Sunday Creek Irrigation Reconfiguration

Goulburn Murray Water - Connections Project

Preliminary Design Report

Revision | A

17 April, 2019

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1. Introduction

Jacobs has been engaged by Goulburn Murray Water (GMW) Connections Project to assist in delivering a water savings project on behalf of the Sunday Creek Management Committee (SCMC) and Parks Victoria.

Jacobs reviewed existing project documentation including the report *Lake Moodemere – Water Savings Assessment (DEPI, 2014)* during the Concept Design phase of the current project. The review was limited to assessing the adequacy of proposed infrastructure required to reconfigure Lake Moodemere and surrounds for irrigation and recreational purposes.

The proposed reconfigured infrastructure at Lake Moodemere and surrounds include:

- A new 36 ML/d angled axial flow pump station.
- A new 36 ML/d capacity HDPE delivery pipeline and bubbler pit.
- A replacement for the existing Lake Moodemere regulating structure.
- A new embankment at “Hells Gate”.

The Concept Design endorsed the design criteria proposed in the DEPI report (with some minor modifications) and presented this information to GMW Connections Project and the SCMC. Approval to progress to Preliminary Design based on the above-mentioned design criteria was granted on 1st March, 2019.

The Preliminary Design presents the functional design requirements of the reconfigured infrastructure to relevant project stakeholders. As part of the Preliminary Design the following has also been undertaken:

- Constructability review of proposed infrastructure.
- Safety in Design review.
- Operations and Maintenance assessment.
- Updated cost estimates of proposed infrastructure.
- Refined Draft Operational Rules.

2. Project Understanding

2.1 Project Site and Current Irrigation Configuration

The SCMC represents irrigators in the area surrounding Lake Moodemere, which is approximately 5 km west of Rutherglen in northern Victoria. The current irrigation scheme draws water from Sunday Creek, which is a waterway to the east of the main body of Lake Moodemere and its surrounding wetlands. Sunday Creek is filled when the water level in Lake Moodemere is high enough to pass through an artificial channel known as Hells Gate.

The natural water level in Lake Moodemere cannot reliably supply Sunday Creek for irrigation purposes. The water level in Lake Moodemere is required to be artificially maintained during the irrigation season (15 August to 15 May). This is achieved by filling the lake from the Murray River – either by gravity flows when river level is above 128.55 m AHD (DEPI, 2014), or by pumping when the river is too low for gravity flows.

Water either flows through a river bank inlet structure or is pumped over the bank at a location to the north-west of the lake. A small regulating structure, known as the Lake Moodemere Regulator, is located near the existing pump station. This structure functions both as a flow control device into Lake Moodemere, and also a level control device by preventing backflow to the Murray River with one-way gates.

2.2 Reconfiguration Drivers

The current usage of Lake Moodemere has led to detrimental environmental impacts due to having to maintain artificial water levels in Sunday Creek for irrigation purposes. The lake and surrounding wetlands require a 'wetting and drying' cycle to remain healthy and sustainable. The requirement to maintain a water level high enough in the lake to allow irrigation from Sunday Creek prevents this natural cycle from occurring during the irrigation season. Removing the need for these high water levels in Lake Moodemere is desirable to return the wetlands to a more natural state.

Potential water savings, through reduced seepage and evaporation loses, have also been identified if the irrigation scheme could be reconfigured such that Sunday Creek could be filled independently from Lake Moodemere.

2.3 Proposed Reconfiguration

The Preliminary Design has provided functional design requirements for the following proposed infrastructure:

- Construction of a 36 ML/d pump station and DN560 HDPE pipeline to supply Sunday Creek directly from the Murray River;
- Construction of an embankment at Hells Gate to allow Sunday Creek to fill independently of the water level in Lake Moodemere; and
- Replacement of the existing Lake Moodemere Regulator adjacent to the Murray River.

The proposed reconfiguration intends to return Lake Moodemere and the surrounding environment to near-natural conditions. However, there are socio-economic factors which dictate that lake levels are set at minimum levels for events and activities which are important to the local area. The replacement regulator will have the same functional characteristics as the existing regulator.

3. Basis of Design

A Basis of Design was presented in the Concept Design report, which included a number of assumptions that were to be confirmed at Preliminary Design. Additional investigations have been carried out to refine and complete the Preliminary Design. These additional investigations are described in the following sections.

3.1 Geotechnical Investigation

Geotechnical site investigations were completed by BM Civil Engineers between 2 and 11 September 2018 and provided to Jacobs on 22 October 2018. A total of 9 boreholes were completed across the 4 proposed construction areas, including:

- 2 boreholes at the Lake Moodemere regulator site.
- 1 borehole at the pump station site.
- 4 boreholes along the pipeline alignment.
- 2 boreholes at Hells Gate site (hand drilled due to site access restrictions).

Borehole laboratory testing indicated that groundwater was encountered in all boreholes, expect borehole 04 (along the pipeline alignment), at depths varying between 2.8 m and 7.0 m.

Soil samples indicate that many of the samples are dispersive and that the likely impact of soil erosion when formulating design options will need to be considered at detailed design.

Refer to Appendix A for the Geotechnical Investigations.

3.2 Site Survey

Field survey of the pump station and pipeline area, as well as the regulator site was completed by Chris Smith and Associates on 21 November 2018. Due to access restrictions, survey of Hells Gate was finalised on 15 January 2019. Compiled data was provided to Jacobs on 29 January 2019.

Refer to Appendix B for the Site Survey Check Plot.

3.3 Chambers Gauge Level Assessment

The “zero-mark” on Chamber’s Gauge has been previously surveyed at 127.10 m AHD (DEPI, 2014). Four of the six visible posts with level markings are shown in Figure 3-1 below.

Figure 3-1: "Chamber's Gauge" Posts

Chris Smith and Associates surveyed top water level marker levels on 4 accessible posts as shown in Figure 3-2.

Figure 3-2: Chris Smith and Associates Surveyed Marker Levels

The consistent results support the assumed “zero-mark” at the base of the sixth post at 127.10 m AHD.

The fourth gauge had a top mark surveyed at 129.805 m AHD. In addition, the water level on the day of the survey is measured at approximately +2.0 m (129.10 m AHD) as shown in Figure 3-3.

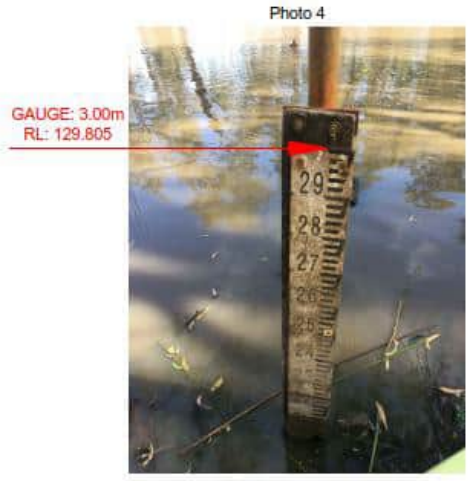

Figure 3-3: Potential Movement at Chamber's Gauge Post

The level surveyed at the top of the fourth post suggests the post itself may have moved approximately 300 mm and is currently lower than installation level. The water level on the day of the survey was 128.82 m AHD, which is 280 mm lower than the level that is obtained from the Chamber's Gauge marker.

The fifth and sixth markers were not safely accessible to surveyors on-site and a top mark level was not recorded.

Further investigation into the appropriateness of adopting Chamber's Gauge levels for the design of civil infrastructure may be required.

For the purpose of Preliminary Design with current available information, levels presented in the Concept Design that are relative to the Chamber's Gauge zero marker have been adopted.

3.3.1 Corowa Gauge Location

Murray River levels at the site of the pump station and at the Lake Moodemere have been adapted from relative level data available at the nearby Corowa River Level Gauge. The gauge is approximately 4 km upstream of the proposed pump station location, and approximately 6.5 km of the Lake Moodemere Regulator. These locations are shown below in Figure 3-4.

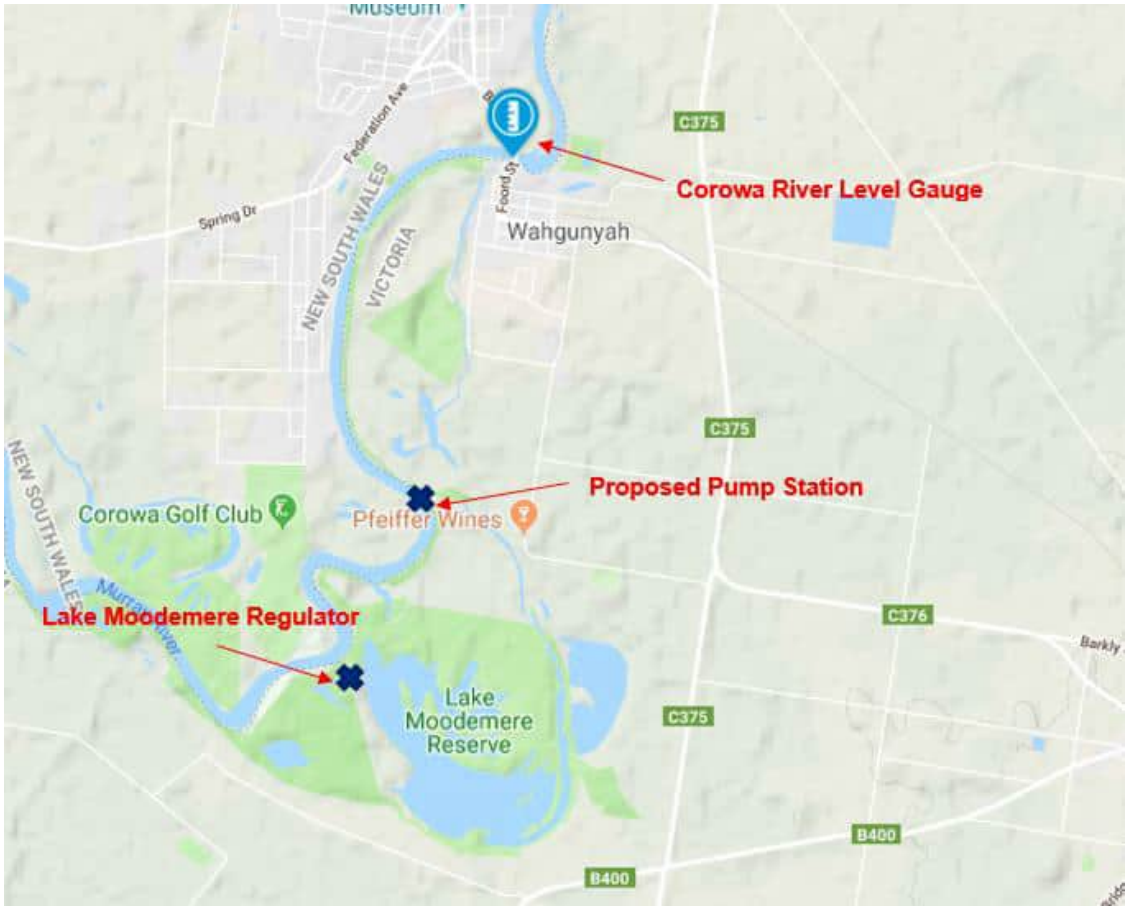

Figure 3-4: Murray River Bank Infrastructure and Corowa Gauge Location

There are no tributaries or level controlling structures in the river between the gauge and the proposed infrastructure that would affect operating level measurements. In absence of detailed river profiles and modelling, data from the Corowa Gauge has been assumed to be appropriate to specify operating levels in the Preliminary Design.

3.3.2 Adopted Operating and Minimum River Levels

An extract of Corowa Gauge data from 2009 onwards is presented in Figure 3-5 below. This indicates that regulated operating levels in the Murray River at Corowa vary around approximately +3.8 m, while low water levels are approximately +0.3 m.

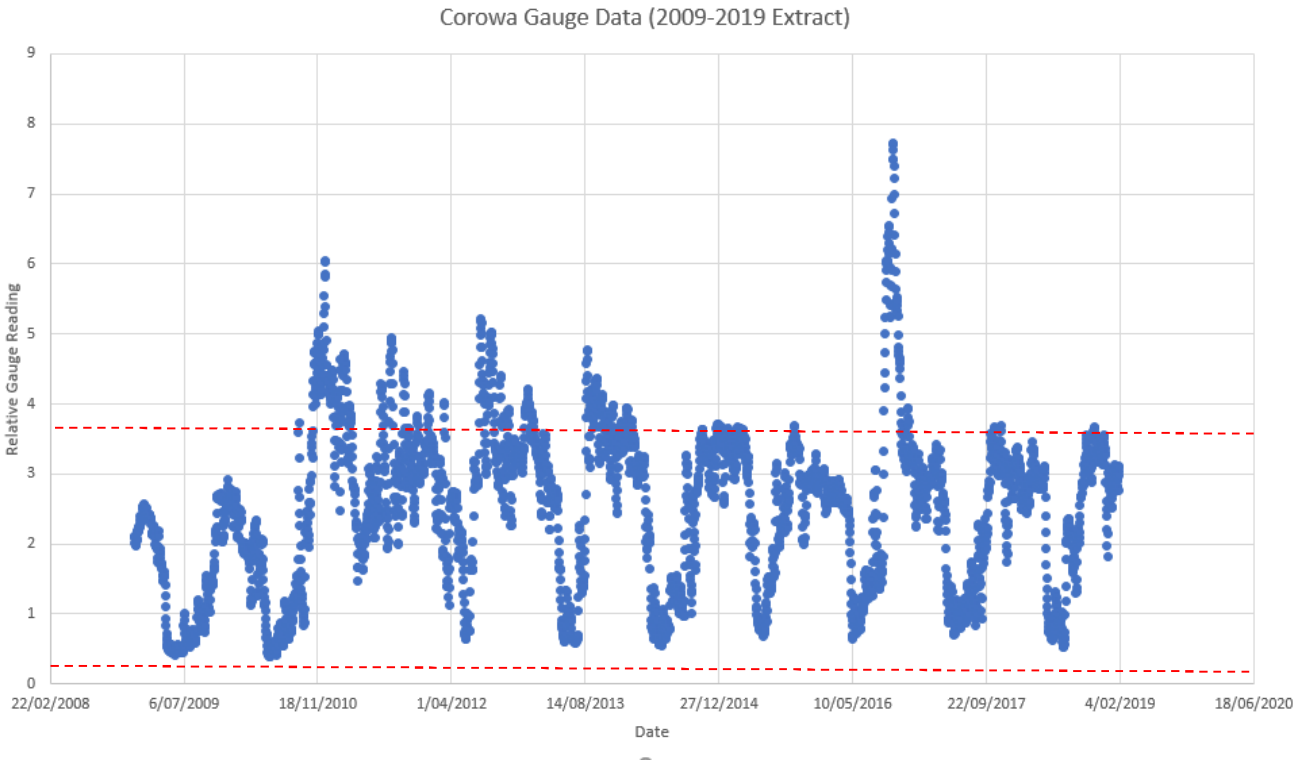

Figure 3-5: Corowa Gauge Relative Level Data (2009-19)

The proposed pump station site was surveyed on 21 November 2018 and the water level was surveyed at 128.50 m AHD. On the same day the Corowa Gauge read +3.326 m.

Known information from the surveyed water level, relative levels from the Corowa Gauge and allowances for variations due to unknowns have been used to develop indicative design levels in the Preliminary Design. These indicative levels are presented in Table 3-1.

Table 3-1: Adopted River Operating Levels from Survey Data and Gauge Readings

Design Level	Indicative Level (m AHD)
Regulated Operating Level	128.50
Low Water Level	125.00

3.3.3 1% AEP Flood Event River Level

Advice from the North East Catchment Management Authority (NECMA) was sought on flood levels at the project location to assist in ensuring electrical components of the pump station are sufficiently elevated. The NECMA provided information which states the 1% AEP (Average Exceedance Probability) flood level at the site is 133.80 m AHD. It is proposed that electrical components will be situated a minimum 0.5 m above this level at 134.30 m AHD (Note: This is 200mm above the level advised by the NECMA and is based on advice from Jacobs mechanical engineers).

The maximum Corowa Gauge reading recorded is +8.5 m in October 1975. This corresponds to 133.70 m AHD which supports the details above.

The NECMA advice letter is presented in Appendix E.

3.4 Overbank Flow into Lake Moodemere

Inundation of Lake Moodemere by overbank flow and floodplain flows commence at a Murray River level of 130.00 m AHD (DEPI, 2014). This level has been developed in previous studies by SKM and GHD.

The overbank flow level of 130.00 m AHD has been adopted in the Preliminary Design. This level has been interpreted as the 'low point' of the interface between the Murray River and Lake Moodemere and surrounding wetlands. The reconfigured infrastructure is required to ensure that water can be retained in Lake Moodemere through overbank flows to a level of 130.00 m AHD

3.5 Hydraulic and Geotechnical Characteristics of Sunday Creek

Under the proposed reconfigured irrigation scheme, the existing Sunday Creek depression will be required to transfer water from the pipeline discharge pit to the irrigation pool. This distance may be up to 3.5km in length and has not been surveyed or assessed geotechnically. The Preliminary Design assumes that:

- The irrigation pool will be created by gravity flows along Sunday Creek, and to the required level by the embankment at Hells Gate.
- There are no obstructions along Sunday Creek that would prevent the transfer of water.
- The existing geotechnical conditions along Sunday Creek are suitable for transferring water.

4. Preliminary Infrastructure Design

The proposed reconfigured infrastructure to allow reconfiguration of Lake Moodemere and Sunday Creek for irrigation and recreational purposes are as follows:

- Construction of a 36 ML/d pump station and DN560 HDPE pipeline to supply Sunday Creek directly from the Murray River;
- Construction of an embankment at Hells Gate to allow Sunday Creek to fill independently of the water level in Lake Moodemere; and
- Replacement of the existing Lake Moodemere Regulator adjacent to the Murray River.

Refer to Appendix C (Drawing 477714 Sheet 01) for the Locality Plan and Key Plan.

4.1 River Pump Station and Sunday Creek Pipeline

4.1.1 Design Criteria

Table 4-1 lists design criteria adopted for the Preliminary Design of the Sunday Creek Pump Station and Pipeline from the Murray River to supply Sunday Creek.

Table 4-1: Sunday Creek River Pump Station and Pipeline Design Criteria

Design Criteria	Adopted Value	Comments
Peak Flow Rate	1.5 ML/hr (36 ML/d)	Flow rate calculated to meet water entitlements of Sunday Creek Irrigators under proposed operating conditions of operating pumps 7 hours per day during the irrigation season.
Operating Conditions	7 hours per day during irrigation season, off peak power	Potential to increase supply by using on-peak power
Minimum River Operating Level	125.00 m AHD	Corowa Gauge/Survey Data approximation
Top of Bank at Pump Site	132.40 m AHD	Survey
1% AEP Flood Event Level	133.80 m AHD	NECMA Advice, information sourced from Murray River Flood Declaration Maps 2004. Refer to Appendix E
Sunday Creek Irrigation Operating Levels	128.70 – 128.90 m AHD	Required level within Sunday Creek for irrigation supply, to be set by the Hells Gate structure. Levels as presented and approved in the Concept Design. GHD (2010) has indicated that between these operating levels, Sunday Creek holds 10.1 ML which is a supply buffer for Sunday Creek Irrigators

Design Criteria	Adopted Value	Comments
		It is proposed that the pump will start-up when Sunday Creek falls to 128.70 m AHD and shut-off when Sunday Creek reaches 128.90 m AHD relative water level.
Maximum Static Lift	Approx. 8.3 m	From minimum river level to top of bank
Approximate Pipeline Length	350 m	Pipeline to terminate at surveyed upstream end of Sunday Creek.

4.1.2 River Pump Station Options Assessment

The Concept Design presented an axial flow (sloped down the bank) pump arrangement located on the river bank, as shown indicatively in Figure 4-1.

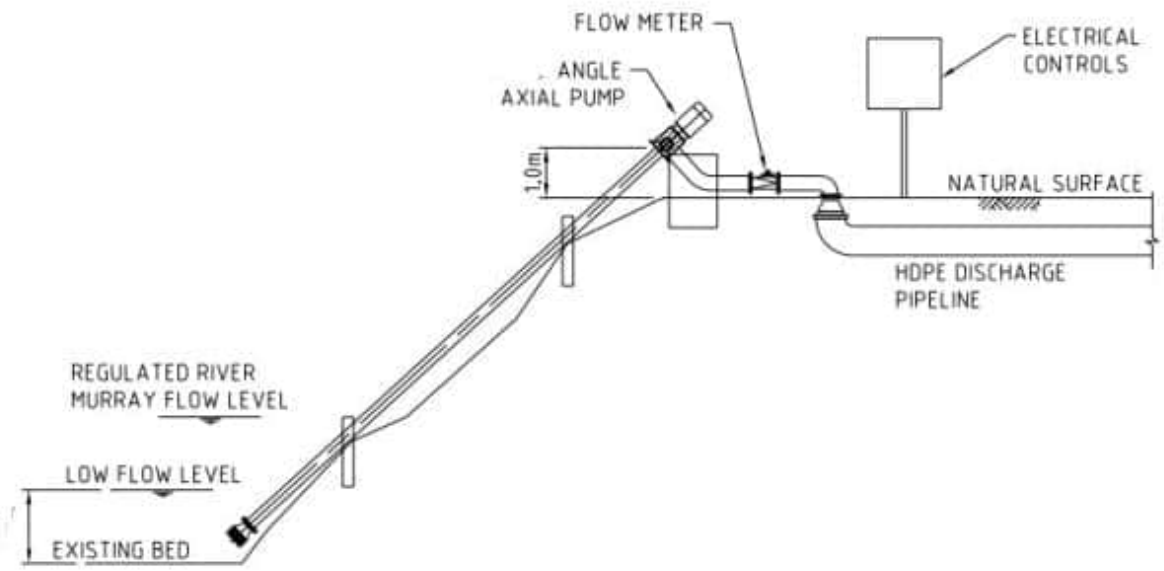

Figure 4-1: Concept Design Pump Station Arrangement (Indicative)

An options assessment was carried out to confirm the selection of the arrangement presented in the Concept Design. The assessment was undertaken following concerns raised by the SCMC about the proposed arrangement.

While several options were considered, none of these were technically and/or economically feasible. The Preliminary Design has been carried out with the pump station arrangement presented in the Concept Design.

The pump station options assessment is presented in Appendix D.

4.1.3 River Pump Station Arrangement

The proposed pump station is to be located on the Murray River bank approximately 10 m south of the existing disused pump station building. The pump station will be accessed by the existing access track.

A single sloping axial flow pump (duty only, no standby) is to be installed down the river bank, avoiding native vegetation on the bank as shown in Figure 4-2. The pump motor is to be elevated above flood level, as outlined above.

The pump station pipework will include isolation valves and air valves and a flow meter in a pit.

Figure 4-2: Sunday Creek River Pump Station Location

Table 4-2 provides preliminary river pump station details, and Table 4-3 provides preliminary electrical and control details.

Table 4-2: Preliminary River Pump Station Details

<table>
<tr><th>Pump Station (Irrigation)</th><th>Comments</th></tr>
<tr><td>System Characteristics</td><td>The pump station nominal duty is 36 ML/d with pumping heads varying between 4.8 – 8.3 m head.
Refer to Appendix C (Drawing 477714 Sheet 02) for the Preliminary Drawing of the Pump Station arrangement.
The pump station will be configured as a single (duty only) axial flow pump sloping down the river bank. The exact pump duty will be dependent on the River Murray water level. Minimum and typical operation levels for the proposed pump station are shown below.
<table>
<tr><th>River Murray Water Level</th><th>Duty Flow (ML/d)</th><th>Duty Head (m head)</th><th>Frequency (Hz)</th></tr>
<tr><td>Low water level (RL 125.00)</td><td>36</td><td>8.3</td><td>50</td></tr>
<tr><td>Regulated river level (RL 128.50)</td><td>36</td><td>4.8</td><td>~40</td></tr>
</table>
</td></tr>
<tr><td>Pump Materials</td><td>The pump construction will be of non-corrosive pipe with stainless steel impeller and fishtail strainer (or similar). Above ground manifold pipework to be made of stainless steel with below ground pipework to be HDPE.</td></tr>
<tr><td>Pump System Configuration</td><td>One axial flow pump is proposed to be installed on the river bank in an inclined arrangement.
The pump column will be anchored into the bank with pipe supports. A concrete slab and shade structure is proposed on the bank crest to house the electrical cabinet, valves and manifold pipework.
A variable frequency drive will be fitted to the pump motor to provide a constant flow from the variable river water levels.

Refer to Appendix C (drawing 477714 Sheet 02) for the preliminary design drawings.</td></tr>
<tr><td>Pump Selection and System Curve</td><td>Final pump selection will be determined through the detailed design and then a tendering process. Based on the preliminary assessment, a two stage Ornal Flood lifter FE403 with a 490 mm bowl diameter could be a suitable solution. However, this selection will need to be confirmed during detailed design.
A plot of the system curve over the FE403 pump curve for 6-Pole 50 Hz motor operation is provided within Appendix F.</td></tr>
<tr><td>Control philosophy</td><td>The proposed pump station will lift water from the Murray River and deliver into Sunday Creek via a bubbler pit structure. Private irrigators will pump from the Sunday Creek pool (upstream of Hells Gate Regulator).
It is proposed to control the pump station to a set point level with a level sensor (pressure transducer) situated at Hell’s Gate Regulator. The</td></tr>
</table>

Pump Station (Irrigation)	Comments
	level sensor cannot be located at the pipeline discharge pit as this level is above the level above the creek bed and irrigation pool. A level signal from a pressure transducer will be sent back to the pump station via radio telemetry. Once the pool level falls to a set point level the pump will turn on. The pump will turn off when a set point high level is reached. A flow signal will also be inputted into the PLC from the flow meter (located near the pump station) to modulate the pump speed in achieving the nominal 36 ML/d continuous flow rate.
Suction Conditions	The pump will require a minimum submergence condition (2 m) at the low water level for normal operation. It will also require a minimum clearance under the fishtail strainer, with a possible local pool required to be excavated as indicated in Appendix C (Drawing 477714 Sheet 02).
Station valves	The pump station will incorporate the following valves and fittings in the above ground pipework located within the pump station compound: · Isolation valve · Combination air valve · Pressure sensors · Pressure gauges · Auxiliary ports · Flow meter
Station pipework	The pump station above ground discharge pipework will be thin wall 316SS. Below ground discharge pipework to be PN8 PE100 HDPE.
Flow measurement	A flow meter will be incorporated as a pump station PLC input to ensure constant flow with varying river levels.
Fencing	A security fence is required to be built around the concrete slab, including the discharge pipework, electrical cabinets and pump motor.
Operation and Alarms	The pump station will incorporate standard GMW input and alarms.

Table 4-3: Preliminary Electrical and Control Details

Electrical and Control	Comments
Electrical Overview and Power Supply	An existing 3 phase 22 kV powerline is situated near the proposed pump station. The pump is proposed to be electric driven with a 55 kW 6 pole motor directly installed on the axial flow pump. It is anticipated a 100-kVA pole mount transformer will be required at power pole number 5207686. Loadings and electrical design will be validated at detailed design. The Ausnet application for connection approval to be prepared and submitted by post Preliminary Design approval and final pump details provided by the selected supplier.
SCADA/Control	A local radio telemetry link will also be required for the end of pipeline level (pressure) and monitoring sensor for pump station control. An assessment of telemetry requirements will need to account for vegetation, and will be addressed at Detailed Design.

4.1.4 Sunday Creek Pipeline Horizontal Alignment

The proposed pipeline will connect from the above-ground pump station pipework, and head east crossing the existing track. A flow meter contained within a pit will be located on the eastern side of the access track, and the pipeline will traverse an existing clearing towards the river access track and power lines, as shown in Figure 4-3.

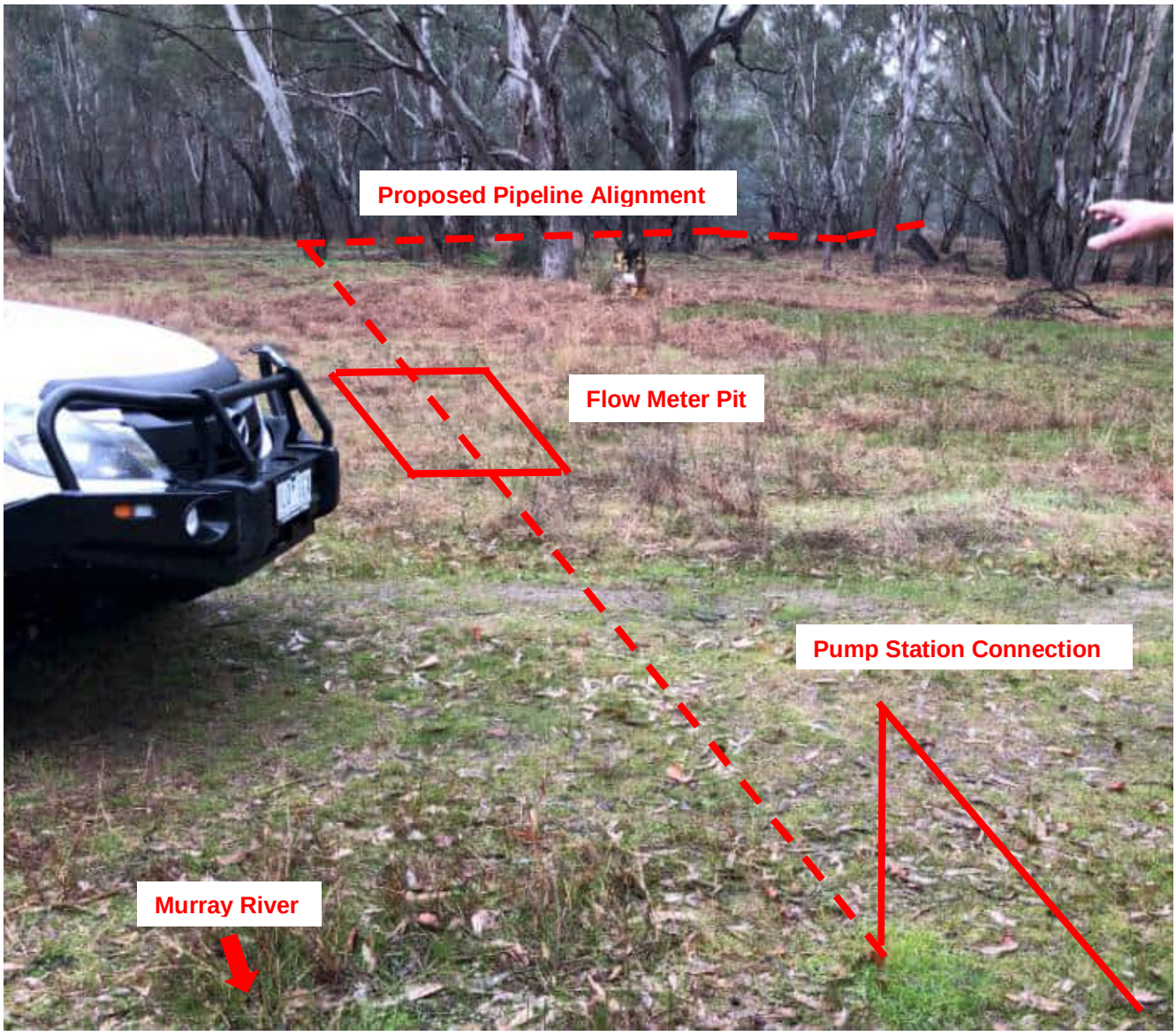

Figure 4-3: Pipeline to Pump Station Connection and Alignment (at pump site and RD 0, looking east)

The pipeline will run with a 3 m offset as shown in Figure 4-4.

Figure 4-4: Pipeline Alignment Through Clearing and Perpendicular to Access Track (looking east at approximately RD 45 m)

The pipeline will have a 4.5m offset from the powerlines for approximately 130m as shown in Figure 4-5;

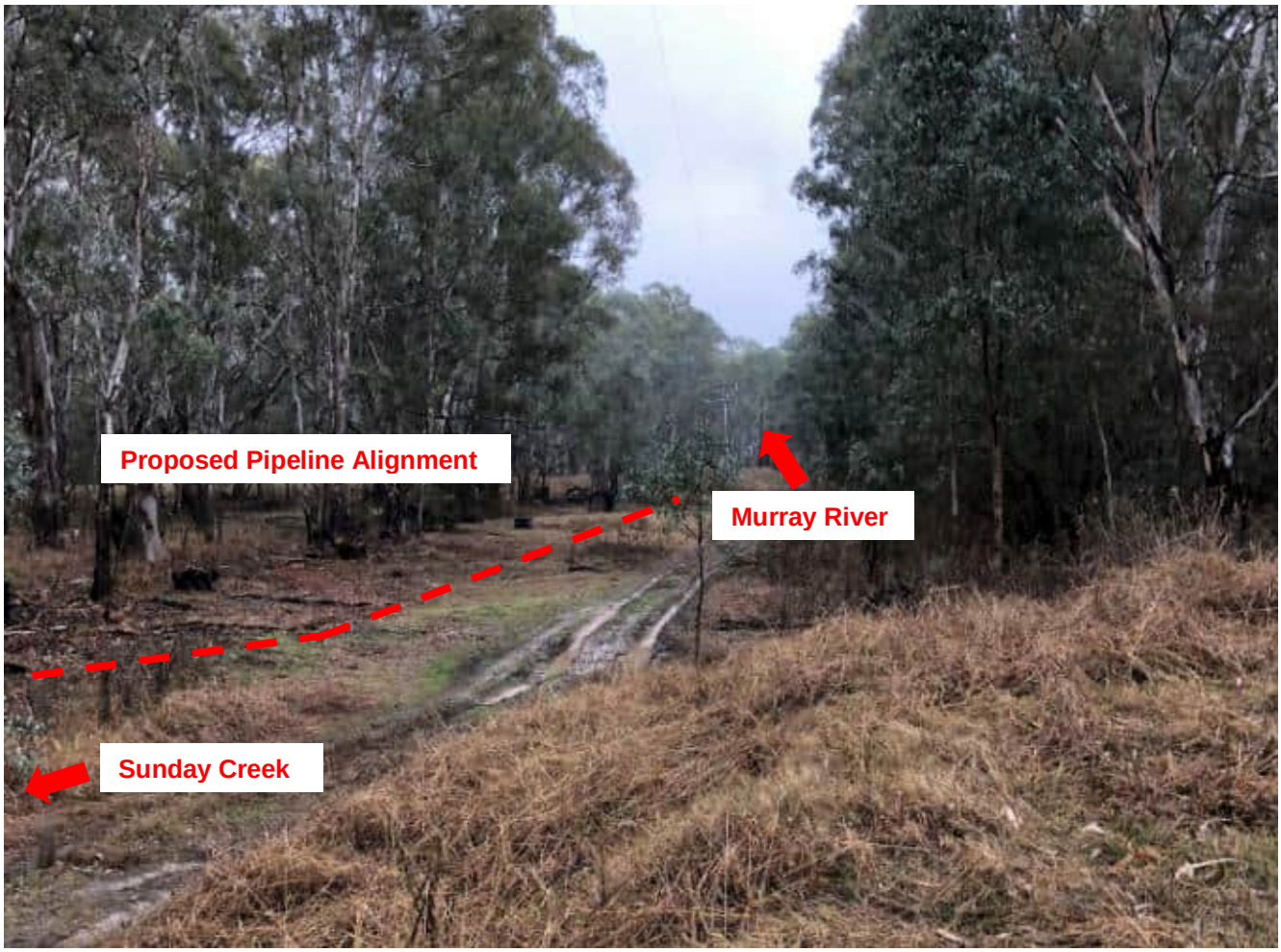

Figure 4-5: Pipeline with 4.5m offset to powerlines Alignment in Clearing Below Powerlines (at RD 305 into Sunday Creek)

The pipeline is proposed to terminate at the upstream end of Sunday Creek in a bubbler pit approximately 10m downstream of the existing fence line as shown in Figure 4-6.

