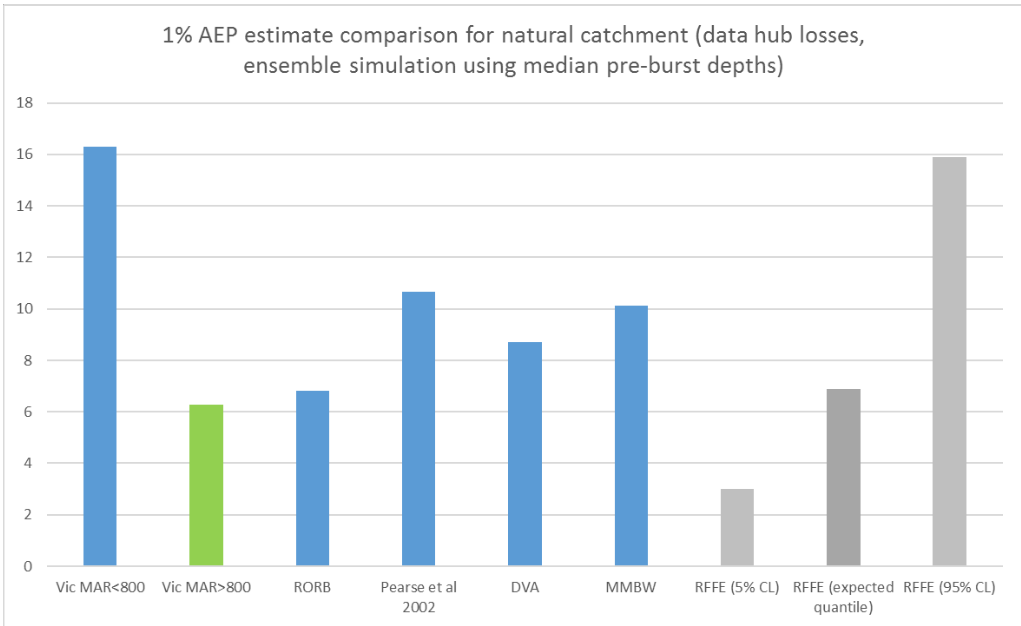

Figure C-10 Peak flow comparison using various equations for k_c

A sensitivity analysis was also undertaken by varying the continuing loss value for a k_c value of 4.4. The results of the sensitivity analysis are presented in Table C-5

Table C-5 RFFE and ensemble 1% AEP design flow comparison

Estimate	1% AEP flow (m^3/s)
RFFE 5% confidence limit	3.0
RFFE expected quantile	6.9
Natural RORB model ensemble result (no drowned reaches) with temporal pattern filtering using k_c=4.4	6.3
Natural RORB model ensemble result (no drowned reaches) CL=2.6 mm/hr with temporal pattern filtering using k_c=4.4	7.7
Natural RORB model ensemble result (no drowned reaches) CL =1.8 mm/hr with temporal pattern filtering using k_c=4.4	8.4
RFFE 95% confidence limit	15.9

For Beaconsfield Reservoir, there is not sufficient direct gauge data for calibration, however, validation against both the RFFE for the reservoir catchment without a dam, and the Gum Scrub Creek catchment to the Princes Highway at Officer, suggests that the k_c value from the > 800 mm MAR regional equation, and the data hub losses and pre-burst are appropriate.

No adjustment has been made to the recommended k_c (from the applicable regional equation in ARR) or data hub loss values on the basis that:

1. The reliability of the RFFE is not always high.
2. Peak flows can be adjusted in a variety of ways which affect the volume of the hydrograph and bias the routing results without sound justification.
3. Adjusting loss values to match the RFFE may be contrary to concern that (in some areas at least) data hub loss values are already creating an underestimation bias.

Published on 12/02/2019, “Review of ARR Design Inputs for NSW” prepared by WMAWater for the NSW Office of Environment and Heritage, suggests that the losses are too high for NSW, and make a number of recommendations. Whilst based on NSW data, investigation of Victorian data would be required before disregarding the findings, and many of the fundamentals may still be of relevance. Summarised from the Executive Summary of ‘Review of ARR Design Inputs for NSW’, the recommended hierarchical approach to loss selection is (pending further research and advice that is more definitive):

1. Use the average of calibration losses from the actual study if available
2. Use the average calibration losses from other studies in the catchment if available and appropriate for the study
3. Use the average calibration losses from other studies in the similar adjacent catchments if available and appropriate for the study
4. Use FFA-Reconciled Losses for nearby similar sites (data is provided for NSW). Additional scrutiny should be applied to initial loss values for catchments of 100 km^2 or less, and
5. Until revised losses are generated using a better predictor equation, based on NSW data, WMAWater suggests applying a multiplication factor of 0.4 to the raw data hub values. Use the unmodified ARR data hub initial losses, and apply additional scrutiny to them for catchment areas of 100 km^2 or less, to ensure they are representative for the catchment

The WMAWater work calculated probability neutral burst initial loss values to be used in all instances where good local initial loss data is not available (Cases 4 and 5), unless a detailed Monte Carlo assessment of pre-burst and losses has been carried out.

The final RORB parameters adopted are summarised in Table C-6 below.

Table C-6 Adopted RORB parameters

Parameter	Value
m	0.8
k_c	4.4
Storm initial loss (mm)	25
Continuing loss (mm/hr)	4.4

Appendix D – Dambreak

D.1 Breach modelling

D.1.1 General

Breach parameters were estimated using a variety of empirical equations and simulated in 'FLDWAV' hydraulic modelling software to generate breach hydrographs.

Parameters which can be varied and that will affect the breach outflows include:

- Time for breach development
- Height of breach
- Width of breach
- Breach side slopes
- Mode of breaching (piping or overtopping)

Characteristics such as the volume and profile of the storage and the head (height of water in the storage above the downstream level or whether the breach is submerged) also affect the outflow.

Piping breaches along the foundation were assumed (centreline of piping breach and minimum breach level RL 87 mAHD). Consistent with previous assumptions based on poor compaction, a breach side slope of 1.0V:0.2H was adopted, unless a specific side slope is given for an estimation method.

D.1.2 Estimation of breach parameters

Various empirical equations have been derived using regression analysis on data from historical failures. Given the fact that there is significant scatter observed in the historical breaches, these equations are all different approximations of the most likely breach parameters and flows. An actual breach may fall either side of these estimates (larger or smaller), although some methods have better prediction accuracy than others (Wahl, 2004, Pierce et al., 2010).

"Dam Break Mechanisms" (Allen, 1994) recommends that the breach time and breach size be estimated in accordance with MacDonald Langridge-Monopolis relationships, which consider the volume of material in the embankment eroded to form a breach. A sensitivity analysis is also recommended.

As suggested in ANCOLD Bulletin 97 (Allen, 1994), minimum breach base widths conforming to the Singh and Scarlatos (1988) relationships were also considered.

The breach parameters predicted by the various empirical equations described below are summarised for each scenario in Table D-1 to Table D-3 following. Notes related to all three tables are provided at the end of Table D-6.

Wahl (2004) provides separate equations for earthfill and rockfill embankments based on MacDonald Langridge-Monopolis relationships. The following equations show the relationship as cited in Wahl.

Equation D-1 MacDonald Langridge-Monopolis (Wahl, 2004)

$$V_{er} = 0.0261(V_w \times h_w)^{0.769}$$

$$\boldsymbol{tf} = 0.0261 V_{er})^{0.364}$$

Where V_{er} the volume of material eroded from the embankment in cubic metres

V_w the volume of water in the storage in cubic metres

h_w the head of water in metres

Side slopes of 1H:2V could be assumed in most cases according to Wahl (2004).

There are also a number of other empirical equations for estimating breach time and size, which have been used for sensitivity analysis, as shown in Table D-1.

Table D-1 Empirical equations for breach parameters

Method	Equation for breach size	Equation for breach development time (time to fully form)	Side slope recommendations
Bureau of Reclamation	$B_{ave} = 3 \times h_w$	$t_r = 0.011 \times B_{ave}$	1H:1V
Von Thun and Gillette (erosion resistant)	$B_{ave} = 2.5 \times h_w + C_b$	$t_r = \frac{B_{ave}}{4.0 \times H_w}$	1H:1V (unless with cohesive shell or very wide cohesive core where 1H:2V or 1H:3V could be more appropriate)
Froehlich (2008)	$B_{av}=0.27K_0V_w^{0.32}*H_b^{0.04}$	$t_r = 0.01756 \sqrt{\frac{V_w}{gh_b^2}}$	1H:1V overtopping 0.7H: 1V otherwise

Table D-2 contains bounds for breach development time and width, developed by Singh and Scarlatos (1988) using historical dam failure data.

Table D-2 – Singh and Scarlatos recommended bounds

Parameter	Suggested minimum	Suggested maximum
Breach top width/breach base width: B/d	1.06	1.74
Breach top width/breach depth: B/d	0.84	10.93
Breach angle:	10	50

The resulting minimum and maximum breach sizes, which conform to the Singh and Scarlatos geometry bounds, are summarised below in Table D-3.

Table D-3 Minimum and maximum base widths conforming to Singh and Scarlatos geometry bounds

Crest level (m AHD)	Breach height 'd' (m)	Assumed side slope	Minimum base width based on Singh and Scarlatos (m) based on B/b=1.74	Maximum base width based on Singh and Scarlatos (m) based on top width 10.93 x d
97	10	0.2	5.4	105.3
96.1	9.1	0.2	4.9	95.8

The author of FLDWAV, Fread recommends breaches be calibrated to the following equation:

Equation D-2 Fread (1981) peak flow equation

$$Q = B_r \times \left(\frac{C}{Tf + \frac{C}{H^{0.5}}} \right)^3$$

Where Q is the breach flow in cubic feet per second (ft^3/s)

B_r is the average final breach width in feet (1H to 5H)

And C equals 23.4 * (A_s / B_r)

Where A is the reservoir surface area at failure elevation in acres

H is the failure depth above breach elevation in feet

Tf is the time of failure (H/120) hours (minimum 10 min (0.17 hours))

Froehlich (1995) also produced an empirical equation for peak breach outflow, which produces a good fit to many of the available case studies (Pierce et al., 2010).

Equation D-3 Froehlich (1995) peak flow equation

$$Q=0.607*(V_w^{\ 0.295}* \text{ x } H_w^{1.24})$$

Where Q is the breach flow (m^3/s)

V_w is the volume of water in m^3

And H_w is the height of the water in m

The work of Pierce et al. (2010) for the US National Dam Safety Review Board Steering Committee on Dam Breach Equations, suggests an empirical equation based on volume, head, and crest length may provide a very high correlation of predicted to measured peak outflow. This was derived by multi-variable regression analysis of historical failure data and has a quoted R^2 of 0.919 – 0.99 depending on the dataset used.

This is shown in Equation D-4 below.

Equation D-4 Pierce et al. (2010)

$$Q_p = 0.012 \times V_w^{0.493} \times H_w^{1.205} \times L^{0.226}$$

Where V_w is volume in cubic metres

H_w is the height of water behind the dam in metres

L is the embankment length in metres

Table D-4 Breach parameters from empirical equations for FSL = RL 93.0 mAHD

Empirical equation	Side slope	Sunny day base width (m)	Sunny day breach development time (min)
MacDonald Langridge Monopolis (Wahl)[1]	0.2	-0.6	10
Bureau of Reclamation	0.2	16	12
Froehlich (2008)[2]	0.7	3.2	8
Von Thun Gillette (1990)	1	11.1	53
Singh and Scarlatos minimum breach base width	0.2	5.4	22 (applying Wahl earthfill equation to volume of embankment eroded)

Table D-5 – Breach parameters from empirical equations for FSL = RL 94.0 mAHD

Empirical equation	Side slope	Sunny day base width (m)	Sunny day breach development time (min)
MacDonald Langridge Monopolis (Wahl)[1]	0.2	-0.1	12
Bureau of Reclamation	0.2	19.2	14
Froehlich (2008)[2]	0.7	5.1	11
Von Thun Gillette (1990)	1	14.5	51
Singh and Scarlatos minimum breach base width	0.2	5.4	22 (applying Wahl earthfill equation to volume of embankment eroded)

Table D-6 – Breach parameters from empirical equations for FSL = RL 95.0 mAHD

Empirical equation	Side slope	Sunny day base width (m)	Sunny day breach development time (min)
MacDonald Langridge Monopolis (Wahl)[1]	0.2	0.5	14
Bureau of Reclamation (2014)	0.2	22	16
Froehlich (2008)[2]	0.7	5.9	12
Von Thun Gillette (1990)	1	16.1	49
Singh and Scarlatos minimum breach base width	0.2	5.4	22 (applying Wahl earthfill equation to volume of embankment eroded)

Notes:

1) Breaches predicted do not conform to the geometry bounds suggested by Singh and Scarlatos. The breach base widths were increased to the minimum base width suggested by Singh and Scarlatos, and the breach time adjusted for the larger amount of embankment material removed, as shown in the last row of the table.

2) Breaches predicted do not conform to the geometry bounds suggested by Singh and Scarlatos. As there is no relationship between the predicted size of the breach and the predicted breach time these have not been adjusted.

D.1.3 Breach results and validation

The resulting breach hydrographs for each scenario are shown in Figure D-1 to Figure D-3, along with peak breach estimates from three empirical equations for validation described previously. A consistent scale has been used on all three figures for comparison purposes.

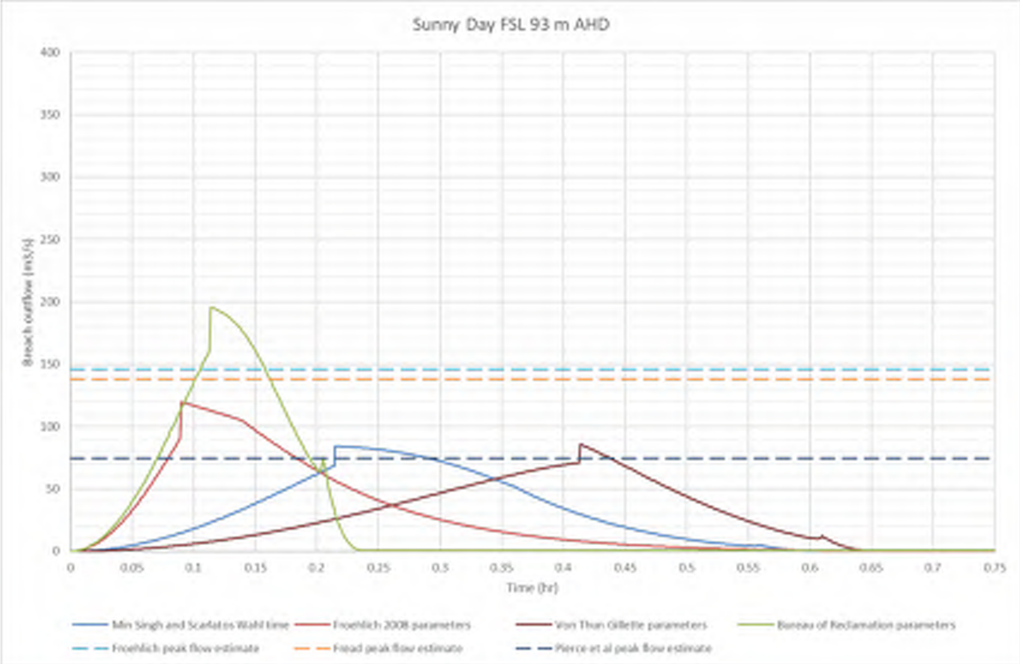

Figure D-1 SDF for FSL = RL 93.0 mAHD breach hydrographs

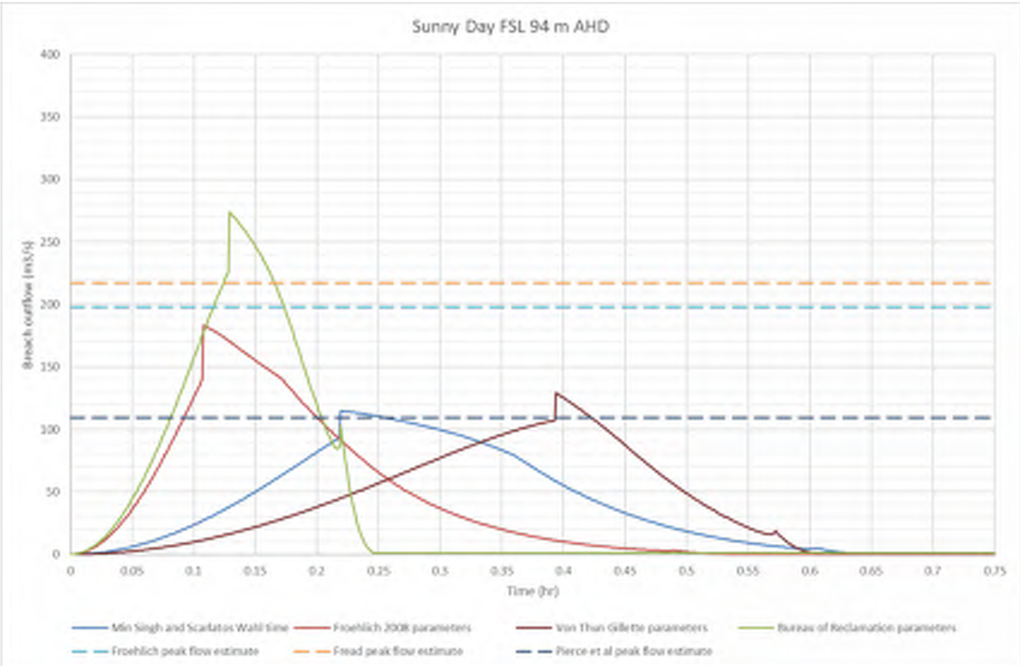

Figure D-2 SDF for FSL = RL 94.0 mAHD breach hydrographs

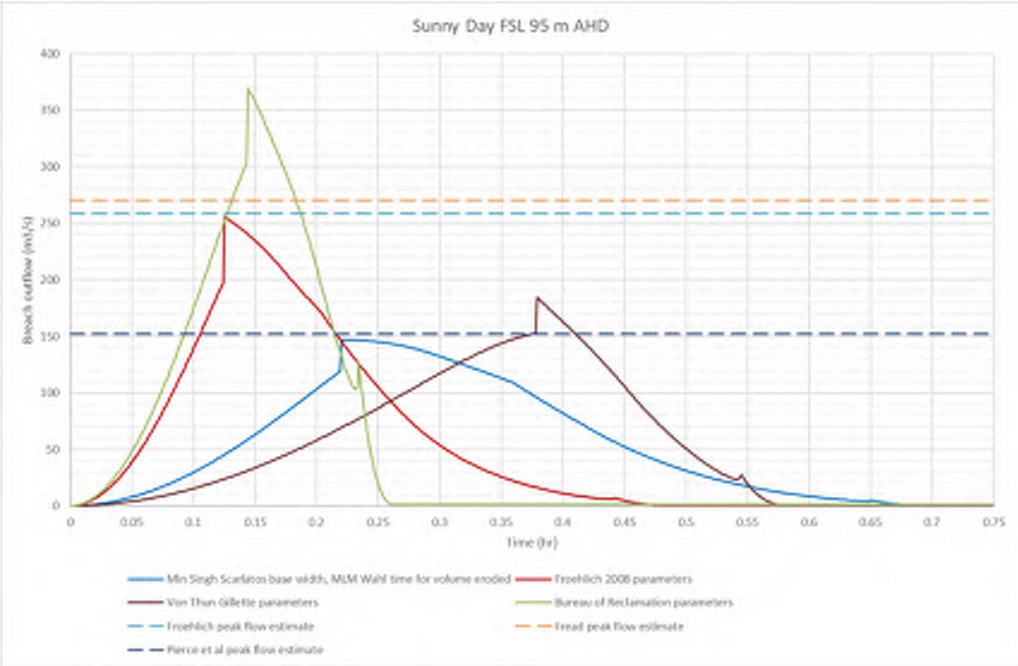

Figure D-3 SDF for FSL = RL 95.0 mAHD breach hydrographs

D.1.4 Adopted breach parameters

For each scenario, a most likely, upper bound and lower bound breach were selected after reviewing all the breach hydrographs collectively along with the empirical peak flow estimates (refer Section 4.1 and D.1.1. to D.1.3). There are a number of reasons for selecting multiple breach hydrographs rather than a single value:

1. To provide a sensitivity analysis on the breach assumptions (not just the most conservative);
2. To test the impact of timing on downstream flooding, acknowledging that a latter but smaller breach peak may coincide with downstream flood peaks to produce worse flooding in some areas; and
3. Depending on the floodplain characteristics, features such as constrictions or diversions may allow greater volume to reach downstream PAR during a more gradual release, resulting in higher consequences even though the peak at the dam was lower.

D.1.5 Dwellings

PAR for dwellings was derived by applying average occupancy rates of 2.8 from the 2016 census to the number of residential properties that were within the estimated inundation area.

During day time, dwelling occupancy was assumed half the night time rate recorded in the census. Floor levels were assumed to be 300 mm above the ground surface where no surveyed floor level was specified.

D.1.6 Boon Roses

Located on McMullen Road in Officer, the Boon Roses sheds and glasshouses are inundated by breach flows. It has been assumed that on average there are four (4) people working here during the day only.

D.1.7 Scout Park

The GWS Anderson Scout Park (http://www.gwsandersonscoutcamp.org.au/) is located on Haunted Gully Creek approximately one kilometre downstream of Beaconsfield Reservoir. In addition to buildings, the Scout Park includes a number of areas where numbers of people gather outside on a regular basis.

Occupancy assumptions for the Scout Camp were based on discussions with the caretaker in 2016, as outlined in Table D-7. Locations are shown in Figure D-4. Whilst it is noted that the maximum occupancy will not always be realised, there was not sufficient information available to reliably assign a “typical” occupancy.

Table D-7 Scout Park usage/occupancy assumptions

Area	ID	Frequency	Max. day time PAR	Max. night time PAR	Day time PAR (exposure factors applied)	Night time PAR (exposure factors applied)
Family Camp	UNI1	Four times a year	140	140	1.53	1.53
Scouts Camp	UNI2	Two days a fortnight	30	30	4.29	4.29
Nature Walk	UNI3	Two hours, once a month	30	0	0.20	0.00
Loch Lowe Canoe Area	UNI4	Two hours once a fortnight	30	0	0.43	0.00

Figure D-4 Locations of PAR considered at GWS Anderson Scout Park

D.1.8 Major roads

The Princes Highway is affected by some of the SDF breaches, and was considered separately to the PAR originating from buildings. The approximate Average Annual Daily Traffic volume (AADT) is 13,000 vehicles in each direction.

An average vehicle occupancy rate of 1.5 was applied. The number of vehicles assumed to be on a length of road at any given time was estimated based on the speed limit, length of road inundated and assumption that 80% of traffic occurs during the 10 hour day time period. It was assumed that 90% of the traffic were itinerants (from outside the area and not already accounted for).

If the water level rises almost instantaneously to the peak level on the road, it can be assumed that the PAR equals the number of people expected on average to be on the length of road that becomes inundated:

$$\frac{Length\ inundated\ (km)}{S\ (km/hr)} x\ average\ vehicle\ occupany\ x\ average\ number\ of\ vehicles\ per\ hour$$

Average day time vehicles per hour = 0.8 x AADT/10

Average night time vehicles per hour = 0.2 x AADT/14

Table D-8 Major road PAR assuming instantaneous inundation

Scenario	Length of Princes Hwy inundated (km)	Length of Princes Fwy inundated (km)	Day time PAR	Night time PAR	Average weighted PAR
SDF for FSL= RL 93.0 mAHD	0	0	0	0	0
SDF for FSL= RL 94.0 mAHD	0	0	0	0	0
SDF for FSL= RL 95.0 mAHD	0.09-0.11	0	1.61-2.08	0.29-0.37	0.84-1.08

D.1.9 Total Population at Risk

The total PAR for each scenario is summarised in Table D-9 to D-11 below.

Table D-9 – Total PAR-SDF for FSL = RL 93.0 mAHD

Location	Day (10 hours)	Night (14 hours)	Weighted average
Dwellings (2-3 flooded above assumed floor level)	3-4	6-8	4-7
Boon Roses	4	0	2
Scout Camp (UNI3, UNI4)	0.6	0	0.4
Princes Hwy	0	0	0
Total	**8-9**	**6-8**	**6-9**

Table D-10 – Total PAR-SDF for FSL = RL 94.0 mAHD

Location	Day (10 hours)	Night (14 hours)	Weighted average
Dwellings (3-4 flooded above assumed floor)	4-6	8-11	7-9
Boon Roses	4	0	2
Scout Camp (UNI1, UNI3, and UNI4)	0.6-2	0-2	0.4-2
Princes Hwy	0	0	0
Total	**9-13**	**8-13**	**9-13**

Table D-11 – Total PAR-SDF for FSL = RL 95.0 mAHD

Location	Day (10 hours)	Night (14 hours)	Weighted average
Dwellings (3-4 flooded above assumed floor level)	4-6	8-11	7-9
Boon Roses	4	0	2
Scout Camp (UNI1, UNI3 and UNI4)	2	2	2
Princes Hwy	1.61-2.08	0.29-0.37	0.84-1.08
Total	**12-14**	**10-13**	**12-14**

D.2 Probable Loss of Life (PLL)

D.2.1 Breach fatality rates

A fatality rate is applied to each location of PAR, based on the amount of warning and how hazardous the flood is (as defined by the velocity depth product). In 2014, the U.S. Bureau of Reclamation released an interim report titled “RCEM – Reclamation Consequence Estimating Methodology: Guidelines for Estimating Life Loss for Dam Safety Risk Analysis” (USBR, 2014). The new method has largely replaced Graham (USBR, 1999), which was released by the Bureau of Reclamation in 1999.

RCEM is very similar to the 1999 procedure in that it continues to rely on case history data to guide the selection of fatality rates; however, it now relies on a graphical representation of fatality rate as a function of flood severity and warning time. Flood severity is now defined quantitatively in terms of DV (product of flood depth and velocity).

The method uses two sets of curves, one representing where little or no warning is given and another for adequate warning. As it has been judged that there is little or no warning, the set of curves shown in Figure D-5 was used in the estimation of PLL.

The four curves represent the upper and lower bounds of overall and suggested limits. The final estimate for fatality rate is generally the median of the two suggested curves. In circumstances where the population is more vulnerable due to the nature of shelter available (such as at the Scout Camp), the overall upper curve may be appropriate.

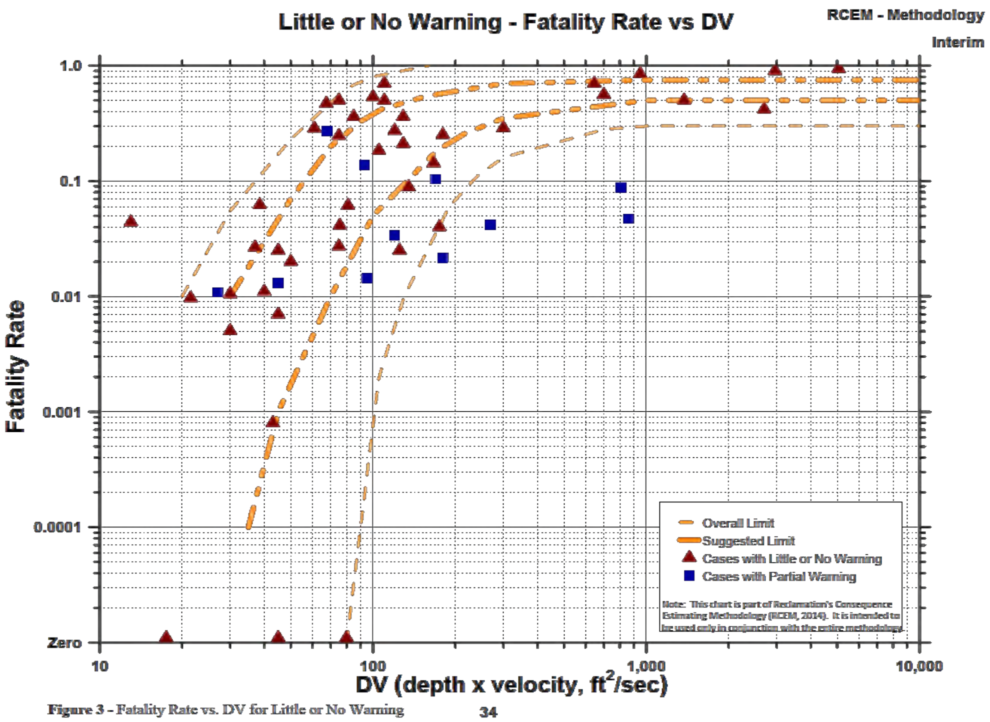

Figure D-5 Little or no warning - fatality rate vs DV (reproduced from USBR, 2014)

UK RARS (EA, 2013) offers an alternative fatality rate curve, which is derived from the Graham data, and intended to apply to small storages in populated areas. The no warning UK RARS, USBR suggested upper and USBR suggested lower curves are plotted together for comparison in Figure D-6 following.

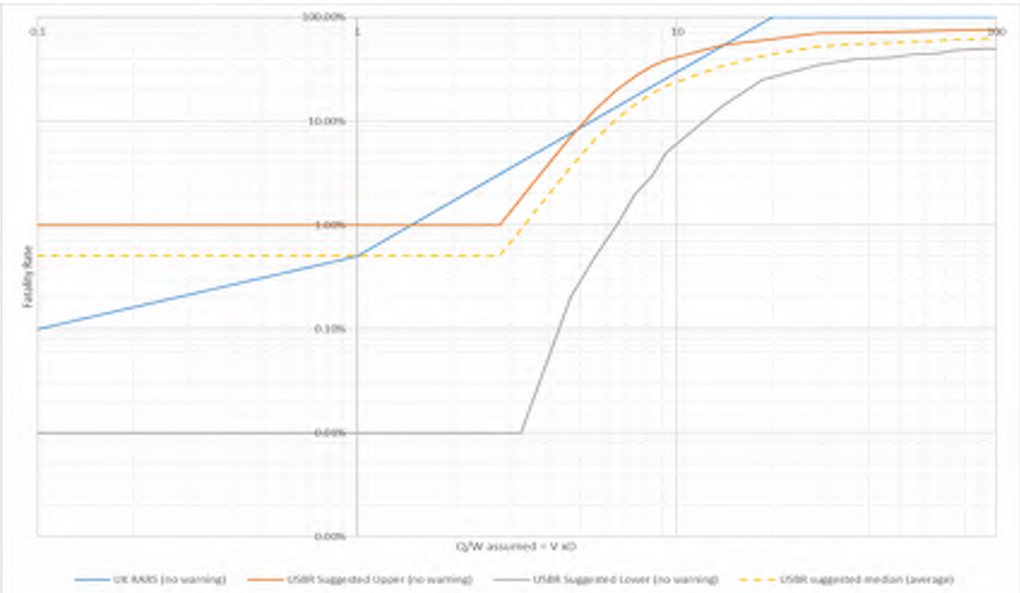

Figure D-6 Comparison of UK RARS and USBR no warning fatality rate curves

D.2.2 Potential Loss of Life on roads

Modelling of the SDF for an FSL of RL 95.0 mAHD predicts inundation of the northern (eastbound) carriageway of the Princes Highway.

The principles of the Campbell et al. (2013) ‘Flooded Cars’ method were applied to estimate PLL on the Princes Highway, considering the likelihood of vehicles being on the road when the flood wave arrives, or driving into flood waters when the road is already inundated.

