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GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY

Project Cost Evaluation for Remote Operation & Control of Outlet Structures in the Lower Goulburn Levees

CONCEPT DESIGN & COST REPORT

FINAL REPORT

23rd October 2015

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Project Cost Evaluation for Remote Operation & Automated Control of Outlet Structures in the Lower Goulburn Levees - CONCEPT DESIGN & COST REPORT

1 PURPOSE

The following is a brief report prepared in response to the GBCMA project brief "Project Cost Evaluation for Structures Lower Goulburn Levees (August 2015)", being part of the "Business Case Development for the Management of Constraints within the Goulburn Valley" project. Section 4 of that brief outlined the following key tasks;

- *Site visits be carried out . . . . . ;*
- *Initial review on soundness of existing structures based on visual inspections only;*
- *Review as to whether the structures are of sound condition to allow augmentation to achieve the design objectives of containing 55,000 ML/d, or whether a new structure/s are required.*
- *Conceptually design automated replacement structures that contain environmental watering within the levee system.*

The 5 x outlet structures nominated by the GBCMA for evaluation are as follows;

1. Loch Garry Regulator
2. Deep Creek Outlet
3. Wakiti Outlet
4. Hagen's Lane
5. Hancock Creek Outlet

2 BACKGROUND

We understand that the GBCMA is considering the installation of outlet controls at the above structures and to also allow these outlets to be remotely monitored and operated.

This functionality is intended to facilitate the containment of environmental flows within the levees systems and also to possibly enable a managed discharge of floodwaters beyond the levees for controlled inundation of the trees along the waterway.

3 PREVIOUS REPORTS

3.1 Preliminary Report

We produced an earlier "Preliminary Report (dated 4/9/15)" on this subject which presented our initial observations and structural assessment of the existing structures. That report included a description of each structure, also detailed site photo logs and sketches. This report considers that information and supplements it with additional survey information and existing conditions drawings for each site.

3.2 Draft Concept Design & Cost Report

We also presented a draft version of this Concept Design & Cost Report at a meeting with the client (Friday 25/9/15). At the conclusion of that review the following changes to the brief were noted;

- Removal of the requirement for the remote control structures to include "automated" operations.
- Nomination of a series of flood levels at each of the structures at which the [1]current modelling indicates the 55,000 ML/d is contained. The flood levels nominated were noted as follows;
  - RL 106.98m at the Loch Garry outlet.
  - RL 105.31m at the Deep Creek outlet.

[1] *As advised by Water Technology.*

  - RL 102.60m at the Wakiti Creek outlet.
  - RL 100.88m at the Hancock's Creek outlet.

- It was also noted that it was preferable that the top of the proposed gates be set lower than the top of the levee embankment.

- Consideration to be given to the following further costs;
  - relevant planning considerations including impact assessments, geotechnical, cultural heritage and environmental, also cultural heritage impact management plans.
  - site access for construction.
  - detailed design costs.
  - project management costs.
  - 40% provision for contingencies for unforeseen costs escalation during detailed design.

3.3 Final Concept Design & Cost Report

Some further comments were received from our client the GBCMA, including suggestions about a response to the loss of waterway capacity arising from the installation of the proposed gates. These suggestions are also dealt with in this final version of the report.

The draft Concept Design & Cost Report was then referred to Goulburn Murray Water for comment and also "SGM Consulting (Aus) Pty Ltd & Australian Dams & Water Consultants Pty" for independent review. The feedback received from that process was considered was discussed at a further meeting at the GBCMA on Thursday 15/10/15.

The various suggestions made by the client and the outcomes of our meeting (15/10/15) have been taken into account in the preparation of this final report. Where practicable we have attempted to denote amendments arising from that process by incorporating the term "feedback".

4 REVIEW OF GMW DRAWINGS

We have now received and reviewed a series of scanned design drawings for four of the structures which have been provided by GM Water, summarised as follows.

1. Loch Garry Regulator
   - 5 x sheets, SRWC drawings circa 1924 and 1960.
   - includes original concrete structure and timber bridge design, 2 x sheets (circa 1924).
   - includes timber and steel walkway design drawings, 1 x sheet (circa 1960).
   - a hydrograph which relates gauge heights at Shepparton (in feet) to estimated flows at Shepparton with flood events pre & post Eildon dam (circa 1960).
2. Deep Creek Outlet
   - 4 x sheets, SRWC drawings circa 1979.
   - includes existing conditions plan for predecessor structures (1 x sheet), a survey plan with waterway cross sections (1 x sheet), also structural design drawings and steel schedule (2 x sheets).
3. Wakiti Outlet
   - 3 x sheets, SRWC drawings circa 1977.
   - includes a feature survey with contours (1 x sheet), also design drawings for inlet and outlet modifications to existing brick structure to rectify downstream scour damages, design describes installation of sheet piling and an extensive RC outlet apron (2 x sheets).
4. Hagen's Lane
   - no drawings available.
5. Hancock Creek Outlet
   - 9 x sheets, SRWC drawings circa 1979.
   - describes new structure as an "inlet and outlet structure".
   - includes a general arrangement drawing, a feature survey of site complete with levels (1 x sheet).
   - includes levee realignment design, plan and long section (1 x sheet), cross sections (2 x sheets), log screen details (1 x sheet).
   - also includes structural design for inlet and outlet endwalls, steel schedule, plans and sections (4 x sheets).

5 DESIGN CONSIDERATIONS

5.1 Review of Existing Structures

Our review of the existing structures has been further aided with access to the design drawings provided by GM Water as above. Our review of the structures is limited to a visual assessment of the structures as built. The dimensions recorded onsite have been used to develop a series of existing conditions drawings, refer to the attached.

The existing conditions drawings very closely resemble the design drawings. We did not identify any substantial departures. For the purposes of this report we have concluded that the "as built" form of the structures is very close to that described in the design drawings provided by GM Water in every respect, ie. including the concrete strength and structural reinforcement.

The existing conditions drawings also document the apparent defects identified during the assessment of the structures. The defects observed are briefly summarised as follows;

Structure	*Structural Condition*	*Waterway Condition*
1. Loch Garry Regulator	Main elements of concrete structure are structurally sound, minor defects only. The disused timber bridge is in danger of collapse.	Downstream waterway is badly eroded and in poor condition.
2. Deep Creek Outlet	Main concrete structure is relatively new and in good condition.	Downstream waterway is badly eroded and in poor condition.
3. Wakiti Outlet	The original brick structure has some cracks and subsidence and is in need in of repair.	Downstream waterway is badly eroded and in poor condition.
4. Hagen's Lane	In good condition.	Upstream side of structure is blocked with debris
5. Hancock Creek Outlet	The inlet and outlet structures are sound, however there are several badly cracked, broken and subsided pipe sections, ie. requires reconstruction.	Downstream waterway is badly eroded and in poor condition.

5.2 Mode of Operations

During our project update 11/9/15 we observed that at present the mode of operations for each structure was as follows;

Structure	*Existing Control*	*Current Status*
1. Loch Garry Regulator	Has drop boards in place.	Structure is normally closed.
2. Deep Creek Outlet	[2]Has an informal set of vertical doors.	Structure is normally closed.
3. Wakiti Outlet	[3]Has no control mechanism.	Structure is normally open.
4. Hagen's Lane	Has no control mechanism.	Structure is normally open.
5. Hancock Creek Outlet	Has no control mechanism.	Structure is normally open.

In summary, we observed that only one existing structure had any formal control mechanism in place, and it was "normally closed off" to prevent any discharge. The other 4 structures had no formal waterway controls in place. Our client responded with the following advice;

> *"On the operations of the structures, we are expecting 4 to 6 natural flow events per 10 years on average, and 1 to 2 events where environmental releases are added.*
>
> *Hence the normal operation is likely to be fully open most of the time to pass any natural events which occur (ie Hancocks and Wakati and Hagans currently always open), and Deep Creek and Loch Garry*

[2] *We understand that the vertical doors were not part of the original SRWC design and have been installed by local landholders, ie. without any formal approval.*
[3] *This structure appears to have had a set of doors or drop boards installed when it was first erected.*

usually closed and opened according to rules as flow rises. The aim would be for all these structures to be fully closed when one of the environmental releases is being planned and delivered.

