



BUNGENDORE FLOOD RISK MANAGEMENT IMPLEMENTATION PLAN PRELIMINARY CONCEPT DESIGN REPORT – STAGE I



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Foreword

Public Works Advisory (PWA) has been commissioned by Queanbeyan-Palerang Regional Council to undertake the investigation of flooding issues and concept design of mitigation works for Bungendore in light of managing existing, future and residual risks in the Study Area.

PWA has extensive experience and knowledge in complex and challenging flood process evaluations and design of effective flood mitigation works in consideration of social, ecological and economic factors relating to flood risks.

Executive summary

The Bungendore Flood Risk Management Implementation Plan project is being prepared for Queanbeyan-Palerang Regional Council in order to manage existing, future and residual flood risks in the Study Area.

The primary objective of the New South Wales Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible. Queanbeyan-Palerang Regional Council is obligated to comply with the New South Wales Government's Flood Prone Land Policy. The *Floodplain Development Manual: the management of flood liable land* (NSW Government 2005) is provided to assist councils to meet their obligations through the preparation of floodplain risk management plans. The Manual also documents the process for plan preparation, implementation and review.

The first three key stages of the process have been finalised with the latest completion of the Bungendore Floodplain Risk Management Study (FRMS) and Bungendore Floodplain Risk Management Plan (FRMP) by Worley Parsons in 2014.

The subject of this study is part of the final stage of the process, including developed concept design, in order to implement the mitigation works in Bungendore.

Following the completion of Bungendore Floodplain Risk Management Study and Floodplain Risk Management Plan, Council has identified three Flood Modification Measures as the preferred solutions, for further investigation and design, those being:

- Removal of dense vegetation and creek re-shaping at the confluence of Turallo, Halfway and Millpost Creeks (Measure 1).
- Upgrade of the existing Turallo Terrace levee (no extension) (Measure 2);
- Construction of an overflow channel across Tarago Road (Measure 3);

These measures are part of the floodplain risk management strategy recommended for implementation in the Bungendore Floodplain Risk Management Plan, named S4B. This project requires further review and investigation of these recommended flood mitigation works and aims to deliver developed concept plans for implementation.

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Abbreviations

Abbreviation	Description
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARR	Australian Rainfall and Runoff
BOM	Bureau of Meteorology
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation

1 Introduction

1.1 General

The Bungendore Floodplain Risk Management Implementation Plan project is being prepared for Queanbeyan-Palerang Regional Council in order to manage existing, future and residual flood risks in the Study Area. The first three key stages of the process have been completed with the completion of the Bungendore Floodplain Risk Management Study (FRMS) and Bungendore Floodplain Risk Management Plan (FRMP) by Worley Parsons in 2014.

The subject of this study is the first part of the final stage of the process, including developed concept design, in order to implement the mitigation works in Bungendore.

1.2 Scope of Works

The scope of works is outlined below and is to be undertaken in two stages, namely:

STAGE I: Investigation and feasibility of proposed Mitigation Works

STAGE IA: Vegetation clearing & creek re-shaping at the confluence of Turallo and Halfway Creeks

STAGE II: Concept Design

STAGE IIB: Concept Design Report

Stage I and **Stage IA** should be undertaken simultaneously in a phased approach as outlined below:

- Reviewing information and the flood modelling data of initial proposed design from previous study;
- 3D modelling of proposed Measures 1, 2 & 3 (vegetation clearing and creek re-shaping, levee upgrade & overflow channel), including 1D hydraulic modelling assessment for the proposed Measure 3;
- Additional Data Acquisition (survey and services briefs);
- Geotechnical Investigation;
- Environment Impact Assessment including REF/EIS;
- Preliminary Concept Design Drawings;
- Preliminary Concept Design Report.

The purpose of this report is to document the information gathered during **Stage I** & **Stage IA** in accordance with the study program. This report outlines the methodology, analysis and key outcomes of these stages and is structured to include all the information required for the preferred option to progress further to the Concept Design phase.

1.3 Study Location

Bungendore is located approximately 27 km north-east of Queanbeyan, in the Southern Tablelands Region of New South Wales, within the QPRC Local Government Area. Refer to **Figure 1-1**. All the investigations for the preferred Flood Mitigation Option have been undertaken within the locations of the three identified Flood Modification Measures which are as follows:

- The confluence of the Turallo and Halfway Creeks;
- Along the existing Turallo Terrace Levee;
- Along the proposed alignment of overflow channel, including the Tarago Road crossing.

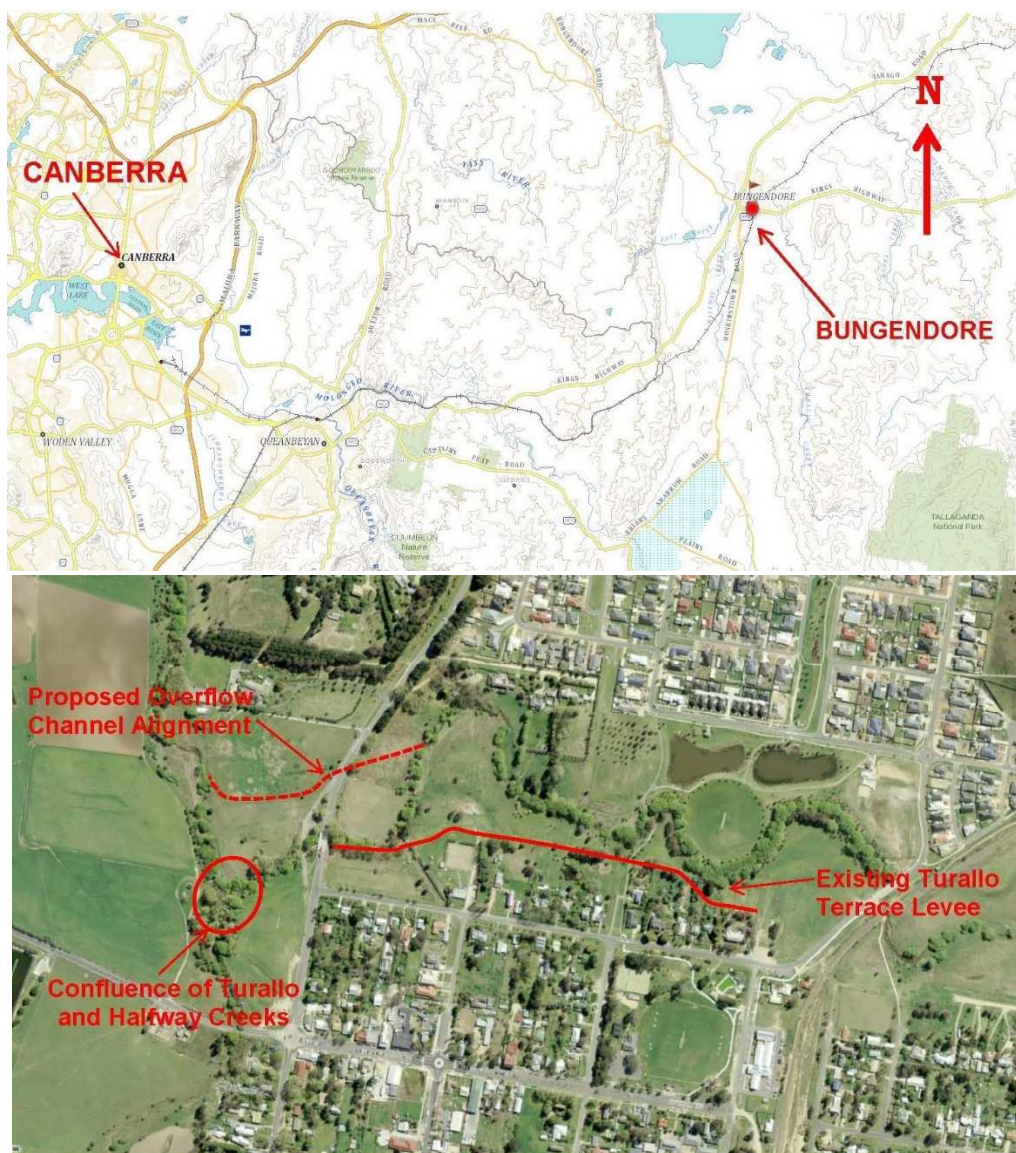


Figure 1-1: Study Area

2 Compilation and Review of Available Data

2.1 Review of Relevant Studies

The two current and most important studies considered relevant to this project have been reviewed and they are listed below:

- *Bungendore Floodplain Risk Management Study* (Worley Parsons, December 2014);
- *Bungendore Floodplain Risk Management Plan* (Worley Parsons, December 2014);

2.2 Existing digital flood models

A summary of the hydrologic and hydraulics models used in the relevant flood studies is presented in **Table 2-1**

Table 2-1: Summary of previous flood models

Catchment	Report	Model (Hydrologic / Hydraulic)
Bungendore (Flood Study)	Patterson Britton & Partners, 2002	XP_RAFTS RMA-2 2D model
Bungendore (Floodplain Risk Management Study & Plan)	Worley Parsons, 2014	XP_RAFTS Updated RMA-2 2D model

As part of the floodplain risk management study, the 2D RMA-2 hydrodynamic model developed as part of 'Bungendore Flood Study' (2002) by Patterson Britton & Partners was updated to incorporate topographic data acquired since 2002. The model was also updated to ensure it reflected current catchment conditions such as recent development of the floodplain and updates to hydraulic control structures.

The original XP_RAFTS hydrologic model that had been developed for the 2002 flood study was used as the basis for the updated RMA-2 model inflows.

All the flood modelling results for the three measures of the preferred Floodplain Risk Management option have been reviewed using the WaterRIDE package and utilised in the further investigation and modelling as part of this study.

2.3 Available Data

To proceed with the further engineering assessment of the proposed Floodplain Risk Management option, PWA had requested and were provided with the additional data by Council including:

- Additional topographic data and site survey plans and aerial photography;
- Location of existing underground and overhead services;
- Location and dimensions of drainage assets;
- Work As Executed (WAE) Tarrago Road Bridge Design Drawings including long section of the Tarrago Road centreline;

3 Hydraulic and 12d Modelling

3.1 General

The “developed” concept design of this project, as required by the project scope, is based on the results indicated in the Flood Risk Management Study and Plan. The previous modelling results are assumed final to the satisfaction of Council and no further 2D hydraulic modelling has been undertaken to confirm the previously modelled flood characteristics.

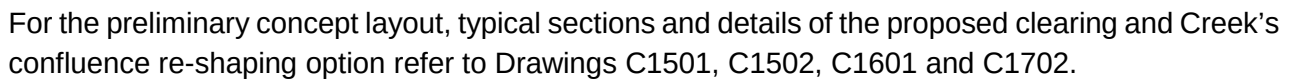
The three-dimensional ground survey and hydraulic model were integrated with the 12d Model, where the recommended flood modification works were further assessed, modelled and optimised including alternative alignments for the proposed levee and overflow channel measures. Further development of a 12d model has resulted in economic sizing of the proposed mitigation works which do not impact on existing services. Utilising the 12d Model, PWA has delivered Concept Design Drawings, documenting the full extent of works including cadastral information and services. Modelling of the three proposed measures are detailed in the Sections below.

3.2 Clearing and creek re-shaping at the confluence of Turallo and Halfway Creeks

12d software has been used for 3D modelling of clearing extent, re-shaping works and volumes at the confluence of Turallo and Halfway Creeks. The proposed locations of the creek’s confluence re-shaping are shown on **Figure 3-1**. Generally, within the confluence of the two creeks, the work is divided into two sections, namely the northern side (Confluence 1) which encompasses the northern and eastern banks (meander) of the Turallo Creek and the western side/bank of Halfway Creek (Confluence 2). Confluence 1 is approximately 110 m in length while Confluence 2 is approximately 85m in length.

The northern re-shaping area is located within a grassed paddock with some occasional shrubs and trees. The ground is relatively flat with typical slope of less than 5% towards the creek bank. The creek’s bank batter is heavily overgrown with blackberry bush, weeds and grasses.

The western re-shaping area is located within a terraced slope/creek bank. The accessible section of the area comprises a grassed and relatively flat paddock. The rest of the area (towards the creek) is moderately vegetated with trees and shrubs.



3.3 Upgrade of existing Turallo Terrace Levee

3.3.1 Existing Levee Bank

In the initial 120m of the alignment, the natural surface levels are generally above flood levels, apart from a minor (approximately 15m long) section between the railway and Turallo Terrace, where the levee bank upgrade has not been proposed, following the Council's request.

Between Chainage 140m to Chainage 280m, the levee bank is located within private properties (No. 56 to 64 Turallo Terrace). The levee bank heights have been estimated to be about 0.8m to 1.2m, with crest levels in the order of RL 691.8m to RL692.4m. The crest and batters are typically grassed, with minor bare surface area where an access track traverses the levee bank (No. 60 property's backyard). Furthermore, there is a newly built fence along the levee crest within the grounds of the Bungendore Pre-school (No. 62-64).

At approximate Ch280m, the levee bank exits the private properties and generally runs parallel to the rear property fence lines up to Ch590m. Between Ch280m and Ch540m, the levee bank heights have been estimated to be about 0.7m to 1.0m, with crest levels in the order of RL 691.1m to RL 691.8m. From Ch540m, the levee bank heights gradually increase from 0.9m to approximately 2.2m near Ch580m, with crest levels in order of RL 691.3 to RL 692m. In the remaining part of this section, between approximate chainages Ch580m and Ch680m, the natural surface levels are above design flood levels.

The levee batters are well grassed while the crest is typically sparsely grassed up to Ch350m and then becomes a bare surface where the levee bank is used as an access track. There are some ruts/depressions along the levee crest between Ch350m and Ch590m, where water can pond. These are interpreted to have been caused by vehicular traffic when the subgrade was softened.

There are lines of mature trees located on the inner and outer levee batters between approximate Ch400m and Ch450m. There are also other occasional individual trees along this section, a pedestrian footpath at approximate Ch355m and a drainage pipe at approximate Ch550m.

Between Chainage 720m to Chainage 840 m the proposed levee alignment crosses a drainage channel. The existing channel bank heights are in the order of 3.6m and 2.8m, with the channel bed at RL 687.9m and top of the banks at RL 691.5m (eastern bank) and RL 690.7m (western). The batters of the channel are steep to very steep (in order of 18° to 25°) and vegetated.

After the channel crossing, the existing levee bank (Chainage 720m to Chainage 840m) follows the Council's property fence line and exits just before its terminating point at the Molonglo Street Bridge abutment. The existing levee crest levels are in the order of RL 690.7m to RL691.3m. The levee bank heights have been estimated to be similar for the majority of the alignment at about 1m or less. However, the topography descends towards the creek and therefore, the overall heights of the levee bank and natural slope are well in excess of 1m. Along this section, the existing levee crest and batters are generally grassed with occasional mature trees on the inner (creek side) batter of the levee bank.

3.3.2 Proposed Levee

12d software has been used for 3D modelling of the raised levee concept design to the 1% AEP design flood event with 0.50 freeboard.

The proposed levee bank is approximately 840m in length, commencing at the railway embankment (Ch0m) on the western side of Turallo Terrace and terminating at the bridge abutment in Molonglo Street (Ch840.41m).

The levee upgrade preliminary concept design drawings indicate a typical crest width of about 3 m with outer batter (properties side) of 1(V):3(H) and inner batter (creek's side) of 1(V) : 4(H). The proposed crest design level gradually reduces from RL 693.4m (Ch0m) to RL 691m (Ch840m).

The proposed levee bank upgrade will follow the existing levee alignment; however, there are sections of the levee where realignments are being considered. These are where the existing levee bank is located within private properties (approximate Ch120m to Ch280m) and where significant mature trees are located on the levee batters (approximate Ch400m to Ch450m).

For the deviation around the private properties, the levee will comprise an earthen bank with a concrete retaining wall section where there is limited room between the property fence line and the creek. Refer to **Figure 3-2**. Following the survey results from the private properties owners, Council has selected its preferred levee realignment option which is to be modelled further and progressed to the preliminary concept design.



Figure 3-2.: Levee alignment options

The alternative deviation of the existing levee alignment, where significant mature trees are located on the levee batters, comprises an earthen bank and this has been modelled for the preliminary concept design.