Appendix E – PLL estimation and severity of damage and loss

Sunny Day Lower bound Failure - Current PAR and PLL Breakdown by VicMap Zones (USBR, 2014) - Floor Flooded

Zone	Zone Code	Zone Num	PAR Vulnerability	Occupancy		Description	Buildings	PAR		Loss of Life (day)											Loss of Life (night)											Loss of Life (day and night)										
											no warning					adequate warning						no warning					adequate warning						no warning					adequate warning				
				day	night			day	night	Best Estimate	Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit	Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit	Best Estimate	Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit	Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit	Best Estimate	Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit	Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit
Residential	R1Z	1	3	1.4	2.8	Residential 1 Zone - moderate range of densities	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	R3Z	2	3	1.4	2.8	Residential 3 Zone - moderate range of densities	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RGZ1	3	3	1.4	2.8	Residential Growth Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	NRZ1	4	3	1.4	2.8	Neighbourhood Residential Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GRZ1	5	3	1.4	2.8	General Residentia;l Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	FZ-RES	6	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ1	7	3	1.4	2.8	Farm Zone (Residential building footprints)	1	1	3	0.007	0.000	0.000	0.007	0.014	0.014	0.000	0.000	0.000	0.000	0.002	0.014	0.000	0.000	0.014	0.028	0.028	0.000	0.000	0.000	0.001	0.003	0.011	0.000	0.000	0.011	0.022	0.022	0.000	0.000	0.000	0.000	0.003
	GWZ2	8	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ3	9	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ4	10	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ5	11	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWAZ1	12	3	1.4	2.8	Green Wedge A Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	LDRZ	13	3	1.4	2.8	Low Density Residential Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ	14	3	1.4	2.8	Urban Growth Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ1	15	3	1.4	2.8	Urban Growth Zone 1	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ2	16	3	1.4	2.8	Urban Growth Zone 2	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ3	17	3	1.4	2.8	Urban Growth Zone 3	1	1	3	0.007	0.000	0.000	0.007	0.014	0.014	0.000	0.000	0.000	0.000	0.002	0.014	0.000	0.000	0.014	0.028	0.028	0.000	0.000	0.000	0.001	0.003	0.011	0.000	0.000	0.011	0.022	0.022	0.000	0.000	0.000	0.000	0.003
	UGZ4	18	3	1.4	2.8	Urban Growth Zone 4	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mixed Use Zone	MUZ	19	3	1.4	2.8	Mixed Use Zone (Mix of residential, commercial, industrial and other uses)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Township Zone	TZ	20	3	1.4	2.8	Small townships with no specific zoning structures	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Residential Total	**2**	**3**	**6**	**0.014**	**0.000**	**0.000**	**0.014**	**0.028**	**0.028**	**0.000**	**0.000**	**0.000**	**0.001**	**0.003**	**0.028**	**0.000**	**0.001**	**0.028**	**0.056**	**0.056**	**0.000**	**0.000**	**0.001**	**0.001**	**0.007**	**0.022**	**0.000**	**0.000**	**0.022**	**0.044**	**0.044**	**0.000**	**0.000**	**0.000**	**0.001**	**0.005**
Industrial	IN1Z	21	3	5.95	0	Main zone to be applied in most industrial areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	IN2Z	22	3	5.95	0	Large industrial zones away from residential areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	IN3Z	23	3	5.95	0	Garden supplies/nurseries, quarries	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Business	B1Z	24	3	5.95	0	Main zone to be applied in most commercial areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B2Z	25	3	5.95	0	Offices and associated commercial uses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B3Z	26	3	5.95	0	Offices, manufacturing industries and associated uses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B4Z	27	3	5.95	0	Mix of bulky goods retailing and manufacturing industries	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B5Z	28	3	5.95	0	Mix of offices and multi-dwelling units	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Commercial	C1Z	29	3	5.95	0	Commercial 1 Zone (replaces Business 1, 2 & 5 Zones)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	C2Z	30	3	5.95	0	Commercial 2 Zone (replaces Business 3 & 4 Zones)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Business/Industrial Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Rural Zones:																																										
Rural Zone	RUZ	31	3	0	0	Main zone to be applied in most rural areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Environmental Rural Zone	ERZ	32	3	0	0	Rural areas with specific environmental considerations	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rural Living Zone	RLZ1	33	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ2	34	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ3	35	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ4	36	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ5	37	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ6	38	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Farm Zone	FZ	39	3	0	2.8	Farming Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Rural Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Public Land Zones:																																										
Service and Utility	PUZ1	40	3	0	0	Power lines, pipe tracks, reservoirs and retarding basins	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Education	PUZ2	41	3	0	0	Education facilitioes	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Health and Community	PUZ3	42	3	0	0	Health and community facilities (hospitals, etc.)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Transport	PUZ4	43	3	0	0	railways and tramways	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cemetary/ Crematorium	PUZ5	44	3	0	0	Cemetary and crematorium	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Local Government	PUZ6	45	3	0	0	libraries, sports complexes and offices/depots	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other Public Use	PUZ7	46	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rural Conservation Zone	RCZ2	47	3	1.4	2.8	Rural conservation zone	1	1	3	0.007	0.000	0.000	0.007	0.014	0.014	0.000	0.000	0.000	0.000	0.002	0.014	0.000	0.000	0.014	0.028	0.028	0.000	0.000	0.000	0.001	0.003	0.011	0.000	0.000	0.011	0.022		0.000	0.000	0.000	0.000	0.003
Public Park and Recreation Zone	PPRZ	48	3	0	0	Main zone for public open space, incl. golf courses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Public Conservation and Resource Zone	PCRZ	49	3	0	0	Protection of natural environment or resources	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Road Zone 1	RDZ1	50	3	0	0	Major roads and freeways	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Road Zone 2	RDZ2	51	3	0	0	Secondary and local roads	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Public Land Total	**1**	**1**	**3**	**0.007**	**0.000**	**0.000**	**0.007**	**0.014**	**0.014**	**0.000**	**0.000**	**0.000**	**0.000**	**0.002**	**0.014**	**0.000**	**0.000**	**0.014**	**0.028**	**0.028**	**0.000**	**0.000**	**0.000**	**0.001**	**0.003**	**0.011**	**0.000**	**0.000**	**0.011**	**0.022**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.003**
Special Purpose Zones:																																										
Special Use Zone	SUZ1	52	3	0	0	Development for specific purposes	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ2	53	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ3	54	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ4	55	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Comprehensive Development Zone	CDZ1	56	3	0	0	Large and complex developments- residential	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Urban Floodway Zone	UFZ	57	3	0	0	Land identified as part of an active floodway	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Capital City Zone	CCZ1	58	3	0	0	Special Use Zone for land in Melbourne's central city	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Docklands Zone	DZ1	59	3	0	0	Special Use Zone for land in Docklands area	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Commonwealth Land	CA	60	3	0	0	Army barracks, CSIRO	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Special Purpose Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Unique Identifiers																																										
Scout Camp - Family Camp	UNI1	61	3	1.5	1.5	Scout Camp - Family Camp	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scout Camp - Scouts Camp	UNI2	62	3	4.3	4.3	Scout Camp - Scouts Camp	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scouts Activities - Nature Walk	UNI3	63	3	0.2	0.0	Scouts Activities - Nature Walk	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scouts Loch Lowe Canoe Area	UNI4	64	3	0.4	0.0	Scouts Loch Lowe Canoe Area	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI5	65	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI6	66	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI7	67	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI8	68	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI9	69	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI10	70	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI11	71	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI12	72	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI13	73	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI14	74	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI15	75	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Unique Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
						TOTAL	**3**	**4**	**8**	**0.021**	**0.000**	**0.000**	**0.021**	**0.042**	**0.042**	**0.000**	**0.000**	**0.000**	**0.001**	**0.005**	**0.042**	**0.000**	**0.001**	**0.042**	**0.084**	**0.084**	**0.000**	**0.000**	**0.001**	**0.002**	**0.010**	**0.034**	**0.000**	**0.001**	**0.034**	**0.067**	**0.044**	**0.000**	**0.000**	**0.001**	**0.001**	**0.008**

G:\31\36304\Tech\011. Dambreak and Consequence\FinalConcept\Beaconsfield Reservoir_SDF_Lower_Par & LOL Estimation_FAIL_excluding_unique.xlsm

Lower bound Sunny Day Unique properties Failure - Current PAR and PLL Breakdown by VicMap Zones (USBR, 2014) - Property Flooded

Zone	Zone Code	Zone Num	PAR Vulnerability	Occupancy day	Occupancy night	Description	Buildings	PAR day	PAR night	Loss of Life (day) Best Estimate	Loss of Life (day) no warning Overall Lower Limit	Loss of Life (day) no warning Suggested Lower Limit	Loss of Life (day) no warning Suggested Median	Loss of Life (day) no warning Suggested Upper Limit	Loss of Life (day) no warning Overall Upper Limit	Loss of Life (day) adequate warning Overall Lower Limit	Loss of Life (day) adequate warning Suggested Lower Limit	Loss of Life (day) adequate warning Suggested Median	Loss of Life (day) adequate warning Suggested Upper Limit	Loss of Life (day) adequate warning Overall Upper Limit	Loss of Life (night) Best Estimate	Loss of Life (night) no warning Overall Lower Limit	Loss of Life (night) no warning Suggested Lower Limit	Loss of Life (night) no warning Suggested Median	Loss of Life (night) no warning Suggested Upper Limit	Loss of Life (night) no warning Overall Upper Limit	Loss of Life (night) adequate warning Overall Lower Limit	Loss of Life (night) adequate warning Suggested Lower Limit	Loss of Life (night) adequate warning Suggested Median	Loss of Life (night) adequate warning Suggested Upper Limit	Loss of Life (night) adequate warning Overall Upper Limit	Loss of Life (day and night) Best Estimate	Loss of Life (day and night) no warning Overall Lower Limit	Loss of Life (day and night) no warning Suggested Lower Limit	Loss of Life (day and night) no warning Suggested Median	Loss of Life (day and night) no warning Suggested Upper Limit	Loss of Life (day and night) no warning Overall Upper Limit	Loss of Life (day and night) adequate warning Overall Lower Limit	Loss of Life (day and night) adequate warning Suggested Lower Limit	Loss of Life (day and night) adequate warning Suggested Median	Loss of Life (day and night) adequate warning Suggested Upper Limit	Loss of Life (day and night) adequate warning Overall Upper Limit
Residential	R1Z	1	3	1.4	2.8	Residential 1 Zone - moderate range of densities	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	R3Z	2	3	1.4	2.8	Residential 3 Zone - moderate range of densities	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RGZ1	3	3	1.4	2.8	Residential Growth Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	NRZ1	4	3	1.4	2.8	Neighbourhood Residential Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GRZ1	5	3	1.4	2.8	General Residentia;l Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	FZ-RES	6	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ1	7	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ2	8	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ3	9	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ4	10	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ5	11	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWAZ1	12	3	1.4	2.8	Green Wedge A Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	LDRZ	13	3	1.4	2.8	Low Density Residential Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ	14	3	1.4	2.8	Urban Growth Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ1	15	3	1.4	2.8	Urban Growth Zone 1	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ2	16	3	1.4	2.8	Urban Growth Zone 2	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ3	17	3	1.4	2.8	Urban Growth Zone 3	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ4	18	3	1.4	2.8	Urban Growth Zone 4	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mixed Use Zone	MUZ	19	3	1.4	2.8	Mixed Use Zone (Mix of residential, commercial, industrial and other uses)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Township Zone	TZ	20	3	1.4	2.8	Small townships with no specific zoning structures	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Residential Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Industrial	IN1Z	21	3	5.95	0	Main zone to be applied in most industrial areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	IN2Z	22	3	5.95	0	Large industrial zones away from residential areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	IN3Z	23	3	5.95	0	Garden supplies/nurseries, quarries	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Business	B1Z	24	3	5.95	0	Main zone to be applied in most commercial areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B2Z	25	3	5.95	0	Offices and associated commercial uses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B3Z	26	3	5.95	0	Offices, manufacturing industries and associated uses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B4Z	27	3	5.95	0	Mix of bulky goods retailing and manufacturing industries	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B5Z	28	3	5.95	0	Mix of offices and multi-dwelling units	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Commercial	C1Z	29	3	5.95	0	Commercial 1 Zone (replaces Business 1, 2 & 5 Zones)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	C2Z	30	3	5.95	0	Commercial 2 Zone (replaces Business 3 & 4 Zones)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Business/Industrial Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Rural Zones:																																										
Rural Zone	RUZ	31	3	0	0	Main zone to be applied in most rural areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Environmental Rural Zone	ERZ	32	3	0	0	Rural areas with specific environmental considerations	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rural Living Zone	RLZ1	33	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ2	34	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ3	35	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ4	36	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ5	37	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ6	38	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Farm Zone	FZ	39	3	0	2.8	Farming Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Rural Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Public Land Zones:																																										
Service and Utility	PUZ1	40	3	0	0	Power lines, pipe tracks, reservoirs and retarding basins	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Education	PUZ2	41	3	0	0	Education facilitioes	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Health and Community	PUZ3	42	3	0	0	Health and community facilities (hospitals, etc.)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Transport	PUZ4	43	3	0	0	railways and tramways	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cemetary/ Crematorium	PUZ5	44	3	0	0	Cemetary and crematorium	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Local Government	PUZ6	45	3	0	0	libraries, sports complexes and offices/depots	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other Public Use	PUZ7	46	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rural Conservation Zone	RCZ1	47	3	0	0	Rural conservation zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Public Park and Recreation Zone	PPRZ	48	3	0	0	Main zone for public open space, incl. golf courses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Public Conservation and Resource Zone	PCRZ	49	3	0	0	Protection of natural environment or resources	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Road Zone 1	RDZ1	50	3	0	0	Major roads and freeways	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Road Zone 2	RDZ2	51	3	0	0	Secondary and local roads	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Public Land Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Special Purpose Zones:																																										
Special Use Zone	SUZ1	52	3	0	0	Development for specific purposes	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ2	53	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ3	54	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ4	55	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Comprehensive Development Zone	CDZ1	56	3	0	0	Large and complex developments- residential	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Urban Floodway Zone	UFZ	57	3	0	0	Land identified as part of an active floodway	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Capital City Zone	CCZ1	58	3	0	0	Special Use Zone for land in Melbourne's central city	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Docklands Zone	DZ1	59	3	0	0	Special Use Zone for land in Docklands area	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Commonwealth Land	CA	60	3	0	0	Army barracks, CSIRO	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Special Purpose Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Unique Identifiers																																										
Scout Camp - Family Camp	UNI1	61	3	1.5	1.5	Scout Camp - Family Camp	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scout Camp - Scouts Camp	UNI2	62	3	4.3	4.3	Scout Camp - Scouts Camp	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scouts Activities - Nature Walk	UNI3	63	3	0.2	0.0	Scouts Activities - Nature Walk	1	0	0	0.001	0.000	0.000	0.001	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000
Scouts Loch Lowe Canoe Area	UNI4	64	3	0.4	0.0	Scouts Loch Lowe Canoe Area	1	0	0	0.002	0.000	0.000	0.002	0.004	0.009	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.002	0.004	0.000	0.000	0.000	0.000	0.001
Boon Roses	UNI5	65	3	4.0	0.0	Boon Roses	1	4	0	0.020	0.000	0.000	0.020	0.040	0.040	0.000	0.000	0.000	0.001	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.000	0.008	0.017	0.017	0.000	0.000	0.000	0.000	0.002
	UNI6	66	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI7	67	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI8	68	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI9	69	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI10	70	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI11	71	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI12	72	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI13	73	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI14	74	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI15	75	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Unique Total	**3**	**5**	**0**	**0.023**	**0.000**	**0.000**	**0.023**	**0.046**	**0.051**	**0.000**	**0.000**	**0.001**	**0.001**	**0.007**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.010**	**0.000**	**0.000**	**0.010**	**0.019**	**0.021**	**0.000**	**0.000**	**0.000**	**0.000**	**0.003**
						TOTAL	**3**	**5**	**0**	**0.023**	**0.000**	**0.000**	**0.023**	**0.046**	**0.051**	**0.000**	**0.000**	**0.001**	**0.001**	**0.007**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.010**	**0.000**	**0.000**	**0.010**	**0.019**	**0.021**	**0.000**	**0.000**	**0.000**	**0.000**	**0.003**

G:\31\36304\Tech\011. Dambreak and Consequence\FinalConcept\Beaconsfield Reservoir_SDF_Lower_Par & LOL Estimation_FAIL_UNIQUE_Properties_only.xlsm

Excluding unique properties Sunny Day Upper bound Failure - Current PAR and PLL Breakdown by VicMap Zones (USBR, 2014) - Floor Flooded

Zone	Zone Code	Zone Num	PAR Vulnerability	Occupancy day	Occupancy night	Description	Buildings	PAR day	PAR night	Loss of Life (day) Best Estimate	Loss of Life (day) no warning Overall Lower Limit	Loss of Life (day) no warning Suggested Lower Limit	Loss of Life (day) no warning Suggested Median	Loss of Life (day) no warning Suggested Upper Limit	Loss of Life (day) no warning Overall Upper Limit	Loss of Life (day) adequate warning Overall Lower Limit	Loss of Life (day) adequate warning Suggested Lower Limit	Loss of Life (day) adequate warning Suggested Median	Loss of Life (day) adequate warning Suggested Upper Limit	Loss of Life (day) adequate warning Overall Upper Limit	Loss of Life (night) Best Estimate	Loss of Life (night) no warning Overall Lower Limit	Loss of Life (night) no warning Suggested Lower Limit	Loss of Life (night) no warning Suggested Median	Loss of Life (night) no warning Suggested Upper Limit	Loss of Life (night) no warning Overall Upper Limit	Loss of Life (night) adequate warning Overall Lower Limit	Loss of Life (night) adequate warning Suggested Lower Limit	Loss of Life (night) adequate warning Suggested Median	Loss of Life (night) adequate warning Suggested Upper Limit	Loss of Life (night) adequate warning Overall Upper Limit	Loss of Life (day and night) Best Estimate	Loss of Life (day and night) no warning Overall Lower Limit	Loss of Life (day and night) no warning Suggested Lower Limit	Loss of Life (day and night) no warning Suggested Median	Loss of Life (day and night) no warning Suggested Upper Limit	Loss of Life (day and night) no warning Overall Upper Limit	Loss of Life (day and night) adequate warning Overall Lower Limit	Loss of Life (day and night) adequate warning Suggested Lower Limit	Loss of Life (day and night) adequate warning Suggested Median	Loss of Life (day and night) adequate warning Suggested Upper Limit	Loss of Life (day and night) adequate warning Overall Upper Limit
Residential	R1Z	1	3	1.4	2.8	Residential 1 Zone - moderate range of densities	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	R3Z	2	3	1.4	2.8	Residential 3 Zone - moderate range of densities	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RGZ1	3	3	1.4	2.8	Residential Growth Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	NRZ1	4	3	1.4	2.8	Neighbourhood Residential Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GRZ1	5	3	1.4	2.8	General Residentia;l Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	FZ-RES	6	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ1	7	3	1.4	2.8	Farm Zone (Residential building footprints)	1	1	3	0.007	0.000	0.000	0.007	0.014	0.014	0.000	0.000	0.000	0.000	0.002	0.014	0.000	0.000	0.014	0.028	0.028	0.000	0.000	0.000	0.001	0.003	0.011	0.000	0.000	0.011	0.022	0.022	0.000	0.000	0.000	0.000	0.003
	GWZ2	8	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ3	9	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ4	10	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ5	11	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWAZ1	12	3	1.4	2.8	Green Wedge A Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	LDRZ	13	3	1.4	2.8	Low Density Residential Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ	14	3	1.4	2.8	Urban Growth Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ1	15	3	1.4	2.8	Urban Growth Zone 1	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ2	16	3	1.4	2.8	Urban Growth Zone 2	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ3	17	3	1.4	2.8	Urban Growth Zone 3	1	1	3	0.007	0.000	0.000	0.007	0.014	0.014	0.000	0.000	0.000	0.000	0.002	0.014	0.000	0.000	0.014	0.028	0.028	0.000	0.000	0.000	0.001	0.003	0.011	0.000	0.000	0.011	0.022	0.022	0.000	0.000	0.000	0.000	0.003
	UGZ4	18	3	1.4	2.8	Urban Growth Zone 4	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mixed Use Zone	MUZ	19	3	1.4	2.8	Mixed Use Zone (Mix of residential, commercial, industrial and other uses)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Township Zone	TZ	20	3	1.4	2.8	Small townships with no specific zoning structures	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Residential Total	**2**	**3**	**6**	**0.014**	**0.000**	**0.000**	**0.014**	**0.028**	**0.028**	**0.000**	**0.000**	**0.000**	**0.001**	**0.003**	**0.028**	**0.000**	**0.001**	**0.028**	**0.056**	**0.056**	**0.000**	**0.000**	**0.001**	**0.001**	**0.007**	**0.022**	**0.000**	**0.000**	**0.022**	**0.044**	**0.044**	**0.000**	**0.000**	**0.000**	**0.001**	**0.005**
Industrial	IN1Z	21	3	5.95	0	Main zone to be applied in most industrial areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	IN2Z	22	3	5.95	0	Large industrial zones away from residential areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	IN3Z	23	3	5.95	0	Garden supplies/nurseries, quarries	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Business	B1Z	24	3	5.95	0	Main zone to be applied in most commercial areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B2Z	25	3	5.95	0	Offices and associated commercial uses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B3Z	26	3	5.95	0	Offices, manufacturing industries and associated uses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B4Z	27	3	5.95	0	Mix of bulky goods retailing and manufacturing industries	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B5Z	28	3	5.95	0	Mix of offices and multi-dwelling units	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Commercial	C1Z	29	3	5.95	0	Commercial 1 Zone (replaces Business 1, 2 & 5 Zones)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	C2Z	30	3	5.95	0	Commercial 2 Zone (replaces Business 3 & 4 Zones)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Business/Industrial Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Rural Zones:																																										
Rural Zone	RUZ	31	3	0	0	Main zone to be applied in most rural areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Environmental Rural Zone	ERZ	32	3	0	0	Rural areas with specific environmental considerations	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rural Living Zone	RLZ1	33	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ2	34	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ3	35	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ4	36	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ5	37	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ6	38	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Farm Zone	FZ	39	3	0	2.8	Farming Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Rural Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Public Land Zones:																																										
Service and Utility	PUZ1	40	3	0	0	Power lines, pipe tracks, reservoirs and retarding basins	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Education	PUZ2	41	3	0	0	Education facilitioes	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Health and Community	PUZ3	42	3	0	0	Health and community facilities (hospitals, etc.)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Transport	PUZ4	43	3	0	0	railways and tramways	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cemetary/ Crematorium	PUZ5	44	3	0	0	Cemetary and crematorium	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Local Government	PUZ6	45	3	0	0	libraries, sports complexes and offices/depots	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other Public Use	PUZ7	46	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rural Conservation Zone	RCZ2	47	3	1.4	2.8	Rural conservation zone	2	3	6	0.014	0.000	0.000	0.014	0.028	0.028	0.000	0.000	0.000	0.001	0.006	0.028	0.000	0.001	0.028	0.056	0.056	0.000	0.000	0.001	0.002	0.012	0.022	0.000	0.000	0.022	0.044		0.000	0.000	0.001	0.001	0.009
Public Park and Recreation Zone	PPRZ	48	3	0	0	Main zone for public open space, incl. golf courses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Public Conservation and Resource Zone	PCRZ	49	3	0	0	Protection of natural environment or resources	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Road Zone 1	RDZ1	50	3	0	0	Major roads and freeways	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Road Zone 2	RDZ2	51	3	0	0	Secondary and local roads	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Public Land Total	**2**	**3**	**6**	**0.014**	**0.000**	**0.000**	**0.014**	**0.028**	**0.028**	**0.000**	**0.000**	**0.000**	**0.001**	**0.006**	**0.028**	**0.000**	**0.001**	**0.028**	**0.056**	**0.056**	**0.000**	**0.000**	**0.001**	**0.002**	**0.012**	**0.022**	**0.000**	**0.000**	**0.022**	**0.044**	**0.000**	**0.000**	**0.000**	**0.001**	**0.001**	**0.009**
Special Purpose Zones:																																										
Special Use Zone	SUZ1	52	3	0	0	Development for specific purposes	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ2	53	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ3	54	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ4	55	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Comprehensive Development Zone	CDZ1	56	3	0	0	Large and complex developments- residential	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Urban Floodway Zone	UFZ	57	3	0	0	Land identified as part of an active floodway	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Capital City Zone	CCZ1	58	3	0	0	Special Use Zone for land in Melbourne's central city	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Docklands Zone	DZ1	59	3	0	0	Special Use Zone for land in Docklands area	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Commonwealth Land	CA	60	3	0	0	Army barracks, CSIRO	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Special Purpose Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Unique Identifiers																																										
Scout Camp - Family Camp	UNI1	61	3	1.5	1.5	Scout Camp - Family Camp	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scout Camp - Scouts Camp	UNI2	62	3	4.3	4.3	Scout Camp - Scouts Camp	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scouts Activities - Nature Walk	UNI3	63	3	0.2	0.0	Scouts Activities - Nature Walk	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scouts Loch Lowe Canoe Area	UNI4	64	3	0.4	0.0	Scouts Loch Lowe Canoe Area	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Boon Roses	UNI5	65	3	3.2	0.0	Boon Roses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI6	66	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI7	67	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI8	68	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI9	69	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI10	70	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI11	71	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI12	72	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI13	73	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI14	74	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI15	75	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Unique Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
						TOTAL	**4**	**6**	**11**	**0.028**	**0.000**	**0.001**	**0.028**	**0.056**	**0.056**	**0.000**	**0.000**	**0.001**	**0.001**	**0.009**	**0.057**	**0.000**	**0.001**	**0.057**	**0.112**	**0.112**	**0.000**	**0.000**	**0.002**	**0.003**	**0.018**	**0.045**	**0.000**	**0.001**	**0.045**	**0.089**	**0.044**	**0.000**	**0.000**	**0.001**	**0.002**	**0.014**

G:\31\36304\Tech\011. Dambreak and Consequence\FinalConcept\Beaconsfield Reservoir_SDF_Upper_Par & LOL Estimation_FAIL_94mAHD_ExUnique.xlsm

Sunny Day Unique properties upper bound Failure - Current PAR and PLL Breakdown by VicMap Zones (USBR, 2014) - Property Flooded

Loss of Life (day)

Zone	Zone Code	Zone Num	PAR Vulnerability	Occupancy day	Occupancy night	Description	Buildings	PAR day	PAR night	Best Estimate	no warning Overall Lower Limit	no warning Suggested Lower Limit	no warning Suggested Median	no warning Suggested Upper Limit	no warning Overall Upper Limit	adequate warning Overall Lower Limit	adequate warning Suggested Lower Limit	adequate warning Suggested Median	adequate warning Suggested Upper Limit	adequate warning Overall Upper Limit
Residential	R1Z	1	3	1.4	2.8	Residential 1 Zone - moderate range of densities	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	R3Z	2	3	1.4	2.8	Residential 3 Zone - moderate range of densities	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RGZ1	3	3	1.4	2.8	Residential Growth Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	NRZ1	4	3	1.4	2.8	Neighbourhood Residential Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GRZ1	5	3	1.4	2.8	General Residentia;l Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	FZ-RES	6	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ1	7	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ2	8	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ3	9	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ4	10	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ5	11	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWAZ1	12	3	1.4	2.8	Green Wedge A Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	LDRZ	13	3	1.4	2.8	Low Density Residential Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ	14	3	1.4	2.8	Urban Growth Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ1	15	3	1.4	2.8	Urban Growth Zone 1	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ2	16	3	1.4	2.8	Urban Growth Zone 2	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ3	17	3	1.4	2.8	Urban Growth Zone 3	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ4	18	3	1.4	2.8	Urban Growth Zone 4	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mixed Use Zone	MUZ	19	3	1.4	2.8	Mixed Use Zone (Mix of residential, commercial, industrial and other uses)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Township Zone	TZ	20	3	1.4	2.8	Small townships with no specific zoning structures	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Residential Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Industrial	IN1Z	21	3	5.95	0	Main zone to be applied in most industrial areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	IN2Z	22	3	5.95	0	Large industrial zones away from residential areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	IN3Z	23	3	5.95	0	Garden supplies/nurseries, quarries	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Business	B1Z	24	3	5.95	0	Main zone to be applied in most commercial areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B2Z	25	3	5.95	0	Offices and associated commercial uses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B3Z	26	3	5.95	0	Offices, manufacturing industries and associated uses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B4Z	27	3	5.95	0	Mix of bulky goods retailing and manufacturing industries	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B5Z	28	3	5.95	0	Mix of offices and multi-dwelling units	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Commercial	C1Z	29	3	5.95	0	Commercial 1 Zone (replaces Business 1, 2 & 5 Zones)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	C2Z	30	3	5.95	0	Commercial 2 Zone (replaces Business 3 & 4 Zones)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Business/Industrial Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Rural Zones:																				
Rural Zone	RUZ	31	3	0	0	Main zone to be applied in most rural areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Environmental Rural Zone	ERZ	32	3	0	0	Rural areas with specific environmental considerations	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rural Living Zone	RLZ1	33	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ2	34	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ3	35	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ4	36	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ5	37	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ6	38	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Farm Zone	FZ	39	3	0	2.8	Farming Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Rural Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Public Land Zones:																				
Service and Utility	PUZ1	40	3	0	0	Power lines, pipe tracks, reservoirs and retarding basins	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Education	PUZ2	41	3	0	0	Education facilitiees	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Health and Community	PUZ3	42	3	0	0	Health and community facilities (hospitals, etc.)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Transport	PUZ4	43	3	0	0	railways and tramways	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cemetary/ Crematorium	PUZ5	44	3	0	0	Cemetary and crematorium	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Local Government	PUZ6	45	3	0	0	libraries, sports complexes and offices/depots	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other Public Use	PUZ7	46	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rural Conservation Zone	RCZ1	47	3	0	0	Rural conservation zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Public Park and Recreation Zone	PPRZ	48	3	0	0	Main zone for public open space, incl. golf courses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Public Conservation and Resource Zone	PCRZ	49	3	0	0	Protection of natural environment or resources	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Road Zone 1	RDZ1	50	3	0	0	Major roads and freeways	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Road Zone 2	RDZ2	51	3	0	0	Secondary and local roads	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Public Land Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Special Purpose Zones:																				
Special Use Zone	SUZ1	52	3	0	0	Development for specific purposes	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ2	53	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ3	54	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ4	55	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Comprehensive Development Zone	CDZ1	56	3	0	0	Large and complex developments- residential	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Urban Floodway Zone	UFZ	57	3	0	0	Land identified as part of an active floodway	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Capital City Zone	CCZ1	58	3	0	0	Special Use Zone for land in Melbourne's central city	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Docklands Zone	DZ1	59	3	0	0	Special Use Zone for land in Docklands area	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Commonwealth Land	CA	60	3	0	0	Army barracks, CSIRO	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Special Purpose Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Unique Identifiers																				
Scout Camp - Family Camp	UNI1	61	3	1.5	1.5	Scout Camp - Family Camp	1	2	2	0.008	0.000	0.000	0.008	0.015	0.015	0.000	0.000	0.000	0.000	0.002
Scout Camp - Scouts Camp	UNI2	62	3	4.3	4.3	Scout Camp - Scouts Camp	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scouts Activities - Nature Walk	UNI3	63	3	0.2	0.0	Scouts Activities - Nature Walk	1	0	0	0.001	0.000	0.000	0.001	0.002	0.002	0.000	0.000	0.000	0.000	0.000
Scouts Loch Lowe Canoe Area	UNI4	64	3	0.4	0.0	Scouts Loch Lowe Canoe Area	1	0	0	0.002	0.000	0.000	0.002	0.004	0.004	0.000	0.000	0.000	0.000	0.001
Boon Roses	UNI5	65	3	4.0	0.0	Boon Roses	1	4	0	0.020	0.000	0.000	0.020	0.040	0.040	0.000	0.000	0.000	0.001	0.005
	UNI6	66	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI7	67	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI8	68	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI9	69	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI10	70	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI11	71	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI12	72	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI13	73	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI14	74	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI15	75	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Unique Total	**4**	**6**	**2**	**0.031**	**0.000**	**0.001**	**0.031**	**0.062**	**0.062**	**0.000**	**0.000**	**0.001**	**0.001**	**0.007**
						TOTAL	**4**	**6**	**2**	**0.031**	**0.000**	**0.001**	**0.031**	**0.062**	**0.062**	**0.000**	**0.000**	**0.001**	**0.001**	**0.007**