The ability to open at short notice is important if a planned flow event turns into a larger natural event (ie planned eflow event cancelled and revert to current normal structure open to pass flow).

In the future, these structures may also have a role releasing a small flow to water creek lines outside the levee (ie partially open)."

5.3 Available Control Gate Types

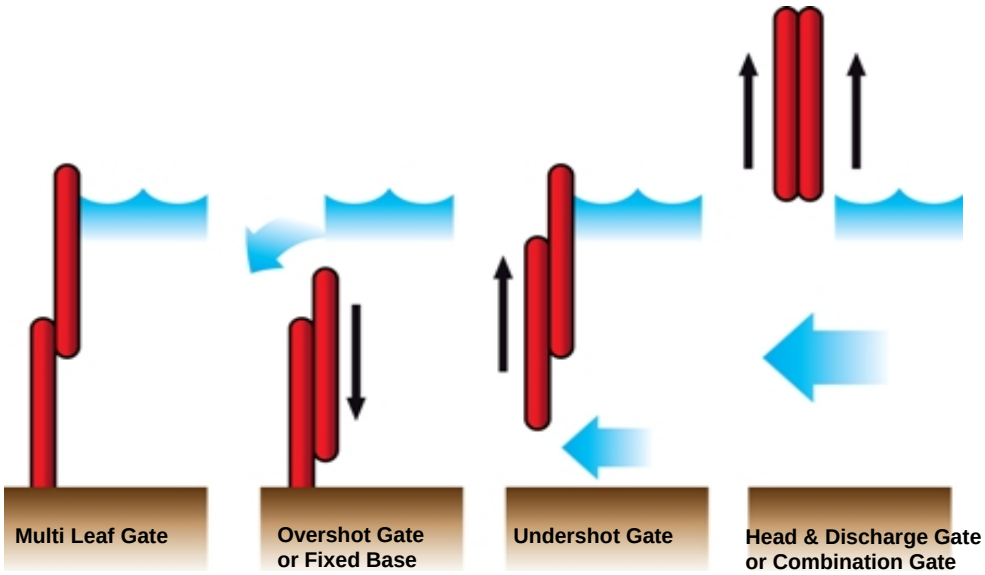
We have consulted with GM Water staff and also local manufacturer Rubicon and identified the following control gate systems which are in common use and readily adaptable to remote and automated operations. The main options available are briefly summarised as follows;

- Lay Flat Gate
  - includes FlumeGate which is a proprietary name for the Rubicon Water product, widely deployed throughout the Irrigation modernisation project.
  - based in Shepparton they offer a range of control solutions.
- Penstock
  - a vertically operated gate sometimes referred to as sluice gates, slide gates or stop gates.
  - supplied by AWMA Pty Ltd (Cohuna).
  - also by BateScrew Pumps & Valves (Tocumwal).
- Sliding Door
  - a door which slides horizontally across the waterway.
  - requires a clear waterway and sturdy guides.
- Flap Door
  - a hinged flap door which allows water to flow only one way.
- Drop Bars
  - as per the current Loch Garry arrangement.
  - requires manual operation, time consuming, not suited to remote control etc.

5.4 Overshot or Undershot Gates

We understand from our research that fish passage through overshot control structures results in greater survival outcomes compared to undershot control structures. Undershot structures are also susceptible to debris damage and blockages. Debris impact is likely in a flooding waterway situation. Both the FlumeGate and Penstock control systems include overshot capability.

An overshot Penstock style gate may have a lower gate fixed in place. That fixed in place lower gate will require any silt and debris on the upstream side to be cleared. Alternatively it may include an upper and lower which may both be operational. See below image from the AWMA website illustrating the various mechanisms available for vertical type penstock gates.



The combination gate appears to offer the most flexibility.

5.5 Operating Mechanism

5.5.1 Available Mechanisms

The various control gate systems manufacturers offer a range of operating mechanisms and devices to lift and lower the gate. The available mechanisms include the following;

- Electric Systems,
  - being either an AC or DC powered system, requiring an electric motor, gear box and an electricity source.
- [4]Cable Drive Systems
  - a stainless steel wire rope and cable drum assembly.
- Hydraulic Systems,
  - oil based system, requiring a hydraulic pump and an electricity source.
- Pneumatic Systems,
  - compressed air based systems, utilising pneumatic rams and requiring a compressor and an electricity source.
- Mechanical Systems,
  - requiring a motor and a gear box.
- Manual Systems,
  - including levers, hinges, winches, cables, gear boxes, threaded bars and wheels, cranks etc.

We understand that the Rubicon systems (and others) include a standby capability which allows their gates to be operated via a gearbox with a battery powered drill. AWMA also offer a portable, actuator for mechanical systems and also a portable, petrol powered, hydraulic power pack.

5.5.2 Preferred Mechanism Configurations

Concept design drawings issued with our draft report depicted combination gates with 2 x doors and a single, centrally mounted shaft, spindle or hydraulic ram which was attached to the top of each of the gates.

Subsequent feedback received from GMW on the draft report has raised concerns regarding situations where centrally mounted single spindles or hydraulic rams that operate the gate may be exposed above the gate within the waterway when operating in overshot mode or when the structure is overtopped.

In that situation the centrally mounted spindle or ram may be subjected to significant impacts from water borne flood debris, which may cause damage to the gate mechanism or with accumulation of debris the waterway may become blocked and the cause the gates to be inoperable.

To address that concern our concept design drawings now depict combination gates with an actuator shaft, spindle or ram at each side of the doors. Mounting the actuator shaft, spindle or ram clear of the waterway reduces the likelihood of potential damage from debris impacts and makes the structure less prone to the accumulation of flood debris. Each door will now require 2 x side mounted actuators.

5.6 Electricity Source

5.6.1 Electricity Source Options

The availability of a reliable onsite electricity source is essential to the remote operation of the waterway controls. The deployment of portable power sources, generators, almost negates the intended remote operation capability.

The sources of onsite electricity may include the following;

- Solar panels, for daylight operations.
- Solar Panel & battery backup for 24 hour operations.
- Reticulated electricity for 24 hour operation.
- Standby generator for emergency power supply.

Solar panels need to be of durable manufacture, clear of shade and mounted clear of the ground to avoid theft and vandalism on free standing masts.

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[4] Rubicon Water use the term CableDrive™ (ie. one word) which is a registered trade mark.

5.6.2 Preferred Electricity Source

Where available reticulated electricity clearly is the preferred source of electricity. A reticulated electricity supply will have a high level of reliability and requires minimal maintenance.

The use of solar panels and batteries is a limiting factor, particularly for night time operations or repeated operations. The individual panels are vulnerable to vandalism and also require some routine maintenance to keep them operating at optimum efficiency.

5.7 Operational Maintenance

Regular site visits will be necessary to ensure the mechanisms are operational, not vandalised, not obstructed by debris etc. Mechanical components will require lubrication, gearboxes, tracks and rams are intact and in good order. Solar panels will also require periodic cleaning.

Discussions with the Rubicon and GM Water personnel suggest that scheduled maintenance and site visits are essential and that the gates needs to be operated regularly to ensure all systems are functional. Different systems will require varying levels of maintenance and attention.

The existing condition of the access tracks varies from site to site. Our estimates include nominal provision for the upgrading of the access tracks to each of the sites, grading, resheeting and drainage works. That provision is nominal and is based upon length to ensure they are trafficable for the duration of the works.

Feedback received on the draft report also recommended that provision be made for the development of "lay-down areas" to facilitate construction and future maintenance activities. That provision has now been added to the cost estimates.