For the preliminary concept layout, typical sections and details of the proposed levee option refer to Drawings C1001, C1101, C1102, C1103, C1104, C1201 C1202 and C1203.

3.4 Overflow Channel

12d software has been used for 3D modelling of the proposed overflow channel to the 1% AEP design flood event.

Generally, the channel is to be located within relatively flat paddocks to the north and north-east of the confluence of the Turallo and Halfway Creeks. The paddocks are separated by the Tarago Road. The paddock to the east of the road crossing is relatively flat (RL 689.7m to RL690m) and typically sparsely grassed. The creek's bank and the western property fence are lined with occasional or stands of mature trees.

The paddock to the west of the road crossing is grassed and is also relatively flat (approximate RL689.5m), with a slightly elevated section at Ch. 260m-Ch. 270m (approximate RL690.5m-RL690.7m). There are occasional mature trees immediately after the road crossing and along the creek's bank. The initial straight alignment of the proposed channel, as proposed in the Flood Risk Management Study has been revised through this area following the property owner's objection that the channel should not be located through the middle of his paddock and preferably moved south towards the property's boundary.

Based on concept designs, the proposed grass lined channel will have a trapezoidal cross section, 4.5m wide floor and cut batters of 1 (vertical) to 3 (horizontal). The proposed overflow channel passes under the existing Tarrago Road where a culvert structure has been proposed. This has a critical impact on the channel design. The proposed overflow channel will cross Tarago Road between approximate chainages Ch110m and Ch140m. The proposed invert level of the concrete box culverts will be at RL687.4m which means that Therefore, the culverts will be founded approximately 2.5 m below existing surface levels.

Considering the existing surface levels, the batter offset from the channel centreline will locally reach 14m (Ch320m). The excavation depths to the proposed invert levels of the channel floor are typically in the order of 2.3 m to 2.8 m between Ch40m and Ch240m, and approximately 3.4 m to 4.2 m between Ch250m and Ch320m.

For the preliminary concept layout, typical sections and details of the proposed overflow channel option refer to Drawings C1301, C1302, C1303, C1304, C1401 and C1402.

3.4.1 Overflow Channel Hydraulic Modelling

HEC-RAS hydraulic software has been used for 1D hydraulic modelling to examine the channel's maximum hydraulic catering capacity and to enable design of a typical cross-section of the proposed channel and culvert structure across Tarago Road.

The 1D model included Turallo Creek's southern meander; i.e. the model commences on Turallo Creek on the east prior to the proposed channel split (i.e. known as upstream junction) and includes the channel's downstream entry back into Turallo Creek (i.e. known as the downstream junction). Refer to **Figure 3-3** for the model plan.

reaches the channel banks. HEC-RAS has the ability to compute flow splits (i.e. distribute flow splits down the split streams) according to the conveyance properties of the cross-sectional flow area of each split stream.

Without the hydraulic influences of the proposed Tarago Road culverts, Halfway Creek's flow contribution and the congestion effects at the downstream junction, the proposed channel dimensions would allow a peak bank-full conveyance of approximately 47 m³/s.

With the presence and consideration of the proposed Tarago Road culverts, Halfway Creek's flow contribution and the congestion effects at the downstream junction, the conveyance capacity of the relief channel is expected to decrease to facilitate a capacity where the entire channel does not experience any bank-full flows. This decrease is a result of the backwater into the channel created by the downstream junction, whereby the split flows from both the channel and Turallo Creek as well as flow contribution from Halfway Creek all meet.

Acknowledging the 1% AEP peak flow at upstream of the upstream junction on Turallo Creek (299 m³/s) and the 1% AEP peak inflow contribution from Halfway Creek into Turallo Creek (161 m³/s), the same ratio between the two peak flows was maintained for the experimental flow values examined with HEC-RAS.

With a peak flow value of 20 m³/s travelling south along Turallo Creek from upstream of the upstream junction, and, 11 m³/s travelling north along Halfway Creek discharging into Turallo Creek at River Station 4 on "Turallo Split", and the inclusion of the Tarago Road twin culverts, the channel bank-full capacity was found to be 10.83 m³/s. At the above mentioned peak flow rates, the entire relief channel would not experience any overbank flows, however due to the backwater effect of the downstream junction, the model peak water level in the channel near the downstream junction was found to be almost at the channel's banks (refer to **Figure 3-4** for this modelled peak flood long-section of the relief channel). Therefore, if Turallo and Halfway Creeks were to be discharging in excess of 20 m³/s and 11 m³/s respectively, the relief channel would first begin to experience overbank flows at the vicinity of the downstream junction.

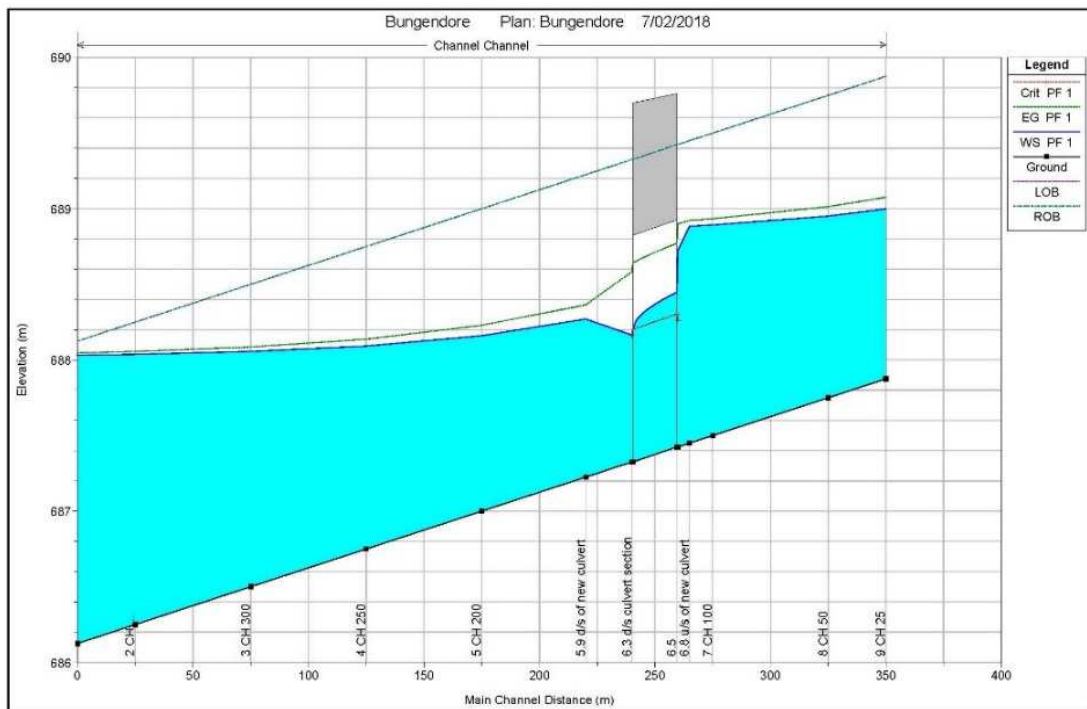


Figure 3-4: Proposed Channel Long Section

Refer to **Figure 3-5** for the modelled flood cross-section at River Station 9 (just downstream of the upstream junction) on the relief channel at a peak flow of 10.83 m³/s.

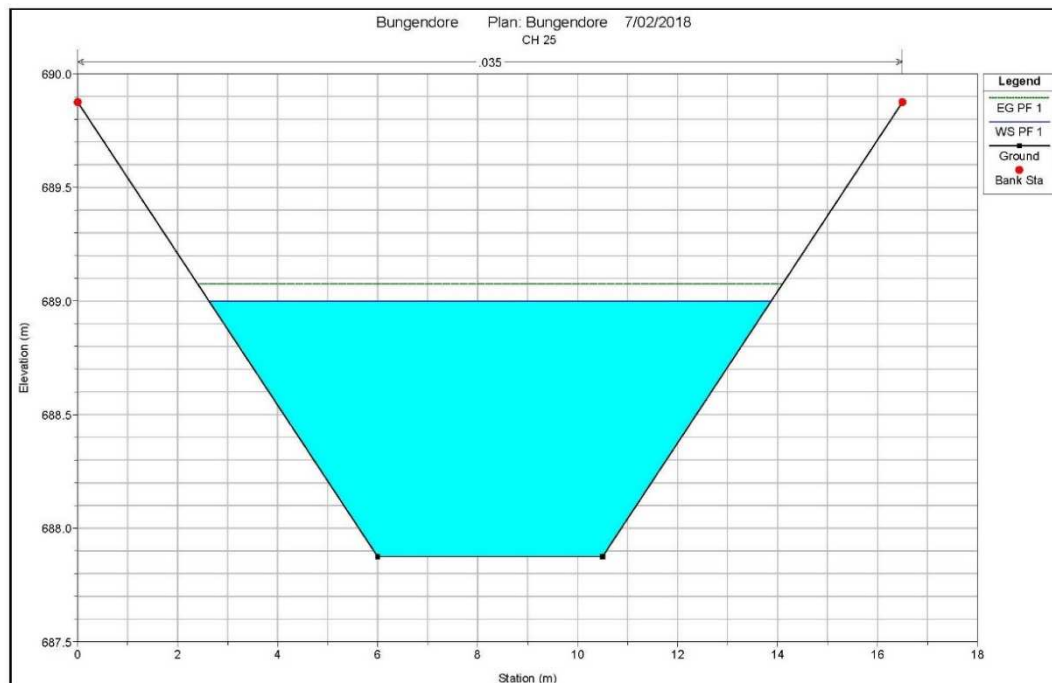


Figure 3-5: Proposed Channel Cross Section D/S of the U/S Junction at Turrulo Ck.

Refer to **Figure 3-6** for the modelled flood cross-section at the proposed Tarago Road culverts on the relief channel at a peak flow of 10.83 m³/s.

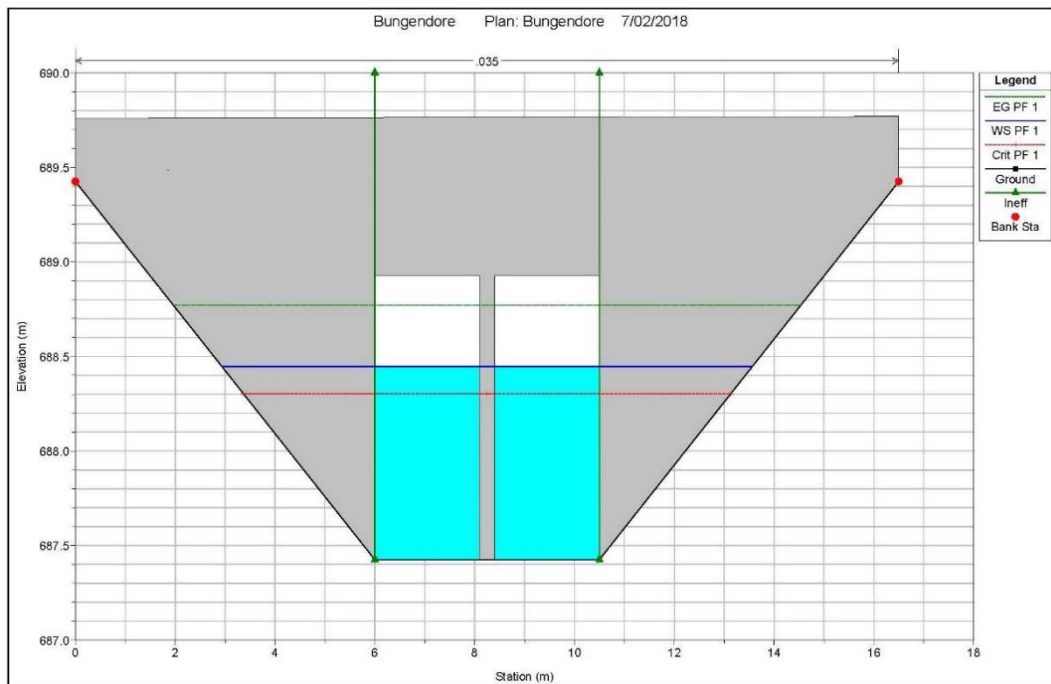


Figure 3-6: Proposed Channel Cross Section at the Proposed Tarrago Rd. Culverts

Refer to **Figure 3-7** for the modelled flood cross-section at River Station 1 (just upstream of the downstream junction) on the relief channel at a peak flow of 10.83 m³/s.

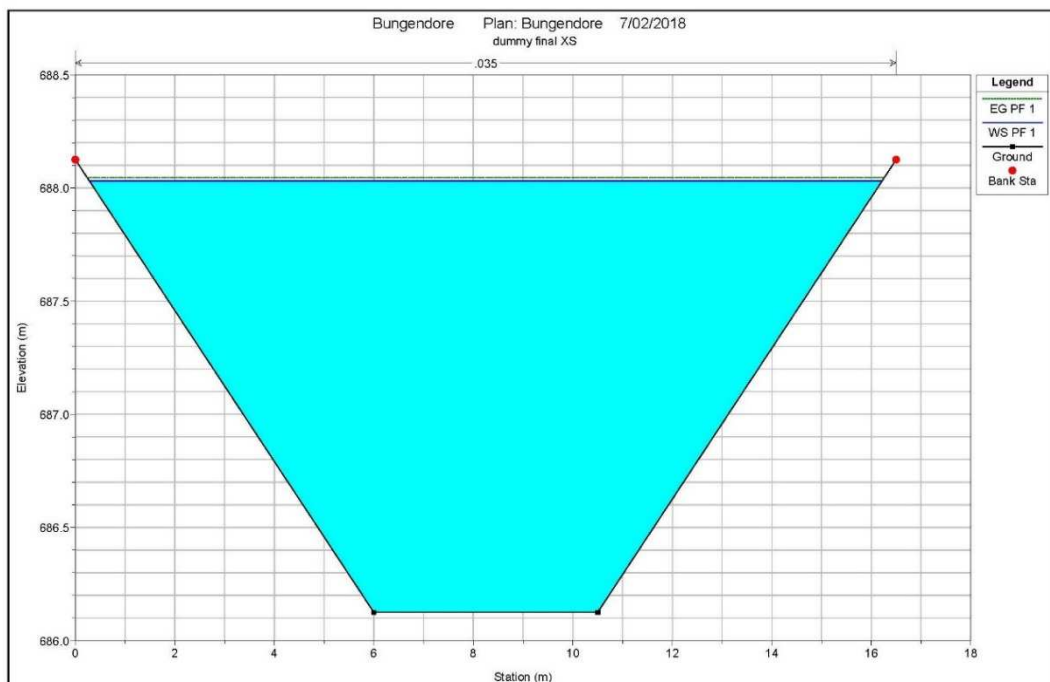


Figure 3-7: Proposed Channel Cross Section U/S of the D/S Junction at Turrulo Ck.

4 Feasibility of the Preferred Flood Mitigation Option

4.1 General

Following the completion of Bungendore Floodplain Risk Management Study and Floodplain Risk Management Plan, Council has identified three Flood Modification Measures recommended for further investigation and design, which are as follows:

- Removal of dense vegetation and creek re-shaping at the confluence of the Turallo and Halfway Creeks (referred to as Measure 1 in the Floodplain Risk Management Plan, **S4B-1**);
- Upgrade of the existing Turallo Terrace levee (referred to as Measure 2 in the Floodplain Risk Management Plan, **S4B-2**);
- Construction of an overflow channel across Tarago Road (referred to as Measure 3 in the Floodplain Risk Management Plan, **S4B-3**);

These measures are part of the floodplain risk management strategy, named S4B, recommended for implementation in the Bungendore Floodplain Risk Management Plan. This flood management option has been identified as the most cost effective solution that will result in a reduction in existing flood damages in Bungendore.

This section details further review and investigation of these recommended flood mitigation works, addressing the following critical issues before delivering developed concept plans for implementation:

- The design and any anticipated or proposed construction techniques have been focussed to minimise the risk of damage to environmentally sensitive areas including trees of significance, and any other infrastructure or services. Any required interfaces between such areas and proposed new works have been documented.
- The design has been undertaken in conjunction and with regard to the findings of the geotechnical and environmental investigations. This has been carefully coordinated not only to produce a quality design but also for the design to be completed efficiently without the need for an excessive rework.

