
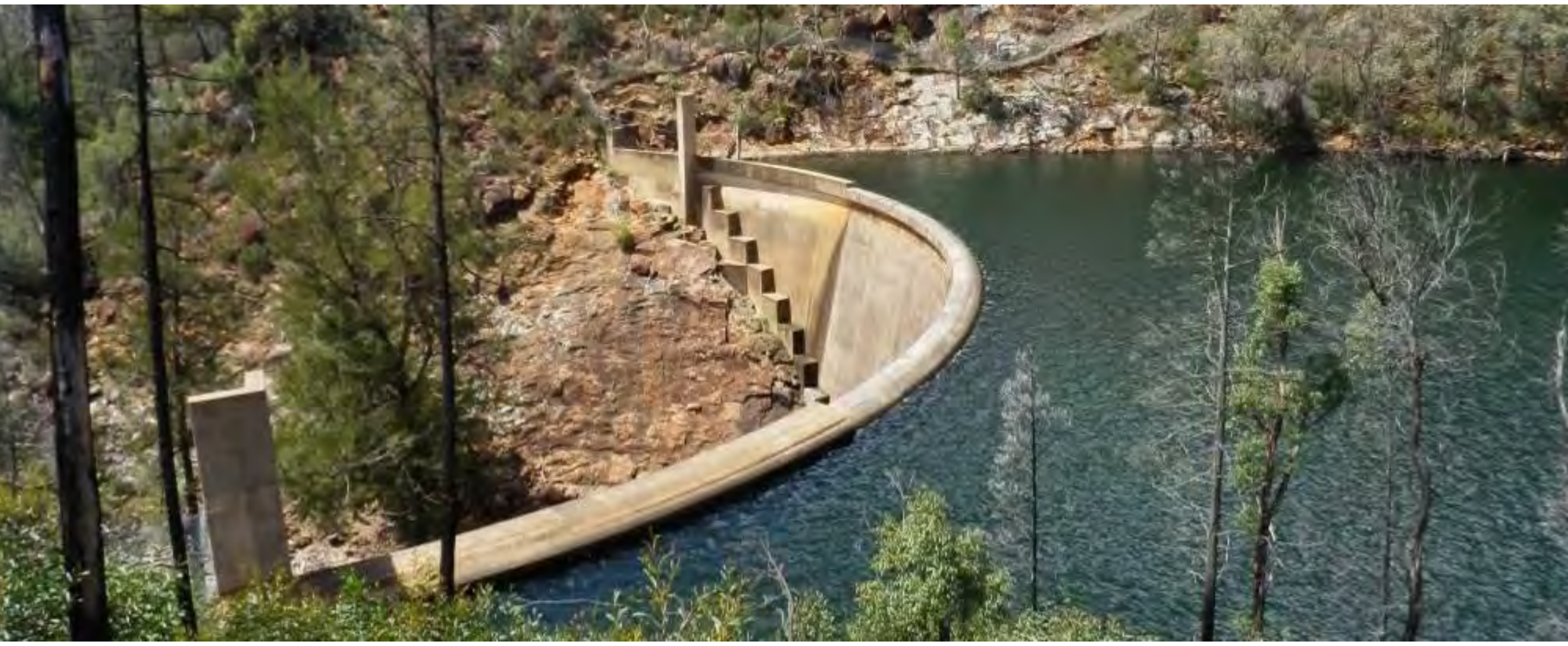

TIMOR DAM RAISING

CONCEPT DESIGN REPORT

Report Number ISR18049

November 2018

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Executive Summary

This report concerns concept design for the raising of Timor Dam. The proposed raised dam will increase its storage capacity from 1,140 ML to 1,810 ML and is expected to meet the additional water security requirements of the Warrumbungle Shire community well into the future.

The preferred dam raising option incorporates increasing the dam's full supply level (FSL) by 3 metres and consequent raising of the existing concrete arch dam and saddle dam. The existing intake trunnion and outlet works will also be upgraded.

In accordance with NSW Dams Safety Committee (DSC) guidelines, Timor Dam has been assigned a HIGH A Flood Consequence Category (FCC) which requires safe passage of the Probable Maximum Flood (PMF). The dam has also been assigned a SIGNIFICANT Sunny Day Consequence Category (SDCC) which requires it to withstand a 0.2% AEP (500 year) earthquake.

Concept design for the raised dam and its components has been based on updated hydrological and geotechnical investigations, seismic and structural assessments. This report presents a detailed concept design for the preferred dam raising option. Drawings and cost estimate are included as well as discussion on project risks and constructability.

Concept design has been undertaken in full compliance of DSC and ANCOLD requirements and current best practice.

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Glossary of Terms / Abbreviations

Abutment

That part of the valley side against which the dam is constructed.

AHD

Australian Height Datum.
A datum for the recording of elevations. Zero metres AHD approximates mean sea level along the cost

ANCOLD

Australian National Committee on Large Dams

Annual Exceedance Probability (AEP)

The probability of a specified magnitude of a natural event being exceeded in any year.

BOM

Bureau of Meteorology

Catchment

The land surface area that drains to a specific point, such as a reservoir.

Consequence

Effects of an action or event (e.g. the potential for loss of life, property or services).

Consequence Category

The scale of adverse consequences subsequent to a dam failure. Refer also Flood Consequence Category and Sunny Day Consequence Category.

Council

Warrumbungle Shire Council (WSC).

Dam Crest Flood (DCF)

The flood event which, when routed through the reservoir, results in a still water reservoir level at the lowest crest level of the dam.

DSC

NSW Dams Safety Committee.

Flood Consequence Category (FCC)

An estimate of the adverse consequences emanating from flood failure of the dam, such as loss of life, property and services damage and environmental effects.

Foundation

The undisturbed material on which the dam structure is placed.

Freeboard

The vertical distance between a stated water level and the top of the non-overflow section of a dam.

Full Supply Level (FSL)

The maximum normal operating water surface level of a reservoir.

GPa

Gigapascal (unit of pressure, measurement of strength or modulus, equivalent to 1,000MPa)

H & V

Horizontal and Vertical e.g. 3.5H to 1V describes the steepness of a slope or batter.

Height of Dam

Normally the maximum height from the lowest point of the general foundation area to the top of the dam.

Inspection

A careful and critical viewing and examination of all visible aspects of a dam.

kc

Routing parameter used with the RORB hydrological model to assess flood runoff within a catchment.

MPa

Megapascal (unit of pressure, measurement of strength, equivalent to about 145psi).

Probable Maximum Precipitation (PMP)

The theoretical greatest depth of precipitation for a given duration that is physically possible over a particular catchment area.

Probable Maximum Flood (PMF)

The flood resulting from PMP and, where applicable, snow melt, coupled with the worst flood-producing catchment conditions that can be realistically expected in the prevailing meteorological conditions.

Probable Maximum Precipitation Design Flood (PMPDF)

The flood derived from the PMP using AEP neutral assumptions, and as such it is estimated to have the same AEP as the PMP.

PWA

Public Works Advisory (formerly NSW Public Works).

RL

Reduced Level (Survey).

RORB

The software program used to analyse the hydrology (rainfall–runoff processes) of the catchment and calculates hydrographs and peak discharges.

SCADA

Supervisory Control and Data Acquisition, a means of remote access, associated with telemetry.

Sunny Day Consequence Category (SDCC)

An estimate of the adverse consequences emanating from the non-flood (e.g. earthquake) failure of a dam, such as loss of life, property and services damage and environmental effects.

WAE

Work As Executed

1. Introduction

1.1 General

Warrumbungle Shire Council has engaged Public Works Advisory (PWA) within the Department of Finance, Services and Innovation to undertake concept design for the proposed raising of Timor Dam. The raising of Timor Dam seeks to increase the storage level by 3 metres, that is, from the current Full Supply Level (FSL) of RL611.21m(AHD) to RL614.21m(AHD). The proposed raised dam will increase the dam's storage capacity from 1,140ML to 1,810 ML, an increase of about 59%. The project aims to meet the additional water security requirements of the Warrumbungle Shire community into the future.

This report presents discussion of associated investigations and concept designs and includes drawings and cost estimate for the preferred dam raising option. The preferred option has been based on recommendations from the Timor Dam Raising Feasibility Study Report and on subsequent concept analyses.

1.2 Project Deliverables

The key deliverables of this project include the following:

- Site inspection and geological reconnaissance of the dam site;
- Timor Dam Raising Feasibility Study;
- Structural review of both the existing and raised arch dam structure including 3D Finite Element (FE) analysis;
- A comprehensive Concept Design Report incorporating discussion of all investigations, analyses and results and including drawings and cost estimate of the preferred raised dam arrangement.

1.3 The Existing Dam

Timor Dam is located on the Castlereagh River 12 km west of Coonabarabran. The dam is accessible by an unsealed road off Timor Road. Timor Dam was designed and constructed by Public Works, being completed in 1962.

The dam is a concrete arch structure with overfall spillway. The dam has a maximum height of 19.5m, a crest length of 68m, a crest width of 1.4m and an arch radius of 33m. The upstream face is vertical and downstream face slopes at 1H to 5V. The dam wall is divided into 13 units with vertical expansion joints between adjacent units. A nappe aeration column is provided at each end of the wall.

There is a saddle dam of homogeneous earthfill construction located 300m north of the main dam. The saddle dam has a maximum height of 4.9m, is 55m long and has a crest width of 3.7m. Its upstream face has a slope of 3.5H to 1V and is protected by rip-rap. The downstream face has a slope of 2.5H to 1V and is topsoiled and grassed.

The dam catchment area is 20km^2, and the reservoir storage area at full supply level is 0.2 km^2. The storage capacity of the reservoir at Full Supply Level (FSL) RL611.16m AHD is 1,140 ML,

Both the main dam and the saddle dam are located on a north-south axis with the downstream face to the east.

A 250mm diameter trunnion, supported by a barrel (float), discharges directly into a spigot/socketed cast iron water supply outlet (trunnion gravity main), with an isolating (gate type) valve located adjacent to the trunnion pivot. The cast iron pipework becomes buried under the ground in a trench or tunnel (within 50m of the tower) and passes underneath the saddle dam. The water gravitates to a conventional water treatment plant and is later distributed into the reticulation system. There is a sluice valve located approximately 80m downstream of the saddle dam for isolation of the line.

The lowest intake level is 11.5m above the storage bed level, resulting in a dead storage of 220 ML. Approximately 170 ML can be extracted by a dead storage pump system during drought times.

The scour outlet is located at the base of the concrete arch wall. The outlet has a carbon steel trash screen mounted to the inlet and has a 600mm guard (gate type) valve located in the valve chamber. A 100mm bypass line branches off upstream of the guard valve within the valve chamber, the bypass line is fitted with its own isolating (gate type) valve. Both the 600mm and 100mm diameter valves are manually operated. Extension spindles are required and the valves are operated from on top of the roof of the valve chamber through penetrations provided in the roof of the valve chamber.

Access to the top of the valve chamber is via an individual-rung (step iron) type vertical ladder located on the side wall of the chamber. Major changes to how the valves are currently operated are required to bring the system up to current standards.

WAE drawings of the existing Timor Dam are attached at **Appendix A**.

1.4 Review of Available Data

The review of available data has included review of the following:

* Timor Dam WAE Drawings
  From the original dam construction (PWA archives).

* Timor Dam Surveillance Report (PWA, 2015)
  This report describes the condition of the dam at the time of inspection (2015) and provides recommendations for continued surveillance. It also provides comment on its performance to date and status of safety documentation in accordance with NSW Dams Safety Committee requirements.

* Timor Dam Mechanical Equipment, Condition Assessment and Upgrade Recommendations (PWA, 2016)
  Site inspection and underwater investigation have revealed that, generally, most intake and outlet mechanical components were in reasonably good condition for their age. However, current WHS regulations are not met and it is questionable if the dam's mechanical components are adaptable to dam raising.

* Hydrology Study (GHD, 2016)
  Using the RORB hydrological model, this study determines the PMP and subsequently presents PMF hydrographs over a range of periods that are to be used for the raised dam design.

* Yield Study Report (NSW Urban Water Services, 2017)
The results of this study suggest the benefits in yield from the proposed raising of Timor Dam.

* Geotechnical Investigation (SMEC, 2016)
The purpose of this investigation has been primarily to develop a geological model of the foundation rock; confirm that no adversely oriented geological structures were present in the dam abutments; and develop design strength parameters for the strength of concrete; concrete lift joints; concrete to rock interface; foundation bedrock; and saddle dam earth fill. Data from this investigation are to be used in the design of the raised dam.

* Dambreak and Consequence Assessment (Entura, 2017)
Based on this assessment, Timor Dam has been assigned a Flood Consequence Category (FCC) of HIGH A and a Sunny Day Consequence Category (SDCC) of SIGNIFICANT. These results determine the flood and earthquake capacity requirements for the raised dam.

* Seismic Assessment (Arup, 2016)
This report details the methodology, assessments, and results of a probabilistic seismic hazard analysis (PSHA) performed for the Timor Dam, as required for the dam raising concept design analysis and input into the 3D Finite Element model.

* WHS Security and Access Audit (Constructive Solutions, 2016)
This study has identified significant deficiencies in the safety of operations at Timor Dam. Particular areas of concern include not managing the risk of remote and isolated work, fall from heights, “on water” operations and the lack of effective hazard and risk management processes. Measures for reducing risk are included which are to be considered in the design of the raised dam.

1.5 Site inspection and Feasibility Study

As part of this project, site inspection of Timor Dam was undertaken by PWA in January 2018. A geological reconnaissance of the main arch dam and the saddle dam sites was also undertaken during the inspection and incorporated in a Site Inspection Report. The site inspection did not identify any engineering impediment to raising either the main concrete arch dam or the earthfill saddle dam. Foundation conditions for the raised dam were considered adequate. Potential material sources for the raising of the saddle dam were also indicated.

A feasibility study for the raised dam and its components was carried out and discussed with Council officers at Council Chambers in June 2018 prior to finalisation. Essentially, the report recommended:

- raising of the main concrete arch dam by superimposing an additional 3m concrete arch on top of the current structure but which acted independently of it;
- raising of the saddle dam in earthfill using locally obtained materials; and
- feasible options for upgrading the intake trunnion and outlet works.

Drawings and cost estimate of the raised dam were included.

2. Hydrological and Flood Considerations

Note: The information provided in this Section is sourced from GHD, *Timor Dam Hydrology Report*, December 2016.

2.1 Hydrology for Timor Dam

The hydrology for Timor Dam was developed using the RORB hydrological model.

The following scope was included as part of the hydrology study:

- Collection, collation and review available historical rainfall, streamflow, dam storage level and storage-stage-surface area relationship data;
- Development of RORB models of the Castlereagh River catchment study area including all contributing sub-catchments;
- Calibration and validation the RORB model against actual rainfall event data;
- Estimation of Probable Maximum Precipitation (PMP) on the Castlereagh River Catchment; and
- Determination of concurrent flood hydrology for catchments downstream of the dam which drain into the main conveyance system and production of flood inflow hydrographs (for the nominated events and durations) to a point where incremental breach impacts are less likely than 0.3m.

Since RORB is not self-consistent, two models have been setup as “end of catchment models”:

- A local Timor Dam RORB model.
- A catchment wide Coonabarabran model to simulate concurrent tributary inflows for input to future dam breach simulations

Compilation of the RORB model has included:

- Catchment delineation based on the topography. For the local Timor Dam model, 13 sub-catchments have been delineated. For the Coonabarabran model, 15 sub-catchments have been delineated.
- Catchment parameter determination, namely sub-catchment area reach lengths and slopes.
- Estimation of impervious areas, where 5% has been adopted to represent the rural nature of the catchment.
- Design rainfall used for the RORB model included the 20%, 10%, 5%, 2%, 1%, 0.1%, 0.01%, 0.001%, 0.0001% as well as the Probable Maximum Precipitation Design Flood (PMPDF)

Design rainfall events were derived in accordance with the procedures of the Australian Rainfall and Runoff, Region 2 (AR&R 1987).

Given the size of catchment and recommended BOM thresholds, the Probable Maximum Precipitation (PMP) was compiled using the Bureau of Meteorology Australia Generalised Short Duration Method

(BOM, 2003). The PMP rainfall depths derived for a range of durations using this method are tabulated below.

Table 2.1 – PMP Rainfall Depths

Duration (hrs)	Local Timor Dam PMP Rainfall Intensity (mm/hr)	Duration (hrs)	Coonabarabran Model PMP Rainfall Intensity (mm/hr)
0.25	600	0.25	440
0.5	440	0.5	320
0.75	373	0.75	267
1	330	1	250
1.5	287	1.5	213
2	250	2	185
3	200	3	150
4	175	4	128
5	150	5	110
6	133	6	98

The PMP rainfall depths have been simulated in the RORB model to calculate the Probable Maximum Precipitation Design Flood (PMPDF). Loss factors have been applied and relevant rainfall losses have been adopted.

The Probable Maximum Flood (PMF) has been estimated by considering the adopted parameters used to calculate the PMPDF. Given the size of the Timor Dam catchment and recognising that adopted rainfall losses are already low, the PMPDF could be adopted as the PMF.

2.2 Flood Hydrographs

The RORB model was simulated using a kc value of 4.86 for the local Timor model, together with design rainfall and rainfall loss estimates in accordance with Australian Rainfall and Runoff. The RORB model was simulated for a range of durations ranging up to 12 hours. For each event, the critical duration at which the peak flood flow occurs was reported, being the duration at which the peak flood flows.

Table 2.2 – Design Flood Peaks

Flood Event AEP	Timor Dam Flood Peak (m3/s)	Critical Duration (hrs)	Coonabarabran Peak (m3/s)	Critical Duration (hrs)
50%	57	6	313	6
20%	90	6	495	6
10%	111	6	626	6
5%	141	6	806	6
1%	213	4.5	1261	6
0.1%	326	4	1803	5
0.01%	493	3	2681	5
0.001%	703	3	3712	5
0.0001%	969	3	4793	4
MPDF/PMF	1256	2.5	5917	4

A number of sensitivity analyses were undertaken to determine the impacts of parameters and assumptions on flood hydrograph behaviour. This was achieved by making adjustments to the Timor Dam RORB model and re-simulation of the 1% AEP event. The items/assumptions assessed in the sensitivity analysis were sensitivity of rainfall loss parameters on the design flood hydrographs, future climate impacts on rainfall and sensitivity of RORB kc parameter

2.3 Design Flood for Timor Dam

The most recent dambreak study (Entura 2017) has assigned a Flood Consequence Category (FCC) of HIGH A for Timor Dam. In accordance with NSW Dams Safety Committee guidelines (DSC3A and DSC3B), the dam is required to pass safely the PMPDF. As concluded in the above hydrology study, the PMPDF can be adopted as the PMF.

From **Table 2.2**, the updated PMF is 1,256 m3/sec. This compares with the PMF of 1,239 m3/sec reported in the previous hydrology study (NSW Public Works, 2004).

When routed through the storage, the PMF updated outflow design flood is estimated to be 1,200 m3/sec (Entura, 2017). This is also the flood that the raised dam spillway will be required to pass safely.

3. Dambreak and Consequence Category Assessment

Note: The information provided in this Section is sourced from Entura, *Timor Dam Dambreak and Consequence Assessment*, November 2017.

3.1 General

This study modelled seven scenarios, three of which include a dambreak:

- Sunny Day Failure (SDF): no concurrent rainfall/flooding;
- Dam Crest Flood (DCF) with no dambreak;
- Dam Crest Flood with dambreak;
- Spillway Design Flood with no dambreak:
- Spillway Design Flood with dambreak;
- Probable Maximum Flood (PMF) with no dambreak;
- Probable Maximum Flood with dambreak.

The dambreak model comprised three components:

- Dambreak;
- 1-dimensional hydraulic model of the Castlereagh River channel;
- 2-dimensional hydraulic model of the floodplain.

A consequence assessment was completed using DSC and ANCOLD recommendations. The Population at Risk (PAR) and Probable Loss of Life (PLL) were determined using the Bureau of Reclamation Method and in accordance with DCS guidelines.

3.2 Consequence Assessment

Based on this assessment, Timor Dam has a flood consequence category (FCC) of **HIGH A** due to the incremental PLL, and a (non-flood) sunny day consequence category (SDCC) of **SIGNIFICANT** due to the Major classification of the severity of damages and losses. This information is summarised in the table below.

Table 3.1 – Consequence Category Classification

Scenario	Incremental Population at Risk (PAR)	Incremental Potential Loss of Life (PLL)	Severity of Damage and Loss	Consequence Category
PMF	149	15	Major	HIGH A
Design Flood	64	6	Major	HIGH A
DCF	3	0	Major	SIGNIFICANT
SDF	0	0	Major	SIGNIFICANT

Total estimates of PAR and PLL for all seven scenarios, for both the day and night conditions, are given in the table below.

Table 3.2 – Total PAR and PLL Estimates

Flood Scenario	PAR Business Hours	PAR After Hours	PLL Business Hours	PLL After Hours
PMF with Dambreak	473	441	9	15
PMF No Dambreak	324	384	0	0
Design Flood with Dambreak	276	320	3	6
Design Flood No Dambreak	212	256	0	0
DCF with Dambreak	1	3	0	0
DCF No Dambreak	0	0	0	0
SDF	0	0	0	0

3.3 DSC Requirements

Based on the above, and in accordance with DSC guidelines, Timor Dam has been assigned a HIGH A Flood Consequence Category (FCC), which requires safe passage of the Probable Maximum Flood (PMF) and a SIGNIFICANT Sunny Day Consequence Category (SDCC), which requires it to withstand a 0.2% AEP (500 year) earthquake (refer DSC3B & DSC3C respectively).

4. Geotechnical Considerations

Note: The information provided in this Section is sourced from SMEC, *Timor Dam Upgrade Geotechnical Investigations,* August 2016 and PWA, *Site Inspection Report,* January 2018.

4.1 Introduction

Relevant to consideration of the geological conditions of the Timor Dam site, the following documents have also been reviewed:

- Dent. B, 1982. *Coonabarabran Water Supply Augmentation. Timor Dam. Report on Engineering Geological Inspection.* Public Works Department, Design & Services, Report No. EG 82002, August 1982.
- SMEC, 2016. *Timor Dam Upgrade Project Geotechnical Investigations. Factual and Interpretive Report – Rev B Draft.* SMEC Project No. 30012236, Prepared for Warrumbungle Shire Council, 25/08/2016.

4.2 Regional Geology

Figure 1 presents the Coonabarabran regional geology from the Gilgandra 1:250,000 geological sheet, compiled by Offenberg (1968). The regional geology of the Timor Dam area has been described by Dent (1982), with extracts of this work presented in SMEC (2016). The Warrumbungles are a volcanic and intrusive shield comprising trachyte and basalt of Tertiary age (**Tv**). These igneous rocks intrude and overlie the **Pilliga Sandstone** that comprises sandstone, conglomerate and shale of Jurassic age (**Jp**).

Other smaller deposits of basalt of Tertiary age (**Tb**) cap the higher areas, especially to the south of Coonabarabran.

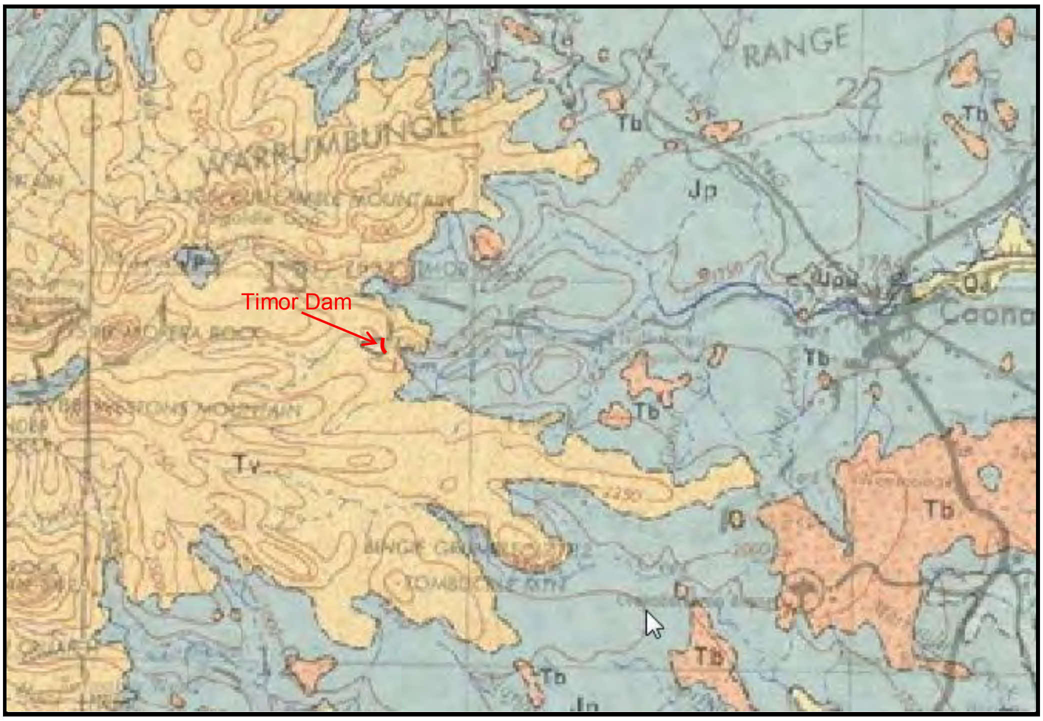

Figure 4.1: Timor Dam Regional Geology

4.3 Site Geology

4.3.1 Arch Dam

The existing concrete arch dam is founded on massive trachyte. The trachyte is underlain at depth by sandstone. At the main arch dam wall, the trachyte has been estimated to be in the order of 12 m thick under the valley base. The storage area and saddle embankment (to the north) are also underlain by trachyte.

On the abutments, the trachyte downstream of the dam wall crops out strongly. The rock mass is jointed with the prominent, near-vertical joint sets sub-parallel to the valley and sub-normal to the valley. These joints are generally moderately wide to widely spaced, tight, and are of limited continuity. On both abutments, exfoliation joints dip into the valley at 30° to 35°. These joints have a similar spacing to the near-vertical joints and are open; however, it is interpreted that they were removed during foundation excavation. Further details on the rock mass are found in Dent (1982) and SMEC (2016).

Limited laboratory tests (6) indicate very strong rock substance strength, and Young's Modulus of 15 – 55 GPa, average 35 GPa (SMEC, 2016). Dry density of the trachyte varied in the range 2.57 t/m^3 to 2.59 t/m^3.

Limited testing during construction showed a tight foundation, which was not grouted. Water pressure tests in recent boreholes confirmed the tightness of the foundation, showing negligible losses in the three boreholes tested (SMEC, 2016).

4.3.2 Saddle Embankment

The saddle embankment is also founded on trachyte, with sandstone occurring at some depth beneath the foundation. Soil profiles are likely to be thicker and less bouldery in flatter areas near the bases of slopes.