5.8 Remote Operation

Remote operation of the control structures will require reliable, real time data to be available for the information of the operator. That data is likely to include the following as a minimum;

- Upstream water level.
- Downstream water level.
- Gate status, or proportion of waterway open.
- Available electricity supply (battery status).

Other useful data may include;

- Discharge velocity.
- Flow rate.
- CCTV vision.

5.9 Proprietary Systems

Water control devices are widely used in the irrigation industry, to manage the delivery of water to consumers and also manage the discharge of surplus and storm drainage water. There are many parallels between the needs of the irrigation system and the management of environmental flows. We have identified the following established manufacturers of water control devices;

- Rubicon Water (Shepparton).
- AWMA Pty Ltd (Cohuna).
- BateScrew Pumps & Valves (Tocumwal).

The recent growth of Rubicon Water systems and solutions through the irrigation modernisation project is widely recognised. They offer a complete package solution which includes hardware, water level measurement systems, solar panel energy sources, remote operation capabilities, software and SCADA systems. They also offer an internet based hosting service for remote management via the web.

5.10 GM Water SCADA System

Goulburn Murray Water operate a comprehensive irrigation system with an established SCADA they also have significant maintenance resources and operations capabilities. There is some potential for a joint management arrangement between GBCMA and GMW.

5.11 Review of Available Communications Systems

The furthest upstream structure is Loch Garry, the furthest downstream structure is the Hancock's Creek outlet, ie. spanning an area about 23km long and about 7km wide, or about 160km^2. The area of interest for the development of any standalone communications system is long and narrow, possibly requiring 2 to 3 towers to provide radio coverage.

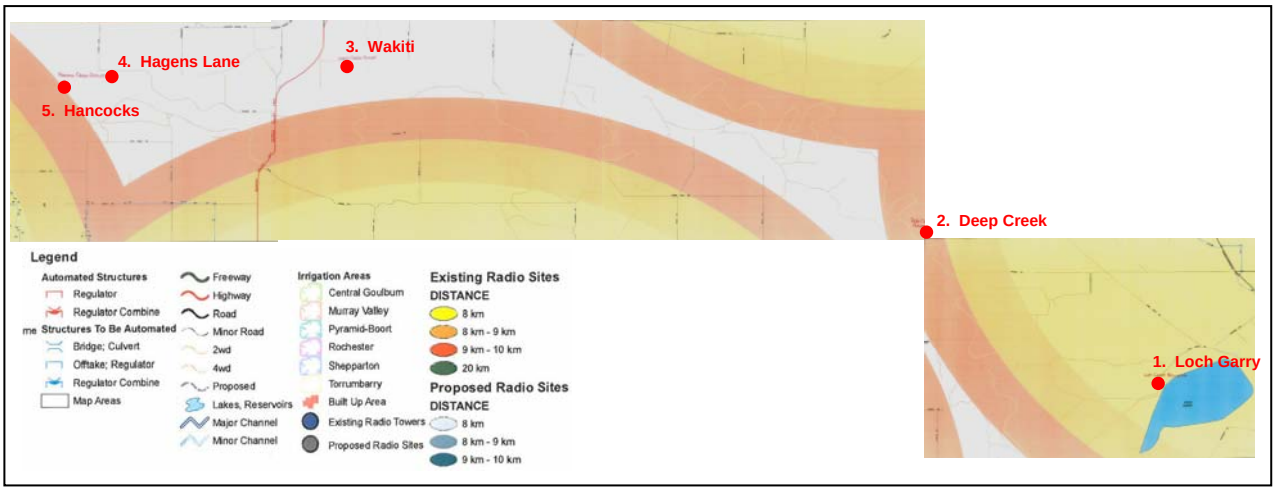
Rather than develop a new standalone communications systems for this series of structures, we suggest that it makes sense to consider any existing systems that may already be in place. The available communications infrastructure in the vicinity of the existing structures includes the following;

- Existing landline telephone infrastructure, ie. copper and fibre network.
- Telstra Mobile Telephone network.
- GM Water Radio network for its irrigation management systems.

The remote siting of the structures places most of them at some distance from the existing landline infrastructure. The nearest locations being assumed to be near to or at the nearest residences. Our previous report noted the availability of mobile telephone coverage at each site. This review did not include provision for any formal or independent testing of either the available Mobile Network systems coverage or the GM Water radio network.

5.11.1 GMW SCADA Coverage

We have reviewed the GMW SCADA Map Series as supplied by GM Water 15/9/15. Please see below our composite diagram of images taken from that mapping illustrating the relative locations and available coverage. We understand that the unshaded areas are presently outside the range of the existing GMW operated SCADA systems.



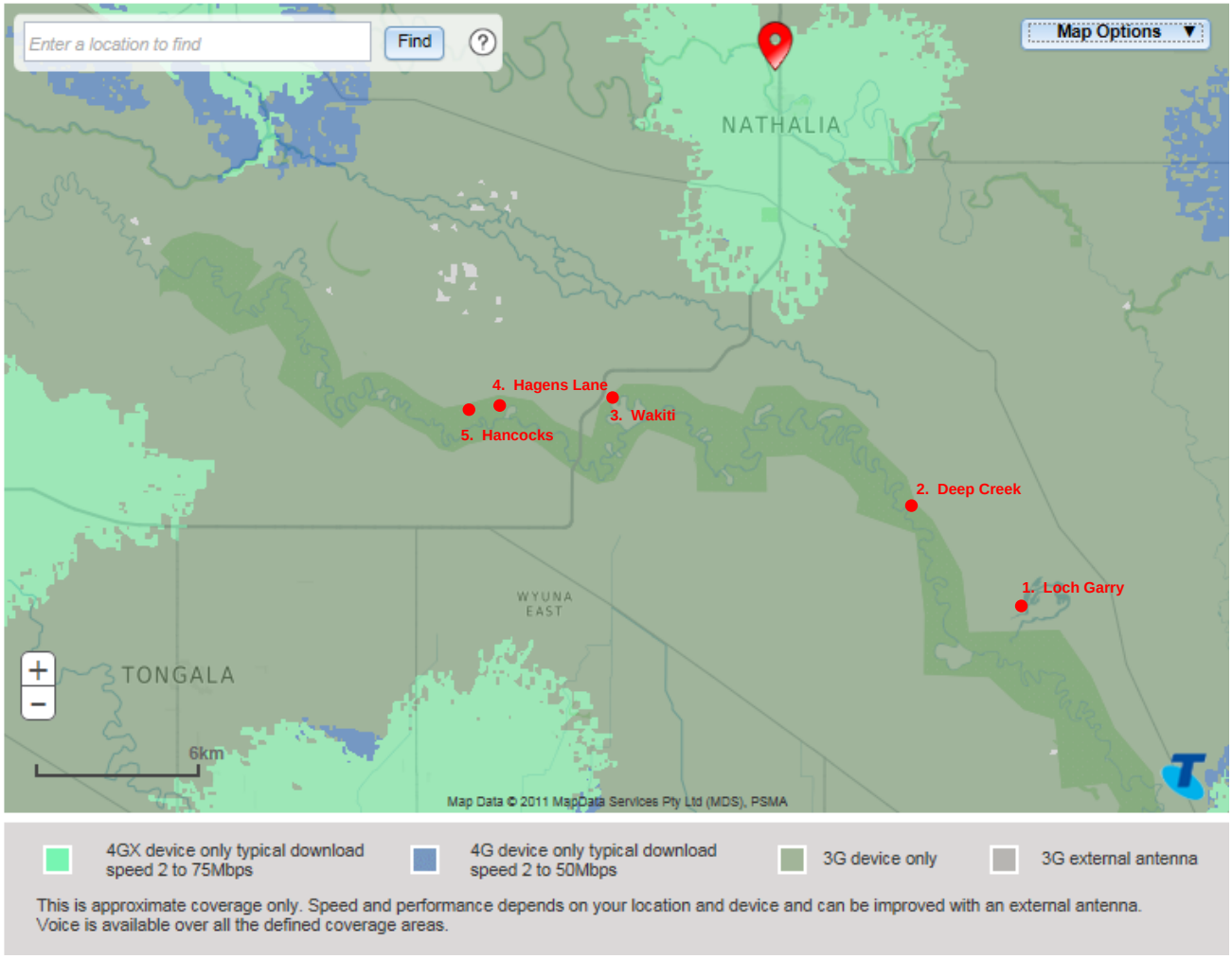
We understand that the GM Water systems can be readily augmented to provide the necessary coverage, possibly by erecting an additional aerial or mast. Also we understand that the Mobile Telephone reception may be similarly improved with the erection of an aerial mast at each site.

