2021-22 Irrigation Modernisation Water Recovery - Audit of GMW Connections Project

Connections Project Report

Report Date:

29 November 2022

Prepared for:

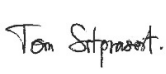
Department of Environment, Land, Water and Planning (DELWP)

Prepared by:

Cardno, now Stantec

Revision	Description	Author		Quality Check		Independent Review	
00-01	Development draft	Tom Sitprasert Christopher Bridge	TS CB	Christopher Bridge	CB	Stephen Walker	SW
01-01	Reviewed version	Tom Sitprasert Christopher Bridge	TS CB	Christopher Bridge	CB	Stephen Walker	SW

Revision	Description	Author		Quality Check		Independent Review	
01-02	Version submitted to GMW	Tom Sitprasert Christopher Bridge	TS CB	Christopher Bridge	CB	Stephen Walker	SW
1-03	Version reviewed by GMW	Tom Sitprasert Christopher Bridge	TS CB	Christopher Bridge	CB	Peter Roberts (GMW)	PR
2-01	First submission to DELWP	Tom Sitprasert Christopher Bridge	TS CB	Christopher Bridge	CB	Stephen Walker	SW
2-02	Version reviewed by DELWP	Tom Sitprasert Christopher Bridge	TS CB	Christopher Bridge	CB	Stephen Walker	SW
3-01	Proposed final version	Tom Sitprasert Christopher Bridge	TS CB	Christopher Bridge	CB	Stephen Walker	SW
A	Final version	Tom Sitprasert Christopher Bridge	TS CB	Christopher Bridge	CB	Stephen Walker	SW

Prepared by  

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SUMMARY FINDINGS

Background and scope

This report details the findings from Cardno, now Stantec's audit of the estimates of the Phase 3 water recovery achieved through irrigation modernisation in northern Victoria for 2021/22. The water recovery is being delivered through the Goulburn-Murray Water (GMW) Connections Project.

The GMW Connections Project has being implemented in two stages. Stage 1, which was funded by the Victorian Government, has been underway since 2008 and Stage 2, which was funded by the Commonwealth, commenced in 2012. The GMW Connections Project must be audited each year. This is the fourteenth annual audit of water savings from irrigation modernisation in the Goulburn-Murray Irrigation District.

The scope of activities included in this audit, as described in the audit brief, is as follows:

The cumulative irrigation modernisation works in place for the 2021-22 water year (1 July 2021 to 30 June 2022).

- An audit of the Phase 3 water recovery volumes generated from the completed GMW Connections Stage 1 and 2 Project for the 2021-22 water year from; regulator automation, meter, channel decommissioning and remediation works.
- Phase 3 mitigation water recovery volumes for the 2021-22 irrigation season from the GMW Connections Stage 1 Project.
- The water recovery volumes shall be reported against the following irrigation areas in GMID (and associated water trading zones in brackets).

  - Shepparton (1A), including the sub-area Shepparton East (1A)
  - Central Goulburn (1A),
  - Rochester (1A),
  - Loddon Valley, split as:
    - Pyramid Hill (1A),
    - Boort (1B),
  - Murray Valley (6) and sub area Lower Broken Creek (6B)
  - Torrumbarry (7).

Auditor statement

We have audited the 2021/22 water savings estimates prepared by the GMW Connections Project. Our audit was conducted in accordance with the scope provided by DELWP on 15 August 2022. Our audit activities included:

- Review of calculations of water savings
- Review of irrigation modernisation activities completed to generate water savings
- Review of construction records of irrigation modernisation activities
- Review of any other associated relevant Connections Project activities e.g., management of outfall flow data.

Based on our audit activities, we consider that the water savings estimates for 2021/22 have been reported in accordance with the Water Savings Protocol (Version 5) and are free from material error.

Audited Water Savings Estimates

Water savings are achieved through modernisation of irrigation infrastructure. The scope of the audit is to review Phase 3 water savings. The Phase 3 water savings estimates represent actual savings realised in the 2021/22 irrigation season as a result of works completed to date based on deliveries in 2021/22 and observed losses.

The audited Phase 3 estimates are set out in the following tables, and as required in the project brief, are separately accounted to the:

- GMW Connections Project Stage 1 (mitigation water separately reported in Table 4-5)
- GMW Connections Project Stage 2

Table 0-1 Phase 3 Water savings from GMW Connections Project Stage 1 (2021/22)- ML/ yr

Water Savings Intervention	SH	SH-EAST	CG1-4	CG 5-9	MV	MV-BC	RO	LV-PH	LV- BO	TO	Total
Phase 3 water savings											
Channel Removal (ML)^	0.0	0.0	0.0	1,869.3	6,129.0	0.0	2,001.6	2,222.1	463.7	8,479.2	21,165.0
Channel Automation (ML)*	0.0	0.0	0.0	14,300.6	2,567.7	0.0	4,248.7	-844.6	573.2	3,484.9	24,330.3
Mitigating Flows (ML)	0.0	0.0	0.0	-32.5	0.0	0.0	0.0	0.0	-1,153.6	-588.1	-1,774.2
Service Point Replacement (ML)	0.0	0.0	0.0	11,882.3	7,026.6	11.9	6,423.9	4,351.7	3,161.0	8,199.3	41,056.6
Service Point Removal (ML)	0.0	0.0	0.0	1,302.8	1,697.5	21.9	1,009.8	958.5	212.7	2,130.0	7,333.2
Channel Remediation (ML)	0.0	0.0	0.0	3,889.1	2,995.5	0.0	1,501.8	0.0	0.0	2,112.2	10,498.6
Total Phase 3 savings (ML)	**0.0**	**0.0**	**0.0**	**33,211.5**	**20,416.3**	**33.8**	**15,185.6**	**6,687.7**	**3,257.0**	**23,817.6**	**102,609.6**

Note totals may not sum due to rounding

^These savings are net channel removal savings after allowance for additional residual pipeline and channel losses are made

** These savings are gross channel automation savings before allowances for mitigation flows are made*

Table 0-2 Phase 3 Water savings from GMW Connections Project Stage 2 (2021/22) – ML/ yr

Water Savings Intervention	SH	SH-EAST	CG1-4	CG 5-9	MV	MV-BC	RO	LV-PH	LV- BO	TO	Total
Phase 3 water savings											
Channel Removal (ML)^	150.6	43.7	1,161.6	6,274.6	7,505.3	0.0	5,972.7	2,605.5	702.8	16,622.4	41,039.2
Channel Automation (ML)	0.0	486.7	0.0	541.4	475.7	0.0	659.6	-56.0	0.0	181.6	2,288.9
Service Point Replacement (ML)	47.3	235.4	163.5	7,893.8	3,561.7	3.3	5,443.4	3,204.6	1,571.7	7,541.2	29,665.8
Service Point Removal (ML)	74.9	55.7	11.1	1,545.2	1,127.6	2.7	894.1	1,062.6	320.6	2,748.4	7,842.7
Channel Remediation (ML)	483.2	0.0	1,131.5	3,443.5	2,720.7	0.0	232.5	171.5	1,307.6	4,170.5	13,661.1
Total Phase 3 savings (ML)	**756.0**	**821.5**	**2,467.6**	**19,698.5**	**15,391.0**	**6.0**	**13,202.4**	**6,988.1**	**3,902.8**	**31,264.1**	**94,497.8**

Note – Totals may not sum due to rounding

^These savings are net channel removal savings after allowance for additional residual pipeline and channel losses are made

Data collection and inputs

Our review for the 2021/22 audit of the information systems and processes used by the GMW Connections Project has found that they continue to be sufficiently robust to generate data and inputs that are as accurate as could reasonably be expected for the purpose of calculating water recoveries.

We found that all assets included in our samples for data trailing had sufficient evidence to support the fact that they have been constructed and commissioned. We are satisfied that the GMW Connections Project has completed the works claimed in the calculations.

Water Savings Protocol Reporting Requirements

The Water Savings Protocol[1] outlines the process for the independent audit of water savings estimates and defines the expected content of the water savings audit. The minimum requirements of the report and where they are fulfilled in this report is summarised inTable 0-3.