4.2 Measure S4B-1 – Clearing and creek re-shaping at the confluence of Turallo and Halfway Creeks

This flood mitigation measure includes the removal of vegetation at the confluence of Turallo and Halfway Creeks and the reshaping of the creeks, which would enhance the capacity for floodwaters to escape more rapidly from the village reach of Turallo Creek. Excavation of overbank areas at the confluence would provide additional capacity when floodwaters exceed the channel capacity.

The Plan of the extent of vegetation removal and excavation is shown on **Figure 4-1**.

Based on concept designs, re-shaping will involve stripping of all vegetation and re-grading the creeks banks. Within the Confluence 1 area (refer **Figure 3-1**), the depths of cuts will vary from

negligible to up to approximately 3m. The deeper cuts appear to be confined to the northern bank of Turallo Creek meander. Within the Confluence 2 area (refer **Figure 3-1**), the depths of cuts will vary from approximately 0.8m to 1.9m.

Considering the subsurface geotechnical profiles of the excavated areas and high velocities (almost 2 m/s within the Confluence 1 area), 200 mm thick reinforced grass cover has been proposed to prevent future erosion of the excavated areas.

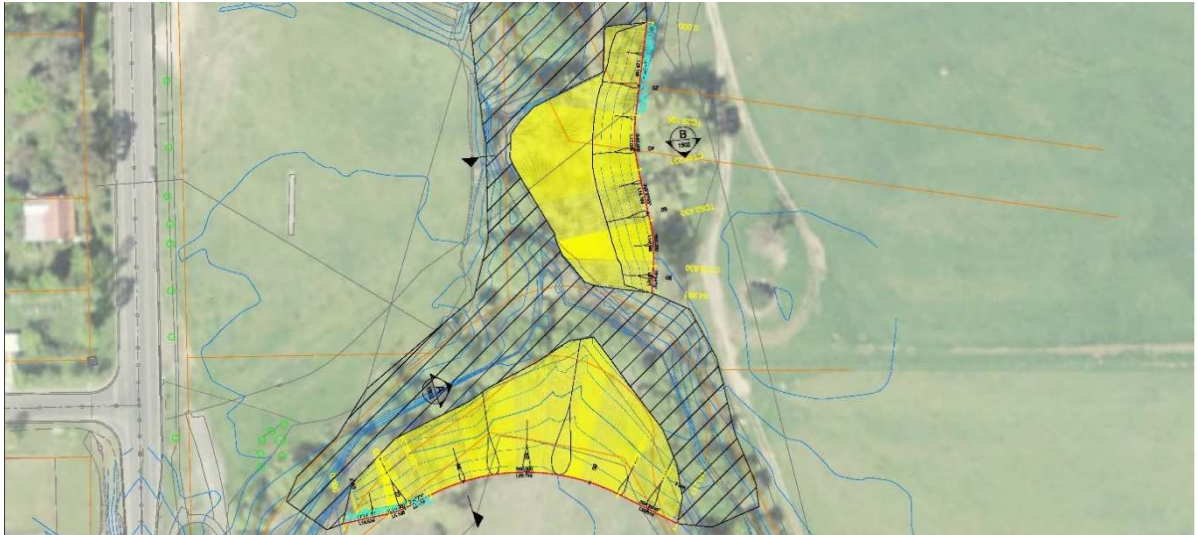


Figure 4-1: Clearing and creek re-shaping at the confluence concept plan

For the preliminary concept layout, typical sections and details of the proposed clearing and creek's confluence re-shaping option refer to Drawings C1501, C1502, C1601 and C1702.

4.3 Measure S4B-2 – Upgrade of existing Turallo Terrace Levee

This flood damage reduction measure involves upgrading of the earth embankment Turallo Terrace Levee to increase crest elevation above the peak 1% AEP flood level, including a freeboard of 0.5 m. The proposed levee bank upgrade will follow the existing levee alignment; however, there are two sections of the levee where realignments are being proposed. These are where the existing levee bank is located within private properties and where significant mature trees are located on the levee batters. For the deviation around the private properties, the levee will comprise an earthen bank with a concrete retaining wall section where there is limited room between the property fence line and the creek. The other deviation will comprise an earthen bank.

The proposed levee upgrade concept design drawings indicate a typical crest width of minimum 3 m with outer batter (properties side) of 1(V):3(H) and inner batter (creek's side) of 1(V) : 4(H). The proposed crest design level gradually reduces from RL 693.4m (Ch0m) to RL 691m (Ch840m).

Where the proposed levee alignment crosses a drainage channel, flood gates with twin DN1200 stormwater pipes have been proposed.

The plan of the proposed levee is shown on **Figure 4-2**.



Figure 4-2: Upgrade of the existing Turallo Terrace levee concept plan

For the preliminary concept layout, typical sections and details of the proposed levee option refer to Drawings C1001, C1101, C1102, C1103, C1104, C1201 C1202 and C1203.

4.4 Measure S4B-3 – Overflow Channel

This measure would allow floodwaters to bypass the Tarrago Road bridge crossing of the creek during major events. The higher flows would be diverted across Tarago Road upstream of the bridge crossing so that they would re-enter the creek downstream of the confluence of Turallo and Halfway Creeks.

The proposed grass lined channel will have a trapezoidal cross section, 4.5m wide floor and with cut batters of 1 (vertical) to 3 (horizontal). The proposed overflow channel passes under the existing Tarrago Road where a culvert structure of twin culverts DN 2100 x 1500 has been proposed and which has a critical impact on the channel design.

To prevent future erosion of the proposed channel and considering the subsurface geotechnical profiles of the excavated areas and the high velocities (refer to **Appendix B**), 200 mm thick reinforced grass cover has been proposed along the whole length of channel bed and on outer channel batters.

The plan of the proposed overflow channel is shown on **Figure 4-3**.

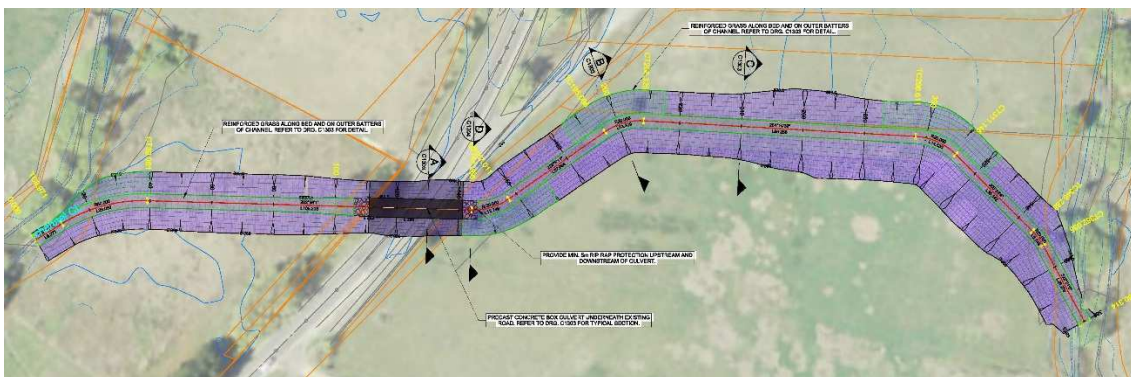


Figure 4-3: Overflow channel across Tarago Road concept plan

For the preliminary concept layout, typical sections and details of the proposed overflow channel option refer to Drawings C1301, C1302, C1303, C1304, C1401 and C1402.

4.5 Construction

The following provides a summary of the likely construction activities.

4.5.1 Construction Activities

Site Establishment:

- Construction compound and laydown areas.
- A separate access to thy Vegetation Clearing and Creek's Confluence Re-shaping work area, to the Turallo Terrace Levee work area and the Channel Overflow work area. An access to the work areas shall occur within existing cleared paths where possible, although some trimming or clearing of vegetation may be required. The works should be undertaken in manner that minimises disturbance.
- Erosion and sediment controls, including in stream controls.

Confluence and Channelisation works:

- Vegetation removal to progressively move along the confluence and the channel;
- All noxious and exotic weeds would be appropriately managed and removed for off-site disposal;
- All debris such as plastic bags, bottles, foam containers and other litter shall be removed;
- Rehabilitation of the confluence area and the channel bed and banks using suitably qualified and experienced bush regeneration contractors.

Levee works:

The embankment fill for the proposed raising of the levee banks will be sourced from the excavations required for the new overflow channel and supplemented by materials stripped from the creek re-shaping at the confluence of the Turallo and Halfway Creeks.

The levee would be dressed with topsoil certified as weed free.

Site dis-establishment:

- Removal of all construction equipment,
- General site clean-up.

4.5.2 Construction Equipment

The following construction equipment is likely to be required to undertake the works:

- Hydraulic excavator for vegetation clearing, works within the confluence and channel areas;
- Small trucks carrying construction materials,
- Large trucks to transport imported material and excavated material to and from the site;

- Concrete mixer for culverts foundation;
- Backhoe / excavator equipment to construct levee; and
- Passenger vehicles to transport construction workers.

4.5.3 Construction Issues

Construction Environmental Management Plan

The proposed works would be undertaken in accordance with a Construction Environmental Management Plan (CEMP) prepared by the construction contractor and approved by Queanbeyan-Palerang Regional Council prior to the commencement of works.

The CEMP would incorporate site specific management plans and would reflect all the mitigation measures identified in the Bungendore Flood Risk Management Implementation Plan REF, additional mitigation measures identified as a result of the contractor's risk assessment and construction methodology and any conditions of the project determination and other licences/approvals.

Construction site layout

The contractor would establish a compound area to accommodate construction facilities for the duration of the construction period. The compound area would accommodate the following facilities:

- Site Office
- Materials and equipment storage area
- Toilets
- Fuel storage

Construction timeframe

The construction works are predicted to take up to six months.

Working hours

The *Interim Construction Noise Guidelines* (DECC 2009) outlines recommended standard construction working hours as:

Monday to Friday 7am to 6pm

Saturdays 8am to 1pm

No work on Sundays or public holidays.

The construction would comply with these recommended hours.

4.6 Operational Issues

Maintenance of Turallo and Halfway Creeks confluence area, the Turallo Terrace levee and the overflow channel areas would form part of Queanbeyan-Palerang Regional Council's overall maintenance program within the LGA and in accordance with current Vegetation Management Plan.

Ongoing management procedures would include:

- Annual removal of foreign material such as plastic bags, bottles, foam containers and other litter (does not include leaf litter, branches or logs).
- Weed control undertaken at frequencies specified by the Vegetation Management Plan by

an experienced and qualified Bush Regeneration Contractor or Bush Regeneration Staff. Weed control would occur using standard bush regeneration techniques such as hand weeding or use of Glyphosate based herbicides.

- Slashing of indigenous herbland or reedland by qualified Bush Regeneration Contractor or Bush Regeneration Staff. Slashing would be undertaken after the species has flowered and set seed. No herbicide shall be used in association with slashing to allow indigenous species to regenerate from root stock, rhizomes or seed. Slashing would occur using hand operated mechanical equipment. Organic debris material would be removed from site.

4.7 Geotechnical Information

A Geotechnical Investigation Report has been prepared by Public Works Advisory on behalf of Queanbeyan-Palerang Regional Council (Report Number ISR 17030).

This section of the report presents a summary of the conclusions identified in the Geotechnical Investigation Report for the Bungendore Flood Risk Management Plan Implementation project.

4.7.1 Clearing and creek re-shaping at the confluence of Turallo and Halfway Creeks

Summary and Discussions

Within the Confluence 1 area, the depths of cuts will vary from negligible to up to approximately 3m. The deeper cuts appear to be confined to the northern bank of Turallo Creek meander. Within the Confluence 2 area, the depths of cuts will vary from approximately 0.8m to 1.9m.

Generally, the drilling has revealed that excavations to the design invert levels will encounter a variety of alluvial sediments dominated by silty sands and sandy silts with varying clay contents and locally, silty and sandy clays. The sediments, due to high silt and fine sand contents, low plasticity properties and dispersive characteristics, are potentially highly erosive.

Excavations within alluvial sediments should readily be achievable by equipment such as hydraulic excavators using conventional earth moving.

4.7.2 Upgrade of existing Turallo Terrace Levee

Summary and Discussions

Visual inspection of the existing levee banks did not detect any slope stability issues nor any batter erosion, with the levee bank batters being well vegetated.

The investigation revealed that dominantly the levee bank was constructed using imported fill materials, as evidenced by the presence of quartz and rock fragments and matrix containing higher clay contents than in-situ alluvial sediments. Generally, the permeability characteristics of the embankment fill are assessed to be in a practically impervious category. The levee bank fill, based on visual assessment and SPT test data, is assessed to be an engineered fill. This is supported by the performance of the banks during a number of flood events.

In conclusion, the existing levee bank can be incorporated into the proposed raised embankment. The new embankment fill may be placed directly onto the existing banks subject to the following subgrade preparation:

- Strip all unsuitable material from the crest and batters. This includes grass root affected fill;
- In areas where the fill is to be placed on the natural subgrade, topsoil and root affected materials should be stripped for the full depth. Following stripping, the subgrade should be inspected for consistency. Any soft spots detected should be excavated out for a depth of at least 400mm and replaced with engineered fill. The stripped subgrade should be scarified to a depth of 150mm-200mm; moisture conditioned to within 2% of modified optimum moisture content and re-compacted to a minimum modified dry density ratio of 93%.

Investigation of proposed deviations of the levee alignment were not part of this geotechnical investigation and therefore, no boreholes were scheduled in these two areas. Nonetheless, the following general comments are provided based on current borehole data.

For the deviation around the private properties, the levee will comprise an earthen bank with a concrete retaining wall section where there is limited room between the property fence line and the creek. The other deviation will comprise an earthen bank.

The foundation conditions at both locations are not known; however, the subsurface profiles are likely to comprise alluvial sandy clayey silts overlying sands with varying concentrations of silt and locally, with some gravel. The alluvium is expected to be of stiff consistency. For the earthen banks it is envisaged that the foundation preparation will comprise stripping the topsoil, inspecting the subgrade for consistency and proof-rolling by typically 4-6 passes of a smooth drum roller (say, 10 tonne static weight). Similar minimum treatment would be required for the concrete retaining wall section; however, for the detail design stage it is recommended that additional detail design investigation be carried to determine the foundation conditions and the extent of any subgrade treatment for the retaining wall designs.

The embankment fill for the proposed raising of the levee banks will be sourced from the excavations required for the new overflow channel and supplemented by materials stripped from the creek re-shaping at the confluence of the Turallo and Halfway Creeks.

Representative samples of the in-situ sediments were selected and tested from the proposed channel alignment and confluence re-shaping locations. The testing was carried out on two major soil groupings of sandy silts with varying clay contents, which were encountered in the upper parts of the profile, and sands, with varying contents of fines and locally gravel, which occur in the lower parts of the profiles.

The surficial deposits of dark grey brown to dark grey sandy silt with some clay, to an average depth of 0.5m, are not considered to be suitable for use as engineered fill in the raising of the existing levee banks. The materials may be stockpiled for subsequent re-use as topsoil. The surficial sand deposits, encountered to a depth of 0.5m in BH12, should also be stripped and put to spoil.

The mottled fine-grained alluvium underlying the surficial deposits may be considered for use as engineered fill. The sediments are dominantly slightly clayey sandy silts of low to medium plasticity

(CL and CI), with lesser silty clays of medium or high plasticity (CI or CH) and clayey silty sands (SC).

The relatively clean gravelly sands and silty sands, which were encountered typically below 2m depth, are not considered to be suitable for raising the levee banks; consequently, careful borrow area management will be required to exclude these materials from the finer grained alluvium.

As indicated above, the clayey sandy silts are potentially highly erosive and all batters should be suitably top-soiled and grassed. The fill should be placed in loose layers not exceeding 150mm and compacted to a minimum modified dry density ratio of 95% at a moisture content in the range of 2% dry to 1% wet of the modified optimum moisture content.