5.11.2 Telstra Mobile Network Coverage

Initially, to establish the available Mobile Network coverage for the 5 x sites we conducted some limited field testing with hand held mobile phones and also our Mobile Network based GPS equipment. See below comparison table for a summary of our observations. We have also reviewed the coverage maps [5]published by Telstra for the 5 x sites. See over for an image of that coverage map with the approximate site locations marked. Telstra also advises the following;

> *"A range of external antennas are available that can provide improved coverage for certain mobile devices in areas where coverage is marginal. Even when you're in an area where handheld coverage is possible, an external antenna solution may also improve the performance of your handset or broadband device.*
>
> *Yagi or external antennas are most effective when mounted in the 'line of sight' of a mobile phone base station, or where the best signal is received. Depending on location and type of antenna used, this can be near a window, building rooftop, pole or other elevated structure.*
>
> *As with all antennas, the general rule when mounting is the higher the better. After the antenna has been fitted, it is connected directly to a mobile device, such as a broadband modem. "*

[5] *From www.telstra.com.au/coverage-networks/our-coverage as at 20/10/15.*



Telstra Mobile Network coverage map from www.telstra.com.au

We note that the coverage depicted in the above Telstra map is consistent with our field tests.

5.11.3 Comparison of Available Communications Coverage

We summarise the apparent coverage of the existing Telstra Mobile Network and the GM Water radio system at the 5 x sites as below.

Structure	***Estimated Landline Proximity***	***Mobile Telephone Coverage***	***GMW SCADA Coverage***
1. Loch Garry Regulator	About 1.8km north east of the site.	Yes	Yes
2. Deep Creek Outlet	About 2.6km south east of the site	Yes	Marginal
3. Wakiti Creek Outlet	About 150m west of the site.	Marginal	None
4. Hagen's Creek Lane	About 2.5km north east of the site	None	None
5. Hancock Creek Outlet	About 2.5km north of the site	None	None

Our assessment of the Mobile Network system coverage is based upon our own mobile phone signal. The Mobile Network system is possibly the simplest to deploy for this project. We anticipate that the limitations of the existing Mobile Network coverage are largely due to the dense tree cover and remote locations.

We also understand from our review of information provided by Telstra that an elevated aerial is likely to provide sufficient signal strength to enable reliable data communications across all 5 sites. Formal testing is required to verify this assumption, confirm the required aerial heights etc.

Alternatively, the development of radio a link may be necessary. Again formal testing will be required to identify the preferred systems and verify the required aerial heights etc.

Feedback received from our draft report included some concerns that the Mobile Network is subject overload and may fail during periods of emergency such as floods. In discussions with our client it was agreed that this issue was not a concern. The intended focus of operations for the proposed waterway controls is during environmental flow events, ie. not during significant flooding events.

5.12 Hydraulic Capacity of Control Structures

5.12.1 Waterway Area Impacts

The concept design solutions presented in this report have been analysed and compared to the existing structures. As a result the available waterway areas are generally slightly reduced on some structures due to the incursions of the frames etc. for the control gates.

The following waterway areas have been calculated for the existing waterways before after the installation of the control gates.

Structure	***Existing Clear Waterway Area (m2)***	***Clear Waterway Area After Installation of Gates (m2)***
1. Loch Garry Regulator	231	195
2. Deep Creek Outlet	20	15
3. Wakiti Outlet	15	14
4. Hagen's Creek [6]Outlet	0.07	0.07
5. Hancock Creek Outlet	6	7

5.12.2 Additional Waterway Capacity Required

In consideration of the feedback received from the reviews of our draft report regarding the above "loss of clear waterway area" at the Loch Garry and Deep Creek structures, it was agreed that this loss of clear waterway area would be compensated by constructing additional waterway cells.

The combined net loss of waterway across the 2 x structures is 36 + 5 = 41 m^2.

Both structures are situated within the same general vicinity (ie. Being only about 5.6km apart) and both discharge to the east side of the river into the same waterway, ie. Bunbartha Creek. The construction of an additional cell at Loch Garry is problematic due to the nature of the existing structure, the abutments and the challenges of attaching new work to an old structure.

It was also generally agreed that the construction of a new structure at a suitable location in the levee somewhere between the Loch Garry and Deep Creek would be more practicable. It was also agreed that the new structure would be of a similar design and function to the existing Deep Creek structure with a required clear waterway area of 41 m^2.

An additional item has been added to the estimate for that new structure.

5.13 Waterway & Embankment Protection

During our review of the existing structures we observed that the outlets of all of the structures have been severely impacted by erosion. Most structures were protected by stone beaching, however the high velocity discharges have caused much of that material to be dislodged and transported downstream, allowing the downstream waterway inverts to be severely eroded.

The displaced beaching leaves waterway invert unprotected and vulnerable to scour and results in the displacement of large volumes of earth. The loss of earth in the invert immediately downstream of the outlet structure also leaves it vulnerable to undercutting and may eventually lead to the structure being destabilised and levee failure through the associated embankment instability.

---

[6] *Assumes existing 300mm diameter culvert is unchanged. The proposed penstock has no impact upon the clear waterway of the culvert.*

We believe a more appropriate treatment of the downstream waterway inverts would incorporate the use of wire gabions or "Reno" mattress structures. These countermeasures when deployed in conjunction with appropriate geotextile cloth will retain the stone in place and allow the use of interlocking structures and ground anchors to prevent displacement.

Our review of recent waterway structures developed by GM Water also noted the deployment of sheet piling beneath the control structures as a protection against undercutting or piping.

Given the significant investment being made in this infrastructure we suggest consideration be given to protecting these structures by deploying sheet piling beneath the structures, particularly where there may be fill beneath the structure.

5.14 Land Status & Planning Controls

5.14.1 Planning Scheme Requirements

The legal status of the existing structures is unclear as regards ownership. All structures appear to be situated on crown land. We believe it would be prudent to have a licensed survey re-establish the adjacent property boundaries before proceeding with any works to ensure there are no incursions into any adjacent private properties.

We believe that 4 of the structures are within the Moira Planning Scheme and the Loch Garry structure is within the Greater Shepparton Planning Scheme. We have reviewed the requirements of the planning schemes as they relate to each structure and note the following overlays apply.

Structure	***Planning Scheme & Map No.***	***Land Use Zoning***	***Environmental Significance Overlay***	***Land Subject To Inundation & Rural Floodway Overlay***
1. Loch Garry Regulator	Greater Shepparton Map No.2	PCRZ	N/A	FO
2. Deep Creek Outlet	Moira Map No.29	PCRZ	ESO2	RFO
3. Wakiti Outlet	Moira Map No.28	PCRZ	ESO2	RFO
4. Hagen's Creek Outlet	Moira Map No.28	PCRZ	ESO2	RFO
5. Hancock Creek Outlet	Moira Map No.9	PCRZ	ESO2	RFO

- PCRZ Public Conservation and Resource Zone
- RFO Rural Floodway Overlay
- ESO2 Environmental Significance Overlay - Schedule 2
- FO Floodway Overlay

From our review of the planning scheme maps it is apparent also that the Loch Garry and Hancock's Creek outlet structures immediately abut or are adjacent to private property. In both cases the outlets discharge onto private land which has been severely impacted by erosion. The downstream waterway restoration works will be undertaken on that private land. We note that this downstream land which receives discharge from these structures is zoned FZ1 or Farm Zone 1.