4.4 Foundation Conditions

4.4.1 Existing Arch Dam

The foundation for the concrete arch was excavated an additional 5 feet (1.525 m) beneath the stripped surface. The foundation is interpreted to comprise slightly weathered, fresh (stained) and fresh trachyte. This interpretation is confirmed by excavation debris downstream of the wall.

SMEC (2016) interpreted Hoek-Brown rock mass strength criteria, using 'Roclab', at a confining stress of 500kPa, the equivalent of a 20m high concrete dam, as c' = 2MPa and φ' = 65°.

Concrete properties from test results on limited core samples are presented in SMEC (2016). Testing results indicate that the substance strength of the concrete is in the order of 20MPa to 25MPa, with modulus values in the order of E = 30GPa. Limiting parameters for concrete lift joint strengths are interpreted as:

- Limiting tensile strength = 1.0MPa; and
- Shear strength parameters of c' = 1.0MPa and φ' = 57°.

Based on three borehole intersections, interpreted concrete-foundation interface strength parameters are:

- ZERO tensile strength; and
- Shear strength parameters of c' = 0.2MPa and φ' = 55°.

4.4.2 Raised Arch

On the left abutment, the footprint of the proposed raised arch is interpreted to have similar surface conditions to those in the middle/upper abutments of the existing dam. However, the curvature of the arch and the left abutment thrust block of the existing dam wall (WAE Drawing 4 - 93) align to almost parallel the slope of the abutment. Detailed survey would be required to optimise the layout of a raised structure.

On the right abutment, the footprint of the proposed raised arch is also interpreted to have similar surface conditions to those in the middle/upper abutments of the existing dam. The arch and the right abutment thrust block of the existing wall are oriented into the abutment. Continuing excavation for a new thrust block for a raised dam wall could be carried out along the same alignment. The proposed foundation footprint comprises a large bouldery layer above trachyte bedrock. Excavation to a similar depth as the existing dam should provide a suitable foundation for a raised wall.

4.4.3 Existing Saddle Embankment

The saddle embankment is located approximately 250m to the north of the arch dam wall. WAE Drawing 7 – 93 shows the saddle embankment to be a homogeneous earthfill embankment of locally won clayey sandy silt soil with gravel, with a thin layer of rip rap on the upstream face. Topsoil was stripped from the foundation and a central cut-off trench was excavated an additional 10 feet (3.05m) to impervious, interpreted weathered trachyte.

Details of the embankment design and earthfill properties are provided in SMEC (2016). The earthfill comprises clayey sandy silt, with approximately 15% gravel (rock fragments), with a CL Unified Classification. Earthfill within the embankment is non-dispersive. Shear strength parameters interpreted from tests on highly compacted borehole tubes were not typical of CL materials. Typical parameters would be C’ = 3 – 5kPa and φ’ = 30º – 33º, when placed at 1.70 t/m^3.

4.4.4 Raised Saddle Embankment

The extended foundation footprint for a raised saddle embankment will extend beyond the currently fenced area. The footprint is likely to have similar foundation conditions as the existing embankment. On the right abutment, there is substantial boulder outcrop of trachyte.

On the shallower sloping left abutment, trachyte boulder outcrop is not prominent immediately above the existing embankment, indicating potential for a variation in conditions. This difference in surface conditions may be a result of clearing during the original construction; however, upstream of the boat shed, there are lines of bouldery trachyte along the shoreline.

A similar weathering profile is interpreted on the right abutment; hence, foundation excavation as carried out for the existing embankment would be appropriate. At this stage, similar depths of excavation should be anticipated on the left abutment, unless modified by later geotechnical investigation data.

4.5 Construction Materials

Construction materials required for the proposed raising include concrete, earthfill, filter material (fine and coarse) and small rockfill for use as rip-rap. Volumes of these materials are relatively small. It is unlikely that concrete will be batched on site and will be obtained from existing commercial suppliers. Potential sources of other construction materials for raising the saddle embankment have been identified.

5. Seismic Hazard Assessment

Note: The information provided in this Section is sourced from Arup, *Timor Dam Seismic Assessment,* February 2018.

5.1 General

A probabilistic seismic hazard analysis (PSHA) has been carried out at Timor Dam to support the dam raising concept design analysis.

Timor Dam sits on the Castlereagh River within a corridor of sedimentary rocks deposited on and between the Lachlan Fold Belt rocks to the south and west, and the New England Fold Belt to the northeast. The site is on the northwest margin of the South East Seismic Zone, and has low to very low seismicity as recorded in the instrumental catalogue. The closest neotectonic feature (e.g. showing recent displacement) is the 34.5km long reverse Walgett Scarp, 115km to the north-northeast of the dam site.

An earthquake catalogue was compiled and processed for the study area from instrumental and historical records. Instrumental records from 1900 were compiled from the International Seismological Centre, the EHB Bulletin in ISC, the ISC-GEM Global Instrumental Earthquake Catalogue and Geoscience Australia.

Review of the existing geotechnical investigations at the site shows the local ground conditions correspond to a Site Class Ae – Strong Rock with an estimated shear wave velocity (Vs) of 1500 m/s. A suite of Ground Motion Prediction Equations characterising Australian earthquakes, stable continental regions, and active tectonic regions were used to calculate ground motions.

Calculation of the expected ground motion recurrence at the site has included response spectra, peak ground acceleration (PGA), peak ground velocity (PGV), and Modified Mercalli intensity (MMI) for six return periods (500; 1,000; 5,000; 10,000; 50,000; 100,000-years) at 5% damping. The results are presented in the table below.

Table 5.1 – PGA, PGV, MMI Results

Return Period	Earthquake AEP	PGA (g)	PGV (cm/sec)	MMI
500 years	0.2%	0.02	0.53	II
1,000 years	0.1%	0.04	1.56	!V
5,000 years	0.02%	0.1	3.74	V
10,000 years	0.01%	0.12	5.78	V-VI
50,000 years	0.002%	0.33	11.52	VII
100,000 years	0.001%	0.43	17.59	VII

6. WHS, Security and Access

Note: The information provided in this Section is sourced from Constructive Solutions, *Timor Dam WHS, Security and Access Audit,* July 2016.

6.1 General Findings

A WHS, Security and Access Audit for Timor Dam has found four principal areas of non-compliance with current regulations. These can be summarised as follows:

1. **Remote and isolated** – a worker is generally working alone at the dam and there are no communications protocols or systems in place to manage this risk;
2. **Working at heights** – ladders to structures and platforms are non-compliant with current standards and accessing the outlet structures to the dam presents a significant risk;
3. **Provision of safe systems of work** – there are no procedures or guidelines for safe undertaking of the work carried near water where there is a risk of drowning, i.e. “on water” tasks; and
4. **Hazard and risk management** – there is no regular WHS inspection of the site and the only risk assessments sighted were old and significantly deficient.

Further, it has been noted that access to the seepage measurement weir downstream of the main arch dam is very difficult and Council staff are not recording seepages regularly as required by the DSC. Connection to telemetry is also not available.

7. Preferred Dam Raising Arrangement

7.1 Main Arch Dam

As mentioned previously, Timor Dam has been assigned a HIGH A Flood Consequence Category (FCC), which requires safe passage of the Probable Maximum Flood (PMF) and a SIGNIFICANT Sunny Day Consequence Category (SDCC), which requires it to withstand a 0.2% AEP (500 year) earthquake.

The current Full Supply Level (FSL) of the dam is at RL611.210m AHD (survey by Geolyse, 2016). The arch dam crest level is at RL611.502m AHD.

Site assessments have shown the existing concrete arch structure to be in good condition (PWA, 2015 and 2018). 2D analysis (using computer program STRAND 7) has indicated that the existing concrete arch dam would withstand the additional loading imposed by raising the FSL by 3 metres (refer **Appendix C**). The proposed raised FSL would be at RL614.210m AHD and the raised dam crest level at RL614.502m AHD (maintaining the current overfall spillway depth).

Because the existing structure is a concrete arch, the preferred option for raising involves providing an additional 3m deep arch on top of the current structure.

The proposed raising involves a new arch above the existing arch which would be structurally independent from the existing structure. Refer **Figures 1 to 4 at Appendix B**. This ensures true arch action of the raised section. Such action (including shrinkage, creep and temperature effects) would be in doubt if the raised section was bonded to the existing dam. This concept has been successfully employed for the raising of a similar type dam in Victoria.

Separation of the raised arch from the existing structure would also prevent movements and stresses being transmitted vertically down the raised wall into the existing arch dam.

Due to the poor configuration of the abutment contours at crest level, it will be necessary to construct two concrete abutment sections as indicated on **Figure 2, 3 and 4 at Appendix B.** On the left side (looking downstream), the concrete abutment would be constructed within hard rock located to the side of the dam. On the right side, the concrete abutment would continue the arch alignment and, again, be within hard rock foundation. The top of the abutments would be at the same level as the raised saddle dam.

The concrete abutment sections have been analysed for stability against hydrostatic loads and earthquake and appropriate factors of safety have been applied to the design. The abutment blocks are anchored to the rock foundation.

It is proposed, following concept design, to carry out **a 3D finite element analysis** of both the existing arch dam and raised structure which will confirm the final arrangement and section dimensions.

7.2 Saddle Dam

The current crest level of the earthfill saddle dam is RL616.09m AHD. For the existing dam, the updated PMF Outflow Flood Level is RL615.54 (Entura, 2017).

For the raised dam, the revised PMF Outflow Flood Level has been assessed to be at RL618.55m AHD (based on an estimated Outflow Flood of 1,200m3/sec). Adopting a 0.6m freeboard, as required by DSC3A, the raised crest level of the saddle dam would be at RL619.15m AHD.

For raising the saddle dam, the preferred option involves raising by placement of additional earthfill using mainly locally sourced materials. The option is illustrated on **Figures 5 and 6 at Appendix B**.

For the raised saddle dam the upstream face is protected with rip rap while the downstream slope is topsoiled and grassed. Realignment of access roads to both sides of the crest of the saddle dam is also required.

Using appropriate parameters based on site inspection and geotechnical investigation, a 2D stability analysis (using the computer program SLOPEW) has been undertaken which indicates that the raised saddle dam would be safe against the critical load cases of steady state at FSL, steady state with maximum flood, rapid drawdown and earthquake at FSL (refer **Appendix D**). A summary of results is presented in the Table below.

Table 7.1 - Stability Analysis Results

Load Case	Storage	FOS	FOS Required
Steady State (Upstream)	Storage at FSL	2.07	1.50
Steady State (Downstream)	Storage at FSL	1.73	1.50
Steady State (Downstream)	Storage at Maximum Flood Level	1.72	1.50
Rapid drawdown	No Storage	1.40	1.20
0.2% AEP (Upstream)	Storage at FSL (+ 0.02g)	1.74	1.00
0.2% AEP (Downstream)	Storage at FSL (+0.02g)	1.55	1.30

The Factor of Safety (FOS) required is based on the US Corps of Engineers loading conditions and safety factors (reported in R. Fell, P. MacGregor and D. Stapledon).

7.3 Instrumentation

The seepage weir located downstream of the main arch dam is not functioning appropriately and needs repair. A new seepage measurement weir is required to be constructed which should be well accessible in accordance with current WHS standards.

A new seepage weir is also proposed downstream of the saddle dam raised embankment which is connected to the toe drain.

Refer **Figure 8 at Appendix B** for seepage weir concept details.

As the seepage weir is the only form of instrumentation on this dam, it is most important that it is closely monitored and well maintained. It is recommended that seepage measurement be connected by SCADA to Council's offices in order to ensure continual recording of data as preferred by the DSC.

Additionally, a dam monitoring network is to be established which will allow survey monitoring to be undertaken in accordance with DSC and ANCOLD requirements (refer **Section 9**)

7.4 Security

Secure fencing will be provided around the dam site in accordance with DSC2H to prevent unauthorised entry of personnel and vehicles.

7.5 Access

Current access roads around the dam will be paved and well drained to accommodate Council trucks and other traffic in the long term. Widening of current roads is not envisaged. Parking areas are to be provided adjacent to the main concrete wall (left abutment) and the saddle dam. Following completion of the raising works, vehicles will also need to travel across the raised saddle dam crest and to the boat ramp on the left bank of the storage. Refer also **Figures 1 and 5 at Appendix B**.

Photo 7-1: Access between existing boat shed and saddle dam

Access to the seepage weir downstream of the arch dam is currently very difficult and would be upgraded in accordance with WHS requirements as part of the proposed dam raising works.

8. Intake and Outlet Works

8.1 General

A recent condition assessment (NSW Public Works, 2016) indicated that, while the condition of the inlet and outlet works was good, significant upgrading would be required in conjunction with the proposed dam raising in order for the works to meet current WHS regulations and Australian Standards.

8.2 Trunnion Inlet

The current trunnion arrangement is not suitable for an increase in the FSL of the dam. The existing tower is considered to be at its limits in terms of its height and size. Additional loading by supporting the longer trunnion arm and increased height of the tower is likely to require stronger structural support. Further, the current ladder system is unacceptable under current standards and needs to be upgraded to reflect the current Australian Standards and WHS regulations.

Options for upgrading the trunnion inlet were presented in the recent condition assessment (NSW Public Works, 2016) and the Feasibility Study Report (PWA, 2018).

The preferred upgrade option involves decommissioning of the existing arrangement, replacement with an extended trunnion, replacement of the trunnion stay with a larger stay and installation of a floating buoy (capable of raising the trunnion inlet out of the water).

Photo 8-1: Typical trunnion floating buoy

Example drawings of this option are shown on **Figure 7 at Appendix B**.

With this arrangement, the buoy has the ability to lift the trunnion inlet completely out of the water to allow easy maintenance on the inlet screen. This option also allows the water to be drained out of the system due to the inlets ability to be above the water level.

Additionally, this option avoids the complexity and expense of strengthening the existing tower and platform.

8.3 Gravitation Main under Saddle Dam

There is a 250mm diameter cement lined cast iron gravitation main approximately 5 metres under the saddle dam which delivers water from the storage via the trunnion. The pipe is unencased and its condition is unknown (NSW Public Works, 2016). To intercept any possible leakage which may escape from the pipe and into the foundation, a blanket filter is proposed under the raised saddle dam embankment section which is connected to a toe drain. If leakage were to occur, it would be captured by the blanket filter and directed into a seepage measurement weir downstream of the saddle dam.

8.4 Scour Inlet/Outlet

The scour inlet is currently below the silt level and is therefore inoperable. A new inlet is proposed which would include pipework connecting the upstream end of the existing scour inlet to the dam storage above the silt level.

A new outlet system is recommended. The new outlet system is to include a separate facility for environmental flows to comply with modern dam practice.

Current standards require a minimum two valves per line to allow double isolation and isolation for regular operation of the valves for maintenance purposes. This allows the valves to be operated under no flow conditions and therefore does not risk the possibility of the dam draining if a single valve cannot be closed properly. In addition, if one valve fails to close, the other valve can be closed to stop the flow.

Options for upgrading the scour outlet were presented in the recent condition assessment (NSW Public Works, 2016) and the Feasibility Study Report (PWA, 2018).

The preferred option includes the normal scour outlet with a separate environmental flow outlet.

A proposed schematic of the system and a table of all the valves are shown below.

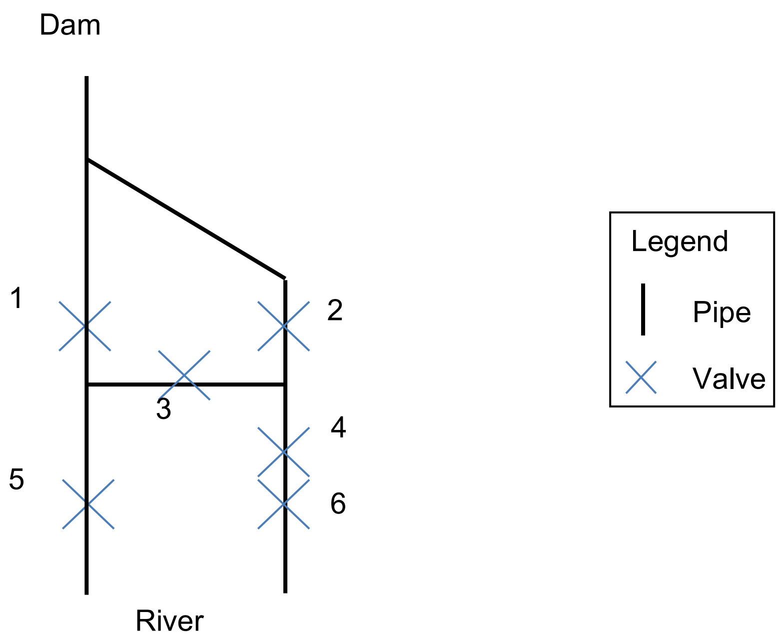

Figure 8-1: Outlet System Schematic

Table 8.2 - Valve Overview

Valve	Description
1	Manually actuated guard valve (double eccentric butterfly type) 600mm
2	Manually actuated guard valve (gate type) 100mm
3	Manually actuated interconnecting valve (gate type) 100mm
4	Manually actuated isolation valve (gate type) 100mm
5	Remotely actuated control valve (gate type) 600mm
6	Remotely actuated control valve (gate type) 100mm

The guard valves (1 and 2) and isolation valve (4) would normally remain open, the end valves would control the flow. The control valves would be remotely operated to allow operation of the valves without requiring operational staff descending to the base of the dam wall.

A bypass or interconnection between the two lines is suggested with a gate valve (3) installed. This would normally remain closed.

It is preferred that the control valves be operated remotely via telemetry (at the Council office) and operated locally at a new control cabinet located on the left hand abutment above the new design flood level. A valve used to control environmental flows is operated more frequently; therefore, if the dam is not regularly visited, then operation from the office is considered very advantageous.

A control cabinet and backup generator port would be installed on the left hand abutment at the end of the access road adjacent to the concrete wall. The electrical lines would need to be protected from damage by spillway overflow while passing from the control cabinet to the valve.

A flow meter should be installed in the offtake to allow easy measurement of flow.

Construction of an enlarged concrete valve block/chamber is proposed for protection of the valves.

The provision of a new trash screen and emergency bulkhead gate at the upstream end of the existing scour pipe is also recommended (the current ones not being in good condition).

9 Dam Survey Monitoring

9.1 General

As part of this concept for the raising of Timor Dam, the establishment of a dam survey monitoring network has been investigated. A precision monitoring report has been produced by PWA and is attached at **Appendix F**. A summary of the report is provided below.

9.2 Survey Control Network

The intention of the proposed survey network described in this report is to monitor both the absolute movement of the main arch dam wall within the valley it sits, and the relative movement of components of the dam wall.

The proposed primary control network is comprised of three concrete pillars located beyond the extent of the concrete dam wall. These pillars will act as stable reference points against which the absolute movement of the wall can be measured. **Figure 9.1** shows the proposed pillar locations. More detailed description is provided in the report attached at **Appendix F**.

Figure 9-1: Survey Pillar Location

The steep embankments found at Timor Dam may prohibit the installation of pillars P2 and P3. If this occurs, other control station options such as stable instrument plates secured into the existing rock surfaces would be investigated.

9.3 Settlement Point Network

The proposed settlement point network consists of a total of seven marks. See **Figure 9.2** below. Five of these marks will be located along the proposed raised crest of the dam wall. These marks will need to be designed in a way so they are easily accessible for each survey. The remaining two settlement point marks are to be located at the toe of the dam wall on the downstream side. These two marks will monitor any unexpected movement that may occur at the base of the wall.

The proposed layout of settlement points should allow for reliable detection of any major dam wall movements and has been designed to ensure that each point can be observed from at least two control points.

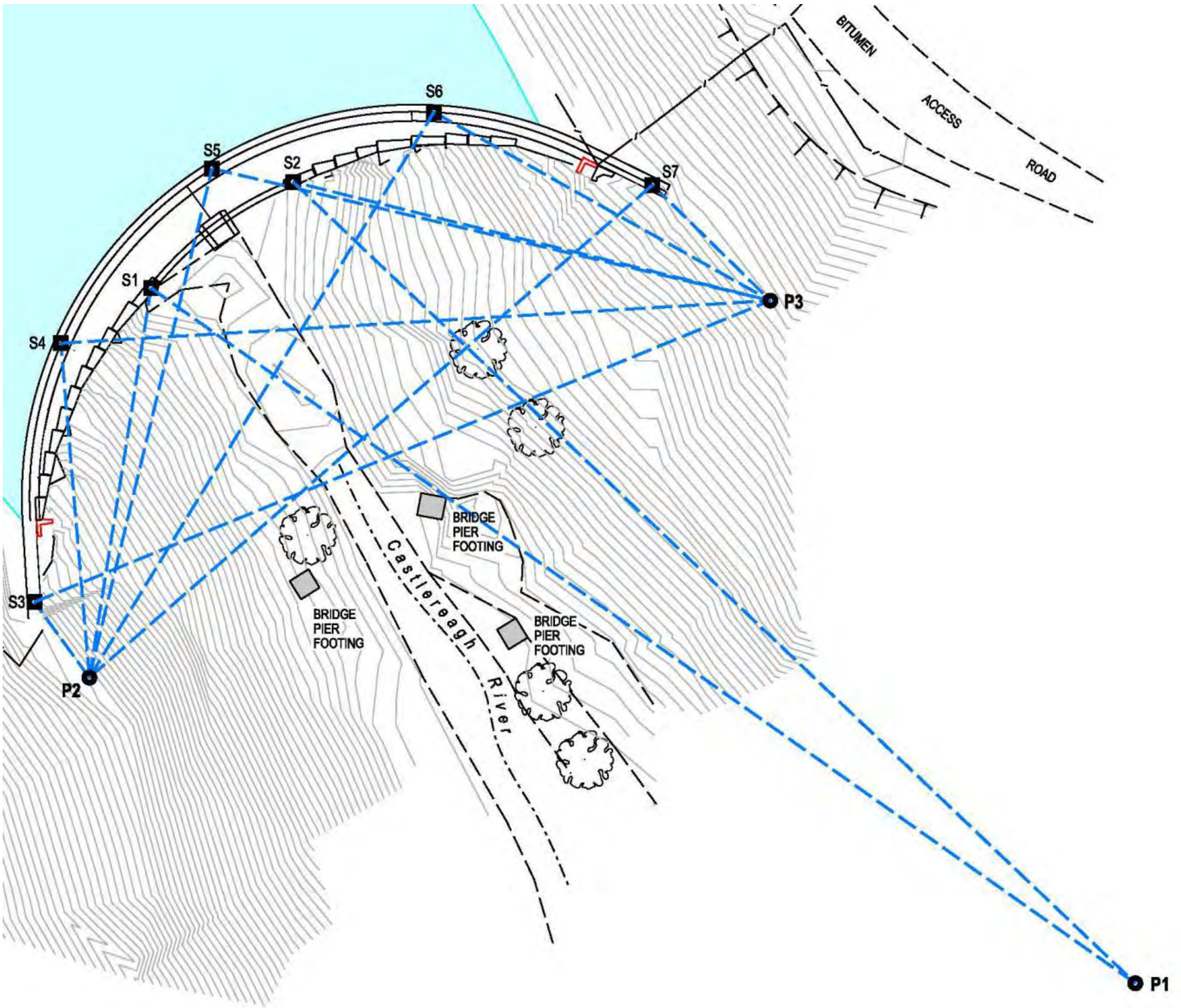

Figure 9-2: Settlement Point Network

9.4 Network Optimisation

The network described above has been subjected to a network optimisation analysis using the Compnet 2.9 Least Squares Adjustment survey software. The optimisation allows for prediction of accuracies that are achievable taking into account instrument locations, instrument type and particular measurement techniques.

9.5 Precise Levels

All concrete survey pillars would incorporate a BM (bench mark) in the base plinth and the top of the thread for each concrete pillar would also be levelled (site permitting). An additional site bench mark may also be required and will be assessed further at the time of the network installation.

Settlement points S1-S2 and the survey pillars would be levelled using precise levelling techniques utilising a Leica DNA03 precise digital level and invar barcode staff, or equivalent. Such a combination would reasonably yield levelling results to +/-1mm (this has been reliably achieved in the past at similar dams by Public Works Advisory).

Settlement points S3 – S7 would be levelled using the Trig. Heightening technique given their difficulty to access. This technique would reasonably yield levelling results to +/-3mm.

9.6 Network Installation

It would be prudent to install the pillars during the dam raising construction process due to the steep terrain of the dam site. Furthermore, the construction activity related to the raising may also present other opportunities for the survey network such as access tracks and clearings.

10 Construction Methodology

10.1 General

It is proposed to raise the full supply level (FSL) of Timor Dam from RL611.21m AHD to RL614.21m AHD. Storage capacity is increased from 1,140ML to 1,810ML.

The following configuration for the raised dam applies:

Raised arch dam spillway FSL = RL614.210m AHD

Raised arch dam crest = RL614.502m AHD

Raised arch dam length = 68m

PMF outflow level = RL618.55m AHD

Raised arch dam concrete abutment blocks crest = RL619.150m AHD

Raised saddle dam crest = RL619.150m AHD

Freeboard at PMF = 0.6m.

Raising of the main arch dam will involve construction of a 3m concrete arch above the existing arch structure while raising of the earthfill saddle dam will incorporate locally sourced materials.

Refer concept drawings attached at **Appendix B** which illustrate the proposed dam raising.

10.2 Lowering of the Storage

To enable construction of the raised concrete arch section, the storage level in the current dam would need to be lowered by about 1 metre below FSL. This lowering of the storage would then allow for demolition of the existing concrete ogee crest and construction of the raised arch section and concrete abutments.

10.3 Establishment for Construction

Contractor site facilities, workshops and material storage areas would be established. Suitable sites appear to be downstream of the dam but final locations would depend on the Contractor. Access for construction and environmental protection works would also be required.

For raising the arch wall, concrete would best be provided from off-site batching plants and transported to the site in trucks.

10.4 Constructability of Main Arch Dam

The preferred option for raising the existing concrete arch dam wall is by constructing a new concrete arch on top of the current structure. The raised concrete arch would terminate at each abutment with large concrete blocks embedded in a solid rock foundation.

Construction access to above the arch wall's left abutment is readily available. To provide adequate access directly to the wall, clearing of vegetation and loose rock as well as provision of safe vehicular access will need to be provided.

Currently there is difficult foot access to the valley base downstream of the dam. Adequate vehicular construction access to the base of the wall and the right abutment would need to be provided. Previously, a hydraulic excavator is believed to have gained slow access to the creek bed area from the right side downstream of the dam. This route may be the most practical access route to the site, but would require a property agreement and extensive upgrading of the access track.

A large crane may be required on the creek bed downstream of the dam toe to enable concrete placement across the dam wall and to both abutments. Site inspection has revealed a number of suitable areas on the valley floor where a crane facility can be established.

For construction of the large abutment concrete blocks at the ends of the raised arch, foundation excavation to a depth of about 1.5m below loose surface boulders would be required. For the original dam, foundation excavation was achieved by blasting. However, blasting would not be permitted adjacent to the existing structure. Non-explosive expansion techniques would need to be utilised for foundation excavation.

10.5 Constructability of Raised Saddle Dam

The preferred option is to construct the raised saddle dam embankment with additional earthfill which would be largely sourced from locally available materials.