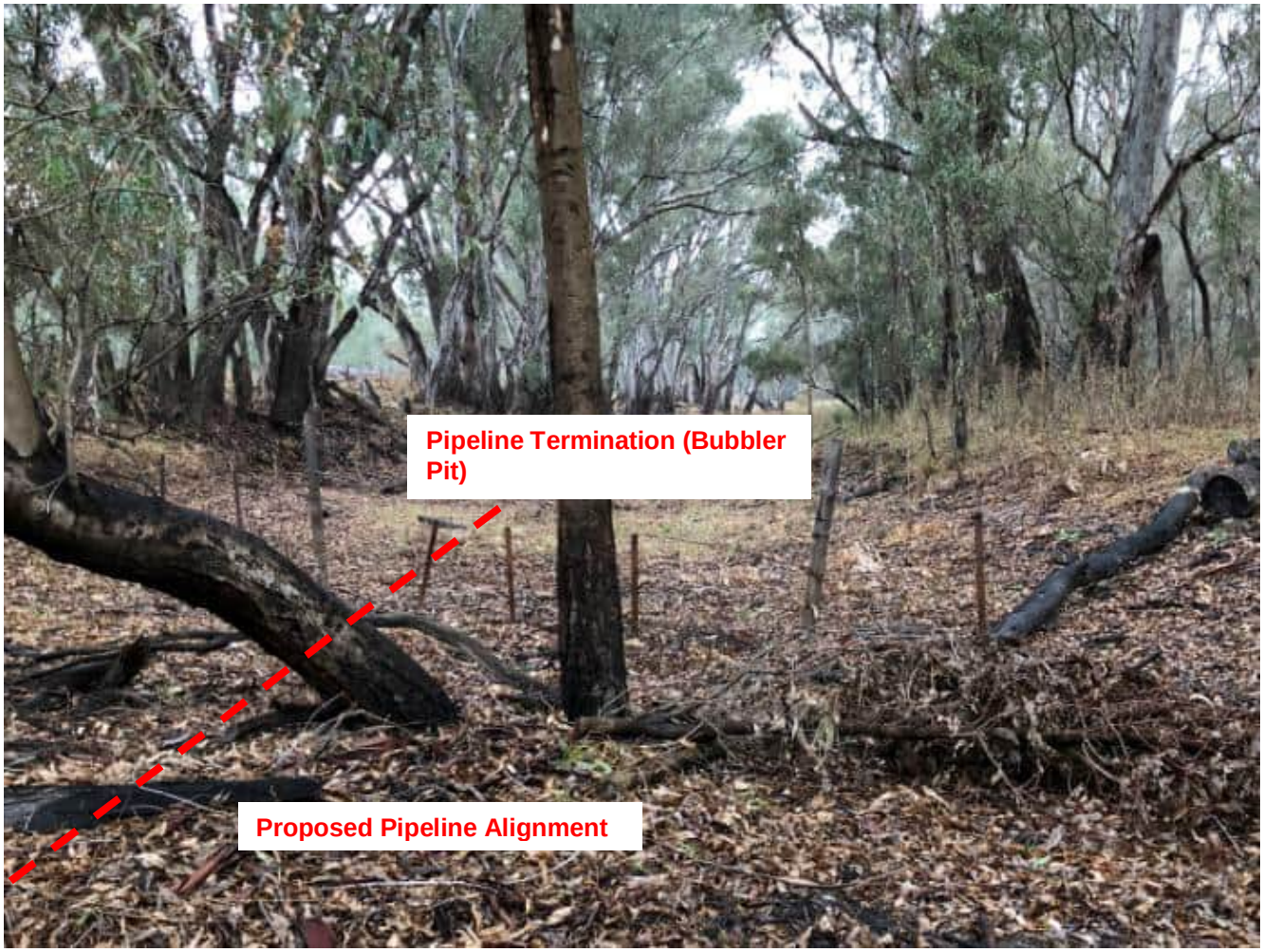

Figure 4-6: Proposed Termination of Pipeline in Sunday Creek (looking south-east at RD 330 m)

The termination point has been chosen to reduce construction activities in the bed of Sunday Creek, as required by NECMA. The flow along Sunday Creek may require some level of erosion protection to be installed.

Refer to Appendix C (Drawing 477717 Sheet 03) for the Preliminary Drawing of the Pipeline Horizontal Alignment.

4.1.5 Pipeline Vertical Alignment

The vertical alignment of the pipeline is to be completed during Detailed Design, based on the following general criteria which are in accordance with GMW Connections Project Standards:

- Minimum Pipe Grade ± 0.15%
- Minimum Pipe Cover 600 mm to the finished surface
- Maximum Trench Depth 2000 mm where possible
- Air vents to be located at high points
- Inspection pits to be located at low points

Due to the falling topography away from the pump station, following pump shut down the entire pipeline length would depressurise and completely drain if the pipeline was graded normally to natural surface. This would result in a pipeline refill and air discharge at every pump start, introducing possible unstable and uncontrolled operation into the system. To mitigate against this action, the pipeline is proposed to be installed as a rising mainline with drop pits at intervals along the pipeline (refer to Figure 4-7). This arrangement would keep the pipe charged when the pump station is off, with minimal air discharge during start-up. Air vents located on each drop pit (high point) and placed above the static and working HGL would allow air exit under low residual pressures.

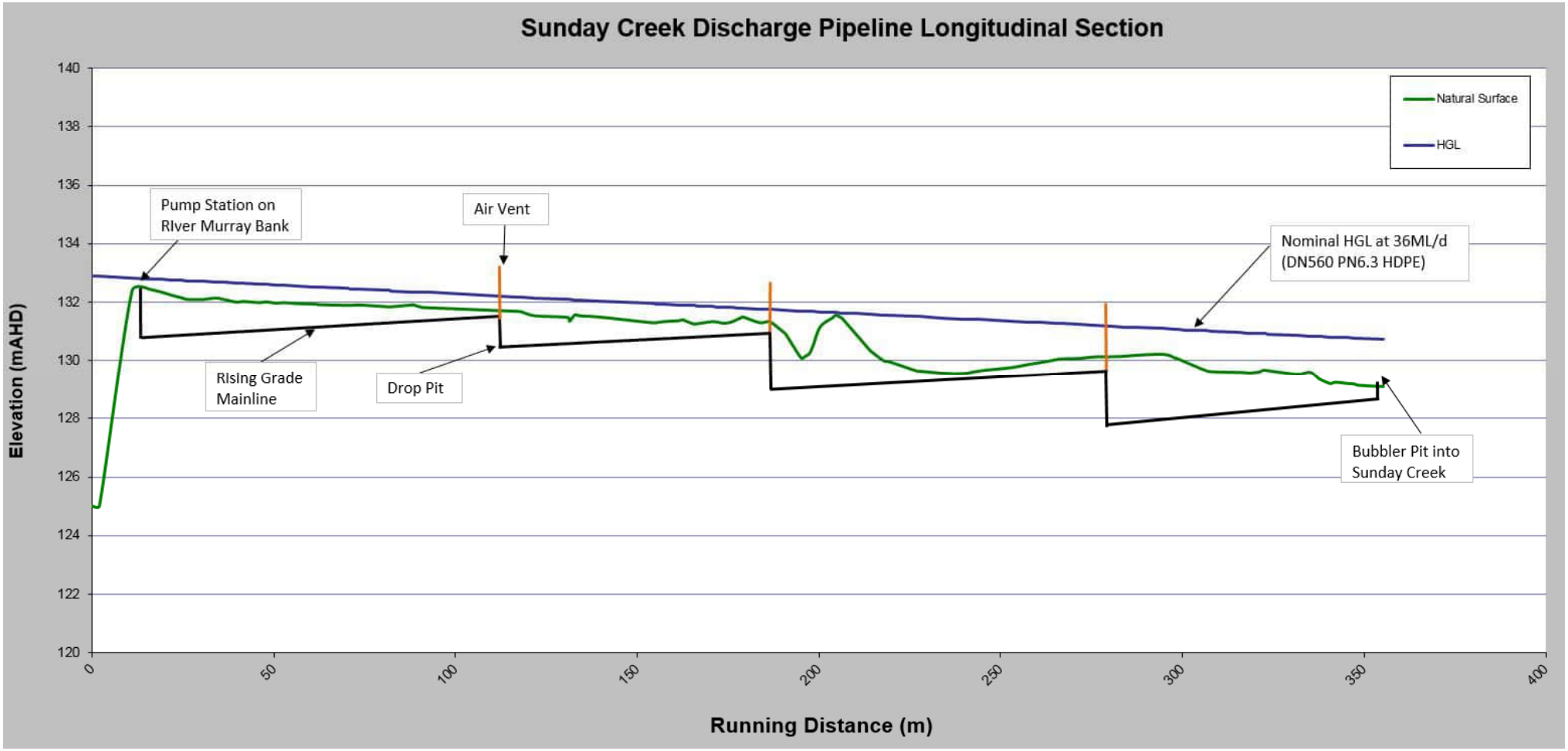

Figure 4-7: Sunday Creek Mainline Longitudinal Section

4.1.6 Pipe Class and Diameter

For the Preliminary Design PN 6.3 HDPE PE100 has been adopted as the required minimum pipe class for a pumped pipeline, in accordance with GMW Connections Project standards.

PN 8 HDPE PE 100 pipe will be adopted for access track crossings, and for the downstream section in the Sunday Creek bed.

4.1.7 Key Assumptions

The following assumptions have been made to allow progression of the Preliminary Design and will need to be addressed at Detailed Design.

- The minimum operating level of the Murray River, which has been derived from historical and survey data, is appropriate for the design of the pump station.
- The pump station and pipeline capacity is based on filling the Sunday Creek pool to the required levels (128.70 – 128.90 m AHD) within the designated timeframe of 7 hours with off peak power.

4.2 Hells Gate Embankment

4.2.1 Design Criteria

Table 4-4 lists design criteria adopted for the Preliminary Design of the Hells Gate Embankment.

Table 4-4: Hells Gate Embankment Design Criteria

Design Criteria	Adopted Value	Comments
Hard Bed Level	127.60 m AHD	Minimum surveyed level in proposed area for Hells Gate structure
Approximate Silt Layer	400-500 mm	Survey data of depth between hard and soft beds in proposed area for Hells Gate structure
Retained Water Level Range in Sunday Creek	128.70 – 128.90 m AHD	Required level within Sunday Creek for irrigation supply, to be set by the Hells Gate embankment. Levels as presented and approved in the Concept Design. GHD (2010) indicated that between these operating levels, Sunday Creek holds 10.1 ML which includes a supply buffer for Sunday Creek Irrigators. It is proposed that the pump will start-up when Sunday Creek falls to 128.70 m AHD, and shut-off when Sunday Creek reaches 128.90 m AHD.
Crest Elevation	129.00 m AHD	As presented in Concept Design. This level is 100 mm above maximum operating level in Sunday Creek of 128.90 m AHD

4.2.2 Hells Gate Structure Options Assessment

The Concept Design presented a driven sheet pile structure located at the narrowest point of Hells Gate.

It was decided to consider other options during the Preliminary Design, due to the following:

- Concern expressed by the SCMC regarding degradation of the sheet pile material.
- Lack of availability of survey and geotechnical information at the time of Concept Design submission, leading to a conservative approach to prevent seepage under the structure.
- The potential to reduce material and construction costs by installing an earthen embankment in lieu of a sheet pile structure.

A geotechnical assessment was completed by Jacobs on the borehole logs at the site, and indicated that:

- Material underlying the site is predominately clay, with permeability values that may be between 10^{-9} to 10^{-7} m/s
- The clay is recommended to be given a consistency/strength designation of “Stiff” based on visual classification testing (i.e. Atterberg Limits, Grading and Moisture Testing)
- The soils are Emerson Class 4 and exhibit non-dispersive properties
- An earthen embankment installed at the site would not be likely to experience bearing or settlement failure, and the risk of soil erosion due to piping beneath the embankment would likely be low (assuming it is keyed into the clay subgrade).

On review it is concluded that a sheet pile structure is not required to meet the functional objectives at Hells Gate, and Preliminary Design has proceeded with an earthen embankment.

The geotechnical investigation memorandum is included in Appendix G.

4.2.3 Hells Gate Embankment Arrangement

The embankment at Hells Gate is to be constructed between the eastern and western banks of the artificial channel between Sunday Creek and Lake Moodemere, and measures approximately 35 m in length. The location for the embankment has been chosen for a number of reasons including:

- Minimising material needed for construction by crossing Hells Gate close to the narrowest point.
- Selecting bank locations with minimal vegetation that may require removal to allow construction
- Avoiding locating the embankment at the natural bend in Sunday Creek to minimise potential erosion concerns.

The embankment is to have crest level of 129.00 m AHD across Hells Gate and is to match into the existing banks which have a maximum elevation of 129.75 m AHD. The embankment crest elevation has been set below the natural bank level to minimise the pumping effort required for Lake Moodemere to be infrequently filled from Sunday Creek via overtopping of the embankment.

Figure 4-8 below shows the bank and bed levels (taken from the survey) and the design elevation of the Hells Gate structure.

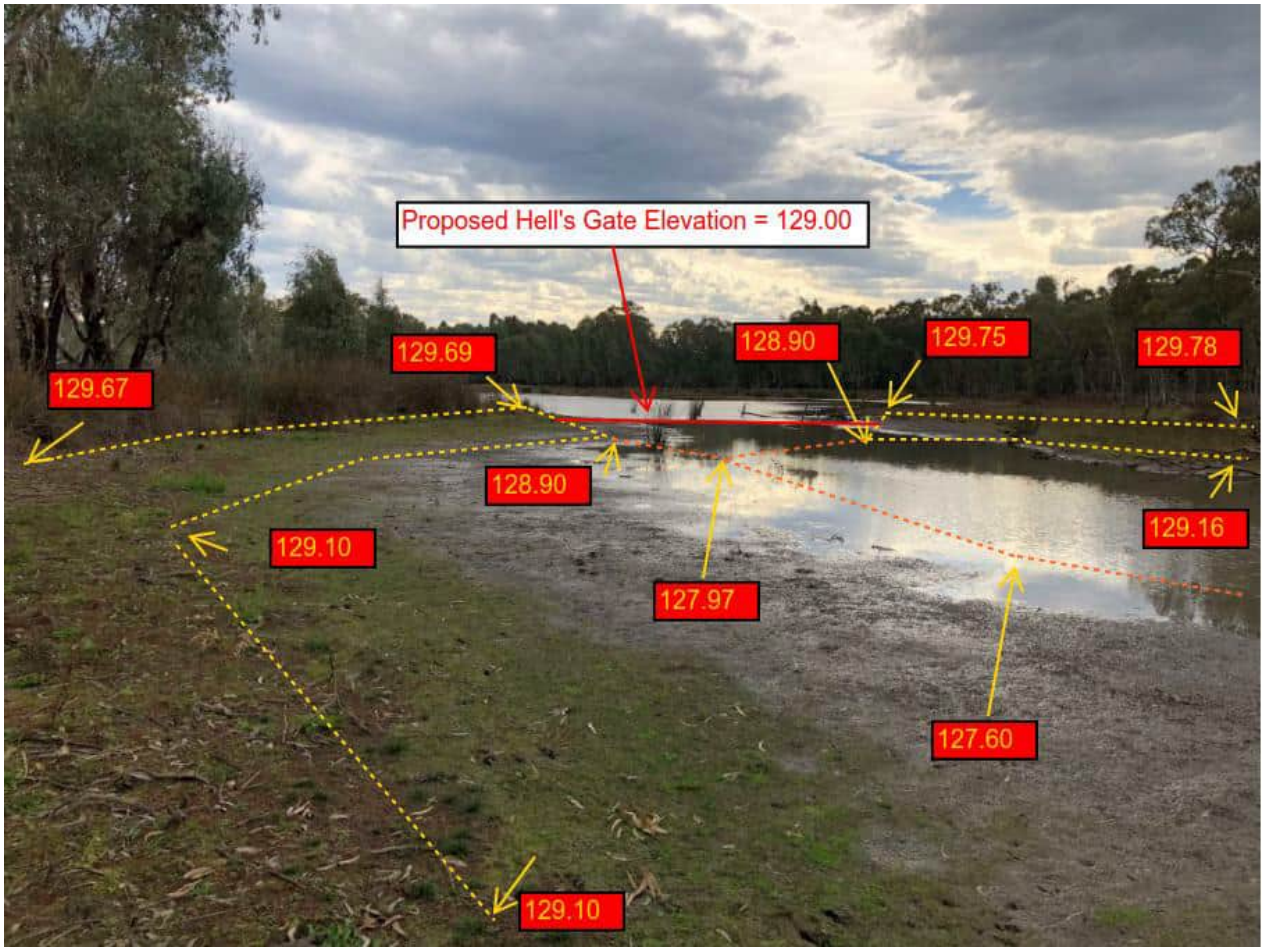

Figure 4-8: Hells Gate and Surrounding Terrain Levels (indicative)

In order to minimise the material required for the earthen embankment at Hells Gate a nominal crest width of 800 mm has been adopted. A crushed rock pavement surface will allow foot traffic to cross the embankment crest. The design does not allow for a trafficable surface over the embankment.

The embankment is to be constructed with impermeable fill and overlain with geofabric and rock beaching to mitigate against bank erosion during embankment overtopping.

A symmetrical embankment, with batter slopes of 1V:4H on both sides, has been adopted to minimise erosion potential during embankment overtopping.

Refer to Appendix C (Drawing 477714 Sheet 04) for the Hells Gate Embankment plan and section.

4.2.4 General Design Requirements

Technical Specifications for materials used for embankment construction will be developed at Detailed Design. The following general requirements are required to be met:

- Impermeable embankment material is to be Select Clay fill with permeability < 10^{-7} m/s
- Beaching stones to be laid on Bidim A44 Geotextile (or approved equivalent).

4.2.5 Flooding Impacts of Embankment Construction

The maximum water level in Sunday Creek required for irrigation in the reconfigured scheme (128.90 m AHD) is slightly below the current maximum water level (128.95 m AHD) during the irrigation season (2014, DEPI). It is not expected that flooding will be exacerbated by construction of the new embankment.

4.2.6 Key Assumptions

The following assumptions have been made to allow progression of Preliminary Design and will need to be addressed at Detailed Design:

- The operating level of Sunday Creek is appropriate for irrigators to operate their private pumps. Jacobs has not conducted any investigations into private infrastructure and assumes that as existing operating levels are generally being retained in the reconfigured scheme there will be no adverse impacts on other infrastructure within Sunday Creek.

- Free draining of Sunday Creek into Lake Moodemere is not required.

4.3 Lake Moodemere Regulator

4.3.1 Design Criteria

Table 4-5 lists design criteria adopted for the Preliminary Design of the Lake Moodemere Regulator.

Table 4-5: Lake Moodemere Regulator Design Criteria

Design Criteria	Adopted Value	Comments
Minimum Top of Concrete	130.00 m AHD	Murray River overbank flow flood level
Maximum Opening Invert/Floor Level	128.31 m AHD	Existing regulator invert level – pump is required at Murray River Levels below this to fill Lake Moodemere. Replacement structure to ensure river level at which Lake Moodemere commences filling is not increased.
Indicative Regulated Murray River Flow	128.50 m AHD	
Finished Top of Bank Level	131.40 m AHD	Surveyed river bank track level Match new structure bank to track level
Minimum Opening Area	0.86 m^2	Maintain existing opening width (or increase) to ensure flow conditions are not negatively impacted. 3 existing openings 610 wide x 470 high
River Side Pipe Culvert Invert	127.84 m AHD	Previous survey level (DEPI, 2014)
Regulator Side Pipe Culvert Invert	127.94 m AHD	Previous survey level (DEPI, 2014) Confirmed in 2018 survey
Design Floor Level of Structure	127.95 m AHD	Allow free drainage of pool between regulator and river bank through existing pipe
Water Level Retained on Lake Side for Regatta	128.70 m AHD	Maximum level artificially maintained for rowing regatta – level maintained by operation of gates between September and February

4.3.2 'Like-for-Like' Structure Replacement Assessment

The Concept Design proposed the replacement Lake Moodemere structure to be 'Like-for-Like'. Design plans for the existing structure were not available, and as such structure measurements have been taken from survey data. These include:

- 150 mm thick sidewalls and middle wall
- 750 mm upstream apron
- 1400 mm downstream apron
- 2400 mm overall structure length
- 3000mm overall structure width

Levels of critical points of the existing Lake Moodemere Regulator, the existing pipe culvert through the Murray River bank and also the surround terrain were taken from the survey.

The survey generally supports the assertion that the maximum water level the existing structure can retain water within Lake Moodemere (with gates closed) is 130.00 m AHD. The survey level of the top of the middle wall is 129.90 m AHD.

Bank levels around the structure vary from 131.10 – 131.60 m AHD. The bank level at the river bank track has been surveyed at 131.40 m AHD and the finished bank level of the new structure will be matched to this level.

The existing structure sill has been surveyed at 128.31 m AHD. The regulated Murray River flow level (approximated at 128.50 m AHD) appears to be realistic in terms of allowing flow into Lake Moodemere from the Murray River through the existing structure.

Survey data supports levels that were assumed to be correct at previous project stages. Ensuring existing flow conditions are maintained (or improved) is important to the design of the replacement structure. The replacement structure layout has been refined from the existing structure to meet strength, stability and safety requirements.

4.3.3 Replacement Structure Arrangement

The key features of the replacement Lake Moodemere Regulator are as follows:

- Top of Bank Level at 131.40 m AHD to match into existing river bank track.
- Top of Concrete at 130.00 m AHD to ensure the overland flow level into Lake Moodemere is not altered by the structure replacement.
- Structure floor at 127.95 m AHD to allow free draining of pool between structure and river bank through existing pipe culvert.
- 250 mm thick sidewalls, middle wall, headwalls and floor.
- 3 No. 600 wide x 700 high rectangular openings through middle wall.
- 3 No. one-way flap gates installed in openings on lake side.
- Invert of openings at 128.75 m AHD to maximise flow through openings into Lake Moodemere.
- Obvert of openings at 128.80 m AHD (50 mm above level required in Lake Moodemere for the regatta).
- Symmetrical structure that allows for potential two-way flow (gates opened), as well as water retained on either side (gates closed, or gates blocked).
- Upstream and downstream headwalls to allow bank remodelling to 1V:2H around structure.
- Upstream and downstream cut-offs to avoid erosion beneath structure.

- Walkway and handrails across structure to allow safe operation of gates.
- Handrails on sidewalls and exposed headwalls to prevent falls from structure.

Refer to Appendix C (Drawing 477714 Sheet 05) for the Lake Moodemere Regulator plan and section.

4.3.4 Design Requirements

Consideration has been given to strength and stability requirements of the replacement structure when developing the layout that would need to be met at Detailed Design. The arrangement presented at Preliminary Design, including member sizing, is a product of preliminary design checks. This would need to be refined at Detailed Design.

4.3.4.1 Preliminary Stability Analysis

A preliminary stability analysis based on *USACE Stability Analysis of Concrete Structures* (2005) has been carried out on the dimensions presented for the Preliminary Design of the Lake Moodemere Regulator. Uplift and sliding have been assessed to ensure the proposed layout is feasible and will pass the Detailed Design stability analysis.

Parameters presented in Table 4-6 have been adopted for the stability analysis at Preliminary Design, and will need to be assessed for suitability at Detailed Design:

Table 4-6: Lake Moodemere Regulator Preliminary Stability Parameters

Parameter	Value
Unit weight of foundation material	18 kN/m^3
Internal angle of friction	28 degrees
Cohesion	0 kPa
Unit Weight of Water	9.81 kN/m^3
Unit Weight of Concrete	24.5 kN/m^3

USACE (2005) describes three loading conditions; “usual”, “unusual” and “extreme”. The “extreme” loading case represents a 1-300 year occurrence such as a large flood or seismic event. For the purpose of analysis at Detailed Design it is considered that the “usual” and “unusual” loading conditions adequately describe the level of detail of the assessment required for this structure, and that requirements prescribed for the “extreme” analysis are not applicable.

Initial checks indicate the structure layout proposed in the Preliminary Design will be adequate for stability.

4.3.4.2 Bearing Capacity

Geotechnical site investigations indicate that for a foundation level of 3 m below natural surface a bearing capacity of 310 kPa is allowable.

Initial checks indicate the structure layout proposed in the Preliminary Design will have adequate bearing capacity for maximum loads applied.

4.3.4.3 Overturning

It is unlikely that this structure could overturn as a monolithic structure. The only scenario where an overturning failure could occur is if the base slab cracks at the middle wall and the lakeside end rotates about the crack and the riverside end. Based on calculations for the unusual condition, the bearing pressure of the lakeside of the

structure is greater than the uplift pressure acting on the same section. Positive pressure exists thus there is no overturning.

4.3.4.4 Seepage

The seepage pathways underneath and around the structures were assessed using Lanes Weighted Creep method. Lanes Weighted Creep determines if the seepage path is sufficiently long so as to reduce the exit gradient to an acceptable level for the foundation material being considered. Hydraulic gradients through founding soil were also considered qualitatively to assess likelihood of pipe and otherwise adverse effects.

Initial checks indicate the structure layout proposed in the Preliminary Design has adequate seepage pathway lengths to reduce exit gradient to an acceptable level under the assumption that the founding material is a medium clay.

4.3.4.5 Walkway and Handrails

The walkway and handrails across the structure are to be in accordance with AS 1657 Fixed Platforms, Walkways, Stairways and Ladders.

4.3.4.6 One-way flap gates

Top-hinged one-way flap gates are to be installed on the lakeside of the structure openings which allow flow from the Murray River into Lake Moodemere, but (when closed) self-seal under gravity pressure and prevent backflow out of the lake.

Preliminary investigations have identified the AWMA Flap Gate as a potentially suitable option. The advantages of this product are:

- Full perimeter seal incorporated into design
- Suitable for sealing for up to 10 m head pressure
- Custom made to suit any sized orifice
- Requires minimal civil works to install
- Available in Grade 316L stainless steel
- Fabrication is in accordance with ‘Australian Technical Specification for Fabricated Water Control Infrastructure’, AS/NZS 1554.6 and AS/NZS 1665
- Minimum 25-year design life
- Minimal maintenance requirements
- Provisions for lifting lug and winch cables to be installed to raise gates in emergency situations

It is proposed that a winch be attached to the walkway to allow the gates to be raised/lowered without the need to access the floor of the structure or reach over the side of the walkway.

The AWMA Flap Gate is suitable for backflow prevention, however further investigations would be needed at Detailed Design to ensure the gate can allow flows into Lake Moodemere while in the lowered position. The gates are custom made, and discussions with AWMA will be required to ensure that the gates will operate under the water level and flow conditions at the Lake Moodemere Regulator.

Refer to Appendix H for the AWMA Flap Gate Product Information Sheet.

4.3.4.7 Batter Slopes

The Preliminary Design has specified batter slopes of 1V:2H which has been taken from recommendations made in the Geotechnical Report

4.3.5 Key Assumptions

The following assumptions have been made to allow progression of Preliminary Design and will need to be addressed at Detailed Design:

- By increasing the opening area, and lowering the opening invert, there are no identified negative impacts on flow through the structure or the level of Lake Moodemere.
- The foundation material underneath the proposed structure, combined with the proposed structure layout including cutoffs, will provide adequate resistance against seepage.

5. Constructability Assessment

There are a number of constructability issues that will need to be considered during detailed design. Jacobs have attempted to mitigate these issues as much as possible during this preliminary design. The issues are listed by proposed reconfigured infrastructure below.

5.1 River Pump Station and Sunday Creek Pipeline

5.1.1 Site Access

The proposed pump station location is accessible via the existing access track.

The pipeline is proposed to run from the pump station in the clearing at the end of the track east to the clearing under the powerlines. The preferred alignment below the powerlines has a defined access track which may need grading and a temporary gravel track laid for construction.

5.1.2 Laydown Areas

There is sufficient space in the clearing adjacent to the pump station site for construction equipment and materials to be stored. There does not appear to be any need to close the river access track to the public assuming the site is appropriately delineated.

It is assumed that construction equipment and materials will be stored to the south of the pipeline alignment. The 4.5 m offset to the south of the power poles will ensure that trenching in the “no-go” zone is avoided. There generally appears to be sufficient laydown space, however some vegetation may need to be removed to allow construction.

5.1.3 Construction in the Murray River

A local pool will need to be excavated around the pump in the Murray River to ensure minimum 2 m submergence from the low river level to the pump centreline and 250 mm minimum clearance to the finished bed are both achieved. The bed level at the pump site has not been surveyed, but available information suggests it to be approximately 1000 mm below the low flow level.

The Preliminary Design assumes that works are to be conducted when the river level is low. It is anticipated that temporary sheet piles or similar structure will be installed in the river and water pumped, and a long-reach excavator situated on the river bank to remove material as required.

5.1.4 Installation of Pipe Supports

Pipe supports will be driven into the bank to support the axial flow pump. The Preliminary Design assumes that a crane or track mounted pile driver will be suitable to carry out this task. A crane hardstand will be required on the river bank.

5.1.5 Groundwater

Geotechnical investigations along the pipeline alignment indicated groundwater at depths ranging between 4.0 – 4.9 m below ground level. The depth of the pipeline trench is to be kept to a maximum of 2 m (where practicable) and it is not expected that groundwater is to be encountered during construction of the pipeline or pump station slab.

5.1.6 Overhead Powerlines

Overhead powerlines are located above the proposed location of the pipeline alignment for approximately 130 m (RD 175 – 305 m). The centreline of the pipe has been offset 4.5 m to the south of the power poles. This will assist the 3m ‘no-go zone’ from the outer cable is not impeded on during trench digging and pipe installation.

5.1.7 Construction within Sunday Creek

The North East Catchment Management Authority (NECMA) indicated that pipeline construction within the Sunday Creek bed is not desirable. The pipeline has therefore been terminated at the top end of Sunday Creek. A short section of pipe, a bubbler pit and rock beaching will be installed at the outfall point, although construction impacts to the creek are expected to be minimal.

5.2 Hells Gate Embankment

5.2.1 Site Access

The best point of access is from the south through private property (Chambers). Jacobs and GMW staff were able to drive to near the location of Hells Gate using the route shown below in Figure 5-1.

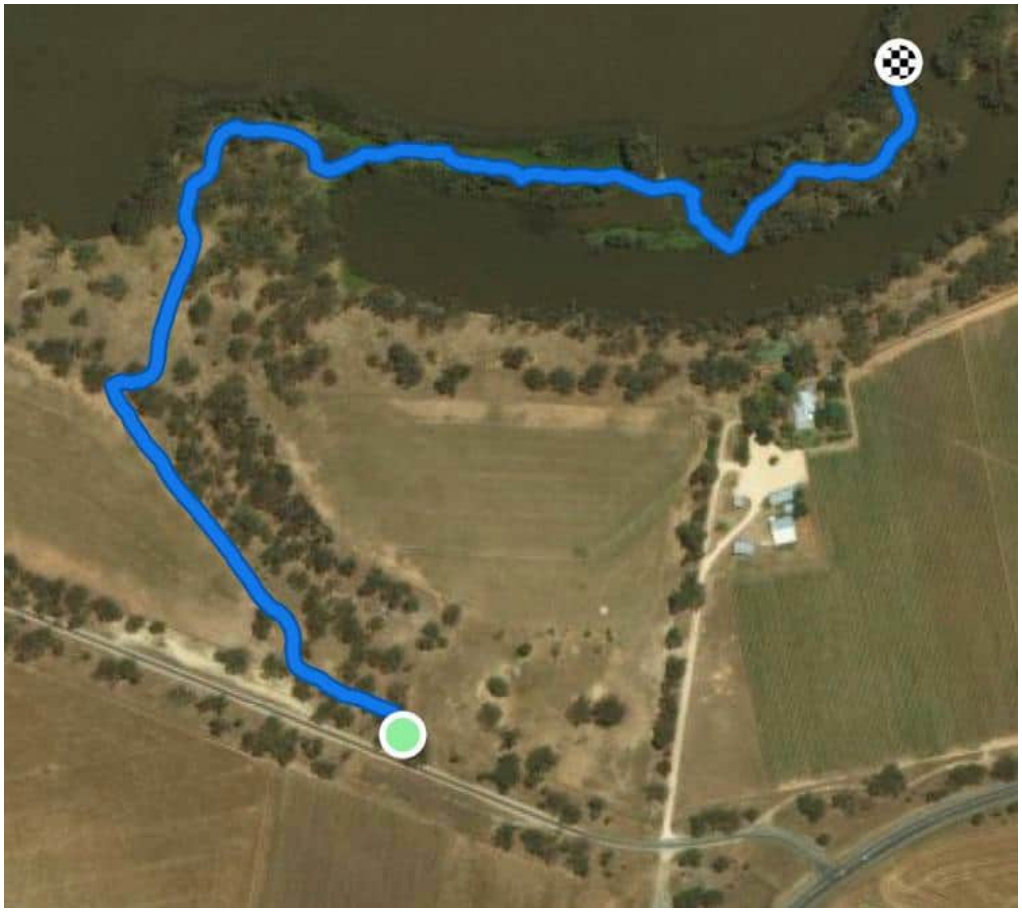

Figure 5-1: Access to Hells Gate from the South

Access to the Hells Gate site is dependent on the lake level being sufficiently low and for the access track to be trafficable. The preliminary cost estimate for the construction of the new Hells Gate structure has allowed for sections of this access track to be graded and gravelled.

Access provisions to the site will need to be suitable for vehicles required to remove, import and install large quantities of earthworks at the embankment.

Native vegetation along parts of this track as shown in Figure 5-2 will require a permit from Indigo Shire Council for removal prior to construction activities.

Figure 5-2: Native vegetation along access track to Hells Gate

5.2.2 Laydown areas

There is limited clear space on the banks of Hells Gate for construction equipment to be stored. Materials will likely need to be brought to site on a needs-basis. There are areas along the access track to the site which may provide space for temporary storage.

5.2.3 Construction within Waterway

Temporary cofferdams will be required to be installed during the construction of the proposed Hells Gate embankment. Cofferdams are required either side of the proposed embankment. The height of the cofferdams is to be determined by water level in Sunday Creek and Lake Moodemere at the time of construction.

A cofferdam could also be installed at the Lake Moodemere regulator to ensure high river flow levels cannot enter the lake during construction through the existing pipe culverts.

5.2.4 Groundwater

Borehole logs provided from the geotechnical investigation at Hells Gate indicate groundwater at a depth of 2.8 – 3.0 m below natural surface level. The hard bed surveyed at the location of the proposed embankment is approximately 3 m below the bank level, and as such groundwater may be encountered during construction. This will need to be managed appropriately.

5.3 Lake Moodemere Regulator

5.3.1 Site Access

The proposed Lake Moodemere Regulator will be constructed in the approximate location of the existing site. The site is located off the river access track at the end of Lake Road. There are no apparent access restrictions.

5.3.2 Laydown Areas

There is adequate space either side of the proposed site for construction equipment and materials.

There does not appear to be any need to close the access track to the public assuming the site is appropriately delineated.

5.3.3 Removal of Vegetation

Due to the flattening of the banks around the proposed structure, it is anticipated than several trees within the construction area may be affected and require removal.

5.3.4 Localised Earthworks

Site survey indicates that the banks around the existing site vary from 131.10 – 131.60 m AHD. The proposed structure has adopted a consistent top of bank level of 131.40 m AHD to match into the existing river bank track level.

Compaction and permeability requirements of earthworks at this site will be addressed at Detail Design.

5.3.5 Groundwater

Borehole logs provided from the geotechnical investigation at the regulator site, indicates groundwater at a depth of 5 m below natural surface. It is not expected that groundwater will be encountered during construction of the regulator structure.

6. Operations and Maintenance Assessment

Operations and Maintenance considerations for the proposed infrastructure have been identified and listed below.

6.1 River Pump Station and Pipeline

6.1.1 Pump Operation and Maintenance

The manufacturer will provide instruction on operation and maintenance requirements of the pump package.

6.1.2 Pipeline Fittings

Air vents/valves and inspection pits should be monitored regularly during asset lifetime to ensure they continue to function correctly.

6.1.3 Erosion Protection in Sunday Creek

Regular monitoring of scouring affects within Sunday Creek at and downstream of the pipeline discharge point should be carried out. Beaching installed may need to be improved or extended of large lengths of the bed are being significantly eroded by flows to the irrigation pool.