Please see attached appendices for copies of the relevant planning scheme maps with the approximate structure locations marked.

We also note the variances between the two schemes, particularly the presence of the "Environmental Significance Overlay" and schedule 2 requirements which apply only to the structures within the Moira Planning Scheme. That schedule is subtitled "MURRAY RIVER CORRIDOR" and prescribes a series of environmental objectives to be considered.

We contacted the planning departments at each of the responsible authorities, ie. the local Council's regarding the need for a planning permit and note the following responses;

5.14.2 Council Responses to Planning Query

We made a formal inquiry regarding the Councils' requirements. We received the following advice from Moira Shire Council's planning department in an email dated 5/10/15.

"Clause 62.02-1 of the Moira Planning Scheme states that there is an exemption for a planning permit requirement triggered by the Planning Scheme under for Maintenance works carried out by a municipality or public authority to prevent or alleviate flood damage.

The sites appear to all be in the Public Conservation and Recreation Zone (PCRZ) which is the only zone in which this exemption does not apply.

Clause 36.03-2 however indicates that in the PCRZ if the work is carried out by or on behalf of a public land manager, such as GBCMA, and if the work being undertaken is in accordance with the Water Act 1989 there is an exemption from the requirement for a planning permit in the PCRZ.

I note that all of the sites are in forested areas. Please be aware that the removal of native vegetation may trigger a planning permit requirement."

We also received the following advice from Greater Shepparton City Council's planning department in a letter dated 19/10/15.

"The land is within the Public Conservation and Recourse Zone and is affected by the Floodway Overlay and the Bushfire Management Overlay.

A Planning Permit would not be required for the proposal subject to the following conditions:

Public Conservation and Recourse Zone:
A building or works carried out by or on behalf of a public land manager or Parks Victoria under the Local Government Act 1989, the Reference Areas Act 1978, the National Parks Act 1975, the Fisheries Act 1995, the Wildlife Act 1975, the Forest Act 1958, the Water Industry Act 1994, the Water Act 1989, the Marine Act 1988, the Port of Melbourne Authority Act 1958 or the Crown Land (Reserves) Act 1978.

Floodway Overlay
. . flood mitigation works carried out by the responsible authority or floodplain management authority.

Wildfire Management Overlay
The proposal is not identified as a use outlined in Clause 44.06-1 of the Planning Scheme.

Subject to compliance with the above, it is considered that a Planning Permit would not be required.

Please ensure that you comply with all of the above requirements."

5.14.3 Summary Planning Status

The apparent exemptions available to the catchment management authority as a "public land manager" may be compromised by the following potential triggers;

- Likely removal of native vegetation.
- Likely significant ground disturbance within "Areas of Cultural Heritage Sensitivity", will trigger the need for the preparation of a "Cultural Heritage Management Plan", see below for further information.

In consideration of the above information we have concluded that a formal planning approval process will be necessary, despite the advice we have received from the Council planners. In all fairness, we provided the planners very information regarding the nature of the proposed works.

5.15 Cultural Heritage Management Plans

We note the following extract from the Office of Aboriginal Affairs Victoria website.

The Aboriginal Heritage Act 2006 (the Act) and Aboriginal Heritage Regulations 2007 (the Regulations) provides for the protection and management of Victoria's Aboriginal heritage with processes linked to the Victorian planning system.

The legislation provides protection for all Aboriginal places, objects and human remains regardless of their inclusion on the Victorian Aboriginal Heritage Register or whether they are located on public or private land.

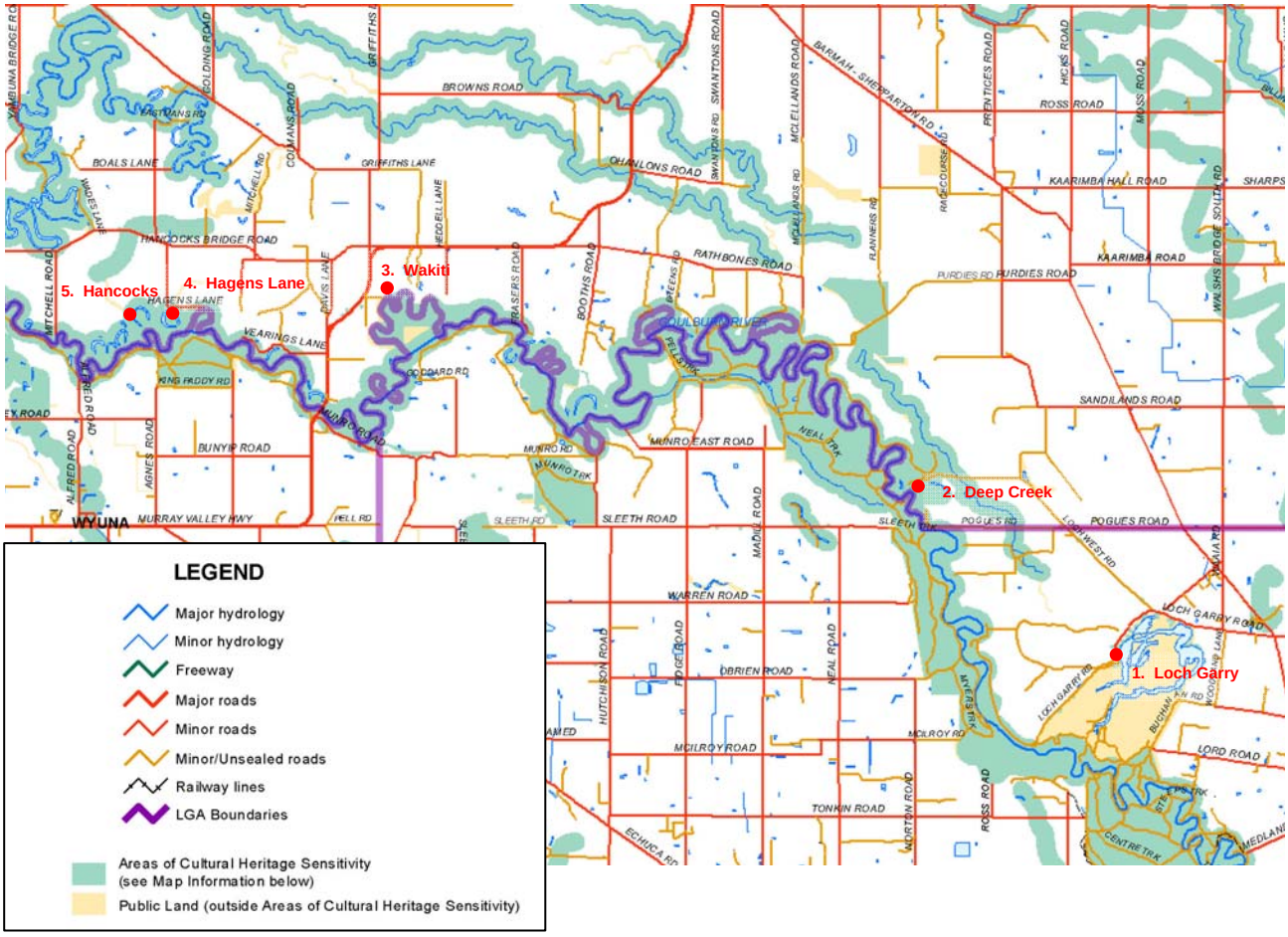
The Act also provides clear guidance to planners and developers about when, and how, Aboriginal cultural heritage needs to be considered, and in some situations work cannot proceed until compliance is met. Large developments and other high impact activities in culturally sensitive landscapes can cause significant harm to Aboriginal cultural heritage. In these situations the Act may require the preparation of a Cultural Heritage Management Plan or the planner or developer may need to obtain a cultural heritage permit.