Fill for the original embankment was won locally from the saddle dam foundation and adjacent surrounds. The existing embankment comprises clayey sandy silt, with gravel (rock fragments), with a marginally low clay content.

For raising the saddle dam, the configuration would include upstream Zone 1 (higher clay content) and downstream Zone 2 (lower clay content) materials. Zone 1 could be extracted from the soil horizon above rock found in the low areas downstream of the embankment. Zone 2 could be ripped from the deeper highly weathered rock portions of the profile.

For construction of the raised saddle dam and extracting materials from surrounding sources, access to all areas is readily available for plant and equipment and would involve minor clearing and upgrading works.

10.6 Inlet and Outlet Works

The preferred option is to decommission the existing tower and replace/extend the existing trunnion with a buoy arrangement. New valves are also to be installed in the valve block downstream of the arch dam.

Replacement of the trunnion would involve divers to unbolt the base and also to seal the scour/outlet for replacement of the outlet valves. Construction access to the top of the trunnion and tower would need to be established. Access to the valve block at the downstream toe of the arch dam is currently difficult and new access would be required from downstream of the dam.

10..7 Order of Work

With respect to overall construction approach, the following general order of work is envisaged –

1. Establishment, including environmental and other approvals
2. Removal of non-significant vegetation around the dam site to allow construction access

3. Stripping of abutments for the raised dam permanent access road
4. Lowering of dam storage (if required) to about 1m below existing FSL
5. Excavation of the left and right abutments for the raised concrete arch and concrete abutment end blocks
6. Removal of the existing arch dam concrete crest structure
7. Stripping of the existing saddle dam crest, abutments and downstream area for the raised embankment footprint and access roads
8. Construction of the 3m high new concrete arch section including surface preparation
9. Construction of the concrete abutment end blocks including foundation preparation and installation of anchor bars
10. Construction of upgraded WHS acceptable access to downstream of raised arch dam
11. Construction of upgraded concrete valve block downstream of raised arch dam and installation of valves
12. Installation of blanket filter, toe drain and seepage weir for the raised saddle dam
13. Placement of fill for the raised saddle dam embankment including crest pavement, rip rap on the upstream slope, topsoil and grassing of downstream slope
14. Construction of new seepage weir downstream of saddle dam
15. Decommissioning and removal of existing trunnion
16. Installation of replacement trunnion including float
17. Installation of all associated mechanical and electrical equipment including control cabinet and standby generator
18. Reinstatement of all electrical supply
19. Construction of a new permanent access road and seal to the raised saddle dam and raised concrete arch dam including parking areas and improved access to the boat ramp
20. Removal of all temporary access and haul roads
21. Rehabilitation of construction areas (including landscaping)
22. Disestablishment

11 Cost Estimate

A concept stage cost estimate for the 3m raising of Timor Dam has been prepared. For raising the main arch dam, the estimate includes the cost of constructing an additional concrete arch section on top of the existing structure and providing concrete abutment end blocks. For raising the saddle dam, the estimate includes the cost of supply and placement of additional embankment fill. The preferred arrangements for raising the main arch dam and the saddle dam are indicated on the attached Figures at **Appendix B.**

The cost estimate is summarised in the Table below. A breakdown of the estimate is provided at **Appendix E.**

Table 6.1 – Summary of Cost Estimate

Timor Dam Raising	Cost Estimate
Preparatory Works	$600,000
Arch Dam Raising	$2,112,000
Inlet and Outlet Works	$2,220,000
Saddle Dam Raising	$324,000
Road Upgrade	$300,000
TOTAL DIRECT COST (ex GST)	**$5,556,000**
Preconstruction, Supervision & Contingencies	$2,500,200
TOTAL COST (ex GST)	**$8,056,200**

The estimate has been based on concept stage designs and layouts as shown on the attached Figures at **Appendix B**. Survey data, hydrological and geotechnical data have been obtained from previous studies and reports as indicated in the List of References (**Section14**) as well as the site inspection and geological reconnaissance undertaken by PWA in January 2018. Updated unit rates and costs have been applied to all components.

The estimate includes costs for ancillary works such as debris clearing and desilting of the storage adjacent to the trunnion and scour inlets, overall access upgrade, establishment of a monitoring survey network and inflow measurement facility.

The total cost includes 10% of the direct cost for pre-construction, 10% for contract supervision and 25% for general contingencies to allow for the concept nature of the design. Further, more detailed design would be required to confirm section dimensions and estimate.

12 Safety in Design

A Safety in Design (SID) Report has been prepared which incorporates a checklist outlining identified Hazards, Implementable Safety Measures and Probability Ratings as determined during concept design of the Timor Dam Raising project.

This SID checklist is designed to be used at the Concept Design phase OR the early stages of the Detailed Design phase of the project. It is intended for the Designer and the Owner of the works to identify, as early as possible, the associated hazards and risks, and means to address those hazards and risks during the engineering handling lifecycle of the designed structure(s).

The NSW Work Health and Safety Regulation 2011 Clause 294 requires that the person who commissions the design of the structure (i.e. the Owner of the Works) must consult with the Designer and provide information about the hazards and risks during the design structure's engineering handling lifecycle. The intent is for the Owner to be aware and assist the Designer to identify, analyse and eliminate / minimise the potential hazards and risks.

This **SID General Quick-Tick List** applies to design of structures that have unusual or atypical features which present risks taking into consideration:

- Geotechnical,
- Survey,
- Civil,
- Mechanical,
- Electrical,
- Environmental, and
- General Safety

aspects that are unique to the particular design.

The more comprehensive **SID Risk Checklist** details more specific items and covers

1. Design,
2. Community Consultation,
3. Site and Services,
4. Work Health and Safety,
5. Environmental and Site Conditions,
6. Construction and Programming, and
7. Additional Risks Identified

The SID Report and Checklists are attached at **Appendix G**.

13 Conclusion

13.1 General

This report outlines the concept design for the raising of Timor Dam. It is proposed to raise the FSL of the dam by 3 metres. The preferred arrangement is based on previous investigations and has been developed following Warrumbungle Shire Council's endorsement of the preferred raising option during the feasibility study stage.

Timor Dam comprises a main concrete arch structure with overfall spillway and outlet works. A homogeneous earthfill saddle dam is located 300m away from the main structure.

Water is drawn from the dam storage through a floating trunnion attached to an operating platform on a square concrete column. From there, water is released downstream via an unencased cement lined cast iron gravitation main which lies beneath the saddle dam.

Timor Dam has been assigned a HIGH A Flood Consequence Category (FCC), which requires safe passage of the Probable Maximum Flood (PMF) and a SIGNIFICANT Sunny Day Consequence Category (SDCC), which requires it to withstand a 0.2% AEP (500 year) earthquake.

13.2 Dam Raising

The following parameters have been adopted:

Raised concrete arch dam spillway FSL = RL614.210m AHD

Raised arch dam crest = RL614.502m AHD

Raised arch dam length = 68m

PMF outflow level = RL618.55m AHD

Raised arch dam concrete abutment blocks crest = RL619.150m AHD

Raised saddle dam crest = RL619.150m AHD

Freeboard at PMF = 0.6m

Review of available data and site inspection have revealed that Timor Dam is generally in good condition and suitable for raising.

For the main concrete arch dam, the proposed raising involves providing an additional 3m deep arch on top of the current structure. The proposed raising involves a new arch above the existing arch which would be structurally independent from the existing structure.

Due to the poor configuration of the abutment contours at crest level, it will be necessary to construct two concrete abutment sections within hard rock. The top of the abutments would be at the same level as the raised saddle dam.

For the saddle dam, raising involves raising by the placement of additional earthfill using mainly locally sourced materials.

For the raised saddle dam the upstream face is protected with rip rap while the downstream slope is topsoiled and grassed. Realignment of access roads to both sides of the crest of the saddle dam is also required.

New seepage weirs are proposed downstream of the main arch dam and downstream of the saddle dam. The weirs would be connected via SCADA to Council's office to facilitate continual monitoring.

13.3 Inlet and Outlet Works

A recent condition assessment indicated that, while the condition of the inlet and outlet works was good, significant upgrading would be required, in conjunction with the proposed dam raising, in order for the works to meet current WHS regulations and Australian Standards.

The current trunnion arrangement is not suitable for an increase in the FSL of the dam. The preferred option is to decommission the existing tower, replace and extend the trunnion, replace the trunnion stay with a larger stay and install a floating buoy (capable of raising the trunnion inlet out of the water).

The scour inlet is currently below the silt level and is therefore inoperable. A new inlet and outlet system is recommended. The new outlet system would include a separate facility for environmental flows to comply with modern dam practice.

Guard valves and isolation valves would normally remain open, end of line valves would control the flow. It is preferred that the control valves be operated remotely via telemetry (at the Council office) and operated locally at a new control cabinet located on the left hand abutment above the new design flood level.

Construction of an enlarged concrete valve block/chamber is proposed for protection of the valves.

The provision of a new trash screen and emergency bulkhead gate at the upstream end of the existing scour pipe is also proposed (the current ones not being in good condition).

Upgrade to current WHS standards is also required for access to the scour valve and seepage weir downstream of the arch dam.

13.4 Cost Estimates

Cost estimates have been prepared based on preliminary designs and review of all available data and previous studies. Updated rates and costs have been applied. A summary of the estimates is as follows:

Timor Dam Raising	Cost Estimate
TOTAL DIRECT COST (ex GST)	**$5,556,000**
Preconstruction, Supervision & Contingencies	$2,500,200
TOTAL COST (ex GST)	**$8,056,200**

The estimates have been based on review of available data, site inspection and preliminary designs. Updated unit rates and costs have been applied to all components.

The total costs include 10% of the direct cost for pre-construction, 10% for contract supervision and 25% for general contingencies to allow for the concept nature of the design.

14 References

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NSW Dams Safety Committee, DSC3A, *Consequence Categories for Dams*

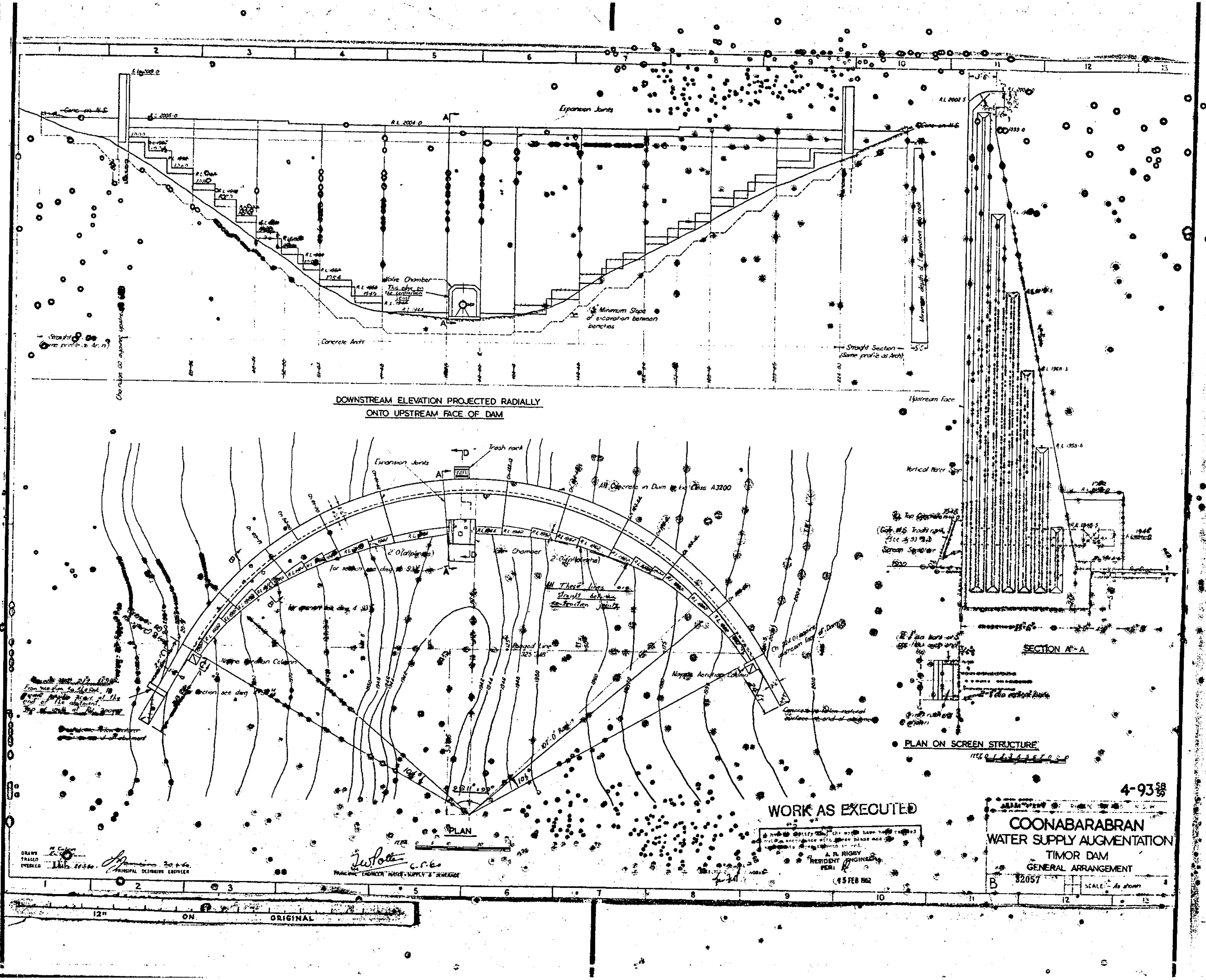
NSW Dams Safety Committee, DSC3B, *Acceptable Flood Capacity for Dams*

NSW Dams Safety Committee, DSC3C, *Acceptable Earthquake Capacity for Dams*

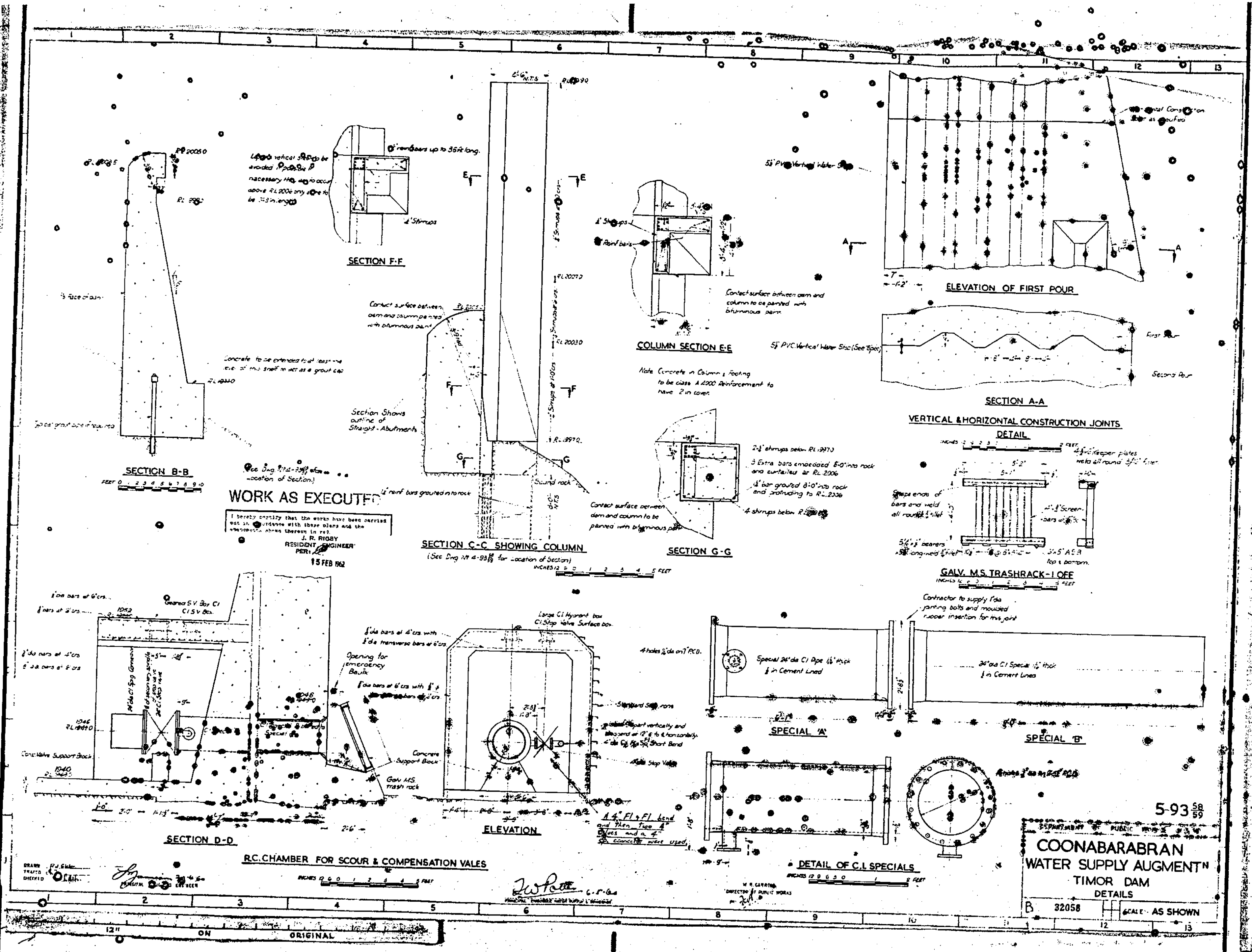
Appendices

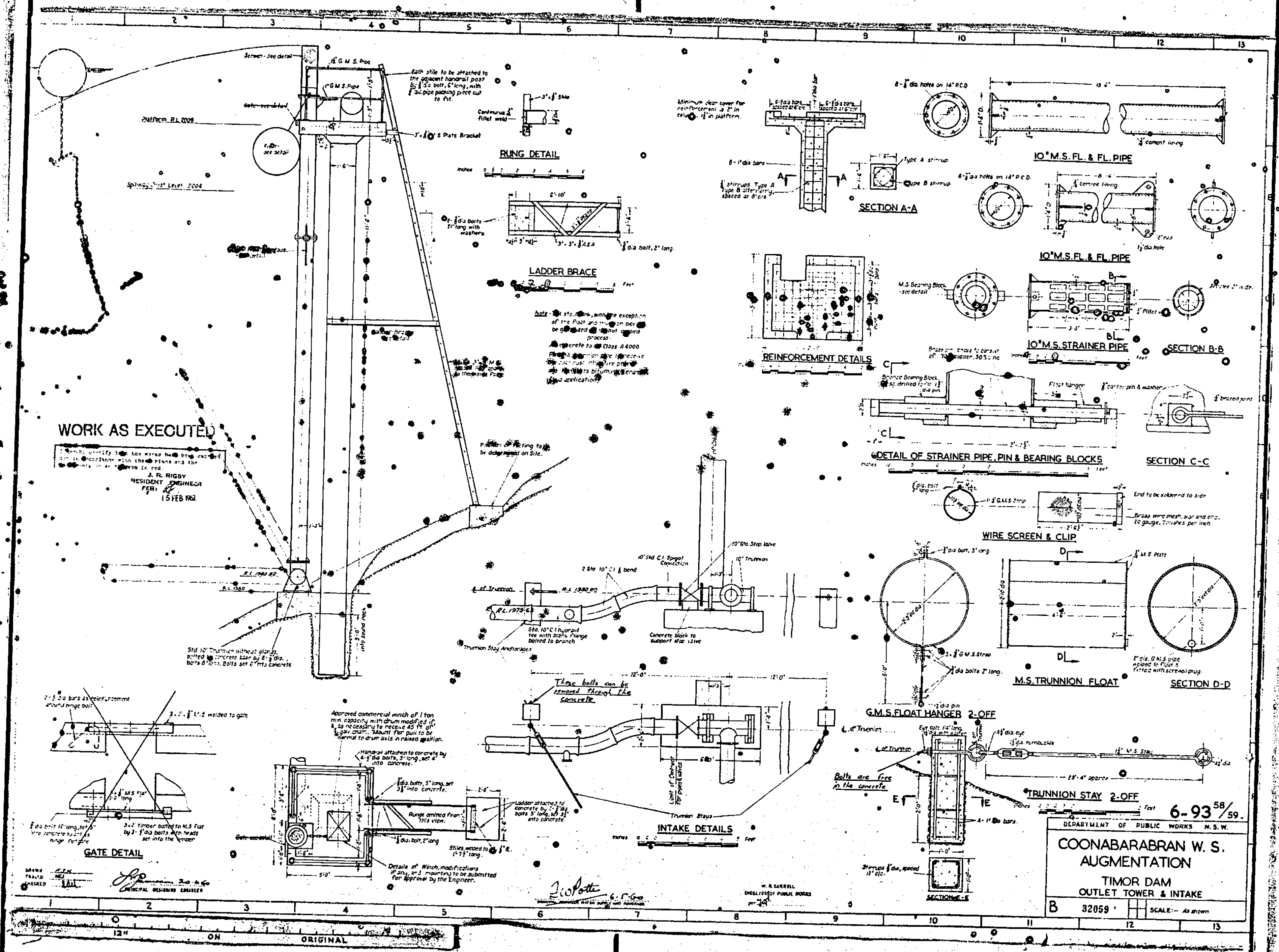
APPENDIX A

TIMOR DAM WAE DRAWINGS

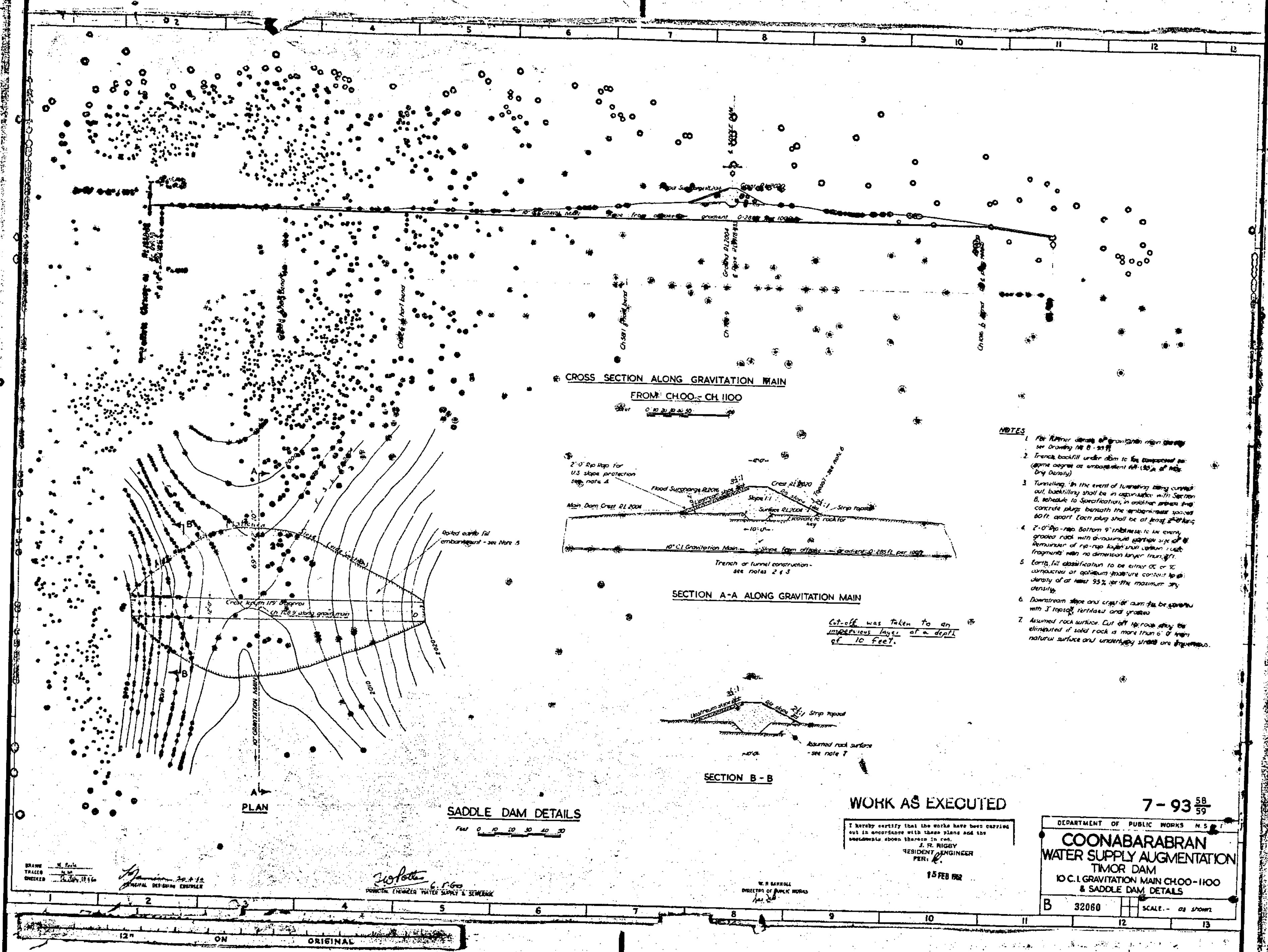


Expansion Joints
R.L. 2004.0
Valve Chamber
Concrete Arch
Minimum Slope of excavation between benches
Straight Section (Same profile as Arch)
DOWNSTREAM ELEVATION PROJECTED RADIALLY
ONTO UPSTREAM FACE OF DAM
Upstream Face
Trash rack
All Concrete in Dam to be Class A3200
Valve Chamber
PLAN
SECTION A-A
PLAN ON SCREEN STRUCTURE
WORK AS EXECUTED
A. R. RIGBY
RESIDENT ENGINEER
15 FEB 1962
PRINCIPAL DESIGNING ENGINEER
4-93 58/59
COONABARABRAN
WATER SUPPLY AUGMENTATION
TIMOR DAM
GENERAL ARRANGEMENT
32057
SCALE As shown
12" ON ORIGINAL


SECTION B-B
SECTION F-F
SECTION C-C SHOWING COLUMN
(See Dwg № 4-93 58/59 for Location of Section)
COLUMN SECTION E-E
Note. Concrete in Column & Footing to be class A 4000 Reinforcement to have 2 in cover.
SECTION G-G
ELEVATION OF FIRST POUR
SECTION A-A
VERTICAL & HORIZONTAL CONSTRUCTION JOINTS DETAIL
GALV. M.S. TRASHRACK - 1 OFF
WORK AS EXECUTED
J. R. RIGBY
RESIDENT ENGINEER
15 FEB 1962
Contact surface between dam and column to be painted with bituminous paint
Section Shows outline of Straight - Abutments
Sound rock
SECTION D-D
ELEVATION
R.C. CHAMBER FOR SCOUR & COMPENSATION VALES
SPECIAL 'A'
SPECIAL 'B'
Special 24" dia C.I. Pipe 1¼" thick ⅜ in Cement Lined
24" dia C.I. Special 1¼" thick ⅜ in Cement Lined
DETAIL OF C.I. SPECIALS
Galv. M.S. trash rack
Concrete Support Block
Opening for emergency Baulk
5-93 58/59
DEPARTMENT OF PUBLIC WORKS N.S.W.
COONABARABRAN
WATER SUPPLY AUGMENTN
TIMOR DAM
DETAILS
B 32058
SCALE: AS SHOWN
12" ON ORIGINAL