6.2 Hells Gate Embankment

6.2.1 Operation

There are no operational considerations regarding the Hells Gate embankment. The level in Sunday Creek is set by the embankment level, measured by the level sensor and subsequently controlled by the pump station and pipeline.

6.2.2 Maintenance

Some general maintenance recommendations to be considered at and around Hells Gate include:

- Ensuring the level sensor functions correctly (refer to manufacturer requirements).
- Beaching remains adequate to protect the embankment, particularly after large floods when the embankment has been submerged.
- Low points that form at the banks that are below the embankment crest as a result of flood damage do not lower the level of water retained in Sunday Creek.
- It is assumed that maintenance activities will occur from the embankment crest due to access restrictions on plant. Major repair works would be required to be completed from the bed either side of the embankment.

6.3 Lake Moodemere Regulator

6.3.1 Operation

There are limited operational considerations at the Lake Moodemere Regulator. It is proposed that the one-way gates will remain closed most of the time. When necessary, the gates can be raised and lowered from winches attached to the walkway. The walkway is elevated above the regulated Murray River flow level, but could become submerged during a flood event.

6.3.2 Maintenance

It is recommended that the concrete structure be subject to regular visual condition assessments over its lifetime. An 80-100 year life expectancy is commonly specified for GMW irrigation structures.

An asset condition assessment on the existing pipe culvert through the river bank has not been carried out within the scope of this project. This asset may need renewal/replacement within the lifetime of the regulator to ensure inflows are able to be maintained.

7. Safety in Design

A preliminary assessment of Safety in Design has been undertaken for each component of the proposed reconfigured infrastructure. The general safety issues that apply are identified below.

- Working on or near water, including access during flood events
- Working near roads/tracks
- Fall from heights
- Manual operation of gates
- Operation and maintenance of pumps and motors

A detailed Safety in Design register is attached in Appendix I.

8. Capital Cost Estimate

A preliminary capital cost estimate has been developed. This estimate should be used as in indication of expected capital costs and is subject to revision at Detailed Design to account for any changes to structure layouts. The preliminary costs (including contingency, contractor costs and project management fees) are listed in Table 8-1 below.

Table 8-1: Preliminary Cost Estimates

Infrastructure	Estimated Cost
Pump Station	$391,000
Pipeline	$472,000
Hells Gate Structure	$217,000
Lake Moodemere Regulator	$375,000
Total	**$1,455,000**

Notes on the cost estimate methodology:

- Contingency of 40% is in accordance with GMW estimating policy
- Pump Station, Hells Gate and Lake Moodemere structures have been costed on previous work by Jacobs and quotes from suppliers
- Volumes used to estimate the costs of Lake Moodemere Regulator and Hells Gate Structure have been approximated, and rates used to calculate a capital cost are taken from a recent GMW regulator construction works.
- It has been assumed that access to the Hells Gate site and Lake Moodemere Regulator site will require maintenance on the existing access tracks for construction.
- Pipeline Cost has been estimated using GMW pipeline estimating tool.
- Costs do not include any works associated with obtaining approvals or for other engineering works associated with this project
- A nominal sum of $10,000 has been included for power supply and connections.

The overall capital cost of the infrastructure reconfiguration is $1,455,000. Refer to Appendix J for a breakdown of estimated costs.

9. Draft Operational Rules

The Draft Operational Rules proposed below for the reconfiguration are reflective of the current stage of the project. Further consultation with stakeholders is required prior to Detailed Design in order to finalise the Operational Rules.

Under the proposed reconfiguration of Lake Moodemere and Sunday Creek, the SCMC will own and operate the pump station and pipeline, whilst ownership of Hells Gate structure and Lake Moodemere Regulator is yet to be determined. In general, this will create two sets of Operational Rules as outlined below.

9.1.1 Sunday Creek (SCMC)

It is proposed Sunday Creek will have the following operational rules following reconfiguration:

- Water may be taken from the Murray River via the new pump station, and delivered to Sunday Creek for irrigation purposes during the irrigation season
- The pump station and pipeline is to have a peak operating flow rate of 1.5 ML/hr, and is to operate for up to 7 hours per day using 'off-peak' power during the irrigation season.
- The water level is to be maintained at between 128.70 – 128.90 m AHD in Sunday Creek during the irrigation season. The pump station is to have an automatic cut-off condition when the water level reaches 128.90 m AHD.

9.1.2 Lake Moodemere Regulator

It is proposed that Lake Moodemere will have the following operational conditions following reconfiguration:

- The top of the structure will be set at the overbank flow level of 130.00 m AHD, and will not lower the level at which Lake Moodemere is inundated at during floods. The sill of the structure is set at 128.05 m AHD.
- One-way flap gates located on the lake-side of the structure will allow flow from the Murray River into Lake Moodemere at river levels between 128.05 – 130.00 m AHD.
- The gates on the new Lake Moodemere regulator will remained closed during the year, other from September to January.
- A minimum level of 128.70 m AHD is required for an annual regatta held on Lake Moodemere (DEPI, 2016). The gates on the Lake Moodemere may be operated at Parks Victoria's discretion between September and January to reduce the lake level to the minimum required.
- Lake Moodemere may be filled from Sunday Creek through agreement with the SCMC. This would require Hells Gate to be overtopped – which in turn would require the pumping operational rules to be temporarily altered.

10. Conclusion

Preliminary Design of infrastructure for sustainable irrigation purposes at Sunday Creek is presented in this report. The proposed infrastructure has been developed to meet functional design requirements of stakeholders.

Constructability reviews, operations and maintenance considerations and Safety in Design assessments have been carried out on the proposed infrastructure. Along with preliminary cost estimates, these are provided to assist GMW Connections determine whether progression to Detailed Design remains feasible.

Appendix A. Geotechnical Investigation

B·M
CIVIL ENGINEERS

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CLIENT:	Jacobs.
JOB DESCRIPTION:	Provide geotechnical site investigation for proposed regulator and sill structures, pump station and pipeline.
JOB LOCATION:	Lake Moodemere.
DATE:	22.10.2018
JOB NO.:	48629-3

Table of Contents

1.0 BRIEF

The proposal is to construct new infrastructure at Lake Moodemere to facilitate irrigation requirements of the local vineyards. The works are to include a new regulator between the Murray River and Lake, a new pump station and pipeline between the River and Lake and a new sill structure between the Lake and Sunday Creek. A geotechnical site investigation is required to assess the existing ground conditions and establish soil parameters for the subsequent design of the pump station and regulating structures.

2.0 SITE CONDITIONS

The proposed works are confined to 3 separate areas within the Lake Moodemere Reserve.

Site 1 – Regulator Site:

This site is located at the northern end of Lake Moodemere. The southern bank of the Murray River is quite close with a gravel surfaced track traversing the narrow strip of land between. An existing concrete regulator structure is present at the site and pipes extend beneath the roadway into the river. Large established trees are located alongside this part of the lake and also the river.

Site 2 – Pump Station & Pipeline Site:

This site is situated towards the northern fringe of the Lake Reserve. A decommissioned pump station is present adjacent to the river's edge and the surrounding land is relatively flat. Grass covers the site and while numerous trees are located across the surrounds, the immediate site is clear. The pipeline site extends south from the pump station and follows a road reserve. A small depression that links to the lake is located at the southern limit. Bushland extends along either edge of the road reserve and overhead powerlines traverse the subject site.

Site 3 – Hells Gate Sill Structure Site:

This site encompasses land that is located on either side of Sunday Creek. On the west side of the Creek the strip of land is relatively narrow and extends between the Creek and the Lake. This land is relatively level and numerous established trees are scattered across the site. There is minimal vegetation. On the east side of the Creek, the site is heavily vegetated and large trees are also present. The surface is slightly undulating.

Photo 1: Existing site conditions – Site 1, Regulator.

Photo 2: Existing site conditions – Site 2, Pump Station.

Photo 3: Existing site conditions – Site 2, Pipeline.

Photo 4: Existing site conditions – Site 3, Hell's Gate Sill.

Geological Survey Maps for Victoria (Wangaratta, Sheet SJ 55-2) indicate that this site is located in an area described as Recent Quaternary fine-grained alluvium of the Shepparton and Coonambidgal Formations. These are deposits of varying clay, silt and sand content laid down in discontinuous lens-like structures. There can be varying combinations and layer thicknesses of these soil types across small areas.

3.0 INVESTIGATION

3.1 Field Work

A total of 7 boreholes were mechanically drilled using a 100mm diameter continuous flight auger at the proposed regulator structure, pump station site and along the proposed pipeline alignment. These boreholes were drilled to depths varying between 5.0 metres and 10.0 metres. A further 2 boreholes were drilled by hand at the Hells Gate Sill structure site, these terminating at a depth of 4.5 metres. The locations and logs are shown on the attached borehole log sheets.

The test sites have been located using a hand-held Global Positioning System unit and the coordinates are listed in the following table.

Site No.	AMG Co-ordinates		Depth
	Easting	Northing	
BH1	55 H 0444074E	6010825N	10.0m
BH2	55 H 0444056E	6010827N	10.0m
BH3	55 H 0444728E	6012256N	10.0m
BH4	55 H 0444853E	6012271N	5.0m
BH5	55 H 0444937E	6012250N	5.0m
BH6	55 H 0444984E	6012243N	5.0m
BH7	55 H 0445028E	6012244N	5.0m
BH8	55 H 0445678E	6009470N	4.5m
BH9	55 H 0445725E	6009484N	4.5m

Figure 1: Test Bore Locations

Samples were recovered from the soil stratum at each of the test sites for visual classification and further laboratory analysis.

3.2 **Test Holes:**

The test holes have been logged and the profile is provided in the attached borehole logs (Appendix A). The soil profile is described here:

Borehole Description:

Site 1 – Regulator Site:

Borehole's 1 & 2: A thin layer of topsoil overlies light brown sandy SILT (ML), present to a depth of between 1500mm and 2000mm. Light brown and light brown yellow sandy CLAY with trace gravel (CL) is then located to a depth of 5000mm and yellow silty SAND (SM) continues to a depth of 8000mm. Orange grey sandy CLAY with trace gravel (CI) follows to the termination of drilling at 10000mm.

Site 2 – Pump Station & Pipeline Site:

Borehole 3: Topsoil is followed by light brown yellow sandy SILT–silty SAND (ML-SM) to a depth of 5500mm, light brown sandy SILT (ML) to 6500mm and light brown SAND with silt and trace gravel (SM-SP) to the end of the borehole at 10000mm.

Borehole 4: 200mm of disturbed soil is followed by light brown sandy CLAY (CL) to a depth of 800mm, yellow sandy SILT (ML) to 2500mm and light brown sandy CLAY (CL) to the termination of drilling at 5000mm.

Borehole 5: 300mm of disturbed soil is followed by light brown sandy SILT (ML) to a depth of 800mm, light brown sandy CLAY (CL-ML) to 2000mm and light brown yellow CLAY with sand (CL) to 3000mm. Light brown sandy CLAY (CL) continues to a depth of 4500mm and light brown yellow coarse SAND is then present to the end of the borehole at 5000mm.

Borehole's 6 & 7: 100mm of disturbed soil is followed by light brown CLAY / CLAY-SAND mix to a depth of between 400mm and 500mm, yellow SAND to around 1300mm and light brown sandy CLAY (CL-ML) to 3000mm. Light brown CLAY with sand (CL) continues to a depth of 4000mm and light brown sandy CLAY (CL) is then present to the end of the borehole at 5000mm.

Site 3 – Hells Gate Sill Structure Site:

Borehole 8: 100mm of disturbed soil is followed by light brown grey CLAY with trace sand (CI) to the termination of drilling at 4500mm.

Borehole 9: 100mm of disturbed soil is followed by light brown grey CLAY with trace sand (CI) to a depth of 1500mm, light brown yellow sandy CLAY (CL) to 2000mm and light brown grey CLAY with trace sand (CI) the termination of drilling at 4500mm.

3.3 **Soil Moisture:**

The upper level silts and sands were in a relatively dry condition. The soil moisture generally increased with depth. A description of the moisture condition of individual soil layers is provided in the borelogs, attached in Appendix A, and the results of moisture content testing undertaken on the soils are tabulated in Table 4.1 below.

3.4 Shear Vane Testing

Shear vane testing has been carried out within the underlying soils at a range of depths below the surface. The results of this testing are provided in the following table:

Site No.	Depth below Surface (mm)	Undrained Shear Strength (t/m^2)
1	2000	**22**
2	2000	**26**
5	1000	**26**
	1500	**26**
	2000	**26**
6	1500	**24**
	2000	**26**
7	2000	**26**
8	500	**26**
	1000	**26**
	1500	**26**
	2000	**26**

Table 3.1: Shear Vane Test Results

This testing established that the clay soils are typically stiff and were in a very firm condition. When determining the shear strength of the underlying soils, the maximum reading (26) was obtained on the measuring device in all bar two instances.

3.5 Groundwater:

Groundwater was encountered in all bar 1 of the boreholes, at a depth varying between 2.8 metres and 7.0 metres, when drilling the boreholes. All holes remained open for a period of up to 3 hours and measurements were taken to detect any further ingress and to establish the static head water level in all instances. The water levels are indicated in the following table.

Borehole No.	Depth below surface to Groundwater (mm)	Depth to Static Head Water Level (mm)
1	5000	3800
2	5000	4200
3	7000	4800
4	N/A	N/A
5	4000	3400
6	4800	4000
7	4900	3800
8	3000	2200
9	2800	2400

Table 3.2: Water Level Depths

4.0 LABORATORY TESTING:

All soil samples have been tested for Moisture Content and a further selection has been tested for Particle Size Distribution, Plasticity Analysis and Emerson Class Number. All testing was carried out to NATA registered tests and procedures and test result sheets are attached in Appendix B.

4.1 Moisture Content:

Moisture content testing has been undertaken on soils collected from the site and the results of this testing are shown below.

Site No.	Depth (mm)			Moisture Content (%)
1	100	to	1500	8.4
	1500	to	2000	11.6
	2000	to	4000	14.3
	4000	to	5000	15.3
	5000	to	7000	24.6
	7000	to	8000	21.2
	8000	to	10000	28.8
2	100	to	2000	6.1
	2000	to	3000	9.1
	3000	to	5000	14.2
	5000	to	8000	17.4
	8000	to	10000	24.0
3	200	to	4000	5.2
	4000	to	5500	11.6
	5500	to	6500	25.2
	6500	to	7500	30.0
	7500	to	10000	24.8

4	200	to	800	19.0
	800	to	2500	6.4
	2500	to	4500	17.1
	4500	to	5000	21.4
5	300	to	800	7.9
	800	to	2000	15.7
	2000	to	3000	22.0
	3000	to	4500	26.6
6	400	to	1200	1.7
	1200	to	3000	12.2
	3000	to	4000	17.8
	4000	to	5000	23.6
7	500	to	1400	2.1
	1400	to	3000	12.1
	3000	to	4000	15.3
	4000	to	5000	23.4
8	100	to	2000	20.0
	2000	to	3000	22.0
	3000	to	4500	28.0
9	100		1500	17.2
	1500		2000	13.4
	2000		2800	20.4
	2800		4500	28.0

Table 4.1: Soil Moisture Contents.

4.2 Plasticity Testing:

Plasticity analysis testing of the soils has been carried out in accordance with test methods AS1289.3.1.2, AS1289.3.2.1, AS1289.3.3.1 and AS1289.3.4.1. The plasticity properties of the various soil types are listed below.

Borehole No.	**Depth** (mm)	**LL** %	**PL** %	**PI** %	**LS** %
1	2000 to 4000	26	16	10	5.0
1	5000 to 7000	19	15	4	2.0
2	100 to 2000	22	21	1	1.0
2	8000 to 10000	36	14	22	10.5
3	4000 to 5500	18	20	0	0.0
3	5500 to 6500	21	20	1	1.0
3	7500 to 10000	-	-	NP	-
4	800 to 2500	19	19	0	0.0
5	2000 to 3000	32	19	13	7.5
5	3000 to 4500	29	20	9	5.0
6	1200 to 3000	23	17	6	4.5
8	100 to 2000	48	20	28	12.0
9	1500 to 2000	26	16	10	5.5

Table 4.2: Plasticity Analysis Test Results.

The plasticity test results indicate that the sands are non-plastic and the clays are of low through moderate plasticity.

4.3 **Particle Size Distribution:**

Sieve analysis testing has also been conducted on the samples to enable classification of the soils. This testing was in accordance with test method AS1289.3.6.1 and the results are shown below.

Borehole No.	**Depth** (mm)	**Australian Standard Sieve Sizes** (mm)				
		13.2	2.36	0.425	0.075	
1	2000 to 4000	100	99	95	58	% Passing
1	5000 to 7000	100	90	50	19	
2	100 to 2000	100	100	99	48	
2	8000 to 10000	100	98	79	64	
3	4000 to 5500	100	100	100	35	
3	5500 to 6500	100	100	100	49	
3	7500 to 10000	100	94	51	10	
4	800 to 2500	100	100	99	40	
5	2000 to 3000	100	100	100	80	
5	3000 to 4500	100	100	100	66	
6	1200 to 3000	100	100	99	66	
8	100 to 2000	100	100	98	97	
9	1500 to 2000	100	100	99	60	

Table 4.3: Particle Size Distribution Test Results.

4.4 Dispersion:

The soils have been analysed for dispersive properties. Samples have been tested for Emerson Classification Numbers in accordance with AS1289.3.8.1. The testing has been carried out using both distilled water (TDS 0 ppm) and tap water (TDS 120 ppm) and the results of this testing are shown below.

Borehole No.	Depth (mm)	Emerson Number	
		Distilled Water (0 ppm)	Tap Water
1	2000 to 4000	Class 2	Class 2
1	5000 to 7000	Class 2	Class 5
2	100 to 2000	Class 2	Class 5
2	8000 to 10000	Class 3	Class 5
3	4000 to 5500	Class 3	Class 5
3	5500 to 6500	Class 3	Class 4
3	7500 to 10000	Class 4	Class 4
4	800 to 2500	Class 3	Class 4
5	2000 to 3000	Class 2	Class 4
5	3000 to 4500	Class 3	Class 4
6	1200 to 3000	Class 3	Class 4
8	100 to 2000	Class 4	Class 4
9	1500 to 2000	Class 4	Class 4

Table 4.4: Emerson Number Test Results.

The results indicate that many of the soils are dispersive when interacting with distilled water and one soil is also dispersive in tap water.

Rainwater that will potentially flow over embankment batters is likely to be similar in nature to distilled water and the water flowing in the lake / river will be similar to tap water. It will be necessary to consider the likely impact of soil erosion when formulating design options.

4.5 Soil Classification:

A selection of the soils has been tested to allow allocation of soil classifications. The laboratory testing has established a number of soil types, however many of the soils are quite similar with only subtle variation in the sand content and level of plasticity. The following classifications have been established for the underlying soils in accordance with AS 1726.

All soils identified have been grouped into these classification categories and are listed in the following tables.

Site 1 – Regulator Site:

Description	Classification	Location		
		Borehole No.	Depth (mm)	
			From	To
sandy **SILT**	ML	1	100	1500
		2	100	2000
sandy **CLAY** with trace gravel	CL	1	1500	5000
		2	2000	5000
silty **SAND** with trace gravel	SM	1	5000	8000
		2	5000	8000
sandy **CLAY** with trace gravel	CI	1	8000	10000
		2	8000	10000

Table 4.5: Soil Classifications.

Site 2 – Pump Station Site:

Description	Classification	Location		
		Borehole No.	Depth (mm)	
			From	To
sandy **SILT**-silty **SAND**	ML-SM	3	200	5500
sandy **SILT**	ML	3	5500	6500
SAND with silt & trace gravel	SM-SP	3	6500	10000

Table 4.6: Soil Classifications.

Site 2 – Pipeline Site:

Description	Classification	Location		
		Borehole No.	Depth (mm)	
			From	To
sandy **CLAY / CLAY** with sand	CL	4	200	800
			2500	5000
		5	2000	4500
		6	3000	5000
		7	3000	5000
sandy **SILT**	ML	4	800	2500
		5	300	800
sandy **CLAY**	CL-ML	5	800	2000
		6	1200	3000
		7	1400	3000

Table 4.7: Soil Classifications.

Site 3 – Hells Gate Sill Site:

Description	Classification	Location		
		Borehole No.	Depth (mm)	
			From	To
CLAY with trace sand	CI	8	100	4500
		9	100	1500
			2000	4500
sandy **CLAY**	CL	9	1500	2000

Table 4.8: Soil Classifications.

5.0 FOOTING DESIGN & CONSTRUCTION RECOMMENDATIONS

5.1 Site Classification:

For brickwork and other construction of residential type parameters, the site classification is Class **'M-D'**. This classification has been made in accordance with AS2870. The recommendation is for brickwork and other residential type buildings to be constructed on an engineer designed footing system suitable for a potential seasonal ground movement of up to 40mm. Design and construction should comply with AS 2870 and AS 3600.

5.2 Founding Levels:

The recommendation is for all load bearing elements of the footing system to be founded through the disturbed surface soils and into the underlying natural soils. This is typically at a depth of around 200mm across each of the sites. The bearing capacity of the underlying soils has been nominated at various depths below the surface and these values are provided below in Table's 5.1 through 5.4.

5.3 Bearing Capacity:

The soil bearing capacity has been estimated for the underlying natural soils based on the results of shear vane testing and laboratory analysis of the soil types present at this site.

The adopted bearing capacity values assume that the footing will be founded in natural ground and allowance has been made for the effect of overburden where the footing extends into the underlying soils. It has also been considered that the founding soils may become saturated during the lifetime of the structure.

Site 1 – Regulator Site:

Depth below Surface	**Allowable Bearing Capacity** (kPa)
0.2m	80
1.0m	100
1.5m	160
2.0m	240
3.0m	310

Table 5.1: Recommended Soil Bearing Capacities.

Site 2 – Pump Station Site:

Depth below Surface	**Allowable Bearing Capacity** (kPa)
0.2m	80
1.0m	100
1.5m	150
2.0m	200
3.0m	290

Table 5.2: Recommended Soil Bearing Capacities.

Site 2 – Pipeline Site:

Depth below Surface	**Allowable Bearing Capacity** (kPa)
0.3m	80
1.0m	100
1.5m	150
2.0m	200
3.0m	320

Table 5.3: Recommended Soil Bearing Capacities.

Site 3 – Hells Gate Sill Site:

Depth below Surface	**Allowable Bearing Capacity** (kPa)
0.2m	100
1.0m	160
1.5m	190
2.0m	210
3.0m	250

Table 5.4: Recommended Soil Bearing Capacities.

The recommended material factor for ultimate limit state design is 0.4 in accordance with Austroads Bridge Design Code.

Please note: Where the base of a footing is situated such that it is at an offset distance from the face of a batter that violates the angle of repose, it will be necessary to reduce the available bearing capacity for these soils.

5.4 Characteristic Soil Surface Movement:

The characteristic soil surface movement is calculated to be in the order of **10mm** to **40mm** for this site.

5.5 Footing Preparation:

Clear the area in the vicinity of the footing layout of all grass and vegetation. It is recommended that the design engineer be contacted should soft spots or areas of undetected fill be encountered during footing excavation.

5.6 Earthworks:

Earthworks filling should be of selected materials free of organic matter, placed in compacted layers to at least 98% of maximum standard dry density and within +/- 2% of optimum moisture content. The placed layers should be limited to a maximum compacted depth of 150mm to ensure adequate compaction of the total layer depth. It is essential that the topsoil and any vegetable matter be stripped from the footprint of the filling zones prior to the placement of filling material. Grade and proof roll all stripped surfaces prior to the placement of subsequent fill layers.

The earthworks code AS3798 is recommended as a guide for the frequency of compaction testing during the course of construction.

The recommended batter slopes, for the soils present at the site, are 2.5H:1V on the upstream (water side) of the embankment (up to 3 metres in height) and 2H:1V on the downstream side. The use of flatter batter slopes is to be encouraged for ease of compaction in fill zones and on-going maintenance of the site.

5.7 Open Excavation:

It is expected that the soils across all sites will be readily excavated using a backhoe or small excavator. Drilling pier footings, using a mechanical auger, will also be undertaken with a low degree of difficulty in these soils however, the presence of trees within close proximity may result in some difficulty should the tree root system be intercepted during the excavation works.

As indicated above, groundwater was intercepted in all bar one borehole (BH4) at depths varying between 2.8 metres and 7.0 metres. In all instances the water began to rise within the boreholes following removal of the drilling auger. It is anticipated that groundwater will impact open type excavation or drilling work that extends to a depth that is within 1.0 metres of the depth at which groundwater was intercepted at each of the sites. From this depth the soil will become wet and the saturated soils will be prone to possible collapse as they soften.

It should be noted that this is a snapshot of the current groundwater situation at the time of the investigation and altered river / lake water levels will **most likely** change the current groundwater conditions.

5.8 Soil Density:

The density of the principal soil types existing across the subject site has been estimated based on a correlation between the classification test results and many density / moisture relationship tests performed in our soils laboratory on similar materials.

CLAY (CI)	Bulk Density	2.0 t/m^3
	Dry Density	1.7 t/m^3
CLAY (CL)	Bulk Density	2.0 t/m^3
	Dry Density	1.8 t/m^3
SAND (SM)	Bulk Density	2.1 t/m^3
	Dry Density	1.8 t/m^3
SILT (ML)	Bulk Density	2.0 t/m^3
	Dry Density	1.7 t/m^3

5.9 Cohesion & Angle of Internal Friction:

The following effective cohesion and angle of internal friction values have been estimated for the natural soil types present at this site, based on a correlation with the soil classification properties, and may be considered appropriate.

CLAY (CI)	Effective Cohesion	c = 13 kPa
	Effective Angle of Friction	ϕ = 25°
CLAY (CL)	Effective Cohesion	c = 10 kPa
	Effective Angle of Friction	ϕ = 28°
SAND (SM)	Effective Cohesion	c = 3 kPa
	Effective Angle of Friction	ϕ = 32°
SILT (ML)	Effective Cohesion	c = 2 kPa
	Effective Angle of Friction	ϕ = 32°

5.10 **Pier / Pile Footings:**

The following Ultimate End Bearing Resistance and Skin Resistance values have been adopted for pier/pile support within the underlying natural soils. These values are applicable for piers / piles where the ratio of the depth to diameter of the base is greater than a value of 4 and founding is at a depth of at least 4 metres below the surface.

Site	***Ultimate End Bearing Resistance*** (f_b)
Site 1 – Regulator	775 kPa
Site 2 – Pump Station	725 kPa
Site 3 – Hells Gate Sill	625 kPa

Table 5.5: Recommended End Bearing Resistance – Pier / Pile Footings.

The recommended capacity reduction factor based on the level of investigation carried out for ultimate limit state design is 0.4.

The bearing capacity values provided in Table's 5.1 to 5.4 above, will be appropriate for piers founded at depths less than 4.0 metres below the surface.

Skin Resistance ($\bar{f}_s$)

The following skin friction/adhesion values have been nominated for the soil types present:

Description	**Skin Resistance** ($\bar{f}_s$)
CLAY (CI)	**20** kPa
CLAY (CL)	**10** kPa
SAND (SM)	**5** kPa
SILT (ML)	**2** kPa

Table 5.6: Skin Resistance – Pier / Pile Footings.

5.11 **Dispersive Soils:**

An Emerson No.1 or 2 indicates that the soil is dispersive in its natural state. The dispersive nature of the existing river/lake bank material necessitates that measures be undertaken to reduce the potential for erosion of the exposed face. The following measures should be considered to ensure successful performance of banks comprising dispersive soils:

- Provide vigilant compaction control when reworking / placing this soil type. Increased compaction reduces the dispersive potential of a soil.

- Place topsoil to the inside face of batters and sow with grass to provide protection to exposed soils.

- Surface slaking and erosion will occur as a result of the wetting and drying cycle. Adopting flatter batter slopes can reduce the erosion effects.

- Limit the surface runoff over the batter by providing intercept drains. This will reduce the erosion caused by the flow of water over the soils.

- Provide beaching to the inside face of the batter to protect the dispersive soils against wave action.

- Regular review of the bank should form part of the site maintenance plan. Early identification and rectification works will ensure adequate performance of the rehabilitated bank.

5.11 **Drainage:**

Installation of a drainage system to the site is recommended to ensure a stable moisture regime is maintained within the existing subgrade soils. Interception drains should be provided at the top of batters and batter drains installed at the toe of all batters. Subsoil drains are also recommended at the toe of batters.

The frequency of borehole sites and the intensity of the testing program have been formulated to reflect the significance of the proposed structures. The testing and reporting is considered reasonable and comprehensive for this project and results correlate to other testing carried out by this company in the region. It must be understood by the client, however, that acceptance of this report is also an acceptance that it is possible that there may be variations in the geotechnical conditions from those described in this report as no geotechnical investigation can be considered exhaustive. The results and recommendations are therefore a reasonable platform upon which to base subsequent design decisions with a flexibility to change course should there be variations in the conditions at the time of construction.

Please do not hesitate to contact us should there be any further enquiries regarding this report.

Peter Willmott BEng (Civil)

6.0 APPENDICES

6.1 Appendix A – Borehole Logs

B.M
CIVIL ENGINEERS

Date: 2.10.2018

Location: Lake Moodemere

Client: Jacobs

Job No.: 48629-3

SITE
INVESTIGATION
BORELOG
LOCATION
PLAN

B.M
CIVIL ENGINEERS

Date: 2.10.2018

Location: Lake Moodemere

Client: Jacobs

Job No.: 48629-3

SITE
INVESTIGATION
BORELOG
LOCATION
PLAN

Site 1 - Regulator

Site 3 – Hells Gate Sill

Site 2 – Pump Station & Pipeline

B.M
CIVIL ENGINEERS

SITE INVESTIGATION LOG

Job No.: 48629-3 **Date:** 11.10.2018

Location: Lake Moodemere - Site 1 Regulator

Client: Jacobs

Borehole No.: 1

Depth	Description	Plasticity	Cohesion Density	Moisture
200	Topsoil			
400				
600	sandy SILT ML	LP	DS	8.4%
800	light brown			
1000				
1200				
1400				
1600				
1800				
2000				
2200				
2400	sandy CLAY with trace gravel CL	LP	ST	11.6%
2600	light brown			
2800				
3000				
3200				
3400	light brown yellow			14.3%
3600				
3800				
4000				
4200				
4400				15.3%
4600				
4800	Groundwater			
5000				
5200				
5400				
5600	silty SAND with trace gravel SM	LP	DS	24.6%
5800	yellow			
6000				
6200				
6400				
6600				
6800				
7000				
7200				
7400	grey			21.2%
7600				
7800				
8000				
8200				
8400				
8600	sandy CLAY with trace gravel CI	MP	ST	28.8%
8800	orange grey			
9000				
9200				
9400				
9600				
9800				
10000	EOB			
10200				

PLASTICITY		**LP**- LOW	**MP**- MEDIUM	**HP**- HIGH	
CONSISTENCY	COHESIVE SOILS	**VS**- very soft **S**-soft **F**-firm **ST** - stiff **VST** - very stiff **H**-hard			
	NON COHESIVE SOILS	**VL** very loose **L**- loose **MD**-medium dense **DS**-dense **VD**-very dense			
MOISTURE CONDITION		**D**-dry **M**- moist **W**-wet **SA**-saturated			
DRILLING METHOD	continuous flight auger	X	hand auger		

B.M
CIVIL ENGINEERS

SITE INVESTIGATION LOG

Job No.: 48629-3 **Date:** 11.10.2018

Location: Lake Moodemere - Site 1 Regulator

Client: Jacobs

Borehole No.: 2

Depth	Description	Plasticity	Cohesion Density	Moisture
200	Topsoil			
400				
600	sandy SILT ML	LP	DS	6.1%
800	light brown			
1000				
1200				
1400				
1600				
1800				
2000				
2200				
2400	sandy CLAY with trace gravel CL	LP	ST	9.1%
2600	light brown			
2800				
3000				
3200				
3400	light brown yellow			14.2%
3600				
3800				
4000				
4200				
4400				
4600				
4800	Groundwater			
5000				
5200				
5400				
5600	silty SAND with trace gravel SM	LP	DS	17.4%
5800	yellow			
6000				
6200				
6400				
6600				
6800				
7000				
7200				
7400				
7600				
7800				
8000				
8200				
8400				
8600	sandy CLAY with trace gravel CI	MP	ST	24.0%
8800	grey with orange seams			
9000				
9200				
9400				
9600				
9800				
10000	EOB			
10200				

PLASTICITY **LP**- LOW **MP**- MEDIUM **HP**- HIGH

CONSISTENCY COHESIVE SOILS **VS**- very soft **S**-soft **F**-firm **ST** - stiff **VST** - very stiff **H**-hard

NON COHESIVE SOILS **VL** very loose **L**- loose **MD**-medium dense **DS**-dense **VD**-very dense

MOISTURE CONDITION **D**-dry **M**- moist **W**-wet **SA**-saturated

DRILLING METHOD continuous flight auger [X] hand auger [ ]

B.M
CIVIL ENGINEERS

SITE INVESTIGATION LOG

Job No.: 48629-3 **Date:** 11.10.2018

Location: Lake Moodemere - Site 2 Pump Station

Client: Jacobs

Borehole No.: 3

Depth	Description	Plasticity	Cohesion Density	Moisture
200	Topsoil			
400				
600	sandy SILT - silty SAND ML-SM	LP	DS	5.2%
800	light brown yellow			
1000				
1200				
1400				
1600				
1800				
2000				
2200				
2400				
2600				
2800				
3000				
3200				
3400				
3600				
3800				
4000				
4200				
4400				
4600				11.6%
4800				
5000				
5200				
5400				
5600				
5800	sandy SILT ML	LP	DS	25.2%
6000	light brown			
6200				
6400				
6600				
6800	Groundwater			
7000				
7200				
7400				
7600	SAND with silt & trace gravel SM-SP	LP	DS	30.0%
7800	light brown			
8000				
8200				
8400				
8600				
8800				
9000	grey white			24.8%
9200				
9400				
9600				
9800				
10000	EOB			
10200				

PLASTICITY		**LP**- LOW **MP**- MEDIUM **HP**- HIGH	
CONSISTENCY	COHESIVE SOILS	**VS**- very soft **S**-soft **F**-firm **ST** - stiff **VST** - very stiff **H**-hard	
	NON COHESIVE SOILS	**VL** very loose **L**- loose **MD**-medium dense **DS**-dense **VD**-very dense	
MOISTURE CONDITION		**D**-dry **M**- moist **W**-wet **SA**-saturated	
DRILLING METHOD	continuous flight auger	X	hand auger

B.M
CIVIL ENGINEERS

SITE INVESTIGATION LOG

Job No.: 48629-3 **Date:** 11.10.2018

Location: Lake Moodemere - Site 2 Pipeline

Client: Jacobs

Borehole No.: **4**

Depth	Description	Plasticity	Cohesion Density	Moisture
100				
200	Disturbed Soil - silty CLAY			
300				
400	sandy CLAY CL	LP	ST	19.0%
500	light brown			
600				
700				
800				
900				
1000				
1100	sandy SILT ML	LP	DS	6.4%
1200	yellow			
1300				
1400				
1500				
1600				
1700				
1800				
1900				
2000				
2100				
2200				
2300				
2400				
2500				
2600				
2700				
2800	sandy CLAY CL	LP	ST	17.1%
2900	light brown			
3000				
3100				
3200				
3300				
3400				
3500				
3600				
3700				
3800				
3900				
4000				
4100				
4200				
4300				
4400				
4500				
4600	- grey seams			21.4%
4700				
4800				
4900				
5000	EOB			
5100				

PLASTICITY		**LP**- LOW **MP**- MEDIUM **HP**- HIGH
CONSISTENCY	COHESIVE SOILS	**VS**- very soft **S**-soft **F**-firm **ST** - stiff **VST** - very stiff **H**-hard
	NON COHESIVE SOILS	**VL** very loose **L**- loose **MD**-medium dense **DS**-dense **VD**-very dense
MOISTURE CONDITION		**D**-dry **M**- moist **W**-wet **SA**-saturated
DRILLING METHOD	continuous flight auger	X hand auger