Table 0-3 Mapping of reporting requirements

Requirement	Where this is addressed in the report
A summary of findings.	Summary of Findings
Background information on the irrigation modernisation projects for which the water savings estimates are being audited, including the water savings targets.	Section 2.0
A description of the method(s) used for the independent audit	Section 3.0
The details and results of any site inspections undertaken. (Note for 2021/22, a remote working methodology was applied)	Section 4.2
An assessment of how well the project proponent's business and information systems and processes support the calculation of water savings.	Sections 0 and 5.0
The results of random and target sampling of the data trails used in the estimates of water savings.	Section 4
An evaluation of all water savings estimates against the Water Savings Protocol.	Section 6.0
Documentation of any instances of non-compliance with the Water Savings Protocol, and the changes required to the project proponent's estimates of water savings.	Section 6.0
Any recommended improvements to the data and methods used to estimate and report the water savings estimates, including revisions to the Water Savings Protocol.	Section 7.0

[1] Water Savings Protocol - A protocol for the quantification of water savings from modernising irrigation distribution systems, Department of Environment, Land, Water and Planning, Version 5.0 2018. Available at: https://www.water.vic.gov.au/__data/assets/pdf_file/0030/397074/WaterSavingsProtocol-V5-October2018_Final.pdf

Table of Contents

LIST OF TABLES

LIST OF FIGURES

Glossary

A	Ratio of the length of channel to be or actually automated to the total length of channel in the defined system (%)
BO	Boort
CG	Central Goulburn
CG1-4	Central Goulburn Channel 1, 2, 3 and 4
CG5-9	Central Goulburn Channels 5, 6, 7 8 and 9
CG2	Central Goulburn Channel 2 System
CL	Ratio of length of spur channel length rationalised to total spur channel length in system
Dbase	Customer Deliveries in the Baseline Year in the irrigation system
DELWP	Department of Environment, Land, Water and Planning
DF	Durability factor to account for the durability of water savings interventions
DF_{error}	Durability factor for reducing measurement error
$DF_{leakage\ around}$	Durability factor for reducing leakage around the meter
$DF_{leakage\ through}$	Durability factor for reducing leakage through the meter
$DF_{unauthorised}$	Durability factor for reducing unauthorised use
DM_{base}	Customer deliveries through the Rationalised meters in the Baseline Year
$DM_{Year\ X}$	Customer deliveries through the replaced meters for the year in question
D_{YearX}	Customer deliveries in the year in question to the irrigation system
E_{Base}	Evaporation in Baseline Year
$EF_{bank\ leakage}$	Effectiveness Factor Channel automation (bank leakage)
EF_{error}	Effectiveness Factor for reducing measurement error
$EF_{leakage\ around}$	Effectiveness Factor for reducing leakage around the meter
$EF_{leakage\ through}$	Effectiveness Factor for reducing leakage through the meter
$EF_{rationaliation}$	Effectiveness Factor for channel removal
$EF_{remediation}$	Effectiveness Factor for channel remediation
$EF_{unauthorised}$	Effectiveness Factor for reducing unauthorised use
EWP	Environmental Watering Plan
$F(LTCE_{Base})$	Long-Term Cap Equivalent Factor to convert Baseline Year volumes to Long-Term Cap Equivalent volume
$F(LTCE_{YearX})$	Long-Term Cap Equivalent Factor to convert Current Year volumes to Long-Term Cap Equivalent volume
F(PA)	Pondage Testing Adjustment Factor to account for dynamic losses in addition to static losses
FL	Proportion of bank leakage recognised as fixed
GIS	Geographic Information System
GMID	Goulburn-Murray Irrigation District
GMW	Goulburn-Murray Water
HR	High Reliability
IPA	Inter-Project Agreement
IPM	Irrigation Planning Module
ITP	Inspection Test Procedure
L_{Base}	Leakage in Baseline Year

$L_{Post\ works}$	Post works bank leakage
LR	Low Reliability
LTA	Defined Fixed Leakage Rate (ML/year/service point) around service points
LTCE	Long-Term Cap Equivalent
LTDLE	Long-Term Diversion Limit Equivalent
LTT	Defined Fixed Leakage Rate (ML/year/service point) through service points
LV	Loddon Valley
M&E	Mechanical and electrical
MCF	Adopted Meter Correction Factor for Dethridge Meter Service Points or associated with deemed Service Points
MV	Murray Valley
MV-BC	Lower Broken Creek
MWC	Mitigation water commitment
$N_{rationalised}$	Number of meters rationalised (removed)
$N_{replaced}$	Number of meters replaced
NVIRP	Northern Victoria Irrigation Renewal Project
$\mathbf{O_{BaseVariable}}$	Variable outfall loss in the baseline year
$\mathbf{O_{YearxVariable}}$	Variable outfall loss in the year in question
$\mathbf{O_{BaseFixed}}$	Fixed outfall loss in the baseline year
$\mathbf{O_{YearxFixed}}$	Fixed outfall loss in the year in question
PB	Pyramid-Boort
PH	Pyramid Hill
PMIS	Project Management Information System. This is an information system developed specifically for managing information associated with delivery of modernisation construction works.
RL	Ratio of length of channel length remediated to total channel length in system
RO	Rochester
S_{Base}	Seepage in Baseline Year
SCADA	Supervisory Control and Data Acquisition
SH	Shepparton
SIAMP	Shepparton Irrigation Area Modernisation Project
SPM	System Planning Module
$S_{post\ works}$	Post works seepage
Stage 1	Stage 1 of the GMW Connections Project
Stage 2	Stage 2 of the GMW Connections Project
the Protocol	the Water Savings Protocol – A Protocol for the quantification of water savings from modernising irrigation distribution systems
the technical manual or Manual	Chapter D of the Water Savings Protocol, the technical manual for the quantification of water savings
t_m	Ratio of the length of time that the service point was replaced for irrigation purposes in the year in question to the irrigation season length in the Baseline Year
TO	Torrumbarry
tr	Ratio of the length of time a channel has been rationalised in the year in question relative to the irrigation season length in the Baseline Year

UBase	Unauthorised use loss in the Baseline Year
Vd	Deemed customer deliveries through individual unmetered service points in the Baseline Year
VL	Proportion of bank leakage recognised as variable
WEE	Water Entitlement Entity

1.0 INTRODUCTION

1.1 PURPOSE OF AUDIT

The Victorian State Government and the Commonwealth Government have committed significant funding for the renewal and modernisation of the Goulburn-Murray Irrigation District (GMID). The water savings achieved through the renewal and modernisation works are to be shared between the environment, Melbourne water retailers and irrigation customers. The works are also expected to improve the efficiency of delivery and increase the level of service provided to irrigation customers.

Goulburn-Murray Water (GMW) is the owner and operator of the GMID. The GMW Connections Project (previously the Northern Victorian Irrigation Renewal Project but since 1 July 2012 part of GMW) forms the greater part of the modernisation of the GMID.

Cardno, now Stantec has been engaged by the Department of Environment, Land, Water and Planning (DELWP) to undertake an independent audit of the Phase 3 water recovery for the 2021/22 irrigation season. The purpose of this report is to present the findings of this independent audit. This is the fourteenth annual audit of the water savings achieved by the renewal and modernisation works in the GMID.

1.2 WATER SAVING PROTOCOL

The purpose of the Water Savings Protocol is to ensure water savings are consistently and transparently estimated and audited. Version 5.0 of the Water Savings Protocol was released in October 2018. This audit is being carried out under this latest version of the Water Savings Protocol.

The Water Savings Protocol includes the water saving audit process (chapter C) and the technical manual (chapter D). The water saving audit process sets out that the independent audit of water savings is to include:

- Verifying that the water savings estimates have been done in accordance with the Water Savings Protocol.
- Ensuring that the data collection and inputs are as accurate as could reasonably be expected for estimating water savings.
- Random and targeted checking that the program of works for irrigation modernisation projects have been implemented as documented in the water savings estimates.
- Confirming that water savings have been estimated based on the nature and the extent of all irrigation modernisation works.
- Providing a corrected estimate of the water savings for any component where the project proponent calculations are found to be non-compliant with the Water Savings Protocol.
- Identifying potential improvements to the data collection, data analysis, assumptions and methods used to estimate the water savings.
- Recommending to DELWP changes to the Water Savings Protocol that will improve the useability and accuracy of water savings estimates.
    - Reporting on the status of the suggested improvements made in previous audits.

A copy of the Water Savings Protocol is available on the DELWP website at this location:
https://www.water.vic.gov.au/water-for-agriculture/investment-in-irrigation-efficiency/water-savings-protocol

1.3 SCOPE OF 2020/21 IRRIGATION SEASON IRRIGATION MODERNISATION WATER RECOVERY AUDIT

The audit scope has been set by DELWP and is set out in the Project Brief, dated 15 August 2022. The scope of works is broadly an audit of water recovery estimates for works undertaken in the Goulburn-Murray Irrigation District by the Connections Project to modernise the irrigation delivery system. The audit scope included the following:

- The cumulative irrigation modernisation completed up to and including the 2021/22 water year (1 July 2021 to 30 June 2022).
- The GMW Connections Project operating area which is the whole Goulburn-Murray Irrigation District (GMID) including the following irrigation areas:
- Shepparton (1A), including Shepparton East (1A)
- Central Goulburn (1A),
- Rochester (1A),
- Loddon Valley, split as:
    - Pyramid Hill (1A),
    - Boort (1B),
- Murray Valley (6) and Lower Broken Creek (6B), and
- Torrumbarry (7).
- The cumulative irrigation modernisation works and fixed and variable water recovery separately accountable to the:
- GMW Connections Project Stage 1 (including mitigation water)
- GMW Connections Project Stage 2; and

The scope requires the auditor to address the following:

- Verifying that stated modernisation works have been carried out by conducting on-site inspections or confirming works have been completed through an alternative remote process.
- Verifying that the GMW Connections Project have estimated water recovery correctly in accordance with the *Water Savings Protocol* (Version 5) (the Protocol) or errata, addendum or other method approved by DELWP. This shall include:
- Phase 3 – water recovery generated in the 2021/22 water year
- Confirming the water recovery estimates or, where appropriate, correcting estimated volumes; and
- Identifying and recommending improvements to the collection and processing of information used for estimating water recovery volumes.