Our review of the "Aboriginal Heritage Act 2006 Practice Note: Significant Ground Disturbance" indicates that any works involving ground disturbance at any of these sites will trigger the need for the preparation of a "Cultural Heritage Management Plan".

The OAAV have recently published a series of 1: 100,000 scale maps describing the "Areas of Cultural Heritage Sensitivity in Victoria". We note the area within which these structures are situated is described on a map listed under the "Hume Region" and entitled "Map No.7925 Shepparton" dated July 2015. Please below an extract from that map describing the location of the structures.

From our review of Map No.7925 Shepparton, we believe that 4 of the 5 structures are situated within (or alternatively very close to) green shaded areas designated as being of Cultural Significance. Also we note that whilst Loch Garry is within an area designated as a Public Land outside an area of Cultural Significance, there are several smaller green shaded areas within that Public Land that are only readily visible when the image is enlarged.

EXTRACT from Areas of Cultural Heritage Sensitivity in Victoria, Map No.7925 Shepparton.



6 RECOMMENDED DESIGN SOLUTIONS

In consideration of the above information we have concluded that the preferred outlet control system will have the following features;

6.1 Loch Garry Regulator

6.1.1 Site Works

The existing access road is in good condition, however some pavement upgrading and drainage improvements are required to ensure there is all weather access throughout the construction phase.

6.1.2 Structural Works

The existing concrete substructure is old however it is generally [7]structurally sound and in good order. However the unused, 3.2m wide timber bridge superstructure has degraded and is beginning to collapse into the waterway and is now hazardous. There is a barricade at each end of the deck preventing access.

In our draft report we concluded that the walkway provided sufficient access and that the timber bridge structure was no longer in use and therefore not required. During the review process there was an alternate view expressed suggesting that vehicular access may be required. Our subsequent feedback discussions concluded that this was an escalation of the scope of works for the project and decided that this was a matter that would be best addressed during the detail design development phase of the project. Consequently the cost estimates assume the bridge is removed and not replaced.

There are a number of minor cracks and exposed joints within the concrete substructure piers and abutments which require some remediation to prevent any further deterioration of the structure.

6.1.3 Walkway Access

The existing steel fabricated, galvanised walkway is positioned conveniently to be retained and utilised to access the new control gates. The walkway will have to be modified to reinstate the floor openings over the existing drop boards. The handrail will also have to be modified to facilitate access to the new gates on the downstream side.

The long structure and walkway is accessible only at the abutments. Access stairs at third points on the upstream side of the structure would make maintenance and general operations access more convenient.

6.1.4 Waterway Control Device

We recommend that the control gates be vertically operated, hydraulic “head and discharge” type gates, allowing both under and over shot operations.

There are presently 47 x common waterway openings about 1.66m high x 2.35m wide. Also 1 x low flow waterway opening (no.38) which is about 2.82m high x 2.07m wide. The upstream side of the structure has a relatively constant waterway opening, in which the drop boards are place. However the waterways on the downstream of the drop boards progressively steps down in even increments each side of the low flow 8 or 9 bays each side of the low flow waterway.

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[7] *In considering feedback received to the draft report there were queries raised regarding the structural capacity of the existing structure. The structural assessment to date had been entirely based upon a visual assessment of the structure and a review of the available drawings.*
We have since returned to the site and conducted a series of Schmidt Hammer tests on the concrete (dated 15/10/15) at 5 separate locations, recording 3 x tests at each location. A Schimdt Hammer is a device used to measure the elastic properties and strength of concrete. The hammer measures the rebound of a spring-loaded mass impacting against the surface of the sample
The lowest concrete strength detected across the 5 x locations after 15 x individual tests was 35MPa. The range of accuracy for that test/device being noted at +/- 7MPa.
This result is a better than expected outcome and supports the conclusions of our visual assessment.

We propose that control gates will be of a similar configuration to the drop boards, ie. 47no. common gates @ 1.66m high x 2.35m wide and 1 low flow gate 2.82m high x 2.07m wide. The gates shall be installed on the downstream side of the existing walkway to facilitate ready access to the hydraulics and control pedestal from the walkway.

The control gates will maintain the same sill level as the existing drop boards. An infill is required in the invert of each cell to fill a void that will be created beneath the new gate structures.

6.1.5 Waterway & Embankment Protection Works

The upstream waterway is sound and in good order. No works are required.

The downstream waterway is heavily eroded and degraded. The outlet structure requires upgrading and the deployment of suitable energy dissipation devices. The downstream waterway also requires significant restoration and erosion protection works. The use of unconfined stone beaching is not suitable in this high velocity environment. We recommend the use of Maccaferri gabions or Reno Mattresses or similar in conjunction with a suitable geotextile filter cloth.

In response to feedback received on the draft report the concept design drawings have been amended to show the downstream waterway protection extended at the lowest level to be not less than 8m in length. We also acknowledge a construction file note (circa 1925) that has been recently recovered from archives by GM Water which indicates that sheet piling has been installed beneath "*both the up and downstream aprons*". That same information indicates a pile length of about 10 feet (3m).

6.1.6 Lay-down Area

In consideration of the draft report there was some feedback regarding the need to make provision for "lay-down areas" during construction and for subsequent maintenance access etc. In subsequent discussion it was agreed that the existing Loch Garry site has an extensive cleared, level area on the upstream side of the structure which is suitable for use as a lay-down area. No additional provisions are proposed.

6.1.7 Electricity Supply

The gates will be powered by solar panel and battery backup systems.

6.1.8 SCADA & Remote Control

We propose that the SCADA and remote operations will be Mobile Network (or similar) based, requiring masts to be erected at each site. The Mobile Network system shall have a direct link to a web based system providing live, real time data and control. Our estimates assume a 15m mast will be adequate. Field testing is required to verify the suitability of the Mobile Network system.

We also note that there are presently two unused masts already installed on the existing structure which may prove to be useful.

6.2 Deep Creek Outlet

6.2.1 Structure

The existing concrete structure is structurally sound, however the rudimentary steel columns and timber doors are not suitable and vulnerable. Whilst the existing abutments are sound and strong enough to support the control gates the waterway opening is too broad to install a single control gate.

To address this issue we propose a modified inlet structure be constructed on the upstream side, to utilise the existing structure and allow the waterway to be divided into separate waterways with the installation of 3 x new cast insitu RC piers.

In consideration of the feedback received the concept design has been modified to ensure that the bridge deck remains at a trafficable width for light vehicles. To accommodate that suggestion the drawings have been modified to depict the control gates installed clear of eth existing bridge kerb on the upstream side.

6.2.2 Walkway Access

The existing prestressed RC slab deck is sound, however we need to remove one deck plank to allow the installation of the gates.

6.2.3 Waterway Control

As for Loch Garry, we recommend that the control gates be vertically operated, hydraulic “head and discharge” type gates, allowing both under and over shot operations.

6.2.4 Waterway & Embankment Protection Works

The upstream waterway is sound and in good order, however there are some small trees which obstruct the waterway that need to be cleared.

The downstream waterway is heavily eroded and degraded immediately downstream of the outfall apron and threatens to undercut the apron. The downstream waterway requires reshaping and erosion protection works. Again the use of unconfined stone beaching is not suitable in this high velocity environment. We recommend the use of Maccaferri gabions or Reno Mattresses or similar in conjunction with a suitable geotextile filter cloth.

6.2.5 Lay-down Area

In consideration of the draft report there was again feedback suggesting that provision should be made for “lay-down areas” during construction and for subsequent maintenance access etc. In subsequent discussion it was agreed that the Deep Creek site was only presently accessible along the levee. There is relatively dense tree cover along both sides of the levee. Some minor clearing is required on the upstream side of the structure to clear the waterway and provide a connecting ramp from the levee access track.