4.7.3 Overflow Channel

Summary and Discussions

The investigation revealed that the channel alignment is located within thick deposits of alluvial sediments which can be broadly grouped into fine grained cohesive and coarse-grained alluvium. Overall, there is potential for bed and toe scour erosion. Furthermore, during periods of inclement weather, the cut batters are expected to be subjected to rutting erosion due to rainfall runoff. To prevent formation of runnels and progressive slope degradation suitable remedial slope protection measures need to be provided. As a minimum, depending on flood velocities, the cut batters should be grassed.

The founding strata along the alignment of the culverts are expected to change from coarse grained sediments to fine grained sediments. For either strata, an allowable bearing pressure of 200 kPa may be adopted in design. However, the foundation conditions should be assessed at the time of construction to ascertain any need for foundation improvement. As a minimum, the subgrade should be proof-rolled by typically 4-6 passes of a smooth drum roller (10 tonne static weight). Any soft spots detected should be excavated out for a minimum depth of 400mm and replaced with engineered fill. Nonetheless, to provide a uniform subgrade, consideration should be given to over-excavate the sediments for a depth of at least 400mm and replace the sediments with road base type material.

Excavations to design invert level will be within alluvial sediments and should readily be achievable using conventional earth moving equipment such as hydraulic excavators.

5 Environmental Information

5.1 Introduction

The Review of Environmental Factors (REF) has been prepared by Public Works Advisory on behalf of Queanbeyan-Palerang Regional Council and is reported separately.

The conclusions identified in the REF for Bungendore Flood Risk Management Plan Implementation project will be summarised in the Concept Design Report at **Stage II**.

6 Conclusion

The objective of the study is to undertake an investigation and design of flood mitigation works for Bungendore area. Central to this is the engineering feasibility for the implementation of the selected preferred flood mitigation option consisting of three flood mitigation measures.

The study program of the project provides for a staged approach, incorporating:

STAGE I: Investigation and feasibility of proposed Mitigation Works

STAGE IA: Vegetation clearing & creek re-shaping at the confluence of Turallo and Halfway Creeks

STAGE II: Concept Design

STAGE IIB: Concept Design Report

Stage I and **Stage IA** should be undertaken simultaneously in a phased approach as outlined below:

- Reviewing information and the flood modelling data of initial proposed design from previous study;
- 3D modelling of proposed Measures 1, 2 & 3 (vegetation clearing and creek re-shaping, levee upgrade & overflow channel), including 1D hydraulic modelling assessment for the proposed Measure 3;
- Additional Data Acquisition (survey and services briefs);
- Geotechnical Investigation;
- Environment Impact Assessment including REF/EIS;
- Preliminary Concept Design Drawings;
- Preliminary Concept Design Report.

This preliminary report completes and summarises all the tasks from the first stage of the project listed above and has been structured to include all the information required for the preferred option to progress further to the Concept Design Stage.

7 References

- Austroroads, *Waterway Design: A Guide to the Hydraulic Design of Bridges, Culverts and Floodways*, 1994
- Crookston, Paxon and Savage, "Hydraulic Performance of Labyrinth Weirs for High Headwater
Institution of Engineers, *Australian Rainfall and Runoff*, 2006
- McLuckie, Babister, Smith and Thomson, *Updating National Guidance on Best Practice Flood Risk Management*, 54th Floodplain Management Association Conference, 2014
- New South Wales Government, *Floodplain Development Manual: the management of flood liable land*, 2005
- Patterson Britton & Partners, *Bungendore Flood Study Report*, 2002
- Worley Parsons, *Bungendore Floodplain Risk Management Study Report*, December 2014
- Worley Parsons, *Bungendore Floodplain Risk Management Plan Report*, December 2014
- NSW Public Works Advisory, *Bungendore Floodplain Risk Management Plan Implementation-Geotechnical Investigation*, February 2018
- NSW Public Works Advisory, *Bungendore Floodplain Risk Management Plan Implementation-REF*, April 2018

Appendix A Concept Drawings

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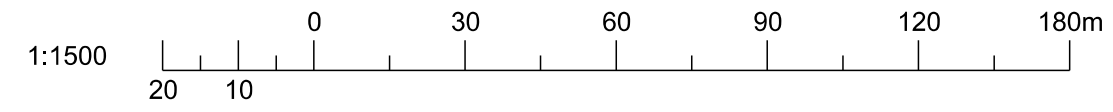
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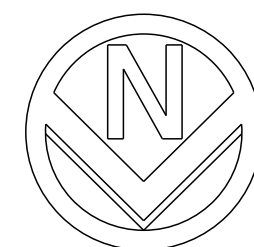
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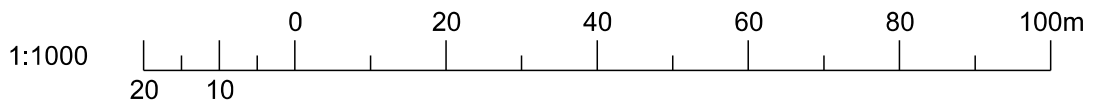
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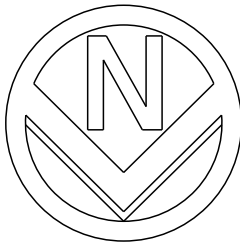


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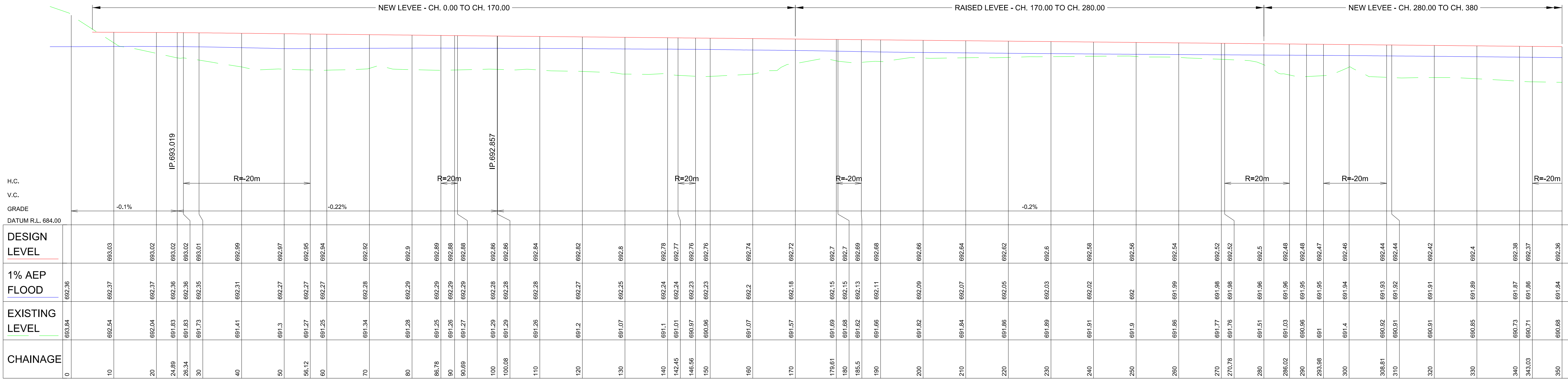
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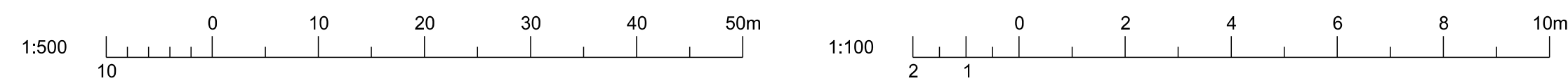


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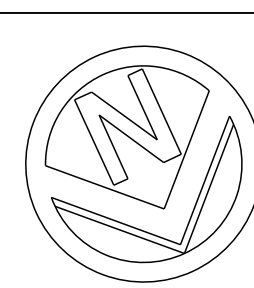
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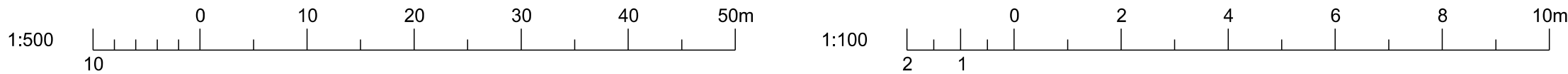
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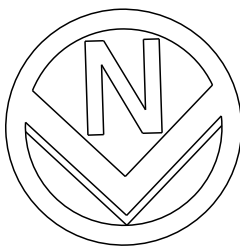
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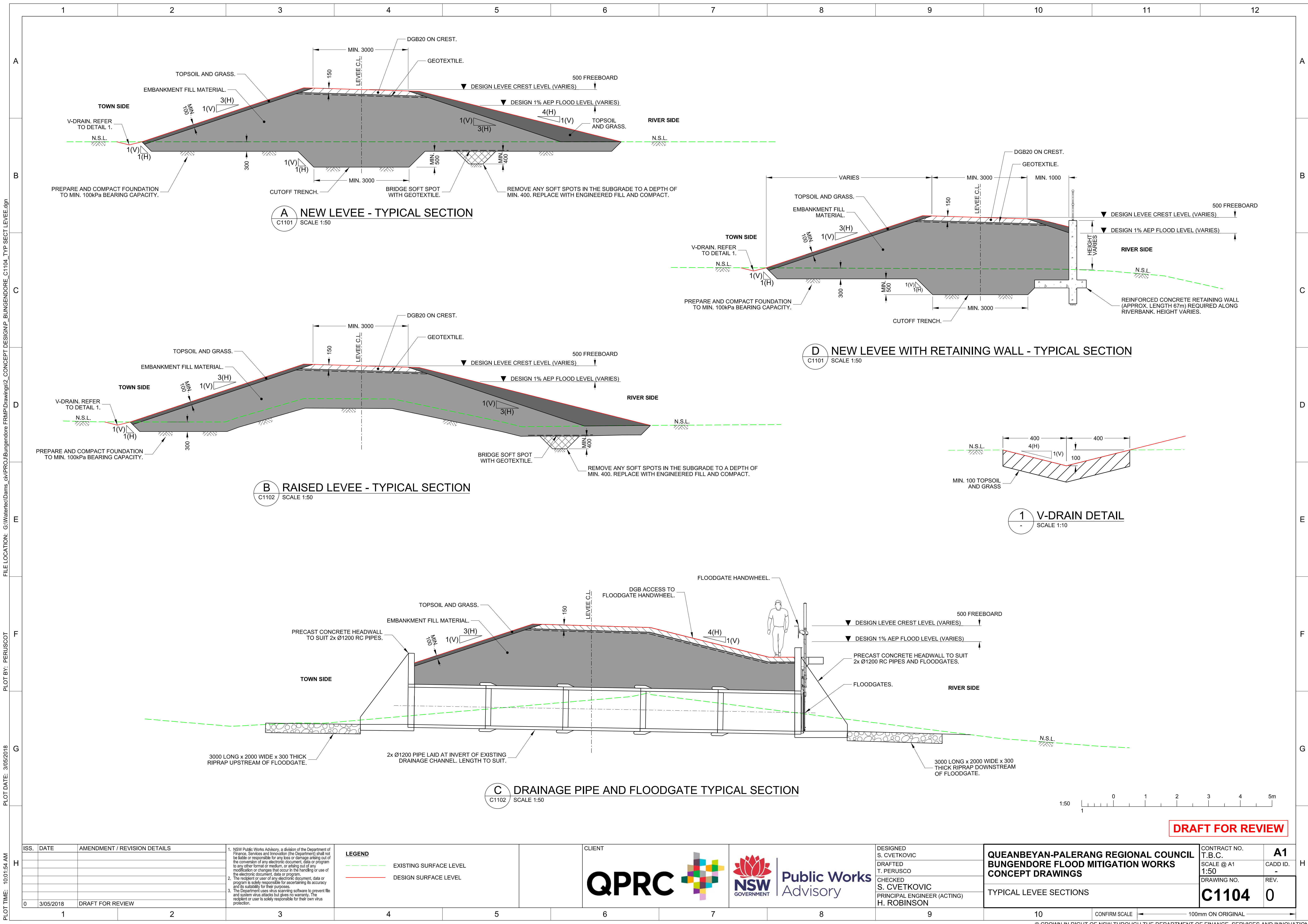
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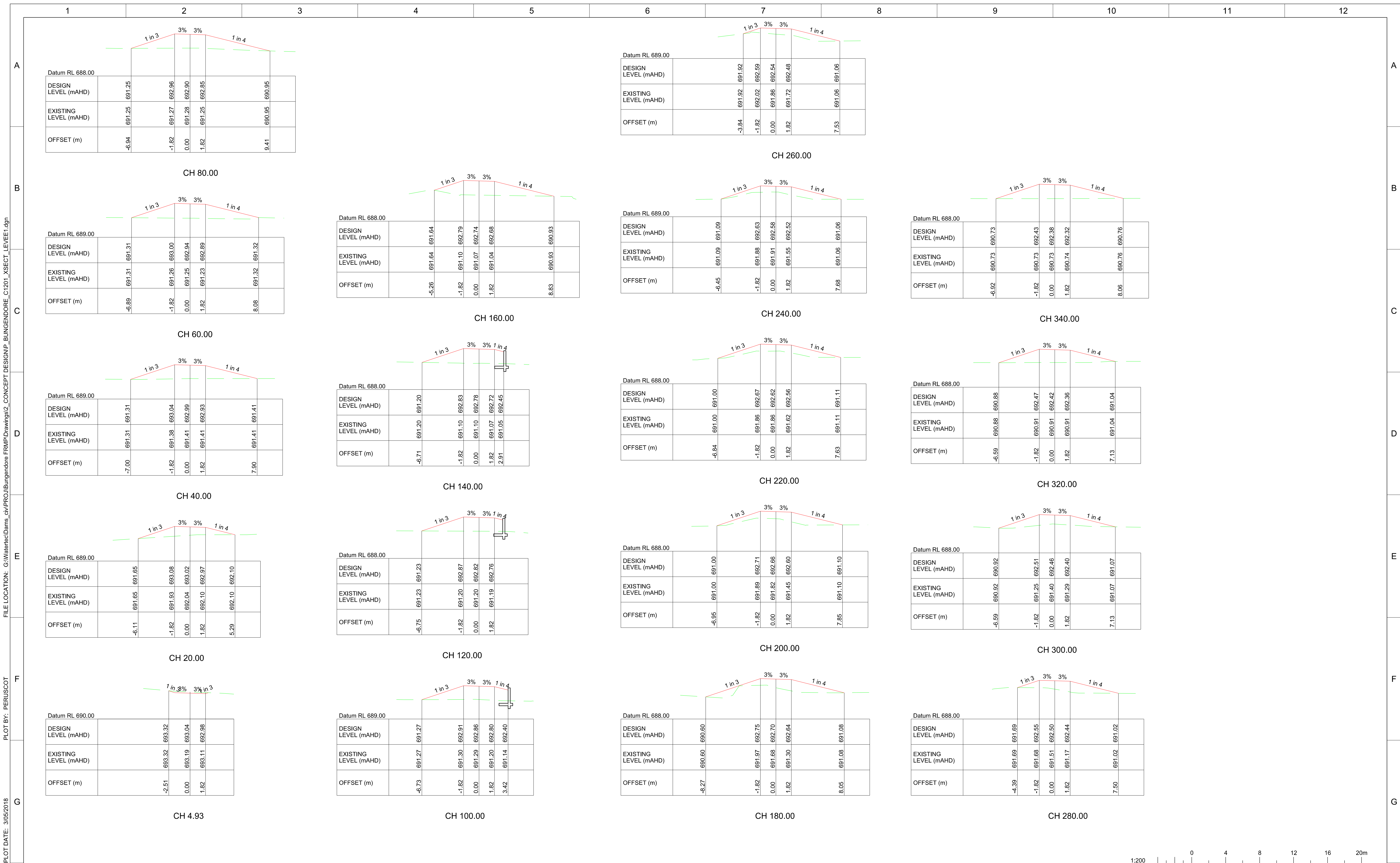