B.M
CIVIL ENGINEERS

SITE INVESTIGATION LOG

Job No.: 48629-3 **Date:** 11.10.2018

Location: Lake Moodemere - Site 2 Pipeline

Client: Jacobs

Borehole No.: 5

Depth	Description	Plasticity	Cohesion Density	Moisture
100–300	Disturbed Soil - silty CLAY			
400–800	sandy SILT ML light brown	LP	DS	7.9%
900–2000	sandy CLAY CL-ML light brown	LP	ST	15.7%
2100–3000	CLAY with sand CL light brown yellow	LP	ST	22.0%
3100–4500	sandy CLAY CL light brown yellow Groundwater	LP	ST	26.6%
4600–4900	coarse SAND light brown yellow	LP	DS	SA
5000	EOB			
5100				

PLASTICITY **LP**- LOW **MP**- MEDIUM **HP**- HIGH

CONSISTENCY COHESIVE SOILS **VS**- very soft **S**-soft **F**-firm **ST** - stiff **VST** - very stiff **H**-hard

NON COHESIVE SOILS **VL** very loose **L**- loose **MD**-medium dense **DS**-dense **VD**-very dense

MOISTURE CONDITION **D**-dry **M**- moist **W**-wet **SA**-saturated

DRILLING METHOD continuous flight auger [X] hand auger [ ]

B.M
CIVIL ENGINEERS

SITE INVESTIGATION LOG

Job No.: 48629-3 **Date:** 11.10.2018

Location: Lake Moodemere - Site 2 Pipeline

Client: Jacobs

Borehole No.: 6

Depth	Description	Plasticity	Cohesion Density	Moisture
100	Disturbed soil			
200				
300	CLAY light brown	LP	ST	M
400				
500				
600				
700	SAND yellow	LP	DS	1.7%
800				
900				
1000				
1100				
1200				
1300				
1400				
1500	sandy CLAY CL-ML light brown	LP	ST	12.2%
1600				
1700				
1800				
1900				
2000				
2100				
2200				
2300				
2400				
2500				
2600				
2700				
2800				
2900				
3000				
3100				
3200				
3300				
3400	CLAY with sand CL light brown	LP	ST	17.8%
3500				
3600				
3700				
3800				
3900				
4000				
4100				
4200				
4300	sandy CLAY CL light brown	LP	ST	23.6%
4400				
4500				
4600				
4700	Groundwater			
4800				
4900				
5000	EOB			
5100				

PLASTICITY		**LP**- LOW	**MP**- MEDIUM	**HP**- HIGH	
CONSISTENCY	COHESIVE SOILS	**VS**- very soft	**S**-soft	**F**-firm **ST** - stiff	**VST** - very stiff **H**-hard
	NON COHESIVE SOILS	**VL** very loose	**L**- loose	**MD**-medium dense **DS**-dense	**VD**-very dense
MOISTURE CONDITION		**D**-dry	**M**- moist	**W**-wet	**SA**-saturated
DRILLING METHOD	continuous flight auger	X	hand auger		

B.M
CIVIL ENGINEERS

SITE INVESTIGATION LOG

Job No.: 48629-3 **Date:** 11.10.2018

Location: Lake Moodemere - Site 2 Pipeline

Client: Jacobs

Borehole No.: 7

Depth	Description	Plasticity	Cohesion Density	Moisture
100	Disturbed soil			
200				
300	CLAY & SAND light brown	LP	ST	M
400				
500				
600				
700	SAND yellow	LP	DS	2.1%
800				
900				
1000				
1100				
1200				
1300				
1400				
1500				
1600				
1700				
1800	sandy CLAY CL-ML light brown	LP	ST	12.1%
1900				
2000				
2100				
2200				
2300				
2400				
2500				
2600				
2700				
2800				
2900				
3000				
3100				
3200				
3300				
3400	CLAY with sand CL light brown	LP	ST	15.3%
3500				
3600				
3700				
3800				
3900				
4000				
4100				
4200				
4300	sandy CLAY CL light brown	LP	ST	23.4%
4400				
4500				
4600				
4700				
4800	Groundwater			
4900				
5000	EOB			
5100				

PLASTICITY		**LP**- LOW	**MP**- MEDIUM	**HP**- HIGH	
CONSISTENCY	COHESIVE SOILS	**VS**- very soft **S**-soft **F**-firm **ST** - stiff **VST** - very stiff **H**-hard			
	NON COHESIVE SOILS	**VL** very loose **L**- loose **MD**-medium dense **DS**-dense **VD**-very dense			
MOISTURE CONDITION		**D**-dry **M**- moist **W**-wet **SA**-saturated			
DRILLING METHOD	continuous flight auger	X	hand auger		

B.M
CIVIL ENGINEERS

SITE INVESTIGATION LOG

Job No.: 48629-3 **Date:** 11.10.2018

Location: Lake Moodemere - Site 3 Hells Gate Sill

Client: Jacobs

Borehole No.: **8**

Depth	Description	Plasticity	Cohesion Density	Moisture
100	Disturbed soil			
200				
300				
400	CLAY with trace sand CI	MP	ST	20.0%
500	light brown grey with orange seams			
600				
700				
800				
900				
1000				
1100				
1200				
1300				
1400				
1500				
1600				
1700				
1800				
1900				
2000				
2100				
2200				
2300				22.0%
2400				
2500				
2600				
2700				
2800				
2900	Groundwater			
3000				
3100				
3200				
3300				
3400	grey orange			28.0%
3500				
3600				
3700				
3800				
3900				
4000				
4100				
4200				
4300				
4400				
4500	EOB			
4600				
4700				
4800				
4900				
5000				
5100				

PLASTICITY		**LP**- LOW **MP**- MEDIUM **HP**- HIGH
CONSISTENCY	COHESIVE SOILS	**VS**- very soft **S**-soft **F**-firm **ST** - stiff **VST** - very stiff **H**-hard
	NON COHESIVE SOILS	**VL** very loose **L**- loose **MD**-medium dense **DS**-dense **VD**-very dense
MOISTURE CONDITION		**D**-dry **M**- moist **W**-wet **SA**-saturated
DRILLING METHOD	continuous flight auger	[ ] hand auger [X]

B.M
CIVIL ENGINEERS

SITE INVESTIGATION LOG

Job No.: 48629-3 **Date:** 11.10.2018

Location: Lake Moodemere - Site 3 Hells Gate Sill

Client: Jacobs

Borehole No.: 9

Depth	Description	Plasticity	Cohesion Density	Moisture
100	Disturbed soil			
200				
300				
400	CLAY with trace sand CI light brown grey with orange seams	MP	ST	17.2%
500				
600				
700				
800				
900				
1000				
1100				
1200				
1300				
1400				
1500				
1600				
1700	sandy CLAY CL light brown yellow	LP	ST	13.4%
1800				
1900				
2000				
2100				
2200				
2300				
2400				
2500	CLAY with trace sand CI light brown grey with orange seams	MP	ST	20.4%
2600				
2700				
2800	Groundwater			
2900				
3000				
3100				
3200				
3300				
3400	grey orange			28.0%
3500				
3600				
3700				
3800				
3900				
4000				
4100				
4200				
4300				
4400				
4500	EOB			
4600				
4700				
4800				
4900				
5000				
5100				

PLASTICITY		**LP**- LOW	**MP**- MEDIUM	**HP**- HIGH	
CONSISTENCY	COHESIVE SOILS	**VS**- very soft	**S**-soft	**F**-firm **ST -** stiff	**VST** - very stiff **H**-hard
	NON COHESIVE SOILS	**VL** very loose	**L**- loose	**MD**-medium dense **DS**-dense	**VD**-very dense
MOISTURE CONDITION		**D**-dry	**M**- moist	**W**-wet	**SA**-saturated
DRILLING METHOD	continuous flight auger		hand auger	X	

6.2 Appendix B – Test Reports

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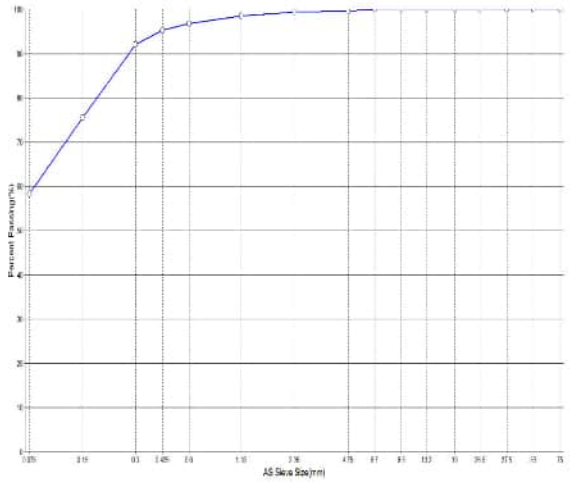
Ph: (03) 5823 5781
Fax: (03) 5823 5782

Quality of Materials Report

Client:	**Jacobs**	Report Number:	**48629 - 1/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number:	**48629**	Report Date:	**15/10/2018**
Project:	**Geotechnical Investigation**	Order Number:	-
Location	**Lake Moodemere , Rutherglen**		**Page 1 of 13**
Lab No:	**181815**	Sample Location	
Date Sampled:	**29/08/2018**	Bore Hole : 1	
Date Tested:	**3/10/2018**	Start Depth (mm) : 2000	
Sampled By:	**Peter Willmott**	End Depth (mm) : 4000	
Sample Method:	**AS1289.1.2.1**	(CL) Sandy CLAY, trace gravel	
Material Source:	**Site**	Spec Description:	-
For Use As:	**Classification**	Lot Number:	-
Remarks:	-	Spec Number:	-

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Specification Minimum	Percent Passing	Specification Maximum
75.00 mm		**100**	
53.00 mm		**100**	
37.50 mm		**100**	
26.50 mm		**100**	
19.00 mm		**100**	
13.2 mm		**100**	
9.50 mm		**100**	
6.7 mm		**100**	
4.75 mm		**100**	
2.36 mm		**99**	
1.18 mm		**99**	
0.600 mm		**97**	
0.425 mm		**95**	
0.300 mm		**92**	
0.150 mm		**76**	
0.075 mm		**58**	

Atterberg Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	**AS1289.3.1.2**		**26**	
Plastic Limit (%)	**AS1289.3.2.1**		**16**	
Plasticity Index	**AS1289.3.3.1**		**10**	
Linear Shrinkage (%)	**AS1289.3.4.1**		**5.0**	

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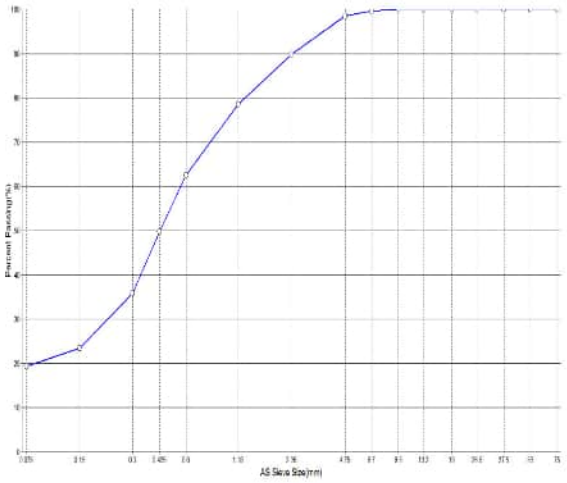
Fax: (03) 5823 5782

Quality of Materials Report

Client:	**Jacobs**	Report Number:	**48629 - 1/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number:	**48629**	Report Date:	**15/10/2018**
Project:	**Geotechnical Investigation**	Order Number:	-
Location	**Lake Moodemere , Rutherglen**		**Page 2 of 13**
Lab No:	**181817**	Sample Location	
Date Sampled:	**29/08/2018**	Bore Hole : 1	
Date Tested:	**3/10/2018**	Start Depth (mm) : 5000	
Sampled By:	**Peter Willmott**	End Depth (mm) : 7000	
Sample Method:	**AS1289.1.2.1**	(SM) Silty SAND, trace gravel	
Material Source:	**Site**	Spec Description:	-
For Use As:	**Classification**	Lot Number:	-
Remarks:	-	Spec Number:	-

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Specification Minimum	Percent Passing	Specification Maximum
75.00 mm		**100**	
53.00 mm		**100**	
37.50 mm		**100**	
26.50 mm		**100**	
19.00 mm		**100**	
13.2 mm		**100**	
9.50 mm		**100**	
6.7 mm		**100**	
4.75 mm		**98**	
2.36 mm		**90**	
1.18 mm		**79**	
0.600 mm		**63**	
0.425 mm		**50**	
0.300 mm		**36**	
0.150 mm		**23**	
0.075 mm		**19**	

Atterberg Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	**AS1289.3.1.2**		**19**	
Plastic Limit (%)	**AS1289.3.2.1**		**15**	
Plasticity Index	**AS1289.3.3.1**		**4**	
Linear Shrinkage (%)	**AS1289.3.4.1**		**2.0**	

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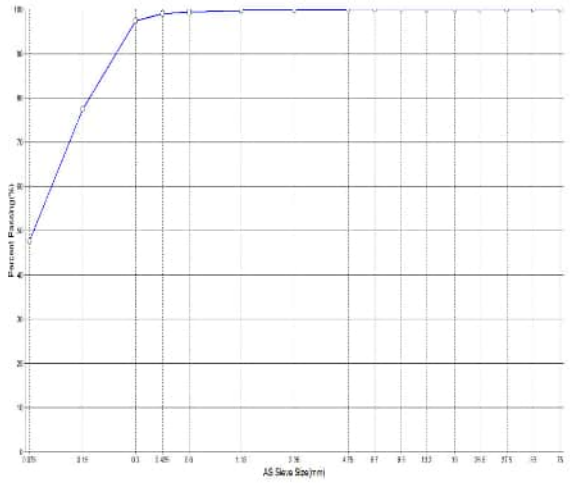
Quality of Materials Report

Client:	**Jacobs**	Report Number:	**48629 - 1/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number:	**48629**	Report Date:	**15/10/2018**
Project:	**Geotechnical Investigation**	Order Number:	-
Location	**Lake Moodemere , Rutherglen**		**Page 3 of 13**
Lab No:	**181820**	Sample Location	
Date Sampled:	**29/08/2018**	Bore Hole : 2	
Date Tested:	**10/10/2018**	Start Depth (mm) : 100	
Sampled By:	**Peter Willmott**	End Depth (mm) : 2000	
Sample Method:	**AS1289.1.2.1**	(ML) Sandy SILT	
Material Source:	**Site**	Spec Description:	-
For Use As:	**Classification**	Lot Number:	-
Remarks:	-	Spec Number:	-

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Specification Minimum	Percent Passing	Specification Maximum
75.00 mm		**100**	
53.00 mm		**100**	
37.50 mm		**100**	
26.50 mm		**100**	
19.00 mm		**100**	
13.2 mm		**100**	
9.50 mm		**100**	
6.7 mm		**100**	
4.75 mm		**100**	
2.36 mm		**100**	
1.18 mm		**100**	
0.600 mm		**99**	
0.425 mm		**99**	
0.300 mm		**97**	
0.150 mm		**77**	
0.075 mm		**48**	

Atterberg Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	**AS1289.3.1.2**		**22**	
Plastic Limit (%)	**AS1289.3.2.1**		**21**	
Plasticity Index	**AS1289.3.3.1**		**1**	
Linear Shrinkage (%)	**AS1289.3.4.1**		**1.0**	

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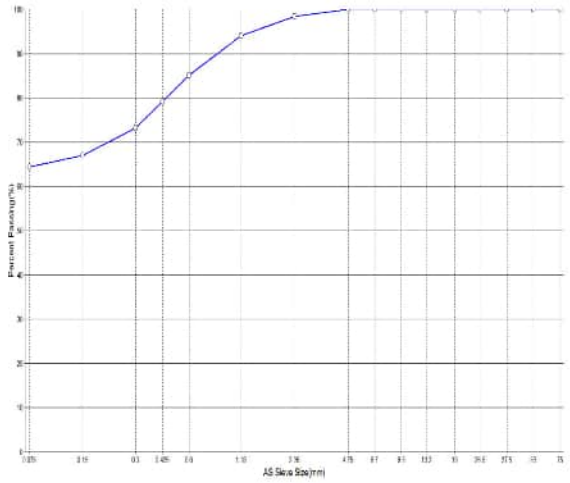
Quality of Materials Report

Client:	**Jacobs**	Report Number:	**48629 - 1/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number:	**48629**	Report Date:	**15/10/2018**
Project:	**Geotechnical Investigation**	Order Number:	-
Location	**Lake Moodemere , Rutherglen**		**Page 4 of 13**
Lab No:	**181824**	Sample Location	
Date Sampled:	**29/08/2018**	Bore Hole : 2	
Date Tested:	**10/10/2018**	Start Depth (mm) : 8000	
Sampled By:	**Peter Willmott**	End Depth (mm) : 10000	
Sample Method:	**AS1289.1.2.1**	(CI) Sandy CLAY, trace gravel	
Material Source:	**Site**	Spec Description:	-
For Use As:	**Classification**	Lot Number:	-
Remarks:	-	Spec Number:	-

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Specification Minimum	Percent Passing	Specification Maximum
75.00 mm		**100**	
53.00 mm		**100**	
37.50 mm		**100**	
26.50 mm		**100**	
19.00 mm		**100**	
13.2 mm		**100**	
9.50 mm		**100**	
6.7 mm		**100**	
4.75 mm		**100**	
2.36 mm		**98**	
1.18 mm		**94**	
0.600 mm		**85**	
0.425 mm		**79**	
0.300 mm		**73**	
0.150 mm		**67**	
0.075 mm		**64**	

Atterberg Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	**AS1289.3.1.2**		**36**	
Plastic Limit (%)	**AS1289.3.2.1**		**14**	
Plasticity Index	**AS1289.3.3.1**		**22**	
Linear Shrinkage (%)	**AS1289.3.4.1**		**10.5**	

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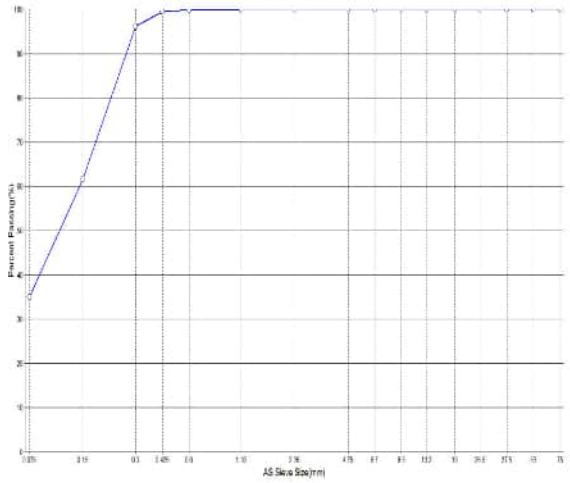
Quality of Materials Report

Client:	**Jacobs**	Report Number:	**48629 - 1/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number:	**48629**	Report Date:	**15/10/2018**
Project:	**Geotechnical Investigation**	Order Number:	-
Location	**Lake Moodemere , Rutherglen**		**Page 5 of 13**
Lab No:	**181826**	Sample Location	
Date Sampled:	**29/08/2018**	Bore Hole : 3	
Date Tested:	**10/10/2018**	Start Depth (mm) : 4000	
Sampled By:	**Peter Willmott**	End Depth (mm) : 5500	
Sample Method:	**AS1289.1.2.1**	(ML-SM) Sandy SILT - Silty SAND	
Material Source:	**Site**	Spec Description:	-
For Use As:	**Classification**	Lot Number:	-
Remarks:	-	Spec Number:	-

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Specification Minimum	Percent Passing	Specification Maximum
75.00 mm		**100**	
53.00 mm		**100**	
37.50 mm		**100**	
26.50 mm		**100**	
19.00 mm		**100**	
13.2 mm		**100**	
9.50 mm		**100**	
6.7 mm		**100**	
4.75 mm		**100**	
2.36 mm		**100**	
1.18 mm		**100**	
0.600 mm		**100**	
0.425 mm		**100**	
0.300 mm		**96**	
0.150 mm		**62**	
0.075 mm		**35**	

Atterberg Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	**AS1289.3.1.2**		**18**	
Plastic Limit (%)	**AS1289.3.2.1**		**20**	
Plasticity Index	**AS1289.3.3.1**		**0**	
Linear Shrinkage (%)	**AS1289.3.4.1**		**0.0**	

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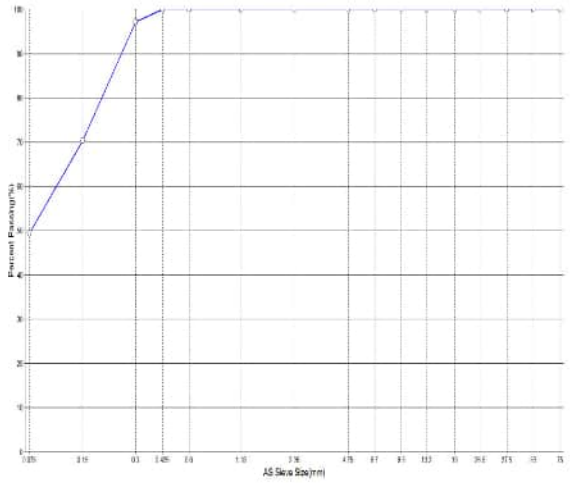
Quality of Materials Report

Client:	**Jacobs**	Report Number:	**48629 - 1/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number:	**48629**	Report Date:	**15/10/2018**
Project:	**Geotechnical Investigation**	Order Number:	-
Location	**Lake Moodemere , Rutherglen**		**Page 6 of 13**
Lab No:	**181827**	Sample Location	
Date Sampled:	**29/08/2018**	Bore Hole : 3	
Date Tested:	**3/10/2018**	Start Depth (mm) : 5500	
Sampled By:	**Peter Willmott**	End Depth (mm) : 6500	
Sample Method:	**AS1289.1.2.1**	(ML) Sandy SILT	
Material Source:	**Site**	Spec Description:	-
For Use As:	**Classification**	Lot Number:	-
Remarks:	-	Spec Number:	-

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Specification Minimum	Percent Passing	Specification Maximum
75.00 mm		**100**	
53.00 mm		**100**	
37.50 mm		**100**	
26.50 mm		**100**	
19.00 mm		**100**	
13.2 mm		**100**	
9.50 mm		**100**	
6.7 mm		**100**	
4.75 mm		**100**	
2.36 mm		**100**	
1.18 mm		**100**	
0.600 mm		**100**	
0.425 mm		**100**	
0.300 mm		**97**	
0.150 mm		**70**	
0.075 mm		**49**	

Atterberg Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	**AS1289.3.1.2**		**21**	
Plastic Limit (%)	**AS1289.3.2.1**		**20**	
Plasticity Index	**AS1289.3.3.1**		**1**	
Linear Shrinkage (%)	**AS1289.3.4.1**		**1.0**	

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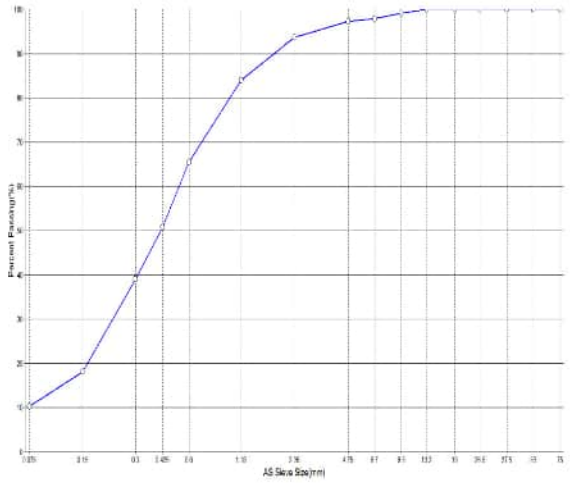
Quality of Materials Report

Client:	**Jacobs**	Report Number:	**48629 - 1/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number:	**48629**	Report Date:	**15/10/2018**
Project:	**Geotechnical Investigation**	Order Number:	-
Location	**Lake Moodemere , Rutherglen**		**Page 7 of 13**

Lab No:	**181829**	Sample Location	
Date Sampled:	**29/08/2018**	Bore Hole : 3	
Date Tested:	**10/10/2018**	Start Depth (mm) : 7500	
Sampled By:	**Peter Willmott**	End Depth (mm) : 10000	
Sample Method:	**AS1289.1.2.1**	(SM-SP) SAND, with silt, trace gravel	
Material Source:	**Site**	Spec Description:	-
For Use As:	**Classification**	Lot Number:	-
Remarks:	-	Spec Number:	-

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Specification Minimum	Percent Passing	Specification Maximum
75.00 mm		**100**	
53.00 mm		**100**	
37.50 mm		**100**	
26.50 mm		**100**	
19.00 mm		**100**	
13.2 mm		**100**	
9.50 mm		**99**	
6.7 mm		**98**	
4.75 mm		**97**	
2.36 mm		**94**	
1.18 mm		**84**	
0.600 mm		**65**	
0.425 mm		**51**	
0.300 mm		**39**	
0.150 mm		**18**	
0.075 mm		**10**	

Atterberg Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	**AS1289.3.1.2**		**-**	
Plastic Limit (%)	**AS1289.3.2.1**		**-**	
Plasticity Index	**AS1289.3.3.1**		**NP**	
Linear Shrinkage (%)	**AS1289.3.4.1**		**-**	

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Approved Signatory

David Sleep
NATA Accred No:5023

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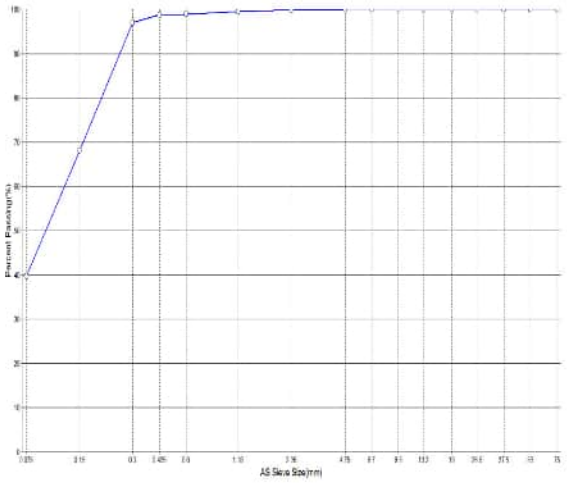
Quality of Materials Report

Client:	**Jacobs**	Report Number:	**48629 - 1/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number:	**48629**	Report Date:	**15/10/2018**
Project:	**Geotechnical Investigation**	Order Number:	-
Location	**Lake Moodemere , Rutherglen**		**Page 8 of 13**
Lab No:	**181831**	Sample Location	
Date Sampled:	**29/08/2018**	Bore Hole : 4	
Date Tested:	**10/10/2018**	Start Depth (mm) : 800	
Sampled By:	**Peter Willmott**	End Depth (mm) : 2500	
Sample Method:	**AS1289.1.2.1**	(ML) Sandy SILT	
Material Source:	**Site**	Spec Description:	-
For Use As:	**Classification**	Lot Number:	-
Remarks:	-	Spec Number:	-

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Specification Minimum	Percent Passing	Specification Maximum
75.00 mm		**100**	
53.00 mm		**100**	
37.50 mm		**100**	
26.50 mm		**100**	
19.00 mm		**100**	
13.2 mm		**100**	
9.50 mm		**100**	
6.7 mm		**100**	
4.75 mm		**100**	
2.36 mm		**100**	
1.18 mm		**99**	
0.600 mm		**99**	
0.425 mm		**99**	
0.300 mm		**97**	
0.150 mm		**68**	
0.075 mm		**40**	

Atterberg Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	**AS1289.3.1.2**		**19**	
Plastic Limit (%)	**AS1289.3.2.1**		**19**	
Plasticity Index	**AS1289.3.3.1**		**0**	
Linear Shrinkage (%)	**AS1289.3.4.1**		**0.0**	

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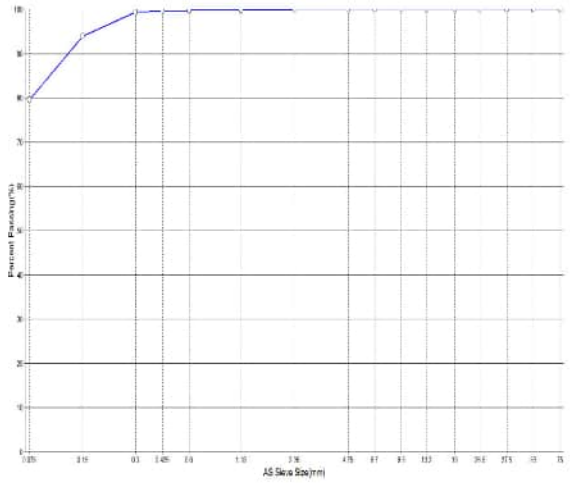
Quality of Materials Report

Client:	**Jacobs**	Report Number:	**48629 - 1/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number:	**48629**	Report Date:	**15/10/2018**
Project:	**Geotechnical Investigation**	Order Number:	-
Location	**Lake Moodemere , Rutherglen**		**Page 9 of 13**
Lab No:	**181836**	Sample Location	
Date Sampled:	**29/08/2018**	Bore Hole : 5	
Date Tested:	**10/10/2018**	Start Depth (mm) : 2000	
Sampled By:	**Peter Willmott**	End Depth (mm) : 3000	
Sample Method:	**AS1289.1.2.1**	(CL) CLAY, with sand	
Material Source:	**Site**	Spec Description:	-
For Use As:	**Classification**	Lot Number:	-
Remarks:	-	Spec Number:	-

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Specification Minimum	Percent Passing	Specification Maximum
75.00 mm		**100**	
53.00 mm		**100**	
37.50 mm		**100**	
26.50 mm		**100**	
19.00 mm		**100**	
13.2 mm		**100**	
9.50 mm		**100**	
6.7 mm		**100**	
4.75 mm		**100**	
2.36 mm		**100**	
1.18 mm		**100**	
0.600 mm		**100**	
0.425 mm		**100**	
0.300 mm		**99**	
0.150 mm		**94**	
0.075 mm		**80**	

Atterberg Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	**AS1289.3.1.2**		**32**	
Plastic Limit (%)	**AS1289.3.2.1**		**19**	
Plasticity Index	**AS1289.3.3.1**		**13**	
Linear Shrinkage (%)	**AS1289.3.4.1**		**7.5**	

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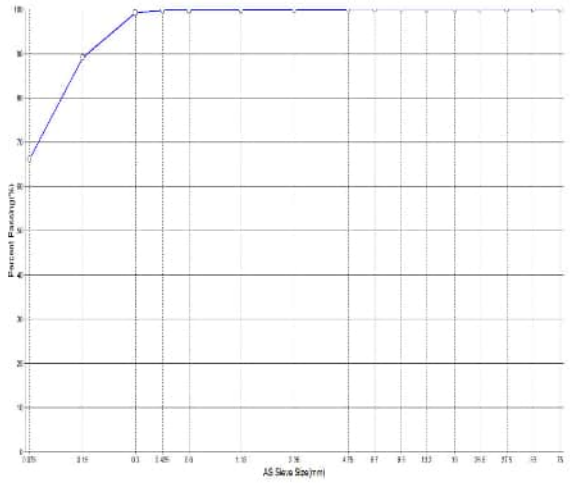
Quality of Materials Report

Client:	**Jacobs**	Report Number:	**48629 - 1/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number:	**48629**	Report Date:	**15/10/2018**
Project:	**Geotechnical Investigation**	Order Number:	-
Location	**Lake Moodemere , Rutherglen**		**Page 10 of 13**

Lab No:	**181837**	Sample Location	
Date Sampled:	**29/08/2018**	Bore Hole : 5	
Date Tested:	**10/10/2018**	Start Depth (mm) : 3000	
Sampled By:	**Peter Willmott**	End Depth (mm) : 4500	
Sample Method:	**AS1289.1.2.1**	(CL) Sandy CLAY	
Material Source:	**Site**	Spec Description:	-
For Use As:	**Classification**	Lot Number:	-
Remarks:	-	Spec Number:	-

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Specification Minimum	Percent Passing	Specification Maximum
75.00 mm		**100**	
53.00 mm		**100**	
37.50 mm		**100**	
26.50 mm		**100**	
19.00 mm		**100**	
13.2 mm		**100**	
9.50 mm		**100**	
6.7 mm		**100**	
4.75 mm		**100**	
2.36 mm		**100**	
1.18 mm		**100**	
0.600 mm		**100**	
0.425 mm		**100**	
0.300 mm		**99**	
0.150 mm		**89**	
0.075 mm		**66**	

Atterberg Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	**AS1289.3.1.2**		**29**	
Plastic Limit (%)	**AS1289.3.2.1**		**20**	
Plasticity Index	**AS1289.3.3.1**		**9**	
Linear Shrinkage (%)	**AS1289.3.4.1**		**5.0**	

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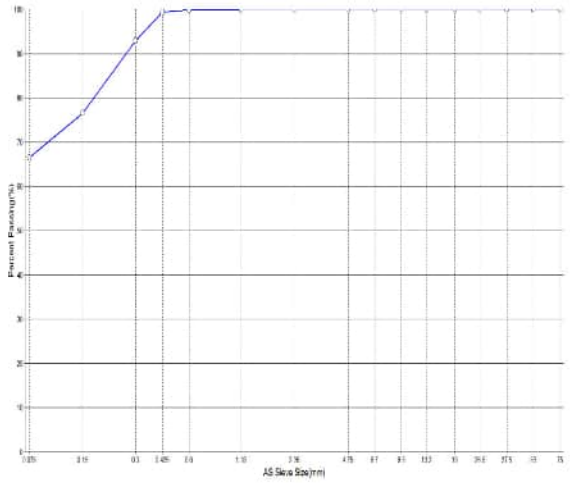
Quality of Materials Report

Client:	**Jacobs**	Report Number:	**48629 - 1/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number:	**48629**	Report Date:	**15/10/2018**
Project:	**Geotechnical Investigation**	Order Number:	-
Location	**Lake Moodemere , Rutherglen**		**Page 11 of 13**
Lab No:	**181839**	Sample Location	
Date Sampled:	**29/08/2018**	Bore Hole : 6	
Date Tested:	**10/10/2018**	Start Depth (mm) : 1200	
Sampled By:	**Peter Willmott**	End Depth (mm) : 3000	
Sample Method:	**AS1289.1.2.1**	(CL-ML) Sandy CLAY	
Material Source:	**Site**	Spec Description:	-
For Use As:	**Classification**	Lot Number:	-
Remarks:	-	Spec Number:	-

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Specification Minimum	Percent Passing	Specification Maximum
75.00 mm		**100**	
53.00 mm		**100**	
37.50 mm		**100**	
26.50 mm		**100**	
19.00 mm		**100**	
13.2 mm		**100**	
9.50 mm		**100**	
6.7 mm		**100**	
4.75 mm		**100**	
2.36 mm		**100**	
1.18 mm		**100**	
0.600 mm		**100**	
0.425 mm		**99**	
0.300 mm		**93**	
0.150 mm		**77**	
0.075 mm		**66**	

Atterberg Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	**AS1289.3.1.2**		**23**	
Plastic Limit (%)	**AS1289.3.2.1**		**17**	
Plasticity Index	**AS1289.3.3.1**		**6**	
Linear Shrinkage (%)	**AS1289.3.4.1**		**4.5**	

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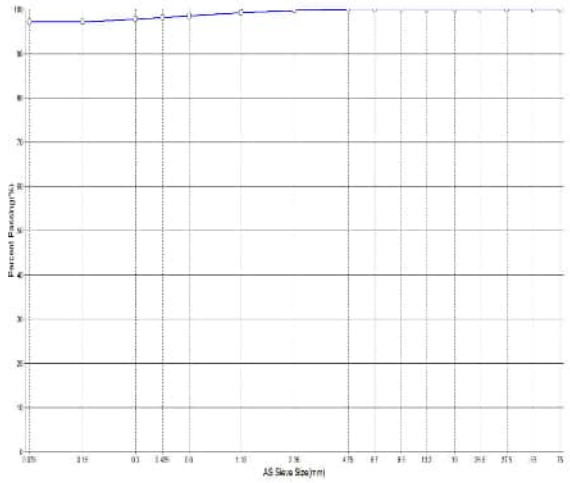
Quality of Materials Report

