TWEED
SHIRE COUNCIL

Clarrie Hall Dam Raising State Significant Infrastructure Application - Preliminary Environmental Assessment, July 2018

DOCUMENT CONTROL

Project Contact

Project Manager	Robert Siebert
Organisation	Tweed Shire Council
Unit/Division	Water and Wastewater Unit, Engineering Division
Position	Coordinator Strategy and Business Management
Address	Tweed Heads Administration Office, Civic and Cultural Centre, Cnr Brett Street and Wharf Street, Tweed Heads NSW 2485
Post	Tweed Shire Council, PO Box 816, Murwillumbah NSW 2484
Ph. **Mob**	02 6670 2506 0411276917
Email	RSiebert@tweed.nsw.gov.au

Document Details

Title	Clarrie Hall Dam Raising, State Significant Infrastructure Application, Preliminary Environmental Assessment, June 2018
Author	David Hannah, Senior Environmental Scientist, Design Unit, Engineering Division, Tweed Shire Council
Reviewers	Robert Siebert (Project Manager), Elizabeth Seidl (Project Engineer), Water and Wastewater Unit, Engineering Division, Tweed Shire Council
Version	V1.0
Issue Date	02/0/2018

Executive Summary

Due to increasing demand for water as a result of projected population growth and the increasing uncertainty of water supply yield associated with climate change, there is a requirement to augment the Tweed Shire district water supply by 2026. Factoring in ongoing demand management implementation and revisions of the secure yield of the Tweed district water supply based on an increase of one degree Celsius by the year 2030, peak demand will exceed secure yield by 2026. Consideration of six water supply augmentation options, including analysis of environmental, social and economic factors consistently indicated that raising of Clarrie Hall Dam was the most advantageous to Council and the community.

Clarrie Hall Dam was constructed in 1983 by the New South Wales Department of Public Works and operated by the Tweed Shire Council for the primary purpose of providing a drinking water supply to the Tweed Shire. The Dam is located on Doon Doon Creek, a third order stream forming a tributary of the south arm of the Tweed River. The dam is located in the suburb of Doon Doon, approximately 15 km south-west of Murwillumbah and 4 km south-west of Uki in the Tweed Shire. The current full supply level of the dam is 16,000 ML.

The optimum size of the Clarrie Hall Dam raising proposal is 42,300 ML based on raising the dam wall height by 8.5 m to a dam wall height of RL70 m (AHD). The raised Clarrie Hall Dam option would, as a result, provide adequate water supply to the Tweed Shire until approximately 2046. Raising the wall height further was not considered feasible due to topographical constraints in the catchment.

In December 2015, Tweed Shire Council resolved to adopt the raising of Clarrie Hall Dam as the preferred option for future water security. In October 2016, Council approved the commencement of a range of investigations at Clarrie Hall Dam to further inform the project team, Councillors and the community on the potential impacts of the proposal, and guide further decision making. Given the timeframes for assessment and construction of a preferred water supply augmentation option, further delays may result in insufficient time prior to 2026 to construct a new dam or Raise Clarrie Hall Dam.

The purpose of this document is to provide supporting information to the NSW Department of Planning and Environment for the application for approval to raise Clarrie Hall Dam for water supply augmentation as State Significant Infrastructure in accordance with Part 5 (Section 5.12) of the NSW *Environmental Planning and Assessment Act 1979*. This Preliminary Environmental Assessment aims to describe the proposal and any potential environmental impacts to assist in the issuing of the Secretary's Environmental Assessment Requirements for the preparation of an Environmental Impact Statement.

The design and environmental assessment for the proposal is well progressed. A detailed concept design is being prepared by NSW Public Works Advisory and has been informed by geological investigations and updated flood hydrology studies. The bulk of the biodiversity assessments were completed in summer 2016/17 and cultural heritage reporting completed in May 2018. Aquatic ecology and environmental flow assessments have recently been commissioned.

Key environmental impacts of the proposal relate to the inundation of about 120 ha of bushland and a further 100 ha of cleared and modified land. As a result, the proposal will require the acquisition of land and subsequent offsetting of biodiversity impacts through

revegetation and restoration strategies. Raising of the dam wall will pose particular challenges in relation to the sourcing and placement of suitable rock fill material, and the staging of works to mitigate flood impacts during construction. The scope of the environmental impact assessment will address these key environmental impacts in addition to other environmental and social issues associated with the proposal.

Table of Contents

Table of Contents

1 Introduction

1.1 Project overview

The Tweed District Water Supply is a run of river supply augmented by releases from Clarrie Hall Dam. Raw water is drawn from upstream of Bray Park weir, effectively a salt water barrage, in the Tweed River. In periods of low flow in the river, flows are augmented by releases from Clarrie Hall Dam to ensure availability of water for the Tweed District Water Supply.

Due to increasing demand for water as a result of projected population growth and the increasing uncertainty of water supply yield associated with climate change, there is a requirement to augment the Tweed district water supply by 2026; this being the point where demand will exceed secure yield.

In 2009, Council commissioned an options study to augment the Tweed District water supply (MWH, 2009). Nine options were initially assessed although options such as desalination, groundwater supply, and potable water reuse were subsequently discounted (MWH, 2009; MWH, 2010) as supply augmentation options. The primary options considered by Council included raising Clarrie Hall Dam, construction of a dam of varying sizes at Byrrill Creek, and links to Gold Coast Water and South East Queensland (SEQ) Water. Consideration of these water supply augmentation options, including analysis of environmental, social and economic factors consistently indicated that raising Clarrie Hall Dam was the most advantageous option to Council and the community.

In December 2015, Tweed Shire Council resolved to adopt the raising of Clarrie Hall Dam as the preferred option for future water security and proceed with the planning approval and land acquisitions phase for the project subject to Council continuing to undertake comprehensive investigations of Council's water supply-demand options. In October 2016, Council approved the commencement of a range of investigations at Clarrie Hall Dam to further inform the project team, Councillors and the community on the potential impacts of the proposal, and to further guide decision making in relation to a preferred option. As a result of these studies, and on-going augmentation assessments, Council is progressing the preferred option to raise Clarrie Hall Dam consistent with the 2015 resolution.

The proposal to raise Clarrie Hall Dam would involve increasing the dam wall height by 8.5 m to a height of 70 m AHD (RL70) thereby increasing the size of the dam from 16,000 ML to approx. 42,300 ML. This would provide adequate water supply to the Tweed Shire until approximately 2046.

The regional and local setting for the proposal is shown in Figure 1 and Figure 2. The proposed land inundation area and dam wall construction area is shown in Figure 3.

Figure 1: Regional location of Clarrie Hall Dam, Tweed Shire Local Government Area

Bray Park Weir | Main Towns | Road Centreline | Tweed Shire Boundary | Surrounding Local Government Areas | Waterways

Coordinate System
MGA Zone 56
Datum - GDA 94

Date Printed: 02 July, 2018

Author: Engineering | Design | J.Tunsted

Filepath: Z:\ESRI\Engineering\ProjectFolders_Data\Design_Environmental_Unit\DaveHannah\Clarrie_Hall_Dam_Planning_Project\Clarrie_Hall_Dam_Planning_Project_Regional_A4.mxd

Cadastre: 02 July, 2018

Boundaries shown should be considered approximate only.

0 1,050 2,100 4,200 M
1:250,000
DO NOT SCALE
COPY ONLY - NOT CERTIFIED

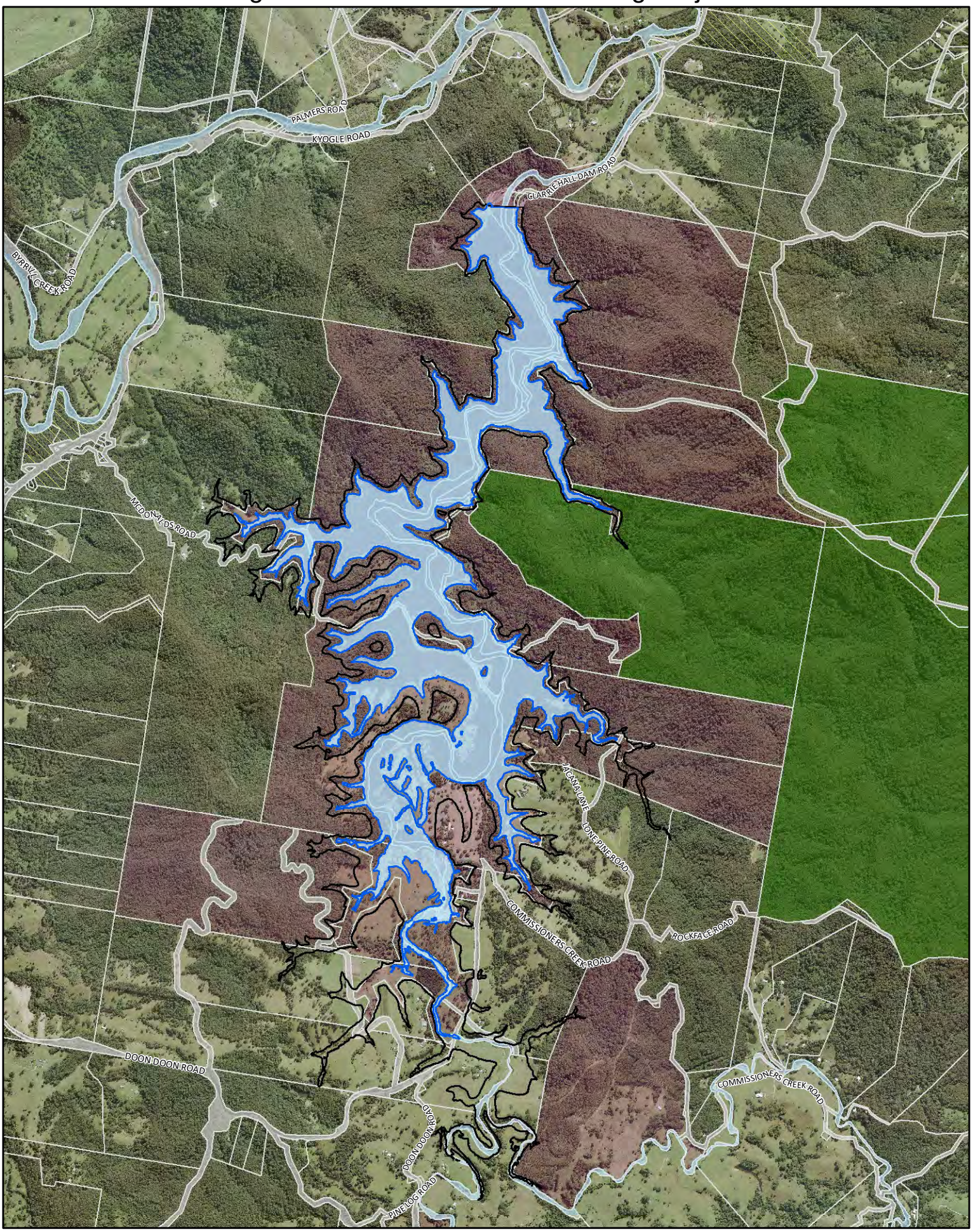
Civic and Cultural Centre
3 Tumbulgum Road
Murwillumbah NSW 2484

PO Box 816
Murwillumbah NSW 2484

T | (02) 6670 2400 | 1300 292 872
F | (02) 6670 2429
W | www.tweed.nsw.gov.au
E | EngineeringandOperations@tweed.nsw.gov.au

TWEED SHIRE COUNCIL

Figure 2: Clarrie Hall Dam Raising Project Area



Clarrie Hall Dam (61.5m Contour)
Proposed Full Surface Level (70m Contour)
Waterways
Community Land
Parcel Boundary
Operational Land
Road Reserve
Council Administered Crown Land
National Parks and Nature Reserves
State Crown Land

Coordinate System
MGA Zone 56
Datum - GDA 94

Date Printed: 02 July, 2018
Author: Engineering | Design | J.Tunsted
Filepath: Z:\ESRI\Engineering\ProjectFolders_Data\Design_Environmental_Unit\DaveHannah\Clarrie_Hall_Dam_Planning_Project\Clarrie_Hall_Dam_Planning_Project_Local_A4.mxd

Cadastre: 02 July, 2018
© Land and Property Information (LPI) & Tweed Shire Council.
Boundaries shown should be considered approximate only.

0 130 260 520 M
1:29,869
DO NOT SCALE
COPY ONLY - NOT CERTIFIED

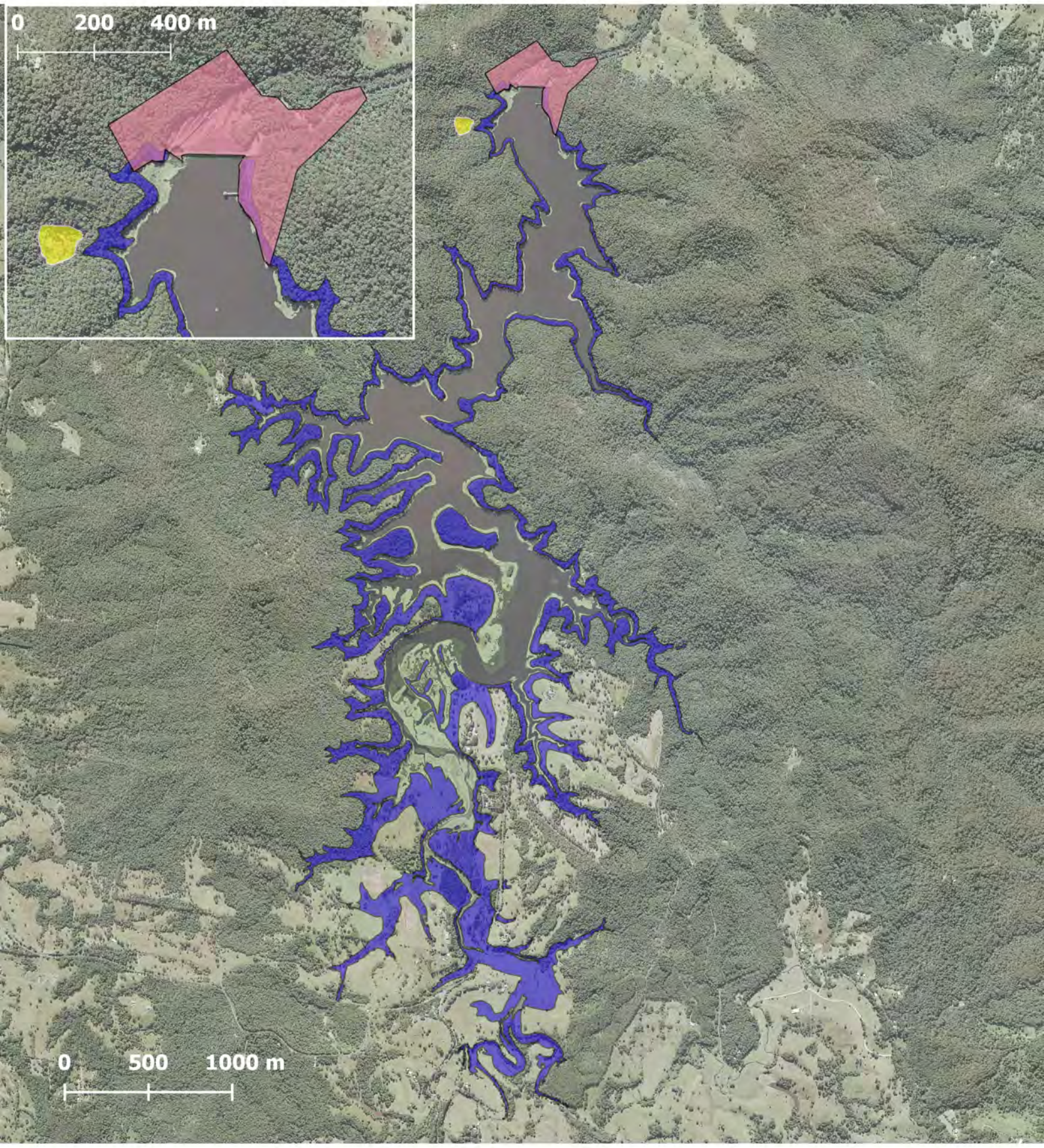
Civic and Cultural Centre
3 Tumbulgum Road
Murwillumbah NSW 2484

PO Box 816
Murwillumbah NSW 2484

T | (02) 6670 2400 | 1300 292 872
F | (02) 6670 2429
W | www.tweed.nsw.gov.au
E | EngineeringandOperations@tweed.nsw.gov.au

TWEED SHIRE COUNCIL

Figure 3: Clarrie Hall Dam Raising Project - Disturbance Footprint



Existing quarry area

Dam wall construction area

R.L. 70 m inundation area

Cadastre: 27/06/2018
© Land and Property Information (LPI) & Tweed Shire Council.
Boundaries shown should be considered approximate only.

Date Printed: 27/06/2018

Author: David Hannah

Coordinate System
MGA Zone 56
Datum - GDA 94
GDA

Civic and Cultural Centre
3 Tumbulgum Road
Murwillumbah NSW 2484

PO Box 816
Murwillumbah NSW 2484

T | (02) 6670 2400 | 1300 292 872
F | (02) 6670 2429
W | www.tweed.nsw.gov.au
E | planningreforms@tweed.nsw.gov.au

TWEED SHIRE COUNCIL

1.1.1 Timeframes and costs

Progressing the preferred option to raise Clarrie Hall Dam formerly started in January 2015 with the commencement of land acquisition, engagement of consultants, and continuance of community consultation. The project must be completed by December 2026; this being the time when peak demand will exceed secure yield. Projected timeframes and key project milestones from 2016 through to 2026 are provided in Figure 4

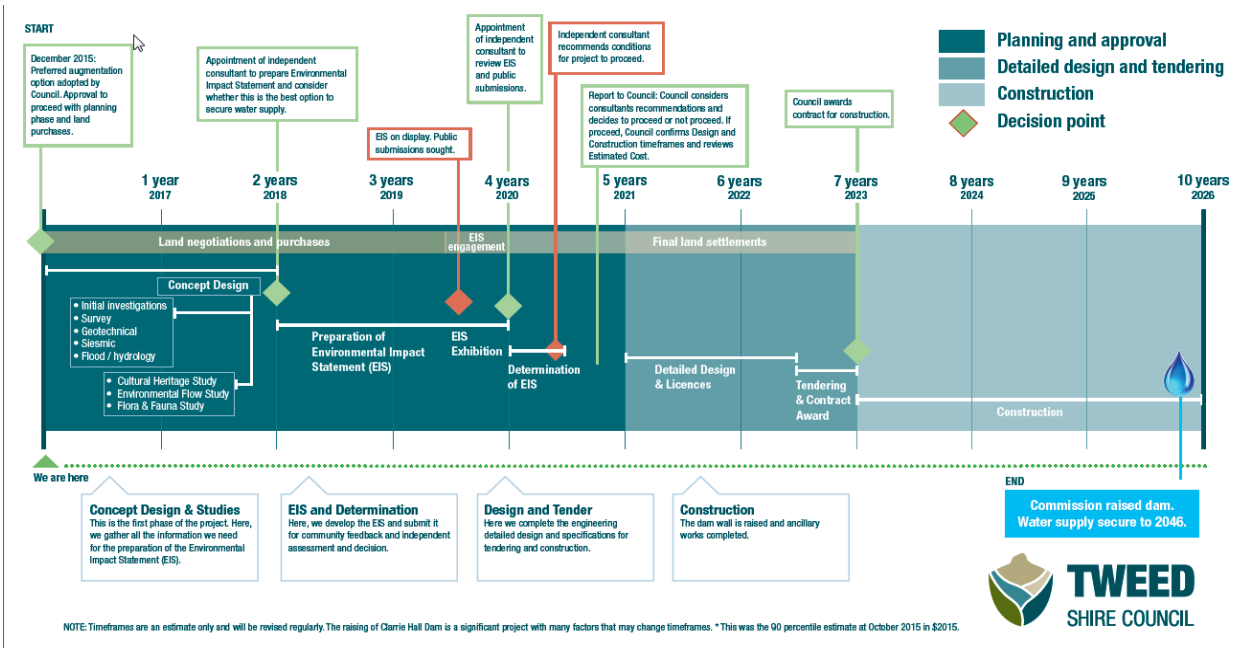


Figure 4: Projected timeframes and key project milestones from 2016 through to 2026

1.2 Subject site and surrounds

Clarrie Hall Dam was constructed in 1983 by the New South Wales Department of Public Works and operated by the Tweed Shire Council for the primary purpose of providing a drinking water supply to the Tweed Shire. The Dam is located on Doon Doon Creek, a third order stream forming a tributary of the south arm of the Tweed River. Clarrie Hall Dam is situated in the suburb of Doon Doon, approximately 15 km south-west of Murwillumbah and 4 km south-west of Uki in the Tweed Shire (refer Figure 3). Access to the dam wall and spillway area (shown in Figure 5) is from Clarrie Hall Dam Road in the north. The southern extent of Clarrie Hall Dam is accessed from Cram's Farm which is located off Commissioners Creek Road (Figure 6).

The current dam has a catchment area of approx. 60 square kilometres and a storage capacity of 16,000 ML. Water is released down Doon Doon Creek via release valves within an intake tower within the dam to the Tweed River, where it is subsequently harvested at the Bray Park weir.

The majority of the Doon Doon sub-catchment of the Tweed River Catchment consists of rural and agricultural land uses (>70% of land is zoned 1a Rural). The Doon Doon catchment incorporates parts of Nightcap National Park in the south-west and Mount Jerusalem National Park in the east and south. The sub-catchment is predominantly vegetated with native bushland (~54%), however, a large portion is cleared (~30%) and

typically used for cattle grazing. The climate is subtropical, characterised by warm temperatures and high rainfall. The average annual temperature in Murwillumbah is a minimum of 14.5 ^{0}C and maximum of 25.7 ^{0}C (BoM 2015). The Tweed Shire has an average rainfall of 1,605 mm per year (BoM 2015).

1.3 Proponent for works

Tweed Shire Council's Water & Waste Water Unit (the Water Unit) is the proponent for works. The Water Unit is a Unit of Council's Engineering Division and is responsible for the provision of water and sewerage services under the provisions of the NSW *Local Government Act 1993*. Council's principal objectives for the provision of water supply services are to:

- provide water supply services within a strategic business planning framework
- provide best practice management of the urban water supply in accordance with Council's Integrated Water Cycle Management Strategy
- meet legislative requirement including licence requirements regarding surface and ground water supply extraction conditions
- provide additional system capacity to meet sustainable growth projections to efficiently and sustainably operate the water supply systems
- provide an equitable, responsive and cost effective water supply service
- provide a high quality, reliable and sufficient water supply service
- promote water cycle education including conservation and reuse
- manage assets on a whole of life cycle cost basis to ensure the on-going effective provision of water supply services and to
- put in place a sound management regime for all matters relating to the provision of the water supply service

Council has several roles with respect to water supply services of which the primary service in relation to the proposal is to ensure that all customers are provided with safe and adequate water supplies.

1.4 Purpose of the report

The purpose of this document is to provide supporting information to the NSW Department of Planning and Environment (DP&E) for the application for approval to raise Clarrie Hall Dam for water supply augmentation as State Significant Infrastructure (SSI) in accordance with Part 5 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). This Preliminary Environmental Assessment (PEA) aims to describe the proposal and any potential environmental impacts to assist in the issue of the Secretary's Environmental Assessment Requirements (SEARS) for the preparation of an Environmental Impact Statement (EIS).

The following definitions have been used in this report (see also Glossary of Terms):

Proposal / the proposal – refers to the raising of Clarrie Hall Dam to RL70 m AHD including the construction and modification to the existing dam wall and associated works.

Proposed disturbance footprint / disturbance footprint / development zone – the area subject to direct disturbance as a result of the proposed dam wall raising (includes the wall construction footprint and the inundation area to the 70 m AHD FSL.

Study area – area including the disturbance footprint and any additional lands that could be affected directly or indirectly by the proposal. This area relates to the inundation zone and any relative buffer zones within the Doon Doon catchment and in relation to downstream environments. The objective of this PEA is to ensure that impacts beyond the direct disturbance footprint are also considered where relevant.

Subject site – Clarrie Hall Dam including lands encompassed within the RL70m inundation zone, the dam wall and adjacent construction zones referred to as the proposed disturbance footprint.