The construction phase of this project will require some open space for a site office and portable toilet, construction vehicles and some material storage and assembly. The nearest suitable alternative clearings or open farmland are about 500 to 600m of the site. A nominal provision has been added to the estimates to allow for development of a 400m^2 lay–down area.

6.2.6 Electricity Supply

The gates will be powered by solar panel and battery backup systems.

6.2.7 SCADA & Remote Control

We propose that the SCADA and remote operations will be Mobile Network (or similar) based, requiring masts to be erected at each site. The Mobile Network system shall have a direct link to a web based system providing live, real time data and control.

Our estimates assume a 15m mast will be adequate. Field testing is required to verify the suitability of the Mobile Network system.

6.3 Wakiti Outlet

6.3.1 Structure

The existing clay brick structure was significantly enhanced in 1980 with the addition of the sheet piling on the upstream and downstream sides of the structure and a large RC apron added on the outlet side. We believe that these improvements are a substantial investment and can be readily utilised.

The waterway shape through structure and the degraded brick abutments are not suited to the installation of control gates. However the upstream side of the structure is readily accessible and suited to modification to install the control gates.

We propose that the waterway be divided into 3 x separate waterways with the installation of 4 x new cast insitu RC piers on the upstream side of the existing brick structure. The new piers shall be linked to the existing brick wingwalls and direct water into the existing structure, utilising the sheet piling and the substantial outfall structure.

6.3.2 Walkway Access

At present there is no walkway across the structure linking the two abutments. A new steel fabricated, galvanised walkway is required.

6.3.3 Waterway Control

As for Loch Garry, we recommend that the control gates be vertically operated, hydraulic "head and discharge" type gates, allowing both under and over shot operations.

6.3.4 Waterway & Embankment Protection Works

The upstream waterway is sound and in good order, however again there are some small trees which obstruct the waterway that need to be cleared.

The downstream waterway is heavily eroded and degraded immediately downstream of the outfall apron and threatens to undercut the apron. The downstream waterway requires reshaping and erosion protection works. Again the use of unconfined stone beaching is not suitable in this high velocity environment. We recommend the use of Maccaferri gabions or Reno Mattresses or similar in conjunction with a suitable geotextile filter cloth.

6.3.5 Lay-down Area

Again in consideration of the draft report there was some feedback suggesting that provision should be made for a "lay-down area" during construction and subsequent maintenance access etc. In subsequent discussion it was agreed that the Wakiti Creek site had some limited open, unused space available along the access track to the pump station and also in the adjacent farmland.

Some minor clearing is again proposed on the upstream side of the structure to clear the waterway, provide space for the control structures and also construct an access ramp up and over the levee to the existing access track on the downstream side.

The construction phase of this project will require some open areas. Subject to reaching an agreement with the landholder there is sufficient space available within the adjacent farmland for a site office and portable toilet, construction vehicles and some material storage and assembly. Some levelling of the ground and gravel will be required. Again we have added a nominal provision to the estimates to allow for development of a 400m^2 lay–down area.

6.3.6 Electricity Supply

The gates will be powered from the nearby aerial supply to the adjacent pump station and shall be augmented by battery backup systems.

6.3.7 SCADA & Remote Control

We propose that the SCADA and remote operations will be Mobile Network (or similar) based, requiring masts to be erected at each site. The Mobile Network system shall have a direct link to a web based system providing live, real time data and control.

Our estimates assume a 15m mast will be adequate. Field testing is required to verify the suitability of the Mobile Network system.

6.4 Hagen's Lane

6.4.1 Structure

The structure is a simple concrete pipe and clay brick endwalls. The endwalls are sound. The outlet endwall (north side of levee) is suited to having a penstock attached to its face. The inlet endwall (south side of levee) is a low wall, likely to be inundated and not readily accessible.

Our cost estimates assumes the existing structures remains as is and the motorised penstock is attached to the existing brick endwall.

Whilst the culvert and endwalls are sound we recommend that consideration be given to reconstructing this outlet to provide additional capacity. Depending upon what size pipe and endwall is installed if upgraded, we suggest a simple motorised penstock will suffice for pipes up to 900mm diameter.

6.4.2 Waterway & Embankment Protection Works

We have allowed for nominal waterway works only, mainly on the downstream or outlet side of the structure to prevent scour and erosion. If the size of the structure is increased or a new endwall is installed further waterway protection works may be required.

6.4.3 Lay-down Area

Again, in consideration of the feedback on our draft report there was a suggestion that provision should be made for "lay-down areas" during construction and for subsequent maintenance access etc. In subsequent discussion it was agreed that this site has sufficient clear open space available, particularly along the upstream side of the levee to accommodate the proposed construction phase works.

The Hagen Lane road pavement is situated nearby and provides ready access. Only nominal provisions have been made in the estimate for these works.

6.4.4 Electricity Supply

The gates will be powered by solar panel and battery backup systems.

6.4.5 SCADA & Remote Control

We propose that the SCADA and remote operations will be Mobile Network (or similar) based, requiring masts to be erected at each site. The Mobile Network system shall have a direct link to a web based system providing live, real time data and control.

Again, our estimates assume a 15m mast will be adequate. Field testing is required to verify the suitability of the Mobile Network system.

6.5 Hancock Creek Outlet

6.5.1 Structure

The existing RC endwalls are in good order, however the circular pipes below are in bad condition and need to be excavated and re-laid or more preferably replaced. We are concerned that this structure is a liability due to its design, ie. depth, high water pressures and the high velocity outlet water discharges.

We believe this structure would be made more serviceable and require less upkeep if it was reconstructed with a higher invert level using "crown unit culvert sections" in place of the rubber ring jointed reinforced concrete circular pipes. The crown unit sections have been sized to provide the equivalent waterway capacity of the existing circular sections.

We also propose that the new structure have a raised invert.

The removal of the old structure will create a highly disturbed site. That demolition process will be expensive and shall require a significant excavation, ie. of up to 4,000m^3. The cost of rehabilitating this site to provide a sound base to construct the new structure will be expensive. Rather than relocate the structure and realign the waterway we propose to install sheet piling beneath the downstream and upstream endwalls to prevent the passage of water beneath the structure through the fill.

6.5.2 Waterway Control

As for Loch Garry, we recommend that the control gates be vertically operated, hydraulic "head and discharge" type gates, allowing both under and over shot operations.

6.5.3 Waterway & Embankment Protection Works

The upstream waterway is sound and in good order, however again there are some small trees which obstruct the waterway that need to be cleared.

The downstream waterway is heavily eroded and degraded immediately downstream of the outfall apron and threatens to undercut the apron. The downstream waterway requires reshaping and erosion protection works. Again the use of unconfined stone beaching is not suitable in this high velocity environment.

We recommend the use of Maccaferri gabions or Reno Mattresses or similar in conjunction with a suitable geotextile filter cloth.

6.5.4 Lay-down Area

In consideration of the draft report there was again feedback suggesting that provision should be made for "lay-down areas" during construction and for subsequent maintenance access etc. In subsequent discussion it was agreed that the Deep Creek site was only presently accessible along the levee. There is relatively dense tree cover along both sides of the levee. Some minor clearing is required on the upstream side of the structure to clear the waterway and provide a connecting ramp from the levee access track.

The construction phase of this project will require some opens space for a site office and portable toilet, construction vehicles and some material storage and assembly. The nearest suitable alternative clearings or open farmland are from 500 to 600m of the site. A nominal provision has been added to the estimates to allow for development of a 400m^2 lay–down area.

6.5.5 Electricity Supply

The gates will be powered by solar panel and battery backup systems.

6.5.6 SCADA & Remote Control

We propose that the SCADA and remote operations will be Mobile Network (or similar) based, requiring masts to be erected at each site. The Mobile Network system shall have a direct link to a web based system providing live, real time data and control.

Again our estimates assume a 15m mast will be adequate. Field testing is required to verify the suitability of the Mobile Network system.