2.0 BACKGROUND

2.1 GOULBURN MURRAY IRRIGATION DISTRICT

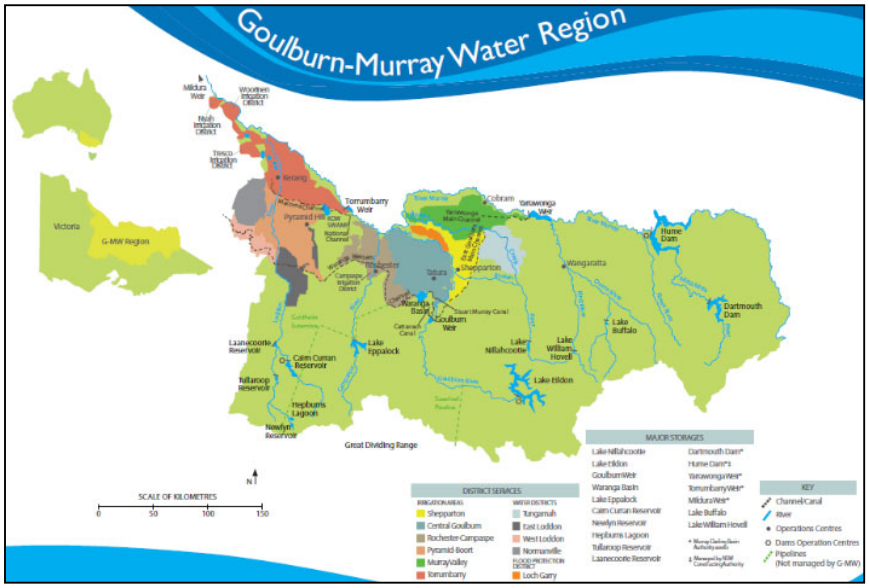
The Goulburn Murray Irrigation District (GMID) is composed of the following main irrigation areas located in northern Victoria:

- Central Goulburn (CG) (which is divided into sub-areas CG1-4 and CG5-9)
- Murray Valley (MV) and Lower Broken Creek (MV-BC)
- Loddon Valley:
  - Pyramid-Hill (LV-PH)[2]*
  - Boort (LV-BO)
- Rochester (RO)
- Shepparton (SH) (including Shepparton East)
- Torrumbarry (TO).

Goulburn-Murray Water (GMW) is responsible as both the Water Resource Manager and System Operator for the GMID. 1 shows the location of the GMID and the main irrigation areas.

Figure 2-1 Goulburn Murray Irrigation District

Source: http://www.g-mwater.com.au/about/regionalmap



2.2 IRRIGATION MODERNISATION

Irrigation modernisation seeks to improve the efficiency of irrigation systems to minimise losses when water is delivered, to provide a better customer service, and to support sustainability outcomes.

[2] The former Pyramid-Boort irrigation areas, now Loddon Valley are divided into two separate water trading zones: Pyramid-Hill (LV-PH, zone 1A) and Boort (LV-BO, zone 1B). The “LV” designation arises from this is the overall larger irrigation area.

Irrigation modernisation typically involves the automation of channel infrastructure, construction of pipelines, upgrading the accuracy of metered outlets to farms, lining, and remodelling of channels and rationalising the channel network. Automation of systems allows water flows to be delivered more accurately and more quickly. These capital works, in unison with changed operational approaches, should have the twin benefits of reducing the amount of water lost in irrigation systems and improving service levels to customers. These are described below:

Channel automation

- Channel automation is a way of improving the efficiency of irrigation networks by using new technology to control the flow of water from the storage (usually a dam) through the distribution system to the irrigator. It involves replacing manual flow control structures in channels with updated gates that accurately measure flows, provide real time measurement data and, in most cases, are automated. The automation greatly reduces the water spilt from the end of channels (known as outfalls). Further the gate measurement allows more accurate location of the worst seepage and leakage losses, and more effective targeting of channel remediation works.
- Automation of the gates also provides the ability to interact with meters and on-farm automation equipment, so best practice irrigation methods can be employed on farms. Other benefits include constant flows and faster water delivery times.

Pipes and channels

- Historically, many irrigation systems relied on open earthen channels to transport water. Inefficient operation and leaky sections resulted in up to 30% of the total volume being lost in the past. Water losses can be minimised by reducing outfall losses, lining, remodelling or pipelining parts of the channel system.

Improved meter accuracy

- Dethridge wheels are inaccurate and on average under-measure water delivery by about 8%. They fail to meet the new metering standards introduced by the Australian Government that specify a maximum of plus or minus 5% measurement inaccuracy. There are also occupational health and safety risks associated with using Dethridge wheels.

2.3 IRRIGATION MODERNISATION PROJECTS

The GMW Connections Project was implemented in two stages. Stage 1, which was funded by the Victorian Government and Melbourne's retail water corporations, commenced in 2008, and Stage 2, which was funded by the Commonwealth, commenced in 2012.

2.3.1 GMW Connections Project Stage 1

Under the funding arrangement between the State and Commonwealth Governments, signed in October 2011, Stage 1 of the project was funded by contributions from the Victorian Government ($600 million initial contribution and $100 million from a portion of the funds relevant to the sale of 102 GL of long-term water savings associated with GMW Connections Project Stage 2) and Melbourne's retail water corporations ($300 million). Stage 1 commenced in 2008 and, combined with Stage 2, works were completed to deliver 429 GL of water recovery by October 2020[3].

The objectives of the GMW Connections Project Stage 1 are to:

[3] https://www.water.vic.gov.au/water-for-agriculture/investment-in-irrigation-efficiency

- Deliver 225 GL of long-term average annual project generated water savings to be shared equally between irrigators, the environment and Melbourne's water retailers.
- Deliver a modernised backbone channel water distribution system
- Connect approximately 30% of those customers currently supplied by smaller spur channels to the backbone channel via a modern connection
- Upgrade metering (including real time measurement)
- Provide channel remediation to reduce high loss channel pools.

2.3.2 GMW Connections Project Stage 2

The Commonwealth and Victorian Governments funded $1.059 billion for Stage 2 of the GMW Connections Project, which commenced delivery in 2012. The Commonwealth Government contributed $953 million and the Victorian Government $106 million from a portion of the funds associated with the sale of 102 GL of long-term average annual water savings associated with GMW Connections Project Stage 2.

The Stage 2 project was scheduled to raise the operating delivery efficiency of the GMID system to over 85%, generating a long-term average of 204 GL of long-term average annual water savings from reduced distribution losses. These savings were transferred to the Commonwealth Government for environmental use and in particular, to meeting Sustainable Diversion Limits in the Murray-Darling Basin.

2.3.3 Project Reset and changes to project delivery approach

A condition of the Stage 2 Project funding agreement between the State of Victoria and the Commonwealth government was that a mid-term review of the project should be conducted. The review occurred in 2015 and recommended Stage 2 of the Project be reset because the actual operating environment in which the project was being delivered did not align with the assumptions made in the original business case.

A Stage 2 Reset Delivery Plan was developed in response to the mid-term review. The Reset Delivery Plan was developed with the objective of ensuring delivery of the full 204 GL of long-term average annual water savings to the Commonwealth within the allocated budget. The Reset Delivery Plan recommended a different delivery approach for the remaining modernisation works as well as increased targeting of works in specific locations. The Reset Delivery Plan recommended extension of the timeframe for delivery to 31 October 2020.

The Stage 2 Reset Delivery Plan was agreed by the Victorian and Commonwealth governments on 7 September 2016.

The Reset Delivery Plan has changed how water savings works have been delivered in the last four years, along with the governance over the works. Major changes include a change in the major delivery contractor with John Holland commencing in this role in February 2017. Although the contractor has changed, the information system previously developed for managing construction information, Project Management Information System (PMIS), has been retained.

Notable changes to the governance and assurance process in place for the project include:

- Contractor payments and achievement of Practical Completion has been linked to the quality of construction documentation received.
- On-farm works will now be carried out by the GMW Connections Project and its contractors rather than landowners.

- The GMW Connections Project's management systems have been externally accredited as meeting the requirements of ISO9001:2015 for Quality Management Systems. The final surveillance audit was undertaken on 28 September 2021.
- The GMW Connections Project has engaged a third party (PwC) to provide assurance activities over the completion and accuracy of construction records. This assurance review is intended to be undertaken every six months and applies to all construction activities during the period. Outputs of reviews undertaken in the last twelve months are summarised in section 4.2.5.