Figure 5: Panoramic view of spillway (foreground), dam wall, and intake tower (background)

Fig. 6a: Entrance to Crams Farm via Commissioners Creek Road

Fig. 6b: Internal road to pontoon and canoe / boat launch area

Fig. 6c: Covered shelter, picnic tables and electric BBQ

Fig. 6d: Amenities building

Figure 6: Images of Crams Farm recreation area, Clarrie Hall Dam

2 Project justification

Studies undertaken for Tweed Shire Council by Hydrosphere to estimate the future demand for water (Hydrosphere, 2014), and studies undertaken by NSW Urban Water Services to estimate the secure yield of Tweed District Water Supply as impacted by climate change (NUWS, 2016), demonstrate a requirement to augment the Tweed District Water Supply by 2026. That is, the secure yield provided by the Tweed River water supply is predicted to fall below peak demand in 2026.

Demand Management and Forecast Demand

Council has been actively engaged in water efficiency and demand management strategies since 1990 including the introduction of the NSW North Coast regional Waterwise program in 1994, the introduction of user pays pricing in 1996, and the commencement of BASIX and associated incentive schemes in 2006. As a result, demand management has reduced per capita consumption by 40% (refer Figure 7). Although significant water savings have been achieved, other factors such as climate still tend to influence demand management outcomes (Hydrosphere, 2014) and despite ongoing demand management actions, the longevity of the water supply still requires augmentation.

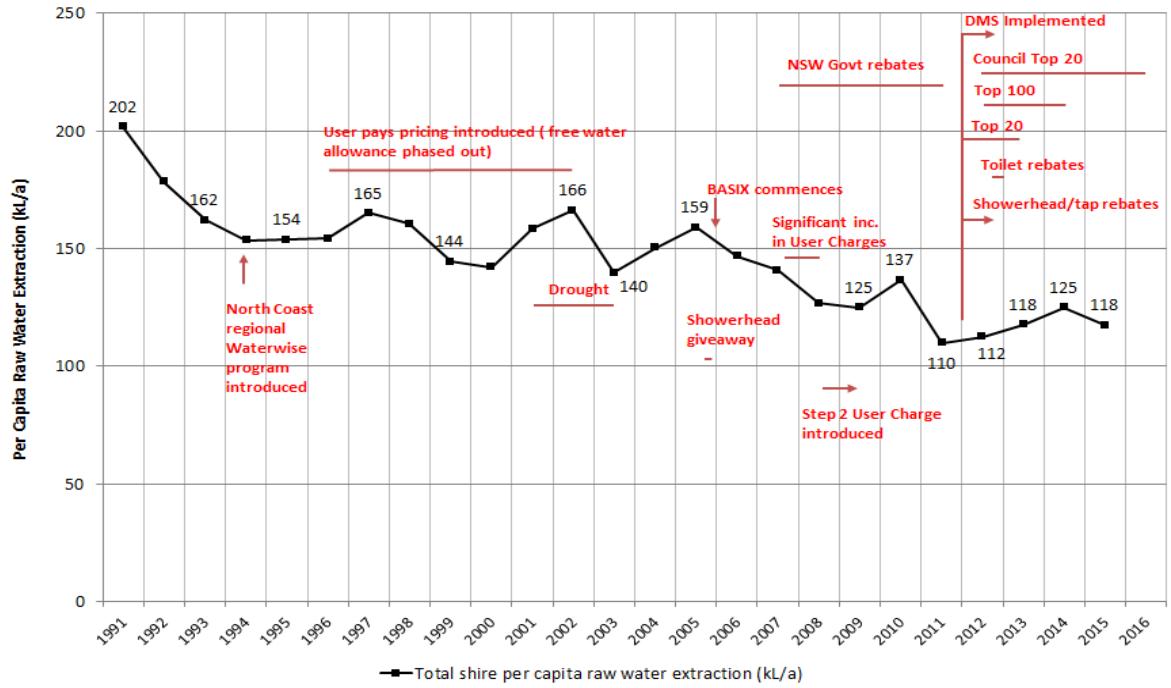


Figure 7: Reduction in demand for water from 1990 to 2015 (source: Tweed Shire Council 2015)

Hydrosphere Consulting has undertaken demand forecasts for the Tweed District Water Supply based on population data provided by idConsulting and the continuance of demand management measures. Demand for water is forecast to increase from approximately 10,000ML/a in 2017 to above 12,800 ML/a in 2035. Given the predicted increased demand for water with the growth of the population and industry, Tweed Shire Council has an obligation to achieve and maintain a secure and safe water supply to meet current and future water supply demand.

Secure Yield and Climate Change

NSW Urban Water Services has undertaken secure yield studies for the Tweed District Water Supply (NUWS, 2016). These studies have also aimed to identify the impacts of climate change on the secure yield for the present water supply. The studies forecast the secure yield will fall from approximately 15,000 ML/a (2014) to approximately 11,250 ML/a by 2030 based on 1 degree warming.

Further, from the same studies, it is projected that the secure yield of the Tweed District Water Supply would fall below existing demand levels sometime after 2033, solely due to climate change. As a result, it is recognised that the Tweed District Water Supply will be severely and adversely impacted by climate change.

Servicing Growth

The North Coast Regional Plan provides a 20 year blueprint for the future of the North Coast (reference). The Plan identifies the Tweed Shire as the gateway between the North Coast and South East Queensland, and is the fastest growing area in the region. The Plan states:

"Tweed Heads is a regional city that continues to develop and integrate with South East Queensland and its 'twin town' of Coolangatta. Tweed residents will continue to access high-quality services and facilities from both sides of the NSW-Queensland border. Local services and facilities are provided at Kingscliff, Casuarina, Cabarita, Pottsville and Murwillumbah.

The coastal settlements of the Tweed Shire have experienced some of the strongest growth on the North Coast. The popularity of the Tweed Coast is expected to continue into the future, particularly as opportunities for Greenfield housing on the Gold Coast become more limited. Kingscliff will be an important centre in this regard and will service the growth of the Tweed Coast's network of villages."

The North Coast Regional Plan forecasts a growth in population in the Tweed to 115,350 people, with the growth in dwellings to 56,060 by 2036. To cater for that growth, the Tweed Shire requires an adequate water supply. Secure yield versus demand is shown in Figure 8.

The point where demand will exceed secure yield is 2026 and an augmented supply is required to mitigate the impact of climate change and provide sufficient water to allow continued growth in the Region consistent with the North Coast Regional Plan.

The point where, solely due to climate change, existing demand will exceed secure yield is after 2033.

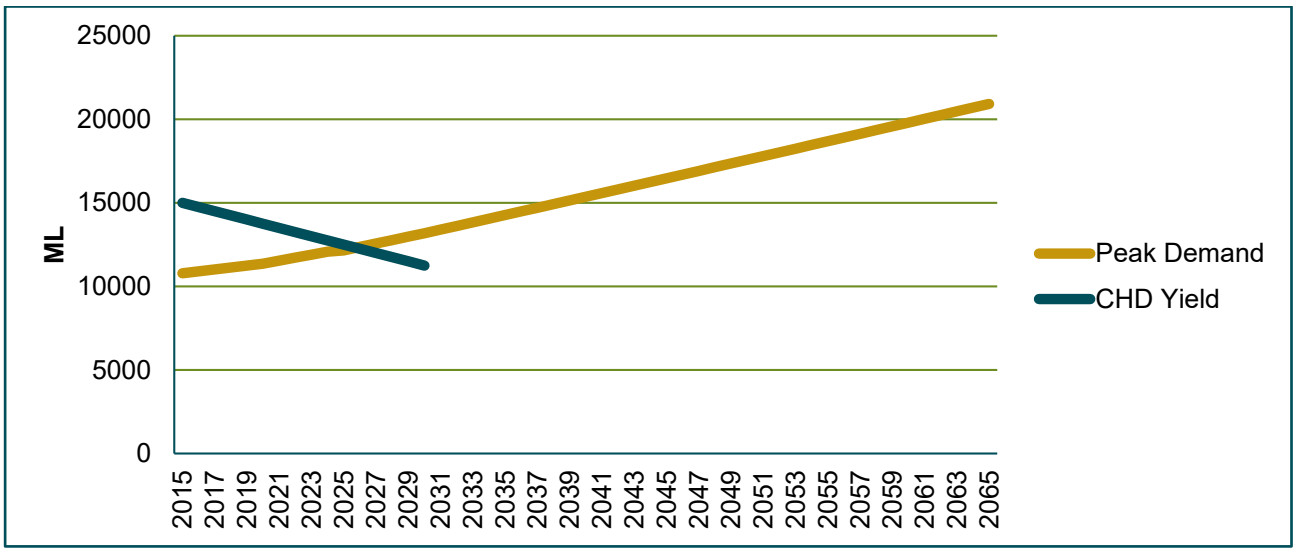


Figure 8: Clarrie Dall Dam secure yield versus peak demand (source: Tweed Shire Council 2015)

The undertaking of this project and the manner in which it is being undertaken is consistent with the requirements of Council's Integrated Water Cycle Management Strategy November 2013 (IWCM). Specifically the IWCM requires:

2a. Community engagement in IWCM decision making.
3a. Ongoing data collection and review: Review of population forecasts.
3b. Improved data management: Improved understanding of customer numbers and types, demand, annual review of growth projections, longer term demand forecasts.
6d. Climate Change adaptation - Surface water availability: Increase knowledge and develop adaption strategies for reduced surface water availability.
8a. Future water supply augmentation: Need for future augmentation is recognised and assessment of option undertaken.

These requirements have been addressed leading to this project.

Options Development and High Level Costings

Since 2007, Council has undertaken a series of studies and community consultation to determine a preferred option for the augmentation of the water supply. These include:

- Clarrie Hall Dam, Determination of Optimum Size and Dam Raising Options Study, Preliminary Report. NSW Department of Commerce, NSW Water Solutions May 2007
- Clarrie Hall Dam, Determination of Optimum Size and Dam Raising Options Study, Advanced Report. NSW Department of Commerce, NSW Water Solutions August 2007
- Clarrie Hall Dam, Determination of Optimum Size and Dam Raising Options Study, Final Evaluation Report. NSW Department of Commerce, NSW Water Solutions May 2008
- Tweed District Water Supply Augmentation Options Study, Stages 1&2 - Course Screen Assessment of Options. MWH October 2009
- Tweed District Water Supply Augmentation Project, a Report by the Community Working Group, Summary March 2010

- Tweed District Water Supply Augmentation Options Study, Stage 3 - Fine Screen Assessment of Shortlisted Options. MWH September 2010
- Tweed District, Uki and Tyalgum Water Supplies: Demand Forecasts. Hydrosphere Consulting November 2014
- Tweed District Water Supply Augmentation Options, Cost Risk Assessment, Report No DC15193. NSW Public Works, NSW Water Solutions October 2015. (Attached)
- Tweed Shire Council Report November 2015
- Tweed Shire Council Resolution 10 December 2015
- Secure Yield Assessment for Tweed Shire District, Summary Report. NSW Urban Water Services June 2016

The majority of these reports are available on Council's website and can be made available upon request.

Selection of a preferred Option

In 2009, Council commissioned an options study to augment the Tweed District water supply (MWH, 2009). The study comprised three stages; an identification of feasible options, coarse screening assessment of options, and fine screening of options. Nine options were identified as worthy for further consideration and included three options involving dams, two options involving pipelines to the assets of other water utilities, and four other options including desalination, groundwater supply, and direct and indirect water reuse options (MWH, 2009). The course screen analysis rejected desalination, potable water reuse options, and the construction of a dam on the Oxley River (MWH, 2009). A fine screen analysis completed by MWH (2010) shortlisted three primary options for further analysis; raising Clarrie Hall Dam, building a new small, large, and staged small to large dam at Byrill Creek, and staged links to South East Queensland (SEQ) Water and to Gold Coast City Council.

A comparison of water supply demand factors in relation to secure yield modeling for the water supply augmentation options found that the raised Clarrie Hall Dam option would be able to provide adequate water supply to Tweed Shire until approx. 2046 (refer Figure 9 below). Additionally, the Clarrie Hall Dam option had the least impacts on short and long term water charges, risks to development, and risk to cost and time factors amongst other things. As a result, the Clarrie Hall Option was adopted by Council as the preferred option for future water security with Councilors resolving to proceed with the planning approval and land acquisitions phase for the project subject to ongoing review and development of demand management and water efficiency initiatives. A report titled ‘Council’s Water Supply Augmentation Selection of Preferred Option’ which outlines in detail the water supply augmentation options assessment is provided in Appendix A.

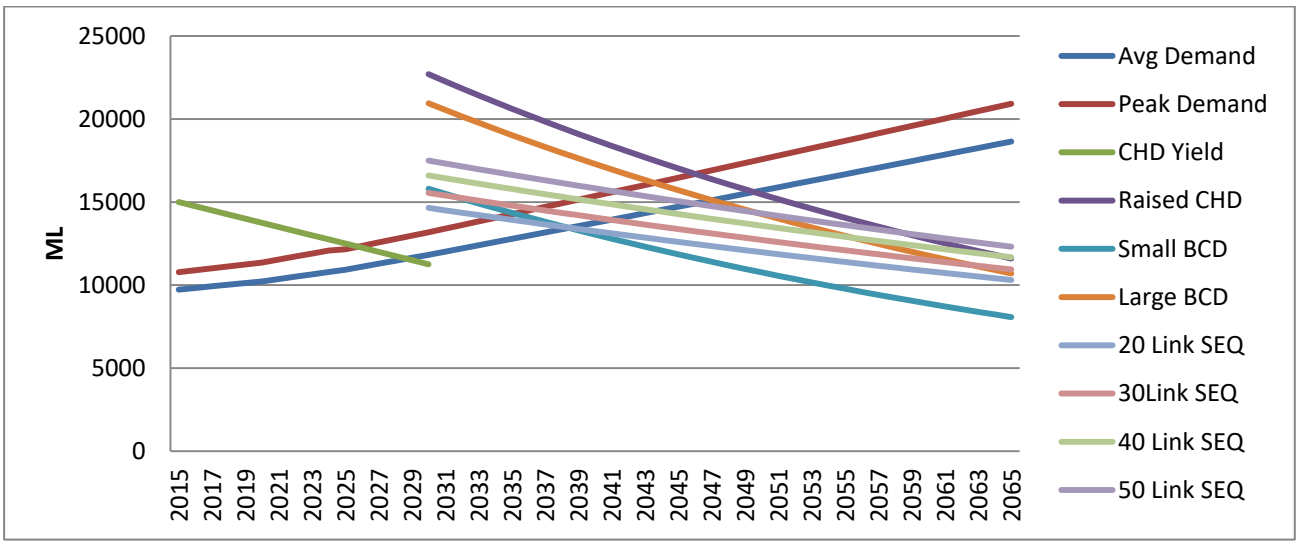


Figure 9: Water supply demand factors in relation to secure yield modelling for a range of water supply augmentation options for the Tweed Shire local government area (source: Tweed Shire Council 2015)

Views of Stakeholders

The views of stakeholders on preferred water augmentation options were considered during a community engagement process in 2009 and 2010. Three options were considered at that time, including Clarrie Hall Dam raising, of which Clarrie Hall Dam was the preferred option. Further studies and assessments continued into water supply augmentation options culminating in a resolution of Council in December 2015 resolving that:

> *"Council adopts the raising of the wall of the Clarrie Hall Dam as the preferred option for future water security and proceeds with the planning approval and land acquisitions phase for the project."*

Since the resolution of Council in December 2015, Council has continued consultation with stakeholders including land owners to resolve issues that will arise due to the raising of the dam. A summary of the stakeholder and community engagement undertaken to date is provided in Section 3 of this report.

Commitment to the Preferred Option

The current status of the project is summarised as follows:

Concept Design. Council has engaged NSW Public Works Advisory to undertake the concept design of the raising of Clarrie Hall Dam. It is envisaged the concept design will be complete by August 2018.

Flora and Fauna Studies. Council's Engineering Design Unit, a business unit of Council specialising in engineering design, environmental impact assessment and approvals, were engaged to determine the impact of a raised dam on flora and fauna in and around the proposed inundation area. Field surveys were completed in 2016-2017 in general accordance with the Framework for Biodiversity Assessment (FBA) process and final report issued October 2017 (REF). The location of potential biodiversity offset sites and associated revegetation strategies are being investigated and developed respectively for the acquired land which will not be inundated.

Cultural Heritage Studies. Council engaged Navin Officer Heritage Consultants to identify and determine the impact of a raised dam on cultural heritage assets in and around the proposed inundation area. A final draft report has been received and presented to the Registered Aboriginal Parties prior to finalisation and development of management plans.

Environmental Flow Studies. Council has engaged Ecological Australia to undertake studies to identify and determine the impact of a raised dam on the aquatic flora and fauna in Doon Doon Creek and the Tweed River to Bray Park Weir. The studies will also identify mitigation measures to lessen the impact of Clarrie Hall Dam on the aquatic environment including recommendations for environmental flow regimes.

Acquisition of Properties. Council has acquired or has under contract all or portion of nine (9) of the sixteen (16) properties that will be impacted by the raising of the dam. Council has committed more than $1.2 m to the above studies. Including land purchases, Council has committed approximately $10.8 m to the project to date.

3 Stakeholder engagement and consultation

In determining a preferred water augmentation option the views of stakeholders were considered in a year-long community engagement. The engagement also included the formation of a Community Working Group which held five (5) meetings in the period December 2009 to March 2010. The Community Working Group was provided with the information on options and considered the various options. The Community Working Group provided a final report to Council, Tweed District Water Supply Augmentation Project, a Report by the Community Working Group, Summary March 2010.

A communication plan was developed in 2015 (revised in June 2017) following a resolution of Council adopting Clarrie Hall Dam as the preferred option for future water security and to proceed with the planning approval investigation and land acquisitions.

Key Messages within the communication plan are:

- Tweed Shire needs a bigger stored water supply by 2026 to meet demand
- Council assessed and considered six options to augment the water supply
- Raising the wall of Clarrie Hall Dam was considered the preferred option on most measures
- Raising the wall of Clarrie Hall Dam is the cheapest option, secures water for the longest time and causes the least environmental damage
- Council is continuing to pursue more water saving and demand management initiatives

Primary and secondary stakeholders were identified in the communication plan. Primary stakeholders were considered to be the main audiences (and usually the largest) directly affected by the proposal. Secondary stakeholders were other audiences not directly affected by the proposal although still needed to be consulted. The primary and secondary groups are:

Primary

- Landowners whose properties will have water inundation at the full level of a raised dam or in Maximum Probable Flood
- Residents of Commissioners Creek whose road access will be cut at McCabe's Bridge at the full water level after the dam is raised
- Tweed Byron Local Aboriginal Land Council
- Future generations – children to young adults

Secondary

- Residents of Commissioners Creek and Doon Doon areas
- Residents of Uki
- Tweed Shire residents and ratepayers
- Tweed Shire Council water customers
- Business groups and chambers of commerce
- Community organisations, such as environmental groups
- Media
- Aboriginal Advisory Committee
- Tweed River Committee
- Council Staff
- Councillors

- Youth Council

Agency stakeholders identified for further contact included:

- NSW Department of Planning and Environment
- NSW Department of Primary Industries Water
- NSW Industry Fisheries
- NSW Office of Environment and Heritage

Since 2015, consultation has included group stakeholder meetings, an open day, one on one meetings with land owners and those whose access may be impacted, and presentations to service clubs and other interested parties. The consultation issues include, property purchases, transition of previous owners off land purchased by Council, access for residents upstream of McCabe's Bridge (which will be inundated), provision of information on environmental studies and future management and use of the catchment and acquired land by groups such as Outward Bound.

A timeline of the primary consultation actions is listed as follows:

- Wide range of consultation in 2009/10 and included a Community Working Group (external facilitator) culminating in report to Council in December 2010.
- 15 December 2015 Council recommended commencement of planning and acquisition phase to raise the wall of the dam
- April 2016, face-to-face meetings commenced with all affected landowners
- September 2016, a series of letters were sent to all properties affected by access associated with the proposed inundation of McCabes Bridge, a two-lane bridge located on Commissioners Creek Road, approx. six kilometres from the intersection of Kyogle and Doon Doon roads, directly south of the entrance to Crams Farm.
- 11 October 2016, a public meeting was held at Crams Farm with landowners directly affected by the proposal and other interested members of the public from the area. At this meeting, 24 properties were engaged and provided permission for flora and fauna surveys with one assisting by the provision of boat storage and access; another was the point of contact for emergencies.
- April 2017, the McCabes Bridge Replacement Options Report was sent to all stakeholders. As a result of further feedback a revised options report was prepared and sent to all stakeholders prior to a second meeting held at Crams Farm in March 2018. In April 2018, the community nominated its preferred access option for recommendation of Council; with Council subsequently accepting the recommendation.
- In August 2017, an Open Day was held at the dam wall area to inform interested members of the community on the proposal and to provide further information on various studies and assessments including cultural heritage, flora and fauna, and engineering concept design elements through the use of pop-up stands and displays.

Council has aimed to provide as much transparency as possible regarding project developments through establishing a dedicated project page on Tweed Shire Council's internet site (https://www.yoursaytweed.com.au/ClarrieHallDam?tool=news_feed#tool_tab).

4 Project description

4.1 Overview of the proposal

4.1.1 Clarrie Hall Dam description

Clarrie Hall Dam consists of a concrete faced rockfill embankment, a concrete lined spillway, intake and outlet works constructed on a foundation of very hard/strong Rhyolite rock (of volcanic origin). The rockfill embankment has a height of 43 m, crest length of 175 m and a volume of about 160,000 m^3. The crest width is 6 metres and the upstream and downstream slopes are 1V to 1.3H. The upstream slope is covered by a 300 mm thick concrete face slab which connects at the top to a wave wall along the embankment crest.

The present full supply level (i.e. the top water level) of the dam is RL61.5 which is 7 metres below the embankment wave wall crest level (RL68.5). The spillway is an un-gated concrete chute with ogee weir and flip bucket located on the left abutment. The spillway chute, and approach area between the dam toe slab and spillway crest, are fully lined and have 6 to 8 m high walls. The spillway chute is 110 m long. The spillway crest is 22 m wide and the chute width narrows to 12 m for much of its length.

A summary of current and proposed design elements are provided in Table 1 below.

4.1.2 Proposal description

The preferred design option involves a single stage construction to a full supply level (FSL) of RL70 increasing the storage capacity from 16,000 ML to 42,300 ML. This would involve increasing the base width on the valley side abutment with a combination of fresh rhyolitic rock overtopped with a mesh and face zone of select rhyolite raising the new embankment crest to RL75.5. Existing parapet walls would be removed. The new top of the parapet walls would be at RL77. The existing embankment upstream face would be extended to the new crest height. The existing upstream and downstream embankment slopes would be consistent with the existing dam at 1V to 1.3H.

As a result of raising Clarrie Hall Dam, other project elements would include:

- Relocating a section of Clarrie Hall Dam road to form a new access to the dam wall area
- Establishing new recreation area and operational facilities at the dam wall area including an amenities facility, public shelters, viewing areas, interpretation signage, pathways, car parking and landscaping, security fencing and lighting, monitoring equipment, and boat ramp and
- Removal and relocation of various infrastructure at Crams Farm such as an operational boat ramp, pontoon, signage, and access roads and an amenities facility.

A detailed scope of works would be developed as part of the EIS process.

Preliminary concept design drawings are provided in Appendix B.

4.1.3 Proposal concept design elements and further considerations

Key design considerations associated with raising Clarrie Hall Dam include the rockfill quality, upstream and downstream slopes, impact on outlet works, embankment stability, toe slab, foundations and grouting, spillway design to cater for flooding, downstream erosion protection (including spillway energy dissipation terminal structure design), intake tower raising and requirements for post-tensioning, and valve house modifications, if required. Identified engineering site constraints include existing structures such as the valve house, spillway structure, intake tower (and bridge), and an existing access road on the right abutment.

Spillway design investigations have included hydrological, seismic, and geological investigations to inform numerical modelling including 3D computational Fluid Dynamics (CFD) to assess spillway hydraulics. These studies are also informing the Intake Tower Finite Element Analysis (FEA). As noted, NSW Public Works Advisory are developing the concept design for the proposal.

The preliminary concept design analysis stage has considered two spillway options:

- Option 1. a smaller channel in the left abutment which reduces the amount of waste excavation, and
- Option 2. raising of the existing concrete spillway crest along with upgrading of the existing concrete lined chute.

Both spillway options have been subjected to hydraulic analysis and concept stage design. This process found that Option 2 was not feasible due to very high velocities generated at the base of the raised ogee structure (exceeding 35m/sec) and very high concrete walls required to be constructed at the upstream end of the spillway (up to 20m). Structural adequacy of the option (2) culvert arrangement through the raised embankment was also difficult to achieve economically. The spillway options assessment will form part of the detailed Concept Design Report to be included within the EIS.