RUNG DETAIL
LADDER BRACE
SECTION A-A
REINFORCEMENT DETAILS
10" M.S. FL. & FL. PIPE
10" M.S. FL. & FL. PIPE
10" M.S. STRAINER PIPE
SECTION B-B
DETAIL OF STRAINER PIPE, PIN & BEARING BLOCKS
SECTION C-C
WIRE SCREEN & CLIP
M.S. TRUNNION FLOAT
SECTION D-D
G.M.S. FLOAT HANGER 2-OFF
TRUNNION STAY 2-OFF
SECTION E-E
INTAKE DETAILS
GATE DETAIL
WORK AS EXECUTED
J. R. RIGBY
RESIDENT ENGINEER
15 FEB 1962
These bolts can be removed through the concrete
Bolts are free in the concrete
Platform R.L. 2009
6-93 58/59.
DEPARTMENT OF PUBLIC WORKS N.S.W.
COONABARABRAN W. S.
AUGMENTATION
TIMOR DAM
OUTLET TOWER & INTAKE
B
32059
SCALE:- As shown
12" ON ORIGINAL



CROSS SECTION ALONG GRAVITATION MAIN
FROM CH.OO - CH.1100
SECTION A-A ALONG GRAVITATION MAIN
Trench or tunnel construction - see notes 2 & 3
Cut-off was taken to an impervious layer at a depth of 10 feet.
NOTES
SECTION B-B
Assumed rock surface - see note 7
PLAN
SADDLE DAM DETAILS
WORK AS EXECUTED
7-93 58/59
I hereby certify that the works have been carried out in accordance with these plans and the amendments shown thereon in red.
J. R. RIGBY
RESIDENT ENGINEER
15 FEB 1962
DEPARTMENT OF PUBLIC WORKS N.S.W.
COONABARABRAN
WATER SUPPLY AUGMENTATION
TIMOR DAM
10 C.I. GRAVITATION MAIN CH.OO-1100
& SADDLE DAM DETAILS
B 32060
SCALE.- as shown
12" ON ORIGINAL

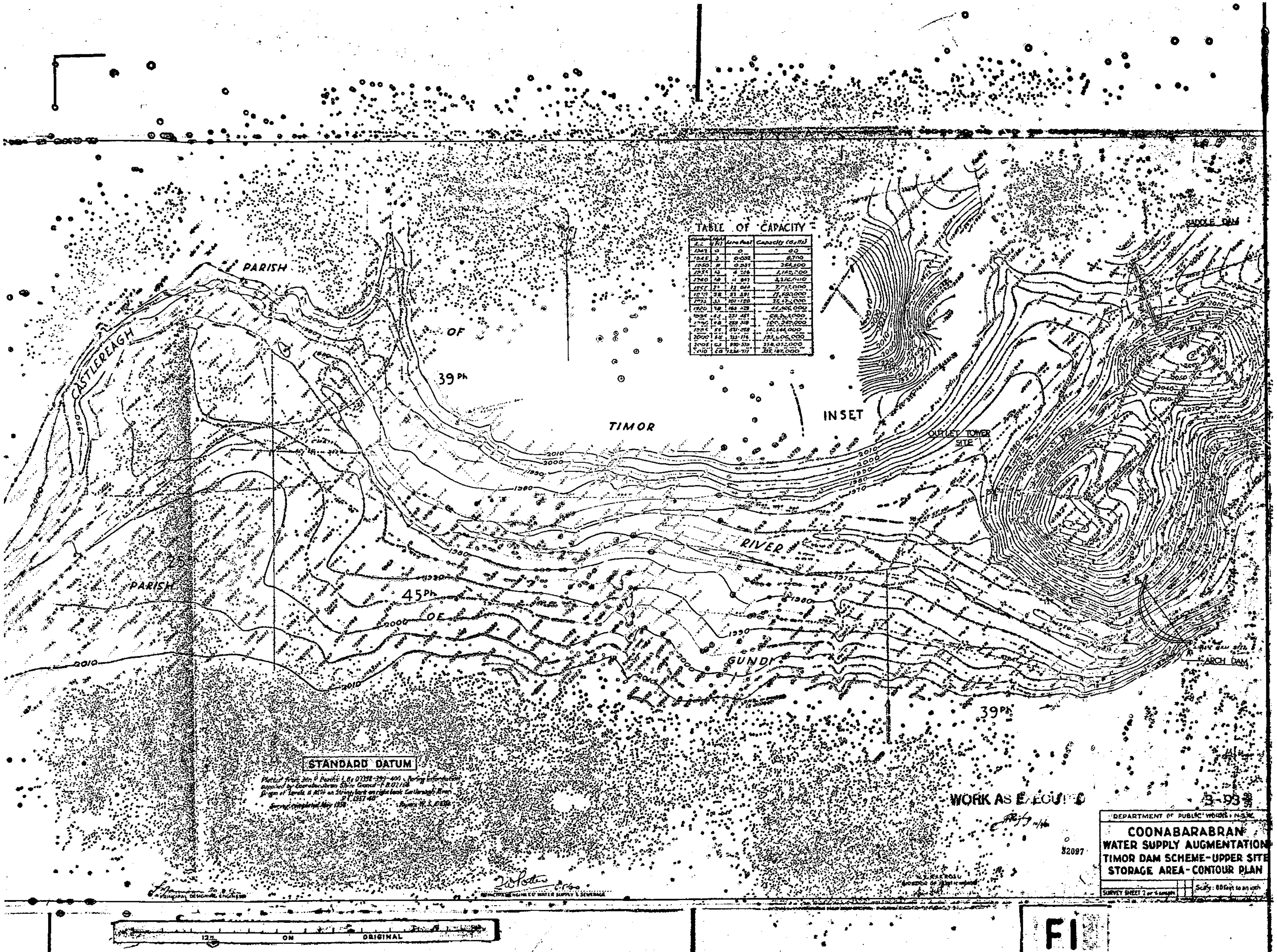


TABLE OF CAPACITY
PARISH
OF
CASTLEREAGH
39 Ph
TIMOR
INSET
SADDLE DAM
OUTLET TOWER SITE
RIVER
25 Ph
PARISH
45 Ph
OF
GUNDY
39 Ph
ARCH DAM
STANDARD DATUM
WORK AS EXECUTED
3-93
32097
DEPARTMENT OF PUBLIC WORKS N.S.W.
COONABARABRAN
WATER SUPPLY AUGMENTATION
TIMOR DAM SCHEME-UPPER SITE
STORAGE AREA-CONTOUR PLAN
SURVEY SHEET 2 of 6 sheets
Scale: 80 feet to an inch
ON ORIGINAL

F1

APPENDIX B

CONCEPT DRAWINGS FOR DAM RAISING

REV	AMENDMENT DETAILS	APPROVED	DATE
0			

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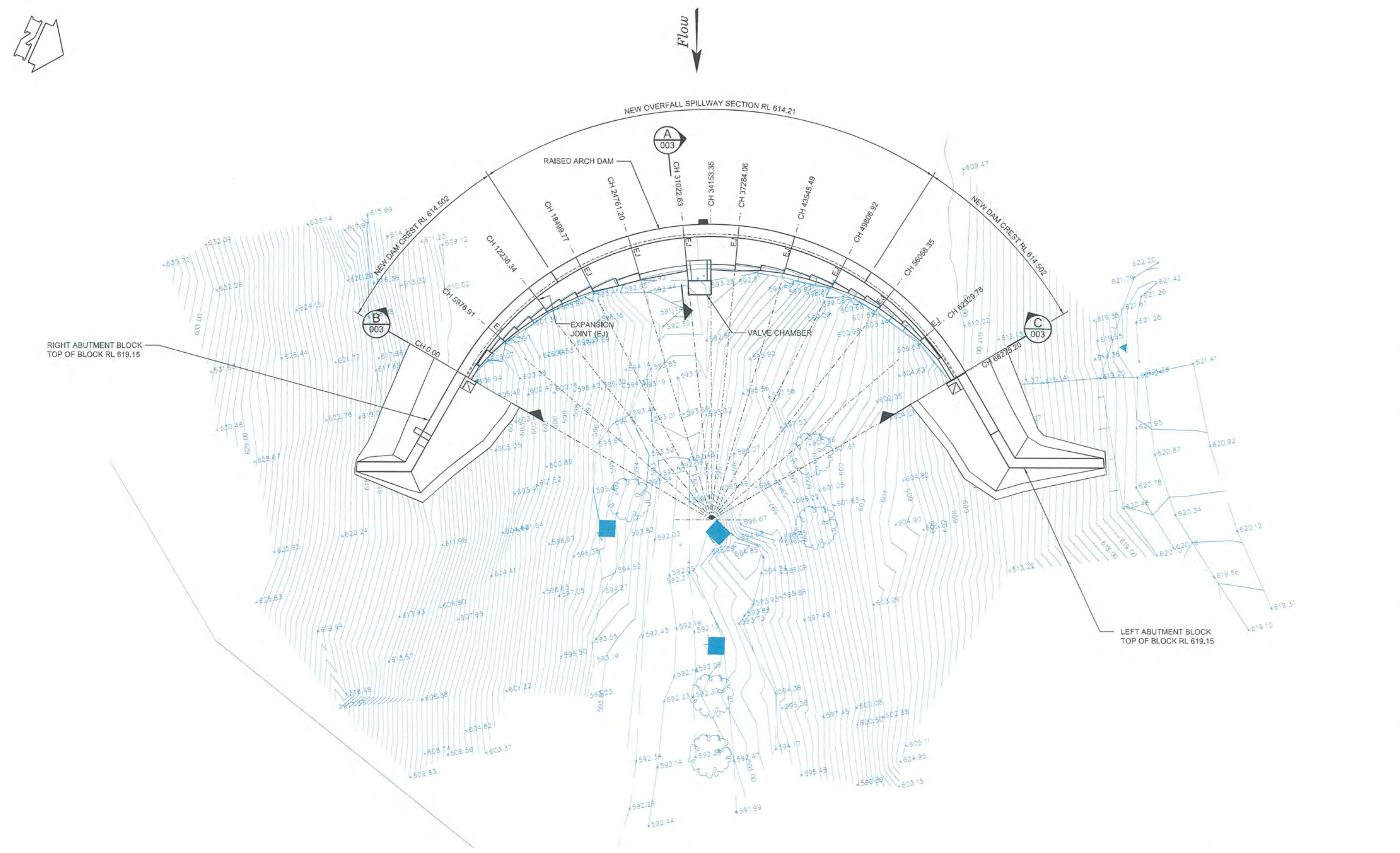
DRAFTED	C. PANG/ C. ZHANG
CHECKED	
PRINCIPAL ENGINEER	G.SAMIOS

COONABARABRAN WATER SUPPLY
TIMOR DAM RAISING
SITE PLAN

PROJECT/CONTRACT No.	-
A1	SCALE @ A1 1:1000
DRAWING No. FIG-001	REV 0

CONFIRM SCALE — 100mm ON A1 ORIGINAL

G:\Waterline\Road\TIMOR DAM UPGRADE\Concept Drawings\P-Timor_Fig001.dgn 5/12/2018 10:54:42 AM ZHANGC2



PLAN
SCALE 1:200

1:200 0 4000 8000 12000 16000 20000 mm

REV	AMENDMENT DETAILS	APPROVED	DATE
0			

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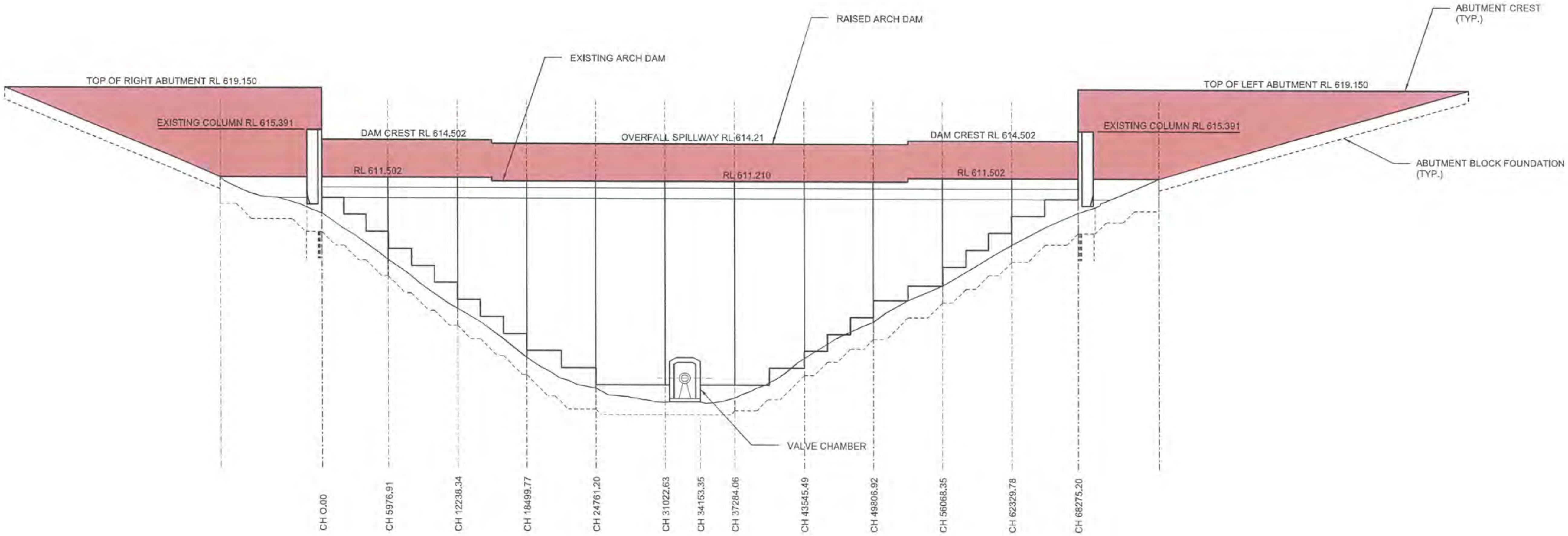
COONABARABRAN WATER SUPPLY
TIMOR DAM RAISING

ARCH DAM RAISING
GENERAL ARRANGEMENT
Sheet 1 of 3

PROJECT/CONTRACT No. -
A1 SCALE @ A1 1:200
DRAWING No. FIG-002 REV 0

CONFIRM SCALE — 100mm ON A1 ORIGINAL

5/12/2018 10:56:17 AM ZHANGC2 G:\Watertec\Pcad\TIMOR DAM UPGRADE\Concept Drawings\P-Timor_Fig002.dwg



DOWNSTREAM ELEVATION PROJECTED RADIALLY ONTO DAM UPSTREAM FACE

SCALE 1:200

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

REV	AMENDMENT DETAILS	APPROVED	DATE
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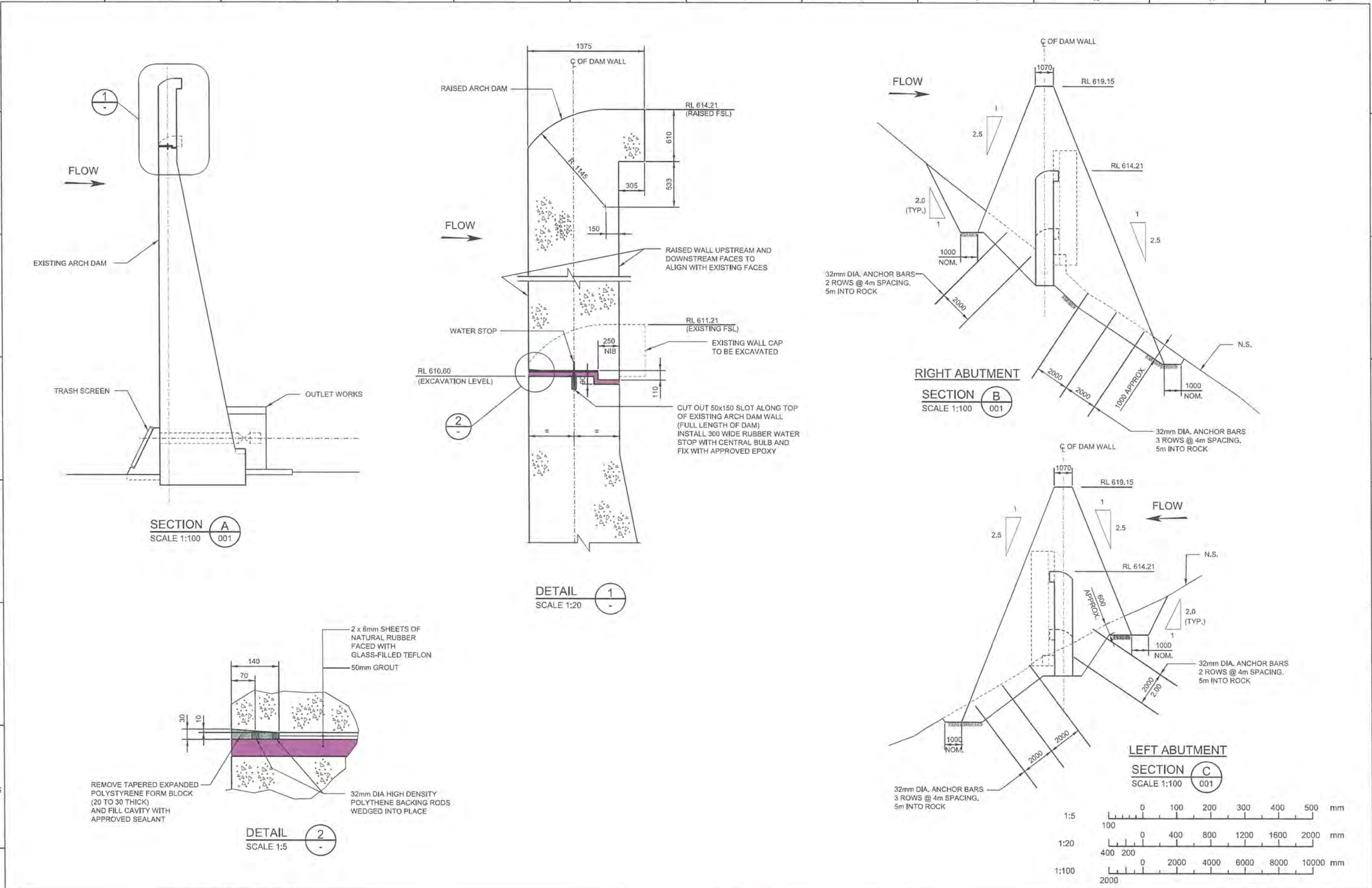
COONABARABRAN WATER SUPPLY
TIMOR DAM RAISING

ARCH DAM RAISING
GENERAL ARRANGEMENT
Sheet 2 of 3

PROJECT/CONTRACT No. -
A1 SCALE @ A1 1:200
DRAWING No. FIG-003 REV 0

CONFIRM SCALE — 100mm ON A1 ORIGINAL

G:\Watertec\Pcao\TIMOR DAM UPGRADE\Concept Drawings\P-Timor_Fig003.dgn 10:57:04 AM ZHANGC2 5/12/2018



REV	AMENDMENT DETAILS	APPROVED	DATE
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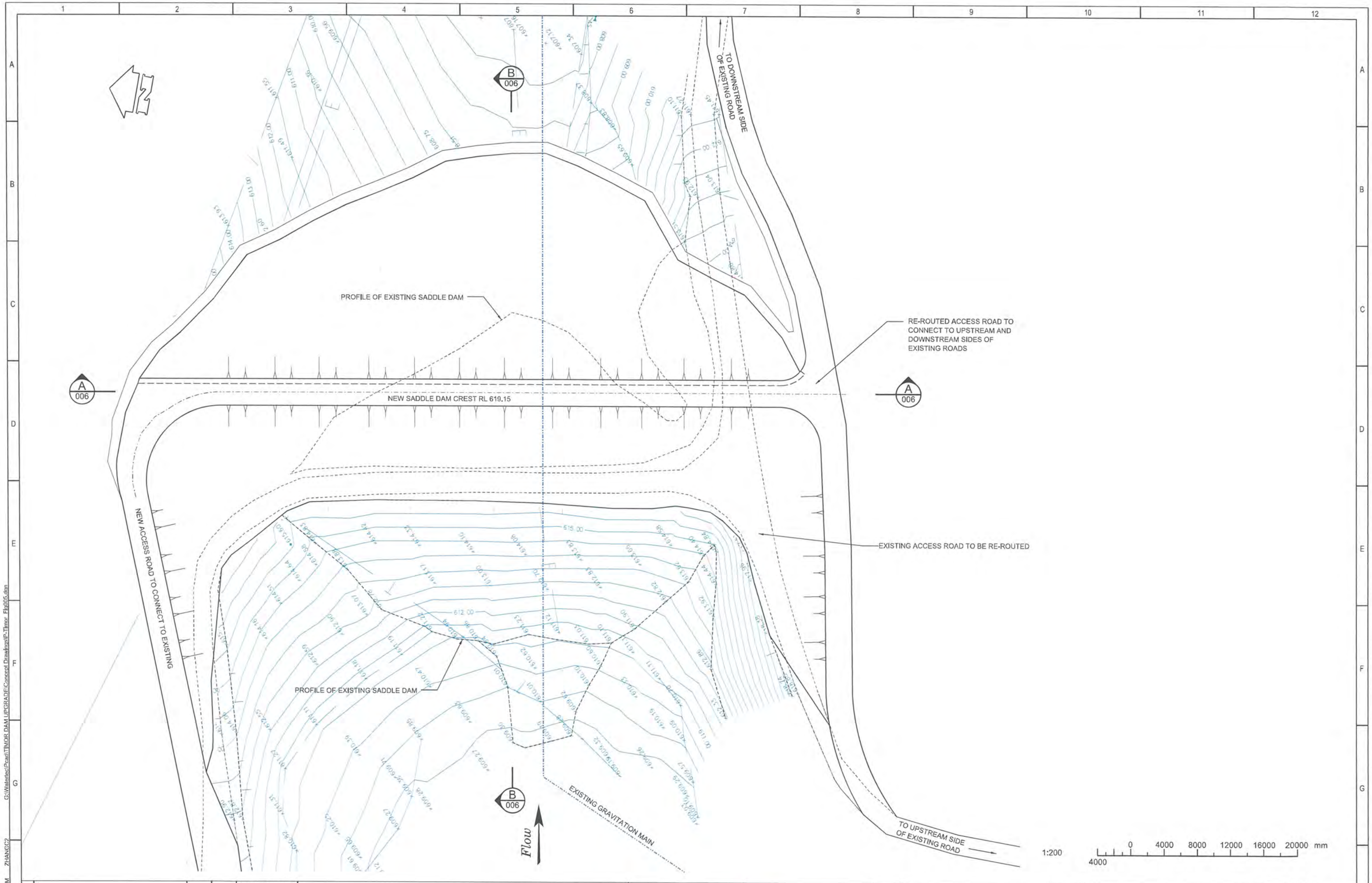
COONABARABRAN WATER SUPPLY
TIMOR DAM RAISING

ARCH DAM RAISING
GENERAL ARRANGEMENT
Sheet 3 of 3

PROJECT/CONTRACT No. -
A1 SCALE @ A1 1:5, 1:20, 1:100
DRAWING No. FIG-004 REV 0

CONFIRM SCALE 100mm ON A1 ORIGINAL

5/12/2018 10:58:09 AM ZHANGC2 G:\Water\rc\Road\TIMOR DAM UPGRADE\Concept Drawings\P-Timor_Fig004.dwg



REV	AMENDMENT DETAILS	APPROVED	DATE
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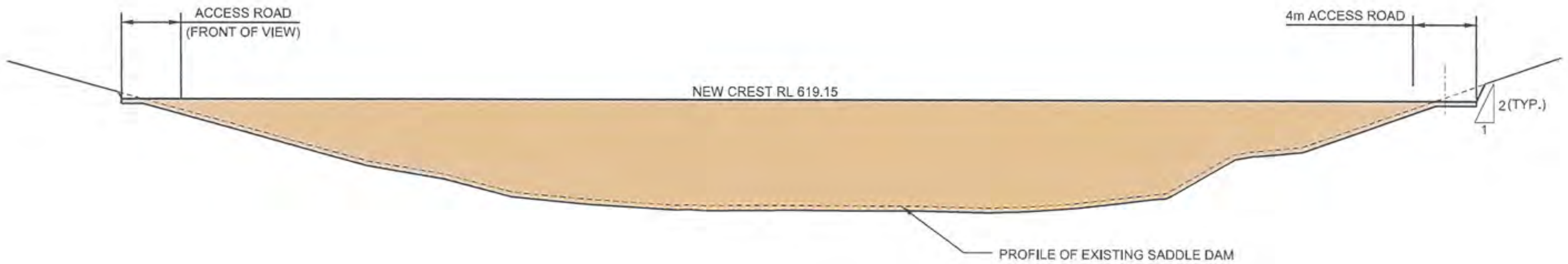
COONABARABRAN WATER SUPPLY
TIMOR DAM RAISING

SADDLE DAM RAISING
GENERAL ARRANGEMENT
Sheet 1 of 2

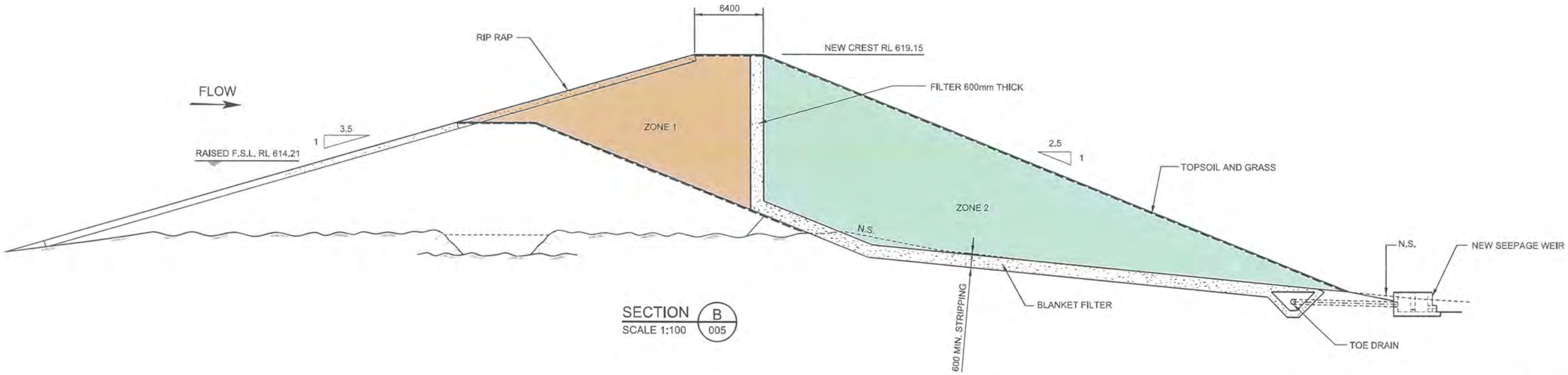
PROJECT/CONTRACT No. -
A1 SCALE @ A1 1:200
DRAWING No. FIG-005 REV 0