Client:	**Jacobs**	Report Number:	**48629 - 1/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number:	**48629**	Report Date:	**15/10/2018**
Project:	**Geotechnical Investigation**	Order Number:	-
Location	**Lake Moodemere , Rutherglen**		**Page 12 of 13**
Lab No:	**181846**	Sample Location	
Date Sampled:	**29/08/2018**	Bore Hole : 8	
Date Tested:	**3/10/2018**	Start Depth (mm) : 100	
Sampled By:	**Peter Willmott**	End Depth (mm) : 2000	
Sample Method:	**AS1289.1.2.1**	(CI) CLAY, trace sand	
Material Source:	**Site**	Spec Description:	-
For Use As:	**Classification**	Lot Number:	-
Remarks:	-	Spec Number:	-

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Specification Minimum	Percent Passing	Specification Maximum
75.00 mm		**100**	
53.00 mm		**100**	
37.50 mm		**100**	
26.50 mm		**100**	
19.00 mm		**100**	
13.2 mm		**100**	
9.50 mm		**100**	
6.7 mm		**100**	
4.75 mm		**100**	
2.36 mm		**100**	
1.18 mm		**99**	
0.600 mm		**98**	
0.425 mm		**98**	
0.300 mm		**98**	
0.150 mm		**97**	
0.075 mm		**97**	

Atterberg Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	**AS1289.3.1.2**		**48**	
Plastic Limit (%)	**AS1289.3.2.1**		**20**	
Plasticity Index	**AS1289.3.3.1**		**28**	
Linear Shrinkage (%)	**AS1289.3.4.1**		**12.0**	

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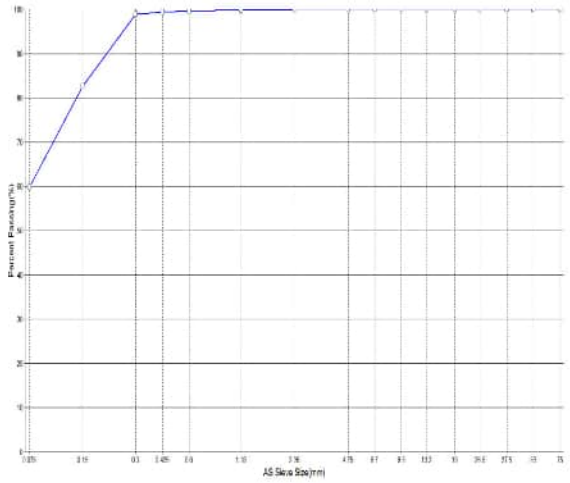
Quality of Materials Report

Client:	**Jacobs**	Report Number:	**48629 - 1/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number:	**48629**	Report Date:	**15/10/2018**
Project:	**Geotechnical Investigation**	Order Number:	-
Location	**Lake Moodemere , Rutherglen**		**Page 13 of 13**
Lab No:	**181850**	Sample Location	
Date Sampled:	**29/08/2018**	Bore Hole : 9	
Date Tested:	**10/10/2018**	Start Depth (mm) : 1500	
Sampled By:	**Peter Willmott**	End Depth (mm) : 2000	
Sample Method:	**AS1289.1.2.1**	(CL) Sandy CLAY	
Material Source:	**Site**	Spec Description:	-
For Use As:	**Classification**	Lot Number:	-
Remarks:	-	Spec Number:	-

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Specification Minimum	Percent Passing	Specification Maximum
75.00 mm		**100**	
53.00 mm		**100**	
37.50 mm		**100**	
26.50 mm		**100**	
19.00 mm		**100**	
13.2 mm		**100**	
9.50 mm		**100**	
6.7 mm		**100**	
4.75 mm		**100**	
2.36 mm		**100**	
1.18 mm		**100**	
0.600 mm		**100**	
0.425 mm		**99**	
0.300 mm		**99**	
0.150 mm		**83**	
0.075 mm		**60**	

Atterberg Tests	Test Method	Specification Minimum	Result	Specification Maximum
Liquid Limit (%)	**AS1289.3.1.2**		**26**	
Plastic Limit (%)	**AS1289.3.2.1**		**16**	
Plasticity Index	**AS1289.3.3.1**		**10**	
Linear Shrinkage (%)	**AS1289.3.4.1**		**5.5**	

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Emerson Class Number Report

Client :	**Jacobs**	Report Number:	**48629 - 2/1**
Client Address :	**Level 11, 452 Flinders Street Melbourne VIC**	Report Date:	**16/10/2018**
Job Number :	**48629**	Order Number:	
Project :	**Geotechnical Investigation**	Test Method:	**AS 1289.3.8.1**
Location :	**Lake Moodemere , Rutherglen**		

Lab No :	181815	181817	181820	181824
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Sampling Method :	AS1289.1.2.1	AS1289.1.2.1	AS1289.1.2.1	AS1289.1.2.1
Date Sampled :	29/8/2018	29/8/2018	29/8/2018	29/8/2018
Date Tested :	13/10/2018	13/10/2018	13/10/2018	13/10/2018
Material Source :	Site	Site	Site	Site
For Use As :	Classification	Classification	Classification	Classification
Sample Location :	Bore Hole : 1 Start Depth (mm) : 2000 End Depth (mm) : 4000 (CL) Sandy CLAY, trace gravel	Bore Hole : 1 Start Depth (mm) : 5000 End Depth (mm) : 7000 (SM) Silty SAND, trace gravel	Bore Hole : 2 Start Depth (mm) : 100 End Depth (mm) : 2000 (ML) Sandy SILT	Bore Hole : 2 Start Depth (mm) : 8000 End Depth (mm) : 10000 (CI) Sandy CLAY, trace gravel
TEST 1				
Soil Description :	**-**	**-**	**-**	**-**
Type of Water Used :	**Distilled Water**	**Distilled Water**	**Distilled Water**	**Distilled Water**
Temperature of Water (°C) :	**22.0**	**22.0**	**22.0**	**22.0**
Emerson Class Number :	**Class 2**	**Class 2**	**Class 2**	**Class 3**
TEST 2				
Soil Description :	**-**	**-**	**-**	**-**
Type of Water Used :	**Tap Water**	**Tap Water**	**Tap Water**	**Tap Water**
Temperature of Water (°C) :	**22**	**22**	**22**	**22**
Emerson Class Number :	**Class 2**	**Class 5**	**Class 5**	**Class 5**
Remarks :				

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APPROVED SIGNATORY

David Sleep
NATA Accred No:5023

FORM NUMBER

RPO52-10

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Emerson Class Number Report

Client :	**Jacobs**	Report Number:	**48629 - 2/1**
Client Address :	**Level 11, 452 Flinders Street Melbourne VIC**	Report Date:	**16/10/2018**
Job Number :	**48629**	Order Number:	
Project :	**Geotechnical Investigation**	Test Method:	**AS 1289.3.8.1**
Location :	**Lake Moodemere , Rutherglen**		

Lab No :	181826	181827	181829	181831
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Sampling Method :	AS1289.1.2.1	AS1289.1.2.1	AS1289.1.2.1	AS1289.1.2.1
Date Sampled :	29/8/2018	29/8/2018	29/8/2018	29/8/2018
Date Tested :	13/10/2018	13/10/2018	13/10/2018	13/10/2018
Material Source :	Site	Site	Site	Site
For Use As :	Classification	Classification	Classification	Classification
Sample Location :	Bore Hole : 3 Start Depth (mm) : 4000 End Depth (mm) : 5500 (ML-SM) Sandy SILT - Silty SAND	Bore Hole : 3 Start Depth (mm) : 5500 End Depth (mm) : 6500 (ML) Sandy SILT	Bore Hole : 3 Start Depth (mm) : 7500 End Depth (mm) : 10000 (SM-SP) SAND, with silt, trace gravel	Bore Hole : 4 Start Depth (mm) : 800 End Depth (mm) : 2500 (ML) Sandy SILT
TEST 1				
Soil Description :	**-**	**-**	**-**	**-**
Type of Water Used :	**Distilled Water**	**Distilled Water**	**Distilled Water**	**Distilled Water**
Temperature of Water (°C) :	**22.0**	**22.0**	**22.0**	**22.0**
Emerson Class Number :	**Class 3**	**Class 3**	**Class 4**	**Class 3**
TEST 2				
Soil Description :	**-**	**-**	**-**	**-**
Type of Water Used :	**Tap Water**	**Tap Water**	**Tap Water**	**Tap Water**
Temperature of Water (°C) :	**22**	**22**	**22**	**22**
Emerson Class Number :	**Class 5**	**Class 4**	**Class 4**	**Class 4**
Remarks :				

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Emerson Class Number Report

Client :	**Jacobs**	Report Number:	**48629 - 2/1**
Client Address :	**Level 11, 452 Flinders Street Melbourne VIC**	Report Date:	**16/10/2018**
Job Number :	**48629**	Order Number:	
Project :	**Geotechnical Investigation**	Test Method:	**AS 1289.3.8.1**
Location :	**Lake Moodemere , Rutherglen**		

Lab No :	181836	181837	181839	181846
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Sampling Method :	AS1289.1.2.1	AS1289.1.2.1	AS1289.1.2.1	AS1289.1.2.1
Date Sampled :	29/8/2018	29/8/2018	29/8/2018	29/8/2018
Date Tested :	13/10/2018	13/10/2018	13/10/2018	13/10/2018
Material Source :	Site	Site	Site	Site
For Use As :	Classification	Classification	Classification	Classification
Sample Location :	Bore Hole : 5 Start Depth (mm) : 2000 End Depth (mm) : 3000 (CL) CLAY, with sand	Bore Hole : 5 Start Depth (mm) : 3000 End Depth (mm) : 4500 (CL) Sandy CLAY	Bore Hole : 6 Start Depth (mm) : 1200 End Depth (mm) : 3000 (CL-ML) Sandy CLAY	Bore Hole : 8 Start Depth (mm) : 100 End Depth (mm) : 2000 (CI) CLAY, trace sand
TEST 1				
Soil Description :	**-**	**-**	**-**	**-**
Type of Water Used :	**Distilled Water**	**Distilled Water**	**Distilled Water**	**Distilled Water**
Temperature of Water (°C) :	**22.0**	**22.0**	**22.0**	**22.0**
Emerson Class Number :	**Class 2**	**Class 3**	**Class 3**	**Class 4**
TEST 2				
Soil Description :	**-**	**-**	**-**	**-**
Type of Water Used :	**Tap Water**	**Tap Water**	**Tap Water**	**Tap Water**
Temperature of Water (°C) :	**22**	**22**	**22**	**22**
Emerson Class Number :	**Class 4**	**Class 4**	**Class 4**	**Class 4**
Remarks :				

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Emerson Class Number Report

Client :	**Jacobs**	Report Number:	**48629 - 2/1**
Client Address :	**Level 11, 452 Flinders Street Melbourne VIC**	Report Date:	**16/10/2018**
Job Number :	**48629**	Order Number:	
Project :	**Geotechnical Investigation**	Test Method:	**AS 1289.3.8.1**
Location :	**Lake Moodemere , Rutherglen**		

Lab No :	181850			
ID No :	-			
Lot No :	-			
Item No :	-			
Sampling Method :	AS1289.1.2.1			
Date Sampled :	29/8/2018			
Date Tested :	13/10/2018			
Material Source :	Site			
For Use As :	Classification			
Sample Location :	Bore Hole : 9 Start Depth (mm) : 1500 End Depth (mm) : 2000 (CL) Sandy CLAY			
TEST 1				
Soil Description :	**-**			
Type of Water Used :	**Distilled Water**			
Temperature of Water (°C) :	**22.0**			
Emerson Class Number :	**Class 4**			
TEST 2				
Soil Description :	**-**			
Type of Water Used :	**Tap Water**			
Temperature of Water (°C) :	**22**			
Emerson Class Number :	**Class 4**			
Remarks :				

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Moisture Content Report

Client :	**Jacobs**	Report Number:	**48629 - 3/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number :	**48629**	Report Date:	**16/10/2018**
Project :	**Geotechnical Investigation**	Order Number:	
Location :	**Lake Moodemere , Rutherglen**	Test Method:	**AS1289.2.1.1**

Lab No :	181813	181814	181815	181816
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Date Sampled :	29/8/2018	29/8/2018	29/8/2018	29/8/2018
Date Tested :	10/9/2018	10/9/2018	10/9/2018	10/9/2018
Material Source :	Site	Site	Site	Site
For Use As :	Classification	Classification	Classification	Classification
Sample Location :	Bore Hole : 1 Start Depth (mm) : 100 End Depth (mm) : 1500	Bore Hole : 1 Start Depth (mm) : 1500 End Depth (mm) : 2000	Bore Hole : 1 Start Depth (mm) : 2000 End Depth (mm) : 4000 (CL) Sandy CLAY, trace gravel	Bore Hole : 1 Start Depth (mm) : 4000 End Depth (mm) : 5000
Drying Temperature(°C):	**105-110**	**105-110**	**105-110**	**105-110**
Moisture Content(%):	**8.4**	**11.6**	**14.3**	**15.3**
Remarks :				

Lab Number:	Soil Description
181813	**-**
181814	**-**
181815	**-**
181816	**-**

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Moisture Content Report

Client :	**Jacobs**	Report Number:	**48629 - 3/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number :	**48629**	Report Date:	**16/10/2018**
Project :	**Geotechnical Investigation**	Order Number:	
Location :	**Lake Moodemere , Rutherglen**	Test Method:	**AS1289.2.1.1**

Lab No :	181817	181818	181819	181820
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Date Sampled :	29/8/2018	29/8/2018	29/8/2018	29/8/2018
Date Tested :	10/9/2018	10/9/2018	10/9/2018	10/9/2018
Material Source :	Site	Site	Site	Site
For Use As :	Classification	Classification	Classification	Classification
Sample Location :	Bore Hole : 1 Start Depth (mm) : 5000 End Depth (mm) : 7000 (SM) Silty SAND, trace gravel	Bore Hole : 1 Start Depth (mm) : 7000 End Depth (mm) : 8000	Bore Hole : 1 Start Depth (mm) : 8000 End Depth (mm) : 10000	Bore Hole : 2 Start Depth (mm) : 100 End Depth (mm) : 2000 (ML) Sandy SILT
Drying Temperature(°C):	**105-110**	**105-110**	**105-110**	**105-110**
Moisture Content(%):	**24.6**	**21.2**	**28.8**	**6.1**
Remarks :				

Lab Number:	Soil Description
181817	**-**
181818	**-**
181819	**-**
181820	**-**

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Moisture Content Report

Client :	**Jacobs**	Report Number:	**48629 - 3/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number :	**48629**	Report Date:	**16/10/2018**
Project :	**Geotechnical Investigation**	Order Number:	
Location :	**Lake Moodemere , Rutherglen**	Test Method:	**AS1289.2.1.1**

Lab No :	181821	181822	181823	181824
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Date Sampled :	29/8/2018	29/8/2018	29/8/2018	29/8/2018
Date Tested :	10/9/2018	10/9/2018	10/9/2018	10/9/2018
Material Source :	Site	Site	Site	Site
For Use As :	Classification	Classification	Classification	Classification
Sample Location :	Bore Hole : 2 Start Depth (mm) : 2000 End Depth (mm) : 3000	Bore Hole : 2 Start Depth (mm) : 3000 End Depth (mm) : 5000	Bore Hole : 2 Start Depth (mm) : 5000 End Depth (mm) : 8000	Bore Hole : 2 Start Depth (mm) : 8000 End Depth (mm) : 10000 (CI) Sandy CLAY, trace gravel
Drying Temperature(°C):	**105-110**	**105-110**	**105-110**	**105-110**
Moisture Content(%):	**9.1**	**14.2**	**17.4**	**24**
Remarks :				

Lab Number:	Soil Description
181821	**-**
181822	**-**
181823	**-**
181824	**-**

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Moisture Content Report

Client :	**Jacobs**	Report Number:	**48629 - 3/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number :	**48629**	Report Date:	**16/10/2018**
Project :	**Geotechnical Investigation**	Order Number:	
Location :	**Lake Moodemere , Rutherglen**	Test Method:	**AS1289.2.1.1**

Lab No :	181825	181826	181827	181828
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Date Sampled :	29/8/2018	29/8/2018	29/8/2018	29/8/2018
Date Tested :	10/9/2018	10/9/2018	10/9/2018	10/9/2018
Material Source :	Site	Site	Site	Site
For Use As :	Classification	Classification	Classification	Classification
Sample Location :	Bore Hole : 3 Start Depth (mm) : 200 End Depth (mm) : 4000	Bore Hole : 3 Start Depth (mm) : 4000 End Depth (mm) : 5500 (ML-SM) Sandy SILT - Silty SAND	Bore Hole : 3 Start Depth (mm) : 5500 End Depth (mm) : 6500 (ML) Sandy SILT	Bore Hole : 3 Start Depth (mm) : 6500 End Depth (mm) : 7500
Drying Temperature(°C):	**105-110**	**105-110**	**105-110**	**105-110**
Moisture Content(%):	**5.2**	**11.6**	**25.2**	**30**
Remarks :				

Lab Number:	Soil Description
181825	**-**
181826	**-**
181827	**-**
181828	**-**

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Moisture Content Report

Client :	**Jacobs**	Report Number:	**48629 - 3/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number :	**48629**	Report Date:	**16/10/2018**
Project :	**Geotechnical Investigation**	Order Number:	
Location :	**Lake Moodemere , Rutherglen**	Test Method:	**AS1289.2.1.1**

Lab No :	181829	181830	181831	181832
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Date Sampled :	29/8/2018	29/8/2018	29/8/2018	29/8/2018
Date Tested :	10/9/2018	10/9/2018	10/9/2018	10/9/2018
Material Source :	Site	Site	Site	Site
For Use As :	Classification	Classification	Classification	Classification
Sample Location :	Bore Hole : 3 Start Depth (mm) : 7500 End Depth (mm) : 10000 (SM-SP) SAND, with silt, trace gravel	Bore Hole : 4 Start Depth (mm) : 200 End Depth (mm) : 800	Bore Hole : 4 Start Depth (mm) : 800 End Depth (mm) : 2500 (ML) Sandy SILT	Bore Hole : 4 Start Depth (mm) : 2500 End Depth (mm) : 4500
Drying Temperature(°C):	**105-110**	**105-110**	**105-110**	**105-110**
Moisture Content(%):	**24.8**	**19.0**	**6.4**	**17.1**
Remarks :				

Lab Number:	Soil Description
181829	**-**
181830	**-**
181831	**-**
181832	**-**

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Moisture Content Report

Client :	**Jacobs**	Report Number:	**48629 - 3/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number :	**48629**	Report Date:	**16/10/2018**
Project :	**Geotechnical Investigation**	Order Number:	
Location :	**Lake Moodemere , Rutherglen**	Test Method:	**AS1289.2.1.1**

Lab No :	181833	181834	181835	181836
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Date Sampled :	29/8/2018	29/8/2018	29/8/2018	29/8/2018
Date Tested :	10/9/2018	10/9/2018	10/9/2018	10/9/2018
Material Source :	Site	Site	Site	Site
For Use As :	Classification	Classification	Classification	Classification
Sample Location :	Bore Hole : 4 Start Depth (mm) : 4500 End Depth (mm) : 5000	Bore Hole : 5 Start Depth (mm) : 300 End Depth (mm) : 800	Bore Hole : 5 Start Depth (mm) : 800 End Depth (mm) : 2000	Bore Hole : 5 Start Depth (mm) : 2000 End Depth (mm) : 3000 (CL) CLAY, with sand
Drying Temperature(°C):	**105-110**	**105-110**	**105-110**	**105-110**
Moisture Content(%):	**21.4**	**7.9**	**15.7**	**22**
Remarks :				

Lab Number:	Soil Description
181833	**-**
181834	**-**
181835	**-**
181836	**-**

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Moisture Content Report

Client :	**Jacobs**	Report Number:	**48629 - 3/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number :	**48629**	Report Date:	**16/10/2018**
Project :	**Geotechnical Investigation**	Order Number:	
Location :	**Lake Moodemere , Rutherglen**	Test Method:	**AS1289.2.1.1**

Lab No :	181837	181838	181839	181840
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Date Sampled :	29/8/2018	29/8/2018	29/8/2018	29/8/2018
Date Tested :	10/9/2018	10/9/2018	10/9/2018	10/9/2018
Material Source :	Site	Site	Site	Site
For Use As :	Classification	Classification	Classification	Classification
Sample Location :	Bore Hole : 5 Start Depth (mm) : 3000 End Depth (mm) : 4500 (CL) Sandy CLAY	Bore Hole : 6 Start Depth (mm) : 400 End Depth (mm) : 1200	Bore Hole : 6 Start Depth (mm) : 1200 End Depth (mm) : 3000 (CL-ML) Sandy CLAY	Bore Hole : 6 Start Depth (mm) : 3000 End Depth (mm) : 4000
Drying Temperature(°C):	**105-110**	**105-110**	**105-110**	**105-110**
Moisture Content(%):	**26.6**	**1.7**	**12.2**	**17.8**
Remarks :				

Lab Number:	Soil Description
181837	**-**
181838	**-**
181839	**-**
181840	**-**

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Moisture Content Report

Client :	**Jacobs**	Report Number:	**48629 - 3/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number :	**48629**	Report Date:	**16/10/2018**
Project :	**Geotechnical Investigation**	Order Number:	
Location :	**Lake Moodemere , Rutherglen**	Test Method:	**AS1289.2.1.1**

Lab No :	181841	181842	181843	181844
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Date Sampled :	29/8/2018	29/8/2018	29/8/2018	29/8/2018
Date Tested :	10/9/2018	10/9/2018	10/9/2018	10/9/2018
Material Source :	Site	Site	Site	Site
For Use As :	Classification	Classification	Classification	Classification
Sample Location :	Bore Hole : 6 Start Depth (mm) : 4000 End Depth (mm) : 5000	Bore Hole : 7 Start Depth (mm) : 500 End Depth (mm) : 1400	Bore Hole : 7 Start Depth (mm) : 1400 End Depth (mm) : 3000	Bore Hole : 7 Start Depth (mm) : 3000 End Depth (mm) : 4000
Drying Temperature(°C):	**105-110**	**105-110**	**105-110**	**105-110**
Moisture Content(%):	**23.6**	**2.1**	**12.1**	**15.3**
Remarks :				

Lab Number:	Soil Description
181841	**-**
181842	**-**
181843	**-**
181844	**-**

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Moisture Content Report

Client :	**Jacobs**	Report Number:	**48629 - 3/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number :	**48629**	Report Date:	**16/10/2018**
Project :	**Geotechnical Investigation**	Order Number:	
Location :	**Lake Moodemere , Rutherglen**	Test Method:	**AS1289.2.1.1**

Lab No :	181845	181846	181847	181848
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Date Sampled :	29/8/2018	29/8/2018	29/8/2018	29/8/2018
Date Tested :	10/9/2018	10/9/2018	10/9/2018	10/9/2018
Material Source :	Site	Site	Site	Site
For Use As :	Classification	Classification	Classification	Classification
Sample Location :	Bore Hole : 7 Start Depth (mm) : 4000 End Depth (mm) : 5000	Bore Hole : 8 Start Depth (mm) : 100 End Depth (mm) : 2000 (CI) CLAY, trace sand	Bore Hole : 8 Start Depth (mm) : 2000 End Depth (mm) : 3000	Bore Hole : 8 Start Depth (mm) : 3000 End Depth (mm) : 4500
Drying Temperature(°C):	**105-110**	**105-110**	**105-110**	**105-110**
Moisture Content(%):	**23.4**	**20.0**	**22.0**	**28**
Remarks :				

Lab Number:	Soil Description
181845	**-**
181846	**-**
181847	**-**
181848	**-**

NATA WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025 - Testing. The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

APPROVED SIGNATORY

David Sleep

NATA Accred No:5023

FORM NUMBER

REP MC-1-10

B·M CIVIL ENGINEERS

B.M CIVIL ENGINEERS PTY.LTD.
A.B.N 36 473 826 551

8 Midstar Crescent, Shepparton, 3631
P.O. Box 6577, Shepparton, 3632

David Earl B. Eng. (Civil), M.I.E. (Aus.) EC30953

Peter Willmott B. Eng. (Civil), M.I.E. (Aus.) EC30681

Ph: (03) 5823 5781
Fax: (03) 5823 5782

Moisture Content Report

Client :	**Jacobs**	Report Number:	**48629 - 3/1**
Client Address:	**Level 11, 452 Flinders Street Melbourne VIC**		
Job Number :	**48629**	Report Date:	**16/10/2018**
Project :	**Geotechnical Investigation**	Order Number:	
Location :	**Lake Moodemere , Rutherglen**	Test Method:	**AS1289.2.1.1**

Lab No :	181849	181850	181851	181852
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Date Sampled :	29/8/2018	29/8/2018	29/8/2018	29/8/2018
Date Tested :	10/9/2018	10/9/2018	10/9/2018	10/9/2018
Material Source :	Site	Site	Site	Site
For Use As :	Classification	Classification	Classification	Classification
Sample Location :	Bore Hole : 9 Start Depth (mm) : 100 End Depth (mm) : 1500	Bore Hole : 9 Start Depth (mm) : 1500 End Depth (mm) : 2000 (CL) Sandy CLAY	Bore Hole : 9 Start Depth (mm) : 2000 End Depth (mm) : 2800	Bore Hole : 9 Start Depth (mm) : 2800 End Depth (mm) : 4500
Drying Temperature(°C):	**105-110**	**105-110**	**105-110**	**105-110**
Moisture Content(%):	**17.2**	**13.4**	**20.4**	**28**
Remarks :				

Lab Number:	Soil Description
181849	**-**
181850	**-**
181851	**-**
181852	**-**

NATA WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025 - Testing. The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

APPROVED SIGNATORY

David Sleep

NATA Accred No:5023

FORM NUMBER

REP MC-1-10

Appendix B. Site Survey Check Plots

HARD COPY CHECK PLOT - SHEET 1 OF 2
REVISION 1
FEATURE SURVEY - SUNDAY CREEK IRRIGATION AREA
SITES 1, 2 & 3: PUMP STATION SITE / PIPELINE ROUTE / LAKE MOODEMERE REGULATOR
CS&A REF: 18146
SURVEY DATE: 21st November, 2018

MGA 94 ZONE 55

ATTENTION - TIM SLAVIN

NOTE: EVERY ENDEAVOUR HAS BEEN TAKEN TO LOCATE VISIBLE STRUCTURES AND SERVICES HOWEVER, THERE IS NO GUARANTEE GIVEN THAT ALL EXISTING STRUCTURES AND SERVICES ARE SHOWN OR LOCATED EXACTLY. POSITIONS AND LEVELS OF THESE SERVICES SHOULD BE PROVEN ON SITE BEFORE COMMENCEMENT OF ANY WORKS.

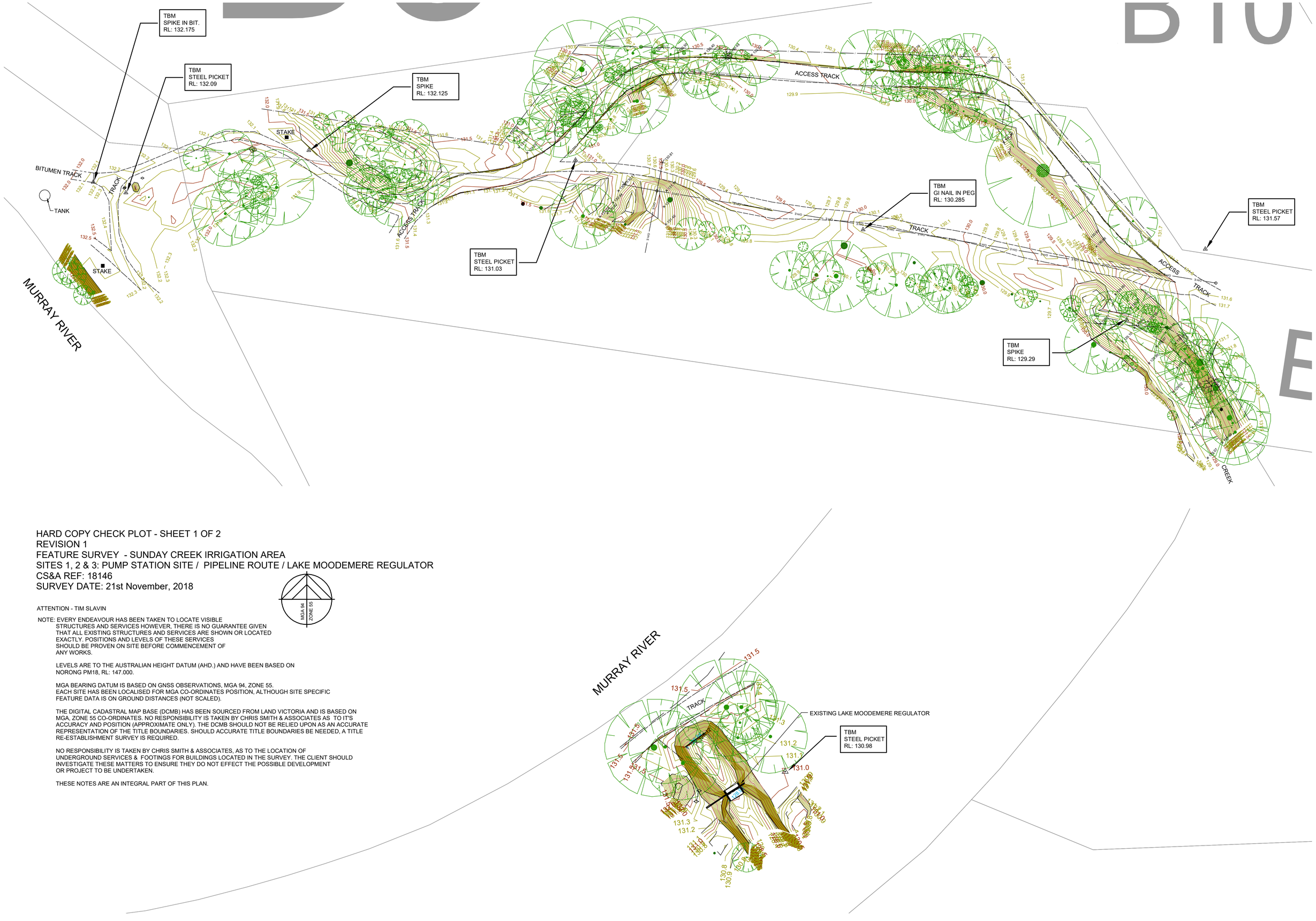
LEVELS ARE TO THE AUSTRALIAN HEIGHT DATUM (AHD.) AND HAVE BEEN BASED ON NORONG PM18, RL: 147.000.

MGA BEARING DATUM IS BASED ON GNSS OBSERVATIONS, MGA 94, ZONE 55. EACH SITE HAS BEEN LOCALISED FOR MGA CO-ORDINATES POSITION, ALTHOUGH SITE SPECIFIC FEATURE DATA IS ON GROUND DISTANCES (NOT SCALED).

THE DIGITAL CADASTRAL MAP BASE (DCMB) HAS BEEN SOURCED FROM LAND VICTORIA AND IS BASED ON MGA, ZONE 55 CO-ORDINATES. NO RESPONSIBILITY IS TAKEN BY CHRIS SMITH & ASSOCIATES AS TO IT'S ACCURACY AND POSITION (APPROXIMATE ONLY). THE DCMB SHOULD NOT BE RELIED UPON AS AN ACCURATE REPRESENTATION OF THE TITLE BOUNDARIES. SHOULD ACCURATE TITLE BOUNDARIES BE NEEDED, A TITLE RE-ESTABLISHMENT SURVEY IS REQUIRED.

NO RESPONSIBILITY IS TAKEN BY CHRIS SMITH & ASSOCIATES, AS TO THE LOCATION OF UNDERGROUND SERVICES & FOOTINGS FOR BUILDINGS LOCATED IN THE SURVEY. THE CLIENT SHOULD INVESTIGATE THESE MATTERS TO ENSURE THEY DO NOT EFFECT THE POSSIBLE DEVELOPMENT OR PROJECT TO BE UNDERTAKEN.

THESE NOTES ARE AN INTEGRAL PART OF THIS PLAN.



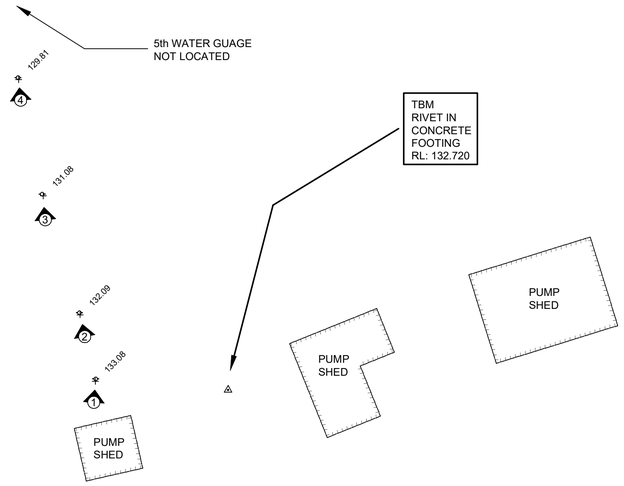


Photo 1

Photo 2

Photo 3

Photo 4

HARD COPY CHECK PLOT - SHEET 2 OF 2
REVISION 1
FEATURE SURVEY - SUNDAY CREEK IRRIGATION AREA
SITES 4 & 5: WATER GUAGES / HELLS GATE
CS&A REF: 18146
SURVEY DATE: 15th January, 2019

MGA 94
ZONE 55

ATTENTION - TIM SLAVIN

NOTE: EVERY ENDEAVOUR HAS BEEN TAKEN TO LOCATE VISIBLE STRUCTURES AND SERVICES HOWEVER, THERE IS NO GUARANTEE GIVEN THAT ALL EXISTING STRUCTURES AND SERVICES ARE SHOWN OR LOCATED EXACTLY. POSITIONS AND LEVELS OF THESE SERVICES SHOULD BE PROVEN ON SITE BEFORE COMMENCEMENT OF ANY WORKS.

LEVELS ARE TO THE AUSTRALIAN HEIGHT DATUM (AHD.) AND HAVE BEEN BASED ON NORONG PM18, RL: 147.000.

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EACH SITE HAS BEEN LOCALISED FOR MGA CO-ORDINATES POSITION, ALTHOUGH SITE SPECIFIC FEATURE DATA IS ON GROUND DISTANCES (NOT SCALED).