The geotechnical site investigation has revealed that rock excavated from the proposed left abutment spillway channel would not be suitable for use as rockfill in the raised dam embankment. As a result, the proposal would investigate rockfill for the raised embankment be obtained from the old quarry site upstream of the dam's left abutment where the rock quality is known. This quarry was used for the initial construction of Clarrie Hall Dam.

Table 1: Summary of proposed Clarrie Hall Dam design features

Design Elements	
Catchment Area	60 sq km
Dam Type	Concrete Faced Rockfill
Storage	42,300 ML (from present 16,000ML)
FSL	RL 70.0 m (from present RL61.5 m)
PMF Inflow	1,720 cumecs
Spillway Width	40 m
PMF Outflow	1,580 cumecs
Max Flood Level	RL 76.9 m
Freeboard	0.5 m
Dam Crest Level	RL 77.4 m
Inundation Area at FSL	350 ha (from present 210 ha)
Embankment	Concrete faced rockfill with parapet wall
Spillway Chute	Fully concrete lined

Design Elements	
Intake Tower Access Bridge	Yes

Other project elements

Council has engaged consultants in the past to provide a feasibility study and business plan for the installation and operation of a mini hydro-electric plant at the existing dam outlet works. The conclusion of these earlier studies was that a modest sized hydro-electric power plant to power approximately 200 homes was feasible both technically and financially at that time. Given the changing cost, technology, and power and carbon markets landscape, Council has commissioned a review to updating these factors to reflect current practice, in order to confirm the project's feasibility. If feasible, a mini hydroelectric plant would be included in the scope or work for the EIS.

Project elements not included within the EIS scope of works

The following works are being progressed by council independent of the proposal to raise Clarrie Hall dam:

- Environmental assessment and approval for the redevelopment of McCabes Bridge, Commissioners Creek Road, Doon Doon
- Power line and pole realignments associated with proposed inundated properties
- Property acquisitions and subsequent demolition of structures.

These activities are being progressed irrespective of the proposal to raise Clarrie Hall Dam and would be subject to separate approvals under Part 5 of the EP&A Act where required.

4.2 Construction and operation

4.2.1 Construction approach

As noted, the proposal intends to raise the current FSL of Clarrie Hall Dam from RL61.5 m to RL70.0 m. The raised maximum flood level will be at RL77. Storage capacity would be increased from 16,000 ML to 42,300 ML.

To achieve the raised FSL of the dam, it is proposed to excavate a spillway channel higher in the left abutment with spillway sill level at RL70.0 m. Rockfill for the raised embankment would be sourced from a combination of material won from the raised spillway excavation from the original Clarrie Hall Dam construction quarry site.

The construction approach and activities is generally described as follows:

- Remove existing concrete parapet wall from the current dam embankment (store recyclable precast concrete panels)
- Remove crest pavement from the embankment to expose existing underlying rockfill
- Excavate left and right abutments for upstream concrete toe slab extension
- Strip foundation downstream of existing embankment for raised embankment footprint
- Demolish concrete walls at existing spillway entrance and dispose to waste
- Excavate new spillway channel higher in left abutment (some blasting may be required in the lower downstream areas)

- Excavate new access road higher in right abutment
- Stockpile suitable rock from spillway excavation
- Establish haul routes to existing quarry site from dam site
- Construct upstream concrete toe slab extension in left and right abutment
- Install grout curtain extension through upstream toe slab extension in left and right abutment (no blasting envisaged but slope correction may be required)
- Strip old quarry site and excavate suitable rockfill (excavation of the quarry will likely require some blasting)
- Transfer rock delivered from the quarry across the length of the raised embankment as required
- Place rockfill in raised embankment
- Extend upstream concrete face slabs
- Construct concrete sill and walls for raised spillway
- Place large rock protection below flip bucket downstream of spillway channel and entry to Doon Doon Creek
- Install precast parapet walls from existing embankment on raised embankment and connect to raised upstream face slabs
- Supply and install new precast concrete parapet walls on ends of raised embankment
- Remove existing tower house
- Demolish existing tower deck
- Remove existing access bridge deck
- Raise concrete intake tower
- Raise concrete piers and construct new concrete abutment support
- Construct raised concrete tower deck
- Construct raised bridge deck
- Construct new tower house
- Install mechanical equipment including additional shutters and trashracks and crane in raised tower
- Reinstate electrical supply
- Construct access road and seal on right abutment to join raised tower bridge and down to new boat ramp location
- Remove temporary access and haul roads
- Rehabilitate construction areas
- Reinstate recreation area shelters, fencing, signage, amenities, parking and associated landscaping.

Other construction elements considered are:

1. Lowering of water storage to facilitate construction works
    - Some lowering of water levels within the dam would be required to allow for construction of the raised embankment including toe slab extension, grout curtain extension and upstream concrete face slab extension. A lowering of 300 mm below full supply level may suffice depending on final construction methodology.

2. Material and transport routes
    - The bulk of the rock required for the project would be sourced and transported from the new spillway excavation area and the existing quarry site.
    - Rock sourced from the spillway excavation would be transported to an adjacent onsite stockpile (downstream of the dam wall) and surplus material disposed either on or off site
    - Rock from the existing quarry would be delivered progressively to the dam site along a designated haul road and craned (or transferred by other means) into position

- The primary transport route for construction equipment and materials would be along Clarrie Hall Dam Road. Access to Clarrie Hall Dam Road at Kyogle Road would be restricted during the construction phase of the proposal.
- During construction Clarrie Hall Dam Road would be realigned at the dam to allow for a new access road higher in right abutment and for completion of construction activities
- The proposal would investigate the supply of concrete from an on-site batching plant rather than supplied by trucks to site.

3. Ancillary activities
   - Contractor's and Principal's office, work areas and equipment and material storage areas would be established downstream of the dam adjacent to the existing and proposed realigned access route. Additional storage areas may be required and would be identified during the EIS.
   - The concrete batching plant and concrete material storage would similarly be located downstream and adjacent to the dam work area

4. Demolition of existing structures
   - The proposal would require demolition of some existing recreational infrastructure at the dam wall area and at Crams Farm. Any existing property fences located within the proposed inundation area would be removed and replaced above the inundation zone where required.

5. Construction programming
   - The construction program is estimated to take approximately 3 years for the completion of the proposal.

The management of construction activities would be the subject of a Construction Environmental Management Plan (CEMP).

4.2.2 Operation

Following construction of the raised dam, Clarrie Hall Dam would continue to be operated by Tweed Shire Council. Operational considerations to be discussed in the EIS would include the management of environmental flows, water quality management including stratification of the water supply, re-establishment of recreation areas and facilities, public access, restoration and management of biodiversity offset areas, and updating of relevant operational plans (e.g. the Dam Safety Management Plan and the Clarrie Hall Dam Catchment Management Plan).

5 Permissibility and strategic planning

5.1 Permissibility and statutory approval pathway

5.1.1 State Significant Infrastructure

The Clarrie Hall Dam raising proposal is considered to be State Significant Infrastructure (SSI) by virtue of Part 3 (14)(1)(a) and (b) of the State Environmental Planning Policy (State and Regional Development) 2011 (SEPP S&RD) which states that:

(1) Development is declared, pursuant to section 115U (2) (now Section 5.12) of the EP&A Act, to be State Significant Infrastructure for the purposes of the Act if:

> (a) the development on the land concerned is, by the operation of a State environmental planning policy, permissible without development consent under Part 4 of the Act, and
>
> (b) the development is specified in Schedule 3.

The proposal to raise Clarrie Hall Dam is permissible without consent under Division 24, Clause 125 of the State Environmental Planning Policy (Infrastructure) 2007 and is thereby consistent with Clause 14(1)(a) above. Similarly, the proposal is specified under Schedule 3(4)(1) of the SEPP S&RD being development for the purpose of water storage or water treatment facilities (not including desalination plants) carried out by or on behalf of a public authority that has a capital investment value of more than $30 million. The Capital Investment Value of this project calculated by NSW Public Works Advisory is estimated to be approximately $49.5 million (see Section 7).

5.1.2 Requirement for an Environmental Impact Assessment

The requirement to undertake an Environmental Impact Statement (EIS) for SSI is outlined within Section 5.16 (formerly 115Y) of the EP&A Act. When an application is made to the Minister for the Department of Planning and Environment (DP&E) by virtue of a planning instrument identifying that a type of development is SSI, then the Minister is required to issue the environmental assessment requirements. These are referred to as Secretary's Environmental Assessment Requirements (SEARs). The ensuing environmental assessment is in the form of an EIS as per Section 5.16(2) (formerly 115Y(2)) of the EP&A Act.

5.2 NSW Legislation

Consideration of relevant NSW legislation, environmental planning instruments and other relevant policies and guidelines are summarised in Table 2 below.

Table 2: Overview of NSW legislative considerations

Relevant environmental planning legislation/ instrument / policy / guidelines	Comments
Relevant NSW legislation	
Environmental Planning and Assessment Act 1979 (EP&A Act)	Proposal to be assessed under Part 5 of the EP&A Act (refer Section 5.1).
Dam Safety Act 2015	The Objectives of the *Dam Safety Act* are to ensure that any risks that may arise in relation to dams (including any risks to public safety and to environmental and economic assets) are of a level that is acceptable to the community, as well as regulating the management and risks associated with dams safety. Changes in the operation and maintenance of Clarrie Hall Dam will require consultation with the NSW Dams Safety Committee. The proposal would also require updating and revision of the Clarrie Hall Dam Safety Emergency Plan.
Dam Safety Act 1978	Clarrie Hall is a Prescribed Dam under Schedule 1 of the Dams Safety Act 1978 (no 96).
National Parks and Wildlife Act 1974 (NP&W Act)	The NP&W Act provides for the care, control and management of all national parks and state conservation areas, historic sites, nature reserves, Aboriginal areas, karst conservation reserves and regional parks. The Clarrie Hall Dam proposal has the potential to impact on known and potential Aboriginal sites and an historical site (NOHC, 2018). Other features declared under the Act occurring in the study area include Mount Jerusalem National Park bordering the dam to the east. The animal and plant provisions of the NP&W Act have been repealed with the enacting of the *Biodiversity Conservation Act 2016*. The proposal requires the revocation of approx. 1.5 ha of Mt Jerusalem National Park. The revocation area allows for land within the RL 70 zone plus a 7 m buffer (total area 14,837 m^2). The intent is that Council would compensate for the loss of land by either providing offset land of similar biodiversity value or money. NSW National Parks and Wildlife Service have listed the subject area for revocation. In accordance with Section 37(1) of the NP&W Act, the revocation is only permitted through an Act of Parliament.
Fisheries Management Act 1994 (FM Act)	The primary Act governing the management of fish and their habitat in NSW is the FM Act. Part 7 of the FM Act outlines legislative provisions to protect fish habitat and Part 7A outlines provisions to conserve threatened species of fish and marine vegetation and their habitat. NSW DPI has jurisdiction over all fish and marine vegetation in State waters. This includes permanent and intermittent freshwater areas and 'water land'. 'Water land' is defined under the FM Act as land submerged by water, whether permanently or intermittently or whether forming an artificial or natural body of water and includes wetlands and any other land prescribed by the regulations as water land. According to Section 218 of the Act, a public authority that proposes to construct, alter or modify a dam, weir or reservoir on a waterway (or to approve of any such construction, alteration or modification): must notify the Minister of the proposal and must, if the Minister so requests, include as part of the works for the dam, weir or reservoir, or for its alteration or modification, a suitable fishway or fish bypass.

Relevant environmental planning legislation/ instrument / policy / guidelines	Comments
	The construction of Clarrie Hall Dam did not include a fishway or fish bypass system and as a consequence, retrofitting a fish passage structure would impose significant constraints on the project. Impacts on aquatic habitats and key threatening processes under the FM Act would be assessed as part of the EIS.
Biodiversity Conservation Act 2016	The biodiversity surveys for the proposed raising of Clarrie Hall Dam commenced in Spring/Summer 2016 and aimed to describe and assess the impacts on flora and fauna species and communities against the provisions of the NSW *Threatened Species Conservation Act 1995*. During this period, biodiversity legislation reforms resulted in the commencement of the *Biodiversity Conservation Act 2016* which repealed several existing Acts, in particular the *Threatened Species Conservation Act 1995*, the *Native Vegetation Act 2003*, the *Nature Conservation Trust Act 2001*, and the animal and plant provisions of the *National Parks and Wildlife Act 1974*. The Biodiversity Conservation (Savings and Transitions) Regulation saves important provisions from legislation and regulations that has been repealed by the new legislation and establishes transitional arrangements for the reforms. Under clause 27(1) (d) of the Biodiversity Conservation (Savings and Transitional) Regulation 2017, the Secretary of the Department of Planning & Environment (DPE) can determine in writing if a proponent has undertaken substantial environmental assessment in connection with an environmental impact statement (EIS). Council has written to the NSW Office of Environment and Heritage (OEH) to discuss the matter and was advised that although it appears that substantial environmental assessment has been undertaken, a formal review could be completed once Council has written to the Secretary of the DP&E for a determination. Council is preparing separate correspondence to the DP&E regarding this matter. A second matter also discussed with OEH is timing for commencement of restoration / revegetation works on acquired properties and the use of these works as offsets for the proposal. Council is liaising separately with the NSW Biodiversity Conservation Trust on this matter.
Heritage Act 1977	Searches undertaken by Navin Officer Heritage Consultants (Navin Officer, 2018) found no NSW listed heritage items for the Clarrie Hall Dam study area. The Register of the National Estate (Non-Statutory archive) has the Tweed River Valley (Place ID: 265) as a historic Indicative Place; significant for its spectacular panoramic views. The chief danger to the characteristics of this non-statutory listing is unsympathetic development (Navin Officer, 2018). Archaeological field surveys recorded three historical sites of which one is likely to be impacted by proposed inundation. Impacts to historical sites and recommendations for management of historical sites are proposed within the Archaeological assessment report.
Protection of the Environment Operations Act 1997 (POEO Act)	Under the POEO Act it is an offence to cause harm to the environment in terms of waste disposal, water pollution, air pollution, noise pollution and land pollution. Subject to final design and

Relevant environmental planning legislation/ instrument / policy / guidelines	Comments
	construction methodology, the proposal may require licensing of scheduled and non-scheduled activities.
Protection of the Environment Operations (Waste) Regulation 2005 (POEO (Waste) Reg.)	The Regulation sets out provisions covering the way waste is managed in terms of storage and transportation as well as reporting and record keeping requirements for waste facilities. The Regulation makes special requirements relating to asbestos and clinical waste and lists exemptions for resource recovery of waste such as excavated natural material (ENM) or excavated road material (ERM). An exemption facilitates the use of these waste materials outside of certain requirements of the waste regulatory framework. Excess material generated by the proposal would require classification and disposal in accordance with the Waste Regulations.
Water Management Act 2000 (WM Act)	The WM Act regulates the management of water in NSW including controlled activity approvals, water infrastructure discharges and releases, and aquifer interference – although the aquifer interference approval component of the WM Act has not yet been enacted. Groundwater interception is currently still covered under the *Water Act 1912* (see below). Public Authorities are exempt from the Controlled Activity approvals. A review of water access licensing requirements, and impacts and modifications to environmental flows would be determined as part of the EIS.
Water Act 1912 (e.g. Ground water licence under Part 5 of the Act)	An aquifer interference approval for the extraction of groundwater would be determined subject to final project design requirements.
Water Sharing Plan for the Tweed River Area Unregulated and Alluvial Water Sources Order 2010	The *Water Sharing Plan for the Tweed River Area Unregulated and Alluvial Water Sources Order 2010* provides for the sharing of water between the environment, town water supplies, basic landholder rights and commercial uses of water. The commencement of the plan enacts the licensing provisions of the WM Act (rather than the Water Act 1912). It sets management rules for water access licences and water supply works and use approvals. Amendments to the existing water sharing plan for Doon Doon Creek and for extraction points within the Tweed River would be amended subject to discussion with the NSW Office of Water.
Local Government Act 1993	The purpose of the *Local Government Act* is to establish the processes and powers by which local government operates in NSW. Section 60 of the *Local Government Act* requires that Council seek the approval of the Minister (NSW Office of Water) to "construct or extend a dam for the impounding or diversion of water for public use or any associated works" (section 60 (A)). Clarification would be sought as to whether a section 60 approval would be issued through the concurrence arrangements associated with the EIS process.
Crown Lands Act 1989 (e.g. General provisions related to notification requirements and short-term licences)	The Crown Lands Act is to be reformed by the introduction of the Crown Land Management Act 2016 which comes into force on the 1 July 2018. Notwithstanding this, there is no Crown Land or Council managed Crown Land associated with the proposal.
Rural Fires Act 1997 (e.g. duty of care, s100B authorisation for residential or rural residential subdivisions or special fire	Section 63 places a 'duty of care' on all land managers/owners to prevent fire spreading on or from their land. This applies to future developments in the provision and maintenance of Asset Protection Zones, fire maintenance trails and water supply. The proposal does not require authorisation under section 100B of the *Rural Fires Act*

Relevant environmental planning legislation/ instrument / policy / guidelines	Comments
protection purposes)	*1997* in respect of bush fire safety as the development does not concern subdivision of land that could lawfully be used for residential or rural residential purposes or development of land for 'special fire protection purposes'. Council manages a network of firebreaks on Council owned land at Clarrie Hall Dam and would continue to maintain these during construction and operation of the raised dam.
Relevant Environmental Planning Instruments	
State Environmental Planning Policy (State and Regional Development) 2011	The Clarrie Hall Dam raising proposal is considered to be State Significant Infrastructure (SSI) by virtue of Part 3 (14)(1)(a) and (b) of the State Environmental Planning Policy (State and Regional Development) 2011 (refer Section 5.1.1 above)
State Environmental Planning Policy (Infrastructure) 2007	The proposal to raise Clarrie Hall Dam is permissible without consent under Division 24, Clause 125 of the State Environmental Planning Policy (Infrastructure) 2007 and therefore complies with the requirements to be SSI (refer Section 5.1.1 above)
State Environmental Planning Policy No 44—Koala Habitat Protection (SEPP 44)	SEPP 44 applies to development applications (applications under Part IV of the EP&A Act). Accordingly, the subject proposal is not bound by the requirements of SEPP44. Notwithstanding this, Koala's are known from the study area and would be assessed under the requirements of the *Biodiversity Conservation Act 2016* and Commonwealth *Environment Project and Biodiversity Conservations Act 1999* (see below).
Other relevant policies, plans and guidelines	
North Coast Regional Plan 2036	The North Coast Regional Plan forecasts a growth in population in the Tweed to 115,350 people, with the growth in dwellings to 56,060 by 2036. To cater for that growth, Tweed requires an adequate water supply.
Community Strategic Plan 2011-2021	The Community Strategic Plan is an integrated planning and reporting framework introduced by the NSW Government to ensure local government operations and strategic planning are meeting the needs of the community. The raising of Clarrie Hall Dam addresses a key objective and strategy identified in the plan being the 'Provision of a secure, high quality and reliable drinking water supply service which meets health and environmental requirements and projected demand'.
Tweed River Water Quality and River Flow Objectives	Clarrie Hall Dam is located in the Tweed River Catchment, where the water quality and river flow objectives developed by the previous EPA apply. The environmental assessment would need to consider these objectives in addition to assessing construction and operation impacts on water quality and environmental flows.
Tweed Integrated Water Cycle Management Strategy November 2013	The proposal is being undertaken consistent with the requirements of Council's Integrated Water Cycle Management Strategy (refer Section 2).
Waste Classification Guidelines, 2009 (NSW EPA)	Waste generated by the proposal requiring disposal would be classified in accordance with the Waste Classification Guidelines.

5.3 Commonwealth legislation

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

Any proposed action likely to result in a significant impact on a Matter of National Environmental Significance requires assessment and approval under the EPBC Act. The EPBC Act Protected Matters database was searched for an area incorporating a 10 km buffer centred on the site. A list of matters and their relevancy to the proposal is provided in Table 3 below. The Protected Matters Search results are retained on file and can be provided upon request. Further discussion on matters of National Environmental Significance is provided in Section 6 of this report.

Table 3: Matters of National Environmental Significance and their relevancy to the proposed activity

Matter of National Environmental Significance	Relevancy to the proposed activity
World Heritage Properties	None
National Heritage Places	None
Wetlands of International Significance (Ramsar Sites)	None
Great Barrier Reef Marine Park	None
Commonwealth Marine Areas	None
Threatened Ecological Communities (TEC's)	2 TEC's: 1. Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland Ecological Community Lowland Rainforest of Subtropical Australia. 2. Lowland Rainforest of Subtropical Australia The flora and fauna assessments completed to date did not record Coastal Swamp Oak Forest in the Study area. Conversely, Lowland Rainforest was recorded within the inundation area. A referral to the Commonwealth Government is recommended and if required, for assessment and approval under the EPBC Act.
Threatened Species	51 Commonwealth listed threatened species were identified as likely to occur within the search area. Of these, the proposal is considered to have the greatest potential impact on one vulnerable plant species, the Red Lilly Pilly (*Syzygium hodgkinsoniae*), and one endangered fauna species, the Giant Barred Frog (*Mixophyes iteratus*). As a result, a pre-referral meeting is recommended to clarify further requirements for assessment and approval under the EPBC Act. In addition, given greater than 20 ha of high quality Koala habitat could be impacted, referral on this basis may also be required.
Migratory Species	15 migratory species were returned from searches and comprised terrestrial and shorebirds/wetland birds. The fauna assessment did not suggest direct or indirect impacts were likely for listed migratory species identified within the broader study area.

Additional matters protected under the EPBC Act identified in the EPBC Protected Matters report are summarised in Table 4 below.

Table 4: Additional matters protected under the EPBC Act and relevancy to the proposed activity

Additional matters protected under the EPBC Act	Relevancy to the proposed activity
Commonwealth Lands	None
Commonwealth Heritage Places	None
Listed Marine Species	21 species
Whales and Other Cetaceans	None
Critical Habitats	None
Commonwealth Reserves	None
State and Territory Reserves	1 - Mount Jerusalem. A proportion of Mt. Jerusalem Nation Park is within the proposed inundation zone
Regional Forest Agreements	1 - The entire Tweed LGA is covered by the North East Regional Forest Agreement (RFA).
Invasive Species	35
Nationally Important Wetlands	None
Key Ecological Features (Marine)	None

6 Preliminary environment assessment

6.1 Overview (existing studies and issues identification)

The identification of environmental hazards and risks for the preferred Clarrie Hall Dam raising option commenced in May 2017 with a preliminary environmental risk identification workshop. The workshop was held at Tweed Shire Council Offices and attended by NSW Public Works Engineers and Geologists, and relevant Council staff including senior Water Engineers, surveying staff, environmental planning and assessment staff, cultural heritage and communication representatives. The purpose of the workshop was to identify the potential environmental, social, economic and cultural risks and opportunities and constraints associated with risk types. The workshop was partly informed by recently commenced investigations (e.g. biodiversity assessments, cultural heritage assessments, and geotechnical investigations), specialist site specific engineering design knowledge provided by NSW Public Works Advisory (due to their staff's involvement during the original construction of Clarrie Hall Dam and subsequent spillway upgrade) and the substantial community consultation that had been undertaken to date. A second workshop was held in October 2017 utilising the NSW D&E Draft Environmental Impact Assessment Guidance Series (DP&E, 2017) and attended by internal Council project staff. The aim of this second workshop was to refine and characterise potential impacts, and identify avoid and minimise strategies, and further assessment requirements.

The aim of this section is therefore to provide a brief overview of the environmental values associated with the subject site and study area and summarise the potential impacts on these values identified from the risk workshops. Further assessment requirements are identified where relevant.

6.2 Soils and geology

The study area occurs primarily within two soil landscapes: Frogs Hollow (fh) and Kunghur (ku) erosional landscapes (refer to Figure 10 below). The Frogs Hollow landscape is characterised by steep hills on the Chillingham Volcanics consisting of rhyolite, rhyolitic tuff, and claystones (Moran 1996). Slopes are steep (40-50%), with soils ranging from moderately deep to deep, moderately well drained brown podzolic soils and brown earths on ridges and upper slopes to deep, moderately well drained red podzolic soils and red clays elsewhere (Morand 1996). The Kunghur landscape consists of undulating and rolling hills on the Bundamba Group sediments consisting of sandstone, siltstone, claystone, and conglomerate (Morand 1996). Morand (1996) describes two landscape variants occurring in relation to the dam and are; 'kua' on slopes with a gradient of 15-40%, and 'kub' on slopes of 5-10%. Soils are shallow to deep well drained yellow podzolic soils on ridges and upper slopes, moderately well drained yellow podzolic soils, red podzolic soils, and red earths on slopes, moderately deep, poorly drained gleyed podzolic soils on lower slopes and poorly drained areas (Morand 1996). An associated landscape, Terrania (te), occurs as a narrow alluvial plain generally upstream of McCabes Bridge and associated with Doon Doon Creek. The geology of this landscape is quaternary sediments (river gravels, alluvium, sand and clay) and soils are dark brown clay loams, brown sandy clays, and brown sandy clay loams (Morand 1996).