CONFIRM SCALE 100mm ON A1 ORIGINAL

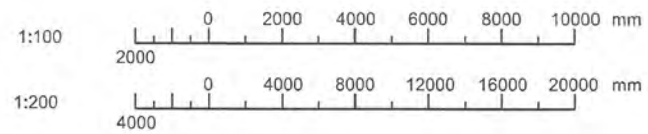
5/12/2018 10:59:03 AM ZHANGC2 G:\Watertec\Pcad\TIMOR DAM UPGRADE\Concept Drawings\P-Timor_Fig005.dgn



SECTION A 005
SCALE 1:200



SECTION B 005
SCALE 1:100



REV	AMENDMENT DETAILS	APPROVED	DATE
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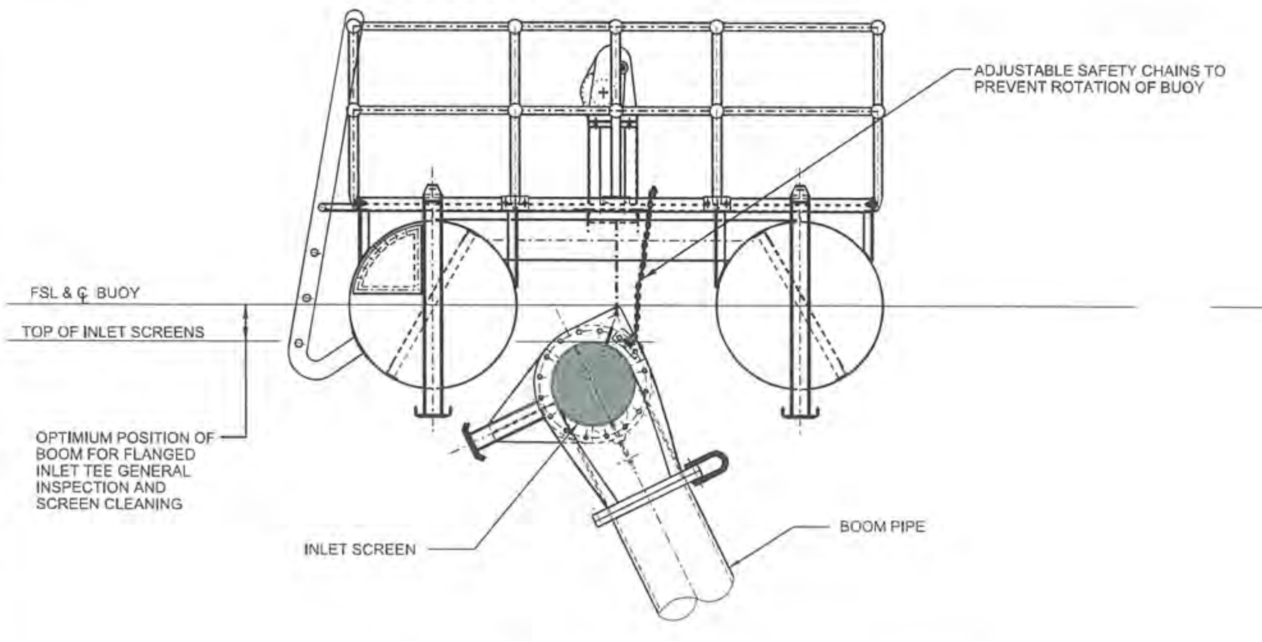
COONABARABRAN WATER SUPPLY
TIMOR DAM RAISING

SADDLE DAM RAISING
GENERAL ARRANGEMENT
Sheet 2 of 2

PROJECT/CONTRACT No. -
A1 SCALE @ A1 1:100, 1:200
DRAWING No. FIG-006 REV 0

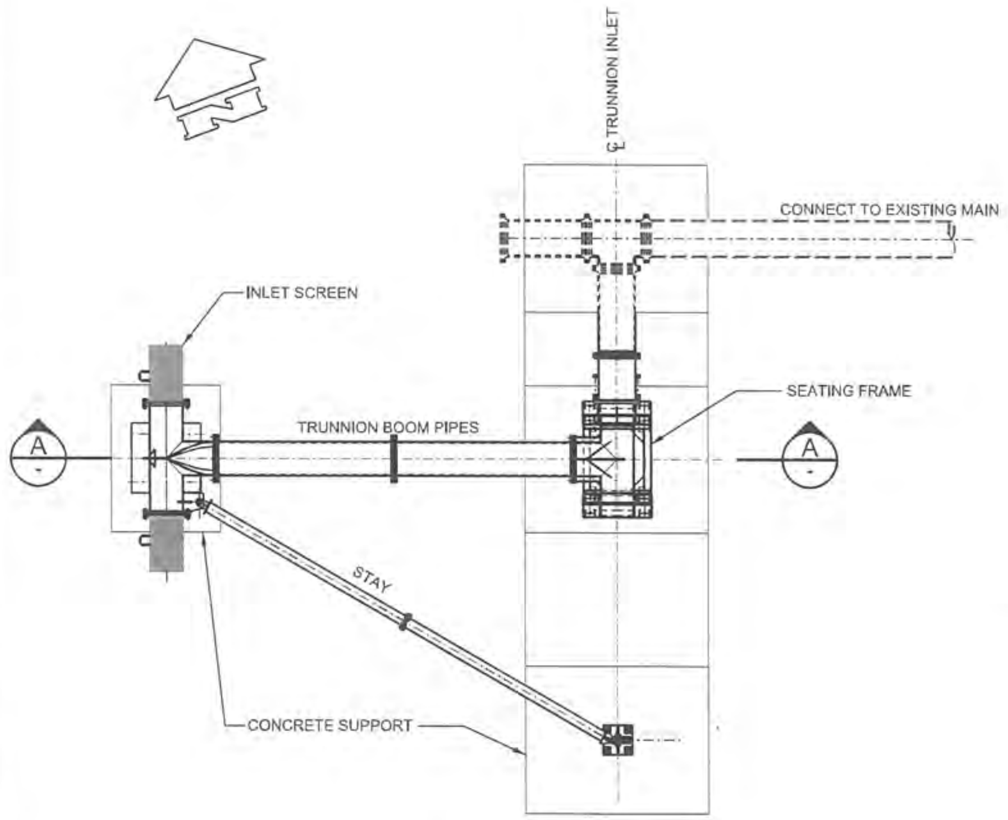
CONFIRM SCALE — 100mm ON A1 ORIGINAL

5/12/2018 10:59:49 AM ZHANGC2 G:\Watertec\Proad\TIMOR DAM UPGRADE\Concept Drawings\P-Timor_Fig005.dwg



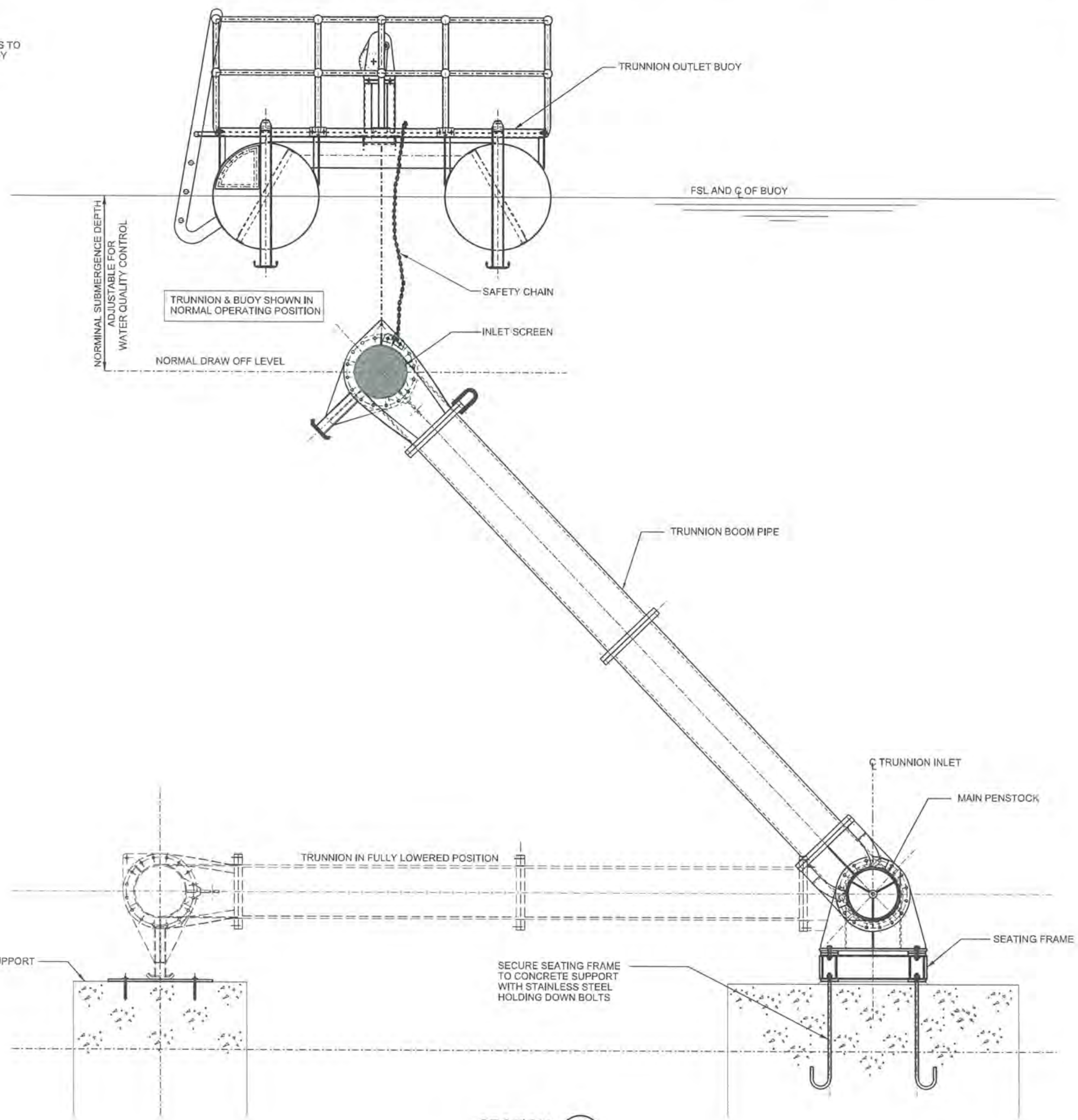
ELEVATION - TRUNNION & BUOY ASSEMBLY

(SHOWN IN CLEANING POSITION)
N.T.S.



PLAN

N.T.S.



SECTION A

N.T.S

REV	AMENDMENT DETAILS	APPROVED	DATE
0			

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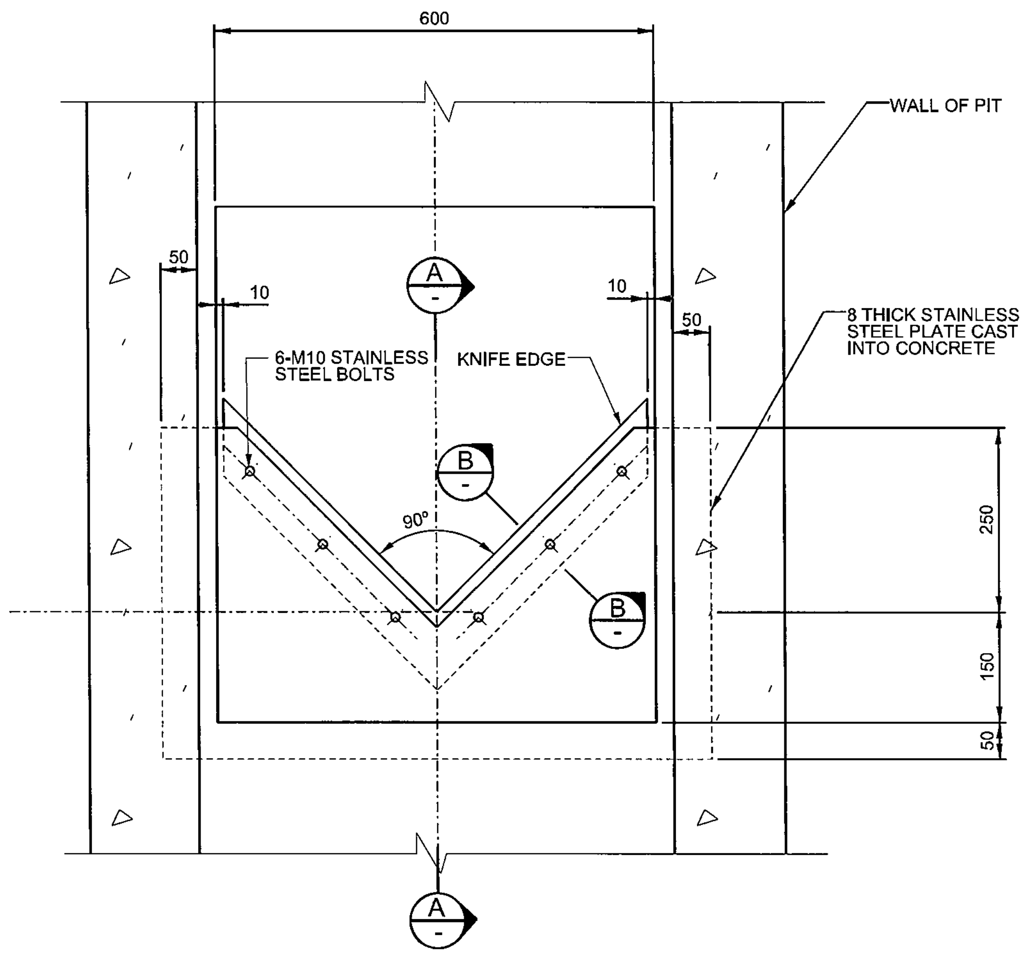
COONABARABRAN WATER SUPPLY
TIMOR DAM RAISING

OUTLET WORK
TRUNNION
ARRANGEMENT SAMPLE

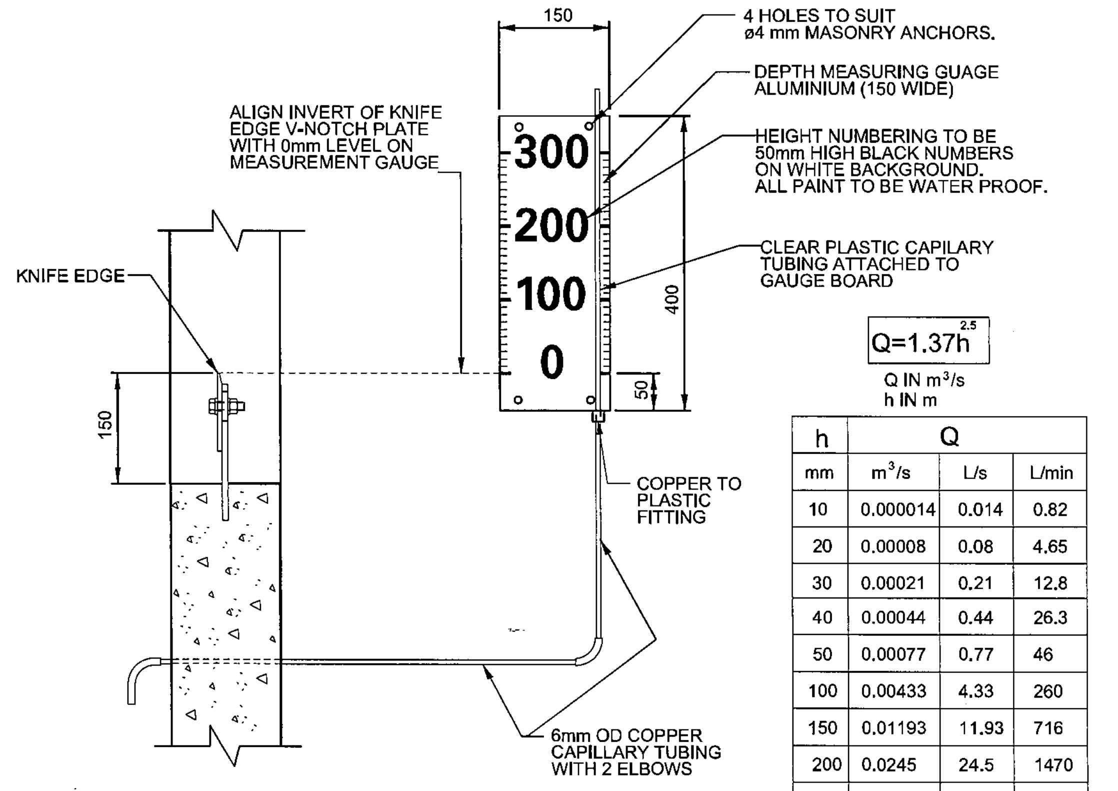
PROJECT/CONTRACT No. -
A1 SCALE @ A1 N.T.S.
DRAWING No. FIG-007 REV 0

CONFIRM SCALE 100mm ON A1 ORIGINAL



SECTION - SEEPAGE MEASUREMENT PIT

SCALE: 1:5



GAUGE PLATE & TUBING

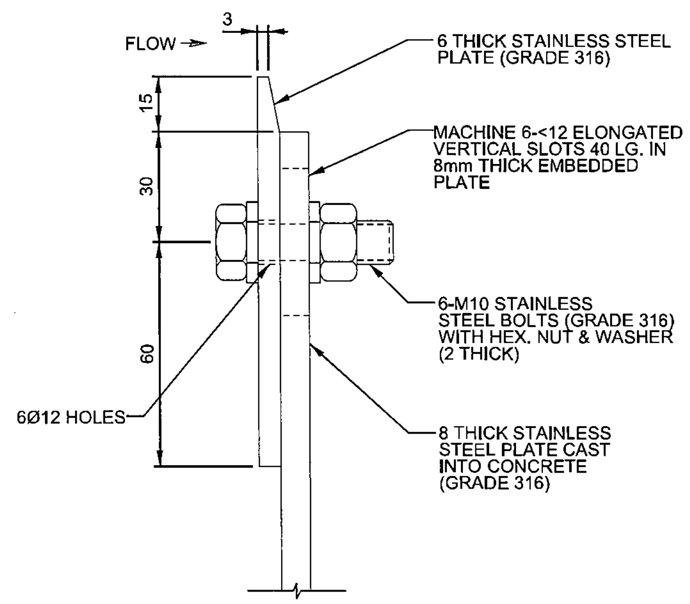
SECTION A
SCALE 1:2.5

$\boxed{Q=1.37h^{2.5}}$

Q IN m^3/s
h IN m

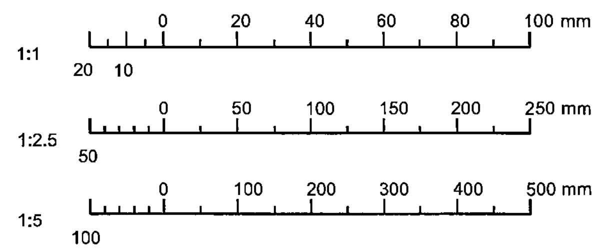
h	Q		
mm	m^3/s	L/s	L/min
10	0.000014	0.014	0.82
20	0.00008	0.08	4.65
30	0.00021	0.21	12.8
40	0.00044	0.44	26.3
50	0.00077	0.77	46
100	0.00433	4.33	260
150	0.01193	11.93	716
200	0.0245	24.5	1470
250	0.0428	42.8	2580

V-NOTCH DISCHARGE TABLE



KNIFE EDGE

SECTION B
SCALE 1:1



REV	AMENDMENT DETAILS	APPROVED	DATE
0			

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CHECKED G. SAMIOS
DRAFTED C. ZHANG
CHECKED
PRINCIPAL ENGINEER G.SAMIOS

COONABARABRAN WATER SUPPLY
TIMOR DAM RAISING

SEEPAGE WEIR CONCEPT DETAILS

PROJECT/CONTRACT No. -
A1 SCALE @ A1 1:1, 1:2.5, 1:5
DRAWING No. FIG-008 REV 0

CONFIRM SCALE 100mm ON A1 ORIGINAL

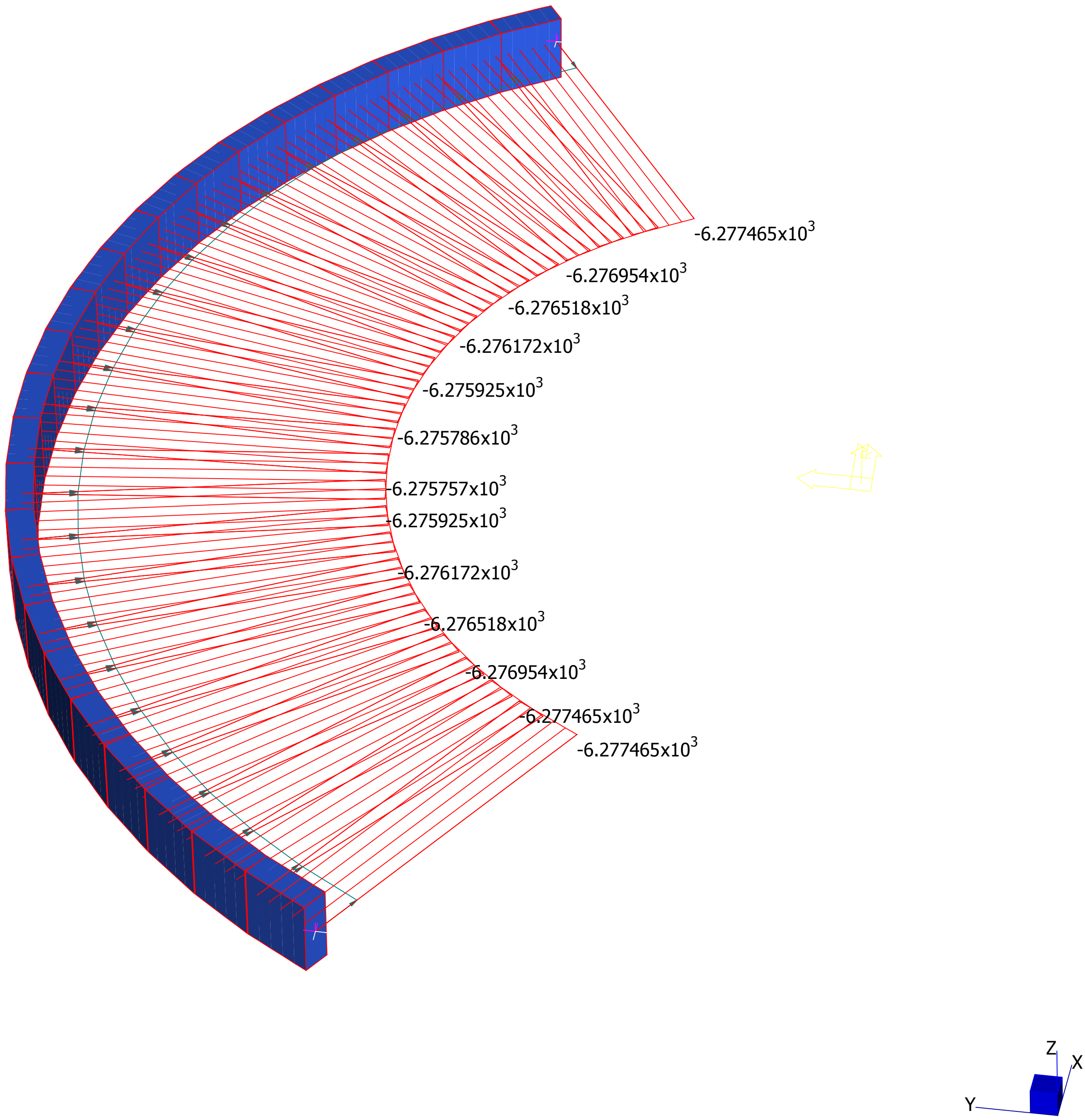
G:\Waterteo\Pcad\TIMOR DAM UPGRADE\Concept Drawings\P-Timor_Fig008.dgn ZHANGC2 1:12:33 PM 5/12/2018

APPENDIX C

RAISED ARCH DAM ANALYSIS

Title:	
Project:	
Author:	Reference:

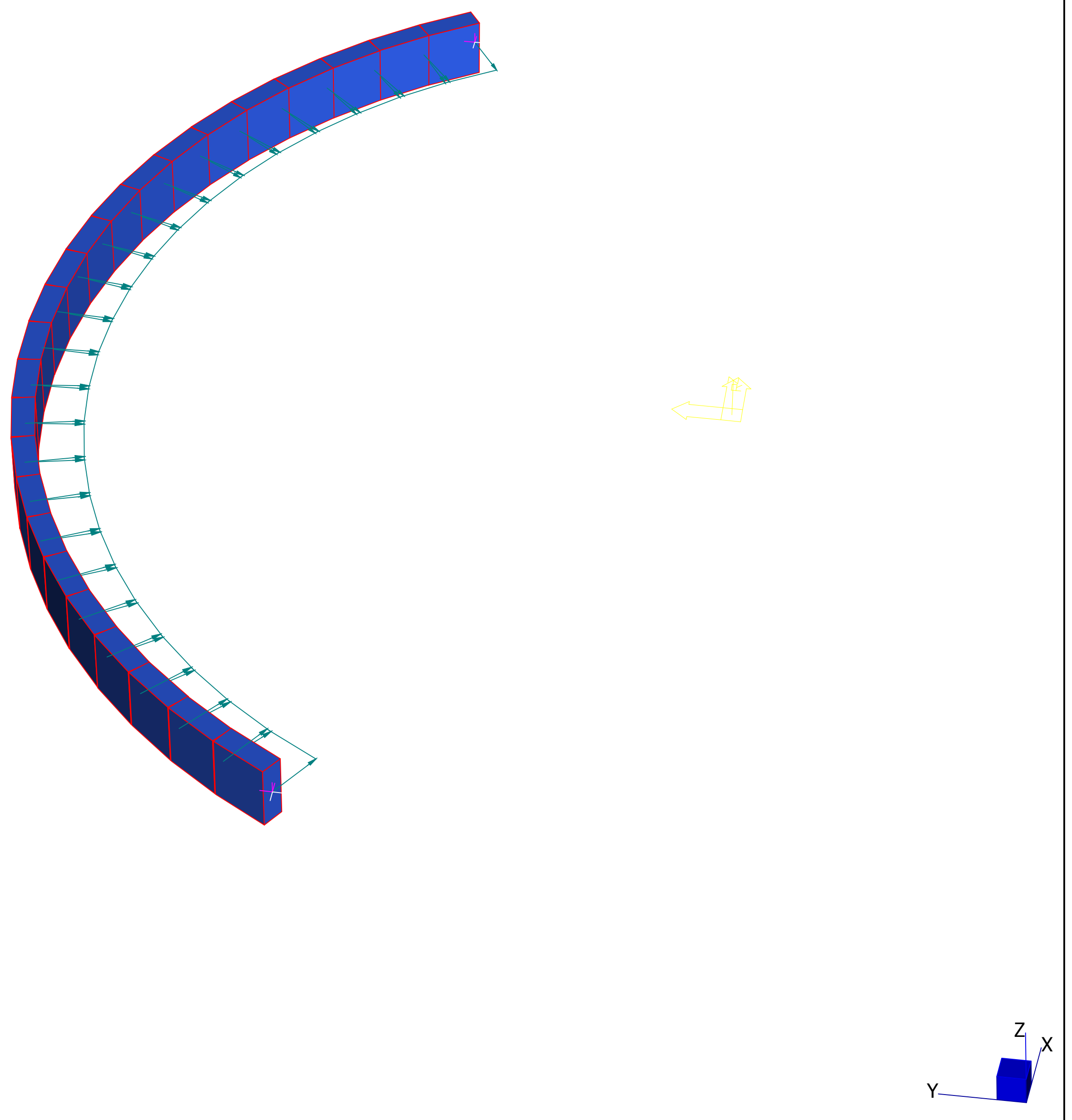
	MIN	MAX
AxForce(kN)	-6.277465×10^3	-6.275757×10^3
	[Bm:24]	[Bm:13]



26 Nodes 24 Beams 0 Plates 0 Bricks 0 Links 0 Paths	0 Vertices 0 Edges 0 Loops 0 Faces 0 Surfaces	View RX: -51.7 RY: -0.5 RZ: 80.5	2: Factored Water Load [Combination 1] 1: Freedom Case 1 Scale: 0.0 %

Strand7 R2.4.6 [Licenced to:Dept. Services Technology Admin.]
Model file: G:\Watertec\Dams_civ\PROJ\Timor Dam Raising Feasibility & Concept\Strand7Model_Raised_Concrete_Band\Beam_Model.st7
Result file: G:\Watertec\Dams_civ\PROJ\Timor Dam Raising Feasibility & Concept\Strand7Model_Raised_Concrete_Band\Beam_Model.LSA
30 July 2018 11:38 am

Title:	
Project:	
Author:	Reference:



26 Nodes 24 Beams 0 Plates 0 Bricks 0 Links 0 Paths	0 Vertices 0 Edges 0 Loops 0 Faces 0 Surfaces	View RX: -51.7 RY: -0.5 RZ: 80.5	1: Water Load 1: Freedom Case 1

Strand7 R2.4.6 [Licenced to:Dept. Services Technology Admin.]