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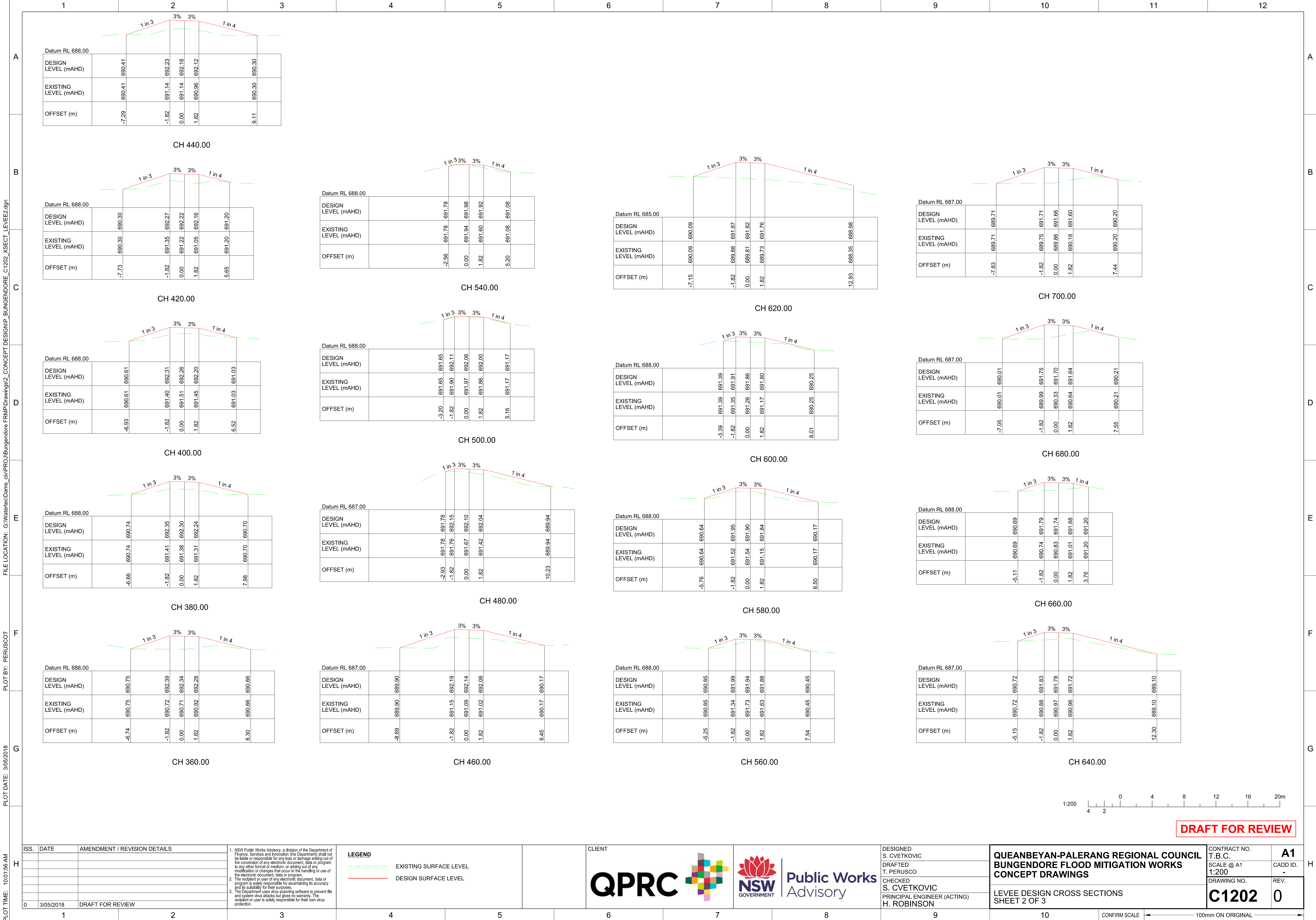
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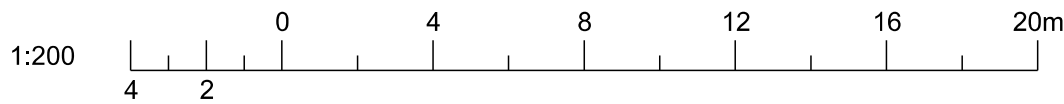
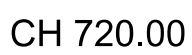
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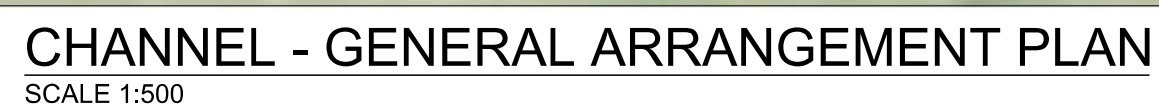
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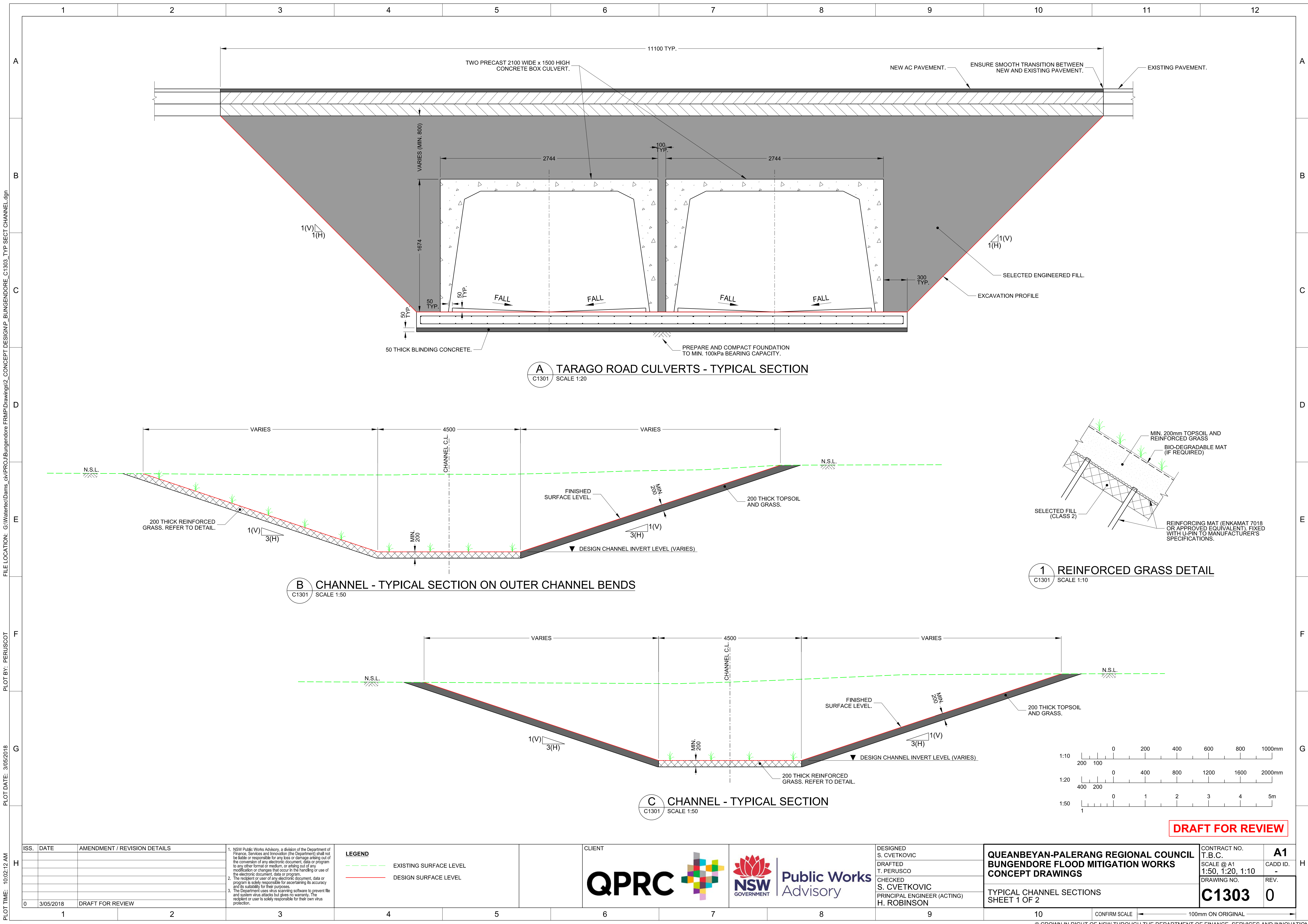
Public Works
Advisory

**QUEANBEYAN-PALERANG REGIONAL COUNCIL
BUNGENDORE FLOOD MITIGATION WORKS
CONCEPT DRAWINGS**

CHANNEL LONGITUDINAL SECTION
SHEET 1 OF 2

CONTRACT NO. T.B.C.	A1
SCALE @ A1 1:500, 1: 100	CADD ID. -
DRAWING NO. C1301	REV. 0

CONFIRM SCALE ← 100mm ON ORIGINAL →



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PLOT BY: PERUSCO

PLOT DATE: 30/05/2018

PLOT TIME: 10:02:12 AM

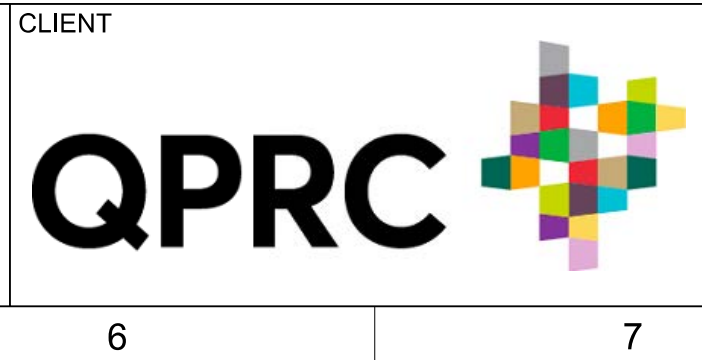
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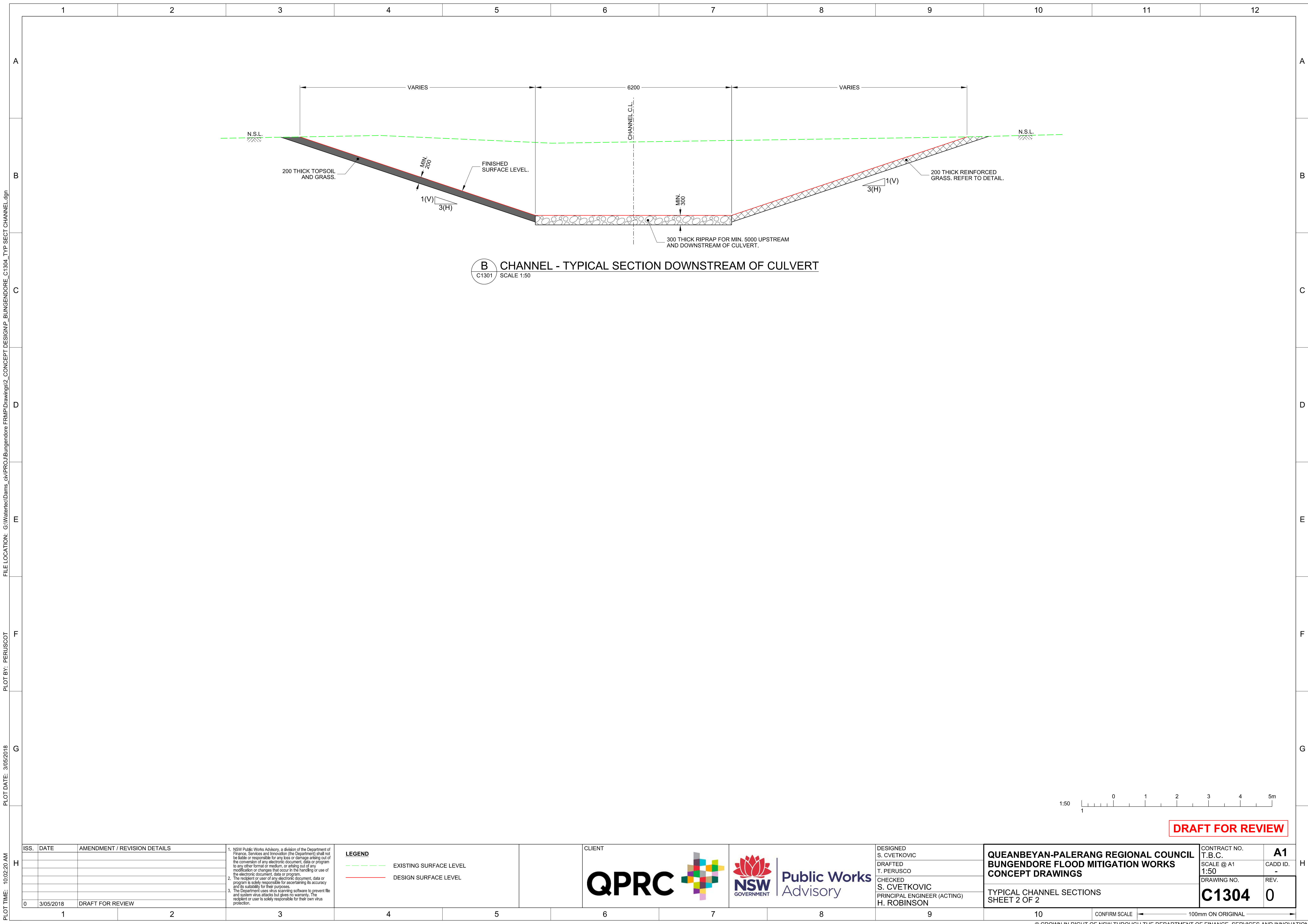
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--- DESIGN SURFACE LEVEL



DESIGNED S. CVETKOVIC
DRAFTED T. PERUSCO
CHECKED S. CVETKOVIC
PRINCIPAL ENGINEER (ACTING) H. ROBINSON

QUEANBEYAN-PALERANG REGIONAL COUNCIL BUNGENDORE FLOOD MITIGATION WORKS CONCEPT DRAWINGS	CONTRACT NO. T.B.C.	A1
TYPICAL CHANNEL SECTIONS SHEET 1 OF 2	SCALE @ A1 1:50, 1:20, 1:10	CADD ID. -
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PLOT BY: PERUSCOT