Loss of Life (night)

Zone Code	Best Estimate	no warning Overall Lower Limit	no warning Suggested Lower Limit	no warning Suggested Median	no warning Suggested Upper Limit	no warning Overall Upper Limit	adequate warning Overall Lower Limit	adequate warning Suggested Lower Limit	adequate warning Suggested Median	adequate warning Suggested Upper Limit	adequate warning Overall Upper Limit
R1Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R3Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RGZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NRZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GRZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FZ-RES	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GWZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GWZ2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GWZ3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GWZ4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GWZ5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GWAZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LDRZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UGZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UGZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UGZ2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UGZ3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UGZ4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MUZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Residential Total	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
IN1Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
IN2Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
IN3Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B1Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B2Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B3Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B4Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B5Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C1Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C2Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Business/Industrial Total	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
RUZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ERZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RLZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RLZ2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RLZ3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RLZ4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RLZ5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RLZ6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rural Total	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
PUZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PUZ2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PUZ3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PUZ4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PUZ5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PUZ6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PUZ7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RCZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PPRZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PCRZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RDZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RDZ2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Public Land Total	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
SUZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SUZ2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SUZ3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SUZ4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CDZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UFZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CCZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
DZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Special Purpose Total	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
UNI1	0.008	0.000	0.000	0.008	0.015	0.015	0.000	0.000	0.000	0.000	0.002
UNI2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Unique Total	**0.008**	**0.000**	**0.000**	**0.008**	**0.015**	**0.015**	**0.000**	**0.000**	**0.000**	**0.000**	**0.002**
TOTAL	**0.008**	**0.000**	**0.000**	**0.008**	**0.015**	**0.015**	**0.000**	**0.000**	**0.000**	**0.000**	**0.002**

Loss of Life (day and night)

Zone Code	Best Estimate	no warning Overall Lower Limit	no warning Suggested Lower Limit	no warning Suggested Median	no warning Suggested Upper Limit	no warning Overall Upper Limit	adequate warning Overall Lower Limit	adequate warning Suggested Lower Limit	adequate warning Suggested Median	adequate warning Suggested Upper Limit	adequate warning Overall Upper Limit
R1Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R3Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RGZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NRZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GRZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FZ-RES	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GWZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GWZ2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GWZ3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GWZ4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GWZ5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GWAZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LDRZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UGZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UGZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UGZ2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UGZ3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UGZ4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MUZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Residential Total	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
IN1Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
IN2Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
IN3Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B1Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B2Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B3Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B4Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B5Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C1Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C2Z	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Business/Industrial Total	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
RUZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ERZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RLZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RLZ2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RLZ3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RLZ4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RLZ5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RLZ6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rural Total	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
PUZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PUZ2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PUZ3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PUZ4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PUZ5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PUZ6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PUZ7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RCZ1	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
PPRZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PCRZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RDZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RDZ2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Public Land Total	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
SUZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SUZ2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SUZ3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SUZ4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CDZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UFZ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CCZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
DZ1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Special Purpose Total	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
UNI1	0.008	0.000	0.000	0.008	0.015	0.015	0.000	0.000	0.000	0.000	0.002
UNI2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI3	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000
UNI4	0.001	0.000	0.000	0.001	0.002	0.002	0.000	0.000	0.000	0.000	0.000
UNI5	0.008	0.000	0.000	0.008	0.017	0.017	0.000	0.000	0.000	0.000	0.002
UNI6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNI15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Unique Total	**0.017**	**0.000**	**0.000**	**0.017**	**0.035**	**0.035**	**0.000**	**0.000**	**0.000**	**0.001**	**0.004**
TOTAL	**0.017**	**0.000**	**0.000**	**0.017**	**0.035**	**0.035**	**0.000**	**0.000**	**0.000**	**0.001**	**0.004**

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Consequence Assessment of Sunny Day Upper bound Failure
Estimate of Severity of Damage and Loss

Type	Explanatory Notes	Estimate	Category
1. Total Infrastructure Costs			
Residential	Total number of houses affected, some destroyed and some damaged.	8,443,260	
Commercial	Including business and agriculture, eg retail, manufacturing, resources, agriculture. These services should be assessed in terms of average annual wage.		
Infrastructure	Such as roads, railways, power, communications, gas, water supply, sewerage, irrigation, drainage, schools, hospitals, community facilities and public buildings. May be expressed in terms of annual cash flow or turnover.		
Dam repair and replacement cost	Repairs to the embankment or wall and appurtenant works which will return the dam to its previous level of service.		
	Total (including indirect damages)	8,443,260	1
		Assessment:	**Minor**
2. Impact on dam Owner's Business			
Importance to the business	Loss of storage is likely to affect the service provided to some degree. It may be appropriate, on one hand, to increase the severity level because of the importance of the reservoir. On the other hand, a less vital water resource may lead to a reduction in the severity of the cost of replacement or repair	Restrictions needed during dry periods	Minor
Effect on services provided by the owner	Water supply, power or recreational facility is no longer available or disrupted to a proportion of the community supplied by the agency.	Minor difficulties in replacing services	Minor
Effect on continuing credibility	Standing or reputation of the organisation in the community	Severe widespread reaction	Medium
Community reaction and political implications	There may be community objection to replacemnt of the dam. Also, the relationship between the dam owner and local, state and federal legislature.	Severe widespread reaction	Medium
Impact on financial viability	Economic and legal liability; ability to meet the costs of repairs and damage; and ability to meet claims from others.	Able to absorb in one financial year	Minor
Value of water in the storage	Loss of income from loss of the stored water.	Can be absorbed in one financial year	Minor
		Assessment:	**Medium**
3. Health and Social Impacts			
Public Health	Human health could be affected by: * Contamination of drinking water * Failure of lack of water supplies, sewage treatment works, power Contamination of services such as food, haelth, recreation areas and facilities caused by the uncontrolled release of sewage, industrial or toxic waste as a result of a dambreak	<100 people affected	Minor
Loss of Services to the community	Loss of gas/power/communications and transport. Distribution of medical supplies, food, especially perishable food item	<100 people affected for one month	Minor
Cost of emergency management	Police, Emergancy Services and volunteers will incur a cost both direct and indirect	<1,000 person days	Minor
Dislocation of people	People whose homes are destroyed or damaged will need to be housed or billeted for various times.	<100 person months	Minor
Dislocation of businesses	Business will be prevented from trading in the short term and may be affected in the long term.	<20 buisness months	Minor
Employment affected	Loss of employment.	<100 jobs lost	Minor
Loss of heritage	Historic sites, both pre and post European settlement.	Local facility	Minor
Loss of recreational facility	Many communities rely, to various degrees, on bodies of water for boating, fishing and other recreational aspects, including visual relief. Other recreational facilities may be located downstream of the reservoir, eg golf course, sports grounds.	Local facility	Minor
		Assessment:	**Minor**
4. Environmental Impacts			
Area of impact	Land damaged by dam failure exclusive of land prone to natural flooding. For tailings dams, the damage will relate to the toxicity of the material in relation to both area of impact and the depth of penetration of the toxic materials	<1km2	Minor
Duration of impact	Habitats may take a long time to recover. (e.g. Substanital erosion, deposition of flood borne materials). The duration of the impact will also relate to the toxicity of discharged material (e.g. saline, tailings, sewerage, cold water, deoxygenated water)	< 1year	Minor
Stock and Fauna	Stock and fauna may ingest contaminated water/fodder. Stock may need to be removed from the area or destroyed. Contaminants may cause damage in relation to reproduction cycle.	Discharge from dambreak would not contaminate water supplies used by stock and fauna	Minor
Ecosystems	Includes organisims and non-living components which interact to form a stable system. Consideration should be given to their environment, habitate, breeding grounds and food chain.	Discharge from dambreak is not expected to impact on ecosystems. Remediation possible.	Minor
Rare and Endangered Species	Information can be gained from state and federal agencies in relation to areas known to contain rare and endangered flora and fauna.	Species exist but minimal damage expected. Recovery within one year	Minor
		Assessment:	**Minor**
		OVERALL ASSESSMENT	**Medium**

Lower bound Wet Day Overtopping Failure - Current PAR and PLL Breakdown by VicMap Zones (USBR, 2014) - Floor Flooded

Zone	Zone Code	Zone Num	PAR Vulnerability	Occupancy		Description	Buildings	PAR		Loss of Life (day)											Loss of Life (night)											Loss of Life (day and night)										
										Best Estimate	no warning					adequate warning					Best Estimate	no warning					adequate warning					Best Estimate	no warning					adequate warning				
				day	night			day	night		Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit	Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit		Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit	Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit		Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit	Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit
Residential	R1Z	1	3	1.4	2.8	Residential 1 Zone - moderate range of densities	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	R3Z	2	3	1.4	2.8	Residential 3 Zone - moderate range of densities	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RGZ1	3	3	1.4	2.8	Residential Growth Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	NRZ1	4	3	1.4	2.8	Neighbourhood Residential Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GRZ1	5	3	1.4	2.8	General Residentia;l Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	FZ-RES	6	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ1	7	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ2	8	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ3	9	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ4	10	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ5	11	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWAZ1	12	3	1.4	2.8	Green Wedge A Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	LDRZ	13	3	1.4	2.8	Low Density Residential Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ	14	3	1.4	2.8	Urban Growth Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ1	15	3	1.4	2.8	Urban Growth Zone 1	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ2	16	3	1.4	2.8	Urban Growth Zone 2	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ3	17	3	1.4	2.8	Urban Growth Zone 3	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ4	18	3	1.4	2.8	Urban Growth Zone 4	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mixed Use Zone	MUZ	19	3	1.4	2.8	Mixed Use Zone (Mix of residential, commercial, industrial and other uses)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Township Zone	TZ	20	3	1.4	2.8	Small townships with no specific zoning structures	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Residential Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Industrial	IN1Z	21	3	5.95	0	Main zone to be applied in most industrial areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	IN2Z	22	3	5.95	0	Large industrial zones away from residential areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	IN3Z	23	3	5.95	0	Garden supplies/nurseries, quarries	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Business	B1Z	24	3	5.95	0	Main zone to be applied in most commercial areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B2Z	25	3	5.95	0	Offices and associated commercial uses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B3Z	26	3	5.95	0	Offices, manufacturing industries and associated uses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B4Z	27	3	5.95	0	Mix of bulky goods retailing and manufacturing industries	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B5Z	28	3	5.95	0	Mix of offices and multi-dwelling units	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Commercial	C1Z	29	3	5.95	0	Commercial 1 Zone (replaces Business 1, 2 & 5 Zones)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	C2Z	30	3	5.95	0	Commercial 2 Zone (replaces Business 3 & 4 Zones)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Business/Industrial Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Rural Zones:																																										
Rural Zone	RUZ	31	3	0	0	Main zone to be applied in most rural areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Environmental Rural Zone	ERZ	32	3	0	0	Rural areas with specific environmental considerations	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rural Living Zone	RLZ1	33	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ2	34	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ3	35	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ4	36	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ5	37	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ6	38	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Farm Zone	FZ	39	3	0	2.8	Farming Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Rural Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Public Land Zones:																																										
Service and Utility	PUZ1	40	3	0	0	Power lines, pipe tracks, reservoirs and retarding basins	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Education	PUZ2	41	3	0	0	Education facilitioes	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Health and Community	PUZ3	42	3	0	0	Health and community facilities (hospitals, etc.)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Transport	PUZ4	43	3	0	0	railways and tramways	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cemetary/ Crematorium	PUZ5	44	3	0	0	Cemetary and crematorium	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Local Government	PUZ6	45	3	0	0	libraries, sports complexes and offices/depots	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other Public Use	PUZ7	46	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rural Conservation Zone	RCZ2	47	3	1.4	2.8	Rural conservation zone	2	3	6	0.014	0.000	0.000	0.014	0.028	0.028	0.000	0.000	0.000	0.001	0.006	0.028	0.000	0.001	0.028	0.056	0.056	0.000	0.000	0.001	0.002	0.012	0.022	0.000	0.000	0.022	0.044		0.000	0.000	0.001	0.002	0.010
Public Park and Recreation Zone	PPRZ	48	3	0	0	Main zone for public open space, incl. golf courses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Public Conservation and Resource Zone	PCRZ	49	3	0	0	Protection of natural environment or resources	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Road Zone 1	RDZ1	50	3	0	0	Major roads and freeways	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Road Zone 2	RDZ2	51	3	0	0	Secondary and local roads	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Public Land Total	**2**	**3**	**6**	**0.014**	**0.000**	**0.000**	**0.014**	**0.028**	**0.028**	**0.000**	**0.000**	**0.000**	**0.001**	**0.006**	**0.028**	**0.000**	**0.001**	**0.028**	**0.056**	**0.056**	**0.000**	**0.000**	**0.001**	**0.002**	**0.012**	**0.022**	**0.000**	**0.000**	**0.022**	**0.044**	**0.000**	**0.000**	**0.000**	**0.001**	**0.002**	**0.010**
Special Purpose Zones:																																										
Special Use Zone	SUZ1	52	3	0	0	Development for specific purposes	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ2	53	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ3	54	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ4	55	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Comprehensive Development Zone	CDZ1	56	3	0	0	Large and complex developments- residential	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Urban Floodway Zone	UFZ	57	3	0	0	Land identified as part of an active floodway	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Capital City Zone	CCZ1	58	3	0	0	Special Use Zone for land in Melbourne's central city	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Docklands Zone	DZ1	59	3	0	0	Special Use Zone for land in Docklands area	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Commonwealth Land	CA	60	3	0	0	Army barracks, CSIRO	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Special Purpose Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Unique Identifiers																																										
Scout Camp - Family Camp	UNI1	61	3	1.5	1.5	Scout Camp - Family Camp	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scout Camp - Scouts Camp	UNI2	62	3	4.3	4.3	Scout Camp - Scouts Camp	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scouts Activities - Nature Walk	UNI3	63	3	0.2	0.0	Scouts Activities - Nature Walk	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scouts Loch Lowe Canoe Area	UNI4	64	3	0.4	0.0	Scouts Loch Lowe Canoe Area	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI5	65	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI6	66	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI7	67	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI8	68	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI9	69	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI10	70	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI11	71	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI12	72	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI13	73	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI14	74	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI15	75	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Unique Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
						TOTAL	**2**	**3**	**6**	**0.014**	**0.000**	**0.000**	**0.014**	**0.028**	**0.028**	**0.000**	**0.000**	**0.000**	**0.001**	**0.006**	**0.028**	**0.000**	**0.001**	**0.028**	**0.056**	**0.056**	**0.000**	**0.000**	**0.001**	**0.002**	**0.012**	**0.022**	**0.000**	**0.000**	**0.022**	**0.044**	**0.000**	**0.000**	**0.000**	**0.001**	**0.002**	**0.010**

G:\31\36304\Tech\011. Dambreak and Consequence\FinalConcept\Beaconsfield Reservoir_OTF_Lower_Par & LOL Estimation_FAIL_Filtered_USPrincesHwy.xlsm

Upper bound Wet Day Overtopping Failure - Current PAR and PLL Breakdown by VicMap Zones (USBR, 2014) - Floor Flooded

Zone	Zone Code	Zone Num	PAR Vulnerability	Occupancy		Description	Buildings	PAR		Loss of Life (day)											Loss of Life (night)											Loss of Life (day and night)										
											no warning					adequate warning						no warning					adequate warning						no warning					adequate warning				
				day	night			day	night	Best Estimate	Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit	Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit	Best Estimate	Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit	Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit	Best Estimate	Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit	Overall Lower Limit	Suggested Lower Limit	Suggested Median	Suggested Upper Limit	Overall Upper Limit
Residential	R1Z	1	3	1.4	2.8	Residential 1 Zone - moderate range of densities	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	R3Z	2	3	1.4	2.8	Residential 3 Zone - moderate range of densities	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RGZ1	3	3	1.4	2.8	Residential Growth Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	NRZ1	4	3	1.4	2.8	Neighbourhood Residential Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GRZ1	5	3	1.4	2.8	General Residentia;l Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	FZ-RES	6	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ1	7	3	1.4	2.8	Farm Zone (Residential building footprints)	1	1	3	0.007	0.000	0.000	0.007	0.014	0.014	0.000	0.000	0.000	0.001	0.005	0.014	0.000	0.000	0.014	0.028	0.028	0.000	0.000	0.001	0.001	0.009	0.011	0.000	0.000	0.011	0.022	0.022	0.000	0.000	0.001	0.001	0.007
	GWZ2	8	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ3	9	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ4	10	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWZ5	11	3	1.4	2.8	Farm Zone (Residential building footprints)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	GWAZ1	12	3	1.4	2.8	Green Wedge A Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	LDRZ	13	3	1.4	2.8	Low Density Residential Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ	14	3	1.4	2.8	Urban Growth Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ1	15	3	1.4	2.8	Urban Growth Zone 1	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ2	16	3	1.4	2.8	Urban Growth Zone 2	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UGZ3	17	3	1.4	2.8	Urban Growth Zone 3	1	1	3	0.007	0.000	0.000	0.007	0.014	0.014	0.000	0.000	0.000	0.000	0.002	0.014	0.000	0.000	0.014	0.028	0.028	0.000	0.000	0.000	0.001	0.003	0.011	0.000	0.000	0.011	0.022	0.022	0.000	0.000	0.000	0.000	0.003
	UGZ4	18	3	1.4	2.8	Urban Growth Zone 4	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mixed Use Zone	MUZ	19	3	1.4	2.8	Mixed Use Zone (Mix of residential, commercial, industrial and other uses)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Township Zone	TZ	20	3	1.4	2.8	Small townships with no specific zoning structures	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Residential Total	**2**	**3**	**6**	**0.014**	**0.000**	**0.000**	**0.014**	**0.028**	**0.028**	**0.000**	**0.000**	**0.001**	**0.001**	**0.006**	**0.028**	**0.000**	**0.001**	**0.028**	**0.056**	**0.056**	**0.000**	**0.000**	**0.001**	**0.002**	**0.013**	**0.022**	**0.000**	**0.000**	**0.022**	**0.044**	**0.044**	**0.000**	**0.000**	**0.001**	**0.002**	**0.010**
Industrial	IN1Z	21	3	5.95	0	Main zone to be applied in most industrial areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	IN2Z	22	3	5.95	0	Large industrial zones away from residential areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	IN3Z	23	3	5.95	0	Garden supplies/nurseries, quarries	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Business	B1Z	24	3	5.95	0	Main zone to be applied in most commercial areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B2Z	25	3	5.95	0	Offices and associated commercial uses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B3Z	26	3	5.95	0	Offices, manufacturing industries and associated uses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B4Z	27	3	5.95	0	Mix of bulky goods retailing and manufacturing industries	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	B5Z	28	3	5.95	0	Mix of offices and multi-dwelling units	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Commercial	C1Z	29	3	5.95	0	Commercial 1 Zone (replaces Business 1, 2 & 5 Zones)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	C2Z	30	3	5.95	0	Commercial 2 Zone (replaces Business 3 & 4 Zones)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Business/Industrial Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Rural Zones:																																										
Rural Zone	RUZ	31	3	0	0	Main zone to be applied in most rural areas	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Environmental Rural Zone	ERZ	32	3	0	0	Rural areas with specific environmental considerations	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rural Living Zone	RLZ1	33	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ2	34	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ3	35	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ4	36	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ5	37	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	RLZ6	38	3	1.4	2.8	Predominantly residential use in rural environment	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Farm Zone	FZ	39	3	0	2.8	Farming Zone	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Rural Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Public Land Zones:																																										
Service and Utility	PUZ1	40	3	0	0	Power lines, pipe tracks, reservoirs and retarding basins	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Education	PUZ2	41	3	0	0	Education facilitioes	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Health and Community	PUZ3	42	3	0	0	Health and community facilities (hospitals, etc.)	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Transport	PUZ4	43	3	0	0	railways and tramways	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cemetary/ Crematorium	PUZ5	44	3	0	0	Cemetary and crematorium	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Local Government	PUZ6	45	3	0	0	libraries, sports complexes and offices/depots	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Other Public Use	PUZ7	46	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rural Conservation Zone	RCZ2	47	3	1.4	2.8	Rural conservation zone	2	3	6	0.028	0.000	0.000	0.028	0.056	0.264	0.000	0.000	0.002	0.004	0.026	0.057	0.000	0.001	0.057	0.112	0.529	0.000	0.000	0.004	0.009	0.051	0.045	0.000	0.001	0.045	0.089		0.000	0.000	0.004	0.007	0.041
Public Park and Recreation Zone	PPRZ	48	3	0	0	Main zone for public open space, incl. golf courses	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Public Conservation and Resource Zone	PCRZ	49	3	0	0	Protection of natural environment or resources	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Road Zone 1	RDZ1	50	3	0	0	Major roads and freeways	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Road Zone 2	RDZ2	51	3	0	0	Secondary and local roads	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Public Land Total	**2**	**3**	**6**	**0.028**	**0.000**	**0.000**	**0.028**	**0.056**	**0.264**	**0.000**	**0.000**	**0.002**	**0.004**	**0.026**	**0.057**	**0.000**	**0.001**	**0.057**	**0.112**	**0.529**	**0.000**	**0.000**	**0.004**	**0.009**	**0.051**	**0.045**	**0.000**	**0.001**	**0.045**	**0.089**	**0.000**	**0.000**	**0.000**	**0.004**	**0.007**	**0.041**
Special Purpose Zones:																																										
Special Use Zone	SUZ1	52	3	0	0	Development for specific purposes	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ2	53	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ3	54	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	SUZ4	55	3	0	0	-	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Comprehensive Development Zone	CDZ1	56	3	0	0	Large and complex developments- residential	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Urban Floodway Zone	UFZ	57	3	0	0	Land identified as part of an active floodway	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Capital City Zone	CCZ1	58	3	0	0	Special Use Zone for land in Melbourne's central city	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Docklands Zone	DZ1	59	3	0	0	Special Use Zone for land in Docklands area	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Commonwealth Land	CA	60	3	0	0	Army barracks, CSIRO	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Special Purpose Total	**0**	**0**	**0**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Unique Identifiers																																										
Scout Camp - Family Camp	UNI1	61	3	1.5	1.5	Scout Camp - Family Camp	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scout Camp - Scouts Camp	UNI2	62	3	4.3	4.3	Scout Camp - Scouts Camp	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scouts Activities - Nature Walk	UNI3	63	3	0.2	0.0	Scouts Activities - Nature Walk	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scouts Loch Lowe Canoe Area	UNI4	64	3	0.4	0.0	Scouts Loch Lowe Canoe Area	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Boon Roses	UNI5	65	3	3.2	0.0	Boon Roses	1	3	0	0.016	0.000	0.000	0.016	0.032	0.032	0.000	0.000	0.001	0.002	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.007	0.013	0.013	0.000	0.000	0.000	0.001	0.005
	UNI6	66	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI7	67	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI8	68	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI9	69	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI10	70	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI11	71	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI12	72	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI13	73	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI14	74	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UNI15	75	3	0.0	0.0		0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
						Unique Total	**1**	**3**	**0**	**0.016**	**0.000**	**0.000**	**0.016**	**0.032**	**0.032**	**0.000**	**0.000**	**0.001**	**0.002**	**0.011**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.007**	**0.000**	**0.000**	**0.007**	**0.013**	**0.013**	**0.000**	**0.000**	**0.000**	**0.001**	**0.005**
						TOTAL	**5**	**9**	**11**	**0.059**	**0.000**	**0.001**	**0.059**	**0.116**	**0.324**	**0.000**	**0.000**	**0.004**	**0.007**	**0.043**	**0.085**	**0.000**	**0.002**	**0.085**	**0.168**	**0.585**	**0.000**	**0.000**	**0.005**	**0.011**	**0.064**	**0.074**	**0.000**	**0.001**	**0.074**	**0.147**	**0.058**	**0.000**	**0.000**	**0.005**	**0.009**	**0.055**

G:\31\36304\Tech\011. Dambreak and Consequence\FinalConcept\Beaconsfield Reservoir_OTF_Upper_Par & LOL Estimation_FAIL_Filtered_US_PrincesHwy.xlsm

Consequence Assessment of Wet Day Overtopping Failure
Estimate of Severity of Damage and Loss

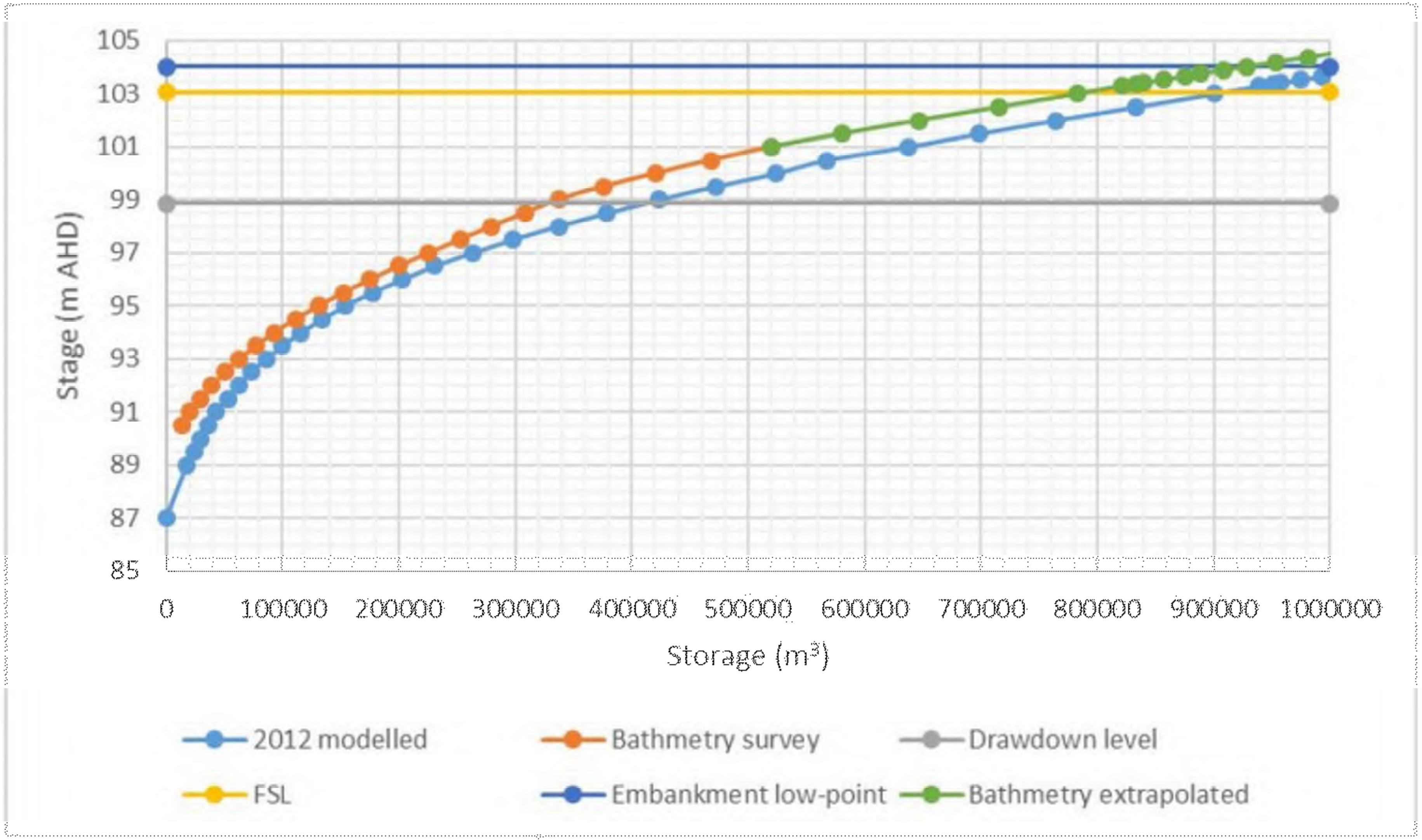
Type	Explanatory Notes	Estimate	Category
1. Total Infrastructure Costs			
Residential	Total number of houses affected, some destroyed and some damaged.	20,238,552	
Commercial	Including business and agriculture, eg retail, manufacturing, resources, agriculture. These services should be assessed in terms of average annual wage.		
Infrastructure	Such as roads, railways, power, communications, gas, water supply, sewerage, irrigation, drainage, schools, hospitals, community facilities and public buildings. May be expressed in terms of annual cash flow or turnover.		
Dam repair and replacement cost	Repairs to the embankment or wall and appurtenant works which will return the dam to its previous level of service.		
	Total (including indirect damages)	20,238,552	2
		Assessment:	**Medium**
2. Impact on dam Owner's Business			
Importance to the business	Loss of storage is likely to affect the service provided to some degree. It may be appropriate, on one hand, to increase the severity level because of the importance of the reservoir. On the other hand, a less vital water resource may lead to a reduction in the severity of the cost of replacement or repair	Restrictions needed during dry periods	Minor
Effect on services provided by the owner	Water supply, power or recreational facility is no longer available or disrupted to a proportion of the community supplied by the agency.	Minor difficulties in replacing services	Minor
Effect on continuing credibility	Standing or reputation of the organisation in the community	Severe widespread reaction	Medium
Community reaction and political implications	There may be community objection to replacemnt of the dam. Also, the relationship between the dam owner and local, state and federal legislature.	Severe widespread reaction	Medium
Impact on financial viability	Economic and legal liability; ability to meet the costs of repairs and damage; and ability to meet claims from others.	Able to absorb in one financial year	Minor
Value of water in the storage	Loss of income from loss of the stored water.	Can be absorbed in one financial year	Minor
		Assessment:	**Medium**
3. Health and Social Impacts			
Public Health	Human health could be affected by: * Contamination of drinking water * Failure of lack of water supplies, sewage treatment works, power Contamination of services such as food, health, recreation areas and facilities caused by the uncontrolled release of sewage, industrial or toxic waste as a result of a dambreak	<100 people affected	Minor
Loss of Services to the community	Loss of gas/power/communications and transport. Distribution of medical supplies, food, especially perishable food item	<100 people affected for one month	Minor
Cost of emergency management	Police, Emergancy Services and volunteers will incur a cost both direct and indirect	<1,000 person days	Minor
Dislocation of people	People whose homes are destroyed or damaged will need to be housed or billeted for various times.	<100 person months	Minor
Dislocation of businesses	Business will be prevented from trading in the short term and may be affected in the long term.	<20 buisness months	Minor
Employment affected	Loss of employment.	<100 jobs lost	Minor
Loss of heritage	Historic sites, both pre and post European settlement.	Local facility	Minor
Loss of recreational facility	Many communities rely, to various degrees, on bodies of water for boating, fishing and other recreational aspects, including visual relief. Other recreational facilities may be located downstream of the reservoir, eg golf course, sports grounds.	Local facility	Minor
		Assessment:	**Minor**
4. Environmental Impacts			
Area of impact	Land damaged by dam failure exclusive of land prone to natural flooding. For tailings dams, the damage will relate to the toxicity of the material in relation to both area of impact and the depth of penetration of the toxic materials	<1km2	Minor
Duration of impact	Habitats may take a long time to recover. (e.g. Substanital erosion, deposition of flood borne materials). The duration of the impact will also relate to the toxicity of discharged material (e.g. saline, tailings, sewerage, cold water, deoxygenated water)	< 1year	Minor
Stock and Fauna	Stock and fauna may ingest contaminated water/fodder. Stock may need to be removed from the area or destroyed. Contaminants may cause damage in relation to reproduction cycle.	Discharge from dambreak would not contaminate water supplies used by stock and fauna	Minor
Ecosystems	Includes organisims and non-living components which interact to form a stable system. Consideration should be given to their environment, habitate, breeding grounds and food chain.	Discharge from dambreak is not expected to impact on ecosystems. Remediation possible.	Minor
Rare and Endangered Species	Information can be gained from state and federal agencies in relation to areas known to contain rare and endangered flora and fauna.	Species exist but minimal damage expected. Recovery within one year	Minor
		Assessment:	**Minor**
		OVERALL ASSESSMENT	**Medium**