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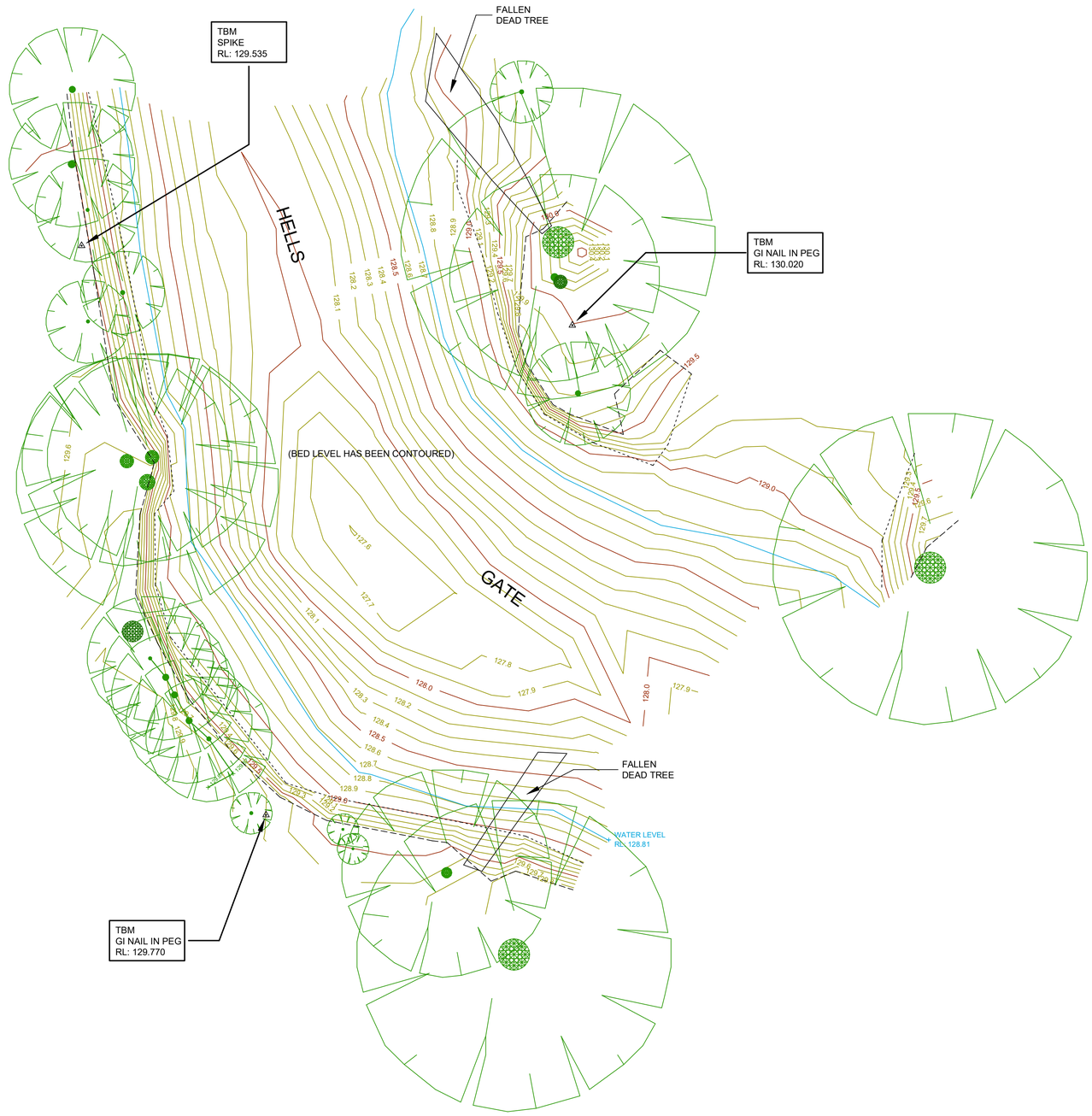
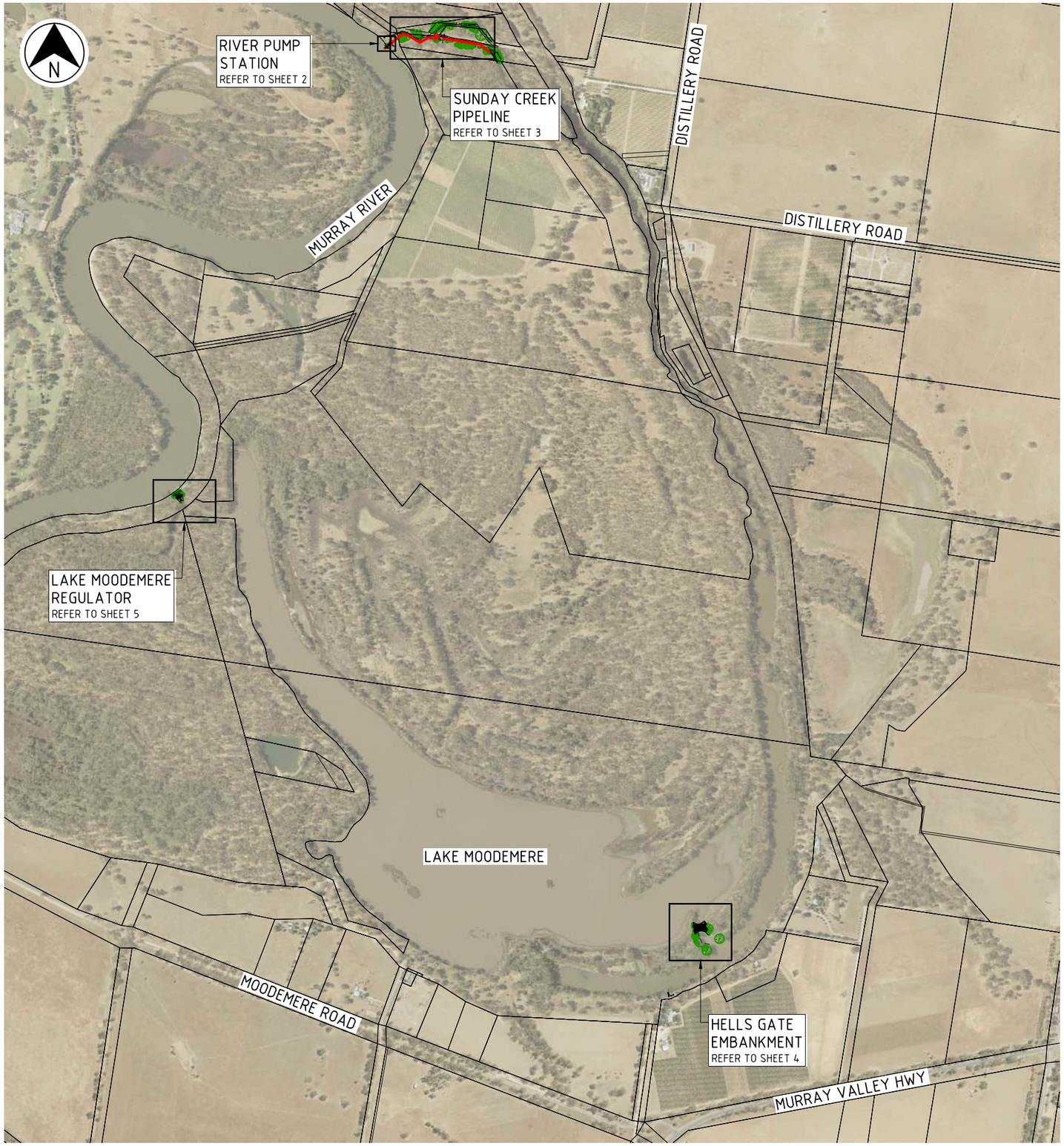
THESE NOTES ARE AN INTEGRAL PART OF THIS PLAN.

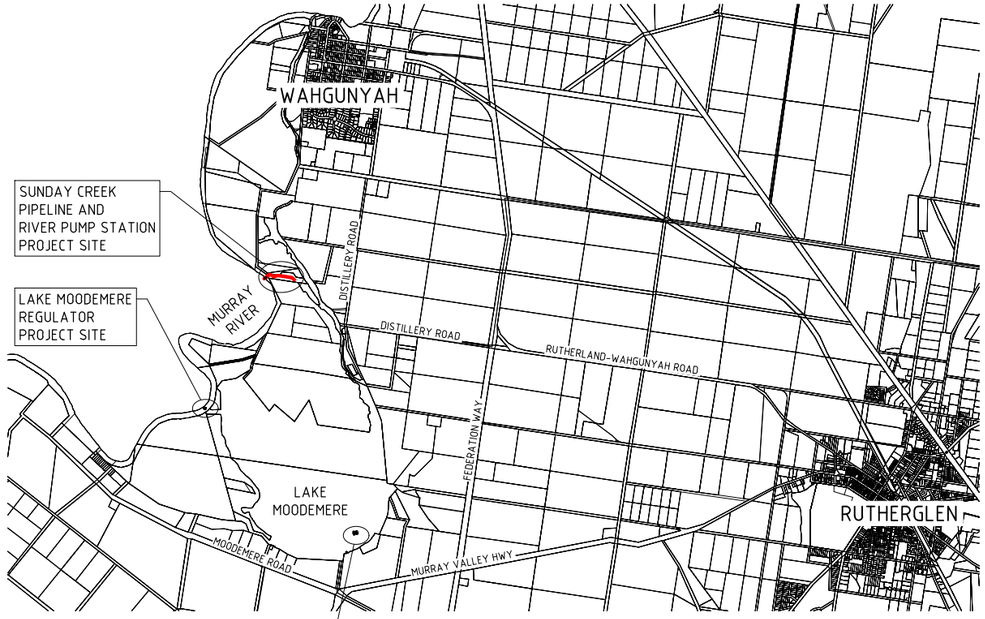
LAKE MOODEMERE



Appendix C. Preliminary Design Drawings



KEY PLAN
NTS



LOCALITY PLAN
NTS

DESIGN BASIS

PROJECT SUMMARY

RECONFIGURATION OF EXISTING IRRIGATION SCHEME AT SUNDAY CREEK AND LAKE MOODEMERE WITH PROPOSED INFRASTRUCTURE INCLUDING A RIVER PUMP STATION, A DN560 PIPELINE AND DISCHARGE PIT, AN EARTHEN EMBANKMENT AND A REPLACEMENT REGULATING STRUCTURE.

RIVER PUMP STATION

- INCLINED AXIAL FLOW DUTY PUMP (NO STANDBY) ON RIVER BANK
- 36 ML/d DUTY
- PUMPING HEAD RANGE 4.8 - 8.3m

SUNDAY CREEK PIPELINE

- 36 ML/d FLOW RATE
- 340m LENGTH
- DN560 HDPE PN6.3 (WITH SECTIONS ON PN8 FOR TRACK CROSSINGS AND ALONG SUNDAY CREEK)

HELLS GATE EMBANKMENT

- EARTHEN EMBANKMENT WITH ROCK BEACHING TO SET LEVEL IN SUNDAY CREEK
- CREST ELEVATION 129.00m AHD
- CREST WIDTH 0.8m
- NOMINATED HARD BED LEVEL 127.67m AHD

LAKE MOODEMERE REGULATOR

- REINFORCED CONCRETE STRUCTURE TO ALLOW LEVEL IN LAKE MOODEMERE TO BE CONTROLLED
- TOP OF CONCRETE 130.00m AHD
- FLOOR LEVEL 127.95m AHD
- 3 OPENINGS 700 HIGH x 600 WIDE
- ONE WAY FLAP GATE ON LAKE SIDE TO PREVENT BACKFLOW INTO RIVER

DRAWING LIST

LEGEND

- SUNDAY CREEK PIPELINE
- OVERHEAD ELECTRICITY
- CADASTRAL BOUNDARY (INDICATIVE)
- SURVEY MARK
- EXISTING FENCELINE
- FENCELINE

NOT FOR CONSTRUCTION

REV	DATE	DESIGN REVIEW	REV'D P.MGR	APP'D P.DIR	REVISIONS
A	16/04/19	AH	TS		ISSUED FOR REVIEW

REV.	PLAN NO.	REFERENCE PLAN TITLE

DRAWN: K. KARAN	DESIGNED: T. SLAVIN	REVIEWED PROJECT MANAGER: T. SLAVIN
DRAWING CHECKED: T. GIBELLINI	DESIGN CHECKED: A. HALL	APPROVED PROJECT DIRECTOR

JACOBS
33 Kerferd Street, Tatura VIC. 3616 Australia
Telephone 03 5824 6400
Facsimile 03 5824 6444
JOB NO. : IS251000

MANAGER ASSETS SERVICE

GMW CORR. NO.

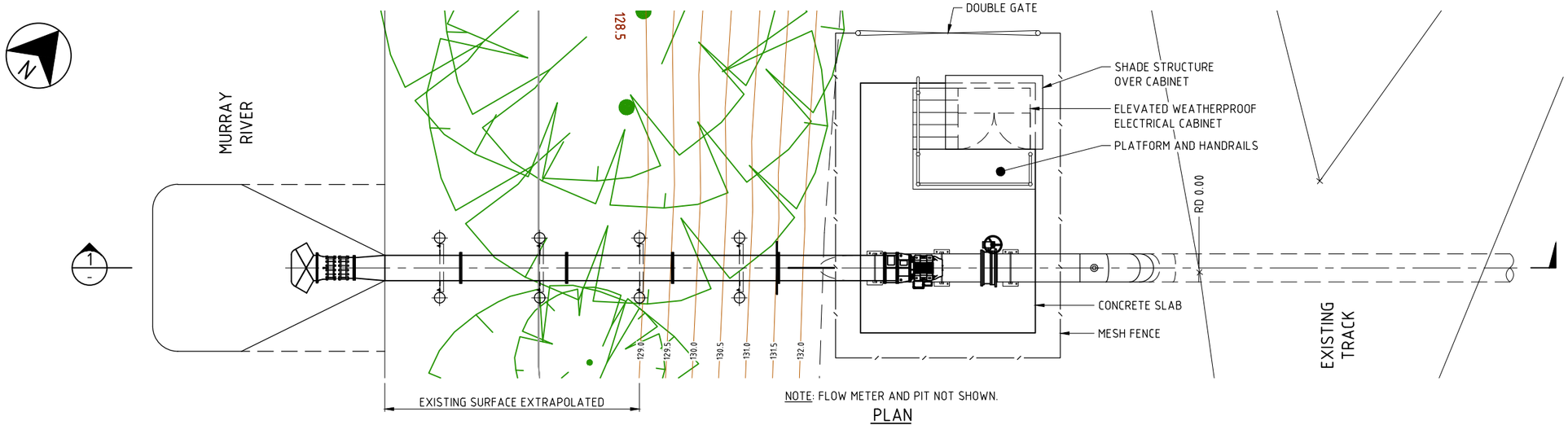
GOULBURN MURRAY RURAL WATER AUTHORITY
40 CASEY STREET (PO BOX 165), TATURA VIC. 3616
Telephone (03) 5833 5500 Fax (03) 5833 5501

SUNDAY CREEK RECONFIGURATION

LOCALITY PLAN, KEY PLAN AND DRAWING LIST

CAD DRAWING INDEX	SHEET NUMBER	DRAWING NUMBER	REVISION
	01 OF 05	477714	A

A1

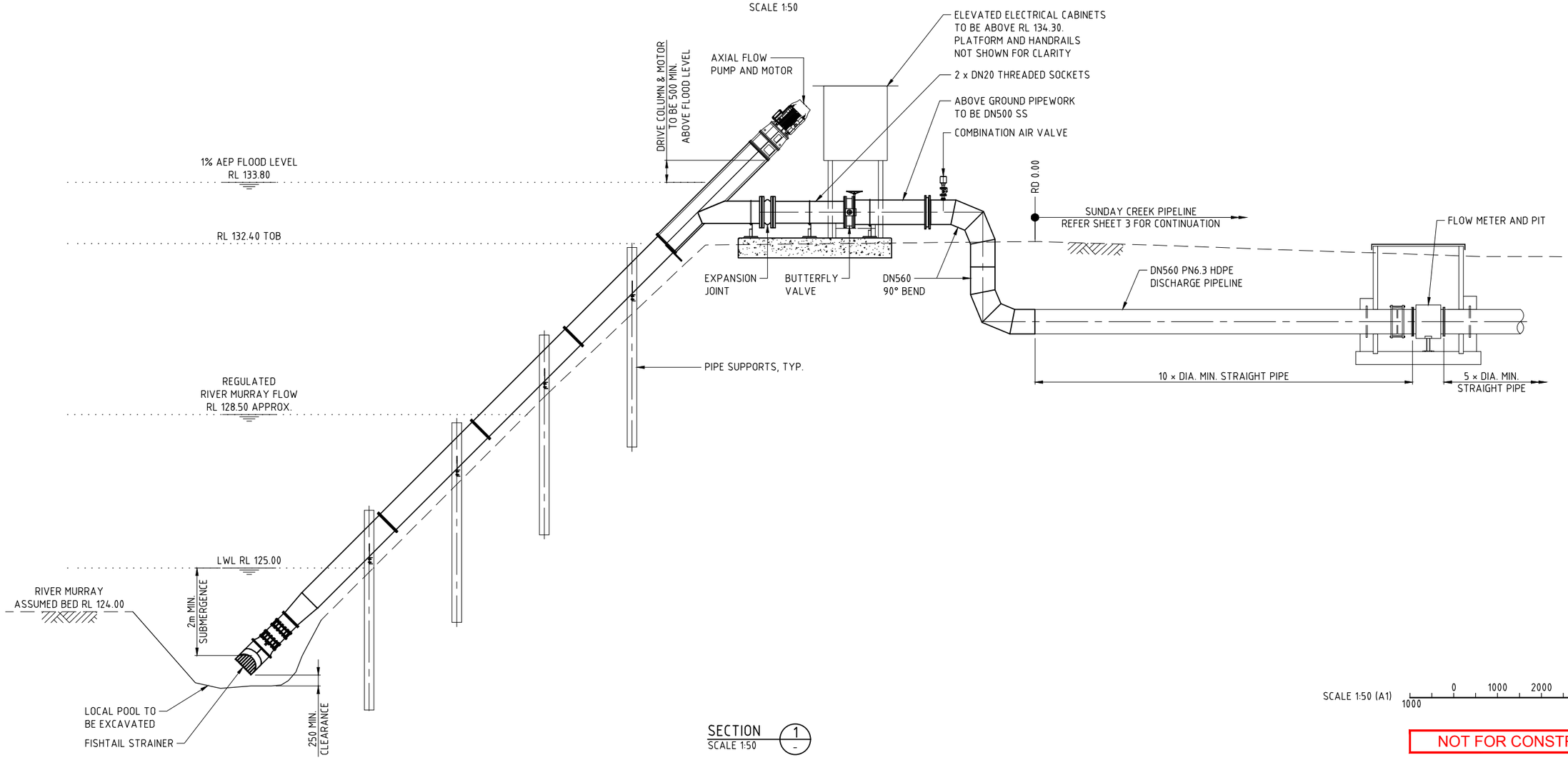


NOTE: FLOW METER AND PIT NOT SHOWN.

PLAN
SCALE 1:50

NOTES

1. PUMP ARRANGEMENT: DUTY (NO STANDBY PROVISION).
2. PUMP DUTY:
   Q: 36 ML/d
   H: 4.8m – 8.3m HEAD.
3. SETOUT INFORMATION NOT PROVIDED.



SECTION 1 / -
SCALE 1:50

SCALE 1:50 (A1) 0 1000 2000 3000 4000 5000mm

NOT FOR CONSTRUCTION

REV	DATE	DESIGN REVIEW	REV'D P.MGR	APP'D P.DIR	REVISIONS
A	16/04/19	MS	TS		ISSUED FOR REVIEW

REV.	PLAN NO.	REFERENCE PLAN TITLE

DRAWN	DESIGNED	REVIEWED PROJECT MANAGER
K. KARAN	D. MOHR	T. SLAVIN
DRAWING CHECKED	DESIGN CHECKED	
T. GIBELLINI	M. SIMPSON	

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33 Kerferd Street, Tatura VIC. 3616 Australia
Telephone 03 5824 6400
Facsimile 03 5824 6444

JOB NO. 15251000

APPROVED PROJECT DIRECTOR

MANAGER ASSETS SERVICE

SUNDAY CREEK RECONFIGURATION

RIVER PUMP STATION

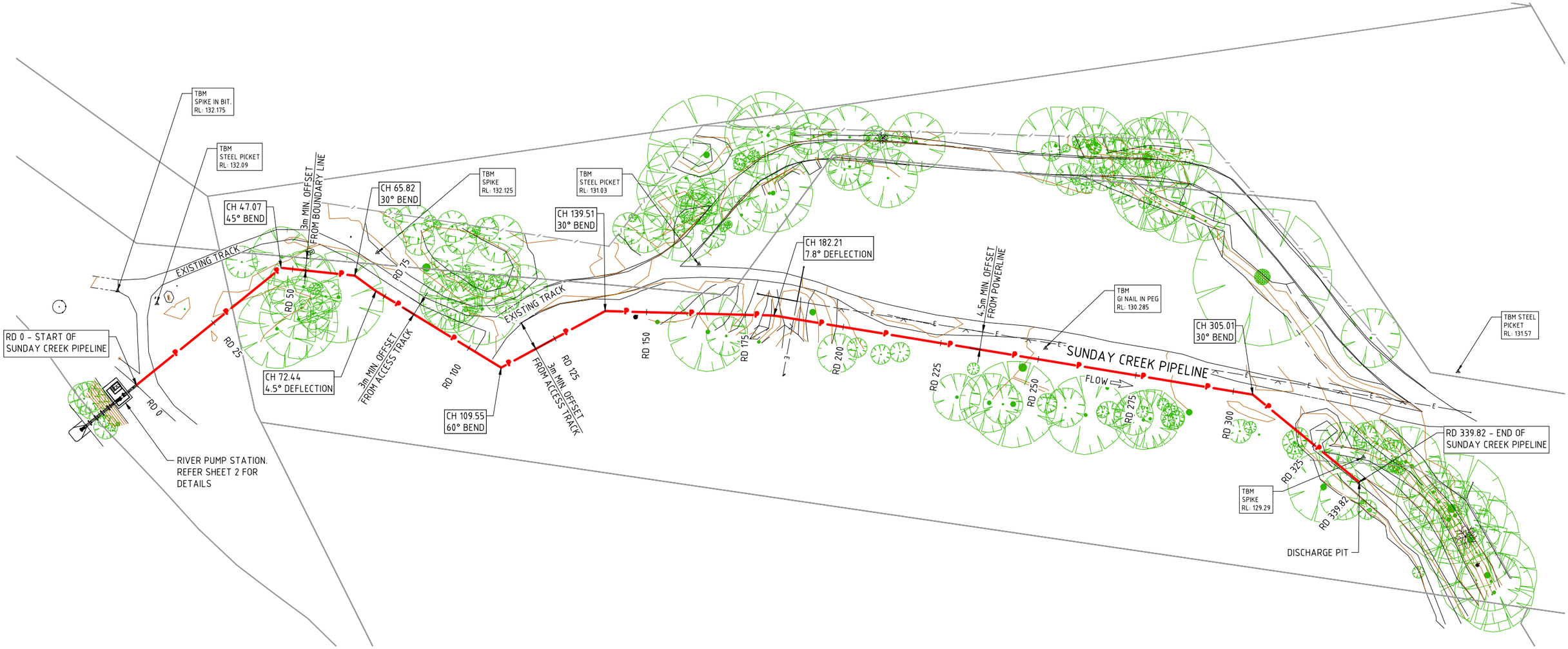
PLAN AND SECTION

GMW CORR. NO.	GOULBURN MURRAY RURAL WATER AUTHORITY	CAD DRAWING INDEX	SHEET NUMBER	DRAWING NUMBER	REVISION
	40 CASEY STREET (PO BOX 165), TATURA VIC. 3616 Telephone (03) 5833 5500 Fax (03) 5833 5501		02 OF 05	477714	A

A1

NOTES

1. FOR LEGEND AND DESIGN BASIS REFER SHEET 1.
2. AIR VALVES, SCOUR VALVES, INSPECTION OPENINGS AND OTHER PIPELINE FITTINGS NOT SHOWN. PIPELINE FITTINGS TO BE CONFIRMED DURING SUBSEQUENT DESIGN PHASE.
3. SETOUT INFORMATION NOT PROVIDED.



PLAN
SCALE 1:500

SCALE 1:500 (A1) 0 10 20 30 40 50m
10 8 6 4 2

NOT FOR CONSTRUCTION

REV	DATE	DESIGN REVIEW	REV'D P.MGR	APP'D P.DIR	REVISIONS
A	16/04/19	AH	T.S.		ISSUED FOR REVIEW

REV.	PLAN NO.	REFERENCE PLAN TITLE

DRAWN	DESIGNED	REVIEWED PROJECT MANAGER
K. KARAN	T. SLAVIN	T. SLAVIN
DRAWING CHECKED	DESIGN CHECKED	
T. GIBELLINI	A. HALL	

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Telephone 03 5824 6400
Facsimile 03 5824 6444

JOB NO. : IS251000

APPROVED PROJECT DIRECTOR

MANAGER ASSETS SERVICE

SUNDAY CREEK RECONFIGURATION

SUNDAY CREEK PIPELINE

HORIZONTAL ALIGNMENT

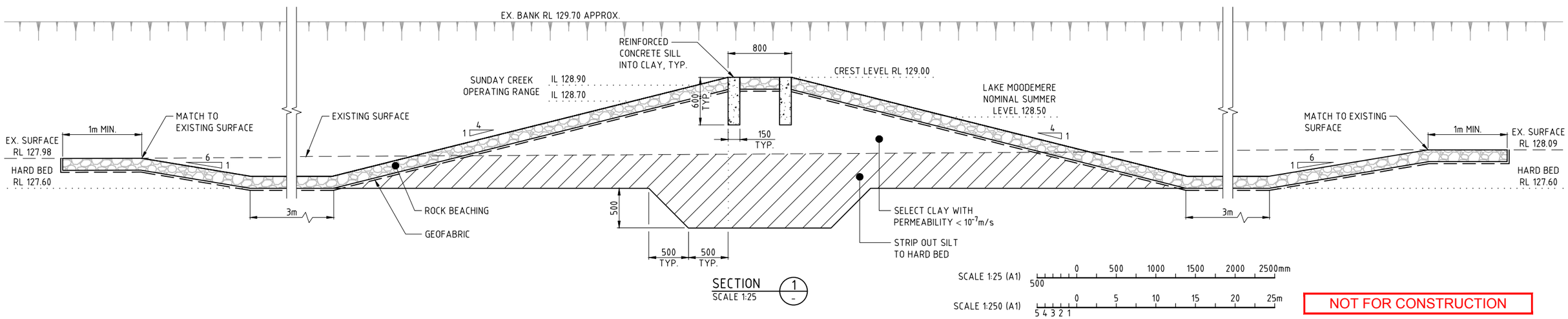
GMW CORR. NO.	GOULBURN MURRAY RURAL WATER AUTHORITY	CAD DRAWING INDEX	SHEET NUMBER	DRAWING NUMBER	REVISION
	40 CASEY STREET (PO BOX 165), TATURA VIC. 3616 Telephone (03) 5833 5500 Fax (03) 5833 5501		03 OF 05	477714	A

A1

PLAN
SCALE 1:250

NOTES

1. FOR LEGEND AND DESIGN BASIS REFER SHEET 1.
2. SETOUT INFORMATION NOT PROVIDED.



SECTION
SCALE 1:25

SCALE 1:25 (A1) 0 500 1000 1500 2000 2500mm

SCALE 1:250 (A1) 0 5 10 15 20 25m

NOT FOR CONSTRUCTION

REV	DATE	DESIGN REVIEW	REV'D P.MGR	APP'D P.DIR	REVISIONS
A	16/04/19	RD	TS		ISSUED FOR REVIEW

REV.	PLAN NO.	REFERENCE PLAN TITLE

DRAWN	DESIGNED	REVIEWED PROJECT MANAGER
K. KARAN	T. SLAVIN	T. SLAVIN
DRAWING CHECKED	DESIGN CHECKED	
T. GIBELLINI	R. DAVIS	

APPROVED PROJECT DIRECTOR

MANAGER ASSETS SERVICE

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VIC. 3616 Australia
Telephone 03 5824 6400
Facsimile 03 5824 6444
JOB NO. IS251000

GOULBURN-MURRAY WATER

SUNDAY CREEK RECONFIGURATION

HELLS GATE EMBANKMENT

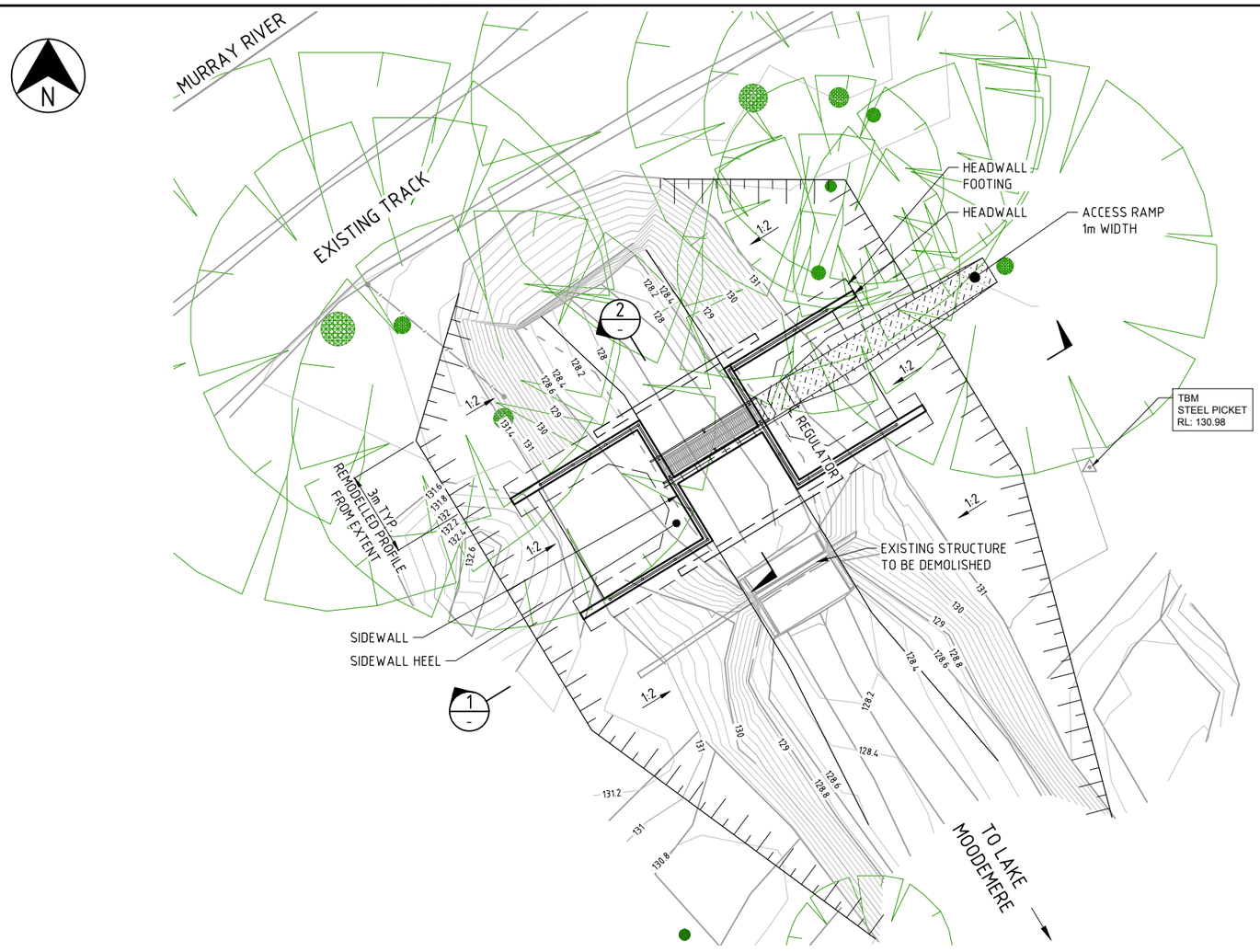
PLAN AND SECTION

GMW CORR. NO.	GOULBURN MURRAY RURAL WATER AUTHORITY	CAD DRAWING INDEX	SHEET NUMBER	DRAWING NUMBER	REVISION
	40 CASEY STREET (PO BOX 165), TATURA VIC. 3616 Telephone (03) 5833 5500 Fax (03) 5833 5501		04 OF 05	477714	A

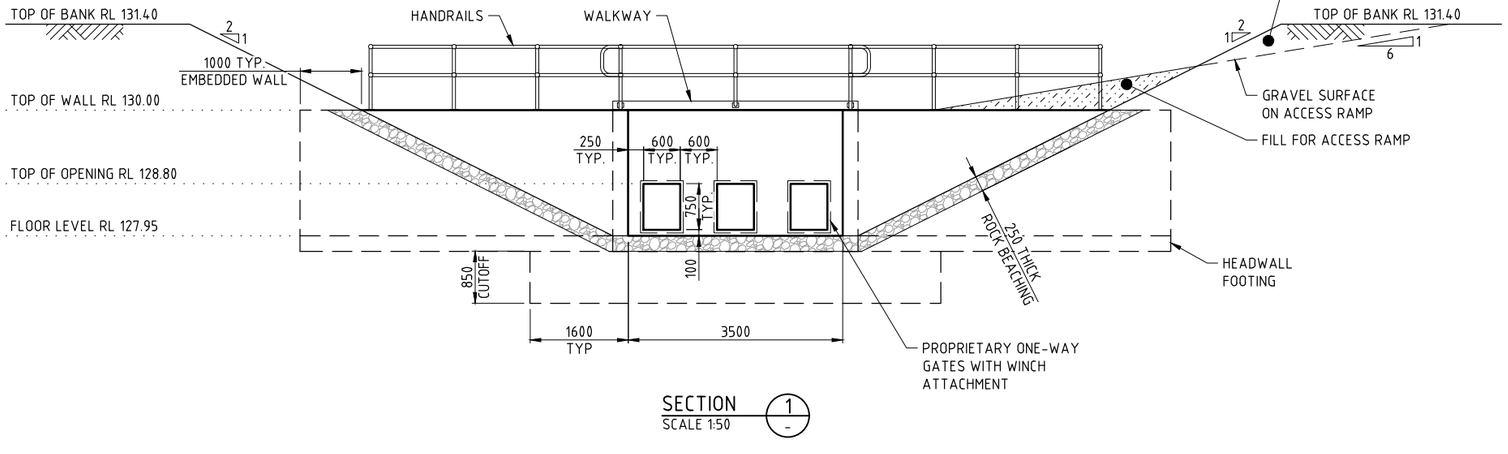
A1

NOTES

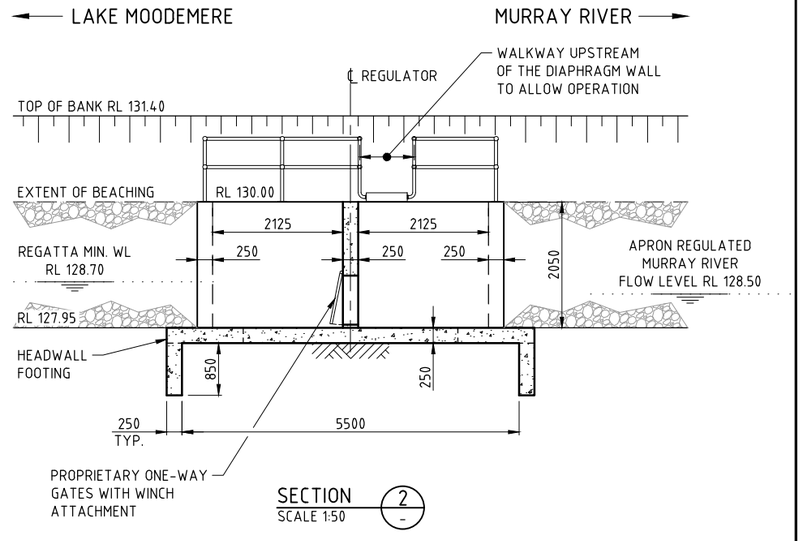
1. FOR LEGEND AND DESIGN BASIS REFER SHEET 1.
2. SETOUT INFORMATION NOT PROVIDED.