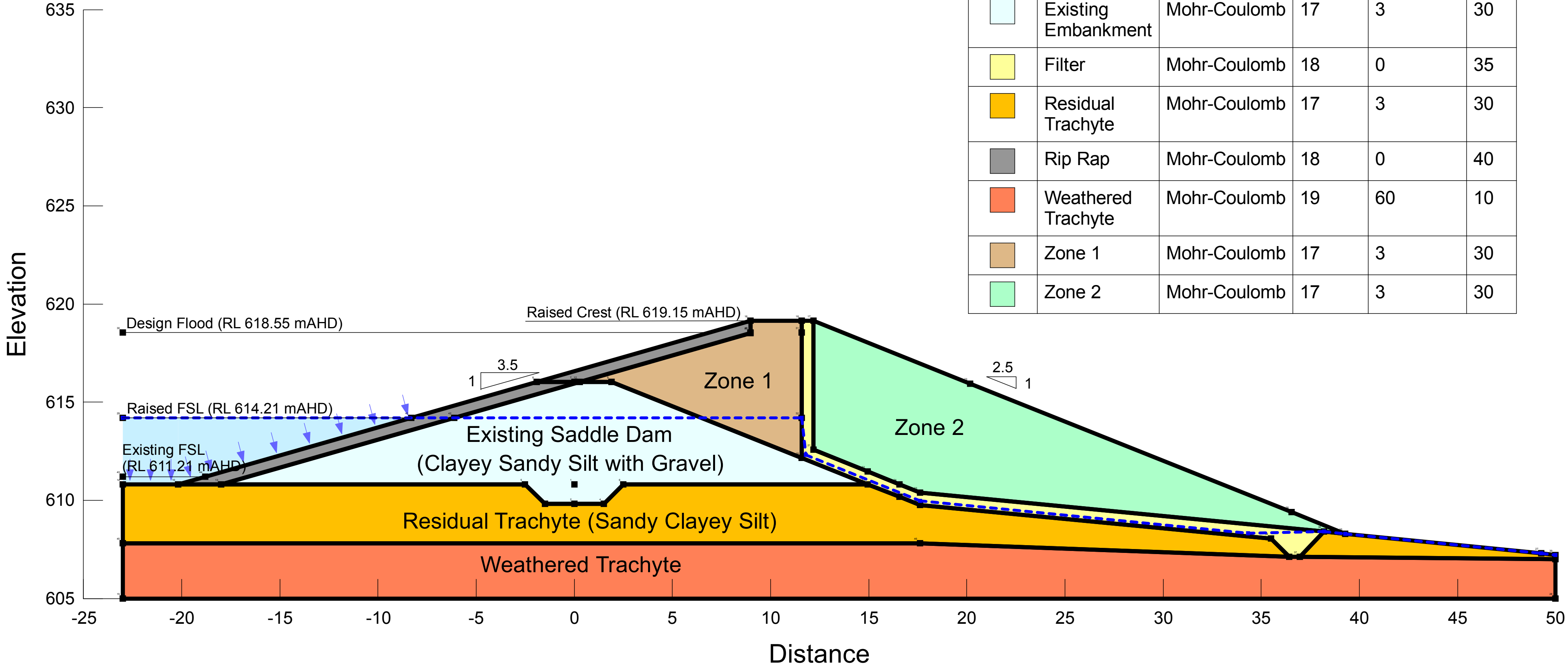
Model file: G:\Watertec\Dams_civ\PROJ\Timor Dam Raising Feasibility & Concept\Strand7Model_Raised_Concrete_Band\Beam_Model.st7

30 July 2018 11:36 am

APPENDIX D

RAISED SADDLE DAM STABILITY ANALYSIS

Timor Dam - Raised Saddle Dam Stability

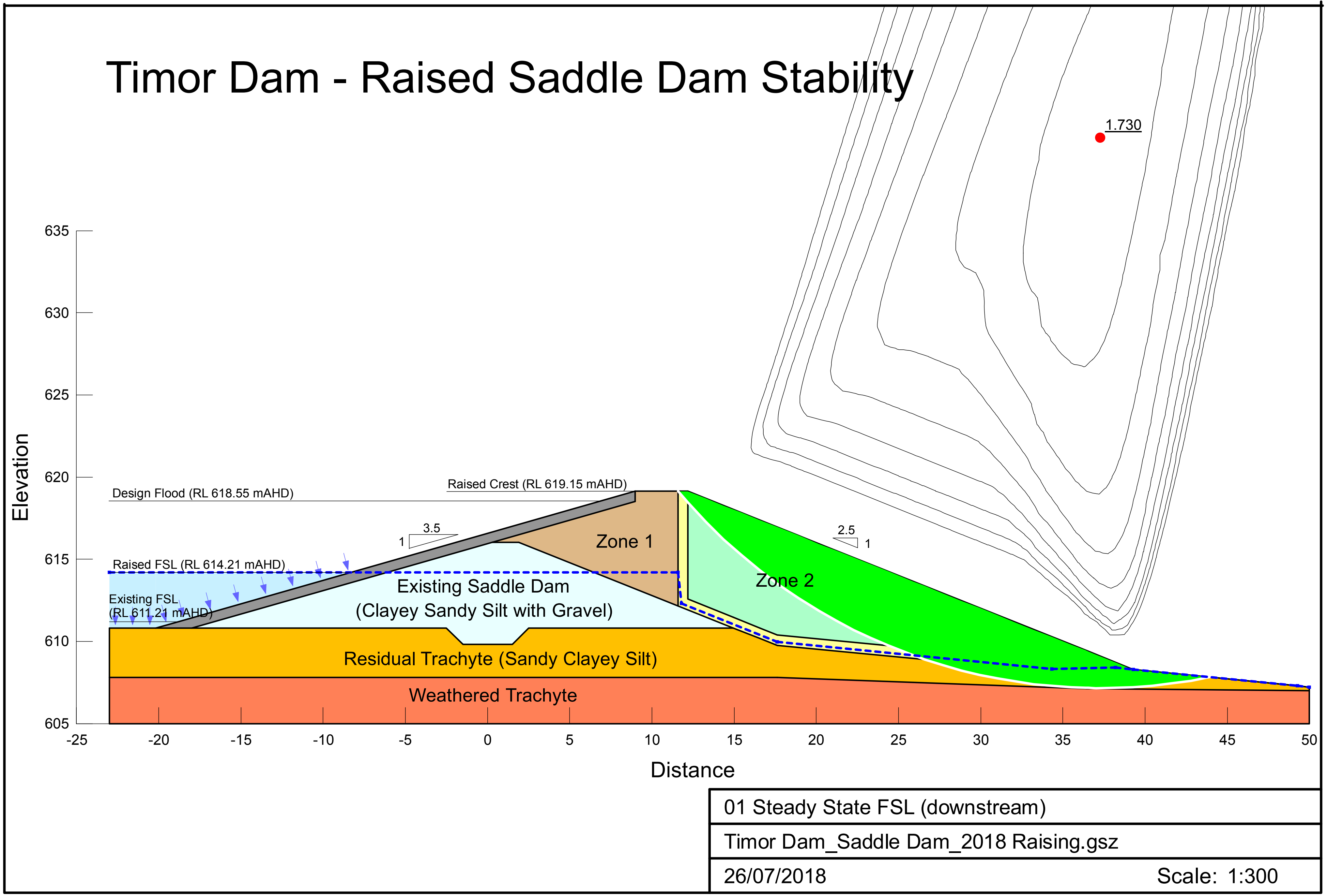


Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Existing Embankment	Mohr-Coulomb	17	3	30
	Filter	Mohr-Coulomb	18	0	35
	Residual Trachyte	Mohr-Coulomb	17	3	30
	Rip Rap	Mohr-Coulomb	18	0	40
	Weathered Trachyte	Mohr-Coulomb	19	60	10
	Zone 1	Mohr-Coulomb	17	3	30
	Zone 2	Mohr-Coulomb	17	3	30

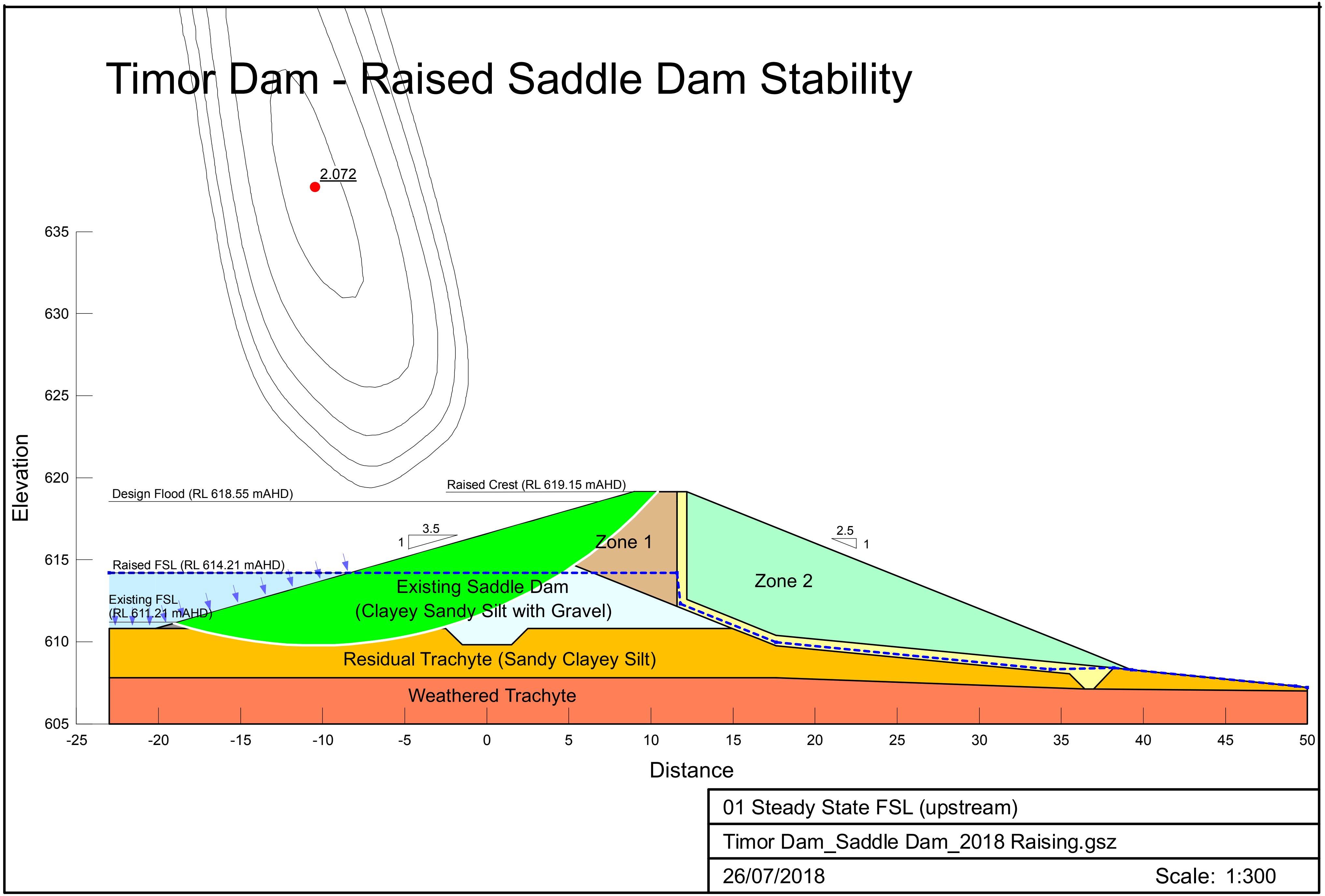
00 Timor Dam - Raised Saddle Dam

Timor Dam_Saddle Dam_2018 Raising.gsz

26/07/2018 Scale: 1:300

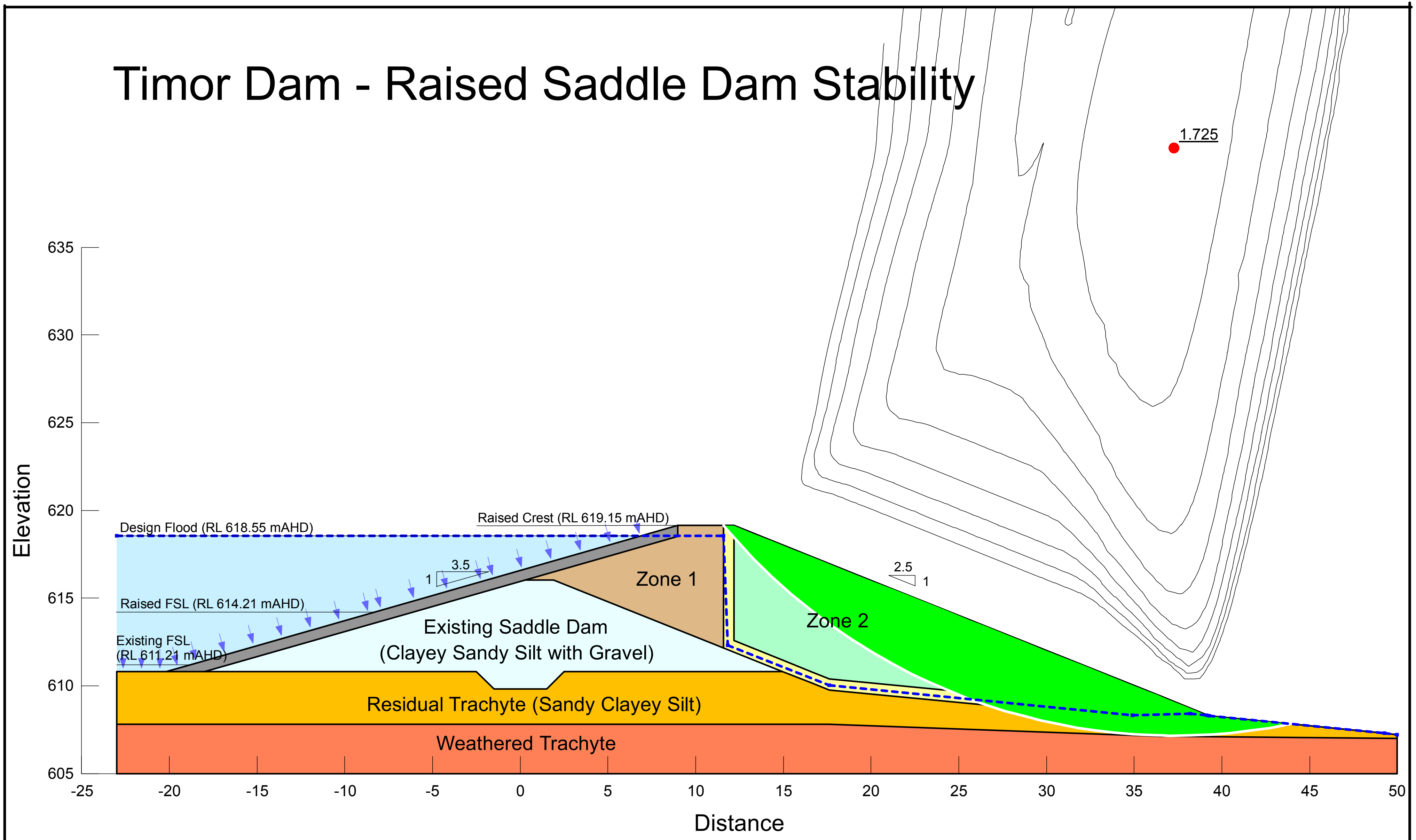


Timor Dam - Raised Saddle Dam Stability
1.730
Elevation
635
630
625
620
615
610
605
Design Flood (RL 618.55 mAHD)
Raised Crest (RL 619.15 mAHD)
3.5
1
2.5
1
Zone 1
Zone 2
Raised FSL (RL 614.21 mAHD)
Existing FSL
(RL 611.21 mAHD)
Existing Saddle Dam
(Clayey Sandy Silt with Gravel)
Residual Trachyte (Sandy Clayey Silt)
Weathered Trachyte
-25
-20
-15
-10
-5
0
5
10
15
20
25
30
35
40
45
50
Distance
01 Steady State FSL (downstream)
Timor Dam_Saddle Dam_2018 Raising.gsz
26/07/2018
Scale: 1:300

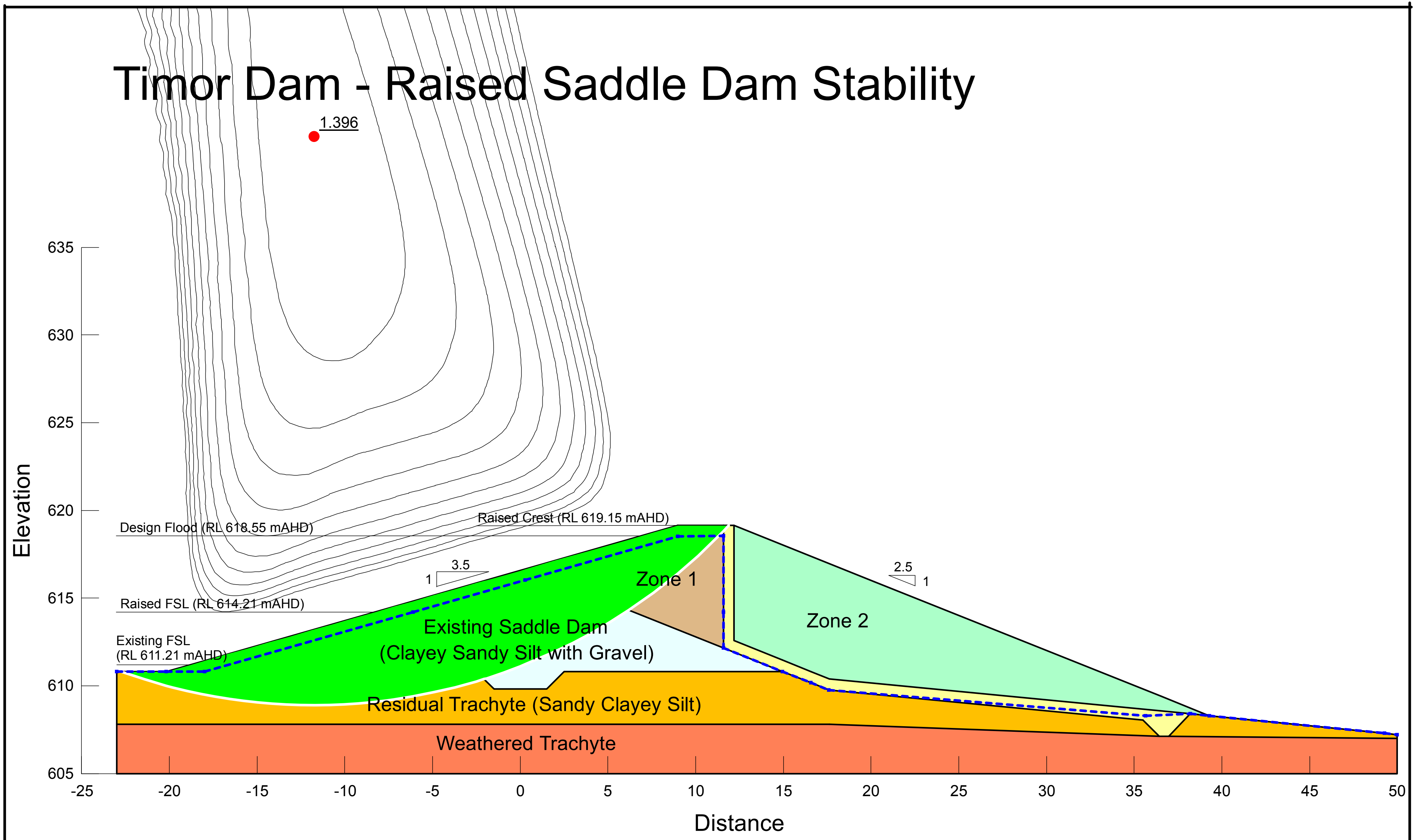


Timor Dam - Raised Saddle Dam Stability
2.072
Elevation
Distance
Design Flood (RL 618.55 mAHD)
Raised Crest (RL 619.15 mAHD)
Raised FSL (RL 614.21 mAHD)
Existing FSL
(RL 611.21 mAHD)
3.5
1
2.5
1
Zone 1
Zone 2
Existing Saddle Dam
(Clayey Sandy Silt with Gravel)
Residual Trachyte (Sandy Clayey Silt)
Weathered Trachyte
635
630
625
620
615
610
605
-25
-20
-15
-10
-5
0
5
10
15
20
25
30
35
40
45
50
01 Steady State FSL (upstream)
Timor Dam_Saddle Dam_2018 Raising.gsz
26/07/2018
Scale: 1:300