PLOT DATE: 30/5/2018

PLOT TIME: 10:02:20 AM



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--- DESIGN SURFACE LEVEL

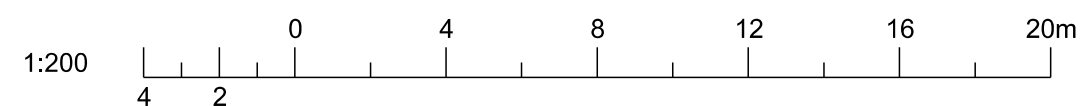
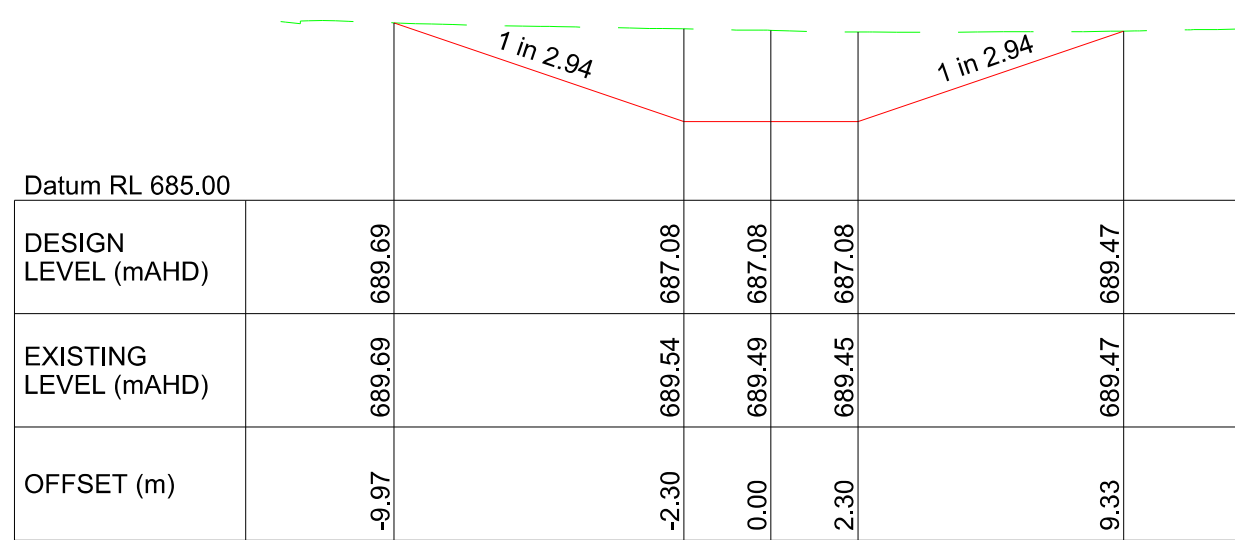
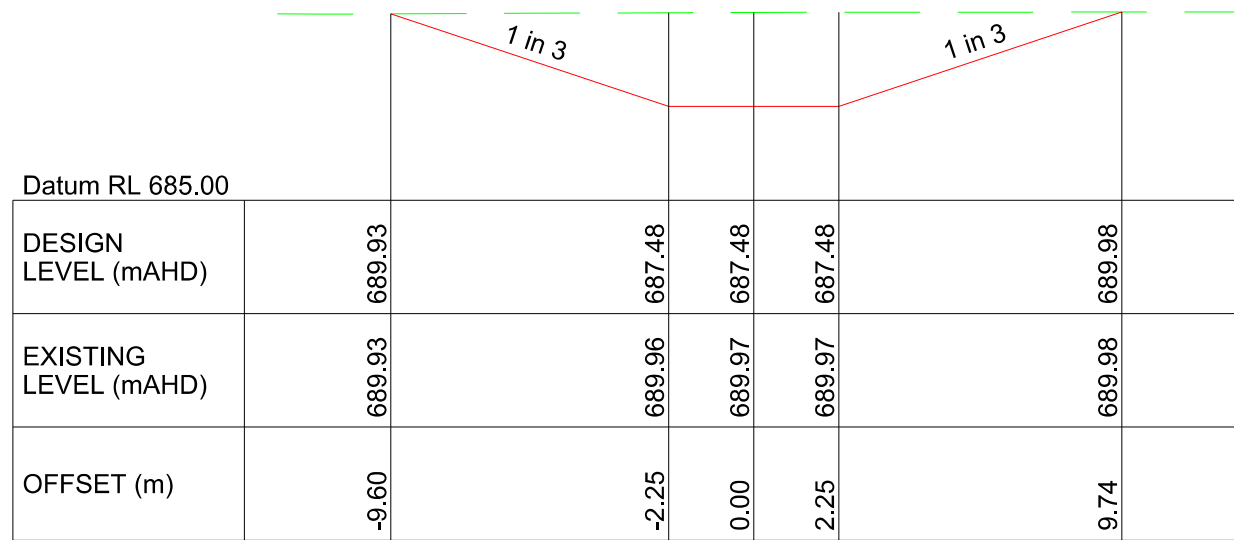
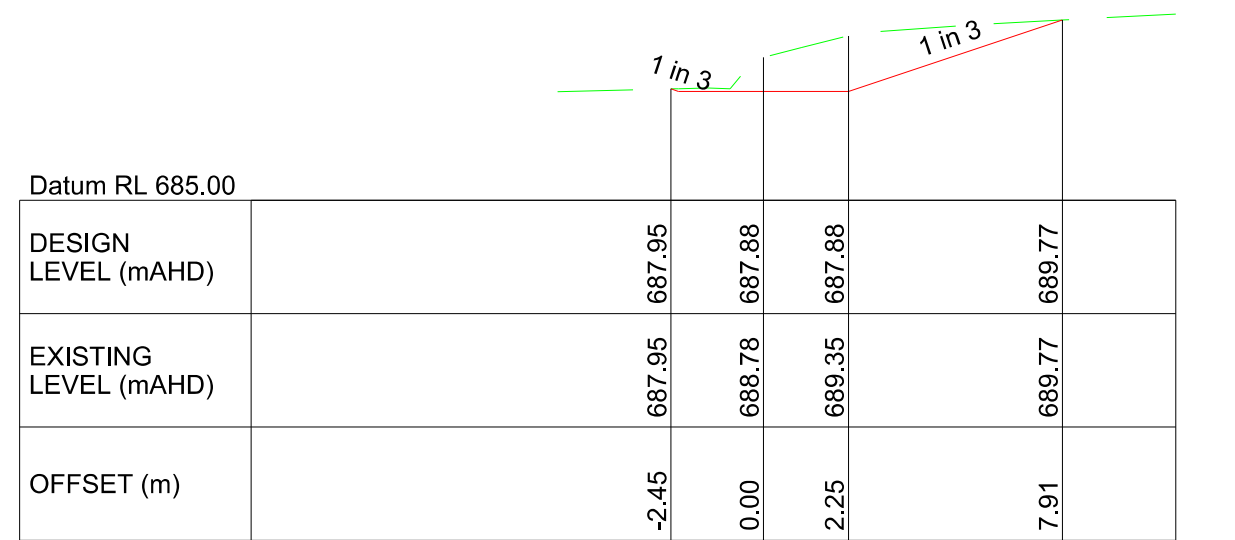


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T. PERUSCO
CHECKED
S. CVETKOVIC
PRINCIPAL ENGINEER (ACTING)
H. ROBINSON

QUEANBEYAN-PALERANG REGIONAL COUNCIL
BUNGENDORE FLOOD MITIGATION WORKS
CONCEPT DRAWINGS

TYPICAL CHANNEL SECTIONS
SHEET 2 OF 2

CONTRACT NO. T.B.C.	A1
SCALE @ A1 1:50	CADD ID. -
DRAWING NO. C1304	REV. 0



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CHECKED S. CVETKOVIC
PRINCIPAL ENGINEER (ACTING) H. ROBINSON

**QUEANBEYAN-PALERANG REGIONAL COUNCIL
BUNGENDORE FLOOD MITIGATION WORKS
CONCEPT DRAWINGS**

CHANNEL DESIGN CROSS SECTIONS
SHEET 1 OF 2

CONTRACT NO

T.B.C.

SCALE @ A1
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DRAWING NO.

DRAWING NO.

C140

0146

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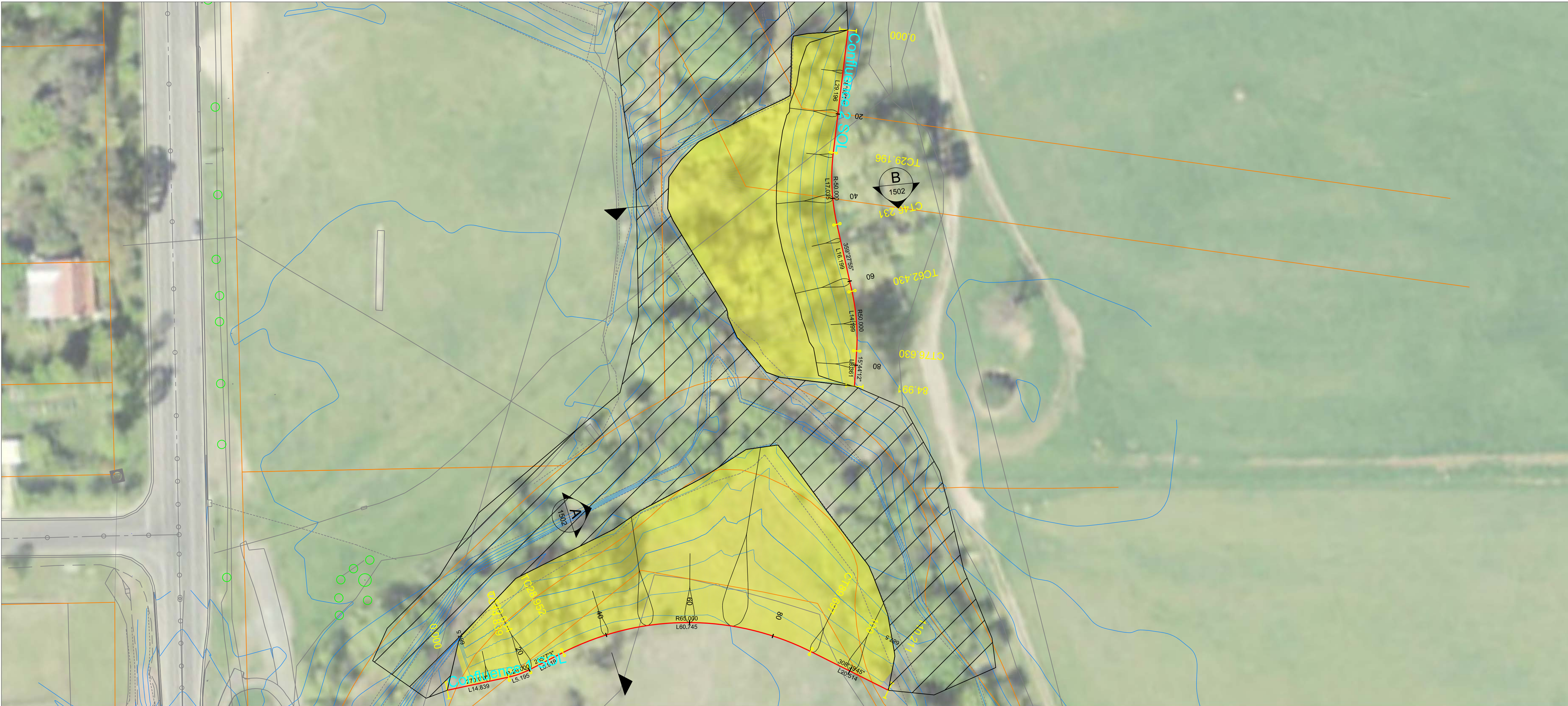
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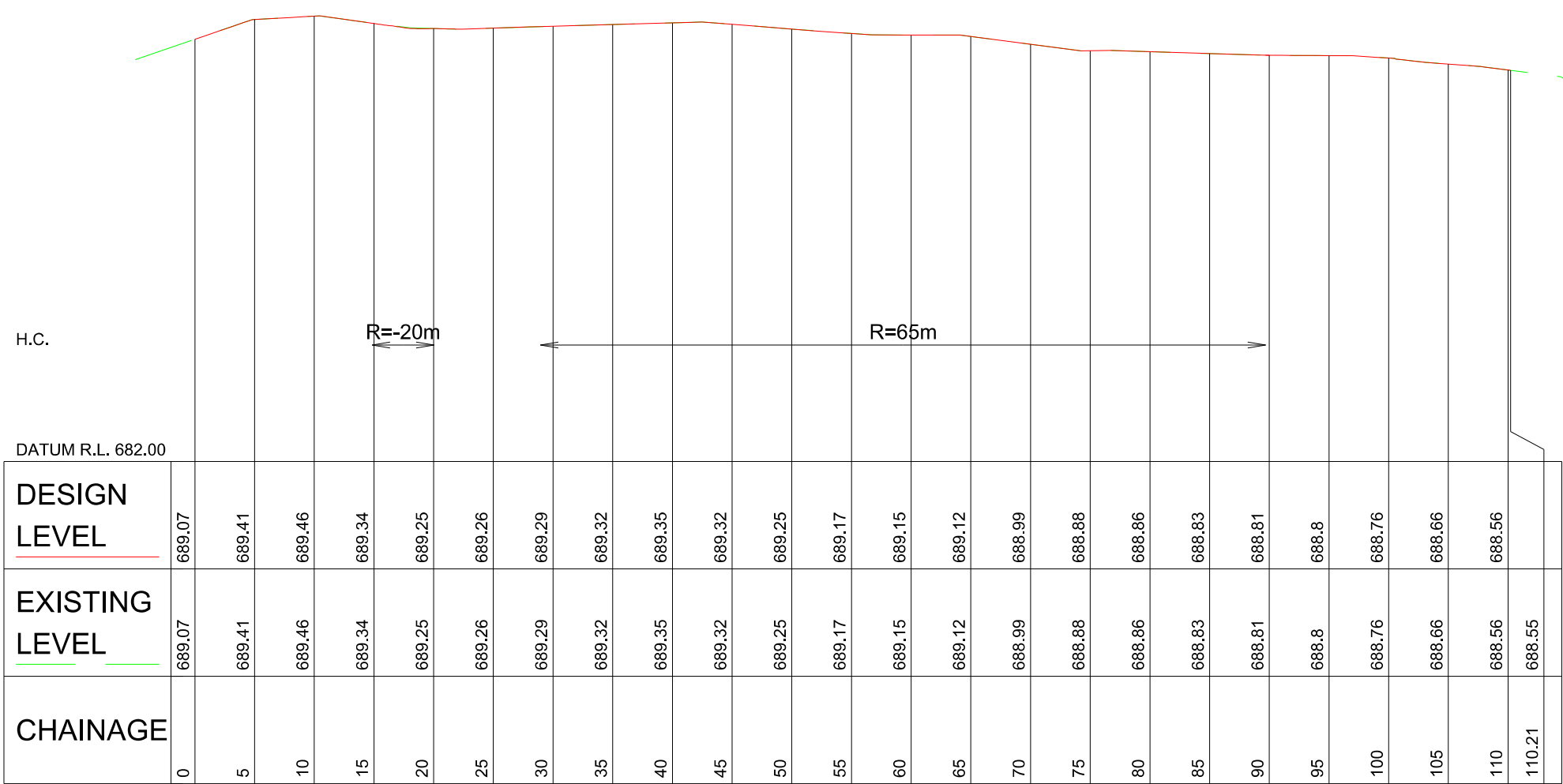
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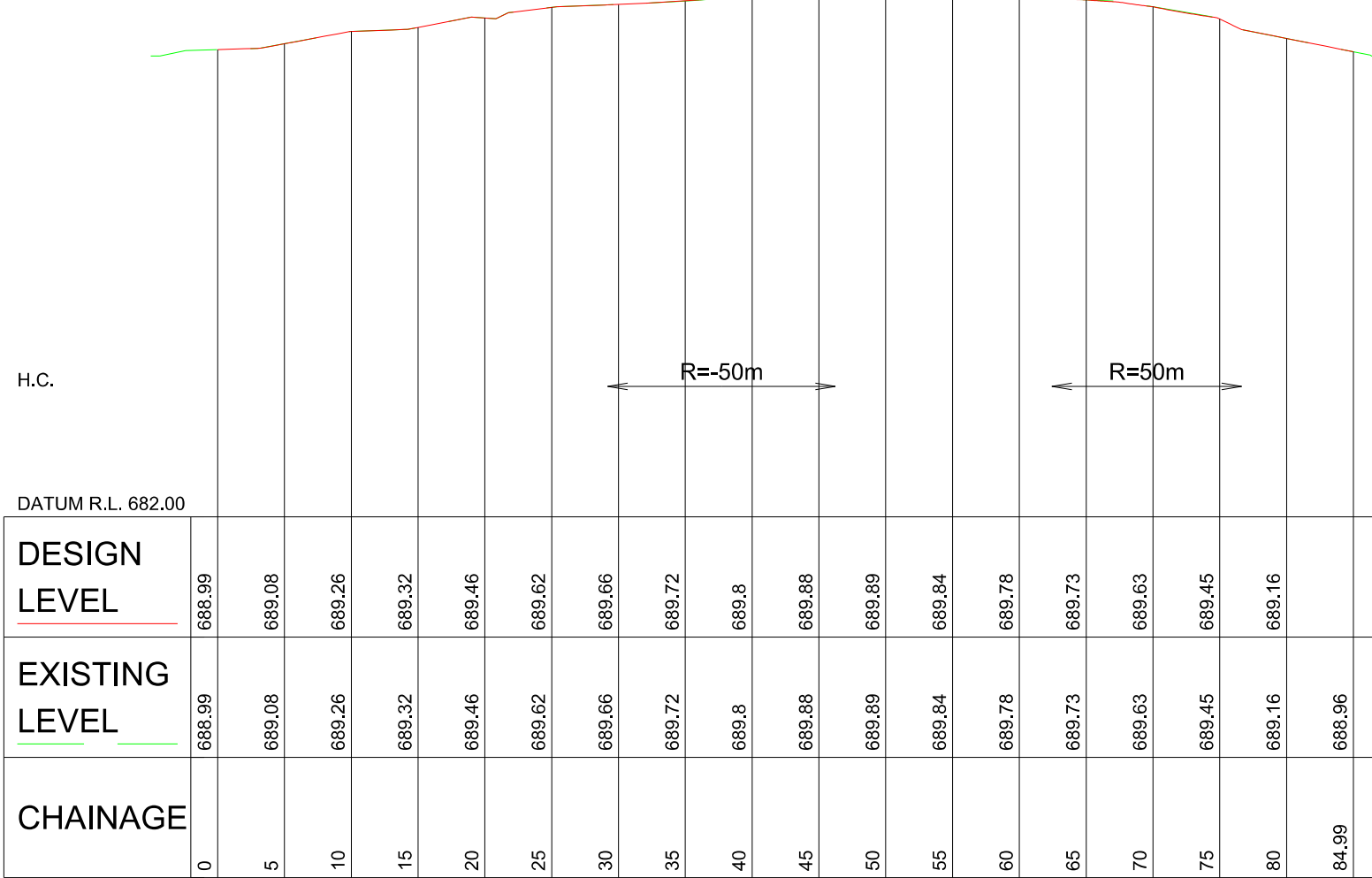
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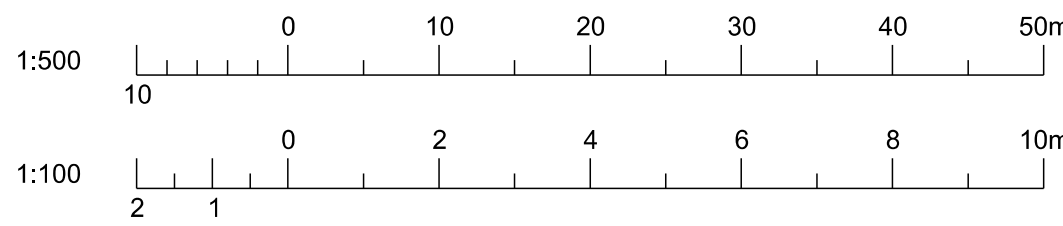
CONFLUENCE EXCAVATIONS - GENERAL ARRANGEMENT PLAN
SCALE 1:500