Appendix F – Multi-Criteria analysis

	MCA categories & sub-categories	Category weighting	Sub-category weighting (out of 4)	OPTIONS				Category & sub-category comments	Options comments
				1	2	3	4		
				Partial Decom'ing / partial height dam	Full Decom'ing / removal of dam	Safety upgrade (full upgrade)	Do nothing / current arrangement		
1	**Cost**	30		21.3	15.6	17.3	23.1	High category weighting for costs due to importance of cost to MWC and community for upgrade/construction works and ongoing maintenance.	
1.1	Construction cost		4	3	1	2	4	All construction costs for each option, including removal/treatment of reservoir silt for full decommissioning option. High sub-category weighting of 5 for construction cost due to magnitude of costs (millions of dollars).	No cost for "Do nothing" (hence best score), lower cost for "Safety Upgrade" , lowest costs for "Full decommissioning" due to full removal of dam.
1.2	Ongoing maintenance cost		4	3	4	2	1	Maintenance costs include ongoing dam safety operations, including routine and periodical dam safety inspections, and regular dam maintenance. High sub-category weighting of 4 for dam maintenance/safety costs due to ongoing commitment of these costs after any upgrade/construction works.	Highest maintenance costs for "Do nothing" (as significant maintenance work still needs to be performed, hence worst score), no dam costs for "Full decommissioning" (hence best score). Some costs for partial to allow for asset inspectiona dn blockage removal.
1.3	Cost of public amenity operations and maintenance		1	3	3	4	4	Public amenties maintenance costs include items such as toilets, roads, carparks, boardwalks, tracks, benches/shelters/picnic areas, playgrounds, etc, along with environmental maintenance such as treating erosion over time and managing plants/trees/weeds/grass/etc. Lower weighting of 2 for amenties maintenance costs due to lower costs associated with maintaining public park amenities, specifically lower cost to MWC.	Higher costs expected for ongoing environmental maintenance for "Partial decommissioning" and particularly for "Full decommissioning" due to potential ongoing environmental management and erosion treatment required in later years (hence lower scores). No additional public assets created for do nothing or safety upgrade, so lowest costs.
1.4	Approvals, public engagement costs		2	2	1	3	4	Approvals (inc environmental/EBPC) and public consultation costs, etc. Lower weighting of 2 for approvals and public engagement costs due to lower cost compared with total construction cost.	Higher costs expected for "Full decommissioning" due to larger environmental impacts (may require more approvals) and public consultations (hence lower score).
1.5	Design, engineering costs		2	3	1	2	4	Costs for engineering design, consultants and MWC for design tasks. Lower weighting of 2 for design and engineering costs due to lower cost compared with total construction cost.	Larger costs expected for "Safety Upgrade" and "Full decommissioning" (due more design tasks required, hence lower score). No cost for "Do nothing" (hence best score).
2	**Satisfying ALARP**	30		25.7	30.0	21.4	7.5	High weighted category due to critical aspect of reducing risks to life and community safety from dam operations, and key driver of upgrade/construction works for Beaconsfield Reservoir.	
2.1	F-N Position / Life safety risk		4	3	4	2	1	Highly weighted sub-category due to importance of achieving "As Low As Reasonably Practicable" risk management for life and community safety for Beaconsfield Res.	"Partial decommissioning" greatly reduces risks associated with the dam (high score). Full decomissioning removes the risk entirely, thus highest score. "Safety Upgrade" reduces risks associated with current dam (residual risks larger than decommissioning options remain, hence medium score). No improvement from current inadequate risk profile for "Do nothing" (hence lowest score).
2.2	Compliance with good practice		3	4	4	4	1	Moderately highly weighted sub-category due to importance of sufficient flood handling capacity for dam safety, and reducing likelihood of dangerous flash flooding from dam failure.	"Partial/Full decommissioning" and "Safety upgrade" greatly reduces risks associated with the dam and meet required spillway capacity (hence highest score). No improvement from current inadequate spillway capacity for "Do nothing" (hence lowest score).
3	**Community impacts**	20		16.3	10.5	16.5	16.5	Lower category weighting due to lower impact visual appearance and amenity compared with life safety risks.	
3.1	Provision of public amenities and safe access		3	4	4	3	2	Potential for provision of amenities such as toilets, roads, carparks, boardwalks, tracks, benches/shelters/picnic areas, playgrounds, etc. Medium weighting for sub-category due to moderate importance.	"Partial/Full decommissioning" options provide greatest opportunity for adding public amenities to site (hence highest score). "Safety Upgrade" offers a good opportunity to add public amenities (hence medium score). "Do nothing" offers little/no opportunity for amenities (hence lowest score).
3.2	Visual appearance of landscape		4	4	4	3	2	Judgement about aesthetics of landscape and environment (after environment and plantings established/recovered from upgrade/construction work). Moderately-hight weighting for sub-category due to higher importance to community.	"Partial decommissionings" allows for greatest range of vegetation, views and environments to provide visual appearance to site (hence highest score). "Full decommissioning" allows for re-planting to 'natural creek' environment but does not have any lake/retained water (hence moderately high score). "Do nothing" maintains current visual appearance with water and bushland (low score). "Safety upgrade" requires expanding dam and spillway footprints which would reduce visual amenity (hence lowest score).
3.3	Visual appearance of lake/retained water		3	2	1	4	4	Judgement about aesthetics of retained lake water (after environment and plantings established/recovered from upgrade/construction work). Moderately-hight weighting for sub-category due to higher importance to community.	Visual appearance of lake/retained water high for "Safety upgrade" and "Do nothing" (hence moderately-high score, note reduced Full Supply Level to be maintained, so water level in reservoir not maximised). Partial area of lake maintained for "Partial decommissioning" (hence medium score). No water retained for "Full decommissioning" (hence lowest score).
3.4	Retention/incorporation of heritage & 'past infrastructure' elements		1	4	2	3	4	Potential educational & public interest benefits from retaining old elements of dam. Low weighting for sub-category due to low importance.	"Partial decommissioning" offers potential to preserve/relocate dam infrastructure through out thepark for visitors (hence highest score). "Full Decommissioning" - after further community consultation, little heritage benefit is retained if the dam is fully decommissioned. "Safety upgrade" offers potential for some old infrastructure to be preserved/relocated for visitors, but others may need to be retained for use or replaced (hence medium score). "Do nothing" keeps all existing infrastructure in place (hence highest score as well).
3.5	Impact on community by construction activity, vehicle movements, etc		3	3	1	2	4	Impacts to local residents and surrounding community by construction activity. Moderately-highly weighted due to being often a key issue for local communities.	Lowest impacts for "Do nothing" (hence highest score). Moderate impacts for "Partial decommissioning" due to lowest requirement for importing of materials to and from site (hence medium score). Large impacts for "Full decommissioning" due to potential to have to import larger quantities of erosion protection and remove silts/spoil from site (hence lower score). Major impacts for "Safety upgrade" due to volume of material required to be imported (hence lowest score).
3.6	Fire		3	3	1	4	4	In order for an air crane access a water body it must be min. 2 m deep and be clear of trees and other obstruction at a 35 m radius from its center. Beaconsfield Reservoir in not in the fire fighting handbook provided to pilots, Cardinia Reservoir and Lake Aura Vale (6km north) are. Saying that, in the event of an emergency any water source can be used for fire fighting.	"Do nothing" and "Safety upgrade" have highest scores at WL 98.85. "Partial decommissioning" has a moderate score as significant (for firefighting purposes) volume of water retained. Low score for "Full decommissioning" as no water retained.
3.7	Flood mitigation		3	3	1	4	4	Flood mititgation potential for dam options. Note that Beaconsfield Reservoir does not primarily function as a flood detention reservoir, hence medium weighting for this sub-category. However, this is a requirement for existing catchments not to increase flooding up to 1% AEP event.	Higher level of (not-extreme storm) flood mitigation achieved with "Do nothing" and "Safety upgrade" conditions (hence moderately-high score). Some flood mitigation possible with "Partial decommissioning" (hence medium score). No flood mitigation possible with "Full decommissioning" (hence lowest score).
4	**Environmental and conservation impacts**	20		15.0	5.0	10.0	17.5	Lower category weighting due to lower impact of environment and conservation of nature compared with life safety risks.	
4.1	Construction and rehabilitation period		3	2	1	2	4	Likely requirements and difficulties for permitting and approvals for upgrade/construction designs. Lower weighting for sub-category due to lower importance.	Full decomissioning will have impacts on aquatic species in the reservoir + weeds may invade water body area during rehabilitation and impacts of construction vehicles (hence lowest score). The partial upgrade will also have a reduced potential for weed invastion during the rehabilitation and contruction vehicle impact. The full dam safety upgrade will have impacts due to heavy machinery. Do Nothing has no impact.
4.2	Long-term impacts on flora & fauna communities		3	4	1	2	3	Potential long-term impacts on environment due to rehabilitation or habitat availability. Current conditions are the 'baseline' (with potential for positive improvements increasing scores). Medium weighting for sub-category due to moderate importance.	Greater opportunity for benefical environmental conditions when environment recovers post-construction, with planting/colonisation of previously-innundated areas for different flora environments (wetland, treed/bushland) for "Partial/Full decommissioning" (hence moderately-high score). Current environmental conditions maintained for "Safety upgrade" and "Do nothing" (hence medium score as 'baseline' conditions).
	TOTAL SCORE	**100**		**78.3**	**61.1**	**65.2**	**64.6**		

Rating	4	Excellent / best performance, best for purpose
	3	Good / performs well
	2	Poor / low performance
	1	Very Poor / worst performance, worst for purpose

Appendix G – Storage-elevation curve



105
103
101
99
97
95
93
91
89
87
85
Stage (m AHD)
0
100000
200000
300000
400000
500000
600000
700000
800000
900000
1000000
Storage (m³)
2012 modelled
Bathmetry survey
Drawdown level
FSL
Embankment low-point
Bathmetry extrapolated

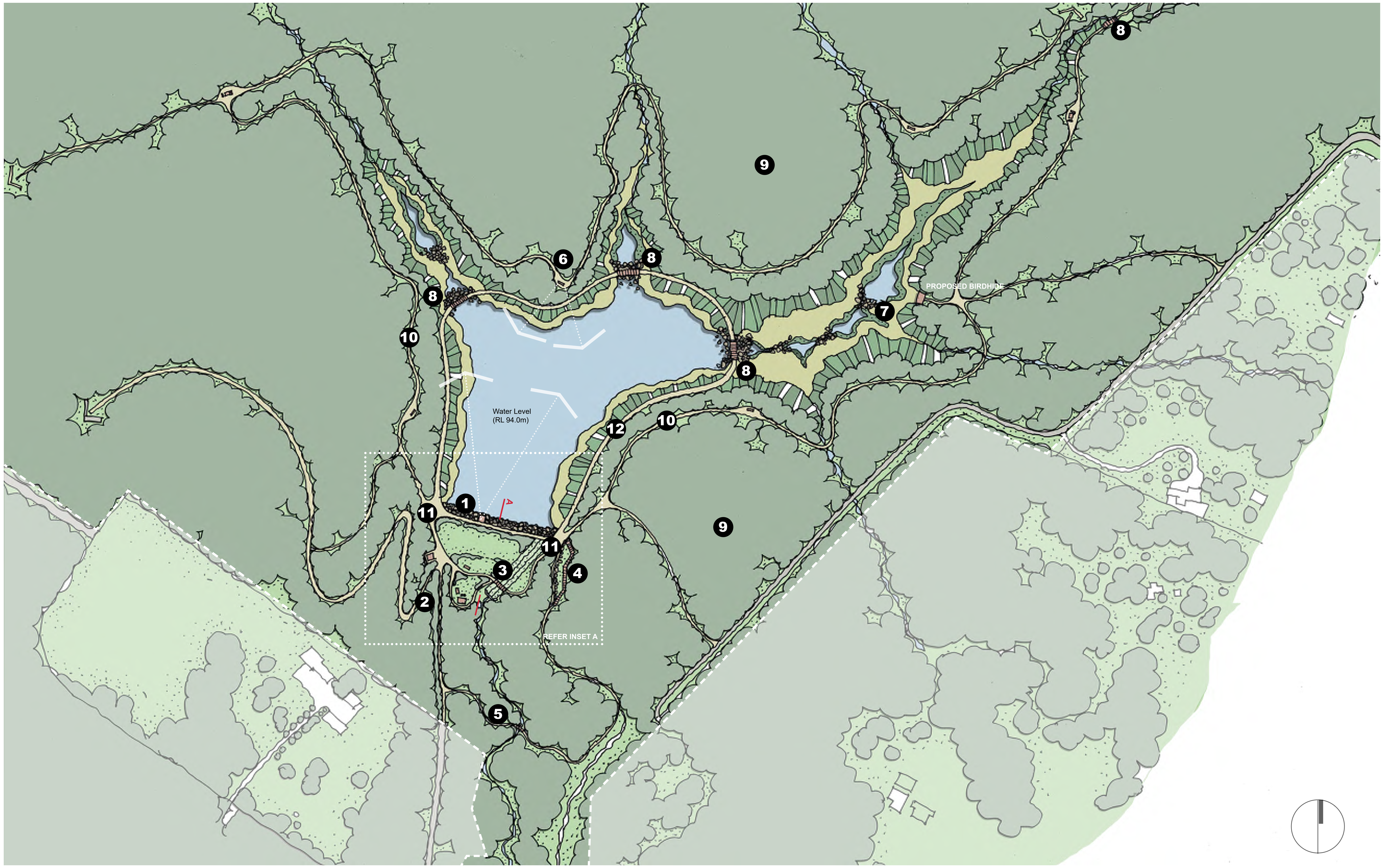
Appendix H – Landscape drawings

Option 1A

Option 1B

Option 1C

Option 1D



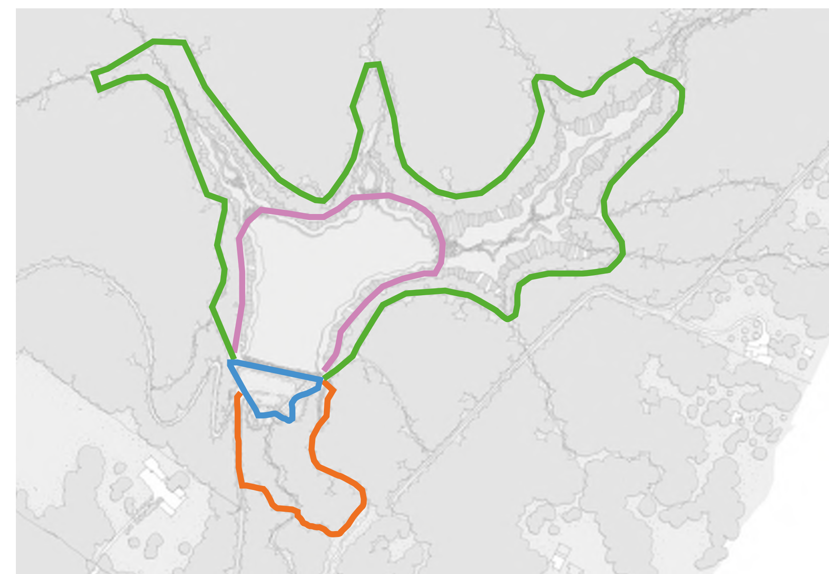
DRAWING NOTES

1. Small cantilevered viewing platform on lowered rock wall to take advantage of long views over water
2. Downgrade existing access road to a walking track width and revegetate
3. Utilise open lawn area to include picnic tables, bbq and a shelter. Create small pedestrian loop path through picnic area that also takes in top of dam wall
4. Install low profile steel boardwalk along base of old spillway to connect walking loop trail that takes in the old spillway gates and Haunted Gully Creek
5. Install small bridge crossing over Haunted Gully Creek to connect new walking trail
6. Create a widening in the current trail to accommodate a seat orientated to take advantage of the long views across water back towards the dam wall
7. Rock & earth bunding to create small ponds of open water surrounded by new indigenous wetland planting
8. New low profile steel bridges to cross small tributaries where required
9. Existing forest
10. Open up existing walking trail to the public
11. New trail signage
12. Establish new track around current water level for maintenance and walking

PROPOSED WETLAND PLANTING

- Allow natural colonisation of indigenous Littoral wetland /margin species in this area. Some new infill planting may be required
- New Ephemeral wetland planting
- New deep marsh/submerged wetland planting

POTENTIAL WALKING TRAILS



- Dam Wall Loop Walk (350m)
- Old Spillway Loop Walk (600m)
- Beaconsfield Dam Loop Walk (2.5km)
- Maintenance Road Loop Walk (1.0km)

PRECEDENT IMAGES


Low profile steel boardwalk


Low profile steel creek crossing


Small cantilevered viewing platform


Walking trail signage

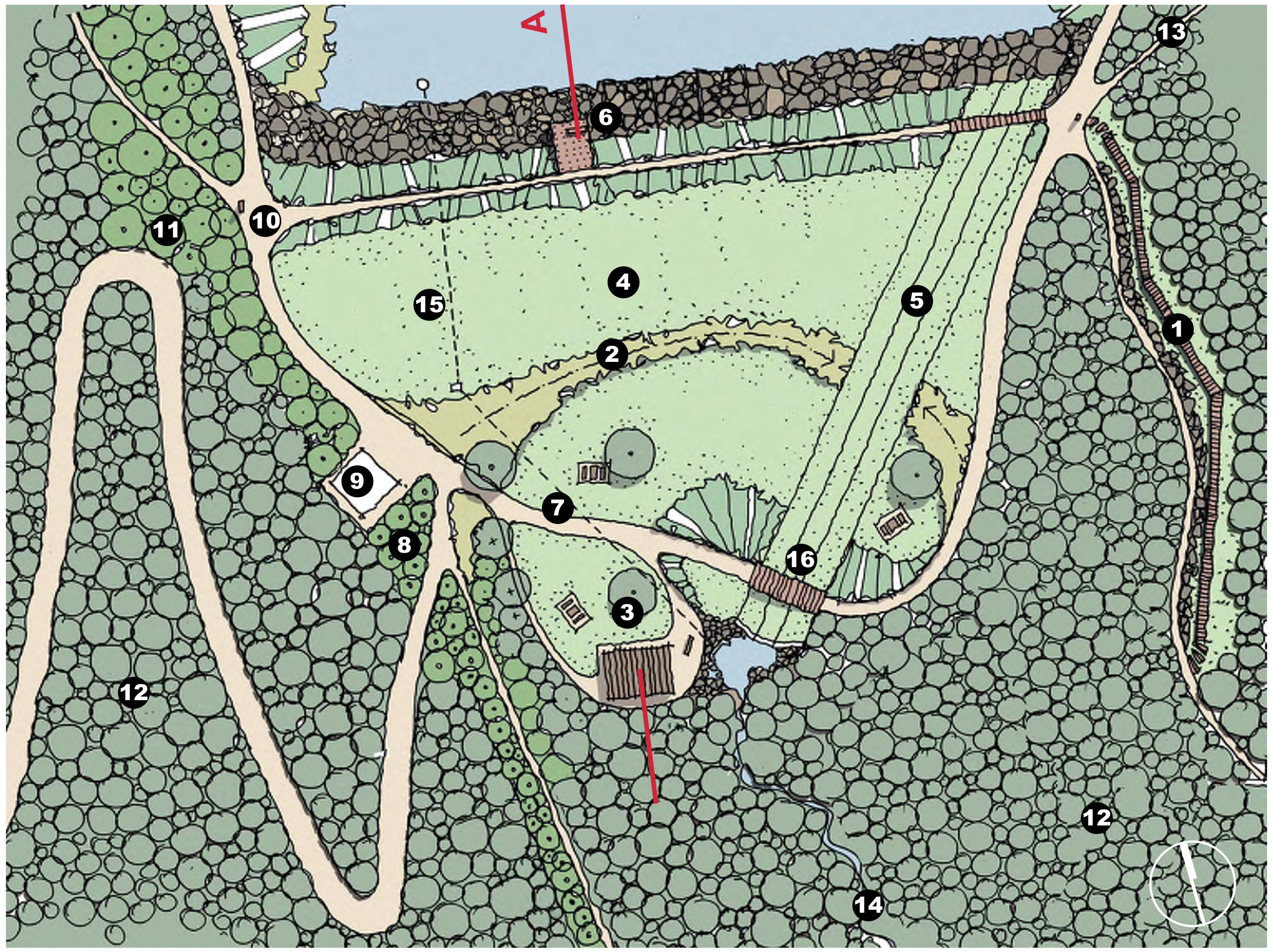

Indigenous grasses to dam crest


Indigenous wetland planting with areas of open water

MELBOURNE WATER: BEACONSFIELD RESERVOIR OPTION A
MASTER PLAN

Job No: 31-36304
Original Size: A1 1:2000
Drawing No: 3136304 L001
Approved:
Date: 22.02.2019
Rev: C

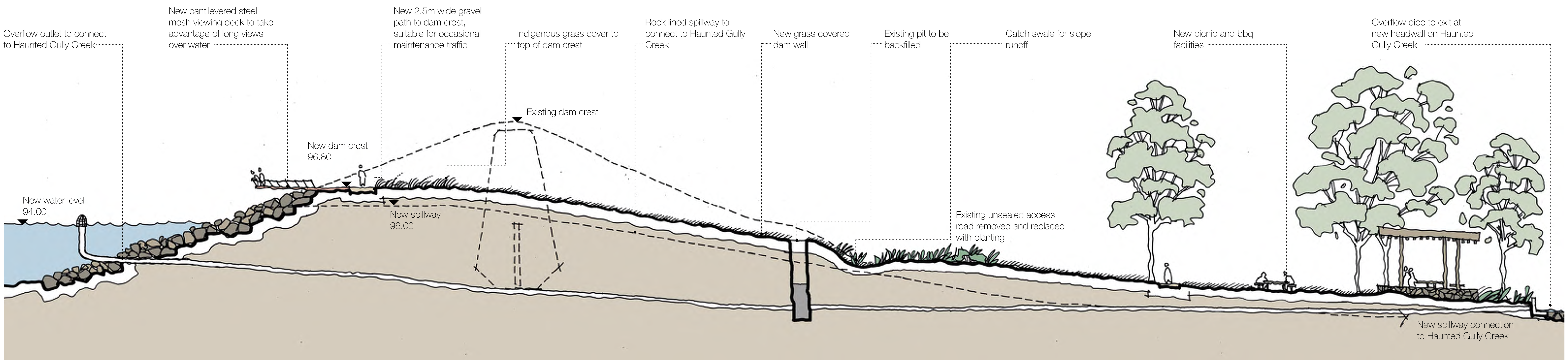
GHDWOODHEAD



INSET A 1:500

DRAWING NOTES

1. Install low profile steel boardwalk along base of old spillway to connect walking loop trail that takes in the old spillway gates and Haunted Gully Creek
2. Planted swale to catch runoff from grass slope and direct to new spillway
3. Utilise open lawn area to include picnic tables, bbq and a shelter. Create small pedestrian loop path through picnic area that also takes in top of dam wall
4. Newly graded grass dam embankment
5. New 10m wide rock lined protected spillway with top soil and grass connected to Haunted Gully Creek
6. Install cantilevered steel mesh lookout to take advantage of long view across water. Incorporate interpretation panel to illustrate history of the dam.
7. New compacted gravel loop path & maintenance track through picnic area that connects to path over new dam wall and larger trails
8. Remove existing access road and parking in the this location but retain track wide enough to accommodate maintenance vehicles. Revegetate areas of removed unsealed road with locally indigenous species
9. Existing shed to be retained
10. New steel totem signage with information regarding walking trails
11. Removal of existing shed in this area and associated hardstand and revegetate with locally indigenous species
12. Existing forest
13. Open up existing walking trail to the public
14. Haunted Gully Creek
15. Underground overflow pipe
16. Bridge crossing for maintenance vehicles



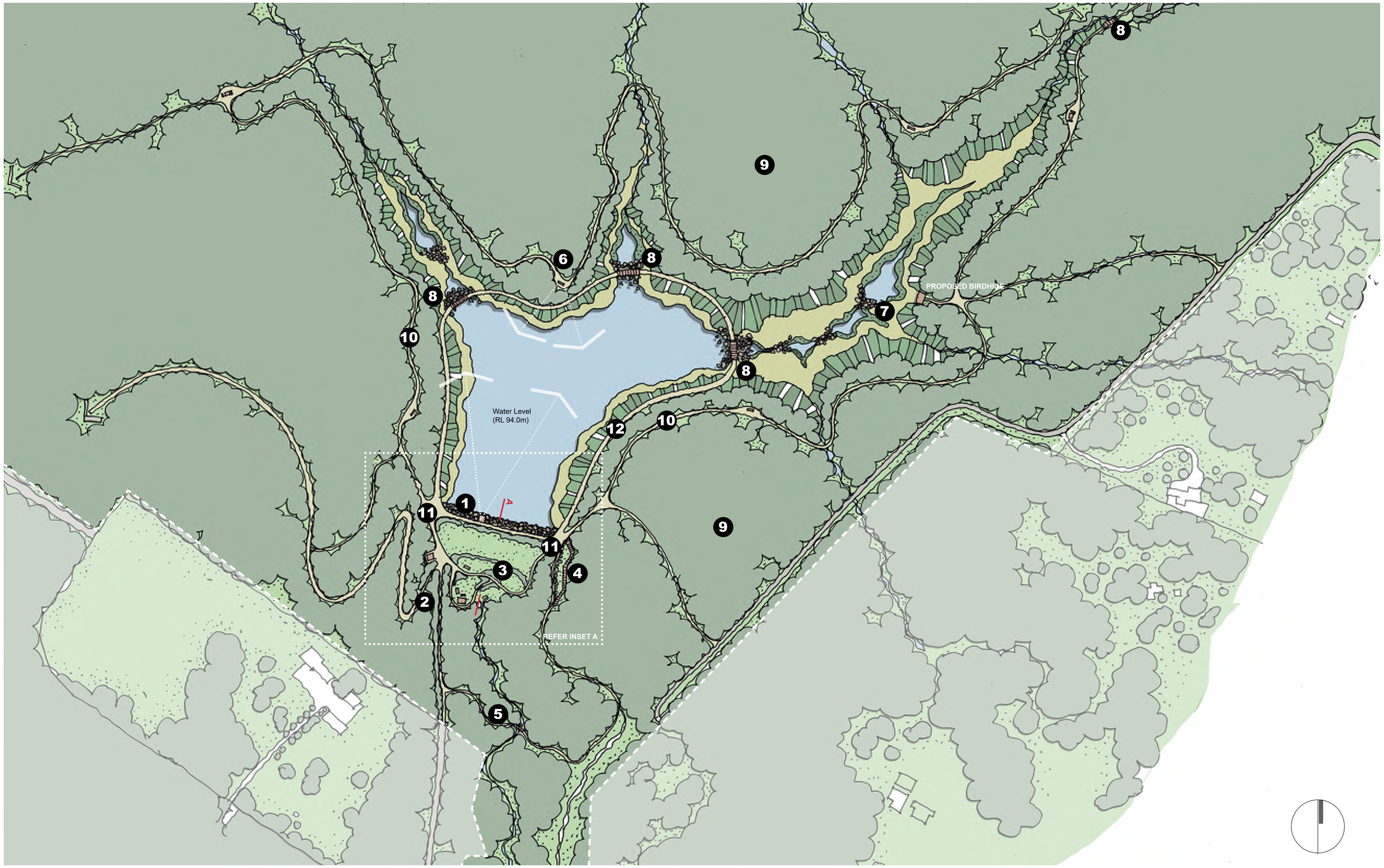
SECTION A - A 1:200

MELBOURNE WATER: BEACONSFIELD RESERVOIR OPTION A

INSET PLAN & SECTION

Job No: 31-36304
Original Size: A1
Drawing No: 3136304 L002
Approved:
Date: 29.10.2019
Rev: D

GHDWOODHEAD



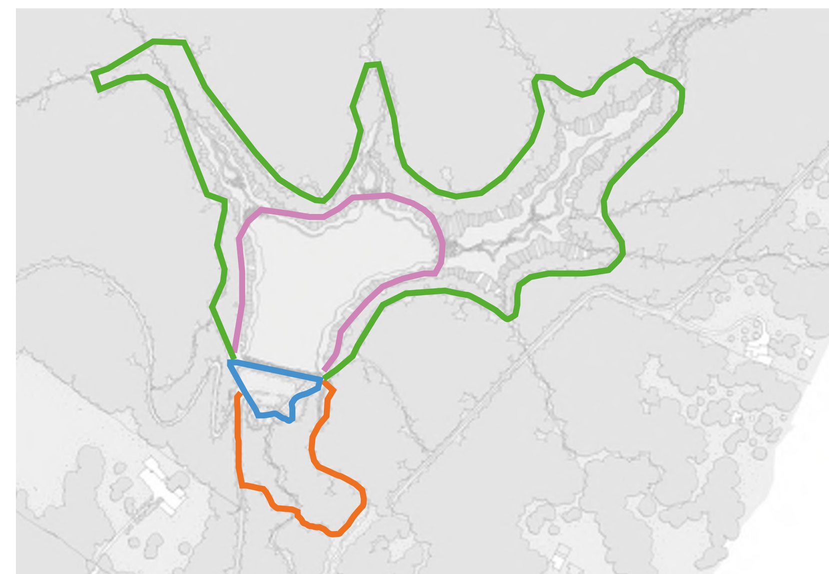
DRAWING NOTES

1. Small cantilevered viewing platform on lowered rock wall to take advantage of long views over water
2. Downgrade existing access road to a walking track width and revegetate
3. Utilise open lawn area to include picnic tables, bbq and a shelter. Create small pedestrian loop path through picnic area that also takes in top of dam wall
4. Install low profile steel boardwalk along base of old spillway to connect walking loop trail that takes in the old spillway gates and Haunted Gully Creek
5. Install small bridge crossing over Haunted Gully Creek to connect new walking trail
6. Create a widening in the current trail to accommodate a seat orientated to take advantage of the long views across water back towards the dam wall
7. Rock & earth bunding to create small ponds of open water surrounded by new indigenous wetland planting
8. New low profile steel bridges to cross small tributaries where required
9. Existing forest
10. Open up existing walking trail to the public
11. New trail signage
12. Establish new track around current water level for maintenance and walking

PROPOSED WETLAND PLANTING

- Allow natural colonisation of indigenous Littoral wetland /margin species in this area. Some new infill planting may be required
- New Ephemeral wetland planting
- New deep marsh/submerged wetland planting