3.0 AUDIT METHODOLOGY

3.1 WATER SAVINGS AUDIT PROCESS REQUIREMENTS

The water savings audit process is outlined in Chapter C of the Water Savings Protocol and sets out the approach to be taken to the independent audit of water savings. The scope of independent audit work relating to irrigation modernisation is to include the elements detailed below. Where each element is addressed in this report is set out in Table 3-1. .

Table 3-1 Mapping of reporting requirements

Water Savings Protocol Reporting Requirement	Where this is addressed in the report
Verifying that the water savings estimates have been done in accordance this Water Savings Protocol.	Section 6
Ensuring that the data collection and inputs are as accurate as could reasonably be expected for estimating water savings.	Section 4
Random and targeted checking that the program of works for irrigation modernisation projects have been implemented as documented in the water savings estimates.	Sections 4, 5 and Appendix C
Confirming that water savings have been estimated based on the nature and the extent of all irrigation modernisation works.	Sections 4, 5 and 6
Providing a corrected estimate of the water savings for any component where the project proponent calculations are found to be non-compliant with the Water Savings Protocol.	Section 6
Identifying potential improvements to the data collection, data analysis, assumptions and methods used to estimate the water savings.	Section 7
Recommending to DELWP changes to the Water Savings Protocol that will improve the usability and accuracy of water savings estimates.	Section 7
Reporting on the status of the suggested improvements made in previous audits	Section 8

The Water Savings Protocol also defines the expected content of the water savings audit report. The minimum requirements of the report and where they are fulfilled in this report is summarised in

Table 3-2.

Table 3-2 Expected Content of Water Savings Audit Report

Requirement	Where this is addressed in the report
A summary of findings.	Summary of Findings
Background information on the irrigation modernisation projects for which the water savings estimates are being audited, including the water savings targets.	Section 2.0
A description of the method(s) used for the independent audit	Section 3.0
The details and results of any site inspections undertaken.	Section 4.2
An assessment of how well the project proponent's business and information systems and processes support the calculation of water savings.	Sections 0 and 5.0
The results of random and target sampling of the data trails used in the estimates of water savings.	Section 4
An evaluation of all water savings estimates against the Water Savings Protocol.	Section 6.0
Documentation of any instances of non-compliance with the Water Savings Protocol, and the changes required to the project proponent's estimates of water savings.	Section 6.0

Requirement	Where this is addressed in the report
Any recommended improvements to the data and methods used to estimate and report the water savings estimates, including revisions to the Water Savings Protocol.	Section 7.0

The following sub-sections detail the audit process undertaken.

3.2 OVERVIEW OF AUDIT METHODOLOGY

The approach taken to auditing water recovery is based around structured interviews with key GMW staff. These structured interviews scrutinise the water recovery calculations and assess the veracity of the supporting information. The audit focused on these areas:

- The systems and procedures in place to manage the data used in the calculations, including trailing the data used in the calculations back to source records
- Verifying that the works claimed are complete and commissioned through review of works handover and commissioning documents as well as inspection of a sample of assets
- Checking that the audit calculations have been performed correctly
- Reviewing the GMW Connections Projects progress on the implementation of previous audit recommendations.

For 2021/22, it was agreed to progress the audit remotely, based on the successful outcome of the 2019/20 and 2020/21 audits which were forced to be run remotely due to the impact of Covid-19. In terms of practical application, this was delivered by:

- Meetings being undertaken by the Microsoft Teams platform which allowed audio and visual connectivity between attendees. In addition, data and documents were shared on screen to aid discussions.
- Verification that works have been completed and commissioned as claimed was undertaken by reviewing construction record work packs, time and date-stamped photographs and use of high-definition aerial photography (via the Metromap platform) if available. A feature of Metromap is that aerial imagery is uploaded at regular intervals for many locations enabling works progress over time to be observed.

3.3 SCHEDULE OF AUDIT MEETINGS

Table 3-3 lists the meetings held to complete the audit work.

Table 3-3 Schedule of Audit Meetings

Date	Audit Work	Auditee	Position
Tuesday 18 October 2022	Start-up Meeting	Peter Roberts	Project Manager, Water Savings (GMW)
		Luke O'Connor	Delivery Manager (GMW)
		Troy Williams	Project Coordinator (GMW)
		Deanne Brown	Document Controller (GMW)

Date	Audit Work	Auditee	Position
		Jennifer Pagon	Project risk and stakeholder reporting (GMW)
	Audit of water savings calculations	Peter Roberts	Project Manager, Water Savings
	Construction record reviews	Peter Roberts	Project Manager, Water Savings
Wednesday 19 October	Review of SCADA records for outfalls	Michael Doherty	Operations Planning Team (GMW)
		Emily Uhe	Senior Water Resources Officer (GMW)
		Peter Roberts	Project Manager, Water Savings
Thursday 20 October 2022	Audit of water savings calculations	Peter Roberts	Project Manager, Water Savings
	Construction record reviews	Peter Roberts	Project Manager, Water Savings
Monday 24 – Wednesday 26 October 2022	Audit of water savings calculations	Peter Roberts	Project Manager, Water Savings
	Construction record reviews	Peter Roberts	Project Manager, Water Savings
Thursday 27 October 2022	Close out meeting	Peter Roberts	Project Manager, Water Savings
		Sean Tenace	Project Director, GMW WEP
		John Davidson	Operations Manager, GMW WEP
		Deanne Brown	Document controller (GMW)

3.4 DOCUMENT REGISTER

A list of the documents received before, during and after the audit are included in Appendix B.

4.0 AUDIT OF DATA COLLECTION AND INPUTS

4.1 OVERVIEW

Our audit considers the systems and processes in use by GMW and its contractors that support the calculation of water recoveries to determine whether they are sufficiently reliable to produce accurate, repeatable, and transparent data. Our review of systems and processes focuses on those business areas central to the water recovery estimates:

- Construction records
- Outfall measurement and recording
- Customer deliveries
- Assignment of works between GMW Connections Project Stage 1 and Stage 2.

Because of the importance of demonstrating that the water recoveries have been calculated based on accurate information, we have complemented this review of systems and processes, with trailing of selected data, used in the calculations, to their source.

To operate its irrigation network, GMW employs a number of information systems. The key systems are:

- SCADA – provides real time monitoring of gate operation, including trending. Field readings are stored and can be accessed through a data warehouse (SPM – System Planning Module). SPM is also GMW's data recording program/database for long-term flow record storage.
- Maximo – asset information system and computerised maintenance management system
- Geocortex (GMW's Geographic Information System - GIS) – records location of channels and control gates. Channel lengths and widths are measured from here.
- The Irrigation Planning Module (IPM) takes customer orders, checks system capacity to deliver orders and records delivered volumes.

4.2 ONSTRUCTION RECORDS

Bar a few isolated exceptions, Connections Project works were completed in the 2020/21 financial year. As a result of this, we have looked at a relatively smaller number of construction records from 2020/21 compared to previous years' audits. We have avoided repeating review of works audited in the 2020/21 audit. As 2021/22 Phase 3 savings are being audited, a focus of the construction record review is to confirm works were a) completed before the 2021/22 irrigation season or b) completed with a suitable adoption date used for water saving calculations if completed in 2021/22.

For the Connections Project, construction works were delivered by John Holland and GMW. Works delivered by John Holland are referred to as ECI (early contractor involvement) works and works delivered by GMW were referred to as E2E (end to end) works. The construction records database, PMIS was used by John Holland to track work packages from planning through construction to handover and acceptance. The system captures relevant information and is also a data store for records such as photos and ITP (inspection and test plan) certificates. PMIS also recorded works undertaken by GMW construction if it was initiated for the Connections Project.

There are also some works that have been delivered by other contractors which do not use this system. In both of these instances, the same processes and record forms are still used.

When new assets are commissioned, or redundant channel removed, an ITP certificate is produced which records relevant commissioning/decommissioning details. These ITP certificates are stored in PMIS along with other documents relevant to the construction and commissioning of each site. These documents are collectively referred to as the 'work pack' for the constructed asset. GMW also use a system called QLIK for project portfolio management. Key completion dates are stored in this system and water savings are usually claimed when the work is at beneficial completion.

This audit focuses on asset commissioning / decommissioning e.g., when the benefit-providing activity is completed, as water recoveries are typically achieved from the time that an asset is commissioned or decommissioned.

We believe that GMW's systems for asset delivery and commissioning are sufficiently robust to completely and correctly record the details of irrigation modernisation asset installation and commissioning.

The following section provides observations arising from our audit of construction records for different work types. Appendix C contains a selection of photographs and aerial imagery demonstrating completed works from 2020/21.

4.2.1 Service point (meter) replacement and removal

We requested commissioning certificates (ITP certificates) and other supporting evidence (e.g., construction photos) for a sample of 10 sites where service points had been replaced or rationalised to confirm that the works have been completed and that work was timely.