7 GMW INDICATIVE COST INFORMATION

7.1 GMW Capital Costs

GM Water have provided the following indicative construction cost outcomes for the supply and installation of gates/regulators for the following recent projects.

Site	*Width*	*Height*	*Gate Material*	*Qty*	*Comment*
Hattah Lakes Project (ex' AWMA)					
Messengers Regulator	2000	4500	Marine aluminium	2	AWMA combination (dual leaf) Penstock Gate. All with rising spindles and hydraulic actuation.
	2000	4500	316 Stainless steel	2	
Oateys Regulator	2000	5000	Marine aluminium	2	
	2000	5000	316 Stainless steel	2	
Cantala Regulator	2000	3000	Marine aluminium	1	
	2000	3000	316 Stainless steel	1	
Hipwell Road Weir Project (ex' Rubicon Water)					
Hipwell Road Weir Regulator	2268	2186	Marine aluminium composite	4	Flume Gates, 8 no.
Hipwell Road Offtake Regulator	2268	2636	Marine aluminium composite	4	

From our review of the above information we note the following;

- The penstock gate costs for the stainless steel gates are about 30% more expensive than the marine grade aluminium gates.
- The various gates range in cost from about $7,200 to $14,300/sq.m.
  The smaller gates being at the higher unit rate.

We understand that these rates are inclusive of the following;

> *To supply necessary materials, fabricate, bench test, transport to site, then install each control device complete with frames, doors, hydraulic rams, pumps, controls, sensors and fixings etc.*

We had previously adopted the stainless steel gate option as the preferred system because of its higher durability, general robustness and lower maintenance costs. We have also excluded the FlumeGate solution from our considerations due to the constraints of this operating environment as described earlier in this report, ie. due to the effects of flood debris impacts, accumulation of transportable silts and remote locations.

In consideration of the feedback received from the review of our draft report, allowing cost escalations since the above works were completed the following clarifications have been made for these estimates;

- The preferred material for fabrication of the gates shall be "Marine Grade Aluminium" or MG Aluminium.
- Our previous review of the GM Water costs adopted a $14,000/$m^2$ unit area cost, being for the higher unit cost for stainless steel gates.
  MG Aluminium gates are on average about 30 cheaper than stainless steel, therefore that rate reduces to $9,800/$m^2$ unit area cost.
  Adjusting that rate for inflation we note that some of these projects date back as far as 2005, ie. now more than 10 years ago.
  That adjustment assumes an average cpi of 3% per annum, the adjusted cost MG Aluminium increase to $13,200/$m^2$ unit area cost
- There is a cost differential between smaller and larger gates, ie. smaller MG Aluminium gates are more 24% more expensive to fabricate and install than larger gates on a unit area basis.
  For the purposes of this cost estimate and in consideration of the above information we have adopted a fabricate, supply and install rates for the control gates shall be;
  - for small gates (ie. equal to less than 6m^2 openable area), allow **$17,000**/$m^2$.
  - for large gates (ie. greater than 6m^2 openable area), allow **$14,000**/$m^2$.

7.2 GMW Operating Costs

We are advised by GM Water of the following typical annual unit costs for the maintenance of their infrastructure assets;

Maintenance costings	
Asset	**Approx Annual Maintenance Costs ($/unit/yr)**
Flume Gate Structure	$ 1,750.00
Node Towers	$ 269,000.00
Fishways	$ 1,800.00
Bridges	$ 400.00

8 COST ESTIMATES

8.1 Capital Cost Estimate

We have prepared cost estimates for the development of each of the proposed control structures on a site by site basis. These cost estimates have been prepared based upon our observations, the above concept design descriptions, the attached drawings and using rates as published by Cordell Commercial Building Cost Guide as at July 2015 and supplemented with other recent project based information as provided by GM Water and others.

These estimates have been adjusted to take into account the feedback received and arising from the review and comments on our draft report. We summarise the our cost estimate outcomes as follows;

Structure	*CONSTRUCTION COST exc' GST*	*TOTAL OVERALL COST exc' GST*	*TOTAL OVERALL COST inc' GST*
1. Loch Garry Regulator	$5,437,085.49	$8,486,482.51	$9,335,130.76
2. Deep Creek Outlet	$733,006.36	$1,195,159.86	$1,314,675.84
3. Wakiti Outlet	$1,045,129.60	$1,668,950.88	$1,835,845.97
4. [8]Hagen's Creek Outlet	$69,442.50	$156,635.88	$172,299.46
5. Hancock Creek Outlet	$1,009,736.25	$1,614,091.19	$1,775,500.31
Total	**$8,294,400.20**	**$13,121,320.32**	**$14,433,452.34**

Please see attached appendix for a detailed breakdown of the capital cost estimates.

The Construction Costs are our estimate of the likely construction cost outcomes. Briefly, the fabrication, supply and installation of the control gates make 60% of the total construction costs, the associated structural works are about 20%, the waterway and embankment works about 10%, the communications and SCADA systems about 5%.

The Total Overall Cost includes provision for detailed design, project management, planning approval (including cultural heritage and environmental impact assessments), also a 40% contingency provision for cost escalation factors due to detailed design, planning conditions etc.

Adjustments to the estimate made in response to the feedback from the review of the draft report have been shaded to facilitate reconciliation.

8.2 Controlled Compensatory Waterway Structure

We propose that a further additional nominal provision of **$2.5M exc' GST** be allowed for the construction of a controlled compensatory waterway between Loch Garry and Deep Creek.

[8] *Assumes the existing culvert and endwall structures at Hagen's Lane are unchanged.*

8.3 Economies of Scale

The above estimates are based upon the above works being undertaken as standalone sites/projects. Considerable economies of scale may be possible if the works were undertaken simultaneously as a whole or complete package. Particular economies will be available in the areas of the SCADA systems hosting, the engagement of design consultants, project managers, preparation of cultural heritage management plans and project management etc.

9 REFERENCES & ACKNOWLEDGEMENTS

A number of references have been reviewed in the preparation of this report and have been acknowledged throughout this report. The following references are specifically acknowledged;

- NSW Department of Industry & Investment - Review of Water control structures: Designs for natural resource management on coastal floodplains, by Ben Rampano (September 2009).
- Rubicon FlumeGate data sheet brochure, 4 x pages 29/7/13.
- Rubicon SlipGate site survey manual (ver 1.0), 24 x sheets dated 20/4/12.
- Rubicon SlipGate data sheet brochure, 4 x pages dated 3/6/14.
- Australian Technical Specification for Fabricated Water Control Infrastructure, revision 8 12/12/12, sourced from www.awmawatercontrol.com.au
- AWMA Penstocks, Stopboards & Bulkheads brochure, 8 x pages dated 8/1/13.
- Hydraulic Modelling Analysis for the Lower Goulburn River, report and appendices for GBCMA by Water Technology (October 2011).
- Lower Goulburn Floodplain Rehabilitation Scheme Hydraulic Modelling Report, prepared for GBCMA by SKM & Water Technology (December 2005).
- Levee Management Guidelines, published by the Department of Environment, Land, Water and Planning (2015), www.delwp.vic.gov.au .
- Various drawings and other information made available by the client and GM Water Staff.

10 APPENDICES

10.1.1 Locality Map & Aerial Images

10.1.2 Planning Scheme Maps

1.	Loch Garry Regulator	Greater Shepparton Planning Scheme Map No.2
2.	Deep Creek Outlet	Moira Planning Scheme Map No.29
3.	Wakiti Outlet	Moira Planning Scheme Map No.28
4.	Hagen's Creek Outlet	Moira Planning Scheme Map No.28
5.	Hancock Creek Outlet	Moira Planning Scheme Map No.9

10.1.3 Existing Conditions Drawings

10.1.4 Proposed Works Drawings

10.1.5 Cost Estimate Sheets

Prepared by GMR 27/9/15
Updated by GMR 30/9/15
Updated 23/10/15