POTENTIAL WALKING TRAILS



- Dam Wall Loop Walk (350m)
- Old Spillway Loop Walk (600m)
- Beaconsfield Dam Loop Walk (2.5km)
- Maintenance Road Loop Walk (1.0km)

PRECEDENT IMAGES

Low profile steel boardwalk

Low profile steel creek crossing

Small cantilevered viewing platform

Walking trail signage

Indigenous grasses to dam crest

Indigenous wetland planting with areas of open water

MELBOURNE WATER: BEACONSFIELD RESERVOIR OPTION B
MASTER PLAN

Job No: 31-36304
Original Size: A1 1:2000
Drawing No: 3136304 L001
Approved:
Date: 22.02.2019
Rev: C

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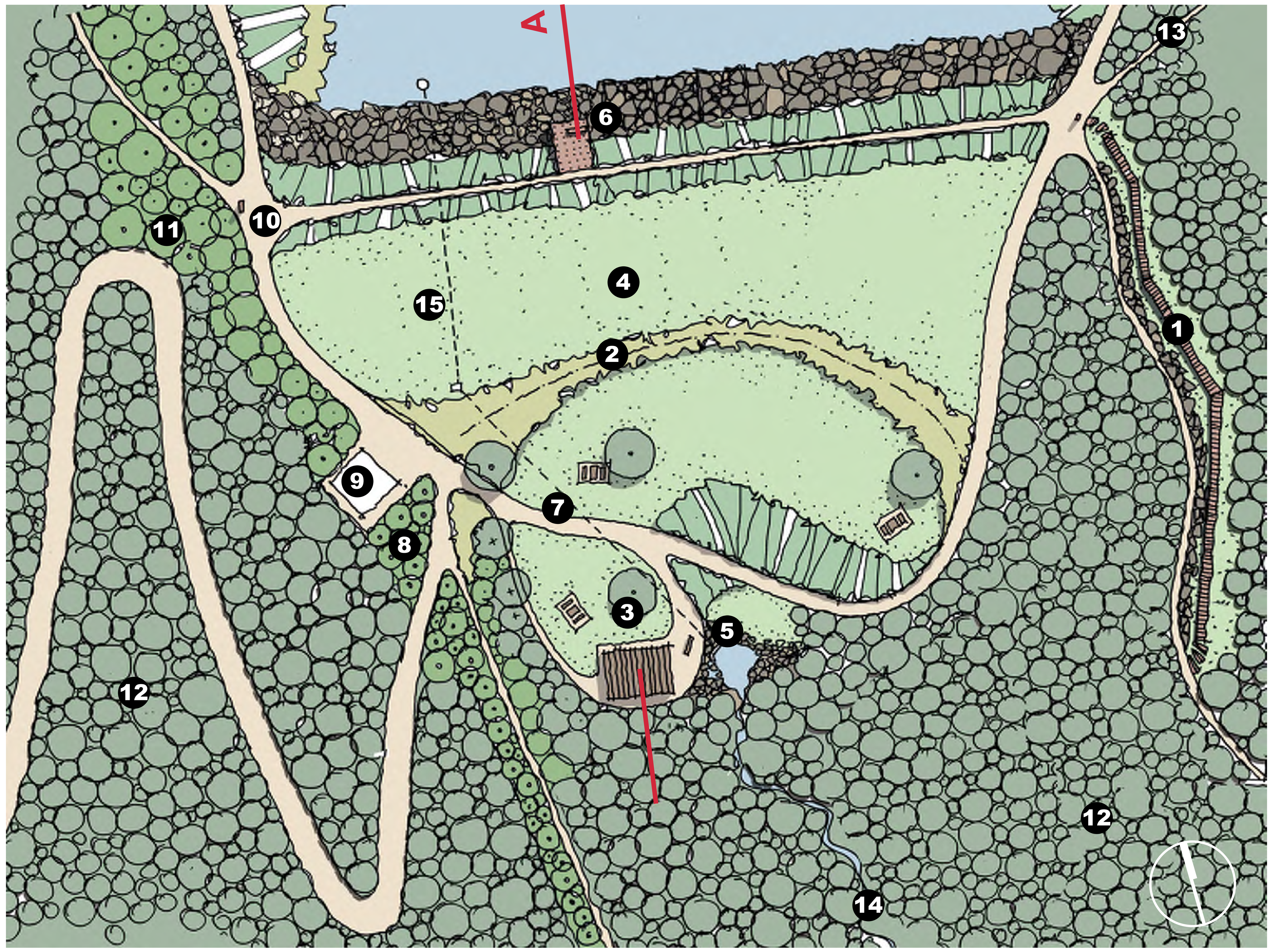
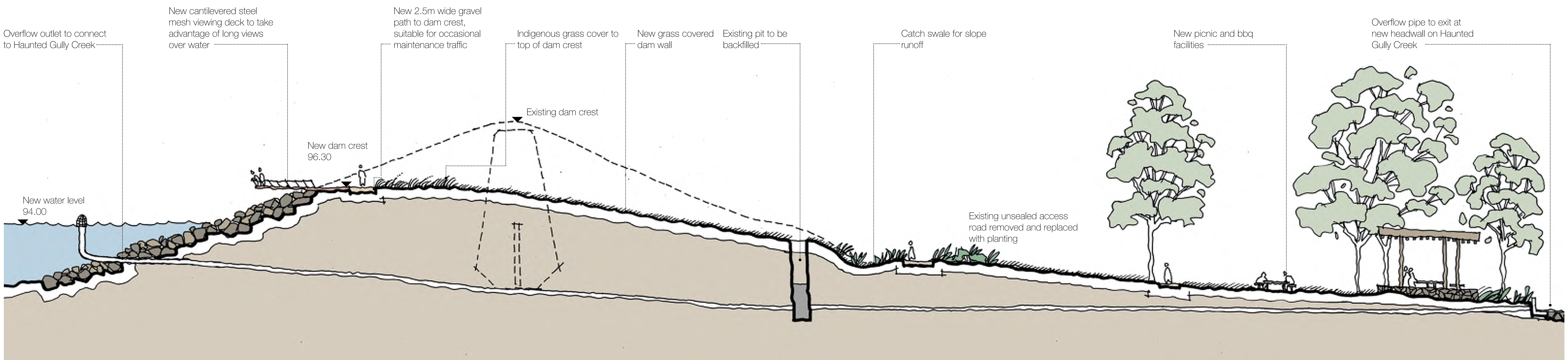


INSET A 1:500

DRAWING NOTES

1. Install low profile steel boardwalk along base of old spillway to connect walking loop trail that takes in the old spillway gates and Haunted Gully Creek
2. Planted swale to catch runoff from grass slope and direct to new spillway
3. Utilise open lawn area to include picnic tables, bbq and a shelter. Create small pedestrian loop path through picnic area that also takes in top of dam wall
4. Newly graded grass dam embankment
5. Overflow pipe to exit at new headwall on Haunted Gully Creek
6. Install cantilevered steel mesh lookout to take advantage of long view across water. Incorporate interpretation panel to illustrate history of the dam.
7. New compacted gravel loop path & maintenance track through picnic area that connects to path over new dam wall and larger trails
8. Remove existing access road and parking in the this location but retain track wide enough to accommodate maintenance vehicles. Revegetate areas of removed unsealed road with locally indigenous species
9. Existing shed to be retained
10. New steel totem signage with information regarding walking trails
11. Removal of existing shed in this area and associated hardstand and revegetate with locally indigenous species
12. Existing forest
13. Open up existing walking trail to the public
14. Haunted Gully Creek
15. Underground overflow pipe



SECTION A - A 1:200

MELBOURNE WATER: BEACONSFIELD RESERVOIR OPTION B

INSET PLAN & SECTION

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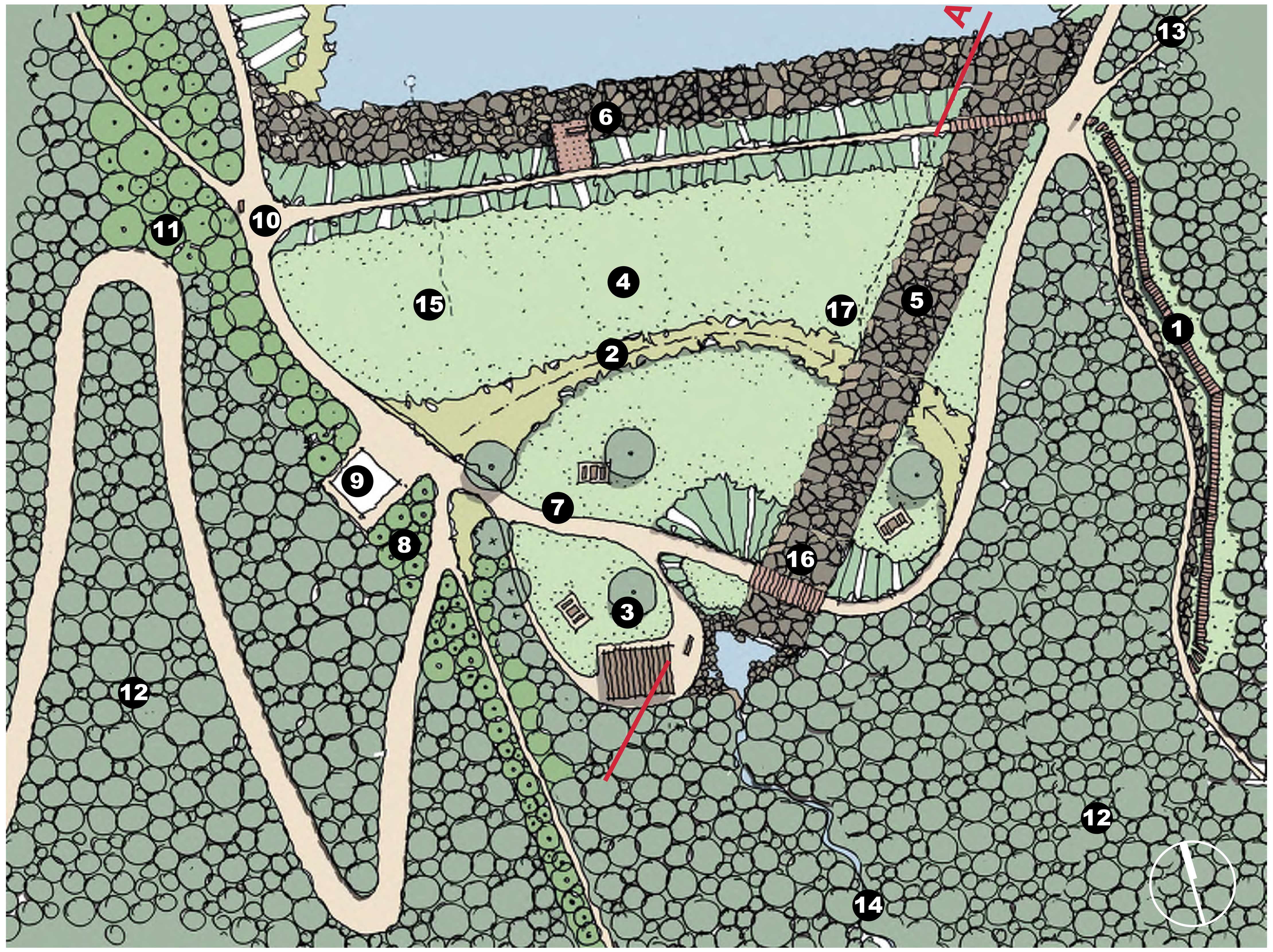
Original Size: A1
Drawing No: 3136304 L002
Approved:
Date: 22.02.2019
Rev: C

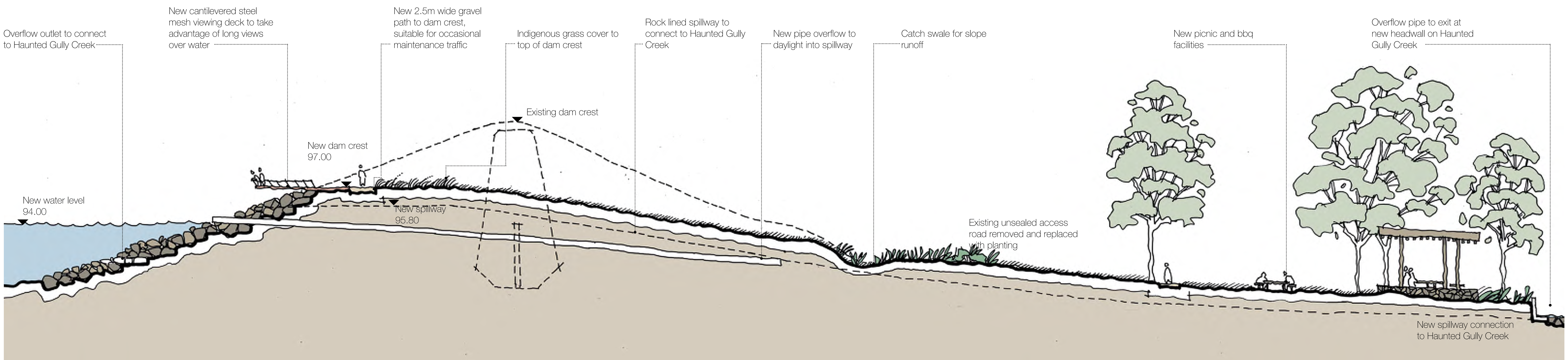
GHDWOODHEAD



INSET A 1:500

DRAWING NOTES

1. Install low profile steel boardwalk along base of old spillway to connect walking loop trail that takes in the old spillway gates and Haunted Gully Creek
2. Planted swale to catch runoff from grass slope and direct to new spillway
3. Utilise open lawn area to include picnic tables, bbq and a shelter. Create small pedestrian loop path through picnic area that also takes in top of dam wall
4. Newly graded grass dam embankment
5. New 10m wide erosion protected spillway to connect to Haunted Gully Creek
6. Install cantilevered steel mesh lookout to take advantage of long view across water. Incorporate interpretation panel to illustrate history of the dam.
7. New compacted gravel loop path & maintenance track through picnic area that connects to path over new dam wall and larger trails
8. Remove existing access road and parking in the this location but retain track wide enough to accommodate maintenance vehicles. Revegetate areas of removed unsealed road with locally indigenous species
9. Existing shed to be retained
10. New steel totem signage with information regarding walking trails
11. Removal of existing shed in this area and associated hardstand and revegetate with locally indigenous species
12. Existing forest
13. Open up existing walking trail to the public
14. Haunted Gully Creek
15. Existing underground overflow pipe to be decommissioned
16. Bridge crossing for maintenance vehicles
17. New overflow pipe to daylight into spillway



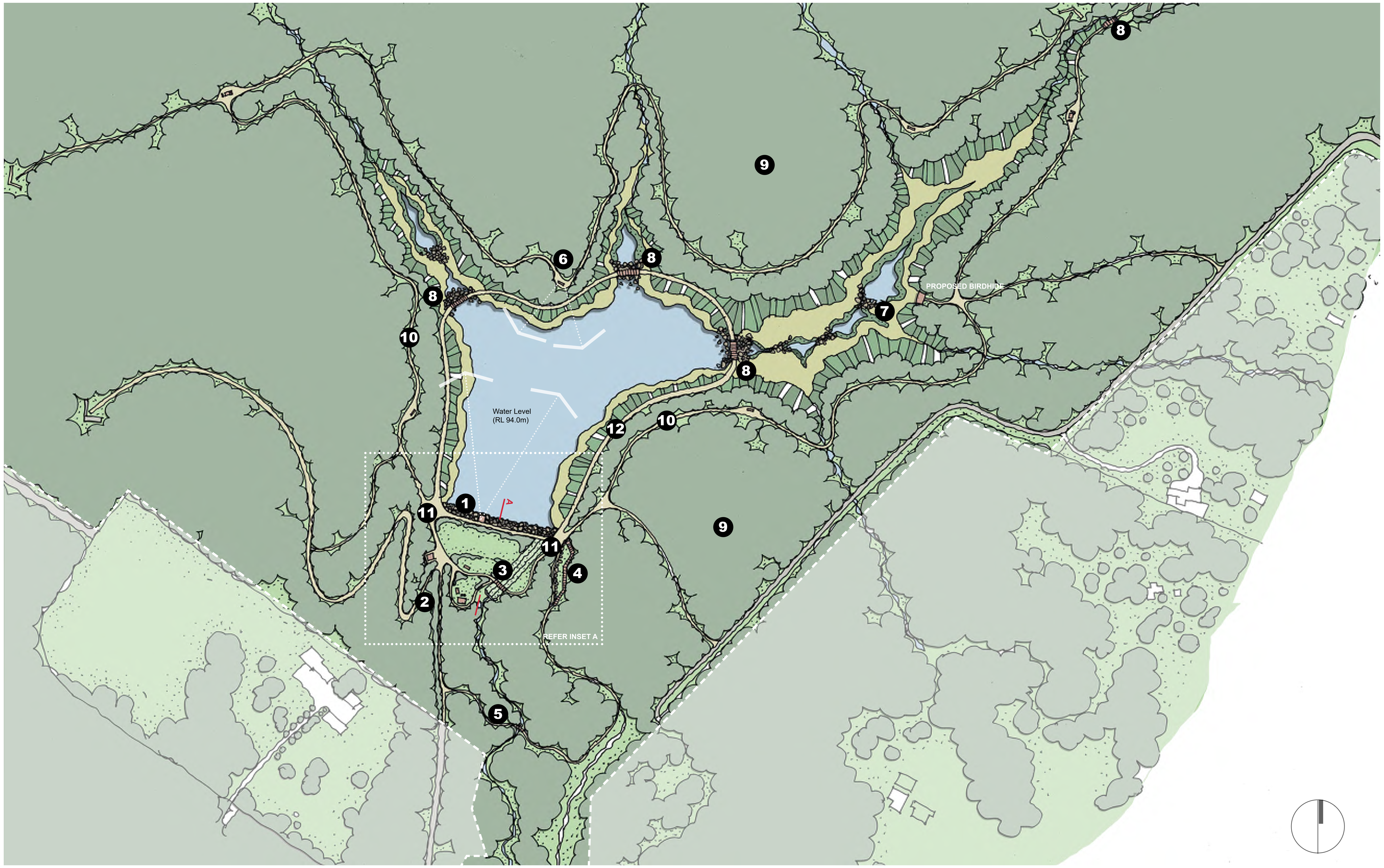
SECTION A - A 1:200

MELBOURNE WATER: BEACONSFIELD RESERVOIR OPTION C

INSET PLAN & SECTION

Job No: 31-36304	Approved:
Original Size: A1	Date: 29.10.2019
Drawing No: 3136304 L002	Rev: C

GHDWOODHEAD



DRAWING NOTES

1. Small cantilevered viewing platform on lowered rock wall to take advantage of long views over water
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11. New trail signage
12. Establish new track around current water level for maintenance and walking

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- Allow natural colonisation of indigenous Littoral wetland /margin species in this area. Some new infill planting may be required
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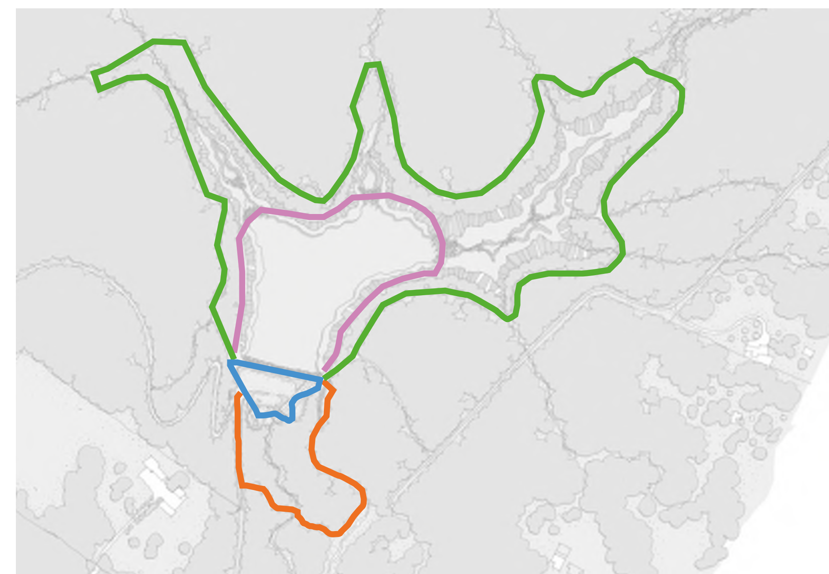
- New deep marsh/submerged wetland planting

POTENTIAL WALKING TRAILS



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- Old Spillway Loop Walk (600m)
- Beaconsfield Dam Loop Walk (2.5km)
- Maintenance Road Loop Walk (1.0km)

PRECEDENT IMAGES

Low profile steel boardwalk

Low profile steel creek crossing

Small cantilevered viewing platform

Walking trail signage

Indigenous grasses to dam crest

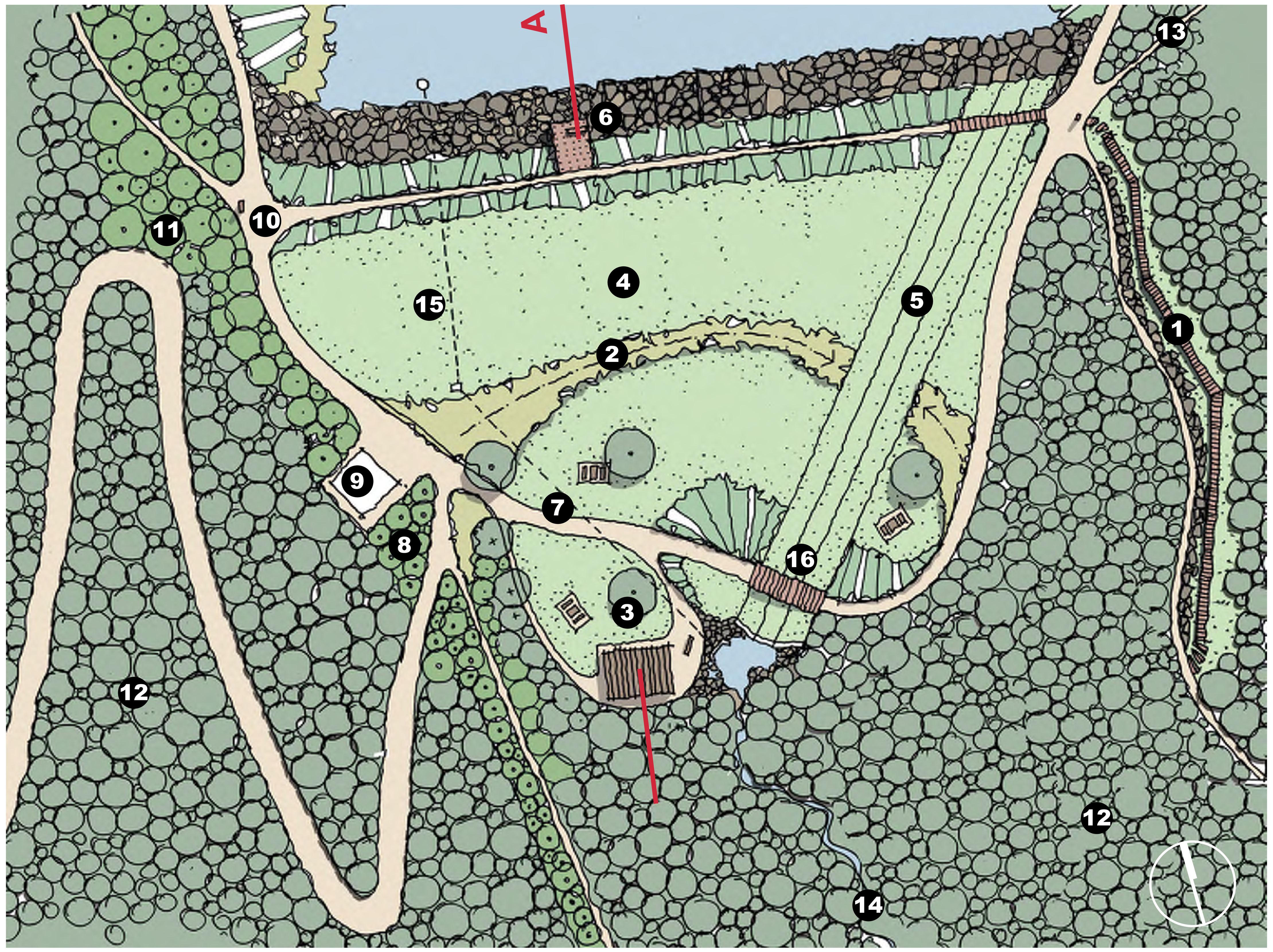
Indigenous wetland planting with areas of open water

MELBOURNE WATER: BEACONSFIELD RESERVOIR OPTION 1D

MASTER PLAN

Job No: 31-36304
Original Size: A1 1:2000
Drawing No: 3136304 L001
Approved:
Date: 29.10.2019
Rev: E

GHDWOODHEAD



INSET A 1:500

DRAWING NOTES

1. Install low profile steel boardwalk along base of old spillway to connect walking loop trail that takes in the old spillway gates and Haunted Gully Creek
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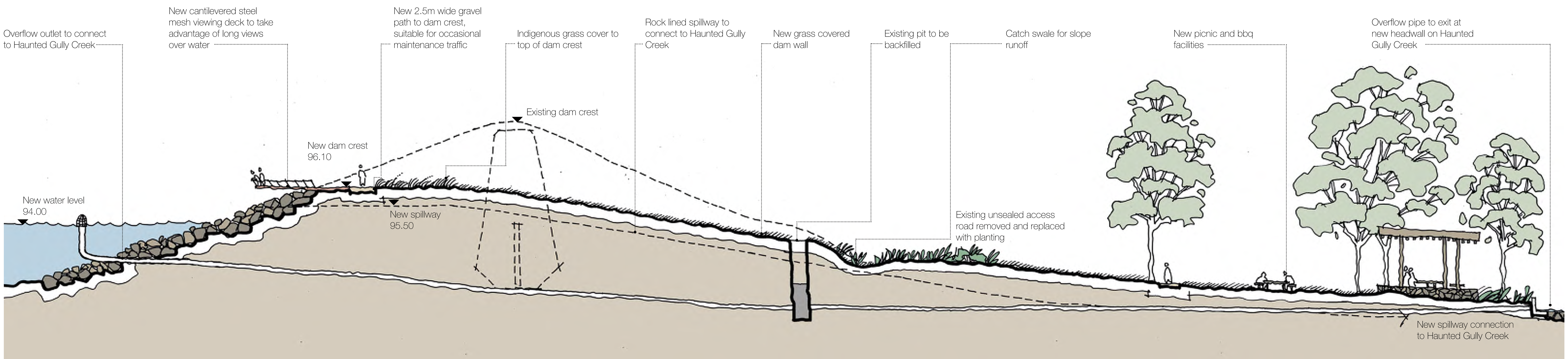
9. Existing shed to be retained
10. New steel totem signage with information regarding walking trails
11. Removal of existing shed in this area and associated hardstand and revegetate with locally indigenous species
12. Existing forest
13. Open up existing walking trail to the public
14. Haunted Gully Creek
15. Underground overflow pipe
16. Bridge crossing for maintenance vehicles



SECTION A - A 1:200

MELBOURNE WATER: BEACONSFIELD RESERVOIR OPTION 1D

INSET PLAN & SECTION

Job No: 31-36304
Original Size: A1
Drawing No: 3136304 L002
Approved:
Date: 29.10.2019
Rev: E