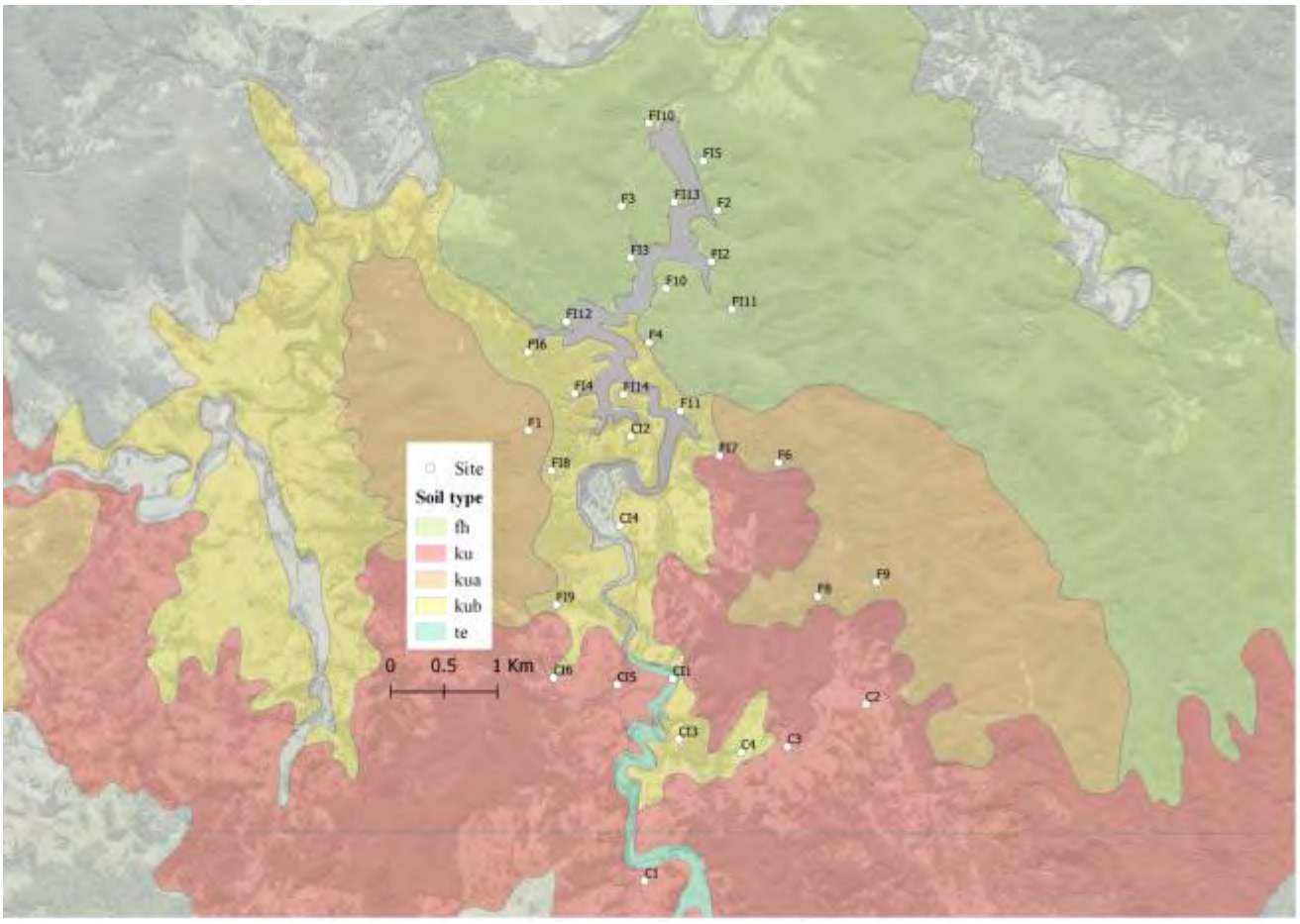


Figure 10: Soil type around Clarrie Hall Dam. fh = Frogs Hollow; ku = Kunghur; kua = Kunghur on slopes with a gradient of 15-40%; kub = Kunghur on slopes of 5-10%; te = Terania.

Geotechnical Investigations for concept design development

Geotechnical investigations to inform the concept design were carried out in accordance with AS 1726-1993 Geotechnical Site Investigation. The program included drilling of boreholes on the right abutment within the upper visitor carpark and on the left abutment. Borehole depth ranged from 5-10 m for the right abutment areas and to a depth of 25-30 m for left abutment areas.

The geotechnical site investigation revealed that rock excavated from the proposed left abutment spillway channel would not be entirely suitable for use as rockfill in the raised dam embankment. As a consequence, it is proposed that rockfill for the raised embankment be obtained from the existing quarry site upstream of the dam's left abutment where the rock quality is known. This was the quarry site for the construction of the dam in 1983.

Soil contamination

A preliminary search of Council's GIS system did not identify any potential land contamination sources associated with the raised dam wall construction footprint or proposed inundation zone. Likely sources of contamination within the study area would include cattle dip sites, agricultural sheds and associated agricultural activities, septics or illegal waste sites.

Two cattle dip sites are known from the area; Gilmore Dip located in the footprint of the original dam inundation area, and Doon Doon Dip. Gilmores Dip has been decommissioned according to the NSW DPI Dip Register. The Doon Doon dip is located at the intersection of Kyogle Road and Clarrie Hall Dam Road on Lot 7006 DP 92894. The dip site is still standing and as a result, a preliminary contamination assessment would be required in the event that the land parcel is identified during the EIS for ancillary activities associated with the proposal.

A number of properties have, or will be acquired to facilitate the raising of Clarrie Hall Dam. The assessment and approvals for demolition of structures associated with acquired properties is being undertaken separately to the EIS.

Other potential sources of contamination could include asbestos materials associated with the intake tower. Sources of contamination associated with these and other ancillary structures would need to be assessed during the EIS.

6.2.1 Potential impacts and further assessment

Potential impacts associated with sourcing suitable and sufficient rockfill material would be further developed and assessed in the detailed design report as part of the EIS. Notwithstanding this, excavation for rockfill sources would expose natural ground and sub surfaces, and would require removal of vegetation and excavation for establishment of access roads and haul roads, construction pads and material stockpile areas, auxiliary work areas and equipment laydown areas. Targeted geotechnical assessment would inform the detailed concept design and associated construction approach.

Impacts from subsidence would also be assessed as a result of blasting (if required) and works associated with the water intake bypass tunnelling (if required). Similarly, these aspects would be developed further as part of the EIS.

Other soil and erosion issues associated with the proposal could relate to bank erosion along shorelines from fluctuations in water levels during construction and at the full surface level. The water supply catchment is substantially vegetated and bank erosion is not considered to be a key issue for the proposal. Management of downstream bank erosion would be assessed as part of environmental flow studies.

A soil and water management plan (S&WMP) would be developed for the project and provide management actions for managing soils during construction. The S&WMP would be developed in accordance with the Blue Book (Urban Stormwater: Soils and Construction Volume 1, Landcom 2004).

The proposal is unlikely to impact on contaminated land. The use of any proposed ancillary sites would be assessed for contamination risks as required. The proposal may have the potential to result in contamination of soil and water as a result of hydrocarbon spills and leaks from construction equipment and other plant and equipment. Standard measures would be implemented to minimise the likelihood of spills or leaks during construction and operation.

The partial demolition of structures such as the intake tower would be assessed for any contaminating materials during detailed concept design. Standard procedures would be developed for the handling and disposal of hazardous materials if required.

6.3 Biodiversity

In October 2016, Council approved the commencement of flora and fauna studies at Clarrie Hall Dam. Up until this time, there had been no detailed flora and fauna assessments at Clarrie Hall Dam since the initial dam construction in 1983.

The flora and fauna assessment (FFA) was predominantly undertaken during spring-summer 2016/17. The study area for surveys comprised a 1 km buffer zone extending out from the proposed inundation area within the Doon Doon catchment. The disturbance footprint comprised the proposed inundation zone and the dam wall construction area and associated ancillary work areas.

The flora assessment methodology was designed in general accordance with the FBA process in regards to vegetation survey stratification, identification of Plant Community Types (PCTs), and plot based assessments of vegetation condition. The fauna survey involved a random stratified approach to quantify habitat suitability and abundance of species and communities within and outside the inundation area in addition to targeted threatened species surveys. The bulk of the biodiversity surveys were completed between October 2016 and March 2017 with additional threatened species surveys undertaken summer 2018. A full report has been uploaded to the project website (https://www.yoursaytweed.com.au/ClarrieHallDam/documents).

In summary, the flora surveys found:

- A total of 363 flora species from 114 families recorded within the study area
- Nine of the flora species recorded are of conservation significance being listed as threatened species under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and/or the New South Wales Biodiversity Conservation Act 2016 (BC Act)
- Two of the threatened flora species recorded indicate a preference for habitat found within the proposed disturbance footprint versus habitat found outside of the proposed disturbance footprint (red lilly pilly and green-leaved rose walnut)
- The proposal would inundate approx. 223 ha of land of which about 120 ha (54 %) is native bushland; the remainder is substantially cleared land, camphor laurel dominated forest, native plantation, and existing open water (eg. farm dams).
- The native bushland is predominantly the ‘wet sclerophyll forest’ vegetation formation however ‘dry sclerophyll forest’ is also present
- A total of 14 vegetation community types as classified under the Tweed Vegetation Management Strategy were recorded within the proposed disturbance area (11 are native vegetation community types; 3 are highly-modified communities)
- A total of six PCTs classified under the NSW Vegetation Information System were recorded within the proposed disturbance area
- One of the vegetation community types/PCTs recorded within the proposed disturbance footprint is of conservation significance – Lowland Rainforest. This

community is listed as an Endangered Ecological Community under the BC Act and a Threatened Ecological Community under the EPBC Act.

The fauna assessment recorded 188 fauna species consisting of 111 bird species, 24 reptile species, 19 amphibian species and 34 mammal species. Of these species, 25 are listed as threatened under the BC Act and four are threatened under the EPBC Act. Most threatened fauna species were found in a similar number of sites, regardless of placement below or above RL70, largely due to similarity in habitat types and most threatened species being mobile birds and mammals. This was also the case with fauna communities, which showed no clear demarcation in species composition between the inundation and non-inundation zone. However, the Jacana, Pale-vented Bush-hen and the Giant Barred Frog were often found around the water's edge given their association with aquatic and semi aquatic habitats.

6.3.1 Potential impacts and further assessment

This assessment found that for most species, habitats, and vegetation communities, the proposal is unlikely to pose any significant residual impacts. This is because the impacts of the proposal are largely ameliorated as a result of Clarrie Hall Dam being connected to very large areas of contiguous forest that provides similar habitats to those potentially impacted by the proposal. That is, although the land around the dam has high ecological value, the proposal would result in the disturbance of about 223 ha of land area (of which about half is native bushland) within a catchment area of about 6000 ha. Composition analysis demonstrated that fauna groups showed no tendency to favour habitats in the inundation zone compared to habitats not potentially impacted by inundation.

Notwithstanding this, the assessment found that a significant impact may be likely for two threatened species, the Red Lilly Pilly and the Giant Barred Frog. The Red Lilly Pilly is listed as Vulnerable under the BC Act and the EPBC Act. The Giant Barred Frog is listed as Endangered under the BC Act and the EPBC Act. The proposal is also likely to impact on Commonwealth threatened ecological community (TEC) - lowland rainforest - on account of the proposal reducing the extent of an ecological community and interfering with the recovery of an ecological community. The FFA recommended further investigation of the Doon Doon catchment to better understand the abundance and distribution of the local population of Red Lilly Pilly, the Giant Barred Frog, and the extent of lowland rainforest, relative to that subject to inundation to further understand project impacts and whether referral to the Commonwealth Government is warranted. Additional sites were located for both species and lowland rainforest although despite this, the impacts remain of a scale that warrants consultation with the Commonwealth Department of Environment (DoE) to determine whether the impacts on Commonwealth threatened species and TEC's require referral to the DoE. Additionally, the koala was found to have a strong preference for tallowwood trees at Clarrie Hall Dam. Modelling of koala occupancy suggested that there was no bias of occupancy toward land in the inundation zone. Despite this, referral to the Commonwealth Government is recommended in accordance with the EPBC Act Referral Guidelines given that >20 ha of high quality koala habitat could be impacted.

In addition to threatened species impacts, the FFA identified the following impacts on biodiversity:

- Direct impacts to vegetation, fauna habitats, and fauna mortality from inundation to RL70

- Indirect impacts on vegetation and fauna species associated with fragmentation and isolation of habitats, creation of habitat islands, ecological edge effects, and periodic inundation of vegetation beyond the full supply level following flooding events
- Changes in water quality from decaying vegetation (from inundation of terrestrial vegetation and flooding of existing aquatic vegetation) and
- Construction environmental impacts associated with the dam wall construction including increases in noise and vibration, dust, erosion and sedimentation, water pollution, and impacts to vegetation and fauna habitats within and directly adjacent the work areas.

Although direct avoidance of impacts as a result of inundation is limited, raising the dam wall in a single stage would limit construction impacts within the vicinity of the dam wall to a single construction event. Biodiversity impact avoidance and minimisation strategies are proposed in the FFA and would be further developed during the EIS. Residual direct impacts to vegetation and habitats, which cannot be avoided or minimised, are proposed to be offset in accordance with the NSW Biodiversity Offset Scheme. To this end, Tweed Shire Council has acquired, or is negotiating the acquisition of land adjacent to Clarrie Hall Dam that could be used for offsetting and is liaising with the NSW Biodiversity Conservation Trust to seek recognition of vegetation restoration activities proposed to be commenced prior to approval of the EIS.

6.4 Aquatic ecology, water quality and environmental flows

Clarrie Hall Dam is located on Doon Doon Creek, a third order tributary of the Tweed River. The dam is situated in a steep and heavily vegetated valley protected by approximately 936 hectares of Council-owned forested land and Mount Jerusalem National Park. The dam has a surface area of 220 ha and an overall catchment of ~60 km^2. The maximum depth of the dam is approx. 41 m and as noted, has a capacity of about 15,000 ML. When flows in the Tweed River fall below the 95th percentile, water is released to the Tweed River (via Doon Doon Creek) by releasing water from the dam. This water flows through to the Uki Weir Pool and Bray Park Weir, which are the raw water intake areas for Uki Water Treatment Plant (WTP) and the Bray Park WTP respectively.

The (draft) CHD Management Plan (TSC, 2014) identifies that the primary function of CHD is to provide storage of water for drinking water supply with an ancillary function of providing amenity as a recreational area. The Management Plan notes that there are a number of water quality guidelines that apply to the reservoir and drinking water in general. The raw water stored within the reservoir is managed under Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000) and that by the time water is distributed to consumers it is required to meet the Australian Drinking Water Guidelines (ADWG) (NHMRC/NRMMC, 2011). Tweed Shire Council has prepared a Drinking Water Management System which details how Council conforms to the ADWG Framework.

Three significant water quality problems are encountered in the Tweed catchment area and typically occur in the still or slow flowing parts of Clarrie Hall Dam and river systems:

- Cyanobacteria (blue-green algae) blooms, which can discolour water, form surface scums, produce unpleasant tastes and odours, and create problems for aquatic life. (NRW, 2006, cited in HWA 2011). Cyanobacteria are a primary health concern in dams and waterways as they have the potential to produce toxins. Cyanobacteria

typically occur in stratified water bodies as they are able to take advantage of the changed buoyancy conditions.

- Salvinia (Salvinia molesta), Cabomba (*C. caroliniana*), Parrots Feather (*Myriophyllum aquaticum*) and Yellow waterlily (*Nymphaea Mexicana*) are all noxious aquatic weeds that disrupt aquatic ecosystems and decreases water quality by causing odours, accumulation of organic matter and stagnation of streams (Ensbey, R. 2009, HWA 2011, TSC 2014).
- High manganese levels, which if unsuccessfully removed in the drinking water treatment process, will result in undesirable taste to beverages and stains to plumbing fixtures and laundry coatings. At concentrations as low as 0.02 mg/L, manganese can form coatings on water pipes that may later slough off as a black precipitate (WHO, 2004, cited in HWA, 2011).

A review of Clarrie Hall Dam water quality data from 1997 to 2011 by Hunter Water Australia (HWA, 2011) found high levels of total phosphorus and total nitrogen within Clarrie Hall Dam, with the median values exceeding the ANZECC ecological trigger value for freshwater lakes and reservoirs. As a result, cyanobacteria counts in Clarrie Hall Dam are commonly classified amongst the alert levels as prescribed by the NPMC 'Alert Level Framework'. HWA (2011) also noted that where it is not possible to reduce or contain nutrient levels, then the next best means of algae and cyanobacteria control in Clarrie Hall Dam is through mixing to inhibit the capability of algae to control their depth and exposure to sunlight. Clarrie Hall Dam utilises a WEARS mixer to create turbulent mixing near the Intake Tower. This promotes integration of the water column (de-stratification), reducing the likelihood of undesirable blooms of cyanobacteria. The design of the intake tower also enables water to be drawn from varying levels in the water column to mitigate the discharge of cold water or poor water quality to Doon Doon Creek thereby reducing impacts on aquatic species.

Water from the Tweed River catchment is treated at the Bray Park Water Treatment Plant, which was upgraded in 2010 to include membrane technology used to treat algal toxins and taste compounds when algae are identified in the raw water supply. The WTP also includes a potassium permanganate dosing system which is used to remove iron and manganese when these parameters are identified in the raw water supply.

Other management measures used to mitigate water quality issues include continued prohibition of fuel-engine boats in the reservoir, restriction on recreation uses, and restricted use of pesticides for weed and pest management (eg. only products registered for aquatic areas).

Aquatic species and habitats

The Bray Park weir is essentially a salt water barrage across the Tweed River at Bray Park, Murwillumbah. Fish passage is facilitated at the weir through the use of fish ladders. At Clarrie Hall Dam, there is no fish ladder or lift fitted.

A survey of the dam conducted by NSW DPI Fisheries in late 2012 suggested a healthy and diverse aquatic ecosystem supporting at least 11 fish species (including 1 exotic species Gambusia holbrooki) and two macro crustaceans. Butler et al., (2012) noted that while, over 86% of all the fish sampled were small-bodied species, Australian bass had the highest biomass, were the most abundant of the large-bodied species, were caught across a wide range of sizes from juveniles to adults, and appear to be having little effect on the overall ecology of the dam. The EIS for Clarrie Hall Dam (DPWS, 1980) noted that should a fish ladder not be constructed, which was the outcome, that stocking the storage with a sport

fish such as Australian bass be proposed (Bishop, 2008). As a result, the dam has been stocked with approx. 440,000 Australian bass since 1990 (Cowden, 2014) and in 2015, the Dam also stocked with approx. 8,000 Mangrove Jack (Cowden, 2014).

Downstream of the dam, sampling by Fisheries NSW across the Tweed River Basin from 1975 through to 2012 resulted in the capture of 28 species of which four were introduced species and of the 24 native species, 20 were predominantly freshwater and the remaining four are estuarine species that occasionally move into the lower freshwater reaches of rivers (Butler et al., 2012). Other aquatic and semi aquatic species known to occur in Doon Doon Creek downstream of the dam include the platypus, at least four species of tortoise, and a number of frog species. Searches for one threatened frog species, the Giant Barred Frog in Doon Doon Creek downstream of the dam did not detect this species (Lollback et al., 2018). Despite this, the Giant Barred Frog is known from a number of locations within the Tweed River upstream of the confluence of Doon Doon Creek, and from at least 3 locations in the upper catchment of Clarrie Hall Dam.

6.4.1 Potential impacts and assessment approach

Council has engaged Ecological Australia to assess the impact of a raised Clarrie Hall dam on key components or facets of the aquatic ecology within Doon Doon Creek downstream of Clarrie Hall dam, and the Tweed River from the confluence of Doon Doon Creek to Bray Park Weir. The assessment will also recommend measures (including environmental flow releases) to mitigate any impact, without causing a reduction in secure yield through the development of an effective environmental flow regime, possible infrastructure installations and environmentally benign bulk water delivery.

The assessment approach includes:

- mapping of instream habitats to identify locations critical to connectivity, aquatic fauna monitoring to identify the fish and frog species present within the study reaches and assess the movement of fish into Doon Doon Creek following bulk water releases
- Pool stratification monitoring to assess the potential for stratification of pools in Doon Doon Creek and the Tweed River
- Hydrological modelling to assess the potential change in different ecosystem components (e.g. connectivity, fish movement, habitat access, pool stratification) within each modelling scenario and will include assessment of the influence of climate change using median global climate model (GCM) flow data
- Describing bulk-water deliveries which are as environmentally benign as possible and
- Development of an environmental flow regime (flow rules) which minimises impacts on the fauna and flora of the study reaches following the development of the enlarged Clarrie Hall Dam. Any possible infrastructure solutions that may aid the environmental flow regime will also be identified.

Other potential impacts on water quality and aquatic systems to be assessed include:

- Impacts associated with construction activities, particularly construction of haul roads and access road realignments, runoff from waste soil and rock stockpiles, contaminant spills, and runoff from dust suppression activities. The mobilisation of sediments into the dam could result in additional siltation of the water supply. Runoff to Doon Doon Creek could result in sedimentation and degradation of aquatic habitats. However, the potential for impacts on aquatic habitat is likely to be minimal and managed using standard control measures.

- Impacts to water quality from flooding of vegetation. As noted, the proposal would result in the flooding of 223 ha of land area of which about 120 ha is native bushland.
- Turnover of the water supply during extended periods of water lowering for construction coinciding with low catchment flows during dry periods.
- Impacts to downstream channel and bank scour erosion.
- Management of flooding during construction including the treatment of dirty water prior to discharge.

6.5 Flooding and hydrology

Clarrie Hall Dam is categorised by the NSW Dams Safety Committee guidelines as a HIGH C category dam. The spillway is required to have the capacity to pass at least a 1:100,000 Annual Exceedance Probability (AEP) flood. The spillway at Clarrie Hall Dam was originally designed to pass a 1:1,000 AEP flood and consequently, the spillway was upgraded in 2014 to comply with flood security requirements in the short term, while keeping in mind the proposal to raise the dam's Full Supply Level in the future.

For the current proposal, the dam raising and spillway would be designed based on the Probable Maximum Flood (PMF). This would increase potential inundation levels to RL77 m AHD and represents the extent of floodwaters in a PMF event. In relation to PMF, the Probable Maximum Precipitation is the theoretical greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographic location. The PMF is then 'the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the drainage basin under study'. For Clarrie Hall Dam, the event is beyond a 1:10,000,000 year event and has flows nearly twice that of the 1:10,000-year event.

On the 30th March 2017, ex-tropical cyclone Debbie began to impact on the northern rivers resulting in heavy rainfall and significant flooding across the Tweed valley (Tweed Shire Council, 2017). The rainfall caused record peaks at many river gauges, including Uki, Chillingham, Murwillumbah and Tumbulgum (Tweed Shire Council, 2017). While there are localised variations, the intensity of the flooding in these areas was generally a 1% AEP (average exceedance probability) or 100 year ARI (average recurrence interval) flood, exceeding the previous 1954 benchmarks at Murwillumbah (Tweed Shire Council, 2017).

Clarrie Hall Dam experienced a flow depth of 3.05 m at the peak of the event and triggered a white alert, the first of 4 levels of alert. The maximum spillway discharge recorded during this event was 355 m^3 per second, which is slightly above the 1% AEP predicted discharge flow rate. The spillway is designed to cater for the PMF flow rate of 1368 m^3 per second.

A review of flood levels and the time taken for flood waters to recede as a result of ex-tropical cyclone Debbie was undertaken for Clarrie Hall Dam to understand the indirect impacts from episodic flood events. Based on reviews of internal data, maximum water levels increased to approx. 64.53 m AHD; a height of 3.03 m above the FSL. The maximum discharge rate was approx. 355 m^3 per second. The total volume discharged over a 4 day period (from 30/03/2017 0:00 to 03/04/2017 0:00) was 32,398.6 ML; more than twice the current volume of the dam. Further, 29,759.7 ML was discharged in the period between 30/03/2017 12:00 to 01/04/2017 0:00 being 92% of the total discharge in only 1 ½ days. Consequently, although a PMF of RL77 has been allowed for, this is primarily in relation to maintenance and property acquisition purposes and not expected flood inundation levels.