The results of reconciling these records with the data used in the water savings calculation is summarised in Table 4-1

Table 4-1 Findings from service point replacement and rationalisation data trailing

IPM / Asset Code	Activity	Audit notes
RN1740	Remove existing emplacement and replace new outlet in existing location	We were provided with sufficient evidence to confirm that the works claimed were complete
RO6647	Remove existing emplacement and replace new outlet in new location	We were provided with sufficient evidence to confirm that the works claimed were complete
TO5078	Remove existing emplacement and replace new outlet in existing location	We were provided with sufficient evidence to confirm that the works claimed were complete
RN2293	Remove existing emplacement and replace new outlet in existing location	We were provided with sufficient evidence to confirm that the works claimed were complete
RN2134A	Remove emplacement (rationalise)	We were provided with sufficient evidence to confirm that the works claimed were complete
RO5512	Remove drum only (Rationalise)	We were provided with sufficient evidence to confirm that the works claimed were complete
TN3843	Remove existing emplacement and replace new outlet in existing location	We were provided with sufficient evidence to confirm that the works claimed were complete
TO6044	Remove emplacement (rationalise)	We were provided with sufficient evidence to confirm that the works claimed were complete
TN4065	Remove emplacement (rationalise)	We were provided with sufficient evidence to confirm that the works claimed were complete

RN2293	Remove existing emplacement and replace new outlet in existing location	We were provided with sufficient evidence to confirm that the works claimed were complete

For all meter replacement or removal activities in the sample that are within the scope of the audit, we were provided sufficient evidence to confirm that the scope of works claimed was complete.

4.2.2 Remediation

No remediation works were completed in 2021/22 and none were remaining to audit from 2020/21.

4.2.3 Channel removal

We reviewed the construction records for the following channel removal activities which were completed in 2020/21. The records reviewed and the findings are detailed in Table 4-2.

Table 4-2 Findings from trailing removal records

IPM/ Asset Code	Works done	Audit notes
CH018124	Block	Records provided confirmed work is done and the extent of assets removed is consistent with calculations.
CH011634	Block	Records provided confirmed work is done and the extent of assets removed is consistent with calculations.
CH006334	Block	Records provided confirmed work is done and the extent of assets removed is consistent with calculations. GMW follow-up with Geocortex plots explained the linkage between pack provided and channel impacted (CH003161)
CH000250	Block	Records provided confirmed work is done and the extent of assets removed is consistent with calculations.
CH003040	Block	Records provided confirmed work is done and the extent of assets removed is consistent with calculations.
CH004033	Block	Records provided confirmed work is done and the extent of assets removed is consistent with calculations.
CH009046	Block	Records provided confirmed work is done and the extent of assets removed is consistent with calculations.
CH014496	Block	Records provided confirmed work is done and the extent of assets removed is consistent with calculations.
CH012611	Block	Records provided confirmed work is done and the extent of assets removed is consistent with calculations.

4.2.4 Regulator gates

We audited the construction records for all remaining regulators that GMW advised as being constructed during 2020/21 but were not finalised before last year's audit. Table 4-3details the findings of the records reviewed. All records had satisfactory evidence of work completion and appropriate work pack sign-off. Photographs with time/date stamps were provided for all reviewed records.

Table 4-3 Sample of regulator gate sites

IPM/ Asset Code	Comment
MV325A	The construction records reviewed provide assurance that the work claimed is completed.
MV342	The construction records reviewed provide assurance that the work claimed is completed.
SH409	The construction records reviewed provide assurance that the work claimed is completed.
TN798	The construction records reviewed provide assurance that the work claimed is completed.

MV470	The construction records reviewed provide assurance that the work claimed is completed.
MV877	The construction records reviewed provide assurance that the work claimed is completed.
TO95	The construction records reviewed provide assurance that the work claimed is completed.
TO960	The construction records reviewed provide assurance that the work claimed is completed.

4.2.5 Findings from third-party review

The assurance activities undertaken by PWC are consistent with the Water Savings Protocol requirement to check that the data collection and inputs are as accurate as could reasonably be expected for the purpose of calculating water savings. We were provided the findings of the review for the following periods:

- 1 April 2021 to 30 September 2021 – this covered both Connections Project and Water Efficiency Project works

In this review, 86 assets were put forward by GMW Connections Project for review. For all but three records, the audit concluded that the evidence provided by the contractor was an accurate representation of the works completed during the review period. For the records not meeting requirements, this was identified as a fault identified as part of the commissioning process.

The audit concluded that evidence provided by contractors is an accurate representation of the works completed.

4.2.6 Summary of Construction Record Review and GMW Response

We observed that the construction records provided met expectations with all work having signed-off ITPs with date/time stamped pre and post construction photographs. All work was completed in line with dates adopted for Phase 3 water saving calculations for 2021/22. GMW provided additional information where required and answered any queries in a timely manner.

We observed the following which enabled two previous audit recommendations to be closed out (also see section 7.0):

- Updated ITPs which provided clarity on when beneficial work was completed i.e., the date a water saving can be claimed from
- Photographs with appropriate labelling e.g., date and time stamps, locations

4.3 PONDAGE TESTING

Pondage testing uses a water balance to estimate seepage and bank leakage in an isolated channel or channels. Where available, pondage test results (pre and post remediation works) are used as inputs to the calculation of water savings. The Water Savings Protocol Technical Manual allows for estimations to be used where no pondage data exists.

No Pondage testing was undertaken in 2021/22. This was largely because 2020/21 was the final year of the Connections Project and this meant that:

- Very limited remediation activities have been undertaken in the two years leading up to 2020/21 and there are no upcoming projects to refine calculations / learn lessons for.
- Through the course of the project, 75% of remediation water savings claims have been supported by pre and post remediation pondage test data. The Water Savings Protocol Version 5 does specifically allow for theoretical estimations to be used for later phases.

4.4 OUTFALL MEASUREMENT AND RECORDING

The volumes of flows through outfalls are an important data input into water savings calculations as savings from outfalls are a significant component of all water savings achieved. Now that irrigation modernisation works in the GMID have been in progress for several years, most major outfalls have online flow measurement which is recorded in the GMW SCADA. Some unmetered outfalls still exist where flows are estimated by operators (mainly on spur channels that may be removed in the future). However, these account for only a small proportion of the water savings achieved. Unmetered outfall measurement is conservative relative to metered outfalls with factors applied for corrections for spot measurement as well as scaling factors (FLTCE).

GMW uses SCADA data (configured to be reported from SPM) as the source data for reporting outfall volumes. Where an outfall does not have online measurement, operational staff record the outfall volume in a logsheet. There is a separate logsheet for each irrigation area. Water resources staff provide operational staff each month a spreadsheet containing outfall data extracted from SPM. Operational staff review the spreadsheet and make adjustments for any erroneous readings, e.g., if the water level in the channel is particularly low, the flow reading may be a false high reading when in fact no water is leaving the outfall. Operational staff also input into this spreadsheet their readings for outfalls without on-line metering and provide this information back to the planning team. SPM records comments and adjustments made my field operators. It is expected that any adjustments in SPM do have a reason provided (via a drop-down menu) and brief commentary.

We selected a sample of outfall data used in the water savings and trailed these back to the IPM database. The findings of this data trailing are summarised in Table 4-4.

Table 4-4 Findings from trailing outfall data

IPM/ Asset Code	Audit notes
SP268	Outfall data used in water savings consistent with data recorded in SPM for this outfall
SP316	Outfall data used in water savings consistent with data recorded in SPM for this outfall
SP392	Outfall data used in water savings consistent with data recorded in SPM for this outfall
TN820	Outfall data used in water savings consistent with data recorded in SPM for this outfall
TN779E	Outfall data used in water savings consistent with data recorded in SPM for this outfall. Operators did remove data from SPM which aligned with a rain event at the time. Operators did select “data entry” as a reason to change the data but did not leave comment in the change log.
TN724	Outfall data used in water savings consistent with data recorded in SPM for this outfall. Operators did remove data from SPM which aligned with a rain event at the time. Operators did select “data entry” as a reason to change the data but did not leave comment in the change log.
MV1004	Outfall data used in water savings consistent with data recorded in SPM for this outfall
MV346	Outfall data used in water savings consistent with data recorded in SPM for this outfall
MV72	Outfall data used in water savings consistent with data recorded in SPM for this outfall
RO818	Outfall data used in water savings consistent with data recorded in SPM for this outfall
RO297	Outfall data used in water savings consistent with data recorded in SPM for this outfall
RO311	Outfall data used in water savings consistent with data recorded in SPM for this outfall
TO663	For this site, we did observe that there was a difference in flow data for outfall recorded in SCADA and that recorded in SPM. Operators confirmed via email that the flow monitor had flatlined at the end of the irrigation season and erroneous data was appropriately removed from SPM.