GHDWOODHEAD

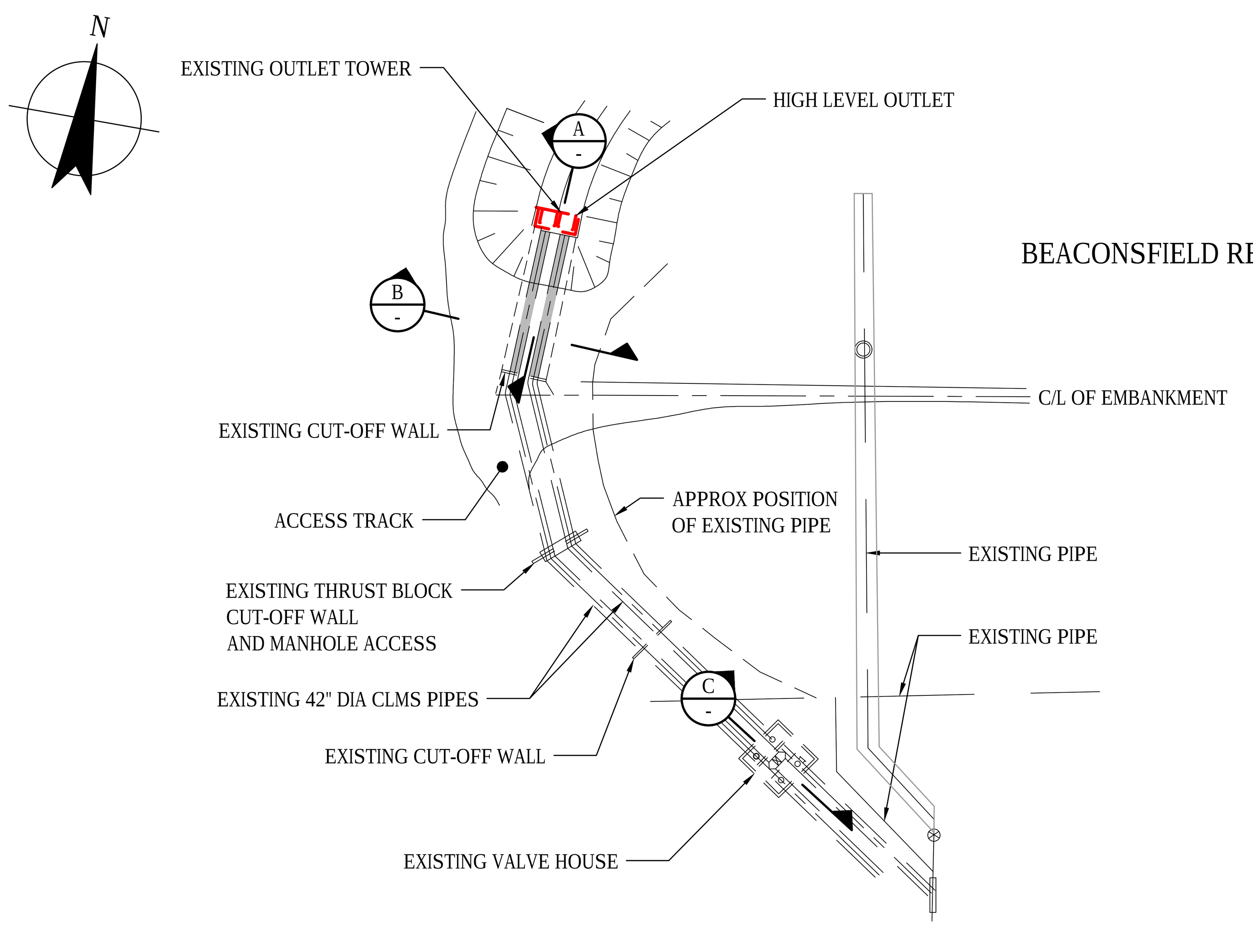
Appendix I – Concept Options drawings

Option 1A

Option 1B

Option 1C

Option 1D

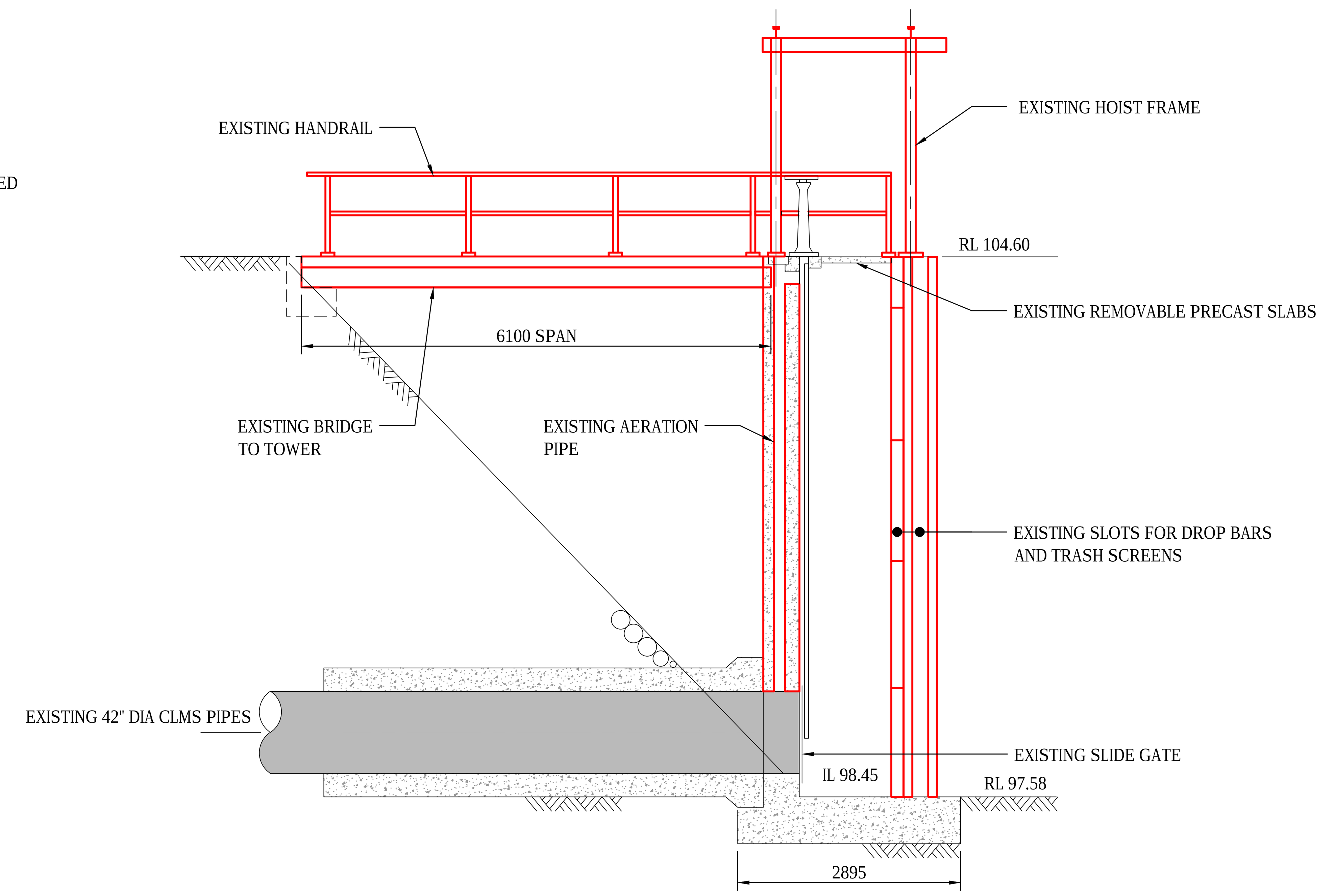


PLAN OF HIGH LEVEL OUTLET

SCALE 1: 500

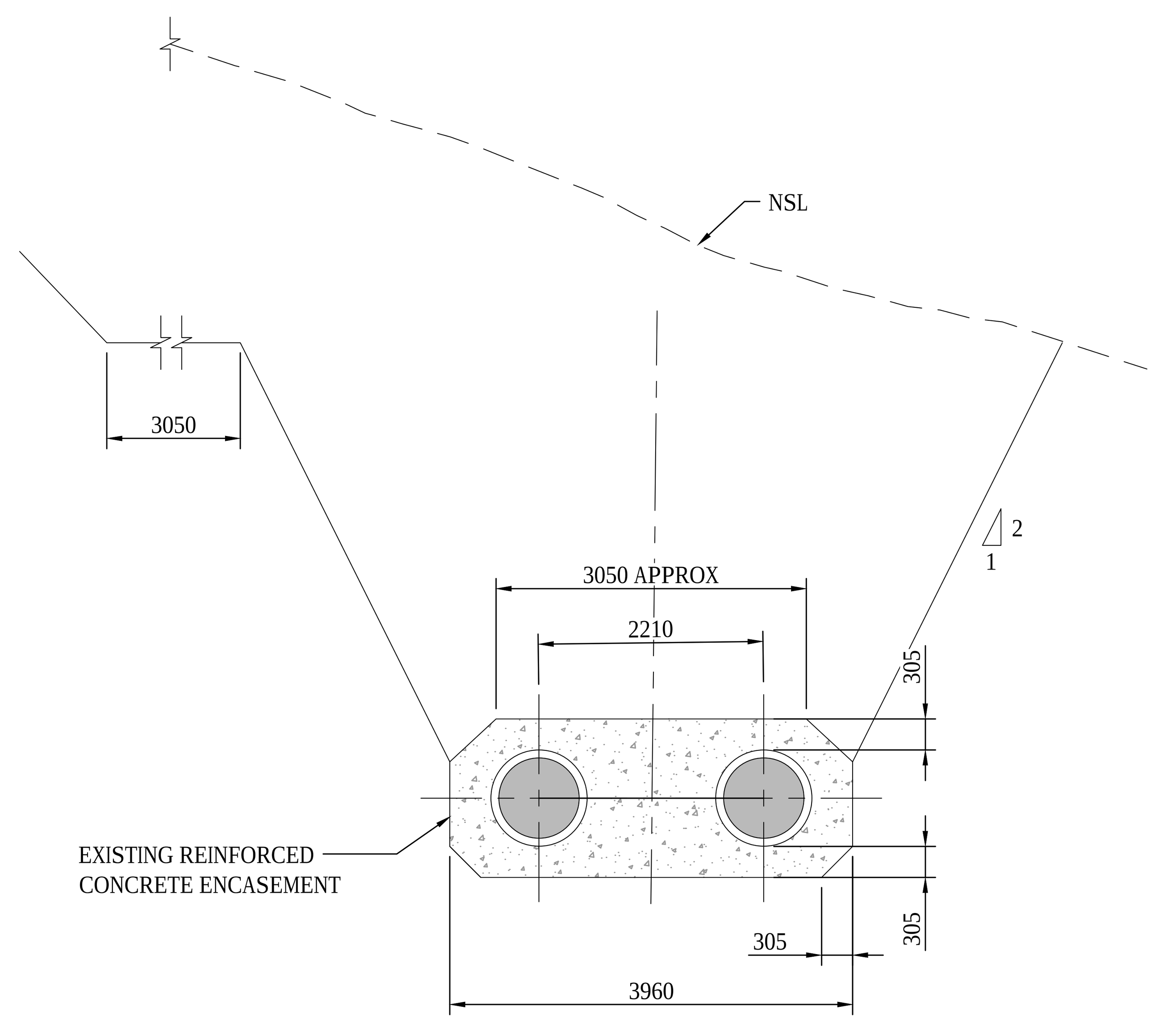
LEGEND

- TO BE DISMANTLED
- TO BE DEMOLISHED
- TO BE CONCRETE BACKFILLED



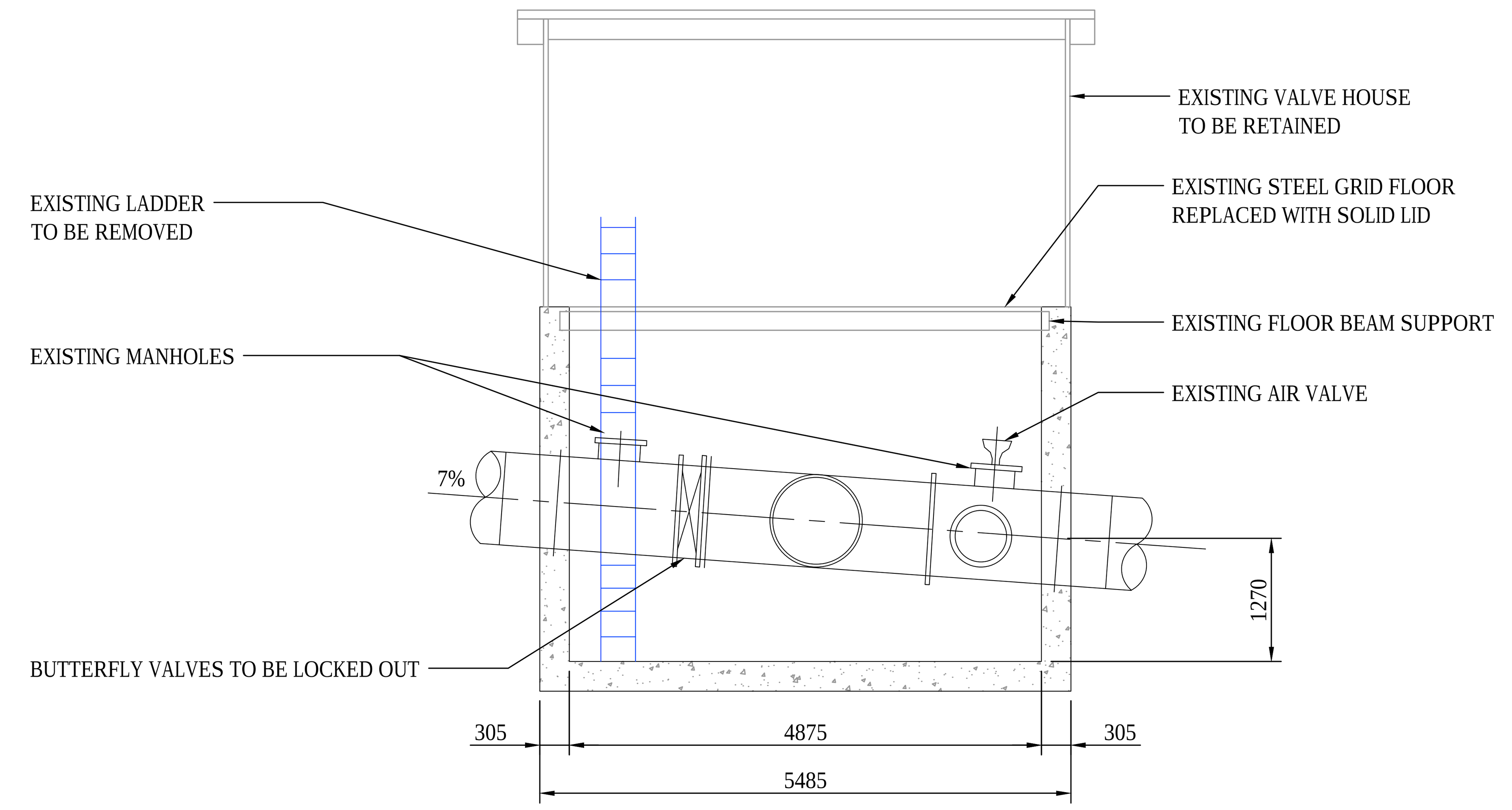
OUTLET TOWER SECTION - DEMOLITION WORKS

A SECTION SCALE 1 : 50



PIPE SECTION - BACKFILL WORKS

B SECTION SCALE 1 : 50



VALVE HOUSE - MINOR WORKS

C SECTION SCALE 1 : 50

0 500 1000 1500 2000 2500mm — SCALE 1:50 AT ORIGINAL SIZE

0 5000 10000 15000 20000 25000mm — SCALE 1:500 AT ORIGINAL SIZE

PRELIMINARY

REV	DESCRIPTION	COMPANY	PROJECT OR WO NUMBER	DRAWN	ENG. CHECK	PR. MAN. APP'D	DATE
C	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	28.10.2019
B	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	31.07.2019
A	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	25.02.2019

GHD

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E melmail@ghd.com.au W www.ghd.com

GHD DRAWING NUMBER 31-36304-C010

Melbourne Water

BEACONSFIELD RESERVOIR

DRAFTER	DESIGNER	DESIGN MANAGER APPROVAL	PROJECT MANAGER APPROVAL
B. WAI	S. TAUBERT		
DRAFTING CHECK	ENGINEERING REVIEW		

TITLE BEACONSFIELD RESERVOIR
CONCEPT DESIGN
HIGH LEVEL OUTLET - DECOMISSION WORKS

PROJECT DATUM

SCALE AS SHOWN

Original Size A1

MELBOURNE WATER CORPORATION

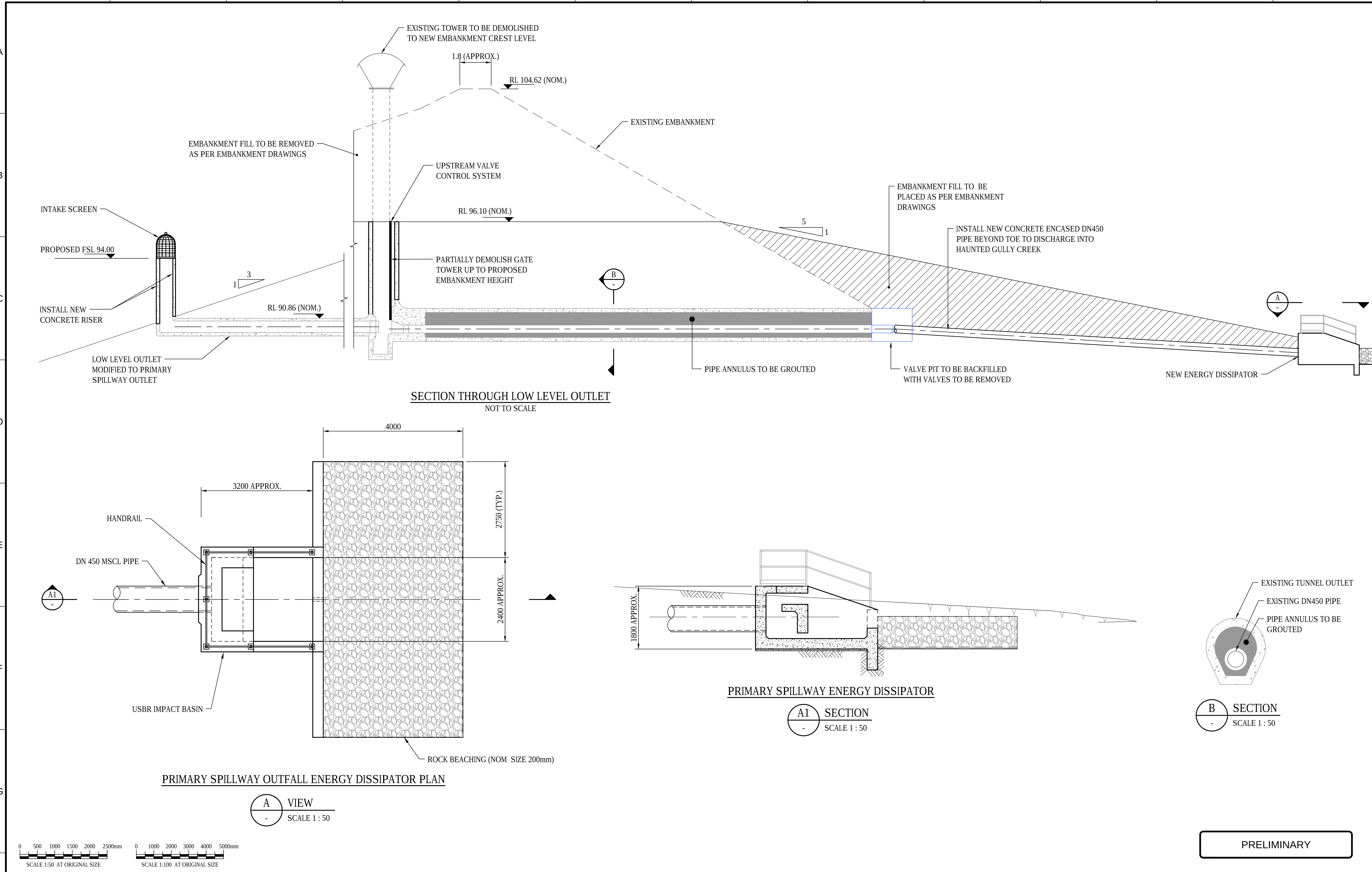
CODE | MW Drawing No (MWC DRAWING NUMBER) | REV C

MW Drawing No A (MWC DRAWING NUMBER, CODE, REV)

Plot Date: 28 October 2019 - 1:33 PM

Plotted by: Bevan Wai, ####

Cad File No: G:\31\36304\CADD\Drawings\31-36304-C010.dwg



PRELIMINARY

REV	DESCRIPTION	COMPANY	PROJECT OR WO NUMBER	DRAWN	ENG. CHECK	PR. MAN. APP'D	DATE
C	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	28.10.2019
B	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	31.07.2019
A	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	25.02.2019

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E melmail@ghd.com.au W www.ghd.com

GHD DRAWING NUMBER: 31-36304-C011

Melbourne Water
BEACONSFIELD RESERVOIR

DRAFTER	DESIGNER	DESIGN MANAGER APPROVAL	PROJECT MANAGER APPROVAL
B. WAI	S. TAUBERT		
DRAFTING CHECK	ENGINEERING REVIEW		

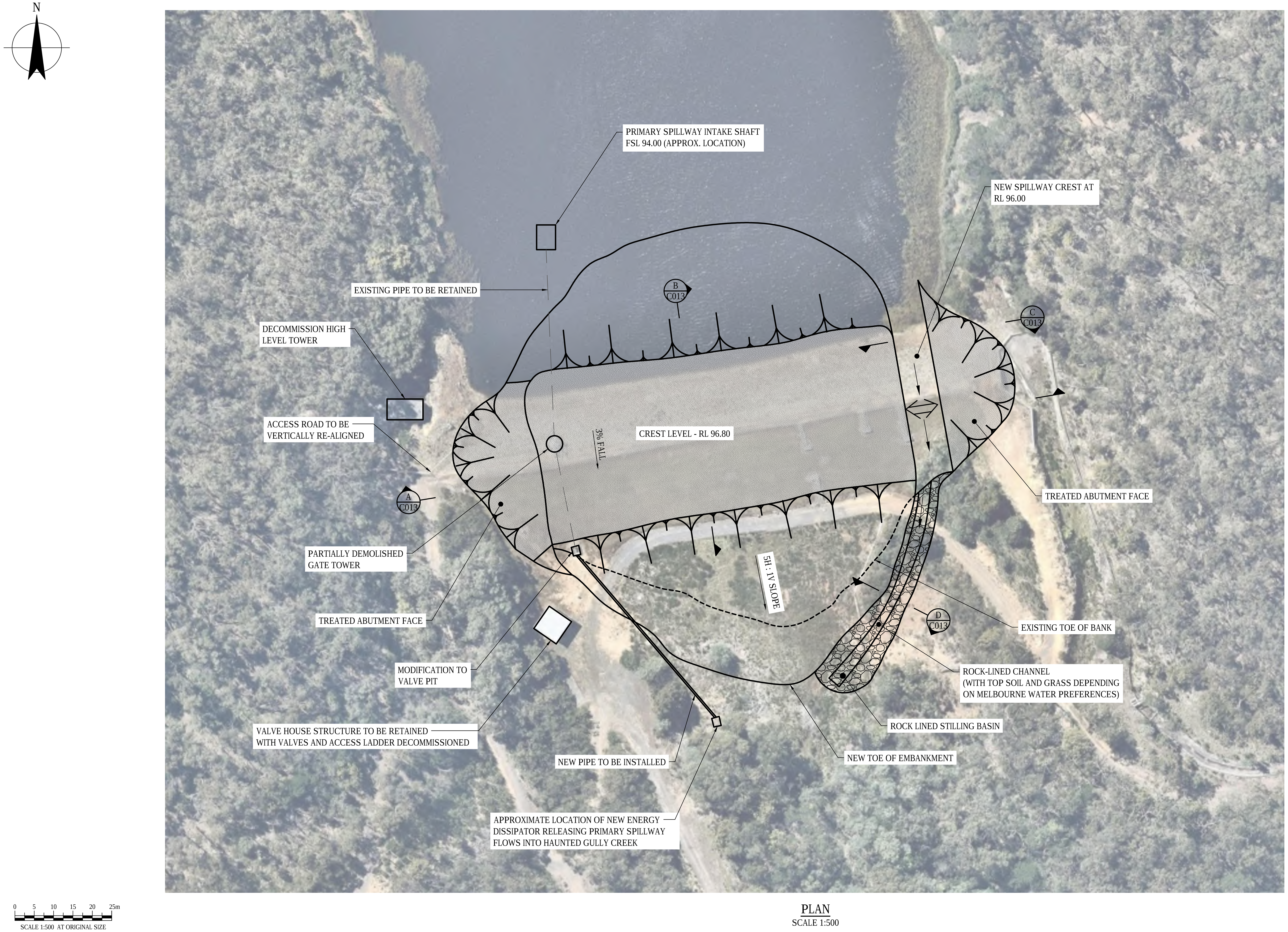
TITLE BEACONSFIELD RESERVOIR
CONCEPT DESIGN
MODIFICATIONS TO LOW LEVEL OUTLET - NEW PRIMARY SPILLWAY

PROJECT DATUM
SCALE AS SHOWN
Original Size A1
MELBOURNE WATER CORPORATION
CODE: C | MWC DRAWING NUMBER: MW Drawing No | REV: C

MW Drawing No | MWC DRAWING NUMBER | REV A | CODE

Plot Date: 28 October 2019 - 1:37 PM
Plotted by: Bevan Wai, ####
Cad File No: G:\31\36304\CADD\Drawings\31-36304-C011.dwg

REV	MWC DRAWING NUMBER	CODE
A	MW Drawing No	



PLAN
SCALE 1:500

PRELIMINARY

REV	DESCRIPTION	COMPANY	PROJECT OR WO NUMBER	DRAWN	ENG. CHECK	PR. MAN. APP'D	DATE
C	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	28.10.2019
B	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	31.07.2019
A	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	25.02.2019

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GHD DRAWING NUMBER
31-36304-C012

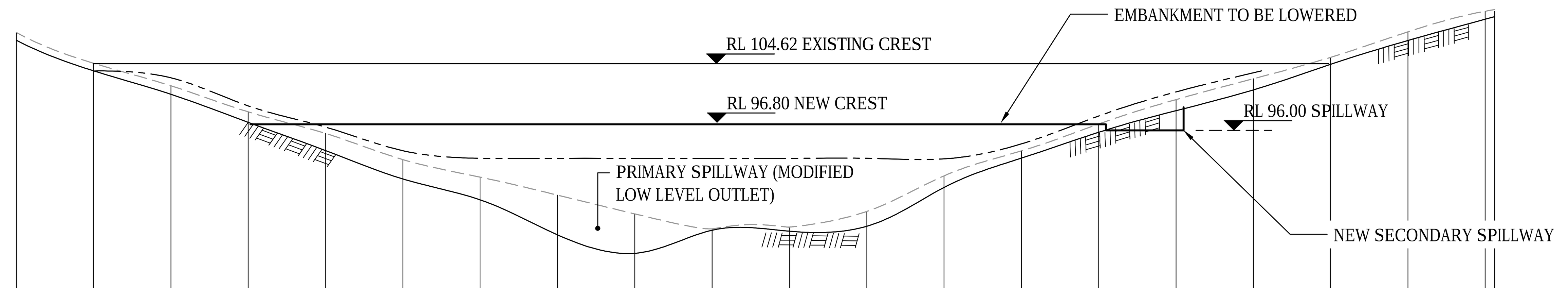
Melbourne Water
BEACONSFIELD RESERVOIR

DRAFTER	DESIGNER	DESIGN MANAGER APPROVAL	PROJECT MANAGER APPROVAL
B. WAI	T. SOLOMON		
DRAFTING CHECK	ENGINEERING REVIEW		

TITLE BEACONSFIELD RESERVOIR
CONCEPT DESIGN
OPTION A - PLAN

PROJECT DATUM	Original Size	MELBOURNE WATER CORPORATION	
SCALE AS SHOWN	A1	C / CODE	MW Drawing No / MWC DRAWING NUMBER	C / REV

Plot Date: 28 October 2019 - 1:42 PM
Plotted by: Bevan Wai, ####
Cad File No: G:\31\36304\CADD\Drawings\31-36304-C012.dwg

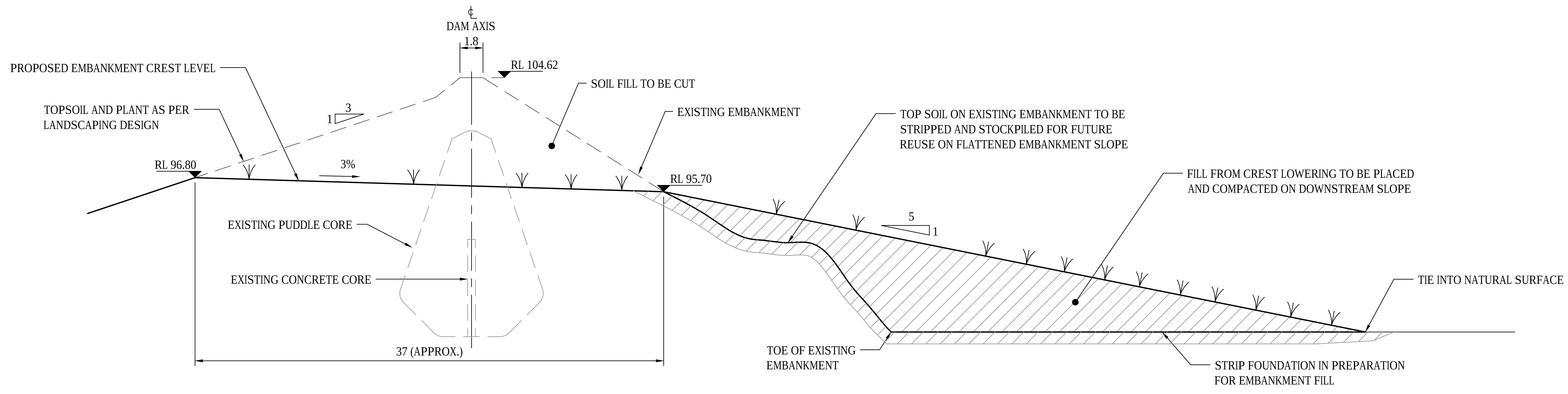


DATIM 70.00 (m)

NATURAL SURFACE LEVEL	108.64	104.67	101.76	98.39	95.61	92.24	89.97	87.65	85.22	83.26	83.53	85.55	90.14	93.35	96.83	99.98	102.67	105.44	108.73	111.39	111.60
ROCK LEVEL (APPROX.)	107.64	103.69	100.67	97.03	93.40	89.74	87.03	82.52	80.14	83.11	82.99	83.63	88.64	92.42	95.76	98.55	101.23	104.53	107.61	110.36	110.69
TOP OF COREWALL LEVEL		103.68	102.80	99.17	96.43	93.38	92.40	92.40	92.40	92.40	92.40	92.40	92.40	94.26	97.86	100.98	103.43				
CHAINAGE (m)	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	211.23

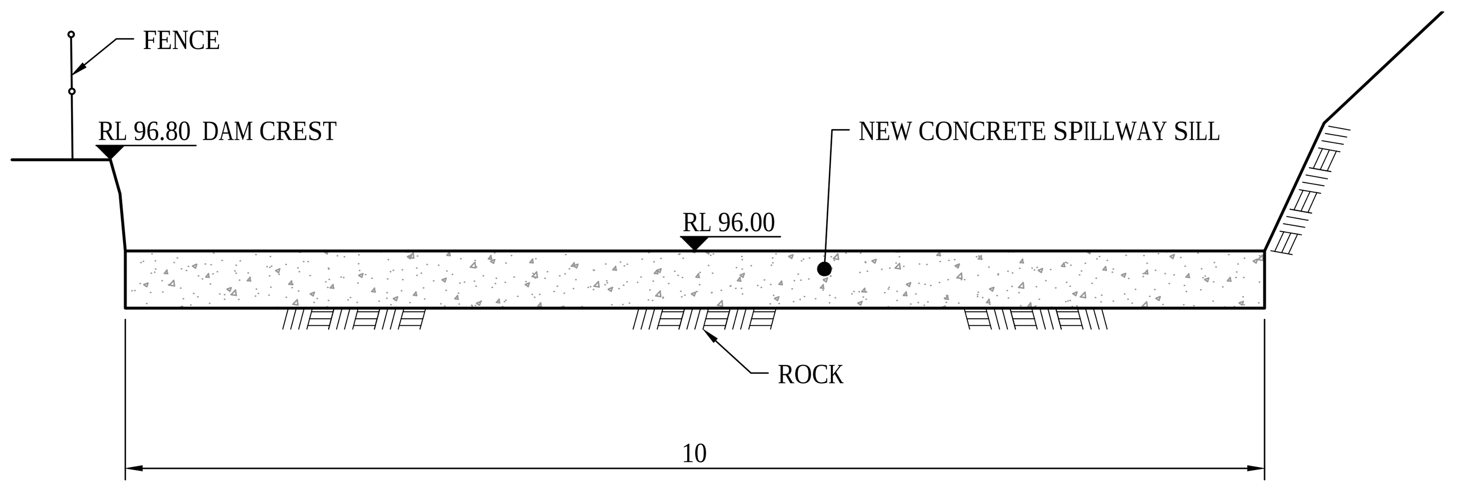
DAM AXIS LONG SECTION - LOOKING UPSTREAM

A SECTION
C012 SCALE 1 : 500



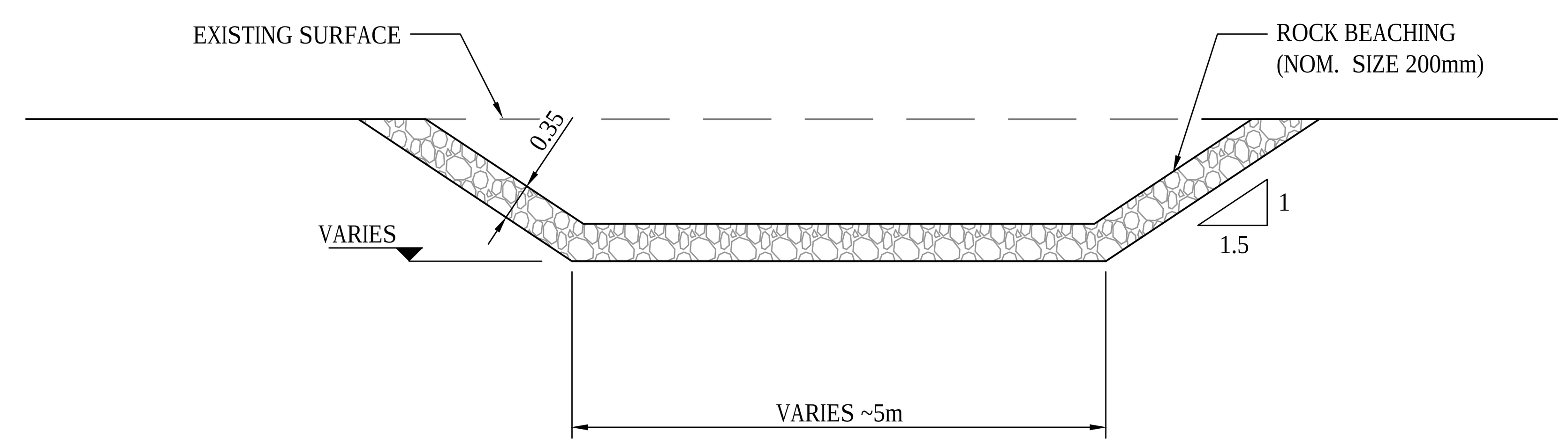
TYPICAL EMBANKMENT LOWERING SECTION

B SECTION
C012 SCALE 1 : 200



SECTION THROUGH SPILLWAY CREST

C SECTION
C012 SCALE 1 : 50



ROCK LINED CHANNEL TYPICAL DETAIL

D SECTION
C018 SCALE 1 : 50

0 0.5 1.0 1.5 2.0 2.5m SCALE 1:50 AT ORIGINAL SIZE
0 2 4 6 8 10m SCALE 1:200 AT ORIGINAL SIZE
0 5 10 15 20 25m SCALE 1:500 AT ORIGINAL SIZE