That is, based on the recent flood data presented, although flood water levels rose about 3 m above the FSL, these flood waters receded a day and a half later.

6.5.1 Potential impacts and assessment approach

The risk assessment workshops for the proposal identified a range of construction and operational flood risks associated with the design, construction and operation of the dam. These are briefly summarised below and would be subject to further consideration and assessment during the EIS.

Design/operation

- Hydrologic modelling of the Doon Doon Creek catchment, as well as the downstream Tweed River (residual catchment) is being undertaken to facilitate the concept design for the dam raising as well as future dam-break studies.
- Hydraulic performance of the new spillway would be assessed to ensure that design floods can be safety passed by the raised dam in accordance with the NSW Dam Safety Committee.

Construction

- The existing dam configuration and constraints around the continued operation of the dam can have a significant impact on construction sequencing and approach. That is, flood diversion and construction of the embankment and spillway structures in a staged manner at an existing large dam in operation is complex. As a result, a preliminary construction program would be prepared with input from construction industry specialists. The sequencing of construction works such that there is no increased risk of damage to the overall dam structure as a result of flooding during the construction works is a requirement of the NSW Dam Safety Committee.
- Temporary floods due to valve opening during construction would need to consider the aquatic environments and impacts to water users and the local community
- During seasonal flooding, accessibility to the construction area may be restricted depending on the spatial variation of rainfall.
- Construction works would also need to consider certification of flood protection structures such as coffer dams, working within flood prone areas, effects of flooding events and potential for pollution from storage of fuels and oils, and other hazardous substances, flood preparation and recovery from flood events, and treatment of runoff.

6.6 Air quality

Clarrie Hall Dam is located within the Doon Doon sub-catchment of the Tweed River catchment. The majority of Doon Doon sub-catchment is made up of rural and agricultural land uses (>70% land zone 1a Rural) and sclerophyll open forest and sub-tropical rainforest bushland (TSC GIS Enlighten, 2013). The Doon Doon sub-catchment incorporates parts of Nightcap National Park in the south-west and Mount Jerusalem National Park in the east

and south. Approximately 932 ha (15%) of land within the Doon Doon sub-catchment is Council-owned land managed for the purpose of maintaining water supply.

There is no long term ambient air quality data for the Clarrie Hall Dam area although given the landscape context, and the absence of heavy industry, air quality in the existing environment is likely to be very good. Meteorological data derived from the Bray Park meteorological station located approximately 16 km from the dam, indicates that winds in the locality occur predominately from the north-east, east, and south-east with wind speeds generally between 10 and 20 km/h about 5 – 15% of the year (BOM, 2018).

6.6.1 Potential impacts and assessment approach

Several potential sensitive receivers occur within the vicinity of the dam wall construction area (Figure 11); the nearest of which is a rural residence located about 400 m to the west on an adjacent ridgeline (not visible from dam area). The remaining sensitive receivers, all being rural residences, are located along Clarrie Hall Dam Road or Kyogle Road. In general, impact to air quality is likely to be low during construction given the separation distances to rural residences. Air quality once the dam is constructed is considered to be similar to existing. Typical construction stage impacts on air quality are discussed below.

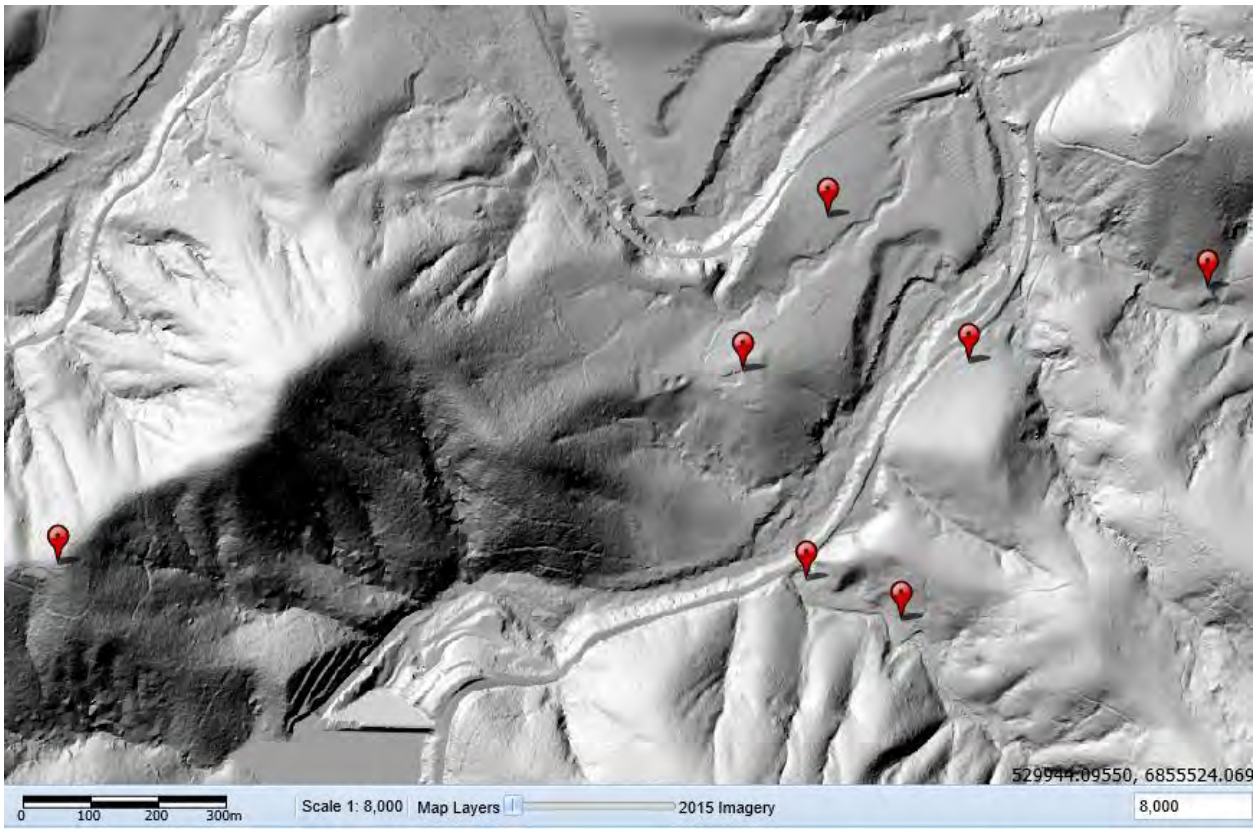


Figure 11: Location of rural residences in relation to surrounding topography in the vicinity of Clarrie Hall Dam wall and spill way area

During construction the primary impacts on air quality would be derived from airborne particulate matter primarily consisting of dust and to a lesser extent, exhaust emissions. Sources of dust and exhaust emissions associated with construction works would include:

- vegetation clearing
- excavations and earthworks

- traffic movement along unpaved roads, including access tracks
- haulage of materials to and from the site
- loading and transport of aggregate material on trucks
- wind erosion from exposed surfaces
- the operation of construction traffic
- the operation of plant and machinery.

The impacts of dust and exhaust emissions during construction would be dependent on several factors including meteorological conditions, the type and intensity of construction activities, soil characteristics, and the quantity and drift potential of the dust particles injected into the atmosphere. The drift potential of dust would be largely dependent on particle size, with large dust particles settling out near the source, and fine particles dispersing over a far greater distance and contributing to the concentration of dust levels in the surrounding ambient air environment.

During the hazard risk workshops, the release of hydrogen sulphide gas was identified as a possible localised risk during water releases during construction. Hydrogen sulfide forms when the concentrations of sulfates in the watershed immediately behind dams are higher than normal. During the summer months, the sulfates are converted to hydrogen sulfide gas through microbial activity occurring in the bottom layers of the reservoir. During water discharged, hydrogen sulfide gas can be released into the air. Although considered a minor risk during operation of the dam, the risk would need to be assessed to determine any impacts during construction.

6.7 Cultural environment

An Aboriginal and historic cultural heritage assessment was commissioned in 2017 for the proposed raising of Clarrie Hall Dam to inform Council and the community on the potential impacts of the proposal on cultural heritage. The assessment was undertaken by Navin Officer Heritage Consultants and included Aboriginal consultation, Aboriginal and historical literature and database review, and field survey of the subject land. A Clarrie Hall Dam Archaeological Assessment and Aboriginal Cultural Heritage Assessment has been prepared (NOCHC, 2018).

A brief summary of findings from the report is presented below.

6.7.1 Aboriginal cultural heritage

Field survey of the project area was undertaken in October 2017 and included Registered Aboriginal Parties. The field sampling strategy was completed in accordance with the Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW (DECCW 2010), and included the inspection of all landforms (and all individual instances of that landform) to be impacted (NOHC, 2018).

The following information is briefly summarised from the draft NOHC (2018) report:

> Nine Aboriginal sites are registered on the OEH AHIMS as occurring in the Clarrie Hall Dam study area. Six previously recorded but unregistered Aboriginal sites are located

in, or adjacent to (within 25 metres of the outer boundary of the study area) the Clarrie Hall Dam study area. Sixty previously unidentified and unrecorded Aboriginal sites were identified during archaeological field survey of the Clarrie Hall Dam study area. Ten previously unrecorded Aboriginal Potential Archaeological Deposits un-associated with surface artefacts were identified during archaeological field survey of the Clarrie Hall Dam study area. The assessment notes that all Aboriginal sites within the study area are of cultural significance to the local Aboriginal community. Also, independent of archaeological sites and objects within the study area, the landscape, flora, and fauna of the Doon Doon Creek Valley are of high cultural significance – and that these cultural values should be taken into consideration when assessing the impacts of the proposal.

The report provides a number of recommendations in relation to further archaeological works and consultation requirements associated with known and potential archaeological deposits, mitigation strategies to avoid harm, and protocols for the unanticipated discovery of archaeological material and suspected human remains.

6.7.2 Historic cultural heritage

Investigations by NOHC (2018) recorded three historical sites of local historical significance of which one, a building platform and associated plantings associated with one of the first landowners in the Doon Doon Creek area, would be potentially impacted. The two other historical sites include the Crams Farm Complex and the Doon Doon Hall which was moved from the Terragon area to a property at Doon Doon then eventually to Crams Farm. Searches by NOHC (2018) did not find any historical heritage items listed for the Clarrie Hall Dam study area. The Register of the National Estate (Non-Statutory archive) has the Tweed River Valley (Place ID: 265) listed as a historic Indicative Place; significant for its spectacular panoramic views. The chief danger to the characteristics of this non-statutory listing is unsympathetic development (Navin Officer, 2018). Archival recording is proposed for historic sites located within the proposed inundation area prior to disturbance.

6.8 Noise and vibration

The noise environment associated with the proposal is a remote wilderness setting at the dam adjacent to rural land primarily used for cattle grazing. As a consequence, the background noise is likely to be low and characterised primarily by background wildlife noise with the occasional vehicles and recreational user. With the exception of Council water quality and maintenance staff, no petrol motorised craft are permitted on the dam.

Sensitive receivers for the noise and vibration assessment are rural residential premises located along or near to Clarrie Hall Dam Road, one additional residence located on a ridgeline to the west of the dam wall (refer to Figure 11), and recreation users accessing the dam from Crams Farm. The status of the rural residences as sensitive receivers would need to be confirmed during the EIS. In relation to the dam wall construction area, distances to potential sensitive receivers range from about 400 m to the residence west of the dam, and about 700 m to the closet residence on Clarrie Hall Dam Road. There are two residences located directly adjacent to Clarrie Hall Dam Road between Kyogle Road and the dam wall.

Potential noise and vibration sources are likely to be associated with excavation works, blasting operations, loading activities and rock placement, heavy vehicle movements, and increased traffic on Clarrie Hall Dam road. Overall the intent is that the construction of the raised dam would cause no adverse noise or vibration related impacts to sensitive receivers. Noise emitted from the operation of the dam, once raised, would be as existing.

6.8.1 Potential impacts and assessment approach

In general, noise impacts on sensitive receivers is expected to be low given there are no residences in close proximity to the dam wall construction area. Some impacts to recreation users are expected. However, access will be restricted to the spillway end of the supply and most recreation users accessing the dam from Crams Farm tend to remain at that area. Noise impacts on adjacent residences to Clarrie Hall Dam Road associated with construction traffic would be generally managed through the designation of standard work hours.

The design would also consider the use of Non-Explosive Controlled Demolition Agent for rock excavation if geotechnical conditions are suitable.

Vibration impacts would be required to be managed to ensure protection of existing dam infrastructure although vibration is similarly anticipated to be low.

6.9 Visual amenity

Council has purchased 27 separate parcels adjacent the reservoir amounting to 932.4 ha of land. To facilitate the proposal to raise Clarrie Hall Dam, Council has acquired or has under contract all or portion of a further nine of sixteen properties. This buffer zone landscape is characterised by steep to moderately inclined hills, rolling hills and undulating rises. The buffer zone is predominantly vegetated with bushland, comprising a mosaic of mature and young regrowth forest, along with pockets of remnant forest. There is also cleared land associated with former pasture, which is regularly slashed, and recreational areas (eg Cram's Farm). Distant views include escarpment and ranges associated with Mt Jerusalem National Park and Nightcap National Park to the east, south and south west and Wollumbin Nation Park (Mt. Warning) to the north depending on viewpoints. As a result, the visual amenity of the subject site is very high.

6.9.1 Potential impacts and assessment approach

Potential visual amenity impacts during construction are considered to be limited primarily to recreation users accessing the dam from Crams Farm. As noted previously, the majority of users accessing the dam from Crams Farm tend to spend their time at that area where there is easy access to amenities, shade and barbeque facilities and a canoe launching area. Recreation access from Clarrie Hall Dam Road will be restricted during construction. A residence located on a ridgeline to the west of the dam wall area is not visible from the construction zone. Similarly, no residences located on Clarrie Hall Dam Road are likely to

have views to the construction zone. Notwithstanding this, the final location of temporary lay down sites and material stockpiles would need to consider impacts on visual amenity.

Filling of the dam to the full supply level of RL70 would result in the flooding of existing grazing and bushland (refer Figure 12 below). The EIS would need to assess the nature and magnitude of this change. For example, for some residences, the foreground and distant views would be transformed from an area mostly dominated by grazing land and patches of bushland to a foreground landscape with greater areas of waterway. Standing dead trees from inundation would be present for a period of time after raising the dam.

Existing viewpoint to McCabe's Bridge over Doon Doon Creek, Commissioners Creek Road.

Modelled view to McCabe's Bridge post raising of the dam wall and raising of McCabes Bridge

Figure 12: Modelled scenario to demonstrate changes in landscape views following inundation from RL61.5 to RL70m

6.10 Social environment

Recreation setting

Clarrie Hall Dam is located in a relatively remote rural setting and does not experience high volumes of recreational users due to the passive recreational requirements at the dam. Recreational access to Clarrie Hall Dam is either via Clarrie Hall Dam Road to the spillway end of the dam, or from Crams Farm via Doon Doon Road and Commissioners Creek Road at the southern end of the reservoir. Clarrie Hall Dam is open to the public from 7am-5pm (6pm during daylight savings) all year round. Access is via security gates at the two access points; at the entrance to Crams Farm and at the intersection of Kyogle Road and Clarrie Hall Dam Road.

Permitted recreational uses at the dam include bushwalking, nature appreciation (bird watching, nature photography), picnicking, recreational fishing, sailing, canoeing, kayaking and rowing, motor boating (electric motors only – fuel motors to be removed from boats), and special uses approved by council (such as fuel motor boats for research and monitoring). Camping and overnight stays are prohibited.

Recreational facilities at the spillway area includes an amenities facility, shade shelters, a viewing area to the dam wall and spillway consisting of seating and interpretive signage, walking paths, visitor car parking, a boat ramp, and security fencing. The public can walk across the top of the dam wall towards spillway. Recreation infrastructure at Crams Farm includes an amenity building, shad structures and barbeques, a boat ramp and adjacent pontoon, a sealed access road and informal car parking. Two buildings identified as local heritage items, Doon Doon Hall and the Crams Farm complex are also located at Crams Farm. Doon Doon Hall is used for functions with bookings managed by Tweed Shire Council.

Property access and disruption to services

The proposed raising of Clarrie Hall Dam would require the acquisition of inundated land and will include a 7 m maintenance zone above RL 70. All affected landholders have been approached to discuss full property acquisitions or boundary adjustments, including fencing realignments and temporary leases.

The raising of the dam would also result in the inundation of McCabe's Bridge, on Commissioners Creek Road, effectively severing access to properties further along Commissioners Creek Road. At a stakeholder information session at Crams Farm on 21 June 2017 five options, including 'do nothing', were presented. As a result of the discussion on those options, Council Officers were directed to investigate to a greater level of detail two options and prepare a report for further community consideration. As a result of these further investigations, and follow up consultation with stakeholders, raising of McCabes Bridge was identified as the preferred option by the community and Council. Council is pursuing planning approvals and design for the reconstruction of McCabes Bridge separate to the EIS process.

Other access changes relate to restricting public access to Clarrie Hall Dam Road during the dam wall construction. Access to residences located on Clarrie Hall Dam Road would remain during construction. It is likely that access to Crams Farm would be restricted during certain stages of the proposal.

The proposal would also inundate land with existing powerline easements. Consequently, the proposal would need to investigate a new alignment and liaise with property owners for the relocation of these powerlines.

6.10.1 Potential impacts and assessment approach

The raising of Clarrie Hall Dam would result in the complete or partial inundation and hence some acquisition of 16 rural properties, disruption to services including the realignment of power easements and the reconstruction of McCabes Bridge, and changes in recreation access and the availability of some recreational facilities. As a result, the EIS would need to assess socio-economic impacts of the proposal on the local and broader community and identify measures to avoid, reduce and mitigate potential social impacts.

6.11 Waste management

At present, there is limited waste associated with the operation of Clarrie Hall Dam, including by-products. No significant changes are expected as a result of the proposal once operational. The primary waste source to be assessed further in the EIS is the management of construction-generated waste. This may include liquid waste from concrete cutting, concrete wash, hazardous wastes (e.g. fuels and oils, gas cylinders, aerosols, batteries) and putrescible and non-putrescible general solid waste. Waste would be classified prior to disposal at a licensed facility or reused in accordance with the NSW Waste Management Guidelines. The nearest licensed waste disposal facility is the Stott's Creek Resource Recovery Centre at Stott's Creek via Murwillumbah.

6.12 Hazards and risks

Hazards and risks identified during the risk workshops undertaken in 2017 for the proposal relate to design and construction risk and hazards. Design risks being further investigated relate to site specific seismic assessments, hydraulic performance of the new spillway to cater for predicted design floods, and flood security of the dam in relation to construction stages.

During construction, likely hazards and risks include worksite flooding including restricted access due to floods, flooding of the worksite from valve releases, working under flood protection structures, bushfire, hazardous substances, and working in and around dangerous machinery.

An interim Dam Safety Emergency Plan (approved by the NSW Dam Safety Committee) for the construction period taking into account the changed conditions and operation of the dam during the works would be required.

6.13 Greenhouse gas and renewable energy

Construction activities are expected to produce greenhouse gas emissions related to land vegetation clearing for quarry access, haul roads, and the Clarrie Hall Dam Road realignment, and the operation of construction plant and equipment. Other greenhouse gas emitting activities would include site electricity consumption and transportation of materials and waste to and from the construction area.

During operation, indirect greenhouse gas emissions may include maintenance activities, including machinery required for weed control, release of methane associated with water releases, and the use of electricity for the operation of water intakes and security lighting.

Council is reviewing the feasibility of a mini hydro-electric plant to be included within the scope of works for the raising of Clarrie Hall Dam. Council has set a target to produce 25% of its own electricity from renewable sources by 2022, and 50% by 2025. Investment in renewable energy sources such as the inclusion of a small hydroelectric system is consistent with Council's Renewable Energy Action Plan.

6.14 Summary of preliminary environmental impacts

A summary of potential impacts on environmental and social matters is provided in Table 5 below. Potential impacts and further assessment requirements were identified during risk hazard identification workshops in May and October 2017 with NSW Public Works and Technical staff from Tweed Shire Council. The prioritisation of impacts is defined as those impacts that require detailed technical studies to determine appropriate measures to minimise or offset the effect of the impact (HIGH), the use of existing technical studies and/or some further assessment to refine approaches (MEDIUM), or management of impacts using standard mitigation approaches (LOW). High and medium priority impacts are those identified as 'key issues' for the project (after DP&E, 2017).

Table 5: Summary of potential impacts of the proposal and their priority in relation to further assessment

Environmental and social matters	Summary of potential project issues and impacts	Priority of issue	Further assessment requirements
Soils and geology	• Rock fill quality and source to be further defined • Access, excavation and placement of rockfill • Management of waste rock and soil material from excavation • Subsidence associated with blasting and works associated with bypass tunnel • Lowering of water supply for construction works resulting in bank erosion along shoreline. • New full surface level resulting in siltation in the upper reaches of the water body. • Erosion and sediment control.	**HIGH**	• Detailed design to inform rock fill quality and source locations • Technical input required into construction activities, staging and site management • Soil and water management assessment required to inform construction erosion and sediment management
Contamination	• Low likelihood of soil contamination within construction footprint • Intake tower may include asbestos containing material	**LOW**	• Assessment of asbestos in building and structures would be assessed as required • The likelihood of soil contamination associated with ancillary sites would also be assessed if required
Biodiversity	• Inundation of approximately 120 ha of native bushland • Inundation of NSW and Commonwealth threatened flora and fauna species and habitats • Potential significant impact on Commonwealth threatened ecological community (lowland rainforest), and two Commonwealth threatened species (Red Lilly Pilly and Giant Barred Frog) • Flooding of aquatic habitat for the Comb-crested Jacana • Isolation of fauna species through creation of islands	**HIGH**	• Additional assessment may be required for those areas identified in the EIS and not already assessed such as the old quarry site, and habitats associated with the dam wal construction zone. • Pre-referral meeting recommended with Commonwealth Department of Environment • Consideration of proposal by NSW DP&E to be assessed under the FBA process given biodiversity assessment were substantially commenced prior to enacting of the Biodiversity Conservation Act 2016 • Biodiversity impacts to be offset on land acquired for the project. Liaison with the NSW Biodiversity Conservation Trust required to recognise preliminary vegetation restoration activities prior to project approval • Assessment of impacts of flooded terrestrial and aquatic vegetation

Environmental and social matters	Summary of potential project issues and impacts	Priority of issue	Further assessment requirements
			• Preparation of pre-inundation fauna habitat management plans to mitigate impacts on fauna isolated from inundation, translocation plans and the aquatic habitat management for the Comb-crested Jacana
Aquatic environment	• Construction run off and containment issues • Changes in environmental flows during construction and operation affecting downstream aquatic ecology • Stratification of the water body (new dam will have a generally deeper water body)	**HIGH**	• Environmental Flow studies required and progressing to identify potential impacts and their management.
Flooding / hydrology	• Hydraulic performance of the new spillway will need to be assessed to ensure that design floods can be safety passed by the raised dam in accordance with the NSW DSC • The existing dam configuration and constraints around the continued operation of the dam can have a significant impact on construction sequencing and approach. • Temporary floods due to valve opening during construction would need to consider the aquatic environments and impacts to water users and the local community • During seasonal flooding, accessibility to the construction area may be restricted depending on the spatial variation of rainfall. • Construction works would also need to consider certification of flood protection structures such as coffer dams, working within flood prone areas, effects of flooding events and potential for pollution from storage of fuels and oils, and other hazardous substances, flood preparation and recovery from flood events, and treatment of runoff.	**MED**	• Hydrologic modelling of the Doon Doon Creek catchment, as well as the downstream Tweed River (residual catchment) is being undertaken to facilitate the concept design for the dam raising as well as future dam-break studies. • Construction program sequencing required to ensure no increased risk of damage to the overall dam structure as a result of flooding during the construction works as required by NSW Dam Safety Committee. • Assessment and management of worksite flooding during construction (see also hazards and risk section)
Air quality	• Construction generated dust impact on air quality. • Very localised issue associated with release of hydrogen sulfide gas at outlet structure related to	**LOW**	• Air quality impact assessment and development of construction mitigation measures. • Integration with community consultation management plans

Environmental and social matters	Summary of potential project issues and impacts	Priority of issue	Further assessment requirements
	water release.		
Cultural Heritage	Aboriginal cultural heritage • Six previously recorded but unregistered Aboriginal sites are located in, or adjacent to (within 25 metres of the outer boundary of the study area) the Clarrie Hall Dam study area. Sixty previously unidentified and unrecorded Aboriginal sites were identified during archaeological field survey of the Clarrie Hall Dam study area. Ten previously unrecorded Aboriginal Potential Archaeological Deposits (PADs) un-associated with surface artefacts were identified during archaeological field survey of the Clarrie Hall Dam study area. • Independent of archaeological sites and objects within the study area, the landscape, flora, and fauna of the Doon Doon Creek Valley are of high cultural significance Historic cultural heritage • Three historic sites were recorded within the study area of which one occurs within the inundation area	**HIGH**	• An archaeological and aboriginal cultural heritage assessment has been prepared for the proposal and provides recommendations in relation to further archaeological works, consultation requirements associated with known and potential archaeological deposits, mitigation strategies to avoid harm, and protocols for the unanticipated discovery of archaeological material and suspected human remains. • Archival recording is proposed for historic sites located within the proposed inundation area prior to disturbance
Noise and vibration	• Potential impacts to rural residents from drilling, blasting, excavation, earth moving equipment, concrete batching, haulage, sirens, compressor, generators, vegetation clearing, chainsaws, vehicle movements, rock breaking. • Vibration from blasting and rock breaking.	**MED**	• Noise and vibration management plan • Blast management plan • Integration with community consultation management plans
Visual amenity	• Changes to views following inundation of grazing land adjacent to some properties, standing dead trees, larger dam wall physical structure, larger shore line exposure during drought periods, loss of screening vegetation to a small number of rural residents	**LOW**	• Visual amenity assessment
Social factors (Public access,	• Inundation of existing access roads and fire trails. • Changes in traffic conditions during construction	**LOW**	• Community consultation and impact assessment • Construction and operation traffic and transport assessment

Environmental and social matters	Summary of potential project issues and impacts	Priority of issue	Further assessment requirements
community facilities and services)	• Requirement for ongoing dam operation maintenance and fire management during construction. • Traffic management for movement of materials to and from site • Restricted recreational access during construction including access for functions and school groups at Crams Farm • Inundation and relocation of services including power pole bases, recreation facilities (boat ramps),		• Revision and updating of dam maintenance procedures to accommodate construction stages • Identification of measures to avoid and minimise impacts on the local community
Waste	• Generation of liquid, solid and hazardous waste • Identification of temporary stockpile sites	**MED**	• A waste management plan would be developed for the proposal
Hazards and Risks	• Flood security of the dam during construction stages • Construction hazards and risks including working within a bushfire prone area, restricted access during floods, work health safety in and around dangerous plant and equipment, working with hazardous substances.	**MED**	• Construction staging design to minimise risk of flooding impacts during construction • Certification of construction flood mitigation structures • Work health safety management plans • Preparation of an interim Dam Safety Emergency Plan (approved by the NSW DSC) for the construction phase taking into account the changed conditions and operation of the dam during the works.
Greenhouse Gas	• Generation of construction and operation emissions	**LOW**	• A greenhouse gas emissions assessment would be developed for the proposal

7 Capital Investment Value

Cost estimations have been prepared for the preferred Clarrie Hall Dam raising option by NSW Public Works Advisory and are based upon the determination of construction items, preliminary material selection, and the substantial experience of Public Works Advisory in the design and construction of dams. Cost risk estimates were prepared based on estimated 10th percentile (P10), 50th percentile (P50) and 90th percentile (P90) costs and a cost risk assessment performed using Version 7 of the Palisade Decision Tools Software, @RISK.