PLAN
SCALE 1:100



SECTION 1
SCALE 1:50



SECTION 2
SCALE 1:50

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SCALE 1:50 (A1) 0 1000 2000 3000 4000 5000mm (1000)

NOT FOR CONSTRUCTION

REV	DATE	DESIGN REVIEW	REV'D P.MGR	APP'D P.DIR	REVISIONS
A	16/04/19	NP	TS		ISSUED FOR REVIEW

REV.	PLAN NO.	REFERENCE PLAN TITLE

DRAWN	DESIGNED	REVIEWED PROJECT MANAGER	APPROVED PROJECT DIRECTOR	MANAGER ASSETS SERVICE
K. KARAN	T. SLAVIN	T. SLAVIN		
DRAWING CHECKED T. GIBELLINI	DESIGN CHECKED N. PAYNTER			

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33 Kerferd Street, Tatura
VIC. 3616 Australia
Telephone 03 5824 6400
Facsimile 03 5824 6444
JOB NO. IS251000

GOULBURN-MURRAY WATER

SUNDAY CREEK RECONFIGURATION

LAKE MOODEMERE REGULATOR

PLAN AND SECTION

GMW CORR. NO.	GOULBURN MURRAY RURAL WATER AUTHORITY	CAD DRAWING INDEX	SHEET NUMBER	DRAWING NUMBER	REVISION
	40 CASEY STREET (PO BOX 165), TATURA VIC. 3616 Telephone (03) 5833 5500 Fax (03) 5833 5501		05 OF 05	477714	A

A1

Appendix D. Pump Station Options Assessment

JACOBS

Memorandum

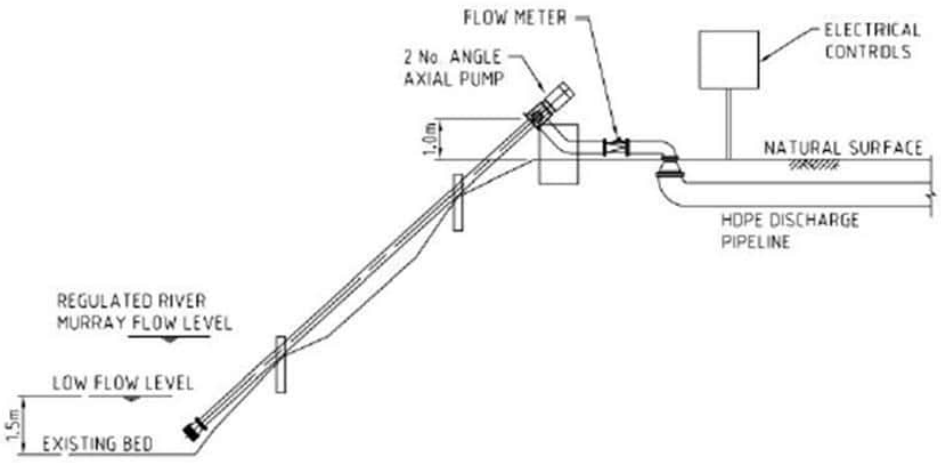
33 Kerferd Street
Tatura VIC 3616 Australia
PO Box 260
Tatura VIC 3616
T +61 3 5824 6400
F +61 3 5824 6444
www.jacobs.com

Subject	**Pump Station Location Options Assessment**	**Project Name**	Sunday Creek Reconfiguration
Attention	Luke O'Connor	**Project No.**	IS251000
From	Tim Slavin		
Date	25 February 2019		
Copies to	**Nick Kelleher, Ross Titchmarsh**		

1. Proposed Pump Station

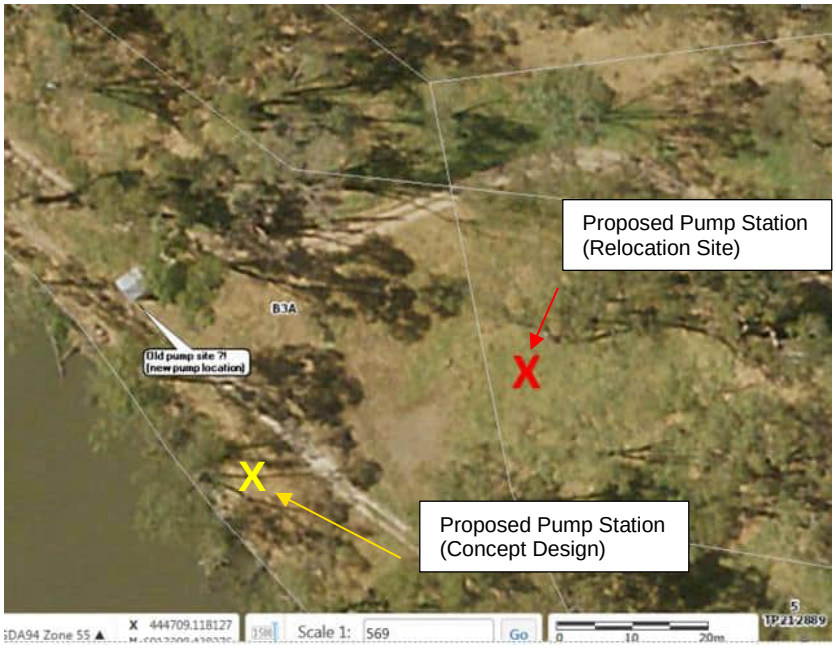
A new pump station is proposed on the bank of the Murray River to enable the reconfiguration of the Sunday Creek Irrigation Scheme. The pump station will supply a pipeline, which will in turn discharge at an appropriate location to allow Sunday Creek to fill and allow irrigation from.

Jacobs concept design proposes to install an angled axial flow pumping arrangement on the river bank, as depicted below;



This is the most simple and reliable method of delivering flow to the pipeline downstream, and is frequently installed in similar situations along the banks of the Murray River.

The landowners have expressed concerns about constructing a pump station at this location and have suggested that setting the pump station back from the river bank and within Crown Land is their preferred option. To satisfy this requirement the pump station would need to be set back approximately 50m from the river bank. The approximate location of the original pump station described in the concept design and of the proposed relocated pump station are shown below;



2. Design Criteria

Preliminary design information that has been gathered for the pump station (assuming the angled axial flow arrangement) is presented below;

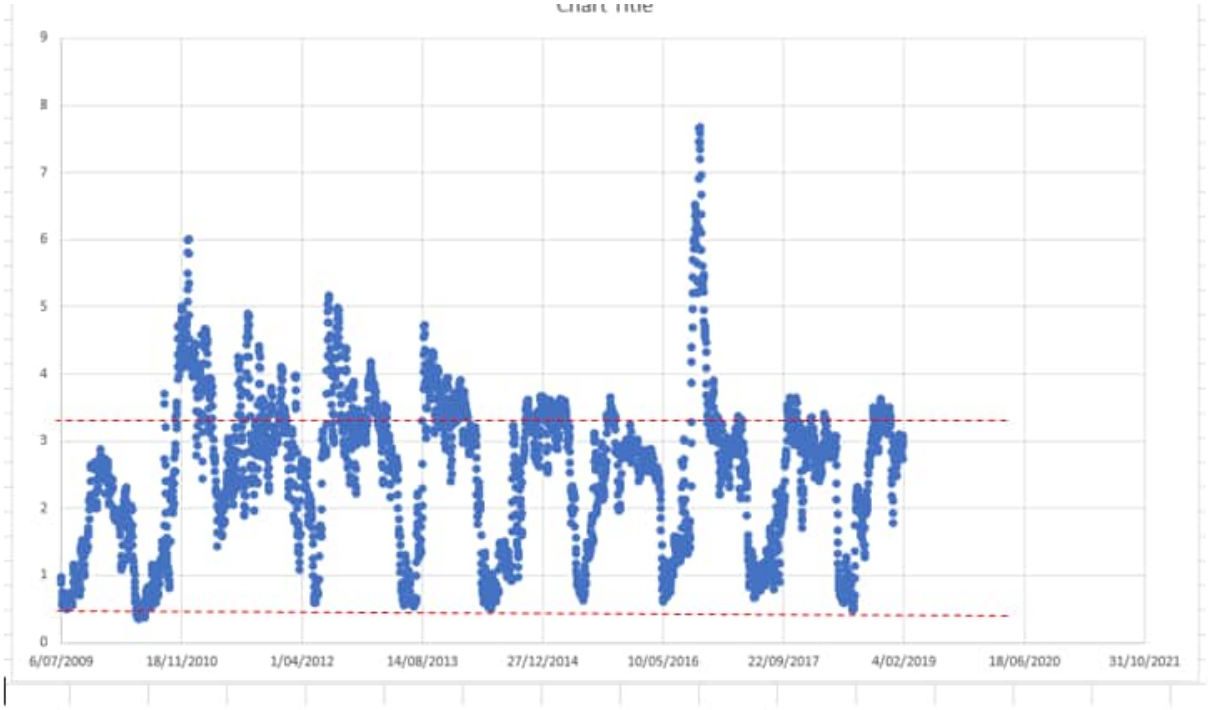
Design Criteria	Adopted Value	Comments
Peak Flow Rate	1.5 ML/hr	Flow rate calculated to meet water entitlements of Sunday Creek Irrigators under proposed operating conditions
Operating Conditions	7 hours per day during irrigation season, off peak power	Potential to increase supply by using on-peak power
Power Requirements	3 Phase Power -183 kVA estimated transformer requirement	Paterson Pump consultation for Concept Design pumping arrangement
Flood Level	4m above bank level	SKM, 2008 estimate of 1:100 year flood
Approximate Pipeline Length	550 - 600m	Approximate length of proposed pipeline along proposed alignment walkthrough (2018)
Preliminary Pipeline Size	560mm HDPE	Preliminary sizing – to be confirmed at Preliminary Design
Maximum Static Lift	Minimum 8.5m	
Top of Bank Elevation	132.37 mAHD	
Natural Surface at Set Back Pump Site	132.00 mAHD	

Design Criteria	Adopted Value	Comments
Maximum Elevation Along Pipeline Alignments	Approximately 132.5 mAHD	
Discharge Elevation	128.90 mAHD	
Estimated head loss though pipeline at design flow	5.5m	

Minimum Water Level Calculations

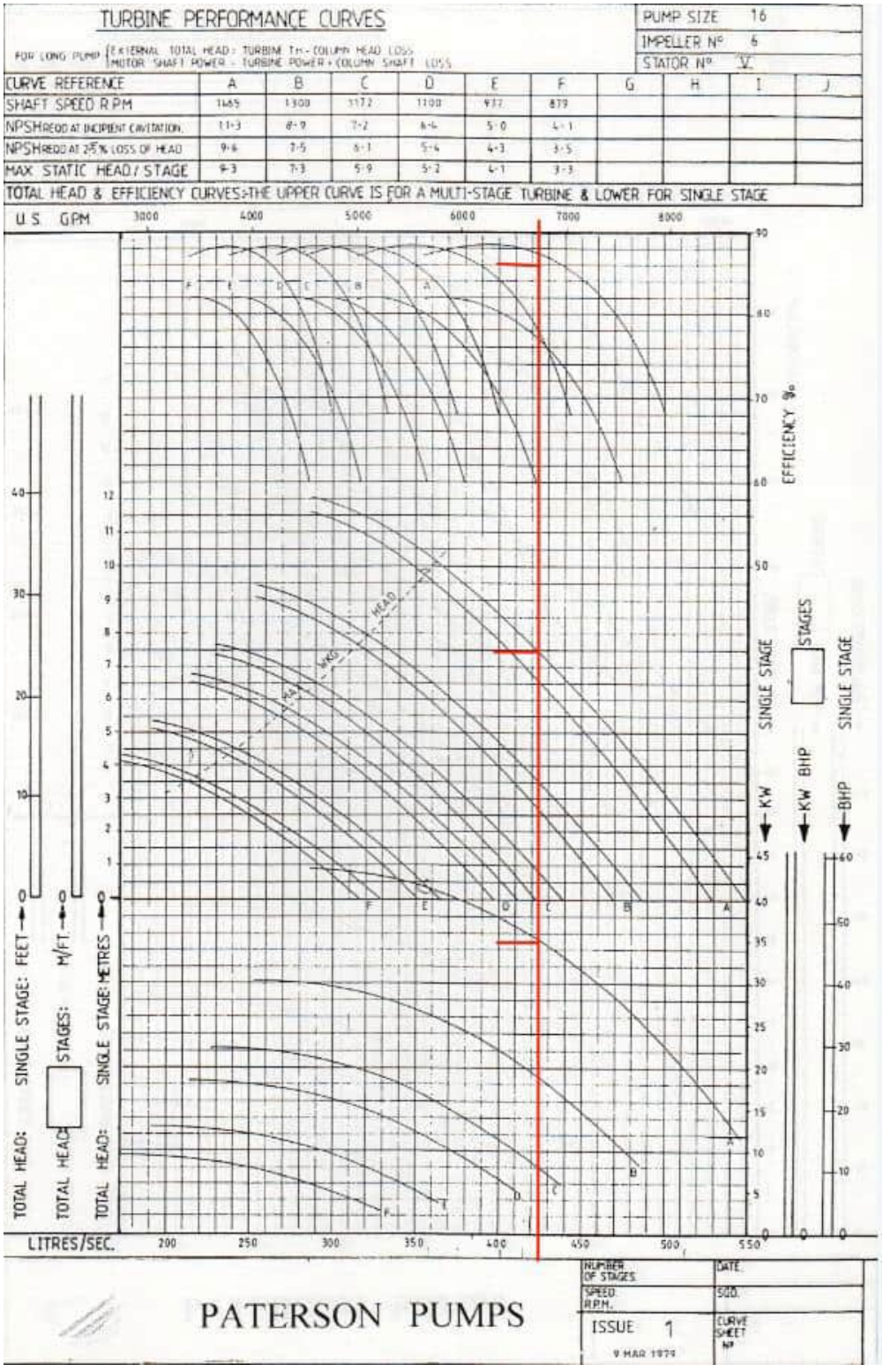
Survey along the bank at the proposed site marked that water level on 21st November 2018 at approximately 4m below the recorded top of bank level.

The Corowa Water Gauge indicated that the river level on 21st November was typical of summer flows;



The water level drops approximately 3m below this in winter. It is acknowledged that the pump station is not required to operate in winter during low flows, however there is considerable variation of the river level within the irrigation season. To ensure supply is always available to the Sunday Creek irrigators, the design of the pump station needs to account for the fluctuations. At this stage of the design process we have allowed for a minimum supply level of 2m below the typical summer flow without a detailed investigation into water levels and irrigation and supply patterns. The end result is that the minimum water level the pump station is designed for is approximately 6m below the top of the bank. This level will be finalised as part of the detailed design process and could be lower depending on final design requirements.

Information from a local pump supplier (Paterson Pumps) has recommended a 3 stage 12/16 pump (12" Impeller/16" Column") to meet these design requirements. A performance curve of this pump has been included below:



3. Possible Alternative Arrangements

Initial advice from Jacobs senior mechanical engineer was that there are potentially several alternative options to set-back the pump station from the river bank. Options identified were:

- Option 1: Shallow buried pipe up the river bank and across to the required pump location, in conjunction with above ground self-priming pumps;
- Option 2: Shallow buried pipe up the river bank, deeper trenched and buried pipe across to the required pump location, in conjunction with self-priming pumps located in a deep dry well;
- Option 3: Wet well at the required location set back from the river, with an inlet pipe bored through the Murray River bank at the depth required to meet submergence requirements;
- Option 4: Pump in a deep pit at the required location set back from the river bank, with a shallow siphon pipe buried between the pit and the river.

These were investigated further.

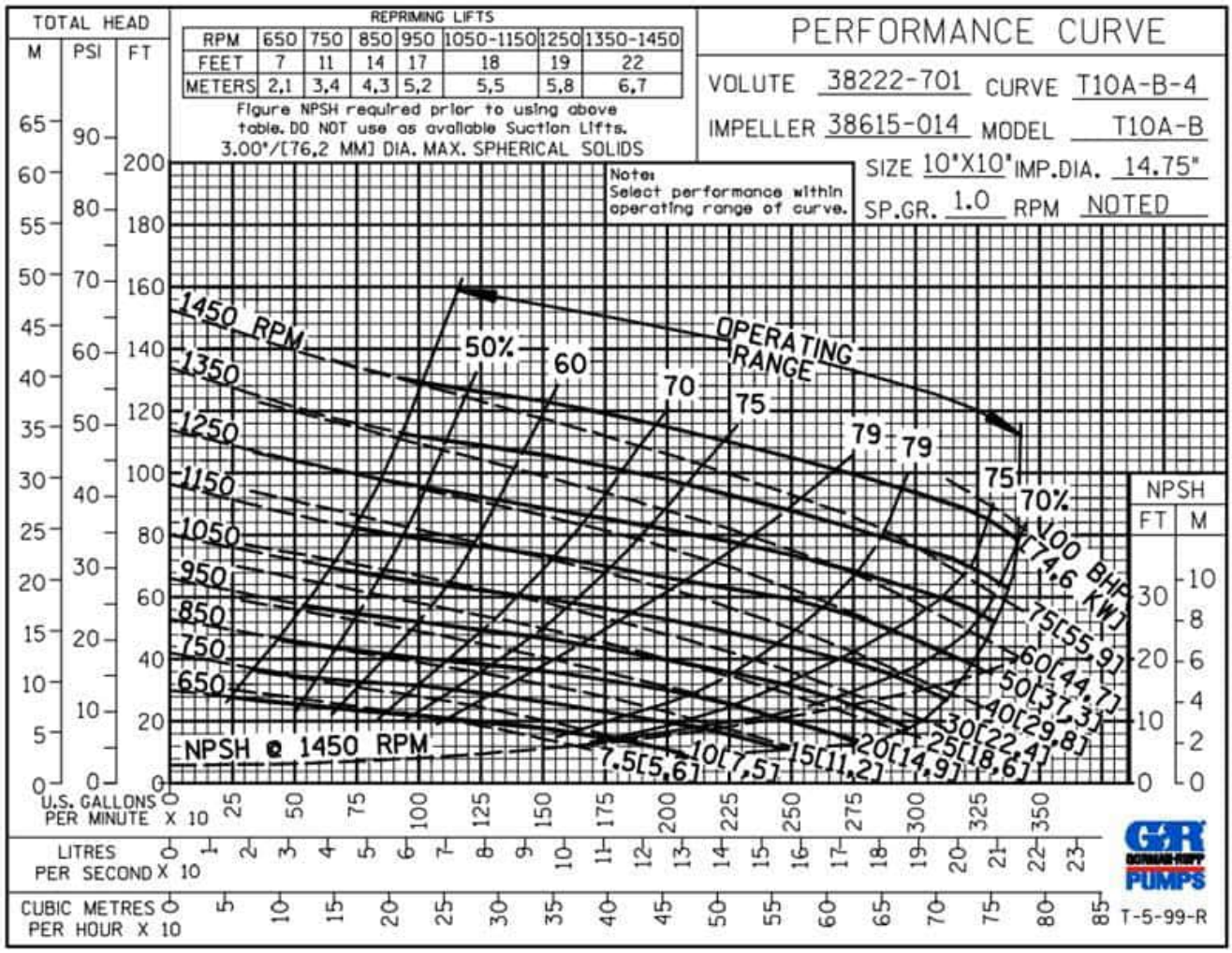
Option 1:

Shallow buried pipe up the river bank and across to the required pump location, in conjunction with above ground self-priming pumps.

Under this arrangement, the pumps would have to draw water from the Murray River low water level to the pump centreline height. The design would include a screened foot-valve located in the Murray River, but the pumps would still need to self-prime on system start-up, or if the foot valve passes and prime is lost.

The required pumped flow is 1.5ML/hr (416.7L/s).

The following is a pump curve for a typical (larger) self-priming pump. It has a capacity of up to nominally 180L/s so notionally three pumps of a similar size would be required.



Some points to note for this application are:

- The assumed pump centreline is 1m above ground level
- The foot valve will lose about 1m of head at full flow, but probably less when priming
- Suction pipe losses at full flow could be about 0.5m, but close to 0.0m when priming
- The required priming lift would be about 8m

- The required operating lift would be about 8.5m
- The losses down the delivery line would be about 4m
- The total head requirement of the pump would be around 12m

Resultant issues are:

- The NPSH available is only about 10 – 8.5 = 1.5m, so the pump would need to be run at reduced speed to avoid cavitation and less than 1000rpm to avoid run-out
- The priming lift (8m) cannot be achieved with this pump (at any speed)
- The screen and the foot valve would be difficult to access to inspection and maintenance
- The pumpset would need to be suitable for inundation in the event of a significant flood

Based on the above, Option 1 is considered not technically viable.

It has been noted that the current pumping arrangement is able to operate while lifting from the river. However, survey data has shown that the bank elevation at the current site is approximately 1m below the bank at the proposed site. This combined with the fact that the existing pump appears to be buried below the bank level by up to 1m and the requirement of a new pump being nominally 1m above the bank level results in a considerably different lifting scenario to the proposed arrangement. The existing pump station is not thought to be comparable to the proposed arrangement for these reasons.

Option 2:

Shallow buried pipe up the river bank, deeper trenched and buried pipe across to the required pump location, in conjunction with self-priming pumps located in a deep dry well.

This is a variant of Option 1. The suction pipe could be buried by (say) 3m and the pump station could be located in a large and (say) 4m deep pit. This would increase the NPSH available at the pump by 4m (to 5.5m) and would reduce the priming lift to 5m. This would allow the pump to be operated at 1000rpm for both priming and for operation.

The main issues with this arrangement are:

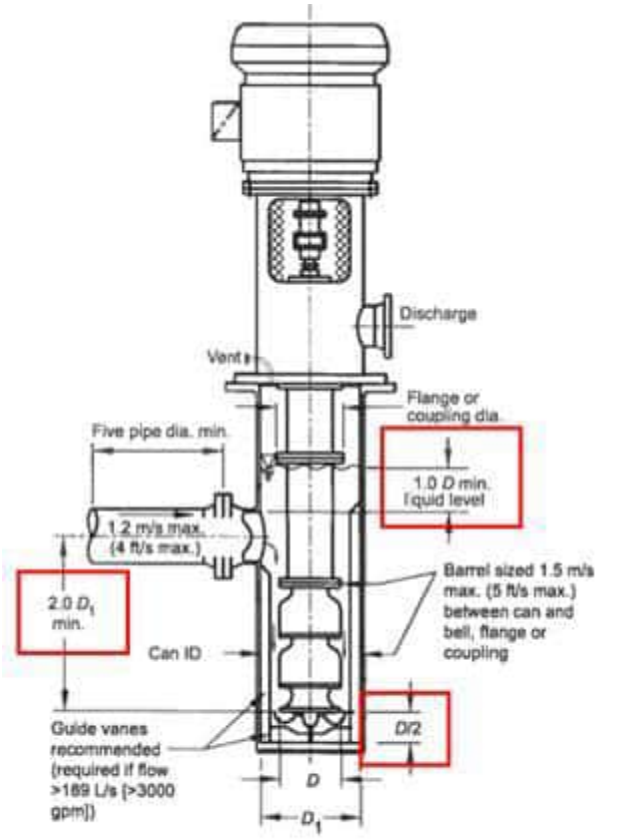
- The cost of a 4m deep ~8m wide pump pit
- The need to design the pit for up-thrust if the surrounding ground becomes fully saturated
- The inundation of the pit under flood, and resultant issues the suitability of the pumps for inundation and issues with removal of sediment
- The screen and the foot valve would be difficult to access for inspection and maintenance

Based on the above the pump station civil works would be expensive and there may be technical issues with pump inundation at potentially up to 6m of water. On this basis, this option is not considered to be a viable alternative.

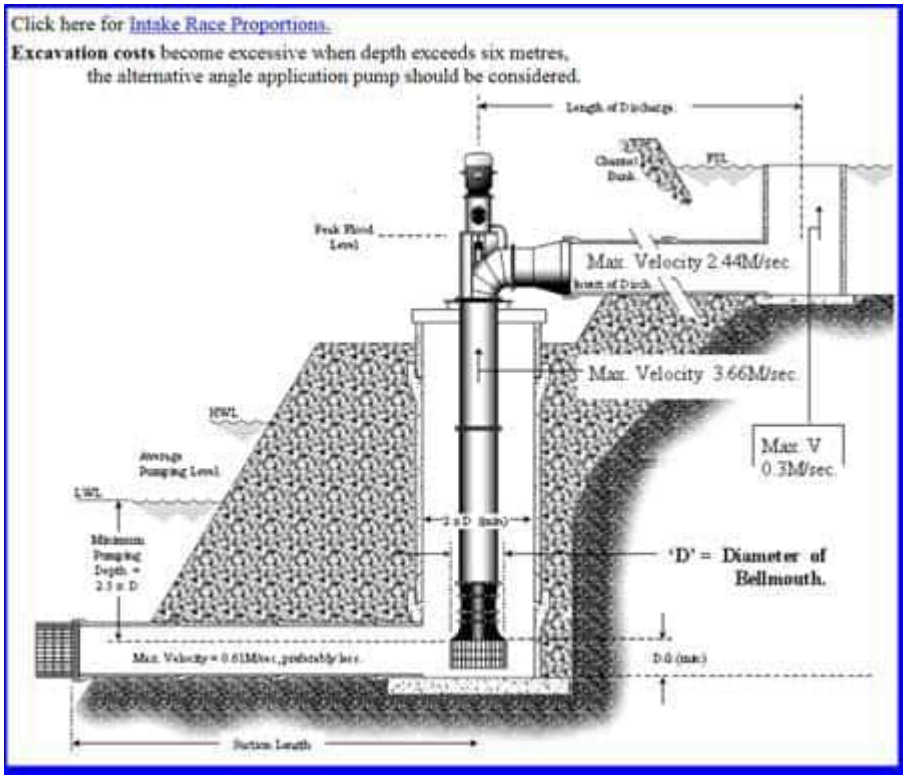
Option 3:

Wet well at the required location set back from the river, with an inlet pipe bored through the Murray River bank at the depth required to meet submergence requirements.

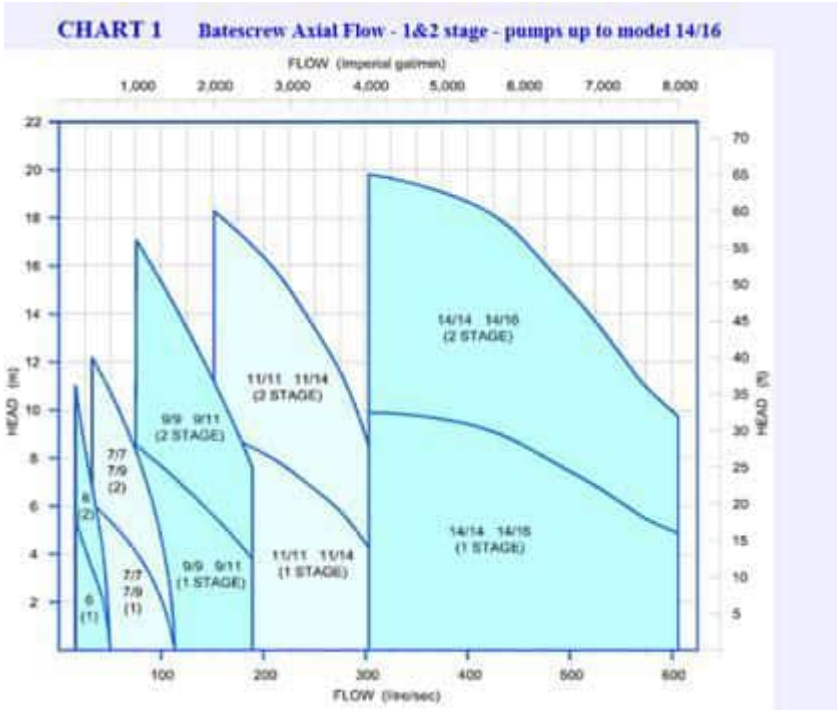
This option would be based on the “Closed Bottom Can Pump” geometries in ANSI/HI 9.8-2012 – Rotodynamic Pumps for Pump Intake Design, (see below) and Batescrew recommendations (also see below).



After installation of the can is complete, the mounting surface of the pumps must be level enough and the can shall be plumb to ensure that the suction bell can be centered within 3% of the suction bell diameter (0.03 x *D*).



For a single pump with a flow of 417L/s (at say 12m head), the pump would need to be either a single or 2-stage impeller. The following is an example from Batescrew.



Application at Sunday Creek would require the following key components / arrangements:

- A screened offtake in the Murray located with sufficient submergence to avoid vertexing
- A 50+ metre long ~9m deep bored pipe nominally 900-1000mm (if Batescrew arrangement) or 700mm if ANSI arrangement
- An 11m deep DN850 pit (ANSI arrangement), but could be larger to suit the shaft that needs to be built for the boring equipment
- The need to break the pipe through the Murray bank, which would require bunding or sheet piling

Issues with this arrangement are:

- The boring would be very expensive
- Pump pit construction (at 11m deep) would be expensive
- There would be significant visual impact on the Murray during construction
- A screen would be required at the Murray River Offtake and possibly at the bottom of the pit
- The risers would be ~10m long and only 0.4m diameter, so it would need some form of supports in the pit to avoid vibration
- It would be a significant job to remove the pump and riser for inspection and maintenance

Based on the above, this option is not considered viable.

Option 4:

Pump in a deep pit at the required location set back from the river bank, with a shallow siphon pipe buried between the pit and the river.

This option is similar to Option 3, but with the suction pipe buried at nominally 3m depth rather than at 9m. The pipe would then drop to nominally 9m depth at the pump station. This would eliminate the need for boring of the suction pipe. However, the top of the buried pipe would be located nominally 3m above the assumed Murray River low water level.

The offtake from the Murray River would have a screen and a foot valve. However, the suction pipe would need to be primed on system start-up, or if the foot valve passes and prime is lost. This would require the use of a vacuum pump located at ground level near the pump station. The vacuum pump system would operate to prevent air accumulation in the suction pipe.

Issues with this arrangement are:

- A screen and a foot valve would be required at the Murray River Offtake, which would be difficult to access.
- The vacuum pumping system would reduce the reliability of the pumping system
- The vacuum pump would either need to draw water from up to 8m of vacuum, or else would require its own store of water to maintain sealing.
- Pump pit construction (at 11m deep) would be expensive
- A second screen may be required at the bottom of the pit
- The risers would be ~10m long and only 0.4m diameter, so it would need some form of supports in the pit to avoid vibration
- It would be a significant job to remove the pump and riser for inspection and maintenance)

Based on the above, this option is also not considered viable.

4. Summary

Assessment of the identified alternative options to set the pump station back from the river established that all options would be faced with significant technical and/or cost issues.

It is our view that the proposed solution presented in the concept design provides the best solution technically while providing a cost-effective outcome.

Appendix E. 100 Year Event Flood River Level (NECMA)

North East CMA Ref No. : NECMA-F-2019-00103
Document No. : 1
Applicant Ref. : Email enquiry 26 March 2019

Date : 2 April 2019

NORTH EAST CATCHMENT MANAGEMENT AUTHORITY

Level 1, 104 Hovell Street
Wodonga VIC 3690
P.O Box 616
Wodonga VIC 3689
Ph: 1300 216 513
Fax: 02 6043 7601
Website: www.necma.vic.gov.au
Email: necma@necma.vic.gov.au
ABN 53 229 361 440

David Mohr
Jacobs
PO Box 260
Tatura VIC 3616
(david.mohr@jacobs.com)

Dear David,

Flood enquiry location

Street : **Off Hynes Road, Wahgunyah**
Cadastral : **Allotment B9, Parish Of Carlyle**

Thank you for your enquiry of 26 March 2019, received at the North East Catchment Management Authority (the Authority) on 26 March 2019.

The North East CMA is a statutory recommending referral Authority for floodplain management under *Section 55* of the *Planning and Environment Act 1987.*

Below is the Authority's understanding of the application:

The applicant(s), David Mohr
of Jacobs

Enquires in relation to;
Enquiry type: **Flood Information Request – proposed pump station**
on the abovementioned site location.

The Authority's assessment of the above information has determined that the proposed development location is covered by the following Zones and Overlays in the Indigo Planning Scheme:

Zone(s): **FARMING ZONE**
Overlay(s): **BUSHFIRE MANAGEMENT OVERLAY**
ENVIRONMENTAL SIGNIFICANCE OVERLAY - SCHEDULE 2
ENVIRONMENTAL SIGNIFICANCE OVERLAY - SCHEDULE 3
FLOODWAY OVERLAY

Under section 56(3) the North East CMA gives the following comments on the application:

Flood levels for the 1% AEP (100 year ARI) flood event have been declared for this area under the *Water Act 1989*. The declared 1% AEP flood level for the location indicated in your enquiry is RL 133.8 m AHD. Relevant flood level information for the property is obtained from Murray River Flood Level Declaration Maps (2004).

Consequently the Authority advises that in the 1% AEP flood event it is likely that the entire area, inclusive of the site indicated in your enquiry, would be subject to deep inundation from the Murray River. The depth at the site should be confirmed by site survey to m AHD. The site would be completely inaccessible in events exceeding approximately 20% AEP.

The Authority notes that this enquiry relates to proposed construction of pump infrastructure. Given the depth and frequency of flooding it is recommended that consideration be given to locating infrastructure on more elevated land near the floodplain margin however if this is not feasible design should ensure as a minimum that:

- Works should be located and designed to minimise impact on native vegetation and the riparian environment. All necessary permits should be obtained prior to commencement of works.
- Filling of the site or access route would not be supported.
- All electrical wiring, power outlets, switches, etc. must, to the maximum extent possible, be located above RL 134.1 m AHD. Any electrical installation below this level must be suitable for continuous submergence in water.
- The foundations and support system for the structure must be designed to withstand lateral loading from floodwaters, inclusive of potential hydrostatic, hydrodynamic and debris loads, and high velocity flows.
- Water resistant materials that minimise the physical effects of flooding on the structure must be used.
- Chemicals, oil, fuel, grease, waste or other potential pollutants shall not be stored on the site.

In Victoria, proposals for development on floodplains are generally assessed against the flood magnitude that has a 1% chance of occurring in any given year, known as the 1% Annual Exceedance Probability (AEP) flood. The 1% AEP flood is the minimum standard for planning in Victoria but is not the largest flood that could occur. There is always a possibility that a flood larger in height and extent than the 1% AEP flood may occur in the future.

Please note, this document contains flood level advice only and does not constitute approval or otherwise of any development at this location.

The Authority has provided this advice as preliminary information only and has been on the information you have provided. Any flood level advice provided is based on the most accurate information currently available and may change if new information becomes available.

The Authority can provide further information regarding any proposed development of the property in response to a planning permit application referred by Indigo Shire in accordance with the *Planning and Environment Act 1987*.

Should you have any queries, please do not hesitate to contact Tim Loffler on 1300 216 513. To assist the Authority in handling any enquiries please quote **NECMA-F-2019-00103** in your correspondence with us.

Yours sincerely,

Natalie Dando
Manager Statutory Planning

Definitions and Disclaimers

1. The area referred to in this letter as the 'proposed development location' is the land parcel(s) that, according to the Authority's assessment, most closely represent(s) the location identified by the applicant. The identification of the 'proposed development location' on the Authority's GIS has been done in good faith and in accordance with the information given to the Authority by the applicant(s) and/or the Local Government Authority.
2. While every endeavour has been made by the Authority to identify the proposed development location on its GIS using VicMap Parcel and Address data, the Authority accepts no responsibility for or makes no warranty with regard to the accuracy or naming of this proposed development location according to its official land title description.
3. **AEP** – Annual Exceedance Probability – is the likelihood of occurrence of a flood of given size or larger occurring in any one year. AEP is expressed as a percentage (%) risk and may be expressed as the reciprocal of ARI (Average Recurrence Interval).