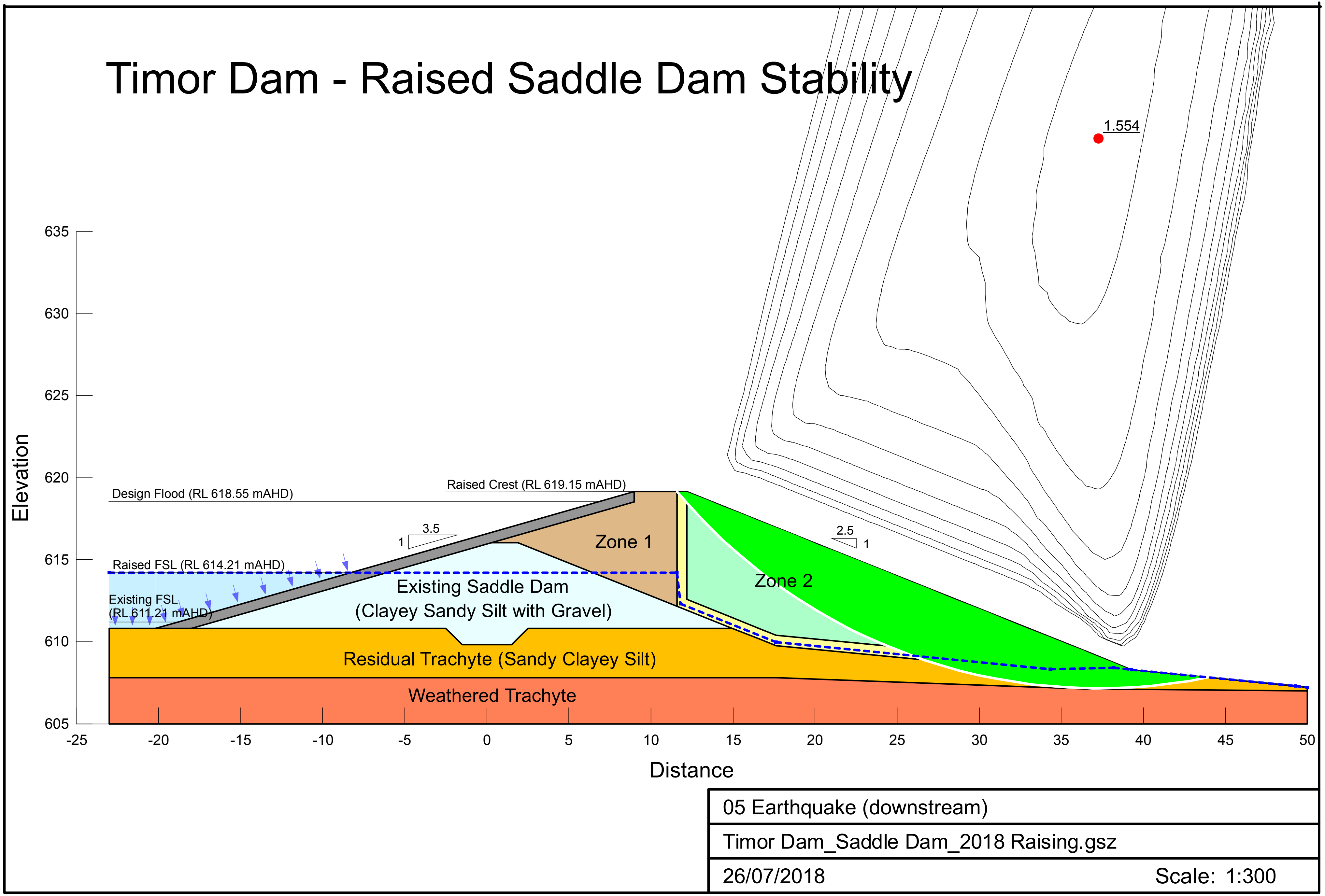
Timor Dam - Raised Saddle Dam Stability



02 Steady State FLOOD (downstream)
Timor Dam_Saddle Dam_2018 Raising.gsz
26/07/2018 Scale: 1:300

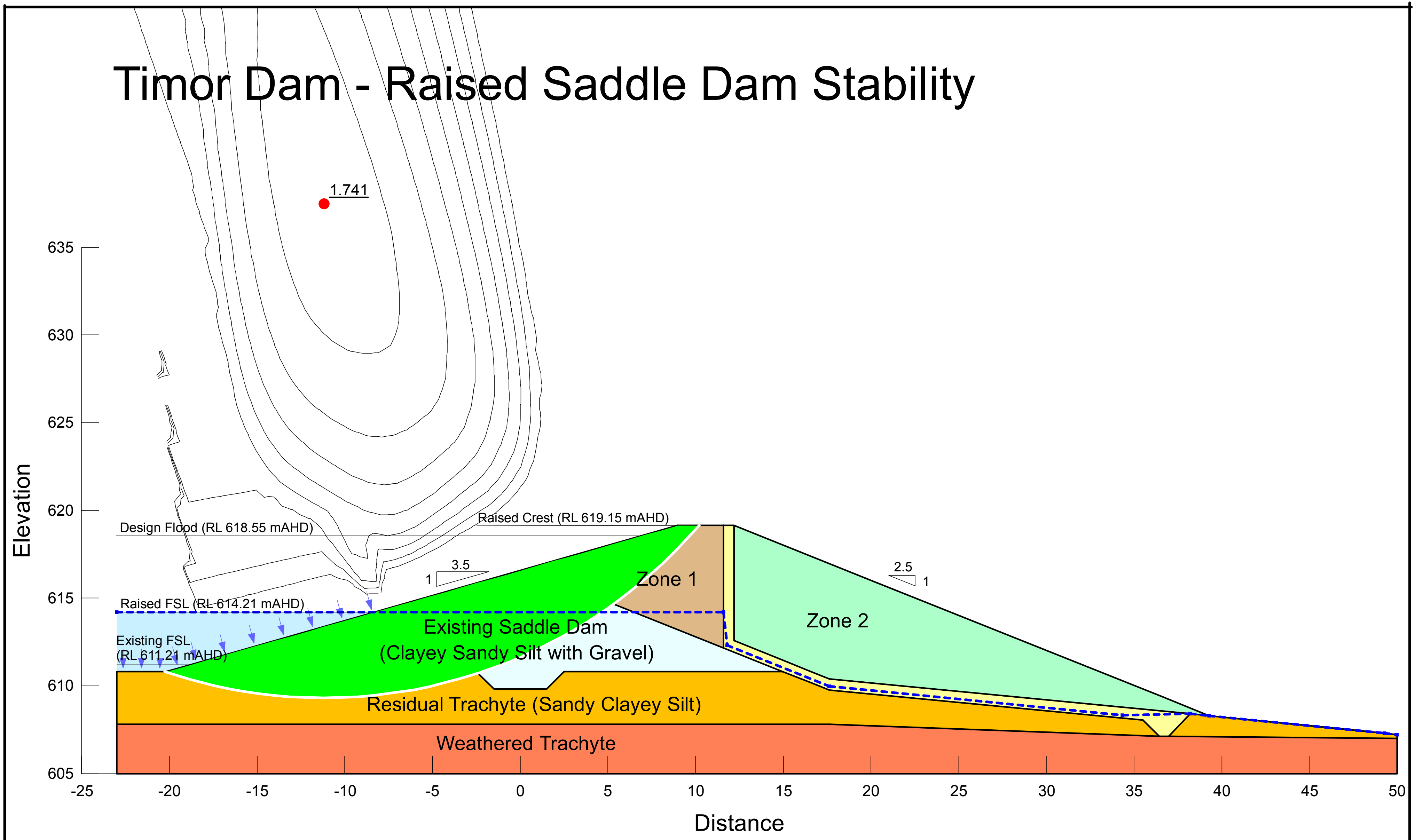


03 Rapid Drawdown (upstream)	
Timor Dam_Saddle Dam_2018 Raising.gsz	
26/07/2018	Scale: 1:300



Timor Dam - Raised Saddle Dam Stability
1.554
Elevation
635
630
625
620
615
610
605
Design Flood (RL 618.55 mAHD)
Raised Crest (RL 619.15 mAHD)
3.5
1
2.5
1
Zone 1
Zone 2
Raised FSL (RL 614.21 mAHD)
Existing FSL
(RL 611.21 mAHD)
Existing Saddle Dam
(Clayey Sandy Silt with Gravel)
Residual Trachyte (Sandy Clayey Silt)
Weathered Trachyte
-25
-20
-15
-10
-5
0
5
10
15
20
25
30
35
40
45
50
Distance
05 Earthquake (downstream)
Timor Dam_Saddle Dam_2018 Raising.gsz
26/07/2018
Scale: 1:300

Timor Dam - Raised Saddle Dam Stability



05 Earthquake (upstream)
Timor Dam_Saddle Dam_2018 Raising.gsz
26/07/2018 Scale: 1:300

APPENDIX E

RAISED DAM COST ESTIMATE

RAISING OF TIMOR CONCRETE ARCH AND SADDLE DAM

COST ESTIMATE NOVEMBER 2018

Item	Quantity	Unit	Rate ($)	Amount ($)
Preparatory Works				
Establishment/Disestablishment		LS		200,000
Dewatering and Flood Protection		LS		100,000
Environmental Management		LS		100,000
Temporary Access Road Upgrade		LS		150,000
SCADA Telemetry		LS		50,000
			Sub-Total	**600,000**
Arch Dam Raising				
Excavation of Existing Concrete	90	Cu m	1,000	90,000
Excavation for Abutment Blocks	400	Cu m	30	12,000
Arch Joint Preparation		LS		80,000
Reinforced Concrete in Arch Wall	320	Cu m	2,000	640,000
Reinforced Concrete Abutment Blocks	800	Cu m	1,200	960,000
Anchor Bars	250	m	200	50,000
Arch Dam Seepage Weir		LS		40,000
Survey Network		LS		60,000
Access Upgrade to Scour Valve and Seepage Weir		LS		180,000
			Sub-Total	**2,112,000**
Inlet				
Debris Clearing and Desilting Upstream of Dam	100	Cu m	200	20,000
Trunnion Replacement		LS		400,000
Trashscreen and Bulkhead Replacement		LS		80,000
Ladders and Platforms		LS		100,000
Mechanical Equipment		LS		100,000
Inflow Measurement Device		LS		50,000
			Sub-Total	**750,000**

Outlet				
Debris Clearing and Desilting Upstream of Dam	1,000	Cu m	200	200,000
Valves Replacement		LS		900,000
Ladders and Platforms		LS		100,000
Reinforced Concrete in Valve Block	10	Cu m	2,000	20,000
Power Supply		LS		250,000
			Sub-Total	**1,470,000**
Saddle Dam Raising				
Excavation in Existing Embankment	300	Cu m	10	3,000
Foundation Excavation/Stripping for Raised Embankment	500	Cu m	20	10,000
Zone 1	2,000	Cu m	15	30,000
Zone 2	3,400	Cu m	15	51,000
Filters	1,000	Cu m	80	80,000
Rip Rap	300	Cu m	80	24,000
Crest Pavement	300	Sq m	20	6,000
Topsoil and Grassing	1,000	Sq m	20	20,000
Toe Drain and Pipework		LS		80,000
Saddle Dam Seepage Weir		LS		20,000
			Sub-Total	**324,000**
Permanent Access Road Upgrade			**Sub-Total**	**300,000**
TOTAL DIRECT COST (ex GST)				**5,556,000**
Preconstruction (10% of TDC)				555,600
Supervision (10% of TDC)				555,600
Contingencies (25% of TDC)				1,389,000
TOTAL COST (ex GST)				**8,056,200**

APPENDIX F

SDAM SURVEY MONITORING REPORT

Warrumbungle Shire Council
Timor Dam Precision Monitoring Survey
Survey Network Design Report

10/08/2018

Document Control

Version	Author	Reviewer	Approved for Issue	
			Name	Date
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Final	Jarad Cannings	Stephen Saunders	Stephen Saunders	10/08/2018

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Abbreviations

Abbreviation	Description
P	Pillar
SP	Settlement Point
IP	Instrument Plate
SSM	State Survey Mark
ppm	parts per million
E	Easting
N	Northing
mm	Millimetres

m	Metres
ML	Mega Litres
SBM	Stable Bench Mark
EDM	Electronic Distance Measurement
ANCOLD	Australian National Committee on Large Dams

Summary

This report compiled by Jarad Cannings describes the conceptual design of a survey network to enable the precision monitoring of Timor Dam by Public Works Advisory (PWA) Surveying.

1. Introduction

This report has been prepared in response to Warrumbungle Shire Council's instruction to undertake a preliminary survey network design process for Timor Dam.

Timor Dam was constructed in 1962 to provide the water supply for Coonabarabran. It is located on the Castlereagh River approximately 12km west of Coonabarabran. The dam is a concrete arch structure 19.5m in height, with a crest length of 59m and a storage capacity of 1140ML. Warrumbungle Shire Council are currently investigating options to raise the dam wall by approximately 3m.

The Timor Dam 2015 Surveillance Report completed by Public Works Advisory (PWA) recommends Council to consider installing a survey monitoring network. This report details a conceptual survey monitoring network that would satisfy the requirements of ANCOLD and achieve the required precisions that are necessary to detect tangible movements of the dam wall.

It should be noted that no site inspection has been undertaken by PWA Surveying. The network that has been proposed in this report has been based upon desktop study only. Should Council wish to proceed PWA would be required to visit the dam site to further develop the particulars of the design in regard to safety, accessibility and pillar construction. This process would best be undertaken during the detailed design stage of the dam raising.

2. Survey Control and Settlement Point Network

2.1 Survey Control Network

The intention of the proposed survey network described in this report is to monitor both the absolute movement of the dam wall within the valley it sits, and the relative movement of components of the dam wall.

The proposed primary control network is comprised of three concrete pillars located beyond the extent of the concrete dam wall. These pillars will act as stable reference points against which the absolute movement of the wall can be measured. Table 1 and Figure 1 describe and show further details of the proposed pillar locations.

Note:

The steep embankments that exist at Timor Dam may prohibit the installation of pillars P2 and P3. If this occurs PWA will investigate other control station options such as stable instrument plates or stainless marks secured into the existing rock surfaces.

Table 1 - Proposed primary control network details

Station	Type	Location	Approximate Coordinates	
			E (MGA 55)	N (MGA 55)
P1	Concrete Pillar	Left hand abutment (downstream side)	705021	6537513
P2	Concrete Pillar	Right land abutment (downstream side)	704893	6537431
P3	Concrete Pillar	Approximately 80m downstream from dam wall	704960	6537492

Figure 1 - Primary Control Network – proposed pillar locations

2.2 Settlement Point Network

The proposed settlement point network consists of a total of seven marks (table 2). Five of these marks will be located along the proposed raised crest of the dam wall. These marks will be designed in a way so they are easily accessible for each survey. Possible options include permanently installing a survey prism at each crest mark location or alternatively a set of survey prisms could be laid out by Council immediately prior to each survey. Both options and others can be explored during the next phase of the survey network design with consideration given to time, budget and WHS procedures.

The remaining two settlement point marks are to be located at the toe of the dam wall on the downstream side. These two marks will monitor any unexpected movement that may occur at the base of the wall. Additionally, the marks can provide extra redundancy to the control network providing they prove to be stable over time.

The proposed layout of settlement points (figure 2) should allow for reliable detection of any major dam wall movements and has been designed to ensure that each point can be observed from at least two control points.

Table 2 - Approximate coordinates of proposed settlement point locations

Point	Location	Approximate Coordinates	
		E (MGA 55)	N (MGA 55)
SP1	Toe of dam	704952	6537441
SP2	Toe of dam	704945	6537454
SP3	Dam Crest	704976	6537428
SP4	Dam Crest	704955	6537433
SP5	Dam Crest	704943	6537448
SP6	Dam Crest	704941	6537467
SP7	Dam Crest	704949	6537484

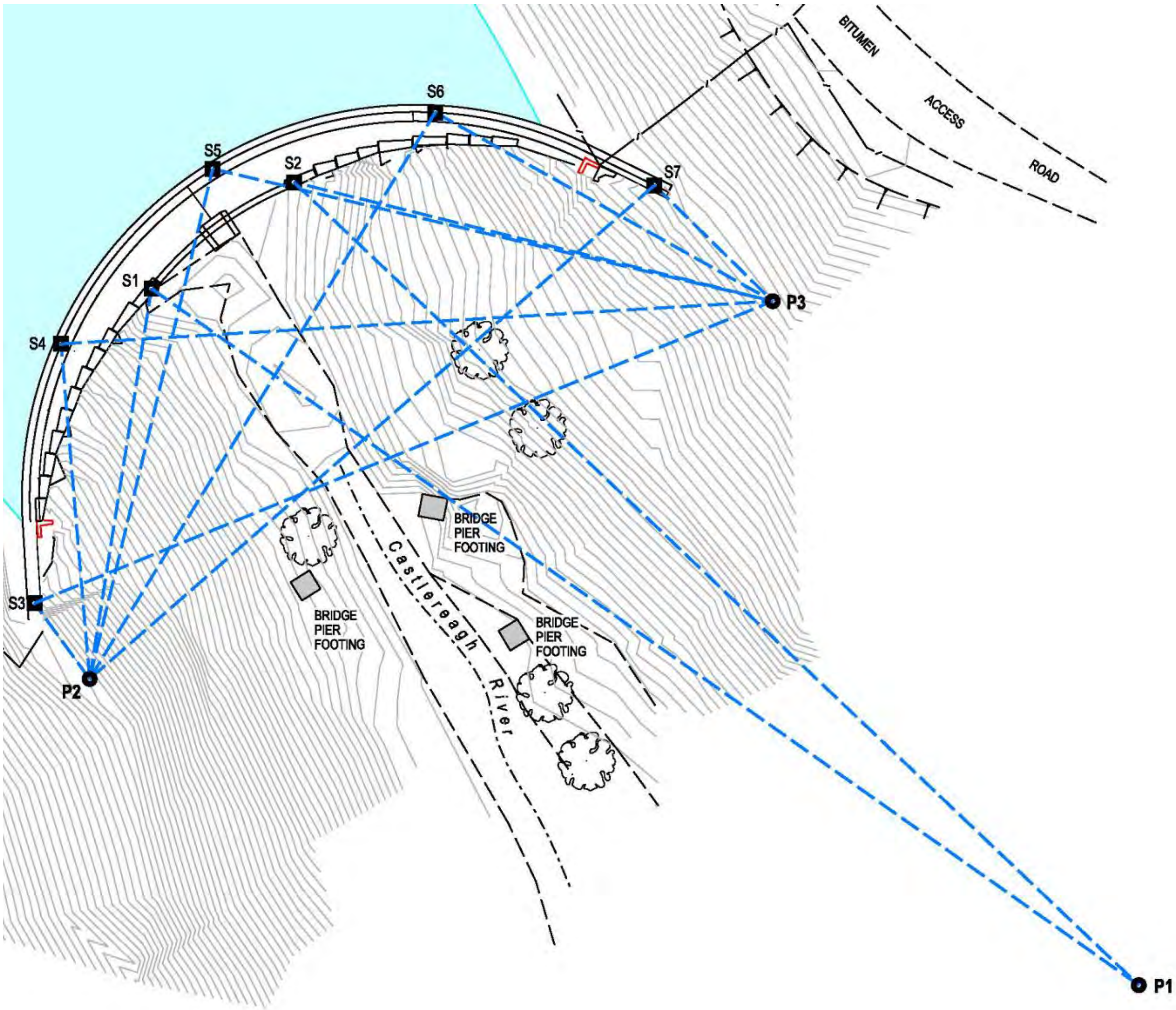


Figure 2 - Settlement Point Network – proposed locations

2.3 Network Optimisation

The network described above was subjected to a network optimisation analysis using the Compnet 2.9 Least Squares Adjustment survey software. An optimisation allows us to predict what accuracies we are going to be able to achieve taking into account instrument locations, instrument type and particular measurement techniques. The Apriori observation precisions were set to be consistent with those reasonably expected for a monitoring class precision survey instrument such as the Leica TM30 total station employed by PWA Surveying (Table 3).

Table 3 - Apriori observation precisions

Horizontal Pointing (“)	0.5”
Distance Measurement PPM	1
Distance Measurement Const (m)	0.0005
Instrument Plumbing (m)	0.0005*
Tripod Plumbing (m)	0.0005*
Vertical Pointing (“)	2”
Instrument Height (m)	0.001
Tripod Height (m)	0.001

NB: values denoted by * are a recognition of repeatability afforded by force centring techniques combined with fixed survey pillars at all instrument stations.

A 3D optimisation was undertaken to gain an indication of the precision of heights derived from total station trig heighting. In the case of this survey this would be the main technique for determining the heights of the settlement points

The results of the network optimisation can be summarised as follows (at a 95% Confidence Interval):

- ✓ The 95% Confidence Interval error ellipses generated by Compnet are nominally 2.8 times larger the standard deviation error ellipse for any point, with the same orientation.
- ✓ All critical horizontal movements can be reliably measured to ± 2mm.
- ✓ Settlement Points have nominally circular and uniform Horizontal Absolute Error Ellipses.
- ✓ The optimisation was based on the assumption that pillars P1-P3 are stable.
- ✓ Settlement points – S1 and S2 will be used as a secondary control points with observations being taken from these marks to the primary control pillars P1-P3.

An image of the Absolute Error Ellipses for the Survey network optimisation described above is shown below in Figure 3 below. The full results of the optimisation are shown in Appendix A of this report.

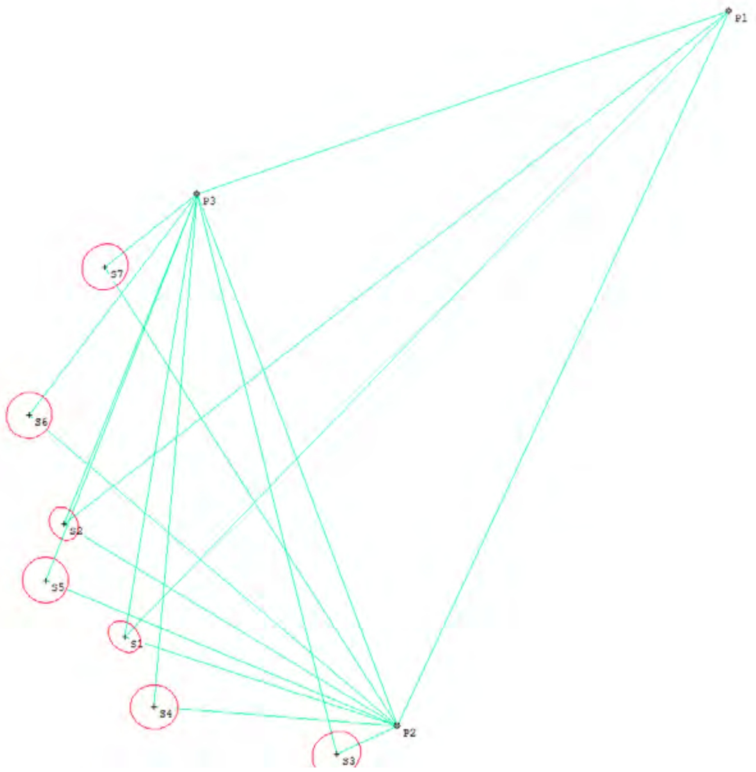


Figure 3 - Network optimisation with absolute error ellipses

2.4 Precise Levels

All concrete survey pillars would incorporate a BM (bench mark) in the base plinth and the top of the thread for each concrete pillar would also be levelled (site permitting). An additional site bench mark may also be required and will be assessed further at the time of the network installation.

Settlement points S1-S2 and the survey pillars would be levelled using precise levelling techniques utilising a Leica DNA03 precise digital level and invar barcode staff, or equivalent. Such a combination would reasonably yield levelling results to +/-1mm (this has been reliably achieved in the past at similar dams by Public Works Advisory).

Settlement points S3 – S7 would be levelled using the Trig. Heighting technique given their difficulty to access. This technique would reasonably yield levelling results to +/-3mm.

3. Network Installation

It would be prudent to install the pillars during the dam raising construction process due to the steep terrain of the dam site. Furthermore the construction activity related to the raising may also present other opportunities for the survey network such as access tracks and clearings.

PWA surveyors will be available to set out the network and liaise with PWA engineers, Council and the construction contractor to ensure marks are installed as per design.
The particular details relating to the construction nature of the pillars and settlement points has not be included as part of this report. These details can be specified and confirmed once a site inspection has taken place and Council wishes to progress the network installation.

4. Conclusion

This report has detailed the design and optimisation of a conceptual survey network for Timor Dam. The design has taken into account site topography, dam magnitude, expected future dam movement and overall cost. These factors have been considered via a desktop review only. The optimisation of the network has yielded theoretical precisions that appear to be suitable and fit for purpose for this project. Furthermore, the network contains a degree of redundancy should any nominally stable survey pillars prove to be less than stable.

Appendices

Appendix A – Network Optimisation Results

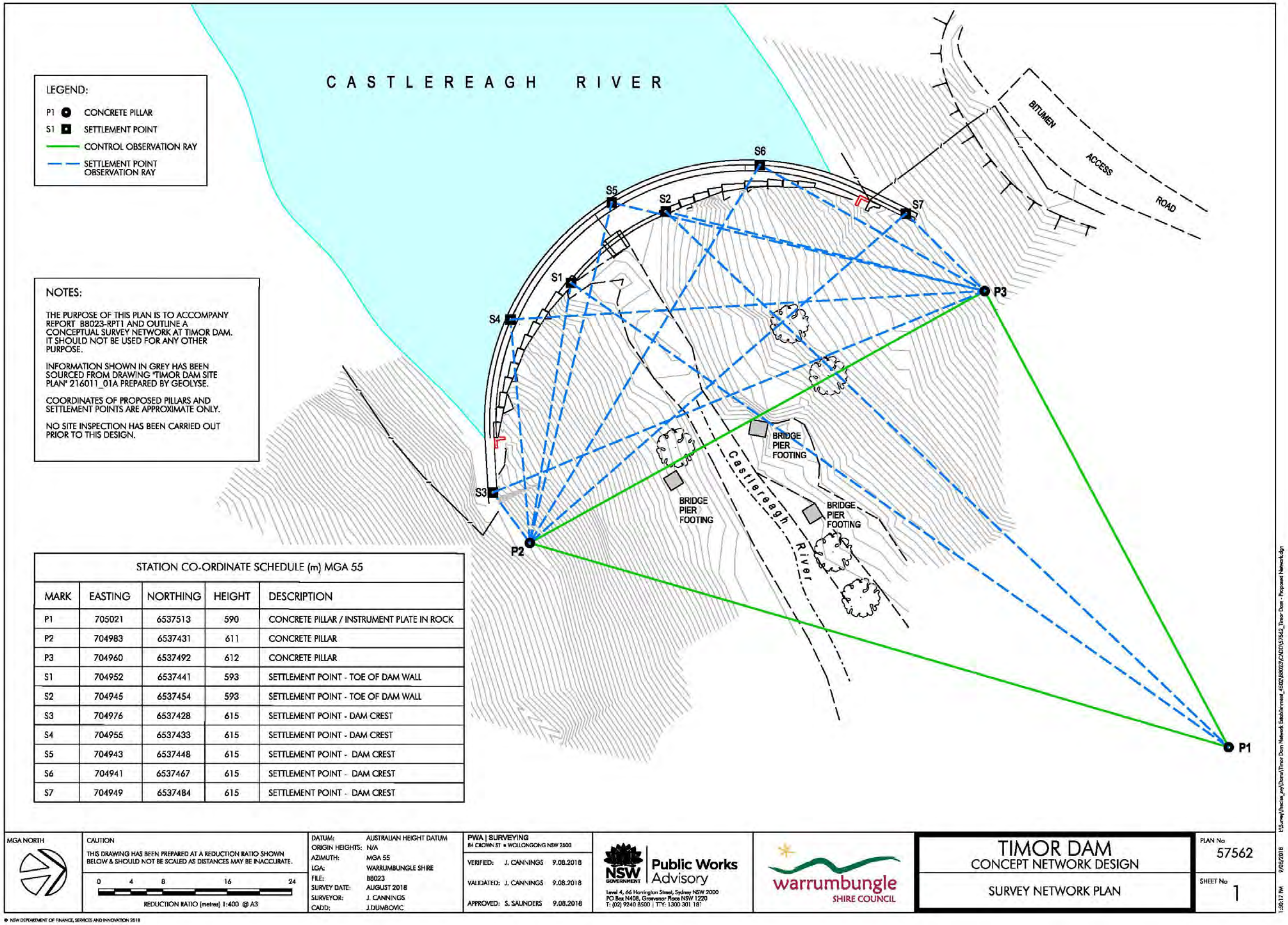
95% Confidence Interval Compnet 2.9 Absolute Error Ellipses (P1, P2, and P3 held fixed)

Table 4 - Nominal Absolute Error Ellipses - Control Network

Point	Semi Major Axis (mm)	Semi Minor Axis (mm)	Orientation (MGA)	Vertical (mm)
SP1	1.3	1	133°	1.5
SP2	1.2	1	152°	1.6
SP3	1.8	1.6	61°	2.6
SP4	1.7	1.6	93°	2.9
SP5	1.6	1.6	117°	2.9
SP6	1.7	1.6	32°	2.9
SP7	1.7	1.6	48°	2.8

NB: The 95% confidence Interval error ellipses generated by Compnet are nominally 2.8 times larger the standard deviation error ellipse for any point, with the same orientation.

Appendix B – Proposed Network Layout Plan– Plan 57562 (IMAGE ONLY)



STATION CO-ORDINATE SCHEDULE (m) MGA 55

MARK	EASTING	NORTHING	HEIGHT	DESCRIPTION
P1	705021	6537513	590	CONCRETE PILLAR / INSTRUMENT PLATE IN ROCK
P2	704983	6537431	611	CONCRETE PILLAR
P3	704960	6537492	612	CONCRETE PILLAR
S1	704952	6537441	593	SETTLEMENT POINT - TOE OF DAM WALL
S2	704945	6537454	593	SETTLEMENT POINT - TOE OF DAM WALL
S3	704976	6537428	615	SETTLEMENT POINT - DAM CREST
S4	704955	6537433	615	SETTLEMENT POINT - DAM CREST
S5	704943	6537448	615	SETTLEMENT POINT - DAM CREST
S6	704941	6537467	615	SETTLEMENT POINT - DAM CREST
S7	704949	6537484	615	SETTLEMENT POINT - DAM CREST

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APPENDIX G

SAFETY IN DESIGN INCLUDING RISK CHECKLIST

SAFETY IN DESIGN (SID) RISK CHECKLIST FOR STRUCTURE THAT HAS UNUSUAL OR ATYPICAL FEATURES

PWF-2119e [Rev 1]

Owner of the Works:

WARRUMBUNGLE SHIRE COUNCIL

NOTE: Owner = Owner of the Works and is interchangeable with 'Principal' and where relevant, 'Client'.