From the risk analysis performed, the estimated likely project cost is $49.5 M (NSW Public Works Advisory, 2018).

As the dam already exists there would be little or no additional operating costs for the raised dam.

A cost risk report prepared by NSW Public Works Advisory has been appended separately to this application.

8 Glossary of terms

AEP - Average Exceedance Probability - the probability that a given rainfall total accumulated over a given duration will be exceeded in any one year (BoM, 2017).

AHD – Australian Height Datum

ARI - Average Recurrence Interval - the average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that the periods between exceedances are generally random (BoM, 2017).

BC Act – NSW Biodiversity Conservation Act 2016

Broader study area – lands within 10 km of the local study area and includes the Atlas of NSW Wildlife and the Commonwealth Protected Matters database search areas.

CEMP - Construction Environmental Management Plan

Direct impacts – impacts that directly affect habitat and individuals. They include, but not limited to, death through predation, trampling, poisoning of the animal/plant itself and the removal of suitable habitat (DECC, 2007).

EIS - Environmental Impact Statement

EPBC Act – Commonwealth Environment Protection and Biodiversity Conservation Act 1999

FBA – Framework for Biodiversity Assessment – see OEH (2014).

FSL – Full Service Level

Indirect impacts – impacts that occur when project-related activities affect species, populations or ecological communities in a manner other than direct loss. Indirect impacts can include loss of individuals through starvation, exposure, predation by domestic and/or feral animals, loss of breeding opportunities, loss of shade/shelter, deleterious hydrological changes, increased soil salinity, erosion, inhibition of nitrogen fixation, weed invasion, fertiliser drift, or increased human activity within or directly adjacent to sensitive habitat areas (DECC, 2007).

OEMP - Operational Environmental Management Plan

PCTs – plant community types classified in accordance with the NSW Vegetation Information System.

PMF - Probable Maximum Flood

Proposal / the proposal – refers to the raising of Clarrie Hall Dam to RL70 m AHD including the construction and modification to the existing dam wall and associated works.

Proposed disturbance footprint / disturbance footprint / development zone – the area subject to direct disturbance as a result of the proposed dam wall raising (includes the wall construction footprint and the inundation area to the 70 m AHD FSL.

Proposed inundation zone – the area subject to flooding under FSL to the RL70 m AHD contour as a result of the proposed dam wall raising.

Region – lands within 50 km of the subject site. This term is used to describe the occurrence of threatened species and communities at a regional level.

Study area – area including the disturbance footprint and any additional lands that could be affected directly or indirectly from the proposal. Specifically, it is a 1 km buffer zone extending out from the inundation zone, but within the Doon Doon catchment. The objective of the assessment is to ensure that impacts beyond the direct disturbance footprint are also considered where relevant.

Subject site – Clarrie Hall Dam including lands within and directly adjacent to the dam wall and proposed disturbance footprint.

Wall construction footprint – The estimated (worst-case) disturbance area required for construction of the proposed raised dam wall, as provided by NSW Public Works in May 2017. This footprint was estimated to incorporate material source areas, construction batters, construction and operation access roads and construction related compounds and material set down areas. It is likely to be refined once geotechnical assessments and detailed design plans are developed.

9 References

ANZECC & ARMCANZ (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

Bishop, K.A. (2008). *Environmental flow scoping study for Doon Doon Creek and the Lower Tweed River, NSW. Study to inform the assessment process associated with the proposal to raise Clarrie Hall Dam.* Draft report prepared for Tweed Shire Council, July, 20018.

Butler, G.L., Welch, J.St.V., Mackay, B. and Bruce, A. (2012). *Fish assemblages of Clarrie Hall Dam, north-eastern New South Wales.* Unpublished report, NSW DPI Fisheries, Grafton.

Cowden, K, (2014). Stocking Mangrove Jack Fingerlings into Clarrie Hall Dam, Review of Environmental Factors Report, October 2014. Unpublished report, Southern Cross University.

Department of Environment and Climate Change (DECC) (2007). *Threatened species assessment guidelines. The assessment of significance.* Department of Environment and Climate Change, Syndey, NSW.

Department of Environment and Climate Change (2010). Aboriginal cultural heritage consultation requirements for proponents 2010. and Department of Environment, Climate Change and Water NSW, April 2010.

Department of Public Works and Services NSW (1980). *Report on Tweed District Water Supply Headworks Augmentation: Part E – Clarrie Hall Dam Environmental Impact Statement.* Prepared for Tweed Shire Council, June 1980.

Ensbey, R. (2009), Salvinia, Primefact 210, 2nd Edition.

Hunter Water Australia (HWA) (2011). *Tweed Catchment Water Quality Report (1997-2011).* Unpublished report prepared for Tweed Shire Council, September, 2011.

Hydrosphere (2014). *Tweed District, Uki and Tyalgum Water Supplies: Demand Forecasts*. Unpublished report for Tweed Shire Council, November, 2014.

Lollback, G., Hannah, D. and Alward, M. (2018). Further Investigation to the Occupancy of *Mixophyes iteratus* within the Doon Doon Catchment. Unpublished report prepared for the Tweed Shire Council Water Unit, March 2018.

Morand, D.T. (1996). Soil Landscapes of Murwillumbah – Tweed Heads 1:100 000 Sheet Report Department of Land and Water Conservation, Sydney

MWH (2009). *Tweed District Waste Supply Augmentation Options Study, Stages 1&2 Coarse Screen Assessment of Options*. Unpublished report to Tweed Shire Council, October 2009.

MWH (2010). *Tweed District Water Supply Augmentation Options Study, Stage 3 Fine Screen Assessment of Shortlisted Options*. Report prepared for Tweed Shire Council, September 2010.

Navin Officer Cultural Heritage Consultants (Navin Officer) (2018). *Proposed Raising of Clarrie Hall Dam, Murwillumbah, NSW. Archaeological Assessment and Aboriginal Cultural Heritage Assessment, June 2018*. Draft report. Navin Officer Heritage Consultants, Kingston, ACT.

NHMRC/NRMMC (2011). *Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy.* National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra.

NSW Department of Planning and Environment (DP&E) (2017). *Scoping an Environmental Impact Statement: Draft Environmental Impact Assessment Guidance Series (Guideline 3), June 2017*. NSw Planning & Environment, Sydney.

NSW Urban Water Services (2016). *Secure Yield Assessment for Tweed Shire District, Summary Report*. Unpublished report by NSW Urban Water Services Pty Ltd for Tweed Shire Council, June 2016.

Office of Environment and Heritage (OEH) (2014b). *Framework for Biodiversity Assessment: NSW Biodiversity Offsets Policy for Major Proposals.* Published by Office of Environment and Heritage for the NSW Government.

Tweed Shire Council (2014). Clarrie Hall Dam Management Plan (Draft). Report prepared by the Design Unit for the Water and Waste Water Unit, Engineering Division, Tweed Shire Council Water.

Tweed Shire Council (2015). *Clarrie Hall Dam De-stratification Business Case*. Tweed Shire Council Unpublished Internal report, Water Unit, July 2015.

Tweed Shire Council (2015). *Water Supply Augmentation – Selection of Preferred Option.* Internal Council Report prepared by the Tweed Shire Council Water and Wastewater Unit, Engineering Division

Tweed Shire Council (2017). *March 2017 Flood*. Report to Council submitted by the Roads and Stormwater Unit, Engineering Division, Tweed Shire Council.

Appendix A: Water Supply Augmentation – Selection of Preferred Option (Council Report, 2015)

TITLE: **[E-CM] Water Supply Augmentation - Selection of Preferred Option**

SUBMITTED BY: **Water and Wastewater**

Valid

Supporting Community Life

LINKAGE TO INTEGRATED PLANNING AND REPORTING FRAMEWORK:

2	Supporting Community Life
2.3	Provide well serviced neighbourhoods
2.3.2	Provision of a secure, high quality and reliable drinking water supply services which meets health and environmental requirements and projected demand

SUMMARY OF REPORT:

There is a requirement for Council to select a preferred option, for the augmentation of Tweed District Water Supply, in the immediate future. This is required so that an additional water source is commissioned by 2026 and Council can fulfil its obligations to prepare a new Developer Servicing Plan.

The following options have been considered:

- Raise Clarrie Hall Dam
- Build Small Byrrill Creek Dam
- Build Small Byrrill Creek Dam and raise it at a later date
- Build Large Byrrill Creek Dam
- Link to SEQ Water
- Link to Gold Coast City Council

From an analysis of various impacts the raising of Clarrie Hall Dam is most advantageous to Council and its community.

If Council continue to delay a decision on a preferred Tweed District Water Supply augmentation option, there may be insufficient time prior to 2026 to implement any of the dam options. This will force Council to link to SEQ Water or Gold Coast City Council neither of which are preferred options.

RECOMMENDATION:

That Council adopts the raising of Clarrie Hall Dam as the preferred option for the augmentation of the Tweed District Water Supply.

REPORT:

Issue

There is a requirement to augment the Tweed District Water Supply by 2026. If the preferred option is to be a dam, the planning, environmental assessment and construction of the dam, such that it can provide the increase in secure yield required by 2026, will take 10 years.

Further, there is a government requirement to revise Council's Developer Servicing Plans (s64 charges). The Developer Servicing Plans cannot be completed until Council has selected a preferred option for the water supply augmentation.

To address these two issues a decision, by Council, on a preferred option for the augmentation of the Tweed District Water Supply is required in the immediate future.

Background

Studies undertaken for Tweed Shire Council by Hydrosphere - to estimate the future demand for water, and NSW Urban Water Services - to estimate the secure yield of Tweed District Water Supply as impacted by climate change, demonstrate a requirement to augment the Tweed District Water Supply by 2026.

Council has previously considered options to augment the Tweed District Water Supply but as yet has no preferred option for the augmentation of the water supply.

OPTIONS:

Consistent with Council resolutions the options of raising Clarrie Hall Dam and links to SEQ Water have been considered. In addition to these options, Byrrill Creek Dam(s) and links to Gold Coast City Council have also been considered. Therefore the options considered are:

- Raise Clarrie Hall Dam
- Build Small Byrrill Creek Dam
- Build Small Byrrill Creek Dam and raise it at a later date
- Build Large Byrrill Creek Dam
- Link to SEQ Water
- Link to Gold Coast City Council

Raise Clarrie Hall Dam

A study has been undertaken by NSW Public Works to determine the optimum size of Clarrie Hall Dam. It determined the optimum size of the dam was 43,000 ML based on raising the dam wall height by 8.5m to a dam wall height of 70m AHD.

The secure yield of the Raised Clarrie Hall Dam has been estimated by NSW Urban Water Services after undertaking stream flow estimation for both present flows and flows adjusted for climate change, and modelling the behaviour of the dam within licenced operating conditions. The modelling estimated the 2030 secure yield as 22,700ML/a. The Raised Clarrie Hall Dam would be able to provide adequate water supply to Tweed Shire until approximately 2046.

Cost estimates for the dam have been prepared by NSW Public Works. Those estimates were amended to include environmental assessment, project management and contingency for preconstruction.

As many of the factors influencing the cost of raising Clarrie Hall Dam are known, there is a higher degree of certainty with the cost estimates and there is only a small probability they could increase relative to other options. To address this, the estimates were subsequently amended by NSW Public Works using @Risk software to determine mean probable cost. The estimated mean probable cost to Raise Clarrie Hall Dam is $43.44M.

As the dam already exists there would be little or no additional operating costs for the raised dam.

Build Small Byrrill Creek Dam

This option consists of the construction of a small Byrrill Creek Dam with capacity of 16,300 ML.

The secure yield of the dam in conjunction with the existing Clarrie Hall Dam has been modelled by NSW Urban Water Services. The modelling estimated the 2030 secure yield as 15,800 ML/a. The dam, in conjunction with the existing Clarrie Hall Dam, would be able to provide adequate water supply to Tweed Shire until approximately 2035.

Cost estimates for the dam have been prepared by NSW Public Works. Those estimates were amended to include a fish ladder, environmental assessment, project management and contingency for preconstruction.

As many of the factors influencing the cost of constructing the small Byrrill Creek Dam are unknown, there is a low degree of certainty with the cost estimates. That is, there is a large probability the cost could increase significantly. To address this, the estimates were subsequently amended by NSW Public Works using @Risk software to determine mean probable cost. The estimated mean probable cost to construct the small Byrrill Creek Dam is $54.35M.

In the longer term, operating costs for the dam would be similar and in addition to the present operating costs of Clarrie Hall Dam.

Build Small Byrrill Creek Dam then Raise the Dam Wall

This option consists of the construction of Small Byrrill Creek Dam with capacity of 16,300 ML and then approximately 9 years later, raising the wall of the dam to provide a dam with a capacity of 36,000 ML.

The secure yield of the raised dam, in conjunction with the existing Clarrie Hall Dam, has been modelled by NSW Urban Water Services. The modelling estimated the 2030 secure yield of the raised dam as 20,950ML/a. The dam would require raising in 2035 and after raising and in conjunction with the existing Clarrie Hall Dam, would be able to provide adequate water supply to Tweed Shire until approximately 2044.

Cost estimates for the small dam and then raising the dam have been prepared by NSW Public Works. Those estimates were amended to include a fish ladder, environmental assessment, project management and contingency for preconstruction.

As many of the factors influencing the cost of constructing and then raising Byrrill Creek Dam are unknown, there is a low degree of certainty with the cost estimates. That is, there is a large probability the cost could increase significantly. To address this, the estimates were subsequently amended by NSW Public Works using @Risk software to determine mean probable cost. The estimated mean probable cost to construct the small Byrrill Creek Dam then raise it is $105.17M.

In the longer term, operating costs for the dam would be slightly above and in addition to the present operating costs of Clarrie Hall Dam.

Build Large Byrrill Creek Dam

This option consists of building a Byrrill Creek Dam with a capacity of 36,000 ML.

The secure yield of the dam in conjunction with the existing Clarrie Hall Dam has been modelled by NSW Urban Water Services. The modelling estimated the 2030 secure yield as 20,950 ML/a. The dam, in conjunction with the existing Clarrie Hall Dam, would be able to provide adequate water supply to Tweed Shire until approximately 2044, the same as the raised Byrrill Creek Dam.

Cost estimates for the small dam and then raising the dam have been prepared by NSW Public Works. Those estimates were amended to include a fish ladder, environmental assessment, project management and contingency for preconstruction.

As many of the factors influencing the cost of constructing the large Byrrill Creek Dam are unknown, there is a low degree of certainty with the cost estimates. That is, there is a large probability the cost could increase significantly. To address this, the estimates were subsequently amended by NSW Public Works using @Risk software to determine mean probable cost. The estimated mean probable cost to construct the large Byrrill Creek Dam is $81.86M.

In the longer term, operating costs for the dam would be similar, slightly above and in addition to the present operating costs of Clarrie Hall Dam.

Link to SEQ Water

This option consists of the construction of a pipeline, capable of transferring up to 20ML/day, from adjacent to the Tugun Desalination Plant to Piggabeen Road and a pump station.

The secure yield of this option in conjunction with the existing Clarrie Hall Dam has been modelled by NSW Urban Water Services. The modelling estimated the 2030 secure yield as 14,650 ML/a. The pipeline, in conjunction with the existing Clarrie Hall Dam would be able to provide adequate water supply to Tweed Shire until approximately 2034. Modelling by NSW Urban Water Services indicated that an average of 3,600 ML would be drawn from SEQ Water.

Cost estimates for the link have been prepared by MWH and updated to present day dollars by NSW Public Works. Many of the factors influencing the cost of constructing the link are known and hence there is a reasonable degree of certainty in costs. As with previous options to address risk the estimates were subsequently amended by NSW Public Works using @Risk software to determine mean probable cost. The estimated mean probable cost to construct the pipeline is $13.64M.

In addition to this SEQ Water have indicated that they would seek a "buy in" of $25.5M making the mean probable cost to construct the pipeline plus buy in is $39.14M.
In the longer term, operating costs consist of:

• Pump Station operation	$ 650,000 pa
• Water Cost @ $1500/ML for 3,600 ML/a	$ 5,400,000 pa
• Annual Access Charge	$ 13,600,000 pa
• Total	$ 19,650,000 pa

As many of the factors influencing the cost of this option are well known, there is only a small probability of significantly increased costs when compared with all options.

Further, larger pipelines were considered. The larger pipelines attracted significantly larger "buy-in" costs and significantly higher Annual Access Charges making the larger pipelines less financially acceptable than the 20ML/day pipeline.

Link to Gold Coast City Council

This option is basically the same as the option above with the exception that no buy in cost is forecast. At this point no access charges are forecast and the price of water is $3.77/kL in accordance with Gold Coast City Council's Fees and Charges.
In the longer term, operating costs consist of:

• Pump Station operation	$ 650,000 pa
• Cost of Water @ $3.77/kL for 3,600 ML/a	$ 13,572,000 pa
• Total	$ 14,222,000 pa

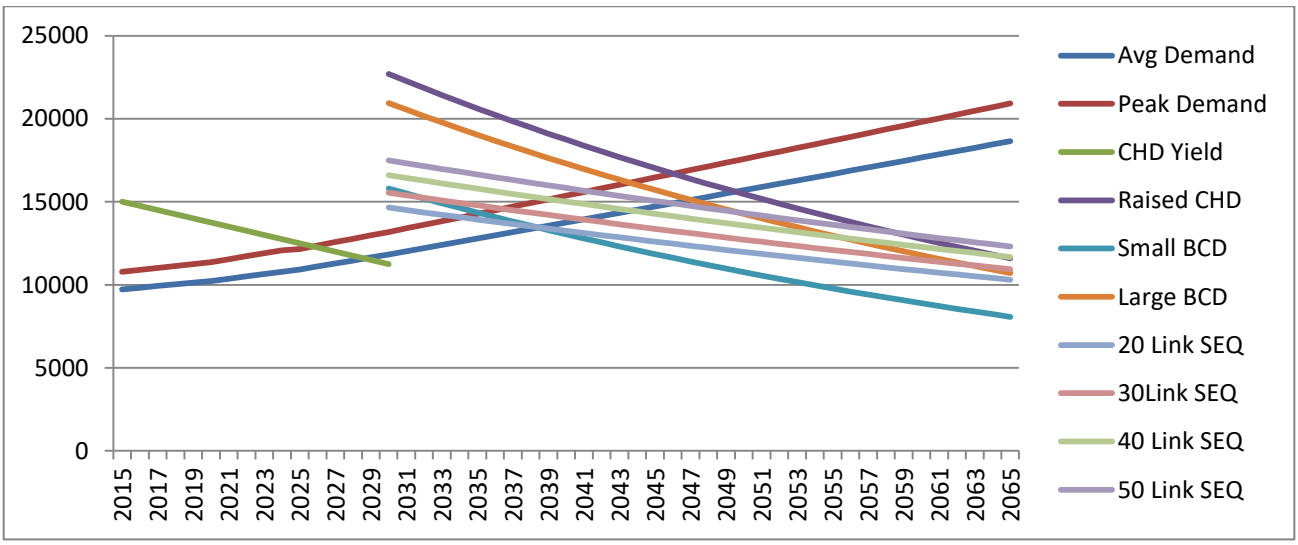
As many of the factors influencing the cost of this option are well known, there is only a small probability of significantly increased costs when compared with all options.

Larger pipelines were considered. Because the cost of water from Gold Coast City Council is significantly greater than the cost of production of water by Tweed Shire Council increasing the pipeline capacity and drawing more water from Gold Coast City Council would cause the cost of water in Tweed to rise further. This would make the larger pipelines less financially acceptable than the 20ML/day pipeline.

COMPARISION OF OPTIONS:

Longevity

Longevity is based on when a further supply augmentation would be required after the implementation of the given option. This was determined by comparing the forecast demand as determined by Hydrosphere and the secure yield of the options.



The longevity of each option is determined as the point at which peak demand exceeds secure yield and is tabulated in Table 1.

Table 1: Longevity of Water Supply Augmentation Options:

Option	**New Supply required by**
Raise Clarrie Hall Dam	2046
Small Byrrill Creek Dam	2035
Staged Byrrill Creek Dam	2044
Large Byrrill Creek Dam	2044
Link to SEQ Water	2034
Link to Gold Coast City Council	2034

Cost

The mean probable cost of the options and longevity are compared in Table 2.

Table 2: Mean Probable Cost, Mean Probable NPV and Longevity:

Option	**Mean Probable Capital Cost $M**	**Mean Probable NPV @7% $M**	**Longevity after 2026 Years**
Raise Clarrie Hall Dam	$ 43.33	$ 34.07	20
Small Byrrill Creek Dam	$ 54.35	$ 43.42	9
Stage Byrrill Creek Dam	$ 105.17	$ 76.16	18
Large Byrrill Creek Dam	$ 81.86	$ 70.75	18
Link to SEQ Water	$ 39.14	$ 222.46	8
Link to Gold Coast City Council	$ 13.64	$ 149.45	8

Financial Impact

The financial impact of each option was considered by HydroScience. After completion of the further cost analysis by NSW Public Works the financial impacts of each of the options was determined using the methodology of HydroScience. The assessment considered both the impact on Developer Charges and the impact on a Typical Residential Bill.