SH209A	For this site, we did observe that there was a difference in flow data for outfall recorded in SCADA and that recorded in SPM. Operators confirmed via email that the flow monitor had flatlined at the end of the irrigation season and erroneous data was appropriately removed from SPM.
TO1100	Outfall data used in water savings consistent with data recorded in SPM for this outfall
PH895	For this site, we did observe that there was a difference in flow data for outfall recorded in SCADA and that recorded in SPM. Upon investigation, GMW identified that the site was subject to a number of communications-based alarms which resulted in a) SCADA continuing to record the same daily flow volume for the alarm period and b) SPM recording a value of zero on affected days. Due to the communications alarms, it is difficult to assess what the actual flow was. This issue was isolated to this site and does not have a significant impact on water savings.
PH978	Outfall data used in water savings consistent with data recorded in SPM for this outfall
PH636D	Outfall data used in water savings consistent with data recorded in SPM for this outfall. Operators did remove data from SPM which aligned what appears to be a monitor flat line. Operators did select “data entry” as a reason to change the data but did not leave comment in the change log.

There is not a requirement to make a specific additional recommendation about correction of flow records in SPM, as was done in the 2019/20 audit to GMW staff working on the Connections Project. However, it is recommended that the GMW staff do improve the audit trail when flow records are updated in SPM for current and future water savings projects. This may be done by providing additional drop-down menus and/or reinforcing the requirement for operators to provide comments when updated are made

4.5 CUSTOMER DELIVERIES

The IPM is the business system used by GMW to manage irrigation supply orders and plan the delivery of these orders. When an order is placed by a customer online or by telephone, it is sent to IPM. For customers on fully automated channels, IPM essentially sends the order to the customer’s outlet. The orders specify the times to open and close the customer outlet and the ordered flow rate. The channel automation system uses a combination of feedback control on water level with feed-forward flow to control to the channel.

IPM also provides management reporting facilities on a range of operational aspects and records delivery volumes for billing purposes. It also records delivery volumes against entitlements and rejects orders where the entitlement has been exceeded.

For the purposes of the water savings calculations, IPM is used to determine customer deliveries through service points.

4.6 MITIGATING FLOWS

Mitigating flows are volumes of water that have been identified for alleviating the impacts of irrigation modernisation on wetlands and waterways of high environmental value. These flows are subtracted from water savings due to automation. Mitigating flow volumes are set out in Environmental Watering Plans (EWP) approved by the relevant Minister. In 2009-2010, GMW prepared 15 EWPs for the GMW Connections Project. The EWPs were reviewed in 2015 which resulted in seven of the Plans being updated.

The North Central Catchment Management Authority authored the EWPs for Lake Elizabeth and Loddon River. These were not updated in 2015.

Mitigating flows have been included in the water savings calculation for 2021/22 at 13 sites (including 1 addition in 2020/21 of RN821 at GC5-9 irrigation area). We reviewed the EWPs relating to each of these sites to confirm that the correct allowance for mitigating flows had been made in the water savings calculations. The mitigation water volume for the year is calculated as the mitigation water commitment (MWC) (which is expressed as a proportion of the total outfall) for that location as specified in the EWP multiplied by the outfall at the location (either in the current year for Phase 3 or long-term equivalent for

Phase 4). For some locations, the MWC is not a proportion of the total but a fixed volume. The result of this data trailing is summarised in Table 4-5 for Phase 3 adjustment volume.

Table 4-5 Findings of review of Environmental Watering Plans for Phase 3

IPM Code	Asset Code	Site of environmental significance	EWP	MWC %	2021/22 Adjustment Volume (Phase 3)	Audit notes
PH1052A	ST025235	Lake Leaghur	Lake Leaghur	33%	33% x 222.2ML = 73.3ML	Confirmed correct allowance for mitigating flows
PH1249	ST008516	Little Lake Boort	Little Lake Boort	67%	67% x 183.9ML = 123.2ML	Confirmed correct allowance for mitigating flows
PH1119	ST023738	Duncan	Loddon River	n/a	0 ML	Structure has been removed
PH1138A	ST023656	Lake Meran	Lake Meran	100%	100% x 159.1ML = 159.1ML	Confirmed correct allowance for mitigating flows
PH1186	ST023234	River Pool	Loddon River	100%	100% x 628.2 ML = 628.2 ML	Confirmed correct allowance for mitigating flows
PH1211	ST025134 (ST025135 in EWP)	Dowdy's	Loddon River	90%	90% x 76.6ML = 68.9ML	Confirmed correct allowance for mitigating flows
PH1184	ST023230	Unnamed	Loddon River	88%	88% x 21.7ML = 19.1ML	Confirmed correct allowance for mitigating flows
PH1096	ST023308 (ST047427 in EWP)	Gannons	Loddon River	85%	85% x 58.7ML = 49.9ML	Confirmed correct allowance for mitigating flows
PH1224	ST073298 (ST023628 in EWP)	Delamare[4]	Loddon River	49%	49% x 65.0ML = 31.8 ML	Confirmed correct allowance for mitigating flows
TO1025	ST004154	Lake Elizabeth	Lake Elizabeth	67%	67% x 321.0ML = 215.1ML	Confirmed correct allowance for mitigating flows
	Straight Cut	Pig Swamp	Pig Swamp	n/a	170ML (Fixed amount)	Confirmed correct allowance for mitigating flows as per EWP
TO70	ST001206	McDonald's Swamp	McDonald's Swamp	100%	100% x 60.4ML = 60.4ML	Confirmed correct allowance for mitigating flows
SH110	ST072390 (ST043937 in EWP)	Round Lake	Round Lake	100%	100% x 142.6ML = 142.6ML	Confirmed correct allowance for mitigating flows
RN821	n/a	Grieners Lagoon	Grieners Lagoon	80%	80% x 40.7ML = 32.5ML	Confirmed correct allowance for mitigating flows

[4] PH1224 is now a weighted average MWC% of previous flows at PH1224 and PH1119 which both provide environmental flows to the Loddon River. These are now combined and reported at PH1224 as PH1119 is no longer an asset. The MWC% weighted average of 49% reported in 2021/22 is appropriate for reporting both flows at one site/location.

4.7 ASSIGNMENT OF SAVINGS BETWEEN GMW CONNECTIONS PROJECT STAGE 1 AND STAGE 2

The Victorian and Commonwealth Governments entered into funding agreements for modernisation works in the GMID which are the basis on which water savings are assigned between the Stage 1 and Stage 2 projects. For all new proposed works, a Business Case is written, and this Business Case details the Stage to which the works belong with reference to the relevant funding agreement. This is sufficient in most instances to link the savings generated to the Stage 1 or Stage 2 project.

The exception is for savings arising from automation which result in reduced outfalls. Previously, there was a reasonably clear delineation between the Stage 1 and Stage 2 works as automation was only funded under Stage 1. The Project Reset means that automation works are now also funded under Stage 2. GMW has previously produced a procedure document Assignment of Water Savings Resulting from Stage 1& 2 and Procedure for Assignment of Water Savings Resulting from Stage 1 & 2 Automation Works (Document number A3381577) that sets out the decision rules for assigning outfalls savings between the projects.

4.8 CONCLUSIONS

Our review for the 2021/22 audit of the information systems and processes used by GMW has found that they continue to be sufficiently robust to generate data and inputs that are as accurate as could reasonably be expected for the purpose of calculating water recoveries.

We found that all assets included in our samples for data trailing had sufficient evidence to support the fact that they have been constructed and commissioned. We are satisfied that GMW has completed the works claimed in the calculations.

4.9 RECOMMENDATIONS

We make the following recommendations regarding the Connections Project's approach to estimating water savings for GMW to consider for implementation:

- Improve the audit trail when flow records are updated in SPM. This may be done by providing additional drop-down menus and/or reinforcing the requirement for operators to provide comments when updated are made.

GMW has reviewed and accepted this recommendation.

5.0 CHECKING OF THE WORK DONE

The Water Savings Protocol requires that random and targeted checking that the program of works for irrigation modernisation projects have been implemented as documented in the water savings estimates.

It was agreed with DELWP and GMW to undertake the 2021/22 EP audit remotely. All construction records assessed did have photographs in addition to work pack information to confirm work had taken place when claimed. The following checklist was applied to construction records:

- Request for work pack including ITP and photographs
- Check of pre (if available) and post construction photographs. Check of location and timestamp
- Check of signature on ITP by GMW or nominated contractor.
- Check alignment of beneficial work completion and relevant date in water savings spreadsheet.
- Send follow-up queries to GMW Connections Project where any of the above was missing or unclear.

A selection of example photographs used to confirm works had taken place for each activity are included in Appendix C.

6.0 AUDIT OF WATER SAVINGS CALCULATIONS

6.1 STRUCTURE OF THIS CHAPTER

This chapter has been structured to align with the structure of the technical manual, part of the Water Savings Protocol, with each water saving intervention presented in the same order as found in that document. The technical manual provides additional discussion on the application of the water savings calculations that have been omitted from this report to avoid repetition.