PRELIMINARY

REV	DESCRIPTION	COMPANY	PROJECT OR WO NUMBER	DRAWN	ENG. CHECK	PR. MAN. APP'D	DATE
C	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	28.10.2019
B	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	31.07.2019
A	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	25.02.2019

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Level 8, 180 Lonsdale Street, Melbourne VIC 3000 Australia
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E melmail@ghd.com.au W www.ghd.com

GHD DRAWING NUMBER 31-36304-C013

Melbourne Water
BEACONSFIELD RESERVOIR

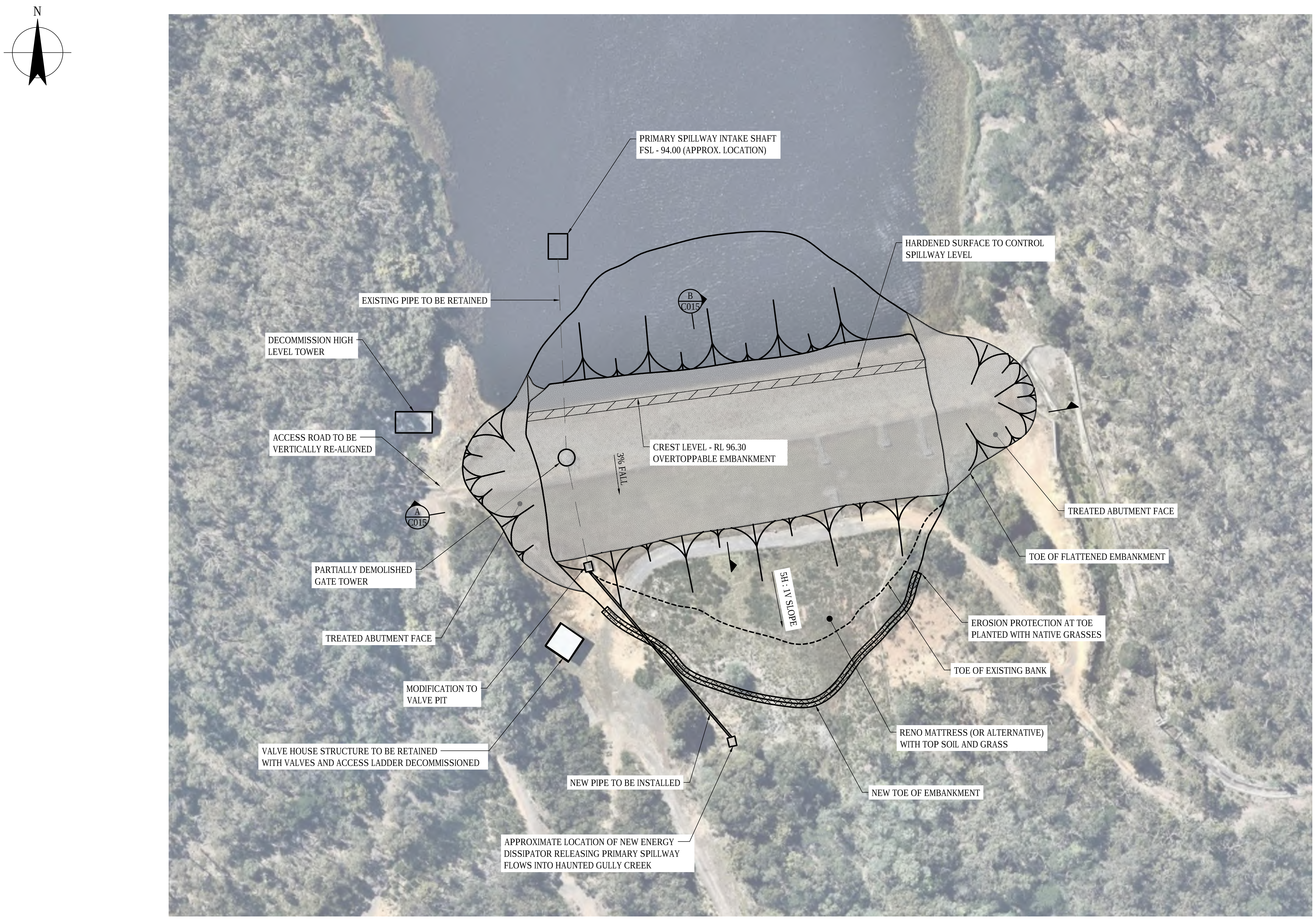
DRAFTER	DESIGNER	DESIGN MANAGER APPROVAL	PROJECT MANAGER APPROVAL
B. WAI	T. SOLOMON		
DRAFTING CHECK	ENGINEERING REVIEW		

TITLE BEACONSFIELD RESERVOIR
CONCEPT DESIGN
OPTION A - SECTIONS

PROJECT DATUM
SCALE AS SHOWN
Original Size A1
MELBOURNE WATER CORPORATION
CODE C | MWC DRAWING NUMBER MW Drawing No | REV C

MW Drawing No | MWC DRAWING NUMBER | REV A | CODE

Plot Date: 28 October 2019 - 1:38 PM
Plotted by: Bevan Wai, ####
Cad File No: G:\31\36304\CADD\Drawings\31-36304-C013.dwg



0 5 10 15 20 25m
SCALE 1:500 AT ORIGINAL SIZE

PLAN
SCALE 1:500

PRELIMINARY

REV	DESCRIPTION	COMPANY	PROJECT OR WO NUMBER	DRAWN	ENG. CHECK	PR. MAN. APP'D	DATE
B	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	28.10.2019
A	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	25.02.2019

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Level 8, 180 Lonsdale Street, Melbourne VIC 3000 Australia
T 61 3 8687 8000 F 61 3 8687 8111
E melmail@ghd.com.au W www.ghd.com

GHD DRAWING NUMBER: 31-36304-C014

Melbourne Water
BEACONSFIELD RESERVOIR

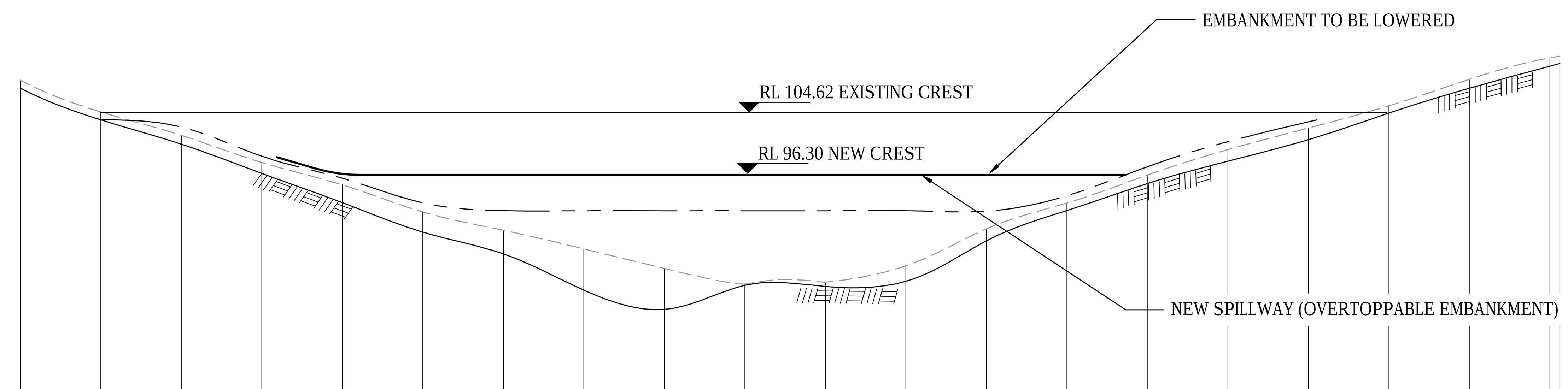
DRAFTER	DESIGNER	DESIGN MANAGER APPROVAL	PROJECT MANAGER APPROVAL
B. WAI	T. SOLOMON		
DRAFTING CHECK	ENGINEERING REVIEW		

TITLE BEACONSFIELD RESERVOIR
CONCEPT DESIGN
OPTION B - PLAN

PROJECT DATUM
SCALE AS SHOWN
Original Size A1
MELBOURNE WATER CORPORATION
CODE: C | MWC DRAWING NUMBER: MW Drawing No | REV: B

MW Drawing No A (MWC DRAWING NUMBER / REV / CODE)

Plot Date: 28 October 2019 - 1:43 PM
Plotted by: Bevan Wai, ####
Cad File No: G:\31\36304\CADD\Drawings\31-36304-C014.dwg

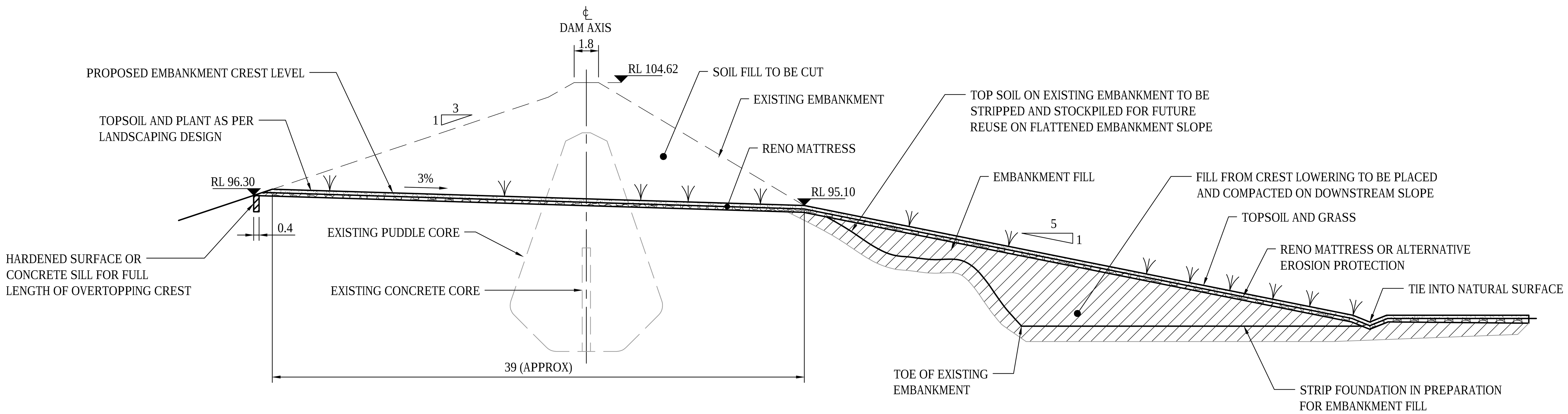


DATIM 70.00 (m)

NATURAL SURFACE LEVEL	108.64	104.67	101.76	98.39	95.61	92.24	89.97	87.65	85.22	83.26	83.53	85.55	90.14	93.35	96.83	99.98	102.67	105.44	108.73	111.39	111.60
ROCK LEVEL (APPROX.)	107.64	103.69	100.67	97.03	93.40	89.74	87.03	82.52	80.14	83.11	82.99	83.63	88.64	92.42	95.76	98.55	101.23	104.53	107.61	110.36	110.69
TOP OF COREWALL LEVEL		103.68	102.80	99.17	96.43	93.38	92.40	92.40	92.40	92.40	92.40	92.40	92.40	94.26	97.86	100.98	103.43				
CHAINAGE (m)	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	211.23

DAM AXIS LONG SECTION - LOOKING UPSTREAM

A SECTION
C014 SCALE 1 : 500



TYPICAL EMBANKMENT LOWERING SECTION

B SECTION
C014 SCALE 1 : 200

0 2 4 6 8 10m
SCALE 1:200 AT ORIGINAL SIZE

0 5 10 15 20 25m
SCALE 1:500 AT ORIGINAL SIZE

PRELIMINARY

REV	DESCRIPTION	COMPANY	PROJECT OR WO NUMBER	DRAWN	ENG. CHECK	PR. MAN. APP'D	DATE
B	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	28.10.2019
A	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	25.02.2019

Level 8, 180 Lonsdale Street, Melbourne VIC 3000 Australia
T 61 3 8687 8000 F 61 3 8687 8111
E melmail@ghd.com.au W www.ghd.com

GHD DRAWING NUMBER
31-36304-C015

BEACONSFIELD RESERVOIR

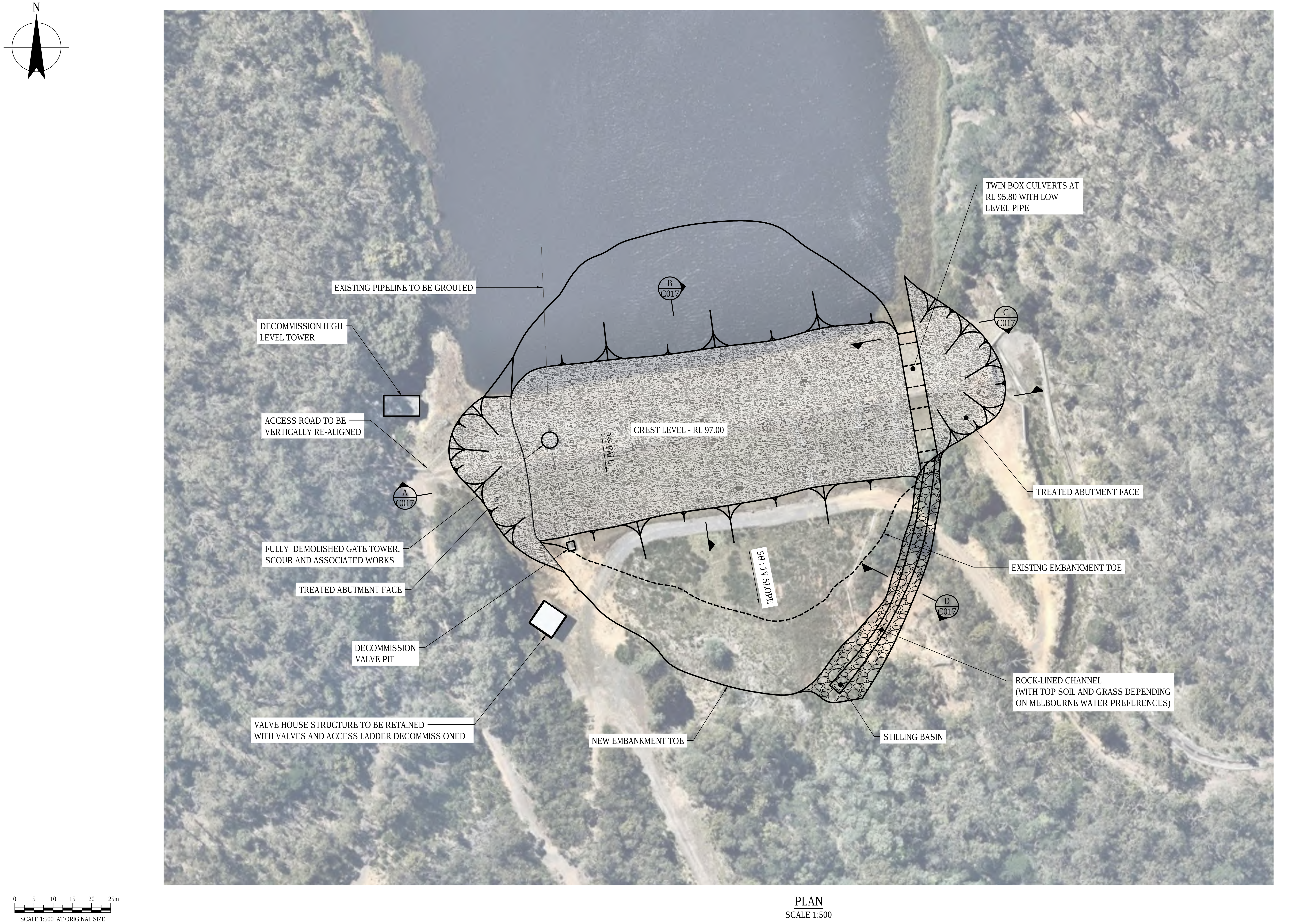
DRAFTER: B. WAI
DESIGNER: T. SOLOMON
DESIGN MANAGER APPROVAL
PROJECT MANAGER APPROVAL
DRAFTING CHECK
ENGINEERING REVIEW

TITLE BEACONSFIELD RESERVOIR
CONCEPT DESIGN
OPTION B - SECTIONS

PROJECT DATUM
SCALE AS SHOWN
Original Size A1
CODE C
MELBOURNE WATER CORPORATION
MWC DRAWING NUMBER: MW Drawing No
REV B

A — MW Drawing No — REV / MWC DRAWING NUMBER / CODE

Plot Date: 28 October 2019 - 1:40 PM
Plotted by: Bevan Wai, ####
Cad File No: G:\31\36304\CADD\Drawings\31-36304-C015.dwg



PLAN
SCALE 1:500

PRELIMINARY

REV	DESCRIPTION	COMPANY	PROJECT OR WO NUMBER	DRAWN	ENG. CHECK	PR. MAN. APP'D	DATE
B	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	28.10.2019
A	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	25.02.2019

Level 8, 180 Lonsdale Street, Melbourne VIC 3000 Australia
T 61 3 8687 8000 F 61 3 8687 8111
E melmail@ghd.com.au W www.ghd.com

GHD DRAWING NUMBER 31-36304-C016

Melbourne Water
BEACONSFIELD RESERVOIR

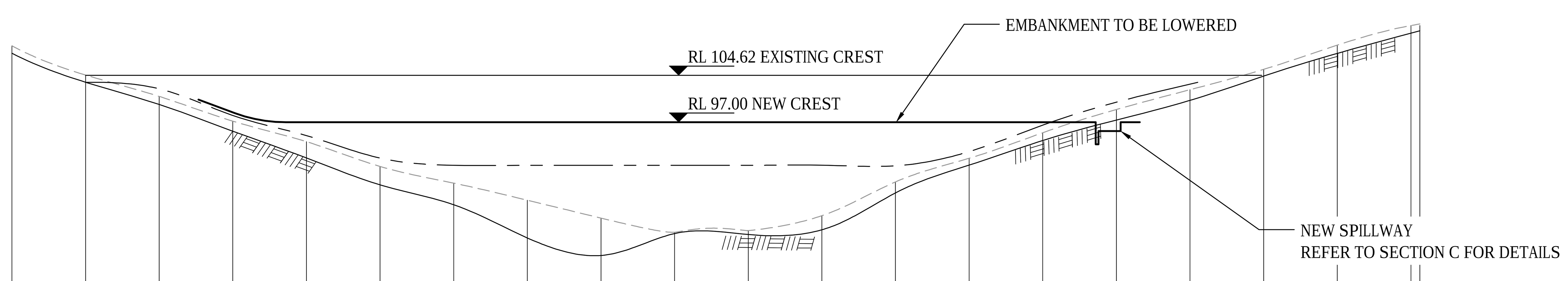
DRAFTER	DESIGNER	DESIGN MANAGER APPROVAL	PROJECT MANAGER APPROVAL
B. WAI	T. SOLOMON		
DRAFTING CHECK	ENGINEERING REVIEW		

TITLE BEACONSFIELD RESERVOIR
CONCEPT DESIGN
OPTION C - PLAN

PROJECT DATUM
SCALE AS SHOWN
Original Size A1
MELBOURNE WATER CORPORATION
CODE C | MWC DRAWING NUMBER MW Drawing No | REV B

MW Drawing No A (MWC DRAWING NUMBER / REV / CODE)

Plot Date: 28 October 2019 - 1:45 PM
Plotted by: Bevan Wai, ####
Cad File No: G:\31\36304\CADD\Drawings\31-36304-C016.dwg

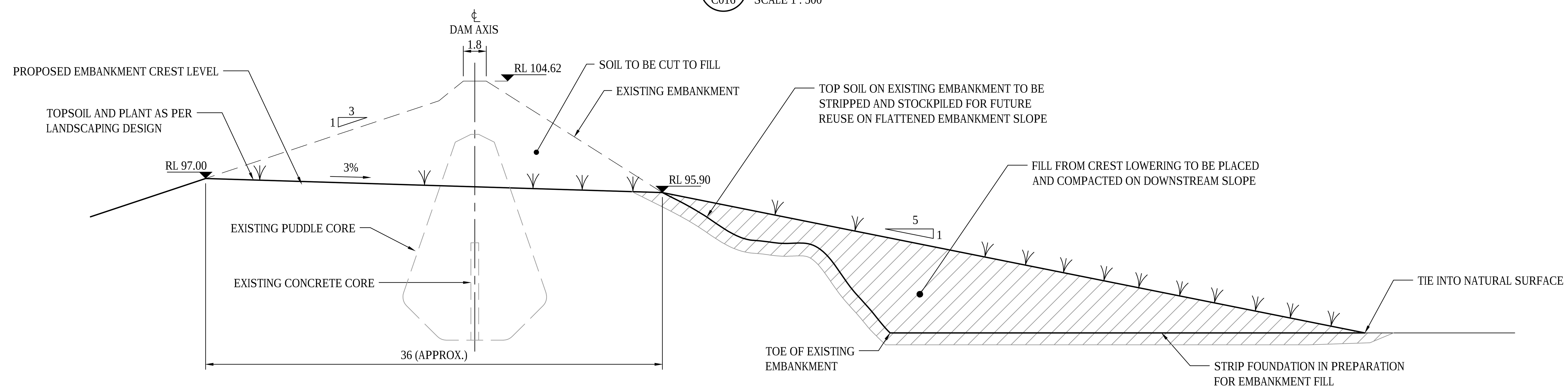


DATIM 70.00 (m)

CHAINAGE (m)	NATURAL SURFACE LEVEL	ROCK LEVEL (APPROX.)	TOP OF COREWALL LEVEL
20	108.64	107.64	
30	104.67	103.69	103.68
40	101.76	100.67	102.80
50	98.39	97.03	99.17
60	95.61	93.40	96.43
70	92.24	89.74	93.38
80	89.97	87.03	92.40
90	87.65	82.52	92.40
100	85.22	80.14	92.40
110	83.26	83.11	92.40
120	83.53	82.99	92.40
130	85.55	83.63	92.40
140	90.14	88.64	92.40
150	93.35	92.42	94.26
160	96.83	95.76	97.86
170	99.98	98.55	100.98
180	102.67	101.23	103.43
190	105.44	104.53	
200	108.73	107.61	
210	111.39	110.36	
211.23	111.60	110.69	

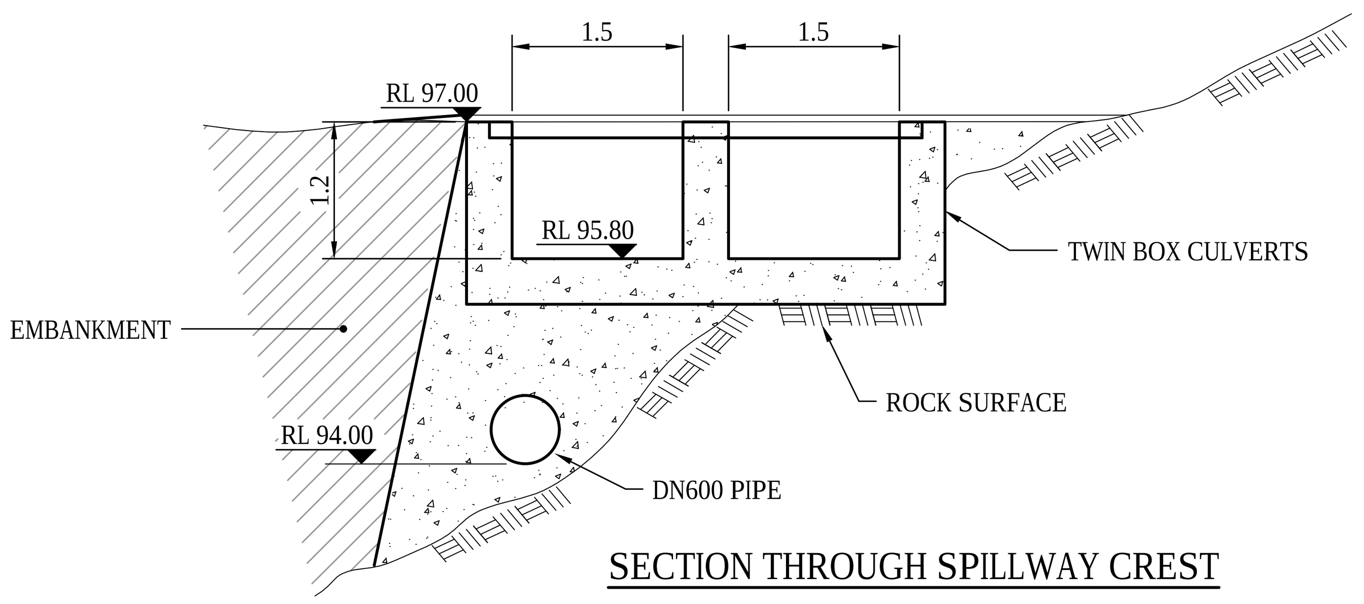
DAM AXIS LONG SECTION - LOOKING UPSTREAM

A SECTION C016 SCALE 1 : 500



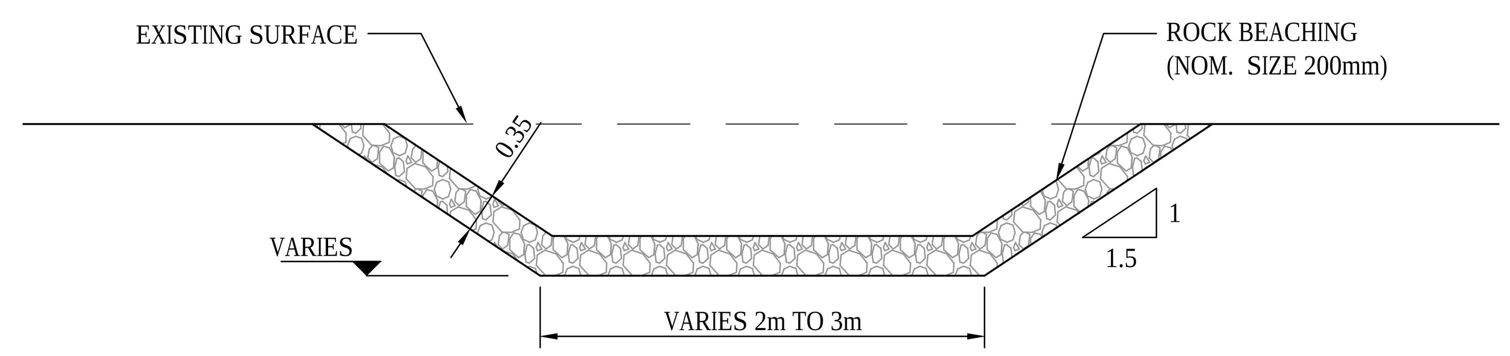
TYPICAL EMBANKMENT LOWERING SECTION

B SECTION C016 SCALE 1 : 200



SECTION THROUGH SPILLWAY CREST

C SECTION C016 SCALE 1 : 50



ROCK LINED CHANNEL TYPICAL DETAIL

D SECTION C016 SCALE 1 : 50

SCALE 1:50 AT ORIGINAL SIZE (0 0.5 1.0 1.5 2.0 2.5m)
SCALE 1:200 AT ORIGINAL SIZE (0 2 4 6 8 10m)
SCALE 1:500 AT ORIGINAL SIZE (0 5 10 15 20 25m)

PRELIMINARY

REV	DESCRIPTION	COMPANY	PROJECT OR WO NUMBER	DRAWN	ENG. CHECK	PR. MAN. APP'D	DATE
B	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	28.10.2019
A	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	25.02.2019

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Level 8, 180 Lonsdale Street, Melbourne VIC 3000 Australia
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E melmail@ghd.com.au W www.ghd.com

GHD DRAWING NUMBER 31-36304-C017

Melbourne Water
BEACONSFIELD RESERVOIR

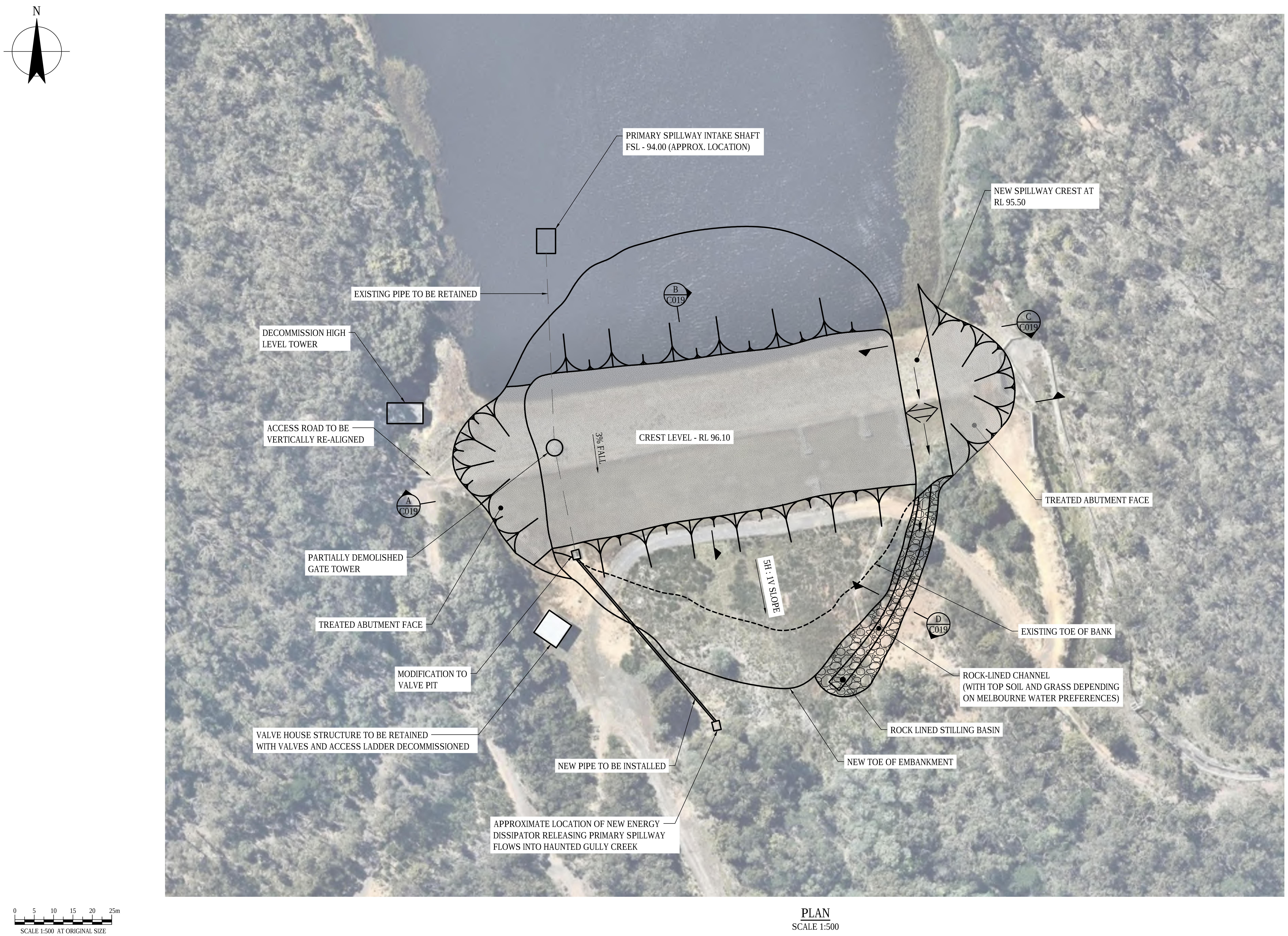
DRAFTER	DESIGNER	DESIGN MANAGER APPROVAL	PROJECT MANAGER APPROVAL
B. WAI	T. SOLOMON		
DRAFTING CHECK	ENGINEERING REVIEW		