Table 3: Financial Impact of Water Supply Augmentation Options:

Option	Increase in Typical Residential Bill	Net Impact on Developer Charges based on average mean Note 1
Raise Clarrie Hall Dam	0	$ 3,649
Small Byrrill Creek Dam	$ 7.55	$ 9,397
Stage Byrrill Creek Dam	$ 10.00	$ 9,425
Large Byrrill Creek Dam	$ 10.00	$ 9,702
Link to SEQ Water	$ 370.00	$ 5,725
Link to Gold Coast City Council	$ 284.00	$ 1,099

Note 1:
The Net Impact on Developer Charges was based on the Equivalent Annualised Annuity of each option adjusted by the reduction in existing Developer Charges by the removal of previously forecast water supply augmentation work.

Based on current charges Water Usage Charges, Typical Residential Bill and Developer Charges would increase as shown in Table 4

Table 4: Gross Typical Residential Bill and Developer Charges for Water Supply Augmentation Options:

Option	Water Usage Charge $/kL	Typical Residential Bill	Developer Charges Note 2
Raise Clarrie Hall Dam	$ 2.70	$ 572.00	$ 16,777
Small Byrrill Creek Dam	$ 2.73	$ 579.55	$ 22,525
Stage Byrrill Creek Dam	$ 2.73	$ 582.00	$ 22,553
Large Byrrill Creek Dam	$ 2.73	$ 582.00	$ 22,830
Link to SEQ Water Note 1	$ 5.12	$ 942.00	$ 18,853
Link to Gold Coast City Council Note 1	$ 3.91	$ 856.00	$ 14,227

Note 1:
Present consumption determined from (TRB - access)/2.7. Usage Charge calculated from (TRB - access)/consumption. In these two cases the typical user charge exceeds the user charge for water at Gold Coast City Council of $3.77/kL.

Note 2:
Consistent with Note 1 Table 3 the actual developer charges will need to be recalculated as part of the revision to the Developer Servicing Plan. That revision will also take into account the lower growth rates which have been experienced as well as new costings and strategies for servicing.

Previous Community Consultation

In 2010 a Community Working Group considered and assessed the options of:

- Raise Clarrie Hall Dam
- New Byrrill Creek Dam
- Pipeline to SEQ Water

The options were assessed on the criteria of Environmental Impact and Social Impacts of the options. The Community Working Group assessed the options on the rating of:

- I can live with this option
- I don't know / am not sure
- I cannot live with this option

The results of the assessment are set out below:

Table 5: Community Working Group Assessment of Options based on Environmental Impact:

Option	Raise Clarrie Hall Dam	New Byrrill Creek Dam	Pipeline to SEQ Water
I can live with this option	9	2	1
I don't know / am not sure	1	0	6
I cannot live with this option	1	8	3

Table 6: Community Working Group Assessment of Options based on Social Impact:

Option	Raise Clarrie Hall Dam	New Byrrill Creek Dam	Pipeline to SEQ Water
I can live with this option	6	2	1
I don't know / am not sure	2	1	5
I cannot live with this option	1	6	2

The results show that more people (15) can "live with" the raising of Clarrie Hall Dam than can "live with" New Byrrill Creek (4). Fewest (2) can "live with" Pipeline to SEQ Water.

Similarly, the results show that the fewest people (2) "cannot live with" Raise Clarrie Hall Dam compared to fourteen (14) who "cannot live with" with Byrrill Creek Dam and five (5) who could not live with Pipeline to SEQ Water.

Subtracting "cannot live with" numbers from "can live with" ranks the options in order of preference as:

- Raise Clarrie Hall Dam (13)
- Pipeline to SEQ Water (-3)
- New Byrrill Creek Dam (-10)

Previous Studies

In 2008 and 2009, a series of studies were undertaken to compare options for the augmentation of the Tweed District Water Supply.

The studies, through a Multi Criteria Analysis, ranked the options. The ranking was:

- Raising Clarrie Hall Dam
- Pipeline to SEQ Water
- New Byrrill Creek Dam

The studies recommended the preferred option for augmenting the Tweed District Water Supply as the raising of Clarrie Hall Dam.

Water Sharing Plan

It was confirmed by the relevant Minister in December 2010 that Clause 48 of the Water Sharing Plan for the Tweed River specifically prevents NSW Office of Water from approving water supply work in the Byrrill Creek Water Source.

Subsequent to that date, the new Minister in October 2011, advised that it was her belief that the inclusion of Clause 48 would not impact on any proposal to construct a major water storage on Byrrill Creek, as the provisions of the EP&A Act for major projects would apply. It should be noted that this is not a legal opinion.

Advice from Office of Water, also in October 2011, advised that Clause 48 of the Water Sharing Plan would not impact on a proposal to build Byrrill Creek Dam, because such a proposal may fall under the provisions of the SEPP on State and Regional Development. The SEPP considers dam proposals in excess of $30m to be state significant infrastructure.

Advice from NSW Planning is that the status of the Water Sharing Plan against the SEPP and legislation is unclear. Were the Water Sharing Plan to be taken into consideration in any development assessment, it is possible Clause 48 could take precedence over the SEPP. It is also possible the provisions of the SEPP could take precedence over the Water Sharing Plan. As the matter is contestable in the Land and Environment Court and no precedence exists, it is unclear whether the Water Sharing Plan impacts on the proposal to build Byrrill Creek Dam.

No differentiation between options can be determined and as such the Water Sharing Plan is not considered further, except in that it poses a significant risk within the planning process with probable significant cost and time implications.

Environmental Impact Assessment

In any environmental assessment of a proposal, alternatives must be considered. Any environmental assessment of the alternatives of links to SEQ Water, links to GCCC and Byrrill Creek Dam would be assessed against an alternative of raising Clarrie Hall Dam on the criteria of impact on the natural environment, social environment and economic environment.

Environmental studies, community consultation and economic analysis has consistently shown Clarrie Hall Dam has less environmental impact than Byrrill Creek Dam, is more readily accepted by the community and provides the best economic outcomes for Tweed

Shire. As such it is anticipated any Environmental Impact Assessment will find raising Clarrie Hall Dam the preferred option.

For Council to do otherwise may cause State Government intervention in Council's decision making process on this matter.

Risk

Risk to Residential Development

Any increase in the Developer Charges will have an adverse impact on the cost of residential development. In simple demand terms, this will reduce the demand for land and hence development within the Shire. Similarly, high user charges will act as a disincentive for people to live in the Shire if user charges are higher than on the Gold Coast.

To mitigate the risk to development of residential land, Developer Charges need to be kept as low as possible while maintaining the financial viability of Council's water and sewerage services. Similarly, user charges need to be kept as low as possible while maintaining the financial viability of Council's water and sewerage services.

The option with both the second lowest Developer Charges and lowest user charges is Raise Clarrie Hall Dam. This option will result in Developer Charges more than $6,000 less than other dam options.

Risks to Commercial and Industrial Development

Risks to maintaining and developing commercial and industrial development within Council, primarily, centred on cost. In essence, if the cost of doing business on the Gold Coast is less than the cost of doing business in Tweed Shire, businesses will move out of the Shire.

When considering costs the total cost of water and sewerage services is compared. Gold Coast City Council's costs are $3.77/kl for water. This can be compared to the present Tweed Shire Council charges of $2.70.

The options of Link to SEQ Water and Link to Gold Coast City Council would place the cost of water above the cost of water from other options and are therefore considered a risk to continued commercial and industrial development within Tweed Shire. The present usage charge at Gold Coast City Council is $3.77 /kL. With the Link to SEQ Water or the Link to Gold Coast City Council the usage charges would be $5.12 and $3.91 respectively.

Risk to Low Income Residents

Low income residents such as pensioners are those persons most adversely impacted by the increase in cost of essential services. Increases in the cost of water from the present $2.70/kL to $3.91 or over $4.00kL are considered unacceptable. Therefore the options of Link to SEQ Water and Link to Gold Coast City Council are considered unacceptable.

Cost Uncertainty

NSW Public Works was engaged to undertake an assessment of cost uncertainty. This was undertaken using @Risk software using a Monte Carlo based assessment methodology. The results are shown in Table 7.

Table 7: Mean Probable and Maximum Capital Costs for Water Supply Augmentation Options:

Option	Mean Probable Capital Cost $M	Maximum Capital Cost $M
Raise Clarrie Hall Dam	$ 43.44	$ 55.22
Small Byrrill Creek Dam	$ 54.35	$ 67.71
Staged Byrrill Creek Dam	$ 105.17	$ 130.78
Large Byrrill Creek Dam	$ 81.86	$ 105.26
Link to SEQ Water	$ 39.14	$ 43.20
Link to Gold Coast City Council	$ 13.64	$ 17.70

The Mean Probable and Maximum Net Present Values of each of the option are shown in Table 8.

Table 8: Mean Probable NPV and Maximum NPV for Water Supply Augmentation Options:

Option	Mean Probable NPV $M	Maximum NPV $M
Raise Clarrie Hall Dam	$ 34.07	$ 43.24
Small Byrrill Creek Dam	$ 43.42	$ 57.60
Staged Byrrill Creek Dam	$ 76.16	$ 85.53
Large Byrrill Creek Dam	$ 70.75	$ 90.57
Link to SEQ Water	$ 222.46	$ 222.74
Link to Gold Coast City Council	$ 149.45	$ 151.73

The Developer Charges in Table 9 were determined using the HydroScience methodology.

Table 9: Typical Residential Bill, Mean Probable Developer Charges and Maximum Developer Charges for Water Supply Augmentation Options.

Option	Water Usage Charge $/kL	Mean Probable Developer Charge	Maximum Developer Charges
Raise Clarrie Hall Dam	$ 2.70	$ 16,777	$ 18,220
Small Byrrill Creek Dam	$ 2.73	$ 22,525	$ 25,157
Stage Byrrill Creek Dam	$ 2.73	$ 22,553	$ 25,266
Large Byrrill Creek Dam	$ 2.73	$ 22,830	$ 26,213
Link to SEQ Water	$ 5.12	$ 18,853	$ 19,433
Link to Gold Coast City Council	$ 3.91	$ 14,227	$ 14,816

Other items that may impact on the cost of options which cannot be assessed at this stage include:

The likely requirement for compensatory habitat for areas inundated by Byrrill Creek Dam and a raised Clarrie Hall Dam are as yet undefined.

Presently unknown environmental conditions at the Byrrill Creek site may require further expenditure on studies and environmental measures. This is exacerbated because ECO-SURE have found high conservation areas both upstream and down-stream of the proposed dam wall.

There are 26 registered cultural heritage sites within the Byrrill Creek Dam catchment. There are most probably, further unknown cultural heritage issues requiring further expenditure on studies and protection measures.

There are 21 registered cultural heritage sites within the Clarrie Hall Dam area. Five (5) sites were inundated in 1983, a further five (5) would be inundated if Clarrie Hall Dam was raised. The area has been well studied and the risk of discovering further cultural heritage sites is low.

The construction of Byrrill Creek Dam would result in the partial inundation of nine (9) properties. Four (4) houses would be inundated. Two properties will be severed. The construction would require major road reconstruction of Byrrill Creek Road. As negotiations to address these items have yet to be undertaken there is no certainty as to the cost of these items and escalation could well occur.

The raising of Clarrie Hall Dam would result in the partial inundation of twenty-four (24) properties. Three (3) houses would be inundated. Three (3) properties would be impacted by road realignment. Discussions with the property owners impacted by any raising of Clarrie Hall Dam occurred in 2010/11.

Legal action.

Time Uncertainty

There is uncertainty associated with the time for completion of the water augmentation options.

Risks to time for the Links to SEQ Water and Gold Coast City Council are centred on three aspects being - acquisition of land, entering into an agreement with the bulk supplier and environmental assessment. As the construction time for these options is short the risk associated with being able to augment the water supply by 2026 are considered very small.

Risks to time for the Raising of Clarrie Hall Dam are centred on acquisition of land, environmental assessment, including legal challenge, and construction. As Council owns the majority of land in the catchment of Clarrie Hall Dam and preliminary discussions had commenced with the remaining land owners, it is considered that the risk of time delays due to land acquisition, although they exist, are not high.

Previous studies have identified the environmental and cultural heritage risks associated with Clarrie Hall Dam. Further, there has been significant community consultation and Raising Clarrie Hall Dam was the preferred option. As with land acquisition, it considered that the risk of time delays due to environmental assessment and planning processes, although they exist, are not high.

Clarrie Hall Dam is an existing dam and the construction required to raise the dam can be well quantified. Further, there are no unknown ground conditions and construction access has already been established. The risk of time delays due to adverse construction conditions, although they exist, are not considered high.

Risks to time for the building of Byrrill Creek Dam are also centred on acquisition of land, environmental assessment, including legal challenge, and construction. Council owns the majority of land in the catchment/inundation area of Byrrill Creek Dam but Council has not commenced discussion with the remaining land owners on the acquisition of their land. It is considered there is a higher risk of time delays due to land acquisition at Byrrill Creek that there is for land acquisition at Clarrie Hall Dam.

Previous studies have identified significant environmental and cultural heritage risks associated with Clarrie Hall Dam. Further, there has been significant community opposition to building Byrrill Creek Dam which may lead to an increased probability of legal challenge. The Fine Screening Assessment estimated that fulfilling the planning obligations for Byrrill Creek Dam would take approximately 2 years longer than fulfilling the planning obligations for Raising Clarrie Hall Dam. It considered that the risk of time delays due to environmental assessment and planning processes are high.

Building Byrrill Creek Dam is a greenfield project and the risks associated with such a project are not as well understood as the risks of Raising Clarrie Hall Dam. Issues such as ground conditions and construction access are unknown. The risk of time delays due to adverse construction conditions are higher than other options.

In general, the time risks for the building of Byrrill Creek Dam are significantly higher than the time risks associated with other options.

It should be noted that if a decision on a preferred option for water supply augmentation is delayed, there may be insufficient time prior to 2026 to construct a new dam or Raise Clarrie Hall Dam. This will force Council to link to SEQ Water or Gold Coast. The risk of this occurring is greater with Byrrill Creek Dam options due to time uncertainty.

Council Resolutions

On 19 October 2010 it was resolved that Council:

"1. Monitors and resources demand management actions with the aim of achieving at least BASIX/WELS reductions and reports to Council annually on progress.

2. Adopts Byrrill Creek Dam as the preferred option for augmenting the Tweed District Water Supply.

3. Proceeds with the Planning Approvals process and Detailed Design in relation to Byrrill Creek Dam.

4. Pursues dialog with the relevant South East Queensland water authorities in parallel as an alternative augmentation option and as an emergency drought option."

On 18 October 2011 it was resolved by Council that:

"…..parts 2 and 3 of Minute 688 from the meeting held 19 October 2010, Item 24 – Tweed District Water Supply Augmentation Options – Selecting a Preferred Option, being:

2. Adopts Byrrill Creek Dam as the preferred option for augmenting the Tweed District Water Supply.

3. Proceeds with the Planning Approvals process and Detailed Design in relation to Byrrill Creek Dam.

be rescinded".

On 15 May 2012 it was resolved that Council places a "moratorium on any dam proposal at Byrrill Creek for a period of the next twenty (20) years, effective from 15 May 2012."

This places Council in a position where it has no preferred option to augment the Tweed District Water Supply and any dam proposal at Byrrill Creek cannot be considered until May 2032.

Given that a new water supply is required by 2026 it removes Byrrill Creek Dam from any further consideration unless Council resolves otherwise.

SUMMARY:

There is a requirement for Council to determine a preferred option for the augmentation of Tweed District Water Supply in the immediate future. This is required so that an additional water source is commissioned by 2026 and Council can fulfil its obligations to prepare a new Developer Servicing Plan.

The following options have been considered:

- Raise Clarrie Hall Dam
- Build Small Byrrill Creek Dam
- Build Small Byrrill Creek Dam and raise it at a later date
- Build Large Byrrill Creek Dam
- Link to SEQ Water
- Link to Gold Coast City Council

From an analysis of various impacts the Raising of Clarrie Hall Dam is most advantageous to Council and its community.

An assessment of each option as compared to the option of Raising of Clarrie Hall Dam is given below:

Build Small Byrrill Creek Dam:

- Shorter life than Raising Clarrie Hall Dam.
- Higher typical residential bill than Raising Clarrie Hall Dam.
- Developer Charges are approximately $6,000 higher than Raising Clarrie Hall Dam.
- Raising Clarrie Hall Dam was preferred by the Community Working Group.
- Raising Clarrie Hall Dam was the preferred option from previous studies.
- Poses a greater risk to residential development than Raising Clarrie Hall Dam.
- Poses a greater risk to commercial and industrial development than Raising Clarrie Hall Dam.
- Poses no significant increase in risk to low income residents.
- Has a higher cost uncertainty than Raising Clarrie Hall Dam.
- Has a higher time uncertainty than Raising Clarrie Hall Dam.
- Is precluded by Council resolutions.

Build Staged Byrrill Creek Dam:

- Similar life than Raising Clarrie Hall Dam (one to two years less).
- Higher typical residential bill than Raising Clarrie Hall Dam.
- Developer Charges are approximately $6,000 higher than Raising Clarrie Hall Dam.
- Raising Clarrie Hall Dam was preferred by the Community Working Group.
- Was not considered in previous studies.
- Poses a greater risk to residential development than Raising Clarrie Hall Dam.
- Poses a greater risk to commercial and industrial development than Raising Clarrie Hall Dam.
- Poses no significant increase in risk to low income residents.
- Has a higher cost uncertainty than Raising Clarrie Hall Dam.
- Has a higher time uncertainty than Raising Clarrie Hall Dam.
- Is precluded by Council resolutions.

Build Large Byrrill Creek Dam:

- Similar life than Raising Clarrie Hall Dam (one to two years less).
- Higher typical residential bill than Raising Clarrie Hall Dam.
- Developer Charges are approximately $6,000 higher than Raising Clarrie Hall Dam.
- Raising Clarrie Hall Dam was preferred by the Community Working Group.
- Raising Clarrie Hall Dam was the preferred option from previous studies.
- Poses a greater risk to residential development than Raising Clarrie Hall Dam.
- Poses a greater risk to commercial and industrial development than Raising Clarrie Hall Dam.
- Poses no significant increase in risk to low income residents.
- Has a higher cost uncertainty than Raising Clarrie Hall Dam.
- Has a higher time uncertainty than Raising Clarrie Hall Dam.
- Is precluded by Council resolutions.

Link to SEQ Water:

- Shorter life than Raising Clarrie Hall Dam.
- Very much higher typical residential bill than Raising Clarrie Hall Dam.
- Developer Charges are approximately $2,000 higher than Raising Clarrie Hall Dam.
- Raising Clarrie Hall Dam was preferred by the Community Working Group.
- Raising Clarrie Hall Dam was the preferred option from previous studies.
- Poses a much greater risk to residential development than Raising Clarrie Hall Dam.
- Poses a much greater risk to commercial and industrial development than Raising Clarrie Hall Dam.
- Poses very significant increase in risk to low income residents.
- Has a similar cost uncertainty to Raising Clarrie Hall Dam although cost may be influenced by other parties.
- Has a similar time uncertainty to Raising Clarrie Hall Dam.

Link to Gold Coast City Council:

- Shorter life than Raising Clarrie Hall Dam.
- Very much higher typical residential bill than Raising Clarrie Hall Dam.
- Developer Charges lower than Raising Clarrie Hall Dam.
- Raising Clarrie Hall Dam was preferred by the Community Working Group.
- Raising Clarrie Hall Dam was the preferred option from previous studies.
- Poses a risk to residential development than Raising Clarrie Hall Dam.
- Poses a much greater risk to commercial and industrial development than Raising Clarrie Hall Dam due tom high usage charges.
- Poses very significant increase in risk to low income residents.
- Has a similar cost uncertainty to Raising Clarrie Hall Dam although cost may be influenced by other parties.
- Has a similar time uncertainty to Raising Clarrie Hall Dam.

The table Comparison of Water Supply Augmentation Options attached, summarises this report.

CONCLUSION:

There is a requirement for Council to determine a preferred option for the augmentation of Tweed District Water Supply in the immediate future. This is required so that an additional water source is commissioned by 2026 and Council can fulfil its obligations to prepare a new Developer Servicing Plan.

From an analysis of various impacts the Raising of Clarrie Hall Dam is most advantageous to Council and its community.

If Council continues to delay a decision on a preferred water supply augmentation option, there may be insufficient time prior to 2026 to construct a new dam or Raise Clarrie Hall Dam. This will force Council to link to SEQ Water or Gold Coast City Council. The risk of this occurring is greater with Byrrill Creek Dam options due to time uncertainty.

COUNCIL IMPLICATIONS:

a. Policy:
The current adopted position of Council as at 15 May 2012 is that Council places a "moratorium on any dam proposal at Byrrill Creek for a period of the next twenty (20) years, effective from 15 May 2012."

Council has an Asset Management Plan for water which details levels of service and is presently updating its Strategic Business Plan for Water Supply in accordance with best practice guidelines.

b. Budget/Long Term Financial Plan:
Significant budget variation dependent on the preferred option which will impact Developer Contributions for any new development as well as user charges for existing users, as detailed within the body of this report.

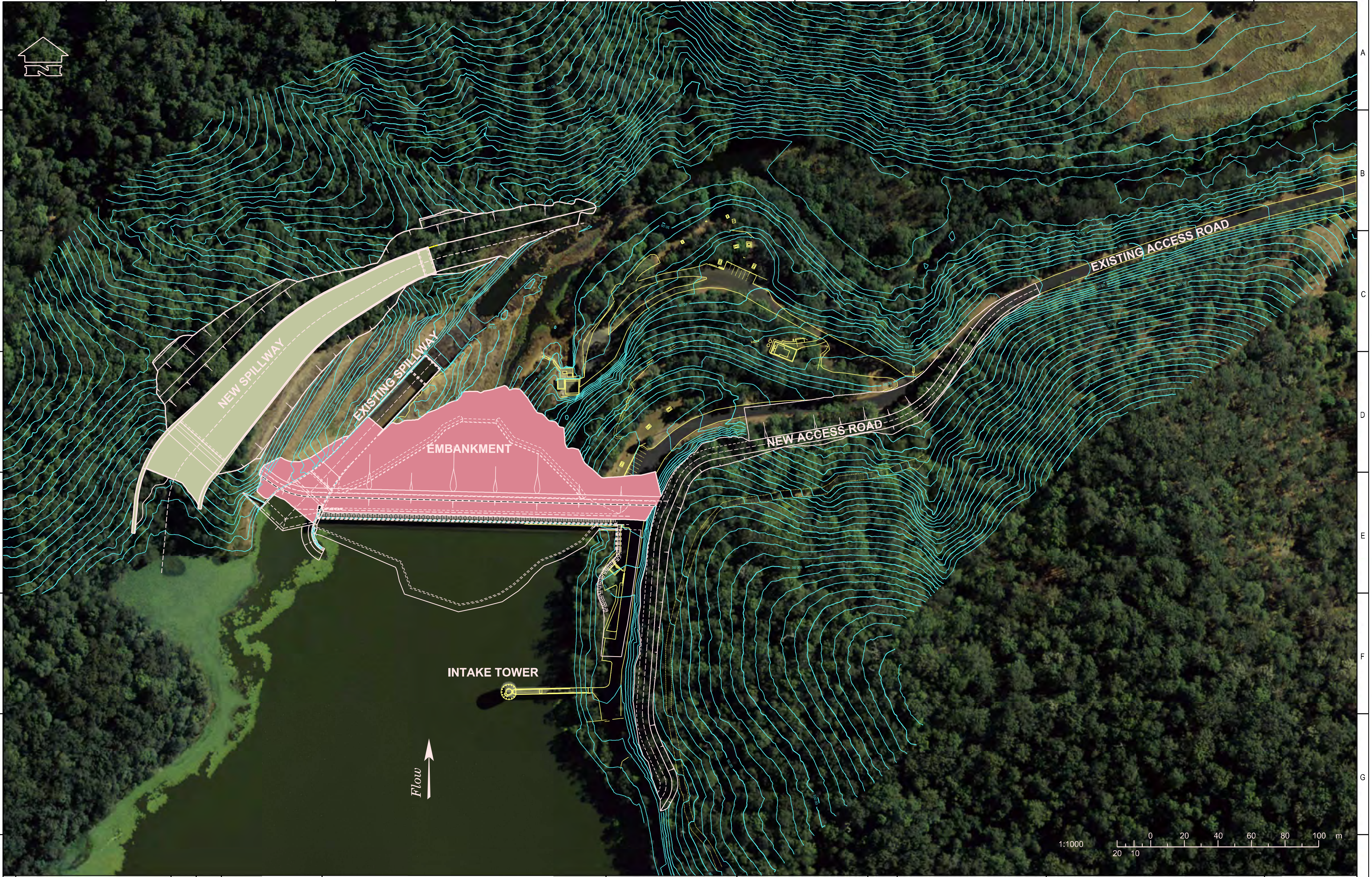
c. Legal:
As per the Report.

d. Communication/Engagement:
Inform - We will keep you informed.