For reference, the calculations used to determine water savings from the technical manual and the input data requirements for these calculations are included in Appendix A.

For each water saving intervention (channel asset removal, channel automation, service point replacement and removal, and channel remediation) we detail:

- The nature of the works that lead to water recovery and the scope of works undertaken to date
- Findings from auditing the water savings calculations
- The water savings resulting from applying the calculations.

The scope of this audit is to review Phase 3 water savings achieved, where Phase 3 savings relate to the actual water savings based on deliveries in a given year and confirmed in a water savings account.

6.2 BASELINE YEAR WATER BALANCE

In calculating water savings, reference is made for some components of water loss that occurred in a baseline year. For most water savings components, the baseline year was the 2004/05 irrigation season. A water balance that establishes the value for water loss components in each irrigation area for this baseline year was compiled by GMW. This baseline year water balance has been previously independently audited.

Since the completion of this independent audit, GMW has revisited the baseline year water balance and made some revisions on the basis of better information being available or a more complete understanding of the nature of losses in the irrigation areas. This revised baseline year water balance was independently audited in 2012 and has been used as the basis of this audit. There have been some minor, iterative changes to the baseline year water balance due to better information since the audit in 2012.

6.3 OVERVIEW OF PHASE 3 WATER RECOVERY ACHIEVED IN 2021/22

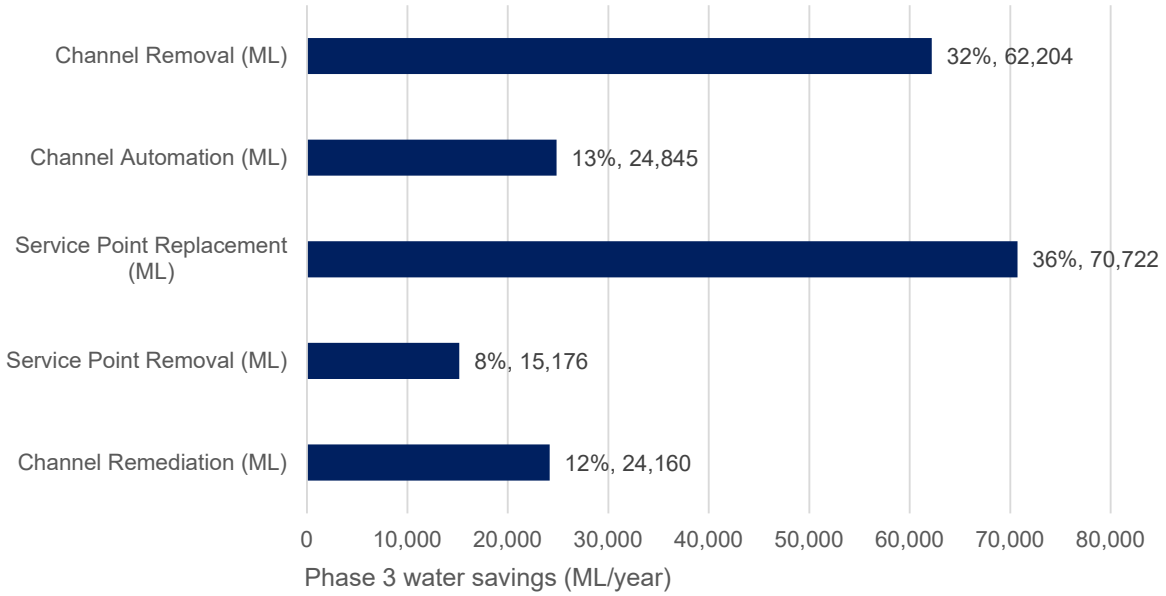
The 2021/22 audit requires water savings to be separately accounted to the GMW Connections Project Stage 1 and Stage 2. The Stage 1 project has been in progress since 2008 while the Stage 2 project commenced in 2012. The Stage 1 project accounts for savings somewhat higher than Stage 2 in this audit 2021/22, as shown in Table 6-1

Table 6-1 Audited Phase 3 water savings by project

Project	Phase 3 water savings (ML)	% Total
GMW Connections Project Stage 1	102,609.6	52%
GMW Connections Project Stage 2	94,497.8	48%
Total	**197,107.4**	**100%**

Table 6-1 provides an overview of the contribution of the different modernisation activities to the audited Phase 3 water savings for 2021/22 for the GMW Connections Project Stage 1 and Stage 2. This figure shows that service point replacement (36 %) and channel removal (32 %) are the most significant contributors to actual water savings achieved in this audit 2021/22.

Figure 6-1 Audited Phase 3 Water Savings Estimates (GMW Connections Project Stage 1 and Stage 2) 2021/22



Note totals may not sum exactly due to rounding

6.4 SAVINGS FROM CHANNEL ASSET REMOVAL

6.4.1 Scope of channel asset removal works

Channel asset removal refers to channels, pipelines or storages that are rationalised, or removed from the publicly owned irrigation distribution system. Removing these assets from the system as part of an irrigation modernisation project will reduce losses to:

- Seepage
- Bank leakage
- Net evaporation

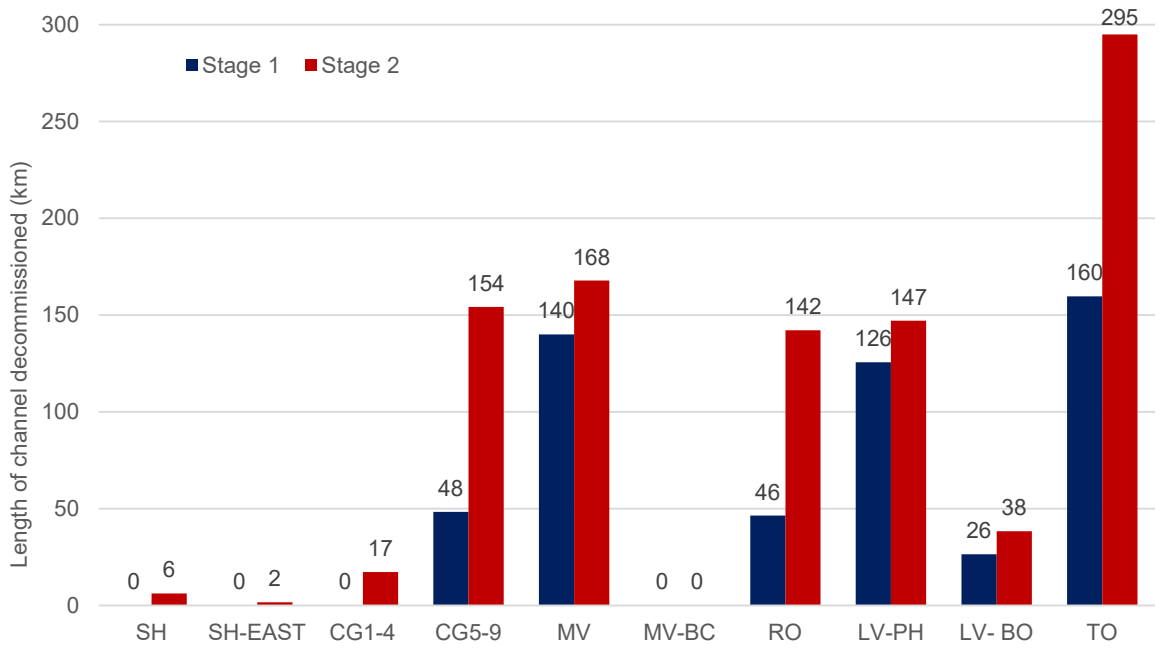
Outfall savings which may be attributable to asset removal are included under channel automation. The associated savings of unauthorised use and leakage through and around meters when channels are removed are included under service point replacement or removal.

An alternative approach to using irrigation distribution system averages to estimate baseline year seepage, bank leakage and evaporation losses from spur channels is to develop a channel loss model (e.g., which relates soil and other channel characteristics to pondage test results for a sample of channels). DELWP provided to us a letter from DELWP to GMW approving use of a loss model to estimate water savings for channel asset removal. This initial approval included a number of conditions including that GMW address a number of items raised by an independent review of the loss model by Hydrology and Risk Consulting Pty

Ltd. DELWP provided to us a letter from Hydrology and Risk Consulting Pty Ltd to DELWP dated 22 March 2019 which concludes that the non-backbone loss model provides a reasonable method for distributing the baseline year bank leakage, seepage, and net evaporation losses to individual channels. Based on the correspondence reviewed, we are satisfied that the loss model approach (version 11) has been appropriately approved for use as required by the Water Savings Protocol.

Figure 6-2 details the cumulative length of channels rationalised in each irrigation area under the GMW Connections Project Stage 1 and Stage 2.