CONFLUENCE 1 SOL - LONGITUDINAL SECTION
HORIZONTAL SCALE 1:500
VERTICAL SCALE 1:100



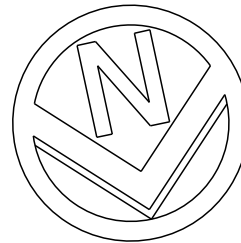
CONFLUENCE 2 SOL - LONGITUDINAL SECTION
HORIZONTAL SCALE 1:500
VERTICAL SCALE 1:100



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DRAFTED
T. PERUSCO
CHECKED
S. CVETKOVIC
PRINCIPAL ENGINEER (ACTING)
H. ROBINSON

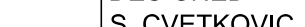
**QUEANBEYAN-PALERANG REGIONAL COUNCIL
BUNGENDORE FLOOD MITIGATION WORKS
CONCEPT DRAWINGS**

RIVER CONFLUENCE EXCAVATION AND CLEARING
PLAN AND LONGITUDINAL SECTIONS

CONTRACT NO.
T.B.C.
SCALE @ A1
1:500, 1: 100
DRAWING NO.
C1501

A1
CADD ID.
-
REV.
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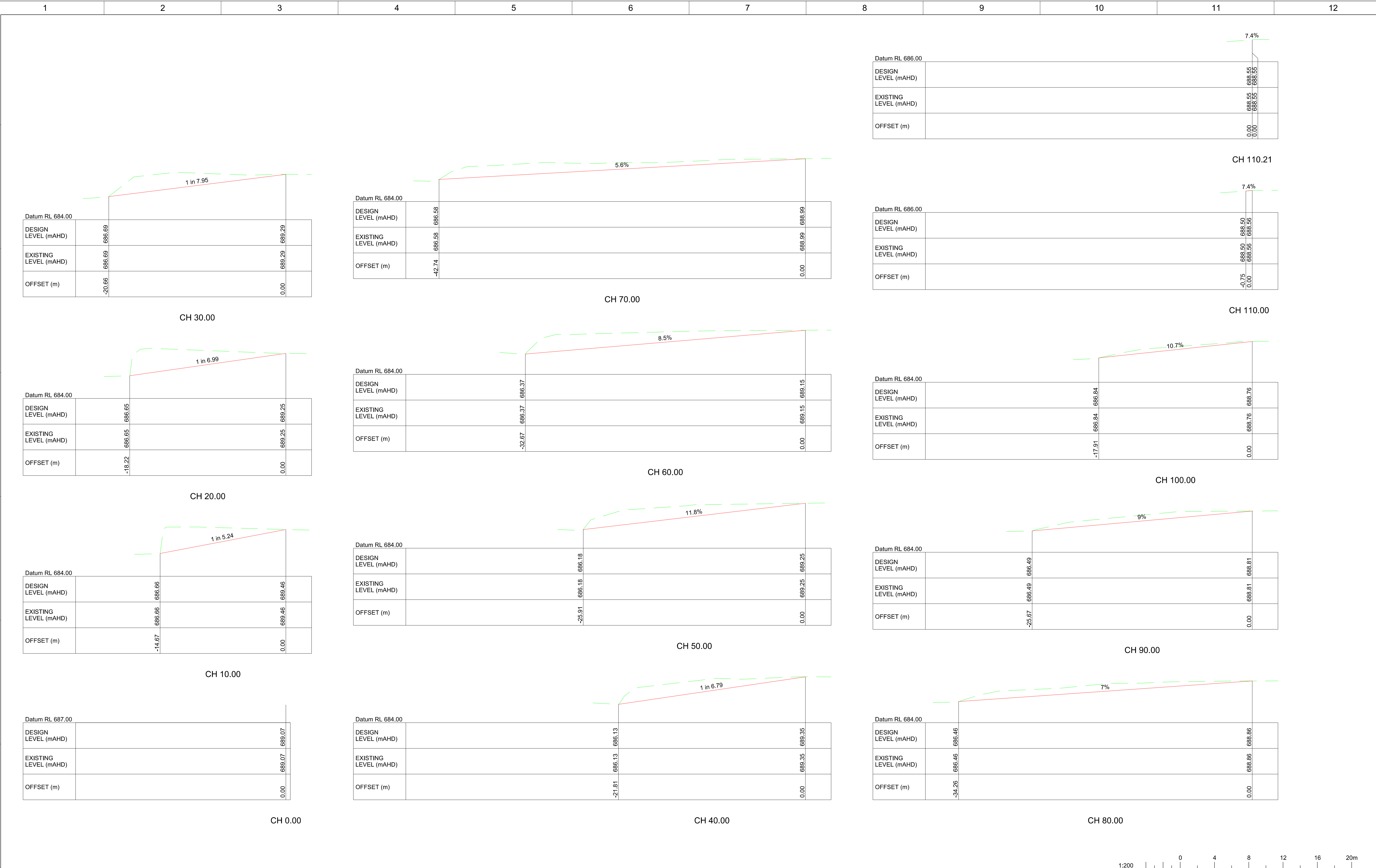
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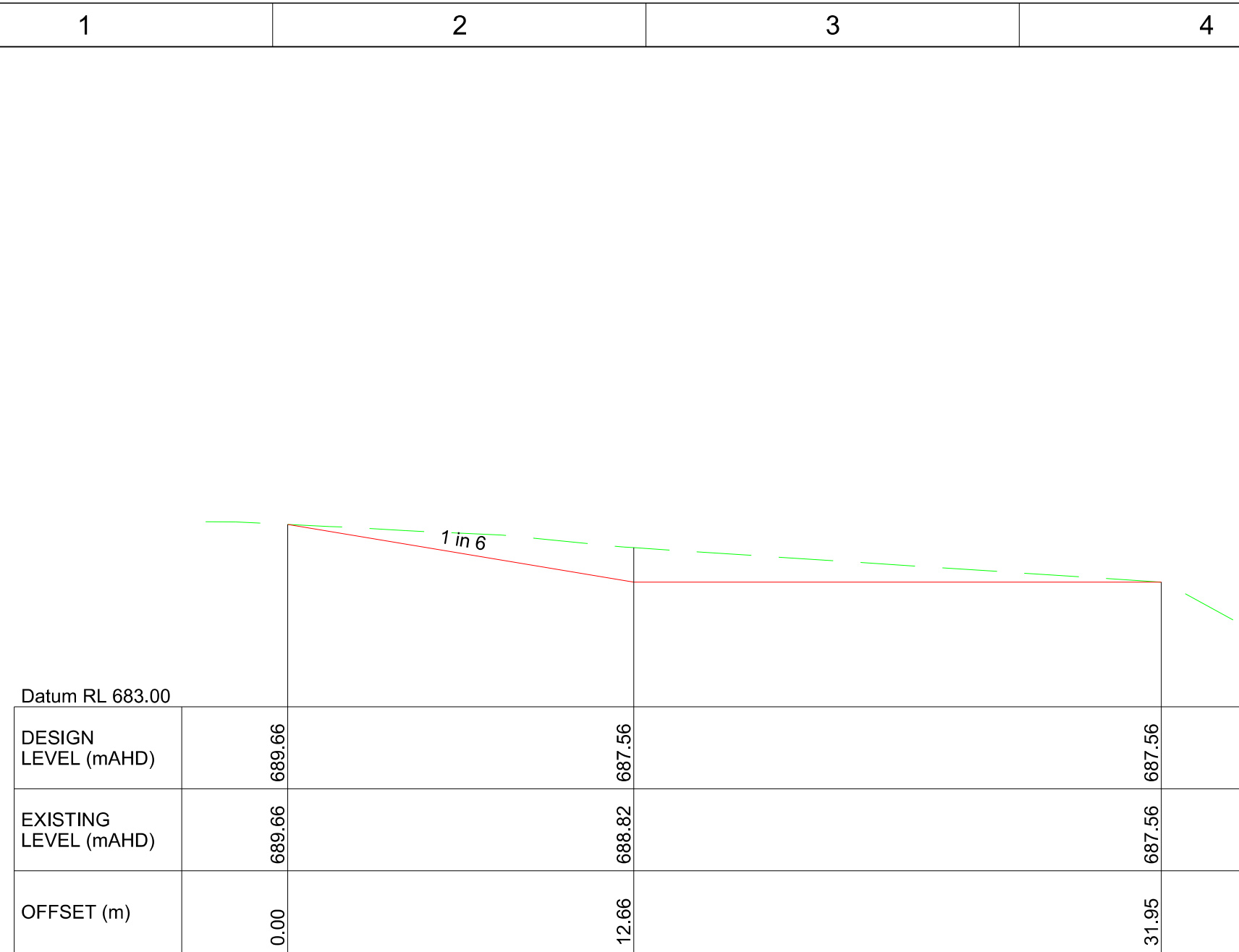
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PLOT TIME: 10:02:19 AM