UNDER SEPARATE COVER/FURTHER INFORMATION:

Attachment 1. Comparison of Water Supply Augmentation Options (ECM 3849961).

Appendix B: Preliminary concept design drawing



REV	AMENDMENT DETAILS	APPROVED	DATE
0	ISSUED FOR REVIEW	XX	XX

1. Public Works Advisory (the Office) shall not be liable or responsible for any loss or damage arising out of the conversion of any electronic document, data or program to any other format or medium, or arising out of any modification or changes that occur in the handling or use of the electronic document, data or program.
2. The recipient or user of any electronic document, data or program is solely responsible for ascertaining its accuracy and its suitability for their purposes.
3. The Department uses virus scanning software to prevent file and system virus attacks but gives no warranty. The recipient or user is solely responsible for their own virus protection.

DRAFT COPY

NSW GOVERNMENT PublicWorks Advisory

DESIGNED	B. CLARK
CHECKED	G. SAMIOS
DRAFTED	C. ZHANG
PRINCIPAL ENGINEER	G. SAMIOS

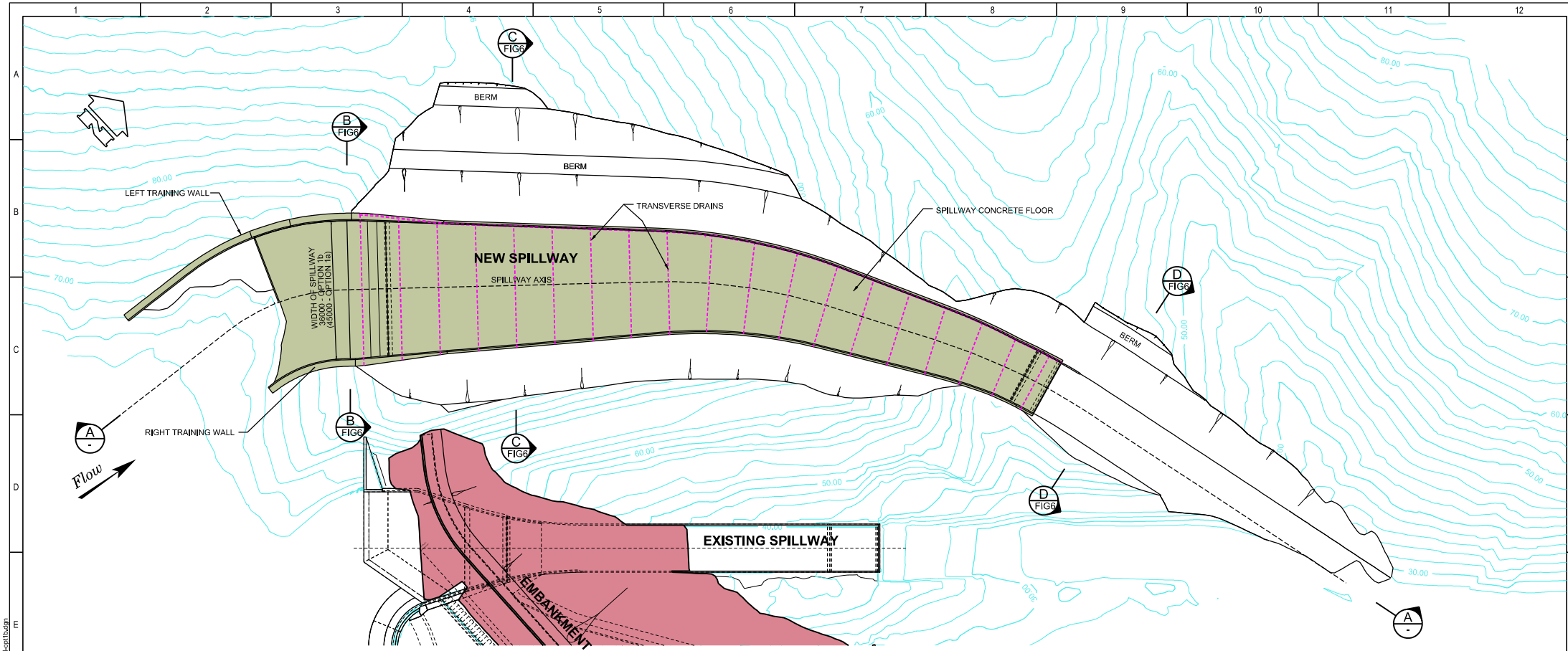
CLARRIE HALL DAM
RAISING OPTIONS

OPTION 1b
GENERAL ARRANGEMENT

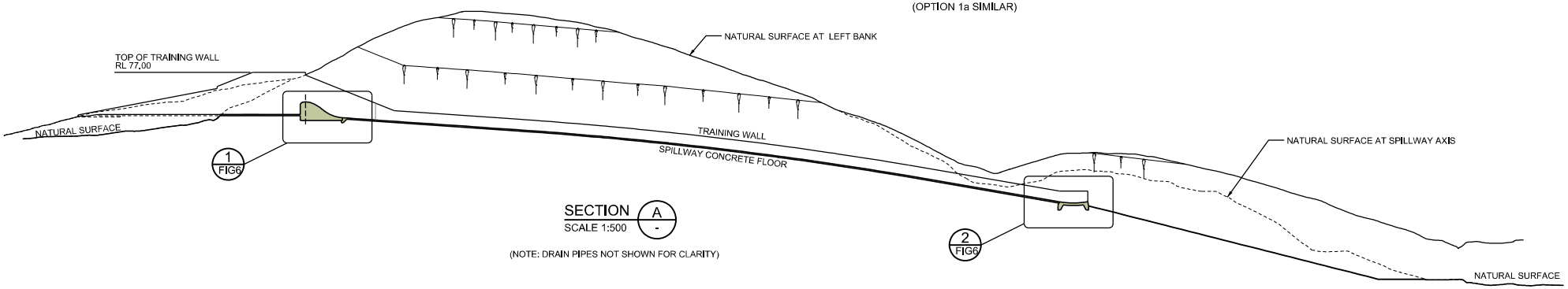
PROJECT/CONTRACT No. ?
A1 SCALE @ A1 1:1000
DRAWING No. FIGURE 3 REV 0

CONFIRM SCALE — 100mm ON A1 ORIGINAL

G:\Waterfed\Post\Clarrie Hall Dam Raising 2018\FIGURES-DRAWINGS\FIG03-ClarrieHall-opt1b.dgn
zhangc2
5:10:47 PM
14/03/2018



PLAN (OPTION 1b)
SCALE 1:500
(OPTION 1a SIMILAR)



SECTION A -
SCALE 1:500

(NOTE: DRAIN PIPES NOT SHOWN FOR CLARITY)

1:500 0 10000 20000 30000 40000 50000 mm
10000

DRAFT COPY

REV	AMENDMENT DETAILS	APPROVED	DATE
0	ISSUED FOR REVIEW	XX	XX

1. Public Works Advisory (the Office) shall not be liable or responsible for any loss or damage arising out of the conversion of any electronic document, data or program to any other format or medium, or arising out of any modification or changes that occur in the functioning or use of the electronic document, data or program.
2. The recipient or user of any electronic document, data or program is solely responsible for ascertaining its accuracy and its suitability for their purposes.
3. The Department uses virus scanning software to prevent file and system virus attacks but gives no warranty. The recipient or user is solely responsible for their own virus protection.

NSW GOVERNMENT Public Works Advisory

DESIGNED	B. CLARK
CHECKED	G. SAMIOS
DRAFTED	C. ZHANG
PRINCIPAL ENGINEER	G. SAMIOS

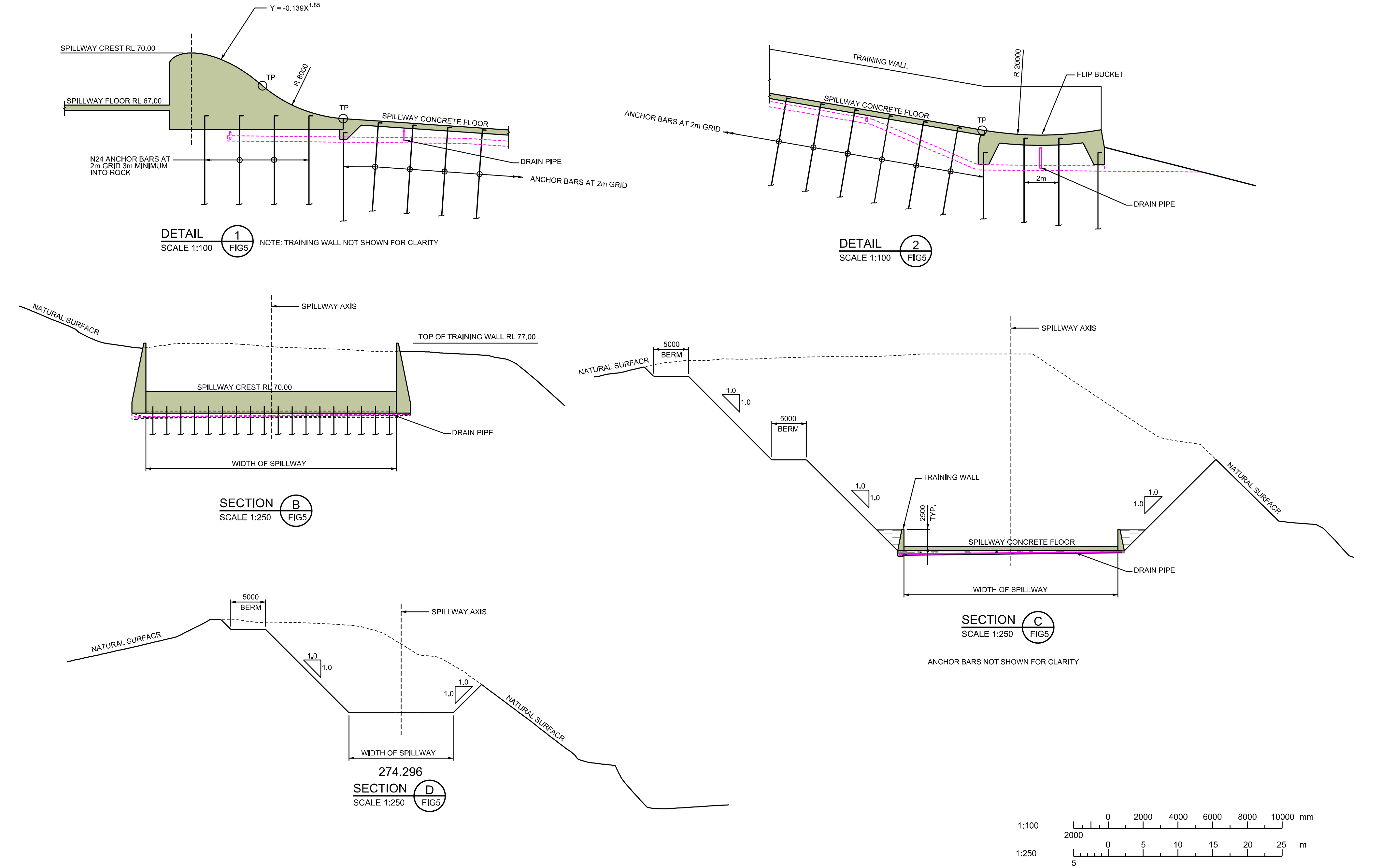
CLARRIE HALL DAM
RAISING OPTIONS

OPTION 1a/1b
SPILLWAY LAYOUT
AND LONG SECTION

PROJECT/CONTRACT No. ?
A1 SCALE @ A1 1:500
DRAWING No. FIGURE 5 REV 0

CONFIRM SCALE 100mm ON A1 ORIGINAL

G:\Waterlec\Pcad\Clarrie Hall Dam Raising 2018\FIGURES\DRAWINGS\Fig05-4-clarriehallopt1b.dgn
zhangc2
4:40:58 PM
14/03/2018



REV	AMENDMENT DETAILS	APPROVED	DATE
0	ISSUED FOR REVIEW	XX	XX

DRAFT COPY

NSW GOVERNMENT PublicWorks Advisory

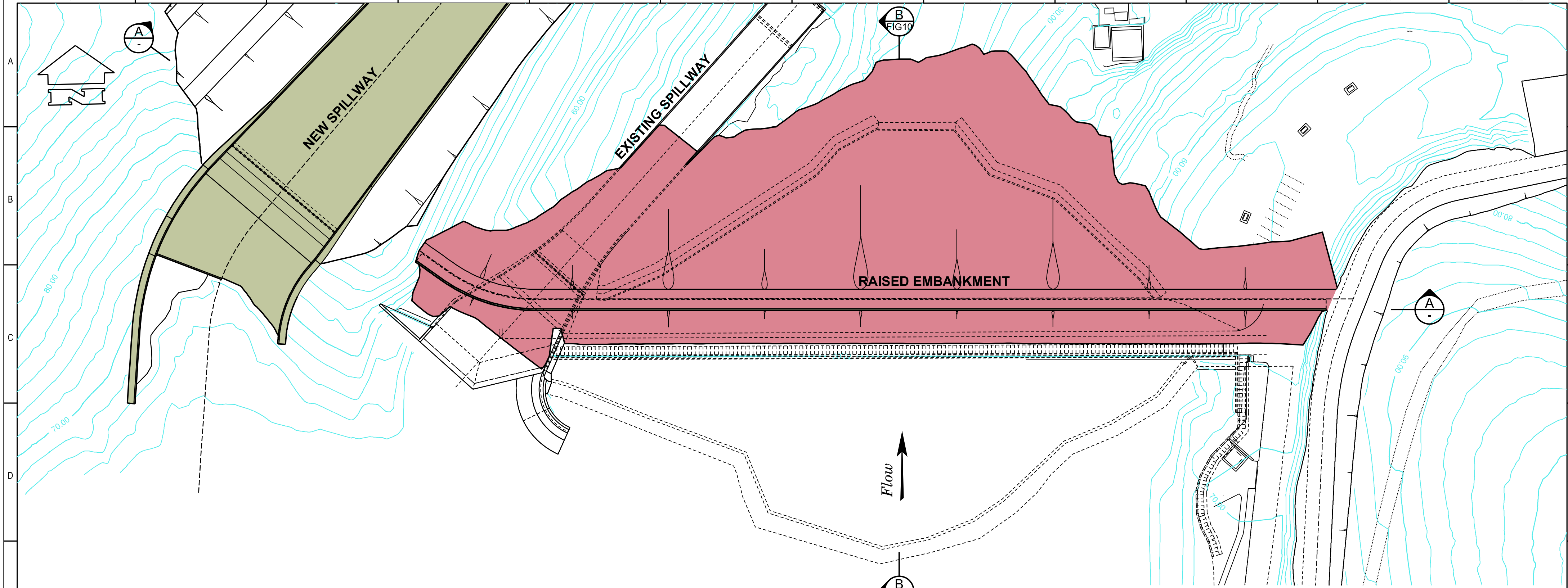
DESIGNED	B. CLARK
CHECKED	G. SAMIOS
DRAFTED	C. ZHANG
PRINCIPAL ENGINEER	G. SAMIOS

CLARRIE HALL DAM
RAISING OPTIONS

OPTION 1a/1b
SPILLWAY DETAILS
AND CROSS SECTIONS

PROJECT/CONTRACT No. ?
A1 SCALE @ A1 1:100, 1:250
DRAWING No. FIGURE 6 REV 0

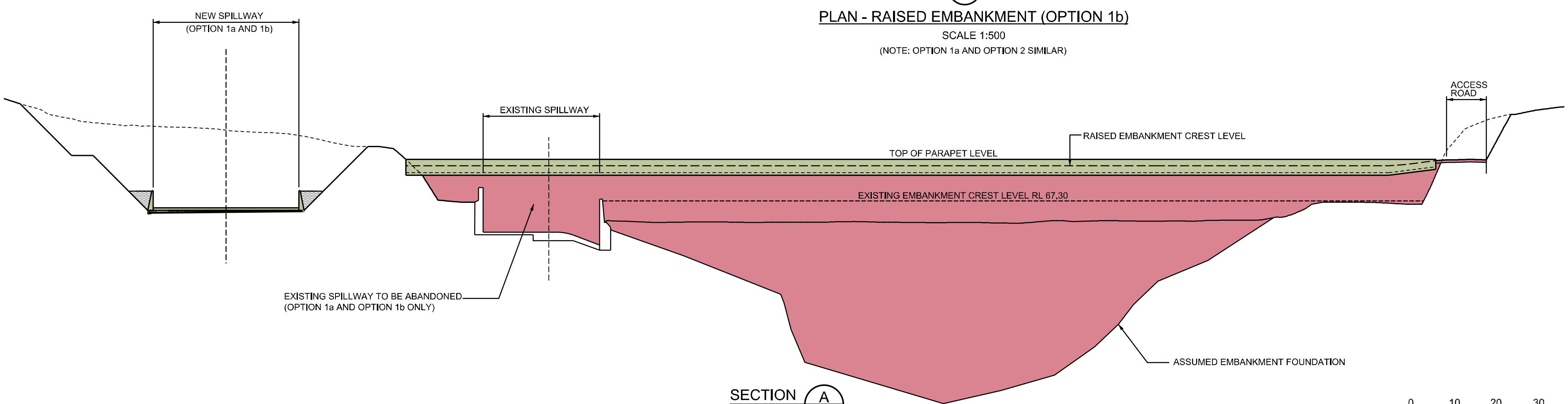
CONFIRM SCALE 100mm ON A1 ORIGINAL



PLAN - RAISED EMBANKMENT (OPTION 1b)

SCALE 1:500

(NOTE: OPTION 1a AND OPTION 2 SIMILAR)



SECTION A

SCALE 1:500

1:500 — 10 0 10 20 30 40 50 m

REV	AMENDMENT DETAILS	APPROVED	DATE
0	ISSUED FOR REVIEW	XX	XX

1. Public Works Advisory (the Office) shall not be liable or responsible for any loss or damage arising out of the conversion of any electronic document, data or program to any other format or medium, or arising out of any modification or changes that occur in the handling or use of the electronic document, data or program.
2. The recipient or user of any electronic document, data or program is solely responsible for ascertaining its accuracy and its suitability for their purposes.
3. The Department uses virus scanning software to prevent file and system virus attacks but gives no warranty. The recipient or user is solely responsible for their own virus protection.

DRAFT COPY

NSW GOVERNMENT | PublicWorks Advisory

DESIGNED	B. CLARK
CHECKED	G. SAMIOS
DRAFTED	C. ZHANG
PRINCIPAL ENGINEER	G. SAMIOS

CLARRIE HALL DAM

RAISING OPTIONS

DAM EMBANKMENT RAISING
PLAN AND LONG SECTION

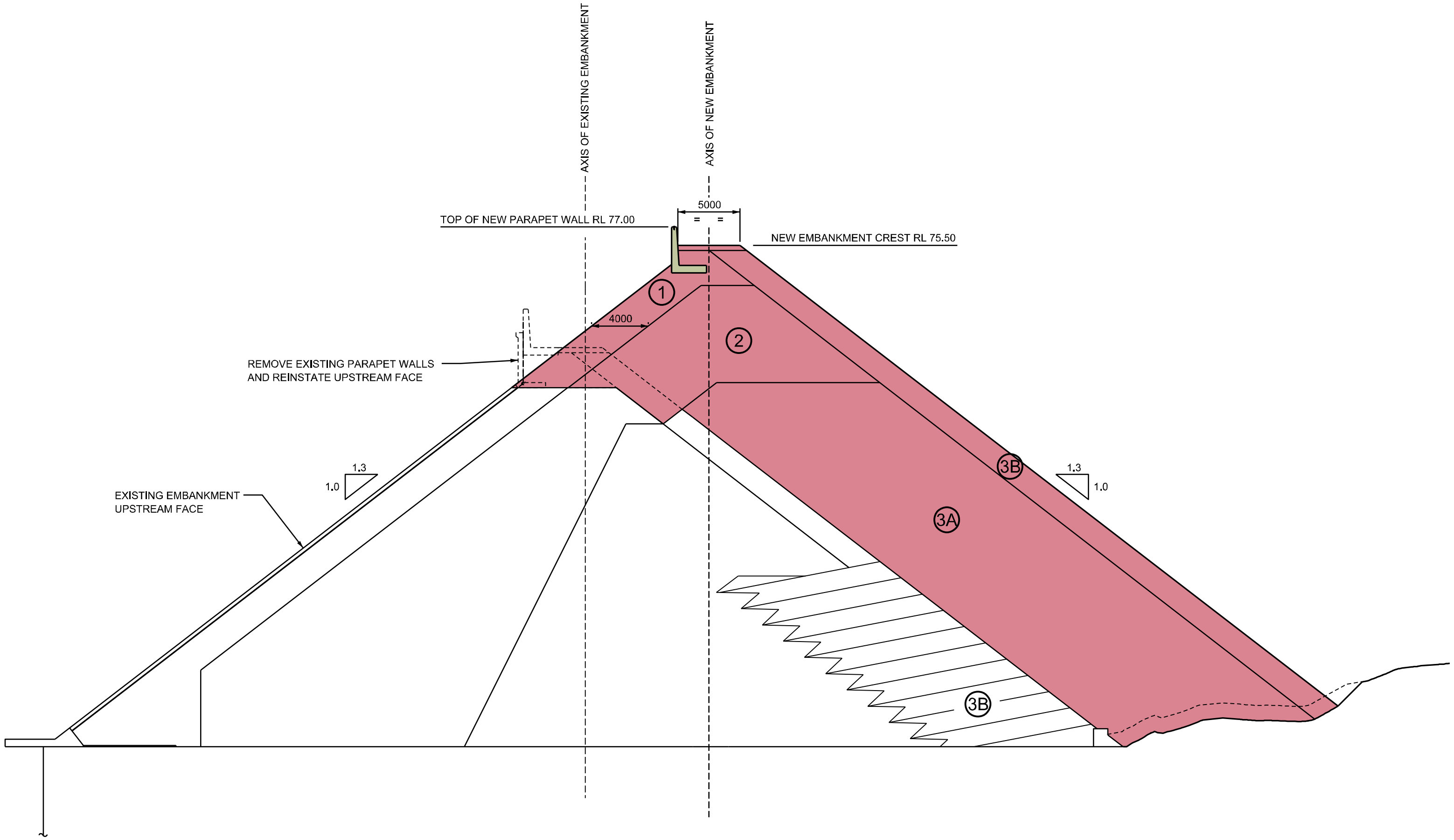
PROJECT/CONTRACT No. ?

A1 — SCALE @ A1 1:500

DRAWING No. FIGURE 9 — REV 0

CONFIRM SCALE — 100mm ON A1 ORIGINAL

G:\Watertec\Pcad\Clarrie Hall Dam Raising 2018\FIGURES-DRAWINGS\FIG09-ClarrieHall-opt1b.dgn
zhangc2
11:40:09 AM
16/03/2018



SECTION B FIG9
SCALE 1:200

ZONE	FUNCTION	DESCRIPTION
1	SEMI-PERMEABLE ZONE	MODERATELY WEATHERED RHYOLITE
2	PERMEABLE INTERMEDIATE ZONE	SLIGHTLY WEATHERED TO MODERATELY WEATHERED RHYOLITE
3A	FRESH ROCK ZONE	FRESH RHYOLITE
3B	MESH ZONE AND FACE ZONE	SELECTED FRESH RHYOLITE

1:200 — 4000 0 4000 8000 12000 16000 20000 mm

REV	AMENDMENT DETAILS	APPROVED	DATE
0	ISSUED FOR REVIEW	XX	XX

DRAFT COPY

NSW GOVERNMENT PublicWorks Advisory

DESIGNED	B. CLARK
CHECKED	G. SAMIOS
DRAFTED	C. ZHANG
PRINCIPAL ENGINEER	G. SAMIOS

CLARRIE HALL DAM
RAISING OPTIONS

DAM EMBANKMENT RAISING
TYPICAL CROSS SECTION

PROJECT/CONTRACT No. ?
A1 SCALE @ A1 1:200
DRAWING No. FIGURE 10 REV 0

CONFIRM SCALE — 100mm ON A1 ORIGINAL

G:\Watertec\Pcad\Clarrie Hall Dam Raising 2018\FIGURES-DRAWINGS\FIG10-ClarrieHall-opt2.dgn
zhangc2
6:48:01 PM
22/02/2018

TWEED
SHIRE COUNCIL

Customer Service | 1300 292 872 | (02) 6670 2400

tsc@tweed.nsw.gov.au
www.tweed.nsw.gov.au

PO Box 816
Murwillumbah NSW 2484