Name and address of project:

TIMOR DAM RAISING, COONABARABRAN NSW

Designer of the Works:

PUBLIC WORKS ADVISORY - DAMS

This SID Checklist is designed to be used at the Concept Design phase OR the early stages of the Detailed Design phase of the abovementioned project. It is intended for the Designer and the Owner of the Works to identify, as early as possible, the associated hazards and risks, and means to address those hazards and risks during the engineering handling lifecycle of the designed structure(s).

The NSW Work Health and Safety Regulation 2011 Clause 294 requires that the person who commissions the design of the structure (i.e. the Owner of the Works) must consult with the Designer, and provide information about the hazards and risks during the design structure's engineering handling lifecycle. The intent is for the Owner to be aware and assist the Designer to identify, analyse and eliminate / minimise the potential hazards and risks.

This SID General Quick-Tick List applies to design of structures that have unusual or atypical features which present risks taking into consideration:

- ***Geotechnical,***
- ***Survey,***
- ***Civil,***
- ***Mechanical,***
- ***Electrical,***
- ***Environmental, and***
- ***General Safety***

phases that are unique to the particular design. This Checklist does not provide an exhaustive list of every conceivable hazard and risk that may become evident during the engineering handling lifecycle of the structure(s).

SID GENERAL QUICK-TICK LIST

<table>
<tr><th rowspan="2">Design Items</th><th colspan="3">Examined in Design?</th><th rowspan="2">Remarks</th></tr>
<tr><th>Yes</th><th>No</th><th>Not Applicable</th></tr>
<tr><th colspan="5">Geotechnical</th></tr>
<tr><td>Latest available geotechnical assessment used for the design</td><td>✓</td><td></td><td></td><td>Design has been based on geotechnical information from previous PWA investigations and the report by SMEC, Timor Dam Upgrade Geotechnical Investigations, August 2016</td></tr>
<tr><td>Approved earthen engineering materials sourcing location(s) (e.g. borrow area, quarry, etc.) have been identified</td><td>✓</td><td></td><td></td><td>Material sources have been identified and design is based on geotechnical investigations as outlined above plus geological reconnaissance undertaken and reported in the PWA, Site Inspection Report, January 2018</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><th colspan="5">Survey</th></tr>
<tr><td>Latest available site survey used for the design</td><td>✓</td><td></td><td></td><td>The survey data used was based on the dam's WAE drawings and the latest survey supplied by Council and produced recently by Geolyse, 2016.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><th colspan="5">Civil</th></tr>
<tr><td>Design caters for the required flood / earthquake / Owner requested etc. design capacity</td><td>✓</td><td></td><td></td><td>The dam raising has been designed in accordance with DSC and ANCOLD guidelines. Timor Dam has been assigned a HIGH A Flood Consequence Category (FCC), which requires safe passage of the Probable Maximum Flood (PMF) and a SIGNIFICANT Sunny Day Consequence Category (SDCC), which requires it to withstand a 0.2% AEP (500 year) earthquake (refer DSC3B & DSC3C respectively).

Data for design of the raised dam has been obtained from the following:
• GHD, Timor Dam Hydrology Report, December 2016
• NSW Public Works, Timor Dam Mechanical Equipment – Condition Assessment and Upgrade Recommendations, December 2016
• NSW Urban Water Services, Coonabarabran Water Supply Yield Study, August 2017</td></tr>
</table>

Design Items	Examined in Design? Yes	No	Not Applicable	Remarks
				• Entura, *Timor Dam Dambreak and Consequence Assessment*, November 2017 • Arup, *Timor Dam Seismic Assessment,* February 2018
Steps, stairs, step irons, ladders, etc. facilities have been designed in accordance with AS1657	✓			All access is designed in accordance with latest WHS requirements. This includes access to the dam and seepage weirs.
Fall hazards (elevation differential of two (2) opened working surfaces > 300 mm) have been protected with min. 1,000 m high guardrails, etc. (refer to AS1657)	✓			Handrails will include Intermediate knee rails and toe boards / kickplates. All guardrails designed to latest RMS requirements and Australian Standards. All access designed in accordance with latest WHS requirements including access to the dam and seepage weirs.
Maximum engineering slopes designed in accordance with AS1657	✓			Maximum design saddle dam embankment slope = 1V to 3H based on slope stability analyses. Max. design slope for rock excavation = 2V to 1H based on geological investigations.
Standard Factor of Safety (FOS – sliding, overturning, shear, bending, etc.), design live / reduction factors, etc. have been used in the design of sections / structural members	✓			Standard Factors of Safety used for stability analyses taken from best practice literature. Refer to Concept Design Report
Bearing capacity of the design structure(s) have been verified	✓			Based on geotechnical investigations. Refer to Concept Design Report
Mechanical				
Access openings are user friendly for retrieval of personnel	✓			Provide lifting davits and personnel anchor points.
Access ladders (vertical)	✓			Designed with fitted safety climbing device.
Protective coating to be suitable for potable water and in accordance with WSA 201	✓			Designed in accordance with WHS Specifications and Regulations.
All mechanical equipment can easily be accessed for maintenance with sufficient space around equipment	✓			Access and spacing conforms with WHS Specifications and Regulations.
Electrical				
Switch room containing switchboards longer than 3 m	✓			Minimum two (2) doors opening outwards designed (AS3000).

Design Items	Examined in Design?			Remarks
	Yes	No	Not Applicable	
Access clearance in front of switchboard	✓			Minimum 600 mm from edge of door in open position designed. (AS3000).
Electrical pits	✓			Pits and covered have been designed to be of heavy duty grade fit for vehicular access.
Electrical pit marking	✓			All cable pits and route directions have been numbered and labelled.
Environmental				
Latest available environmental assessment used for the design	✓			Refer to the REF.
Approval to eliminate identified sensitive environmental items to accommodate for the design has been received	✓			Identified sensitive items as per the REF must not be disturbed by the design.
The design was carried out with the intention of preserving identified sensitive environmental items	✓			The dam raising arrangement is intended to avoid identified Aboriginal scar trees.
General Safety				
Installation of appropriate warning signage specified in the design	✓			'Authorised Personnel Only' and other appropriate safety signage to be installed at site entry.
Speed limit of vehicles have been incorporated in the design	✓			
Others				

NOTE: See the <u>Safety In Design (SID) Risk Checklist</u> below for detail specific items not listed above.

The SID Risk Checklist covers 1. Design,
2. Community Consultation,
3. Site and Services,
4. Work Health and Safety,
5. Environmental and Site Conditions,
6. Construction and Programming, and
7. Additional Risks Identified

CONSEQUENCE PROBABILITY MATRIX

	Probability (Likelihood)			
Consequence	**Very Likely** Could happen any time	**Likely** Could happen sometimes	**Unlikely** Could happen but very rarely	**Very Unlikely** Could happen but probably never will
Very Severe Kill or cause permanent disability or ill health; Complete destruction of the designed structure(s) and / or surrounding infrastructure / environment resulting in major long-term re-engineering works and severe legal penalties.	**1**	**1**	2	3
Severe Long term illness or serious injury; Substantial damages to the designed structure(s) and / or surrounding infrastructure / environment resulting in up to a year of re-engineering works and lengthy legal implications.	**1**	2	3	4
Moderate Medical attention and several days off work; Moderate damages / interruptions to the services offered by the designed structure(s) and / or surrounding infrastructure / environment requiring a mending timeframe of up to 6 months with some legal implications.	2	3	4	5
Minor First Aid needed; Minor damages / interruptions to services offered by the designed structure(s) and / or surrounding infrastructure / environment which could be mended by the Contractor with minimal legal implications.	3	4	5	6

Adapted from WorkCover NSW HAZPAK Worksheet, with added potential general civil and legal implications.

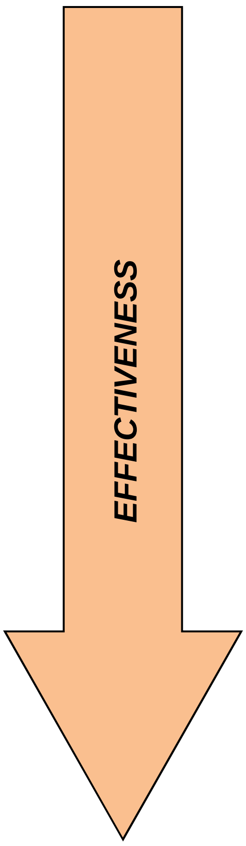
GENERAL DEFINITIONS

A **hazard** is generally defined as the presence of a dangerous item, condition or situation that can cause harm and / or damages to people, the environment and surrounding infrastructure.

A **risk** is generally defined as the potential harm and / or damages caused as a result of being exposed to a hazard.

In the context of SID reporting, the risks of identified hazards are to be distinguished by the achievable level of outcome as a result of implementing safety measures, by application of the Hierarchy of Control, for a particular dangerous situation / item.

HIERARCHY OF CONTROL LEVELS



1. **Elimination** – Remove the source of danger so that it no longer exists to cause harm / damage.
   Example: Proposed structure located below existing overhead power lines – remove / relocate overhead power lines prior to construction.

2. **Avoidance** – Relocate the work so that the source of danger no longer exists to cause harm / damage.
   Example: Proposed structure located on flood-prone land – relocate structure to higher grounds outside of inundation area.

3. **Substitution** – Adoption of operation alternatives to carry out the work so that the probability and severity of harm / damage can be eliminated / minimised.
   Example: Conventional sheet pile installation with crane and hammer rig would hit existing overhead power lines – install using silent 'clamp' piler with water jetting in combination with on-site pile welding to satisfy vertical clearance requirements.

4. **Isolation** – Isolate the potential recipient from the source of danger by temporary relocation so that the probability and severity of harm / damage can be minimised.
   Example: Structure located on flood-prone land – evacuate the structure and / or prevent access to the structure during early phase of critical storm / flood events.

5. **Engineering** – Protect the potential recipient from the source of danger with engineering solutions so that the probability and severity of harm / damage can be minimised.
   Example: Structure located on flood-prone land – construct / install flood barriers to prevent inundation of structure.

6. **Administration** – Notify the potential recipient of the source of danger on-site so that the probability and severity of harm / damage can be minimised.
   Example: warning signage, flood meter, speed humps, bollards, buoys, lighting, etc.

7. **Personal Protection Equipment (PPE)** – Potential recipient to administer on-body protection so that the probability and severity of harm / damage can be minimised.
   Example: formal training, helmet, steel cap boots, safety vests, rope harness, hazmat suit, etc.

SID RISK CHECKLIST

Situation ID	Description of Hazard	Consequence Probability Rating (before Safety Measures)	Hierarchy Control Level of implementable Safety Measures	Consequence Probability Rating (after Safety Measures)	Lifecycle Phase of Action
1 – DESIGN PHASE					
1.1	Design	1	Designs will be undertaken fully in accordance with NSW Dams Safety Committee (DSC) requirements, Australian National Committee on Large Dams (ANCOLD) guidelines and all relevant AS standards as well as current best practice.	6	Detail design
1.2	Construction program and sequencing	1	The existing dam configuration and constraints around the continued operation of the dam will impact significantly on the construction sequencing and approach. A preliminary construction program will be prepared with input from construction industry specialists. This will be a cost-critical exercise because flood diversion and construction of the raised dam structures in a staged manner at an existing large dam in operation is a complex undertaking.	5	Planning
1.3	Construction of structure in close proximity to river – workers / equipment / materials falling into river.	1	Use barge to construct from river Temporary safety barriers Stockpiles min. 10 m away Danger / warning signage PPE: rope and harness gear, etc.	4	Construction

Situation ID	Description of Hazard	Consequence Probability Rating (before Safety Measures)	Hierarchy Control Level of implementable Safety Measures	Consequence Probability Rating (after Safety Measures)	Lifecycle Phase of Action
1.4	Cost estimating	1	Accurate cost estimates are required to inform Council and other key stakeholders in terms of budget planning. To provide understanding and test uncertainty, a probabilistic risk based cost estimate using analysis using Monte Carlo techniques (@RISK) will be utilised.	5	Detail design
2 – COMMUNITY CONSULTATION					
2.1	Advice to landowners	1	Council will need to inform landowners of the works. The Contractor will be responsible for providing landowners with contact details and of the specific times works will be undertaken that may impact vehicle movement or produce noise/vibrations or other disturbance. Council will need to inform affected landowners when manual water releases occur from outlet works.	5	Planning
2.2	Access to site	1	Early consultation with affected landholders will need to be undertaken by Council to ensure that access is granted where necessary. The Contractor will be responsible for providing landowners with contact details and of the specific times that works will be	5	Planning

Situation ID	Description of Hazard	Consequence Probability Rating (before Safety Measures)	Hierarchy Control Level of implementable Safety Measures	Consequence Probability Rating (after Safety Measures)	Lifecycle Phase of Action
			undertaken that may impact vehicle movement or produce noise vibrations or other disturbances.		
2.3	Discovery of an Aboriginal artefact	1	The Principal assumes the risk if an artefact is found. The Contractor is to notify the Principal and the Principal assumes the risk for any additional costs.	4	Planning
3 – SITE AND SERVICES					
3.1	Site access and access roads	3	Site access will be via Timor Road from Coonabarabran. Maintenance of access and all internal roads to be with Contractor. Dilapidation survey's will be required Traffic control, dust control and speed control will be the responsibility of the Contractor	5	Planning/Construction
3.2	Construction impacts on dam wall	2	The Principal will need to carry out an EPOCH survey and compare data before, during and after construction. Vibration monitoring will be required Dilapidation surveys will be required.	4	Planning/Construction

Situation ID	Description of Hazard	Consequence Probability Rating (before Safety Measures)	Hierarchy Control Level of implementable Safety Measures	Consequence Probability Rating (after Safety Measures)	Lifecycle Phase of Action
3.3	Unexpected encounter with existing underground services not shown or incorrectly shown on the design and contract drawings.	2	The Contractor must carry out a complete services search prior to commencing excavation works and is responsible to check and confirm the existence and location of any services in the design are correct.	4	Planning/Construction
3.4	Encountering materially adverse site conditions	1	The Principal bears the risk of materially adverse site conditions. Relevant geological reports will be provided to the Contractor.	4	Planning/Construction
3.5	Site services for construction, water supply, sewerage, power	1	The Contractor will need to make arrangement for services and ensure appropriate use in consultation with the Principal.	4	Construction
3.6	Use of Dam water for construction works	1	The Contractor will likely be permitted to use dam water free of charge only for the purpose of carrying out the works (responsible use). The location and method of water extraction must avoid the risk of dam water contamination, and must be approved by the Principal. Dam water is non potable.	4	Construction
3.7	Working in an operational storage Dam	1	The Contractor will need to manage this risk and fully understand Council's operational requirements. Daily liaison and regular meetings will be necessary.	4	Construction
3.8	Construction may limit operational access	1	Close coordination between the Contractor and Council operators is required to ensure	4	Construction

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			site access restrictions are minimised and managed with adequate notification provided.		
3.9	Illegal site access and vandalism	1	It will be the Contractor's responsible for securing work site.	4	Construction
3.10	Site Office Establishment including fenced compound	1	Only limited amenities exist on-site. Won't be appropriate for larger workforce. The Contractor may approach Council to have a person(s) housed onsite for security.	3	Construction
3.11	Delivery, storage and protection of materials	1	The Contractor will need to ensure adequate processes for delivery, storage and protection of materials are implemented	3	Construction
4 – WORK HEALTH AND SAFETY					
4.1	Identified WHS Construction Risks: • Working at heights • Working over and near water • Flooding • Excavation works • Drilling works • Grouting works • Concrete works • Earthfill haulage, placement and compaction • Scaffolds and work platforms • Hazardous substances	1	Public access is restricted for entire period of construction The dam outlet will be releasing water most of the time. This flow will need to be allowed to pass through without obstruction. Biggest risk for us is walking around the rocky areas – slippery and uneven surfaces. WHS rules are to apply to all personnel on site. Operational access to all parts of the new dam need to be thought of in the design.	4	Planning/Construction

Situation ID	Description of Hazard	Consequence Probability Rating (before Safety Measures)	Hierarchy Control Level of implementable Safety Measures	Consequence Probability Rating (after Safety Measures)	Lifecycle Phase of Action
	• Moving plant • Hazardous equipment • Traffic and vehicular movement • Access and egress • Public access • Demolition activity • Formwork • Vibration • Hydraulic pressure • Power tools • Manual handling • Underground services • Solar radiation • Dust • Noise		Including both sides of the arch dam and saddle dam for inspection. Rock excavation may be a risk to workers. Blasting - alarm and notification to landholders. Consider use of Non-Explosive Controlled Demolition Agent for rock excavation if geotechnical conditions are suitable. Security cameras are required Communication during construction needs to be adequate		
4.2	Management of WHS on site during construction	1	The principal Contractor will be responsible for the management of WHS for themselves, sub-Contractors and all associated construction personnel, including any Council personnel. Council's operations staff will be inducted into and work under the Contractor's WHS system Coordination will be needed to ensure the Contractor's site procedures and Council adopted procedures do not contradict.	4	Planning/Construction

Situation ID	Description of Hazard	Consequence Probability Rating (before Safety Measures)	Hierarchy Control Level of implementable Safety Measures	Consequence Probability Rating (after Safety Measures)	Lifecycle Phase of Action
			Council's dam management operations and emergency procedures will need to be provided for inclusion in the principal Contractor's safety management plan.		
4.3	Falls from height / Working over water	1	It will be the Contractor's responsibility to comply with all WHS requirements. Selection of appropriate subbies, implementation of appropriate management plans and SWMS.	4	Planning/Construction
4.4	Bushfires	1	The Contractor will need to prepare evacuation plans to ensure that adequate procedures are in place in case of bushfires	4	Planning/Construction
4.5	The Contractor will need to prepare evacuation plans to ensure that adequate procedures are in place in case of bushfires	1	It will be the Contractor's responsibility to comply with all WHS requirements. Selection of appropriate subbies, equipment, construction techniques, implementation of appropriate management plans, SWMS, early warning and evacuation.	4	Construction
4.6	Control of jointly occupied site with Contractors and Council.	2	The Contractor will need to manage entry of all personnel to site. (Site control system for all people entering/leaving/transiting site will need to be developed). This should include allowance for emergency night time entry by Council staff.	4	Construction
4.7	Control of landholders' access	2	The Contractor will need to manage safe access for all landholders.	4	Construction

Situation ID	Description of Hazard	Consequence Probability Rating (before Safety Measures)	Hierarchy Control Level of implementable Safety Measures	Consequence Probability Rating (after Safety Measures)	Lifecycle Phase of Action
4.8	Independent certification for coffer dams or other flood mitigation constructions with a structural component or potential impact on water flows to or through the dam	2	The Contractor will need to engage an independent certifier for coffer dams or other flood mitigation constructions. The Contractor will need to arrange, provide and pay all costs for certification.	4	Construction
4.9	Independent certification for formwork	2	The Contractor will need to engage an independent certifier for the formwork. The Contractor will need to arrange, provide and pay all costs for certification.	4	Construction
5 – ENVIRONMENTAL AND SITE CONDITIONS					
5.1	Identified environmental risks: • Dewatering Management • Erosion and sediment control • Contamination of dam water • Contamination of Castlereagh River • Effects of flooding events and potential for pollution storage of fuels and oils, and other hazardous substances • Flora and Fauna • Cultural and Heritage Issues e.g. Indigenous items found during excavation	2	The Environmental Assessment (EA) is to address al environmental and site issues as listed. The Contractor's Construction Environmental Management Plan (CEMP) is to include measures to address the environmental and site issues as listed prior to commencement of the works. Blasting dust, noise and vibration to be considered. Construction noise and dust to be controlled Waste materials to be need adequately managed for disposal. Tree clearing? – generally Council to determine through Environmental Assessment phase	5	Environmental Assessment / Construction / Planning

Situation ID	Description of Hazard	Consequence Probability Rating (before Safety Measures)	Hierarchy Control Level of implementable Safety Measures	Consequence Probability Rating (after Safety Measures)	Lifecycle Phase of Action
	• Impact of Construction Traffic • Weed Control • Mitigation Measures identified in Review of Environmental Factors • Contractors risk (except for Indigenous items found during construction)		Sediment from upstream clearing etc. entering the Castlereagh River is to be avoided. Need to stage any catchment clearing so large areas are not left bear when the dam fills. Storage filling can be controlled to any extent to allow fauna to migrate – consider. De-stratification needs to be determined, current project to speed-up to get results that can be included in the environmental assessment.		
5.2	Contamination of water / management of runoff Protection of the dam storage, the Castlereagh River and groundwater	2	Contractor will need to address in the Construction Environmental Management Plan (CEMP) measures to mitigate the following: Contamination of water could result significant impact of flora and fauna in the Castlereagh River - which is an unacceptable outcome. The Contractor will need to use appropriate controls and systems to ensure there are no environmental issues and will need to manage risk of pollution from the works due to flooding events also. Work methods, materials and sequencing are to allow for effects of flooding events	5	Environmental Assessment / Construction / Planning

Situation ID	Description of Hazard	Consequence Probability Rating (before Safety Measures)	Hierarchy Control Level of implementable Safety Measures	Consequence Probability Rating (after Safety Measures)	Lifecycle Phase of Action
			and potential for pollution. Appropriate storage / treatment of runoff		
5.3	Noise and Vibrations	2	The Contractor will need to comply with Environmental Assessment/Approval (EA) requirements and consult with affected residents. Vibration monitoring will be required on the dam structures during the construction period	4	Environmental Assessment / Construction
5.4	Disposal of surplus material	2	The Contractor, in consultation with the Principal, will need to undertake appropriate disposal of surplus materials, identifying any items for salvage.	4	Environmental Assessment / Construction
5.5	Discharge of dewatering water (and treatment)	2	The Contractor will need to obtain approvals for discharge to receiving waters and outlined in CEMP	4	Environmental Assessment / Construction
5.6	Management of Acid Sulfate Soils & groundwater	2	Acid Sulfate Soils risk is considered unlikely, however the Contractor will need to abide by the EA and geotechnical provisions and obtain approvals for discharge to receiving waters as required.	4	Environmental Assessment / Construction
5.7	Upstream inundation areas	2	Environmental assessment will need to be undertaken on new upstream inundation areas, including for flood surcharge inundation	4	Environmental Assessment

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5.8	Tree clearing	2	Areas subject to inundation that were previously unaffected will need to be assessed for tree removal and the associated environmental impact.	4	Environmental Assessment
5.9	Breach of Project condition of approvals	2	Contractor will need to ensure all project approvals, commitments, and monitoring requirements are included into CEMP Environmental reporting during construction (including management of complaints / incident register) Auditing of environmental compliance during construction	4	Environmental Assessment / Construction / Planning
5.10	Vegetation clearing	2	Early initiation of environmental monitoring commitments Pre-clearing (inundation) surveys and flora/fauna translocation activities	4	Environmental Assessment / Construction / Planning
6 – CONSTRUCTION AND PROGRAMMING					
6.1	Lowering of the Storage During Construction	2	Council need to make a decision on whether any storage lowering during the construction is acceptable and if so to what extent. The timing of the construction may influence the requirements set across the construction period. i.e. lowering may be permitted during “wet season” for example.	4	Planning/Design

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6.2	Damage to/ loss of works/equipment occurring from flooding and overtopping of the dam or other construction areas.	2	The Contractor is responsible for all personnel and equipment and should have insurance for flooding events. Council's consideration to lower the storage during the works does not in any way absolve the Contractor from full responsibility for the impacts of flooding. The Contractor will need to demonstrate how it will manage flooding risks and recover from events. (eg. nightly removal of equipment with hazardous substance or large enough to cause damage, no instream temporary works components that could get caught in spillway etc.)	4	Construction
6.3	Construction sequence / scheduling of works	2	The Contractor is best placed to determine the construction sequence and will be responsible for all construction sequence risks. The construction of works will need to be sequenced such that there is no increased risk of damage to the overall dam structure as a result of flooding during the construction works (in accordance with NSW Dam Safety Requirements) The works sequence will need to be agreed with by the designers	4	Construction / Planning

Situation ID	Description of Hazard	Consequence Probability Rating (before Safety Measures)	Hierarchy Control Level of implementable Safety Measures	Consequence Probability Rating (after Safety Measures)	Lifecycle Phase of Action
			The Contractor will need to show how it will control risks through sequencing.		
6.4	Damage to dam's structural integrity during flooding	2	The construction of works will need to be undertaken and sequenced such that there is no increased risk of damage to the overall dam structure as a result of flooding during the construction works (in accordance with NSW Dam Safety Requirements) Temporary structures must be able to be removed quickly to ensure they do not restrict spillway flow capacity in-situ or through failure, if flooding occurs Independent certification of coffer dam and instream structures will be required	4	Construction
6.5	Dam Safety Procedures	2	There will need to be an interim Dam Safety Emergency Plan (approved by the NSW DSC) for the construction period taking into account the changed conditions and operation of the dam during the works. The Contractor will need to comply with DSEP requirements and the Principal will be in charge of DSEP activities.	4	Construction / Planning
6.6	Water release	2	Contractor will need to be conscious of resulting sprays, odours and other associated consequences. Releases may occur with limited warning.	4	Construction

Situation ID	Description of Hazard	Consequence Probability Rating (before Safety Measures)	Hierarchy Control Level of implementable Safety Measures	Consequence Probability Rating (after Safety Measures)	Lifecycle Phase of Action
6.7	Contamination of water	2	Contamination of water could result in the Principal being unable to continue to provide water supply to the Shire - which is an unacceptable outcome. The Contractor will need to use appropriate controls and systems to ensure no issues and will need to manage risk of pollution from the works due to flooding events also.	4	Construction
7 – ADDITIONAL RISKS IDENTIFIED					
7.1	Existing concrete dam condition	2	The existing concrete arch dam has been assessed as good following detailed inspection and site investigations. At present, the storage water is low and much of the upstream face of the arch dam is exposed. If further assessment of the dam underwater is required during the course of the works, then PWA can provide details of a suggested diving consultant. Suggest using remotely operated vehicle (ROV).	5	Detail Design / Construction
7.2	Concrete Admixtures	2	Concrete specification needs to ensure cheaper additives do not compromise the quality of the concrete. Need to let the Contractor know early about % of additives etc. allowed.	5	Detail Design

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7.3	Operational water quality management	2	Flooding of vegetation has the potential to impact on water quality associated with rotting vegetation.	4	Planning
7.4	Flora and fauna study area	2	Flora and fauna study will need to assess areas associated with extended main arch dam and saddle dam, new access road and construction ancillary areas etc. PWA can provide general footprint of extent of works.	4	Environmental
7.5	Communications on-site	2	Ensure adequate communications on-site during the works - site has poor mobile phone coverage in certain locations at certain times	4	Construction
7.11	Blasting of rock	2	Consider use of Non-Explosive Controlled Demolition Agent for rock excavation if geotechnical conditions are suitable. Consider impact on existing adjacent structure Vibration limits to be imposed	4	Construction
7.13	Loss of survey infrastructure surrounding the dam and the monitoring pins in the existing dam	2	Many marks as possible need to be preserved to allow the existing survey control to be adequately connected to the new structure	4	Construction / Planning

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