TITLE BEACONSFIELD RESERVOIR
CONCEPT DESIGN
OPTION C - SECTIONS

PROJECT DATUM
SCALE AS SHOWN
Original Size A1
MELBOURNE WATER CORPORATION
CODE C | MWC DRAWING NUMBER MW Drawing No | REV B

A REV | MW Drawing No MWC DRAWING NUMBER | CODE

Plot Date: 28 October 2019 - 1:46 PM
Plotted by: Bevan Wai, ####
Cad File No: G:\31\36304\CADD\Drawings\31-36304-C017.dwg



PLAN
SCALE 1:500

PRELIMINARY

MW Drawing No A
CODE | MWC DRAWING NUMBER | REV

REV	DESCRIPTION	COMPANY	PROJECT OR WO NUMBER	DRAWN	ENG. CHECK	PR. MAN. APP'D	DATE
A	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	28.10.2019

GHD
Level 8, 180 Lonsdale Street, Melbourne VIC 3000 Australia
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E melmail@ghd.com.au W www.ghd.com

GHD DRAWING NUMBER 31-36304-C018

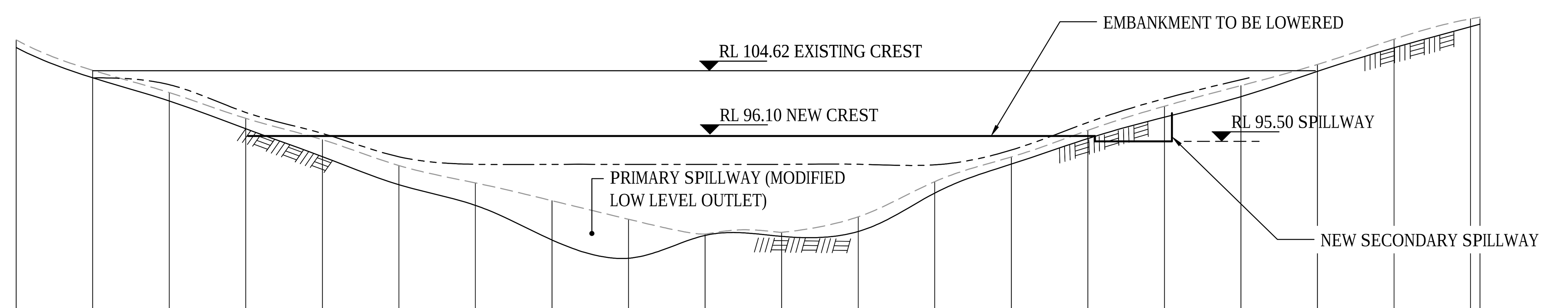
Melbourne Water
BEACONSFIELD RESERVOIR

DRAFTER	DESIGNER	DESIGN MANAGER APPROVAL	PROJECT MANAGER APPROVAL
B. WAI	S. TAUBERT		
DRAFTING CHECK	ENGINEERING REVIEW		

TITLE BEACONSFIELD RESERVOIR
CONCEPT DESIGN
OPTION D - PLAN

PROJECT DATUM
SCALE AS SHOWN
Original Size A1
MELBOURNE WATER CORPORATION
C | MW Drawing No | A
CODE | MWC DRAWING NUMBER | REV

Plot Date: 28 October 2019 - 1:46 PM
Plotted by: Bevan Wai, ####
Cad File No: G:\31\36304\CADD\Drawings\31-36304-C018.dwg



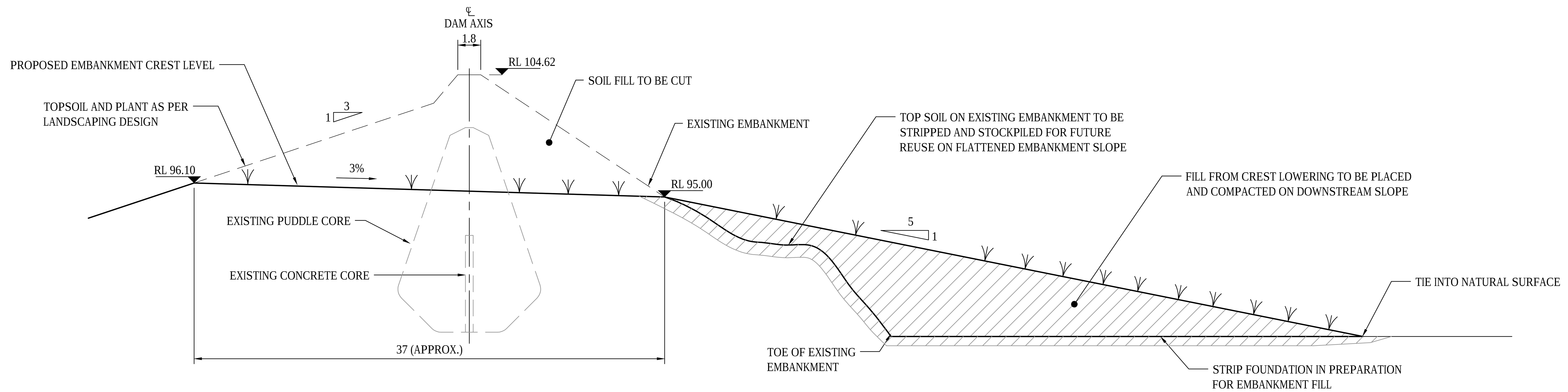
DATIM 70.00 (m)

CHAINAGE (m)	20	30	40	50	60	70	80	90	100	110	120
NATURAL SURFACE LEVEL	108.64	104.67	101.76	98.39	95.61	92.24	89.97	87.65	85.22	83.26	83.53
ROCK LEVEL (APPROX.)	107.64	103.69	100.67	97.03	93.40	89.74	87.03	82.52	80.14	83.11	82.99
TOP OF COREWALL LEVEL		103.68	102.80	99.17	96.43	93.38	92.40	92.40	92.40	92.40	92.40

CHAINAGE (m)	130	140	150	160	170	180	190	200	210	211.23
NATURAL SURFACE LEVEL	85.55	90.14	93.35	96.83	99.98	102.67	105.44	108.73	111.39	111.60
ROCK LEVEL (APPROX.)	83.63	88.64	92.42	95.76	98.55	101.23	104.53	107.61	110.36	110.69
TOP OF COREWALL LEVEL	92.40	92.40	94.26	97.86	100.98	103.43				

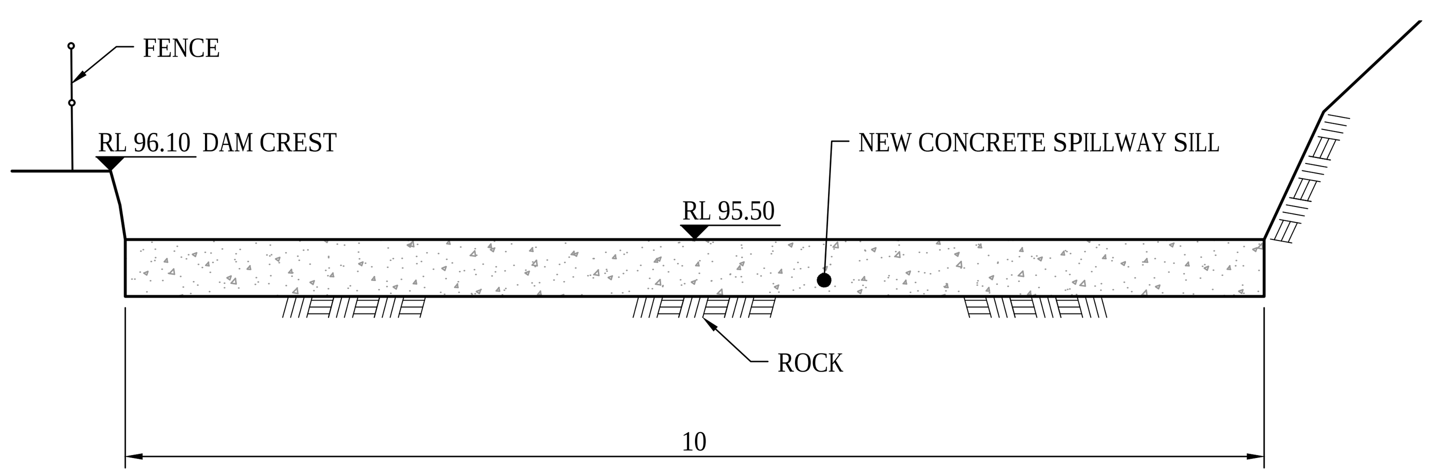
DAM AXIS LONG SECTION - LOOKING UPSTREAM

A SECTION C018 SCALE 1 : 500



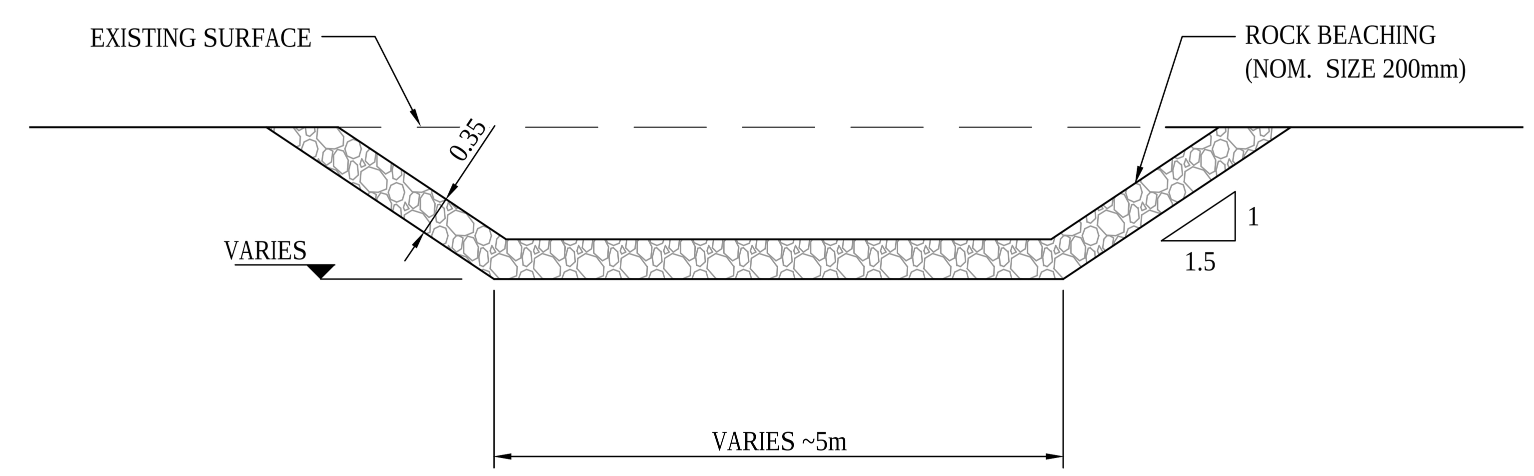
TYPICAL EMBANKMENT LOWERING SECTION

B SECTION C018 SCALE 1 : 200



SECTION THROUGH SPILLWAY CREST

C SECTION C018 SCALE 1 : 50



ROCK LINED CHANNEL TYPICAL DETAIL

D SECTION C018 SCALE 1 : 50

PRELIMINARY

REV	DESCRIPTION	COMPANY	PROJECT OR WO NUMBER	DRAWN	ENG. CHECK	PR. MAN. APP'D	DATE
A	DRAFT UPGRADE CONCEPT DESIGN	GHD		BW		CB	28.10.2019

GHD
Level 8, 180 Lonsdale Street, Melbourne VIC 3000 Australia
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E melmail@ghd.com.au W www.ghd.com

GHD DRAWING NUMBER 31-36304-C019

Melbourne Water
BEACONSFIELD RESERVOIR

DRAFTER	DESIGNER	DESIGN MANAGER APPROVAL	PROJECT MANAGER APPROVAL
B. WAI	S. TAUBERT		
DRAFTING CHECK	ENGINEERING REVIEW		

TITLE BEACONSFIELD RESERVOIR
CONCEPT DESIGN
OPTION D - SECTIONS

PROJECT DATUM
SCALE AS SHOWN
Original Size A1
MELBOURNE WATER CORPORATION
CODE C
MWC DRAWING NUMBER MW Drawing No
REV A

MW Drawing No A (MWC DRAWING NUMBER / CODE / REV)

Plot Date: 28 October 2019 - 1:47 PM
Plotted by: Bevan Wai, ####
Cad File No: G:\31\36304\CADD\Drawings\31-36304-C019.dwg

Appendix J – CAPEX cost estimates

Option 1A

Option 1B

Option 1C

Option 1D

Option 1A

Option 1B

Option 1C

Option 1D (recommended concept design)

Appendix K – RANE cost estimates

Melbourne Water
RANE Template - Output

Beaconsfield Reservoir Concept Design
3136304

3136304-Beaconsfield-RANE-Option1D.xlsm

Appendix L – RANE risk estimates

GHD
Level 18, 180 Lonsdale Street
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https://projects.ghd.com/oc/Victoria1/beaconsfielddaminspe/Delivery/Documents/3136304-REP-1-Beaconsfield Reservoir Concept Design Report.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	T Solomon M Medwell Squier	S Taubert		C Baker		20/11/2019
1	T Solomon M Medwell Squier C Young	S Taubert	[signature]	C Baker	[signature]	18/12/2019

www.ghd.com

Beaconsfield Dam Safety Upgrade

Update December 2021

It's time to upgrade Beaconsfield Dam

The dam was built over 100 years ago and needs to be upgraded in order to meet current guidelines set by the Australian National Committee on Large Dams (ANCOLD). Australia and accordingly, Melbourne Water has a strong emphasis on dam safety management principles set out by these guidelines. These guidelines apply to large and small dams that could present a risk to life for those downstream.

The driver of the Beaconsfield Dam Safety Upgrade project is to protect properties and communities located downstream of the reservoir. Beaconsfield Dam is an asset owned and maintained by Melbourne Water, however the land surrounding the reservoir is managed by the Department of Environment Land Water and Planning (DELWP).

Options we have considered

To determine the right approach for the project, we undertook a Multi-Criteria Analysis (MCA) on four possible options:

- **Option one**: Leave water level at current height and continue to monitor
- **Option two:** Full decommission of the reservoir
- **Option three:** Undertake a safety upgrade, retain existing water level and increase the height of the embankment
- **Option four:** Partial decommissioning of the reservoir. Reduction of the height of the embankment and lowering the water level.

Melbourne Water led a multi criteria analysis in 2018 involving stakeholders and some members of the community against all four options. The criteria looked at a number of categories and sub-categories:

• Safety • cost • community impacts • environmental and conservation impact.

Over the last year, MW has undertaken additional assessments against the four criteria, including engaging independent ecologists to undertake environmental and conservation assessments and impact on lowering the water level. Option four allows us to meet ANCOLD guidelines and maintain a permanent water body. Any impacts on the environmental values of Beaconsfield Nature Conservation Reserve (BNCR) can be managed.

VICTORIA State Government

Melbourne Water
Enhancing Life and Liveability

Beaconsfield Dam Safety Upgrade

OPTIONS ASSESSMENT

OPTION 1

Leave water level at current height and continue to monitor

By doing nothing, the Consequence Category and risk profile remain unchanged. Therefore, 'Do Nothing' is not per ANCOLD guidelines or the Strategic Framework for Dam Safety Regulation (DELWP, 2014). It is therefore not considered a viable option.

OPTION 2

Full decommissioning

Full decommissioning eliminates all dam safety risks associated with Beaconsfield Dam. However, there would be no permanent water body, and an extensive construction period that would also impact the flora and fauna within the BNCR.

Complete removal of the reservoir would lead to unacceptable increases in flood levels along Haunted Gully Creek. For these reasons, it is considered not a viable option.

OPTION 3

Full dam safety upgrade

A full upgrade would be a considerably longer and more costly construction phase in comparison to options 1 & 2.

The consequence is not reduced due to the high volume of water.

There would be major disruption to the local residents due to the high volume of heavy vehicle movements that would bring in the large amount of material required for the embankment. For safety, the public would not be allowed access to the embankment due to the steepness and exposed rock faces.

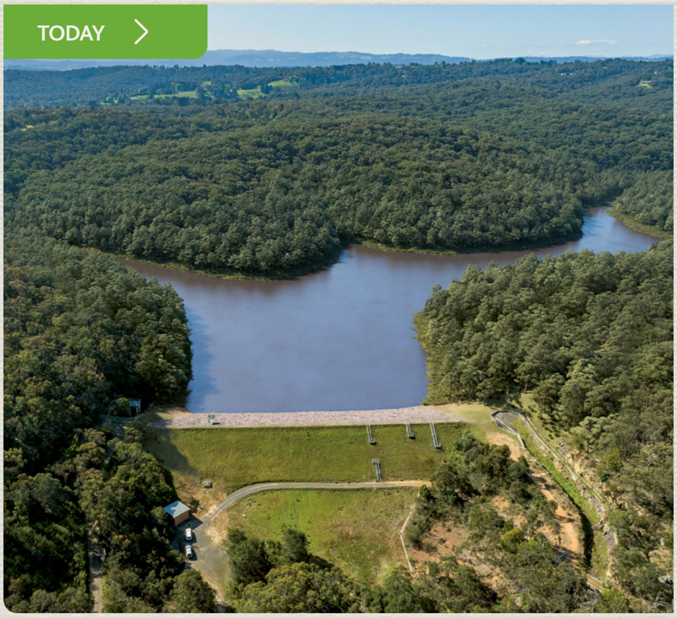
OPTION 4

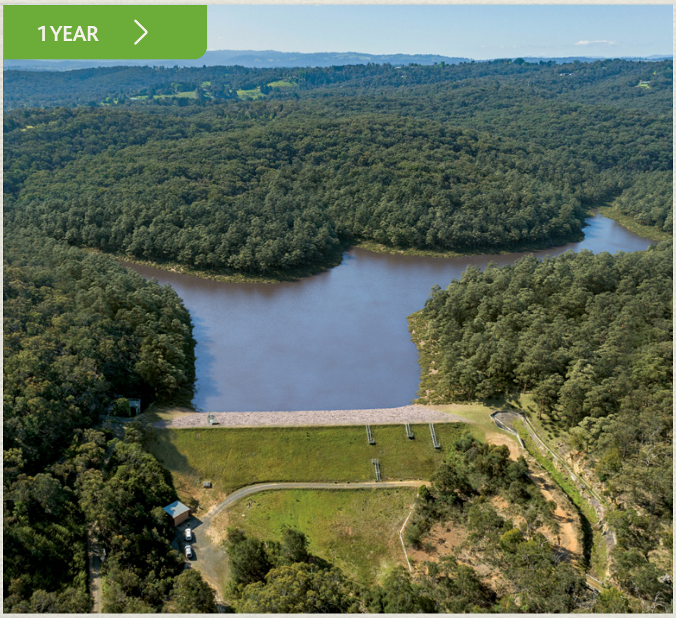
Partial decommissioning (Approved option)

A partial decommissioning offers the benefit of retaining a waterbody while minimising risk.

Environment Impact Assessment recommends a slow lowering of the water level over a 3 to 5 year period before commencing any construction activities.

Melbourne Water will continue to monitor the dam during the lowering of the water level.





Do you know the difference between a Reservoir and a Dam?

Dams are structures that are built on a river in order to retain water for one or more specific purposes. A dam is a physical structure that retains water, and a reservoir is the water body that is created by a dam.

About the approved option – partial decommissioning

This option will involve:

- Lowering the dam crest from 98.5m to 94.00m – reducing the peak water level and modifying the current low-level outlet to act as the new water discharge point.
- Removal of redundant infrastructure, constructing a new energy dissipater to reduce scouring and safely discharge into Haunted Gully Creek, and building a 10m long secondary rock-lined spillway are all part of the safety works.
- The viewing platform will remain, and these works will free up the area next to the dam for potential landscaping by park management in consultation with the Cardinia Environmental Collation (CEC).

Environmental values

Melbourne Water is committed to ensuring environmental values are protected and enhanced as part of these works.

June and July 2021, Arthur Rylah Institute (ARI) for Environmental Research conducted an enhanced environmental impact assessment focused on lowering the water level. The final report (available online at www.melbournewater.com.au/beaconsfield-dam) recommends a slow draw-down of the water level over a three to five year period to allow the emergent and submerged vegetation around the reservoir's edge to migrate with the changing waterline.

The images below show how the emergent and submerged vegetation will grow as the waterline lowers over a five year period.

The report outlines a number of recommendations to minimise the risk to flora and fauna, which Melbourne Water will commit to:

- Before commencing works, a detailed ecological assessment of flora and fauna be undertaken. Field assessments have already commenced and will continue over the next 12 months.
- Lowering the water level should occur over a minimum of three years. This will commence mid 2022.
- Undertake to monitor impacts to biodiversity.
- Collect seed from Swamp Gum and Green Scentbark in the first year of lowering the water level.
- Before any ancillary works (access tracks), undertake spring targeted surveys for threatened species. Spring surveys are currently being undertaken.
- Control all woody weeds. This will continue to be carried out by the CEC.
- Repair the perimeter fence and undertake intensive deer control throughout the lowering of the water level.
- If the wall is reduced, it should be assumed that frogs and skinks may be present in the rock wall, and appropriate care is taken when carrying out works.

Melbourne Water will continue working with the CEC to ensure that any works to the dam result in enhancements to the environmental values within the Beaconsfield Nature Conservation Reserve.

December 2021

About Beaconsfield Dam

The Beaconsfield Dam sits within the Beaconsfield Nature Conservation Reserve (BNCR) on the Haunted Gully Creek, located within Cardinia Shire, approximately 45km southeast of Melbourne.

The reservoir is on-stream storage, with a local catchment area of around 334ha. It was constructed by the State Rivers and Water Supply Commission in 1918 as part of the water supply scheme for the Mornington Peninsula. Water was harvested from the Bunyip River and conveyed to Beaconsfield Reservoir by the Bunyip Main Race which was later supplemented by the construction of the Tarago Main Race.

The reservoir was permanently disconnected from Melbourne's water supply and distribution network in 1988, following the connection of Cardinia Reservoir. Beaconsfield Reservoir is operated by Melbourne Water, but is located on Crown Land managed by the Department of Environment Land Water and Planning (DELWP). The Cardinia Environment Coalition (CEC) manage the surrounding Beaconsfield Nature Conservation Reserve under an agreement with the Minister for Water.

About Beaconsfield Nature Conservation Reserve (BNCR)

In 2005, the state government gazetted the 172-hectares surrounding the reservoir be set aside as the Beaconsfield Nature Conservation Reserve to help conserve species of plants and animals that may be rare or endangered, contain critical habitat, or hold conservation significance. The BNCR includes a variety of vegetation listed as endangered, vulnerable, and depleted in Victoria's east.

This reserve is now an essential remnant of what was once common across the landscape, providing protection for many species. The CEC was appointed the Committee of Management for the BNCR in 2005 and continues to protect the environmental values within the BNCR. While the BNCR is closed to the public, occasionally, the CEC holds community open days and one-off events for groups, bushwalking clubs and field naturalist clubs.

Bush fire risk

Advice from DELWP's Chief Fire Officer has determined that Beaconsfield Reservoir is not a pre-approved location for water pickup by firefighting aircraft. Cardinia Reservoir, located 6km to the north and is much larger and safer to fill from.

ENGAGEMENT ACTIVITIES

- **2012–2021** Design and environmental studies undertaken
- **2016–2021** Consultation and engagement with active and interested community groups, including key government stakeholders and Traditional Owners
- **2022** Community information sessions – March/April (TBC) Commence slow drawdown of water level in line with environmental recommendations
- **2025** Commencement of upgrade works

FOR MORE INFORMATION

131 722

Beaconsfield@melbournewater.com.au

www.melbournewater.com.au/beaconsfield-dam

Interpreter

To access the TTY and Interpreter Services
TTY **133 677**
Interpreter **131 450**

ATTACHMENT 4 - Sample of form letter received 28 February 2021 from Officer & Disctrict Community Association Inc.

From: Cr. Brett Owen
Sent: Sunday, 28 February 2021 10:56 PM
To: MailAtCardinia <mail@cardinia.vic.gov.au>; Peter Benazic

Peter
I understand that you are taking the lead on the upcoming council report which will be presented to the April Council meeting.
Please find the below correspondence from the Officer and District Community Association for council to consider.
Can I please request that this correspondence be considered in the compilation of the report to council for the April meeting.
Kind Regards
Brett

Mayor Cr Brett Owen | Cardinia Shire Council | Beacon Hills Ward
Phone: 0418 993 370 | Web: cardinia.vic.gov.au
PO Box 7 Pakenham 3810 | Customer Service: 1300 787 624
We value: Teamwork | Respect | Accountability | Communication | Customer focus

Officer & District
Community Association Inc.
C/- 103 Starling Road, Officer VIC 3809 PH: 0419 534 269

Dear Cr Brett Owen,

Re: Beaconsfield Reservoir – proposed works by Melbourne Water

The Officer and District Community Association's (ODCA) position on the Melbourne Water refurbishment of the reservoir is for the Safety Upgrade option instead of the proposed Partial Decommissioning.

This should include opening the reserve to the public by linking the existing walking trails through to O'Neill Road.

Melbourne Water's (MW) analysis provided 4 options:

- Do nothing – not acceptable if the current safety criteria are to be met
- Full decommissioning – this is no water body and no dam and not acceptable to all stakeholders
- Safety Upgrade – retain existing water level and dam wall height – estimated cost of $6.2 million (April 2019)
- Partial Decommissioning – reduced water level and reduced dam wall height – estimated cost of $4.4 million (April 2019)

The ODCA was not involved in the initial MW discussion with the Upper Beaconsfield groups but have attended the MW drop-in sessions and a subsequent meeting of all stakeholders on May 16th 2019 at the Upper Beaconsfield Men's Shed.

The May 16th meeting had 19 attendees representing 10 different local community groups. This meeting discussed MW's options for the refurbishment of the Beaconsfield Reservoir with a vote at the end of the meeting having 18 votes for the Safety Upgrade and 1 vote for the Partial Decommissioning.

It is recognised that the Safety Upgrade cost is more and MW stated that with their preferred option the difference in cost could be used for funding public amenities/features in the reserve. Funding for these enhancements could be gained from other sources and grants.

The Safety Upgrade option:

- Leaves the reservoir and dam wall as is. The MW option will reduce the wall height by 6 metres and the water level by 4 metres
- Conversation and environmental objectives can be met
- Safety requirements will be met
- Historical and heritage values are retained

- Retains maximum water for -
  - Fire-fighting use
  - Environmental flows to Gum Scrub Creek
  - Future community needs
- Retains best public amenity for leisure and recreational pursuits
  - Linking of existing walking trails with Cardinia Aqueduct from Dickie Road to O'Neill Road
  - Seating, picnic tables, shelter and toilet facilities

In summary, the Officer Community Association's position is for the Safety Upgrade option by Melbourne Water together with opening/extending the walking trails.

Regards ……… Mike Regards ……… Rob

Michael Petrovich Robert Porter
Secretary President
Officer Community Association Officer Community Association

ATTACHMENT 4 – SAMPLE OF FORM LETTER RECEIVED 8 JANUARY 2022

From: *Details removed to protect privacy*
Sent: Saturday, 8 January 2022 12:08 AM
To: MailAtCardinia <mail@cardinia.vic.gov.au>
Subject: Re: Letter concerning Cardinia Council's statement of support for Melbourne Water's decision re Beaconsfield Reservoir

Resident opposition of Cardinia Shire Council's support for Melbourne Water's plans for Beaconsfield Reservoir.

mail@cardinia.vic.gov.au

The CEO, Mayor and Councillors of Cardinia Shire Council,

We strongly object to Cardinia Council's surprise announcement of support for Melbourne Water's (MW) decision regarding Beaconsfield Reservoir on page 5 of the Star News, dated December 22, 2021, and page 9 of the Pakenham Gazette, dated January 5, 2022.

We are opposed to MW's decision to demolish a substantial amount of the historically significant 103 year old, formerly Heritage Listed, Beaconsfield Reservoir wall. It is absolutely unacceptable that Melbourne Water plan to drain and waste 440 Megalitres of vital water from the reservoir, beginning mid 2022. A significant need exists to retain this wall and water, both historically and for current and future community needs and safety reasons, which has been expressed to Council and MW numerous times. The request for preservation of the reservoir wall and water is upheld and supported by the member for Gembrook in a letter to Cardinia Council's CEO on May 14, and in a Petition to the Victorian Parliament during 2021.

No consultation has occurred with the Cardinia community to allow such demolition and actions to take place. In the absence of formal consultation, there were presentations of MW's stated plans, but residents were not permitted to express their views. MW's decision has been taken without the prior consent of the community. Those of us who are aware of the reservoir, want the Full Dam Safety Upgrade, Option 3, as shown in MW's Beaconsfield Dam Safety Upgrade, Update December 2021, which is a more compelling upgrade option.

We request that Cardinia Council and MW consult Cardinia Shire's residents and openly discuss the legitimate alternatives to MW's decision of Partial Decommissioning, which they publicly announced on page 5 of the Pakenham Gazette, December 15, 2021.

We ask Cardinia Council to confirm whether MW has responded to their requests made in the "Alternate Motion to 6.1.5, dated May 17, 2021 moved Cr. Jeff Springfield, seconded Cr. Tammy Radford. If MW has not responded to all points in the Alternate Motion, why has Council given their support to MW's decision?

Many Cardinia residents and other members of the Victorian community strongly oppose MW's plans for the reservoir. MW should not commence any plans until the requirements of the motion 6.1.5 have been adhered to, as stated in the motion. Cardinia Council need to retract their statements of support for MW's decision until valid responses and reports have been received from MW and consultation has taken place between MW, Cardinia Council and Residents.

Can you please clarify for me the following questions by replying to this email.

1. Which Cardinia Council representative made the statement on behalf of Cardinia Council in the two recent Star News Group newspapers?
2. Have Melbourne Water responded to Cardinia Council's motion 6.1.5 of May 17, 2021?
2. Will Cardinia Council retract its current statement of support for Melbourne Water's decision on Beaconsfield Reservoir, since there has been no public statement that MW have met their obligations in Motion 6.1.5 of May 17, 2021?

Please Cc all correspondence to Savebeaconsfieldreservoir@gmail.com.

Sincerely,
Details removed to protect privacy