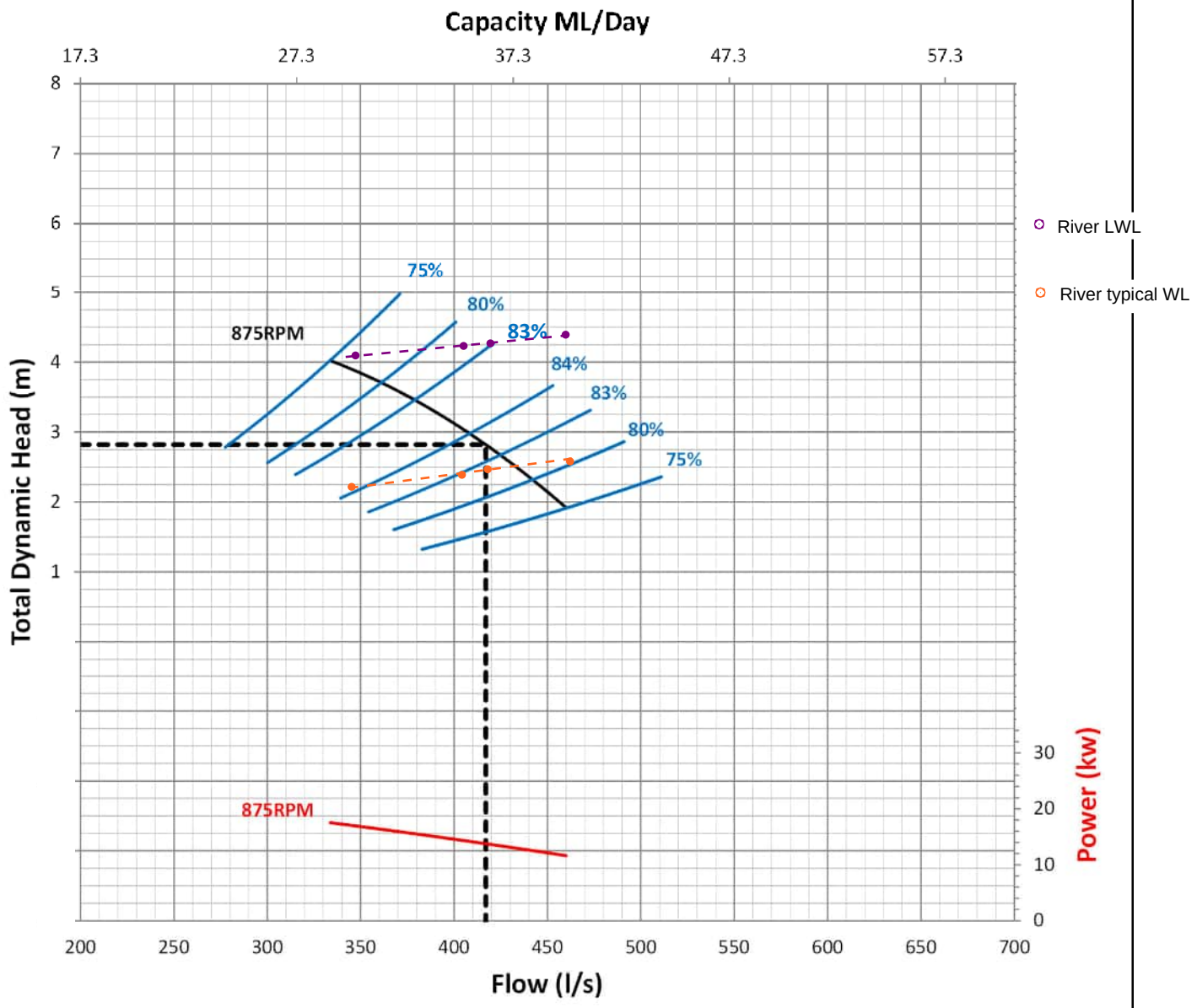
Please note that the 1% probability flood is not the probable maximum flood (PMF). There is always a possibility that a flood larger in height and extent than the 1% probability flood may occur in the future.

4. **ARI** – Average Recurrence Interval – is the likelihood of occurrence, expressed in terms of the long-term average number of years, between flood events as large as or larger than the design flood event. For example, floods with a discharge as large as, or larger than the 100 year ARI flood will occur on average once every 100 years.
5. **AHD** – Australian Height Datum – is the adopted national height datum that generally relates to height above mean sea level. Elevation is in metres.
6. **NFPL** – Nominal Flood Protection Level – is the minimum height required to protect a building or its contents, which includes a freeboard (a minimum of 0.3 m unless otherwise detailed) above the 1% AEP flood level. Freeboard refers to a height above the defined flood level and is typically used to provide a factor of safety in the setting of floor levels for developments, to compensate for effects such as wave action and to provide protection from flooding which is marginally above the defined flood level.
7. No warranty is made as to the accuracy or liability of any studies, estimates, calculations, opinions, conclusions, recommendations (which may change without notice) or other information contained in this letter and, to the maximum extent permitted by law, the Authority disclaims all liability and responsibility for any direct or indirect loss or damage which may be suffered by any recipient or other person through relying on anything contained in or omitted from this letter.
8. This letter has been prepared for the sole use by the party to whom it is addressed and no responsibility is accepted by the Authority with regard to any third party use of the whole or of any part of its contents. Neither the whole nor any part of this letter or any reference thereto may be included in any document, circular or statement without the Authority's written approval of the form and context in which it would appear.
9. The flood information provided represents the best estimates based on currently available information. This information is subject to change as new information becomes available and as further studies are carried out.

Appendix F. FE403 Pump Curve

Fluid Engineering	MODEL No. **FE403**		CURVE No. C-0012a
	875RPM		DATE. 24/02/12
	BOWL DIA. 490mm		
	STANDARD CURVE ILLUSTRATES SINGLE STAGE PERFORMANCE ONLY		DRAWN JS / CHECKED PM

FLOW (l/s)	**417**	**TDH (m)**	**2.82**	**POWER (kW)**	**13.76**	**Efficiency (%)**	**83.78**
FLOW (ML/Day)	**36.0**	**TDH (ft)**	**9.25**	**POWER (HP)**	**18.45**	**NPSHR (m)**	



CLIENT:	***Jacobs***	**JOB/QUOTE:**	***36MLD SD Pump at Typ. WL***

PROPELLER		**BOWL**	
PROPELLER OD	386	**PUMP LENGTH**	590
EFFECTIVE EYE AREA	99.34 E-3 m2	**ADDITIONAL STAGES**	370
NUMBER OF BLADES	3 @ 16 Deg. Pitch	**LATERAL STD.**	10mm
WR2 PER PROPELLER	0.21	**SUCTION SIZE**	400
MAX SPHERE SIZE	26mm	**DISCHARGE SIZE**	400
WEIGHT	27kg	**SINGLE STAGE WEIGHT**	

FLUID ENGINEERING PTY LTD
ABN 50 151 207 528
AXIAL FLOW FLOODLIFTER

PHONE: (02) 6962 9601
FAX: (02) 6962 7692
email: info@floodlifter.com

NUMBER OF STAGES FOR DUTY: **2**

Appendix G. Hells Gate Geotechnical Memorandum

JACOBS

Memorandum

444 Flinders Street
Townsville QLD 4810
Australia
PO Box 856, Townsville QLD 4810
T +61 7 4726 9100

www.jacobs.com

Subject	**Geotechnical Advice on Earth Embankment - Sunday Creek**	**Project Name**	Lake Moodemere / Sunday Creek
Attention	Tim Slavin		
From	Ryan Davis / Thushara Madanayaka		
Date	26 March 2019		
Copies to			

This memorandum presents our review of data from boreholes 8 and 9, assessment of suitability of the proposed earth embankment structure as the block bank between the Lake and Sunday Creek, and the assessment of soil parameters applicable to seepage estimation underneath the proposed earth embankment structure. This assessment incorporates the results from the field investigation and laboratory testing report provided by B.M Civil Engineers Pty. Ltd. (Ref: 48629-3 dated October 2018).

1. Review of Boreholes 8 and 9 Data

1.1 Subsurface Profile

Subsurface conditions of the area where the proposed earth embankment structure to be constructed have been investigated using boreholes 8 and 9 and are presented in appendix A of the report by B.M Civil Engineers Pty. Ltd. (Ref: 48629-3 dated October 2018). In summary, based on boreholes 8 and 9, the site is underlain by the following:

Borehole 8

- TOPSOIL to 0.1m depth comprising disturbed soil; underlain by,
- Medium plasticity, light brown grey CLAY with trace sand (CI) to the termination of drilling at 4.5m.

Borehole 9

- TOPSOIL to 0.1m depth comprising disturbed soil; underlain by,
- Medium plasticity, light brown grey CLAY with trace sand (CI) to the depth of 1.5m; underlain by,
- Low plasticity light brown yellow sandy CLAY (CL) to the depth of 2.0m; underlain by,
- Medium plasticity, light brown grey CLAY with trace sand (CI) to the termination of drilling at 4.5m.

Therefore, it can be concluded that the site is predominantly underlain by CLAY material.

1.2 Groundwater Condition

Groundwater has been encountered at a depth of 3m and 2.8m in boreholes 8 and 9, respectively.

1.3 Soil Moisture Condition

In general, soil moisture has increased with depth in both boreholes. A description of the moisture condition of individual soil layers in borehole 8 given in table 4.1 of the report by B.M Civil Engineers Pty. Ltd. (Ref: 48629-3 dated October 2018) shows that the moisture content values in all the layers (excluding the top 100 mm of disturbed soil) are equal or greater than the plastic limit (PL = 20). Therefore, the entire soil profile can (from a practical perspective) be considered as saturated. In borehole 9, similar observation was made for the depth below 2m, and therefore, the entire soil profile can (from a practical perspective) also be considered as saturated. The soil layers above 2m in borehole 9 are also moist, but the moisture content values are somewhat less than to their plasticity values.

1.4 Consistency

The soil consistency has been assessed based on field shear vane test results done by B.M Civil Engineers Pty. Ltd. As per the values given in Table 3.1 of their report (Ref: 48629-3 dated October 2018), undrained shear strength for the clay material within the borehole 8 has been assessed to be approximately 250kPa. The clay has also been logged as stiff. There are no shear vane test values available for borehole 9. It should be noted that Table 11 of AS1726:2017 indicates that the abovementioned stiff clay soils should be classified as being hard. This assessed classification appears to be conflicting with the information shown on the borehole logs. For this assessment we have considered a conservative approach and considered the consistency of the clay soil as being stiff.

1.5 Soil Dispersivity and Erodibility

Emerson dispersion test results on representative samples taken from both borehole 8 and 9 materials show that the Emerson Class number as 4. This indicates that the soils exhibit non-dispersive properties.

2. Assessment of Geotechnical Parameters of Founding Material

It is noted that, no permeability (in-situ or laboratory) tests, triaxial tests or density tests results are available. Therefore, permeability, density and strength parameters of the founding material have been estimated based on the soil classification results referencing the book titled “Handbook of Geotechnical Investigation and Design Tables” by Burt G Look in 2007.

Considering the colouration of the soil material given in both borehole logs (light brown, grey and yellow), it can be concluded that the founding soils are likely to be inorganic clays (Ref: Table 7.4).

The dry and saturated/bulk density values of founding soils can be estimated as 17 kN/m^3 and 19 kN/m^3 respectively (Ref: Table 7.3). These values are comparable with the values provided in the report by the B.M Civil Engineers Pty. Ltd.

The effective cohesion and friction angle of the founding material has been estimated as 35 kPa and 25°, respectively.

The clay foundation material is assessed to have permeability values between 10^{-9} m/s to 10^{-7} m/s.

3. Suitability of the Proposed Earth Embankment Structure

Geotechnical information of the natural founding material discussed above can be summarized as being predominantly stiff clay which has non-dispersive properties and low permeability. Therefore, geotechnical risks associated with potential settlement issues and bearing capacity failures would be low with the proposed earth embankment structure shown in Figure 1. Also, the risk of soil erosion (due to piping) below the embankment is also likely to be low.

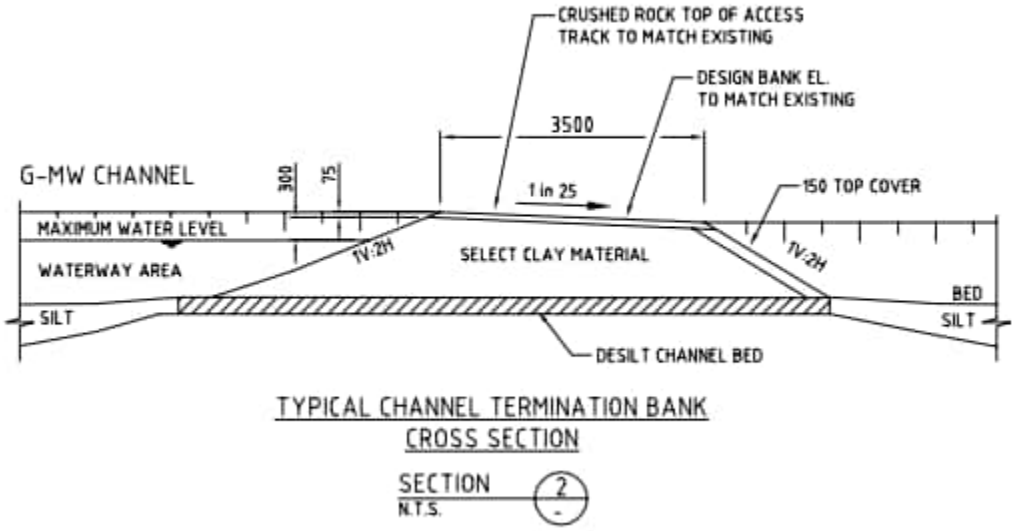


Figure 1: Proposed Earth Embankment Structure

The block bank structure shown in the section shown in Figure 1 above is likely to be appropriate given the soil conditions and assuming the embankment is keyed into the underlying clay subgrade. This in turn would also form a low permeability barrier.

We trust that this assessment meets your requirements. Please don't hesitate to contact us if you require any further clarification or assessment.

Yours sincerely

Ryan Davis
Senior Associate Geotechnical Engineer
Ryan.Davis@jacobs.com

References:

Chapuis, R.P., and Gill, D.E. (1989). Hydraulic anisotropy of homogeneous soils and rocks: influence of the densification process. Bulletin of the International Association of Engineering Geology, 39: 75-8.

Terzaghi, K., Peck, R. B., and Mesri, G. (1996). Soil mechanics in engineering practice, John Wiley & Sons, New York.

Kevin S. Richards, K.S., and Reddy, K.R. (2007). Critical appraisal of piping phenomena in earth dams. Bull Eng. Geol. Environ (2007) 66:381–402.

Appendix H. AWMA Flap Gate Product Information

Flap Gate Valve

The AWMA Flap Gate is a one way/non-return flap gate valve designed to prevent backflow.

Features
- Effective backflow prevention device.
- Top hinged one way flap valve.
- Double pivot hinges as standard.
- Gravity and head pressure achieve automatic sealing.
- Low head loss.
- Full perimeter sealing.
- Suitable for up to 10m head pressure.
- Custom designed and fabricated to suit any size or shaped orifice.
- Requires minimal civil works to install.

Applications
- Commonly used for tidal and flood mitigation as well as sewage and stormwater management.
- Flap valves can be incorporated into the body of a penstock as a failsafe measure.
- The Flap Gate range is used for many applications across all industry sectors.

Sizes
- All AWMA water control gates are custom sized to ensure they meet specific site and operational requirements.
- Customisation reduces installation and civil costs.

Materials
- Constructed from marine grade aluminium or grade 316L stainless steel.
- Suitable for corrosive tidal environments.
- Materials used in the construction of the Flap Gate range have a high corrosion resistance and can be operated for many years with minimal maintenance.

Sealing
- The Flaps are on a 3 degree angle to ensure sealing under low head differential.
- The sealing ability of this gate exceeds that required by the 'Australian Technical Specification for Fabricated Water Control Infrastructure'.

Quality
- All fabrication is in accordance with the 'Australian Technical Specification for Fabricated Water Control Infrastructure', AS/NZS 1554.6 and AS/NZS 1665.
- All stainless steel welding is continuous to avoid crevice corrosion.
- All procedures are in accordance with AWMA's accredited ISO 9001 Quality Management System to ensure each gate is manufactured to a high standard, tested and ready for trouble free operation post approved installation.

Operation
- Gravity and head pressure automatically operate gate for one-way flow only.
- Lifting lugs or cable winch optional to raise the gate in emergency situations.

Maintenance
- The Flap Gate range has a minimum 25year design life.
- Minimal maintenance is required offering low "whole of life" costs.
- If required, all the wearing components can be changed with ease, on site.

Mounting
- Flap Gates are typically wall mounted.
- Spigot or pipe mount options available.

awma Water Control Solutions

HEAD OFFICE

Phone +61 3 5456 3331 Email info@awmawatercontrol.com.au
118 Roviras Road, PO Box 433, Cohuna Victoria 3568
www.awmawatercontrol.com.au

Appendix I. Safety in Design Register

Safety in Design Report

ANZ-SOP-2111-001

Project Summary

Jacobs has been engaged by Goulburn Murray Water (GMW) Connections to assist in delivering a water savings project on behalf of the Sunday Creek Management Committee (SCMC) and Parks Victoria.
Jacobs has reviewed existing project documentation including the report Lake Moodemere – Water Savings Assessment (DEPI, 2014) during the Concept Design phase of the current project. The review was limited to assessing the adequacy of proposed civil infrastructure required to reconfigure Lake Moodemere and surrounds for irrigation and recreational purposes.
The proposed reconfigured infrastructure at Lake Moodemere and surrounds are;
•A new 36 ML/d angled axial flow pump station.
•A new 36 ML/d HDPE pipeline.
•A replacement for the existing Lake Moodemere regulating structure
•A new structure at Hell's Gate.

Purpose of Safety in Design

Designers have a legal responsibility for safe design. The purpose of safety in design is to identify and eliminate or reduce risks to health and safety *So Far As Reasonably Practicable* (SFARP) from designs during the design process. This process offers the greatest cost/time-benefits the earlier it is undertaken.

The process of safety in design begins in the conceptual and planning phases of the project. This process focuses on making choices about the design, methods of construction, on-going operation and maintenance all the way through to demolition and disposal.

This report functions as an output of the structured approach to Safety in Design that Jacobs follows.

Safety in Design Process

The safety in design process was conducted within the preliminary design stages of the project. The engineers that had the key design input for each design package were consulted in regards to hazard identification on this project. Previous GMW projects involving channels, pump stations, regulators and pipelines had their risk registers consulted. The hazards were compiled by Tim Slavin

The hazard register considers the reconfigured infrastructure components: Pump Station, Pipeline, Hells Gate Embankment and Lake Moodemere Regulator

The hazard register excludes works outside of the nominated design packages, alongside hazards that may arise when travelling to and from site.

Total Identified Risks

The total number of project specific risk's identified by this safety in design report can be seen below:

SiD Risk Register		
Risk Level	**Initial Risk Status**	**Residual Risk Status**
Very High Risk	0	0
High Risks	9	0
Medium Risks	3	12
Low Risks	0	0

Table 1: Initial Risk Status vis-à-vis Residual Risk Status

The project total risk score before and after the Safety in Design process is quantified below:

	Before SiD	**After SiD**
Total Risk Score	**33**	**24**

Table 2: Total Risk Scores

Conclusion

Upon review of the identified risks, appropriate control measures were adopted. This reduced the risks to a level that is So Far As Reasonably Practicable. The initial risk status had 9 high risk hazards and 3 medium risk hazards. After implementing the appropriate control measures, there were 12 medium risk hazards.

RISK ASSESSMENT TABLES

based on SA/SNZ HB 436:2013 Risk management guidelines - companion to AS/NZS ISO 31000:2009.

JACOBS

Severity Matrix

Items highlighted YELLOW are not strictly Safety and Health Act covered, but will feature in Client risks

Level	Severity Types					
	Profit Reduction	Health and Safety	Natural Environment	Social / Cultural Heritage	Community / Government / Reputation / Media	Legal
1	<US$10k	No medical treatment required.	Minor effects on biological or physical environment.	Minor medium-term social impacts on local population. Mostly repairable.	Minor, adverse local public or media attention or complaints.	Minor legal issues, non-compliances and breaches of regulation.
2	US$10k-100k	Objective but reversible disability requiring hospitalisation.	Moderate, short-term effects but not affecting ecosystem functions.	On-going social issues. Permanent damage to items of cultural significance.	Attention from media and/or heightened concern by local community. Criticism by NGOs.	
3	US$100k-1M	Moderate irreversible disability or impairment (<30%) to one or more persons.	Serious medium term environmental effects.	On-going serious social issues. Significant damage to structures / items of cultural significance.	Significant adverse national media / public / NGO attention.	Serious breach of regulation with investigation or report to authority with prosecution and/or moderate fine possible.
4	US$1M-10M	Single fatality and/or severe irreversible disability or impairment (>30%) to one or more persons.	Very serious, long-term environmental impairment of ecosystem functions.		Serious public or media outcry (international coverage).	Major breach of regulation. Major litigation.
5	US$10M-100M	Multiple fatalities, or significant irreversible effects to > 50 persons.				Significant prosecution and fines. Very serious litigation including class actions.

Likelihood Matrix

Level	Descriptor	Description	Indicative Frequency (expected to occur)
A	Almost certain	The event will occur on an annual basis.	Once a year or more frequently.
B	Likely	The event has occurred several times or more in your career.	Once every three years.
C	Possible	The event might occur once in your career.	Once every ten years.
D	Unlikely	The event does occur somewhere from time to time.	Once every thirty years.
E	Rare	Heard of something like this occuring elsewhere.	Once every 100 years.

Risk Rating:

	Likelihood	Severity				
		1	2	3	4	5
A	Almost Certain	M	H	H	VH	VH
B	Likely	M	M	H	H	VH
C	Moderate	L	M	H	H	H
D	Unlikely	L	L	M	M	H
E	Rare	L	L	M	M	H

Client:	Goulburn Murray Water Connections Project	Discipline:	
Project Name:	Sunday Creek Reconfiguration	Facility:	
Project Number:	IS251000	Document No:	IS251000-0000-CH-REG-0001

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HAZARD REGISTER

Initial Risk (at initial assessment)								Initiated	Residual Risk (progressive or at Design close out)				Design close out	
Item No.	Facility Area / Lifecycle Stage	Hazard	Hazardous Event / Scenario	Control Measures in Place	Severity (1 - 5)	Likelihood (A,B,C,D,E)	Risk Level	By / Date	Improvement Action	Severity (1 - 5)	Likelihood (A,B,C,D,E)	Risk Level	By / Date	Checked / Date
1	Pump Station, Pipeline and Regulator	Roads and Vehicles	Staff impacted by vehicle	Move out of road reserve/off access track, where not possible, minimise risk as much as possible	4	D	M	Tim Slavin 04/04/19	Design methodology to relocate infrastructure, avoid hazards and minimise risk	4	E	M		
2	Pump Station, Pipeline and Regulator	Roads and Vehicles	Vehicle-vehicle collision	Ensure parking is away from road/access track	4	D	M	Tim Slavin 04/04/19	Design methodology to relocate infrastructure, avoid hazards and minimise risk	4	E	M		
3	Pump Station	Roads and Vehicles	Vehicle-infrastructure collision	Move the infrastructure out of the road reserve or away from access track, where not possible, have the appropriate measures (bollards and guardrailing) in place	4	D	M	Tim Slavin 04/04/19	Design methodology to relocate infrastructure, avoid hazards and minimise risk	4	E	M		
4	Pipeline	Overhead and underground services	Contractor plant/equipment coming into contact with wires, death/serious injury by electrocution	Relocation of infrastructure where possible to avoid services	4	C	H	Tim Slavin 04/04/19	Relocation of infrastructure to be undertaken where possible. Where services were identified on DBYD/survey/photos/site visits, the presence of services has been identified on the design drawings and CCS.	4	D	M		
5	Regulator	Access	Slips, trips and falls, falls into water and falls from heights.	Design walkways and handrails to AS1657	3	A	H	Tim Slavin 04/04/19	Design document produced outlining requirements of walkways and handrails to contractors, included in tender documentation.	3	E	M		
6	Pump Station and Regulator	Access	Vandalism, minor/serious injury.	Moderate public access probability identified. The pump station and regulator are located near public access tracks. Have relevant assets fenced off with locakble security grade fencing.	3	C	H	Tim Slavin 04/04/19	Where public access is required or highly probable, issues highlighted and additional measures implemented as required.	3	D	M		
7	All	Loading	Failure of structures	Design structures for worst case loading	4	C	H	Tim Slavin 04/04/19	Structural Design to be signed off by qualified structural engineer	4	E	M		

Client:	Goulburn Murray Water Connections Project	Discipline:	
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HAZARD REGISTER

Initial Risk (at initial assessment)								Initiated	Residual Risk (progressive or at Design close out)				Design close out	
Item No.	Facility Area / Lifecycle Stage	Hazard	Hazardous Event / Scenario	Control Measures in Place	Severity (1 - 5)	Likelihood (A,B,C,D,E)	Risk Level	By / Date	Improvement Action	Severity (1 - 5)	Likelihood (A,B,C,D,E)	Risk Level	By / Date	Checked / Date
8	All	Required crane access for maintenance	Failure of structures	Design structures for worst case loading	4	C	H	Tim Slavin 04/04/19	Design structure to allow access of a suitably sized crane. Document allowable crane loading and crane type in design report.	4	E	M		
9	Pump Station and Regulator	Heavy reinforcing	Musculoskeletal injury	Reduce amount of on-site work required	3	B	H	Tim Slavin 04/04/19	Use of precast units, adoption of reinforcing cages to be pre-fabricated. Use of mesh to reduce tying requirements	3	D	M		
10	Pipeline	Trenching and shoring and bulk excavation	Inundation, increased OHS requirements for site	Avoid deep excavation requirements, precast and pre-fab to avoid working in trenches	4	C	H	Tim Slavin 04/04/19	Use of precast units, adoption of reinforcing cages to be pre-fabricated. Use of mesh to reduce tying requirements	4	E	M		
11	Precast Items	Incorrect interpretation of precast fpit lifting lug design/specification	Damage to plant/materials, death by crushing	Design drawings/specification to detail specific lifting point location.	4	B	H	Tim Slavin 04/04/19	Design drawings/specification detail specific lifting point requirements, discussions held with precast company to ensure correct interpretation	4	E	M		
12	All	Crane Accident	Crane incident (falling into the channel, overturning)	Crane pad/hardstand to be designed to withstand a substantial load, located an adequate distance away from the bank and other hazards, lockable bollards to prevent vehicles from getting too close to the structures and bank.	4	C	H	Tim Slavin 04/04/19	Qualified crane operator to assess location of crane placement for installation and removal of FlumeGates. Crane operators to conduct works with a risk assessment and a lifting plan.	4	D	M		

Initial assessment undertaken by: Tim Slavin	Date: 4/04/2019	Initial assessment reviewed by:	Date:
Design close out assessment undertaken by: Tim Slavin	Date: 4/04/2019	Design close out assessment reviewed by:	Date:

Client:	Goulburn Murray Water Connections Project	Discipline:	
Project Name:	Sunday Creek Reconfiguration	Facility:	
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JACOBS

HAZARD REGISTER

Initial Risk (at initial assessment)								Initiated	Residual Risk (progressive or at Design close out)				Design close out	
Item No.	Facility Area / Lifecycle Stage	Hazard	Hazardous Event / Scenario	Control Measures in Place	Severity (1 - 5)	Likelihood (A,B,C,D,E)	Risk Level	By / Date	Improvement Action	Severity (1 - 5)	Likelihood (A,B,C,D,E)	Risk Level	By / Date	Checked / Date

Answer the Question: Can I complete or have I completed the design to a level where it can be built and operated with a residual Safety Risk, So Far As Reasonable Practicable (SFARP), as far as they can be influenced in the design ?

YES		Continue with the work but also continue to monitor the situation.
~~NO~~		Discuss further with Discipline Technical Lead

Appendix J. Capital Cost Estimates

JACOBS

COST ESTIMATE

Compiled: Tim Slavin/David Mohr Project: **Sunday Creek - Reconfiguration** Job No: IS251000

Checked: Ross Titchmarsh Item: **River Pump Station** Date: 11/04/2019

Item	Description of Works	Quantity	Unit	Rate $	Subtotal $
1.0	**Preliminaries**				
1.1	Site Establishment, survey, setout, floating and mobilation	0	item	$0.00	$0.00
1.2	Preparation: Clearing and grubbing	225	m^2	$1.00	$225.00
1.3					
				Sub total	**$225.00**
2.0	**Bulk Earthworks**				
2.1	Stripping	56	m^3	$3.40	$191.25
2.2	Sheet Pile and Pile Driving Rig Hire	1	Item	$50,000.00	$50,000.00
2.3	Install Temporary Sheet Piles in Murray River	1	Item	$5,000.00	$5,000.00
2.4	Install Pipe Support Columns in Murray River Bank	1	Item	$5,000.00	$5,000.00
2.5	Pump Pool Dewatering	1	Item	$5,000.00	$5,000.00
2.6	Pump Pool Excavation	50	m^3	$80.00	$4,000.00
				Sub total	**$69,191.25**
3.0	**Construct Associated Infrastructure**				
3.1	Support Columns	8	Item	$500.00	$4,000.00
3.2	Axial flow pump, motor, fishtail strainer & assembly	1	Item	$75,000.00	$75,000.00
3.3	Pump Station Base Slab	13	m^3	$2,700.00	$33,750.00
3.4	Elevated Electrical, Control & VFD Cabinet	1	Item	$25,000.00	$25,000.00
3.5	Shade Structure	1	Item	$3,000.00	$3,000.00
3.6	Outlet Pipework and Valves	1	Item	$5,000.00	$5,000.00
3.7	Security Fencing	40	m	$70.00	$2,800.00
3.8	Security Gate	1	Item	$1,175.00	$1,175.00
3.9	Combination Air Valve	1.0	Item	$1,000.00	$1,000.00
3.10	Flow Meter and Pit	1	Item	$5,000.00	$5,000.00
3.11	PowerCor Electrical Connection & Transformer	1	Item	$10,000.00	$10,000.00
3.12	As builts, Commissioning and Testing	1	Item	$5,000.00	$5,000.00
				Sub total	**$170,725.00**
4.0	**Demobilisation**				
4.1	Provisional sum to replace asphalt track	20	m	$100.00	$2,000.00
4.2	Site Clean up	1	day	$5,000.00	$5,000.00
				Sub total	**$7,000.00**

Total DC (ex. GST)	**$247,141**
Contractor's Costs (13%)	$32,128
Contingency (40% DC)	$98,857
Project Management (5%)	$12,357
TOTAL (ex. GST)	**$391,000**

JACOBS

COST ESTIMATE

Compiled: Tim Slavin Project: **Sunday Creek - Reconfiguration** Job No: IS251000

Checked: Ross Titchmarsh Item: **Sunday Creek Pipeline** Date: 11/04/2019

Item	Description of Works	Quantity	Unit	Rate $	Subtotal $
1.0	**Preliminaries**				
1.1	Site Establishment, survey, setout, floating and mobilation	1	item	$10,000.00	$10,000.00
1.2	Preparation: Clearing and grubbing	8,750	m^2	$1.00	$8,750.00
1.3	Gravel Existing Access Track - 3.5m Grade and Maintain During Construction	350	m	$60.00	$21,000.00
1.4	Crown Land Acquisition (exluding legal fees)	0.88	ha	$5,000.00	$4,375.00
				Sub total	**$44,125.00**
2.0	**Bulk Earthworks**				
2.1	Stripping	875	m^3	$3.40	$2,975.00
2.2	Backfill	525	m^3	$35.00	$18,375.00
2.3	Reinstatement of topsoil	875	m^3	$3.40	$2,975.00
				Sub total	**$24,325.00**
3.0	**Construct Associated Infrastructure**				
3.1	Procure DN560 PN 6.3 PE 100 Pipe, Delivered to site, Installed	150	m	$214.00	$32,100.00
3.2	Procure DN560 PN 6.3 PE 100 Pipe, Delivered to site, Directional Bore, Installed	50	m	$606.00	$30,300.00
3.3	Procure DN560 PN 6.3 PE 100 Pipe, Delivered to site, Install Beneath Powerlines	120	m	$222.00	$26,640.00
3.4	Procure DN560 PN 8 PE 100 Pipe, Delivered to site, Installed	30	m	$288.00	$8,640.00
3.5	Air Vents, supply and install	3	Item	$10,000.00	$30,000.00
3.6	Drop Pits, supply and install	3	Item	$10,000.00	$30,000.00
3.7	Bubbler Pit, supply and install	1	Item	$38,000.00	$38,000.00
3.8	Pressure Test	1	Item	$10,000.00	$10,000.00
3.9	Beaching in Sunday Creek	500	m^2	$45.00	$22,500.00
				Sub total	**$228,180.00**
4.0	**Demobilisation**				
4.1	Site Clean Up	350	m	$5.00	$1,750.00
				Sub total	**$1,750.00**

Total DC (ex. GST)	**$298,380**
Contractor's Costs (13%)	$38,789
Contingency (40% DC)	$119,352
Project Management (5%)	$14,919
TOTAL (ex. GST)	**$472,000**

JACOBS

COST ESTIMATE

Compiled: Tim Slavin Project: **Sunday Creek - Reconfiguration** Job No: IS251000

Checked: Ross Tichmarsh Item: **Hells Gate Embankment** Date: 11/04/2019

Item	Description of Works	Quantity	Unit	Rate $	Subtotal $
1.0	**Preliminaries**				
1.1	Site Establishment, survey, setout, floating and mobilation	1	Item	$5,000.00	$5,000.00
1.2	Preparation: Clearing and grubbing	1,600	m^2	$1.00	$1,600.00
1.3	Gravel Existing Access Track - 3.5m Grade and Maintain During Construction	900	m	$60.00	
				Sub total	**$6,600.00**
2.0	**Bulk Earthworks**				
2.1	Temporary Cofferdams Upstream and Downstream	2	Item	$2,500.00	$5,000.00
2.2	Removal of Silt in Hell's Gate	525	m^3	$80.00	$42,000.00
2.3	Placement and Compaction of Impermeable Material (assumed won on site)	385	m^3	$30.00	$11,550.00
2.4	Placement of Rock Beaching	800	m^2	$45.00	$36,000.00
2.5	Supply and Install Geofabric	525	m^2	$31.50	$16,537.50
				Sub total	**$111,087.50**
3.0	**Construct Associated Infrastructure**				
3.1	Reinforced Concrete Sills	4	m^3	$2,700.00	$9,450.00
3.2	As Builts, Commissioning and Testing	1	Item	$5,000.00	$5,000.00
				Sub total	**$14,450.00**
4.0	**Demobilisation**				
4.1	Site Cleanup	1	Item	$5,000.00	$5,000.00
				Sub total	**$5,000.00**

Total DC (ex. GST)	**$137,138**
Contractor's Costs (13%)	$17,828
Contingency (40% DC)	$54,855
Project Management (5%)	$6,857
TOTAL (ex. GST)	**$217,000**

JACOBS

COST ESTIMATE

Compiled: Tim Slavin | Project: **Sunday Creek - Reconfiguration** | Job No: IS251000

Checked: Ross Titchmarsh | Item: **Lake Moodemere Regulator** | Date: 11/04/2019

Item	Description of Works	Quantity	Unit	Rate $	Subtotal $
1.0	**Preliminaries**				
1.1	Site Establishment, survey, setout, floating and mobilation	1	Item	$5,000.00	$5,000.00
1.2	Preparation: Clearing and grubbing	375	m^2	$1.00	$375.00
1.3	Gravel Existing Access Track - 3.5m Grade and Maintain During Construction	1000	m	$60.00	$60,000.00
1.4	Remove Existing Structure	1	Item	$5,000.00	$5,000.00
				Sub total	**$70,375.00**
2.0	**Bulk Earthworks**				
2.1	Temporary Cofferdam at Existing Pipe Culvert	1	Item	$1,000.00	$1,000.00
2.2	Removal of Existing Bed Material	24	m^3	$80.00	$1,920.00
2.3	Flattening of Banks to 1:2 Around Site	128	m^3	$80.00	$10,240.00
2.4	300mm Impermeable Layer, Material Won on Site	123	m^3	$30.00	$3,690.00
2.5	Bulk Backfill Behind Walls	82	m^3	$30.00	$2,460.00
2.5	Placement of Rock Beaching	115	m^2	$45.00	$5,175.00
2.6	Supply and Install Geofabric	115	m^2	$31.50	$3,622.50
				Sub total	**$27,107.50**
3.0	**Construct Associated Infrastructure**				
3.1	Cutoffs	2	m^3	$2,700.00	$4,050.00
3.2	Base Slab (Main Structure)	5	m^3	$2,700.00	$13,500.00
3.3	Sidewalls	5	m^3	$4,800.00	$24,960.00
3.4	Middle Wall	2	m^3	$4,800.00	$8,640.00
3.5	Headwall Footing	5	m^3	$2,700.00	$13,500.00
3.6	Headwalls	8	m^3	$4,800.00	$38,880.00
3.7	Walkway	4	m^2	$750.00	$2,625.00
3.8	Handrails	25	m	$275.00	$6,875.00
3.9	Flap Gates	3	Item	$5,500.00	$16,500.00
3.10	As Builts, Commissioning and Testing	1	Item	$5,000.00	$5,000.00
				Sub total	**$134,530.00**
4.0	**Demobilisation**				
4.1	Site Cleanup	1	Item	$5,000.00	$5,000.00
				Sub total	**$5,000.00**

Total DC (ex. GST)	**$237,013**
Contractor's Costs (13%)	$30,812
Contingency (40% DC)	$94,805
Project Management (5%)	$11,851
TOTAL (ex. GST)	**$375,000**