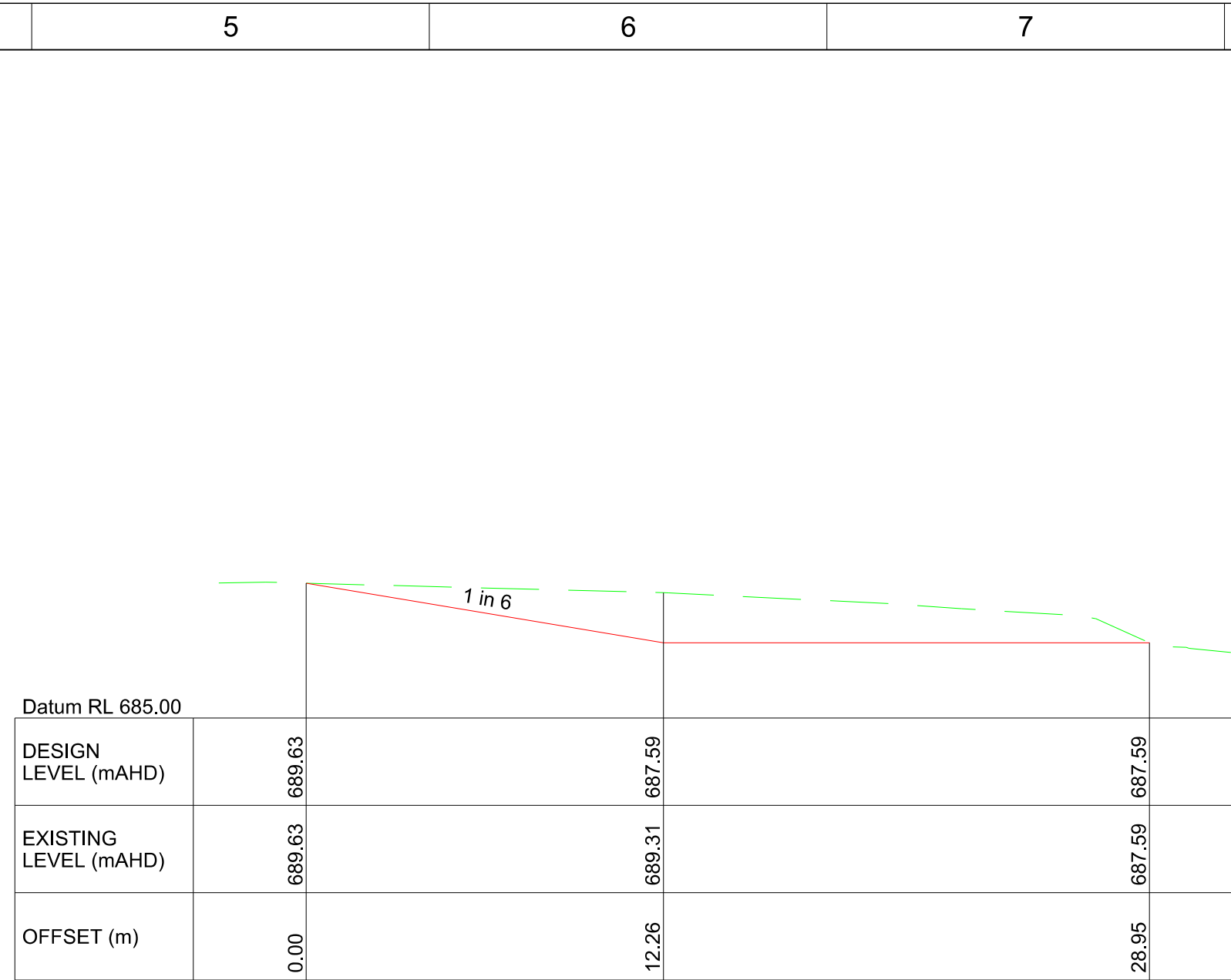


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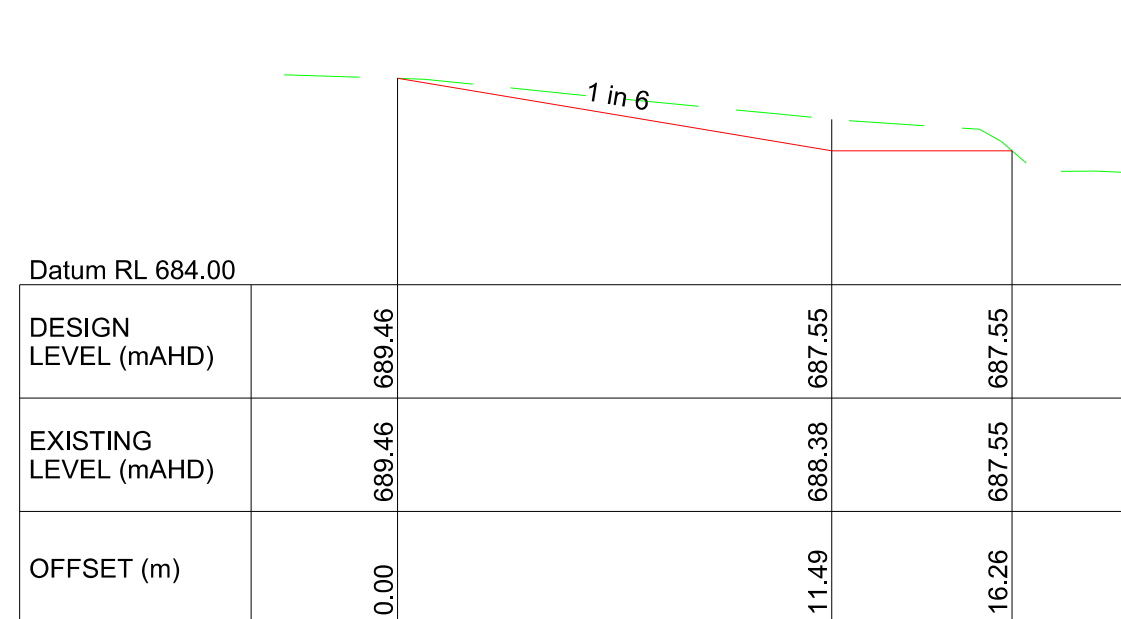
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0		3/05/2018	DRAFT FOR REVIEW								PRINCIPAL ENGINEER (ACTING) H. ROBINSON		RIVER CONFLUENCE EXCAVATION 1 DESIGN CROSS SECTIONS		C1601		0							
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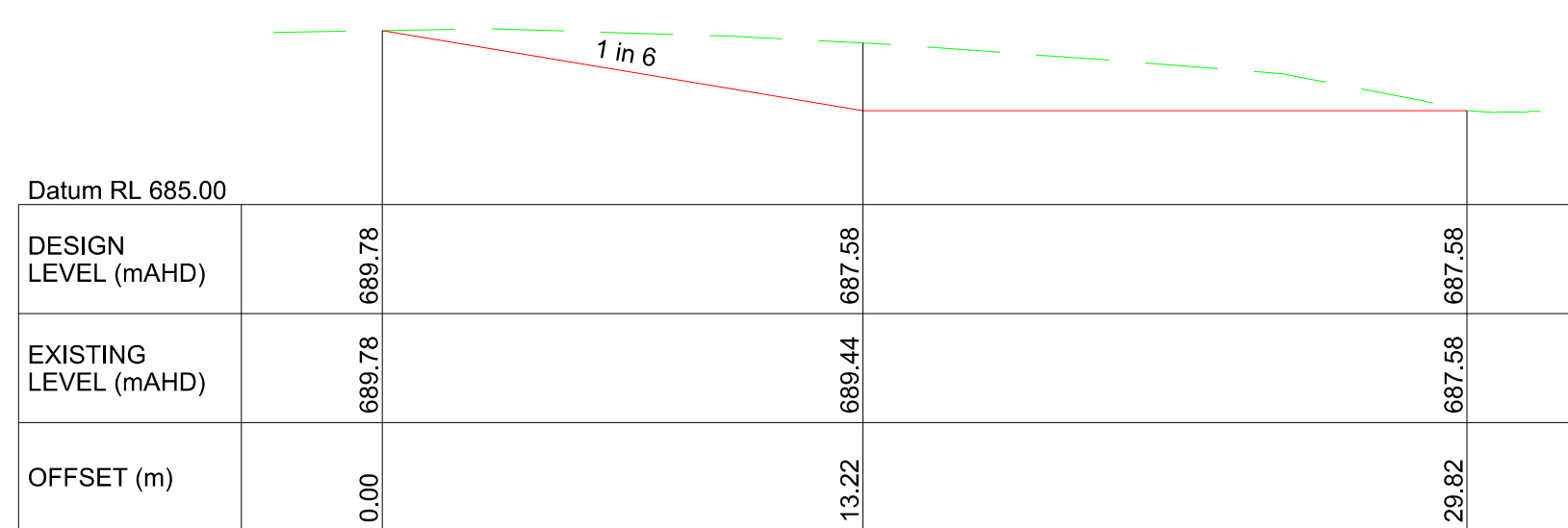
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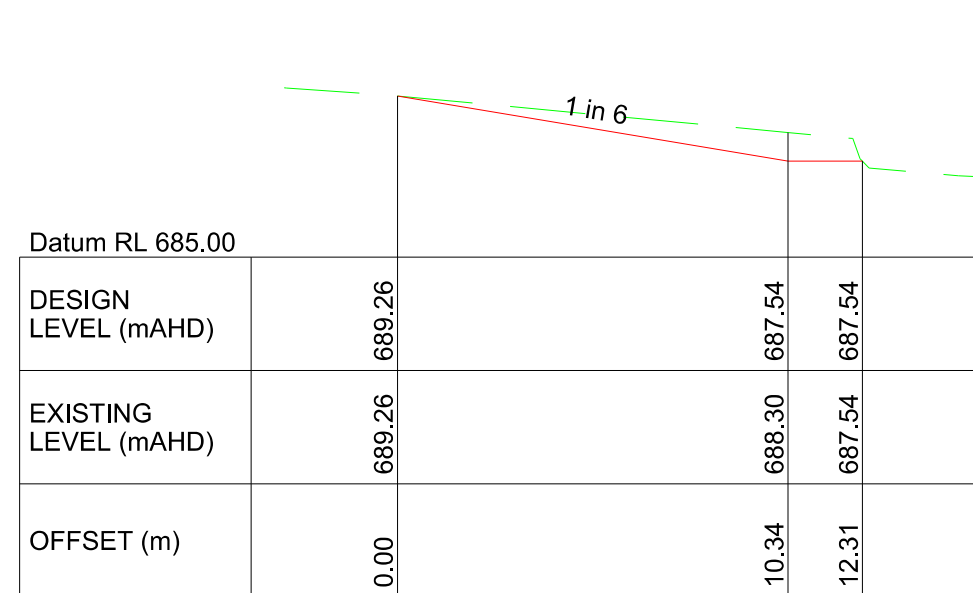
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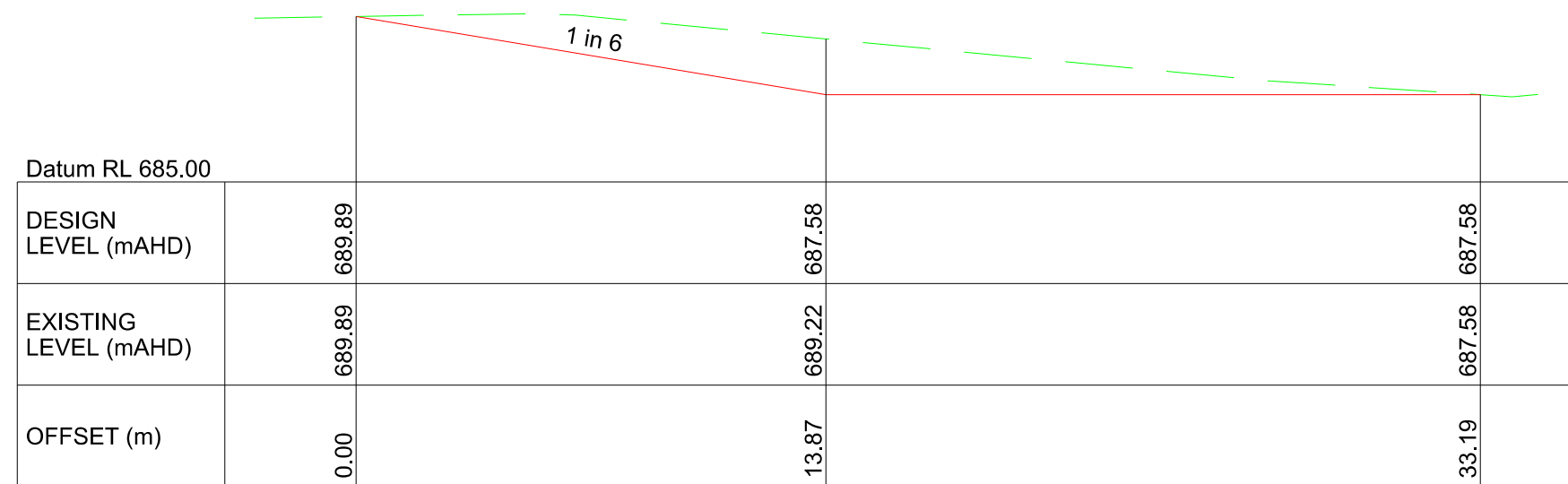
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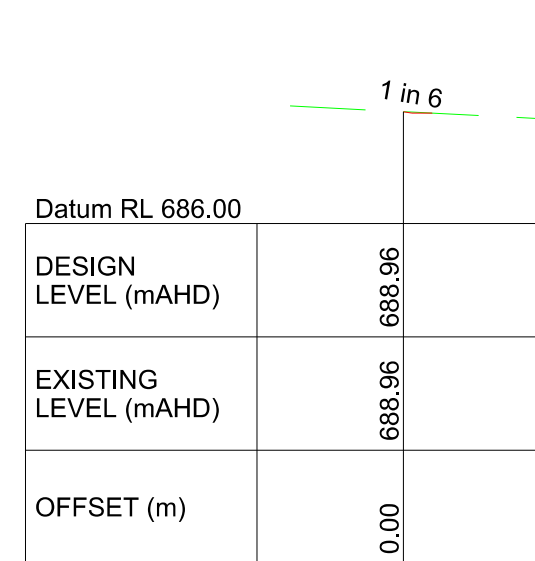
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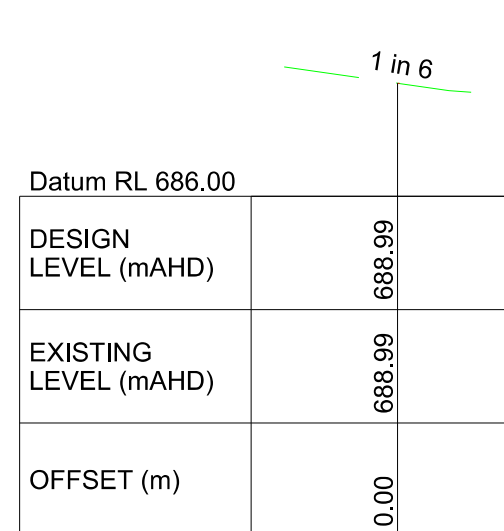
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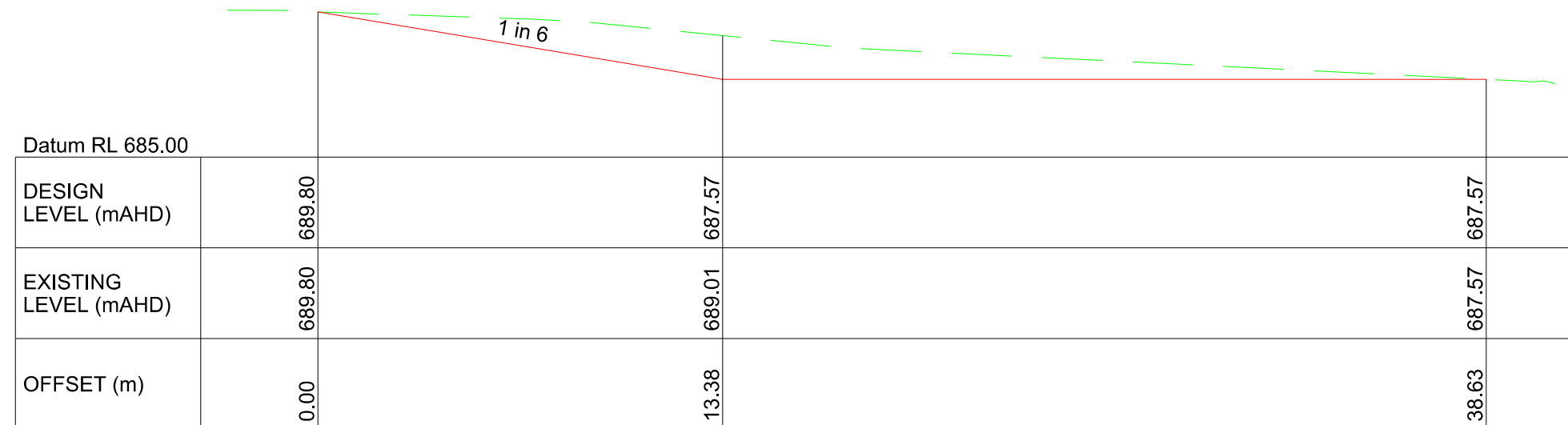
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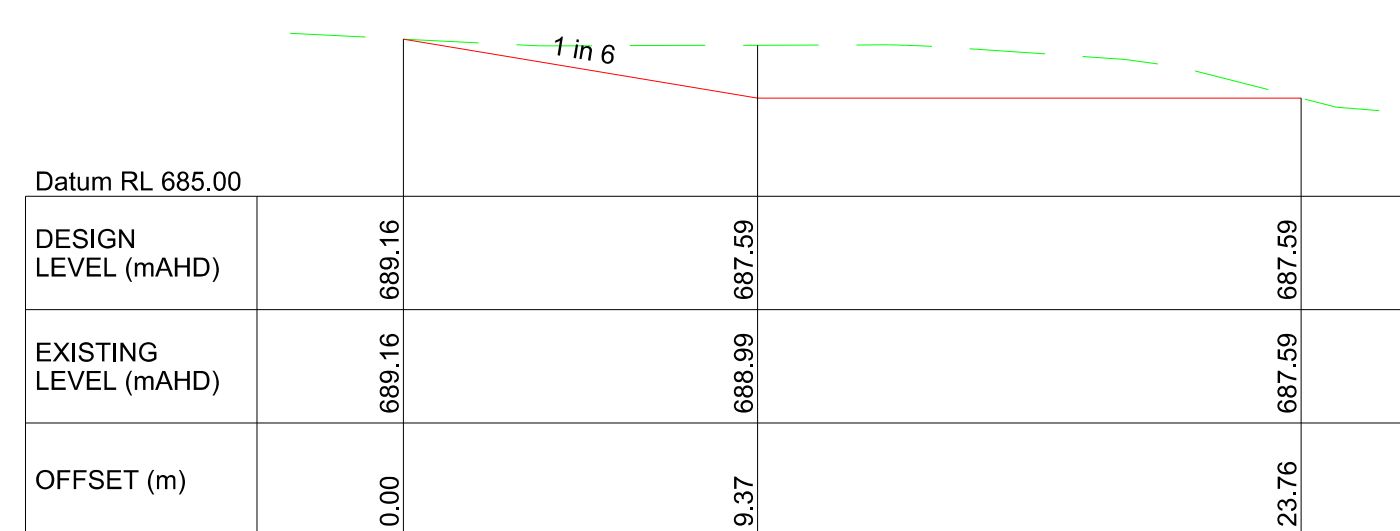
CH 84.99



CH 0.00



CH 40.00



CH 80.00



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0	3/05/2018	DRAFT FOR REVIEW										RIVER CONFLUENCE EXCAVATION 2 DESIGN CROSS SECTIONS			C1702			0											

Appendix B HecRas Modelling Results

HEC-RAS Plan: Bungendore River: Channel Reach: Channel Profile: PF 1

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Cnt W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
Channel	9	PF 1	10.83	687.88	689.00		689.08	0.002634	1.22	8.85	11.24	0.44
Channel	8	PF 1	10.83	687.75	688.95		689.01	0.002028	1.11	9.73	11.70	0.39
Channel	7	PF 1	10.83	687.50	688.89		688.93	0.001117	0.90	12.09	12.86	0.29
Channel	6.8	PF 1	10.83	687.45	688.88		688.92	0.000991	0.86	12.63	13.11	0.28
Channel	6.7	PF 1	10.83	687.42	688.73	688.26	688.90	0.002947	1.85	5.86	12.31	0.52
Channel	6.5		Culvert									
Channel	6.3	PF 1	10.83	687.32	688.16	688.16	688.58	0.012688	2.86	3.78	9.54	1.00
Channel	5.9	PF 1	10.83	687.23	688.27		688.36	0.003504	1.36	7.98	10.77	0.50
Channel	5	PF 1	10.83	687.00	688.16		688.23	0.002327	1.17	9.25	11.46	0.42
Channel	4	PF 1	10.83	686.75	688.09		688.14	0.001301	0.95	11.43	12.55	0.32
Channel	3	PF 1	10.83	686.50	688.06		688.09	0.000711	0.76	14.26	13.84	0.24
Channel	2	PF 1	10.83	686.25	688.04		688.06	0.000400	0.61	17.62	15.22	0.18
Channel	1	PF 1	10.83	686.12	688.03		688.05	0.000305	0.56	19.47	15.93	0.16



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