Figure 6-2 Length of rationalised channel (contributing to water savings only) by irrigation area under GMW Connections Project Stage 1 and Stage 2



6.4.2 Findings from trailing data and audit of calculations

We have reviewed the input data and confirm that the fixed parameters sourced from the technical manual are correct. We cross-checked the baseline year values against the baseline year audit report and confirmed that GMW has used values from the spur channels water balance.

However, we noted a referencing error of pipeline deduction in the water saving summary of channel removal. GMW adopted a pipeline deduction for MV of -0.9ML in error (-0.9ML was for the RO irrigation area). A pipeline deduction of -0.57ML should have been applied for the MV irrigation area. This error had insignificant impact on overall savings. Nevertheless, GMW corrected the error and Cardno, now Stantec, has reviewed and accepted the correction. This issue resulted in an increase of Phase 3 water saving of 0.33 ML.

Our review of the current year parameters used in the calculations found the following:

Customer Deliveries in the Current Year (D_{Yearx})

Customer deliveries through the meters replaced in each irrigation area are determined through IPM. These delivery volumes are used for customer billing, as noted previously, and therefore we believe they will be reliable due to the scrutiny they are subject to by GMW and customers.

Ratio of Channel Length Rationalised to Total Channel Length (CL) – Loss Model Rates

Under the loss model approach, the length ratio approach is replaced by a lookup of loss rates for seepage, evaporation and leakage that are specific to the channel. We confirm that the loss model rates are referenced correctly in the calculations based on our audit trailing and samples.

Ratio of Length of Time Channels Rationalised to Baseline Year (t_r)

This variable is determined from the channel de-commissioning date recorded. This factor has previously been material for Phase 3 savings given that the amount of removal work completed each year is a significant proportion of the total. We confirm that GMW applied this factor correctly in the calculations.

6.4.3 Results

The audited water savings due to channel removal are summarised in Table 6-2.

Table 6-2 Phase 3 Water Savings due to Channel Removal – GMW Connections Project Stage 1 and Stage 2

PHASE 3	SH	SH-EAST	CG1-4	CG5-9	MV	MV-BC	RO	LV-PH	LV- BO	TO	Total
Stage 1											
Seepage (ML)	0.0	0.0	0.0	636.7	2,315.2	0.0	707.0	411.0	61.7	2,358.9	6,490.6
Bank leakage (ML)	0.0	0.0	0.0	981.3	2,860.7	0.0	1,033.0	1,029.7	269.1	5,021.8	11,195.6
Evaporation (ML)	0.0	0.0	0.0	251.5	953.6	0.0	262.4	781.5	132.9	1,098.5	3,480.5
Pipeline deduction (ML)	0.0	0.0	0.0	-0.2	-0.6	0.0	-0.9	0.0	0.0	0.0	-1.7
Total	**0.0**	**0.0**	**0.0**	**1,869.3**	**6,129.0**	**0.0**	**2,001.6**	**2,222.1**	**463.7**	**8,479.2**	**21,165.0**
Stage 2											
Seepage (ML)	5.7	1.3	153.5	2,142.4	2,899.5	0.0	2,117.1	450.9	96.3	4,521.9	12,388.7
Bank leakage (ML)	109.7	35.4	913.1	3,358.2	3,459.5	0.0	3,010.0	1,311.3	416.8	10,092.7	22,706.7
Evaporation (ML)	35.2	7.5	95.2	813.2	1,163.8	0.0	881.4	843.3	190.7	2,050.6	6,080.9
Pipeline deduction (ML)	0.0	-0.5	-0.2	-39.2	-17.5	0.0	-35.8	0.0	-1.0	-42.8	-137.0
Total	**150.6**	**43.7**	**1,161.6**	**6,274.6**	**7,505.3**	**0.0**	**5,972.7**	**2,605.5**	**702.8**	**16,622.4**	**41,039.2**
Total (Stage 1 and Stage 2)	**150.6**	**43.7**	**1,161.6**	**8,143.9**	**13,634.3**	**0.0**	**7,974.3**	**4,827.6**	**1,166.6**	**25,101.6**	**62,204.2**

Note – Totals may not sum due to rounding

6.5 SAVINGS FROM CHANNEL AUTOMATION

6.5.1 Scope of Automation Works

Automation involves provision of regulator gates that can be operated in real time in a network either remotely by operators, or by using a control strategy and system, to regulate a series of channel pool levels to meet customer demands with significantly reduced need for on-site manual intervention. Automation greatly reduces the water spillage at the end of channels (outfalls) and may reduce bank leakage by maintaining the level of water in a pool within a relatively restricted band.

Automation of the backbone channels in the GMW Connections Project works areas is complete for all areas.

6.5.2 Findings from trailing data and audit of calculations

We have reviewed the input data and confirm that the fixed parameters sourced from the technical manual are correct.

To allocate funding, GMW undertook the following steps: Stage 1 principally funded the channel automation through not automating all gates on the backbone channels. Stage 2 funds were then used to fund additional regulators to improve customer service, to service operational resourcing needs and to provide additional water savings. These can be interpreted as four scenarios to determine a proportional saving between Stage 1 and Stage 2.

We noted that there is no issue in the summary figures, except that GMW inconsistently assigned water savings at PH296E (4.8 ML) to Stage 1 for Phase 3 but assigned to Stage 2 to for Phase 4. GMW corrected the issue and both water savings were assigned to Stage 2. Cardno, now Stantec, has accepted the correction.

The following summary is a review of the inputs from the current operating year:

Outfalls in Current Year ($O_{yearX\ –\ fixed}$, $O_{yearX\ –\ variable}$)

In Version 5 of the Water Savings Protocol, outfalls in the current year and baseline year have been divided into fixed and variable components. The variable component relates to customer deliveries and is scaled by customer deliveries. We reviewed GMW's allocation of outfalls between the fixed and variable components and we are satisfied that the approach taken is in accordance with the technical manual. Version 5 of the technical manual confirms that groundwater dilution flows are to be allocated as a fixed component. The largest outfalls responsible for the greatest water savings are generally measured on-line with feedback to GMW's SCADA.

GMW has subtracted environmental mitigating flows volumes from its savings. Environmental mitigating flows are specified in Environmental Watering Plans and are volumes determined by catchment managers as necessary to support specific high value habitats. Mitigating flows occur in the GC5-9, Torrumbarry and Pyramid-Boort irrigation areas. Because mitigating flows occur through some outfalls that have 'negative' savings (i.e., the outfall in this year is greater than that in the baseline year) the mitigating flow cannot be subtracted from the outfall, meaning that it is not possible to reconcile outfall savings and mitigating flows on an outfall-by-outfall basis. In this case the mitigating flow is zeroed, and the loss is deducted from the overall automation savings. We comment on our review of the application of mitigating flows in Section 4.6.

Customer Deliveries in the Current Year (D_{YearX})

Customer deliveries in each irrigation area are determined from IPM reports. The volumes used are sourced from the same reports used for GMW's annual reporting.

6.5.3 Results

The audited water savings due to channel automation are summarised in Table 6-3.

Table 6-3 Phase 3 Water Savings due to Channel Automation

Phase 3	SH	SH-EAST	CG1-4	CG5-9	MV	MV-BC	RO	LV-PH	LV- BO	TO	Total
Inputs											
Obase (ML)	0.0	1,539.2	0.0	26,614.3	9,289.6	0.0	8,163.7	2,993.1	2,198.4	8,864.7	59,663.0
Oyearx (ML)	0.0	93.6	0.0	273.7	775.6	0.0	374.1	2,426.3	1,181.1	1,170.4	6,294.6
Dbase (ML)	0.0	157,085.0	0.0	312,082.0	293,026.0	0.0	199,270.0	146,655.9	75,012.1	405,049.0	1,588,180.0
Dyearx (ML)	0.0	72,027.8	0.0	177,247.7	120,462.3	0.0	128,937.4	74,755.1	59,858.4	202,675.2	835,963.9
Phase 3 Water Savings											
Stage 1	0.0	0.0	0.0	14,268.0	2,567.7	0.0	4,248.7	-844.6	-580.4	2,896.8	22,556.1
Stage 2	0.0	486.7	0.0	541.4	475.7	0.0	659.6	-56.0	0.0	181.6	2,288.9
Mitigating flows (ML) - Stage 1	0.0	0.0	0.0	32.5	0.0	0.0	0.0	0.0	1,153.6	588.1	1,774.2
Gross Phase 3 savings (ML)	**0.0**	**486.7**	**0.0**	**14,842.0**	**3,043.4**	**0.0**	**4,908.2**	**-900.7**	**573.2**	**3,666.5**	**26,619.3**
Net Phase 3 savings (ML)*	**0.0**	**486.7**	**0.0**	**14,809.4**	**3,043.4**	**0.0**	**4,908.2**	**-900.7**	**-580.4**	**3,078.4**	**24,845.1**

Note – Totals may not sum due to rounding

** Net Phase 3 savings exclude mitigating flows (ML)*

D_{yearx} is an adjusted delivery measure (delivery equivalent if no modernisation work completed)

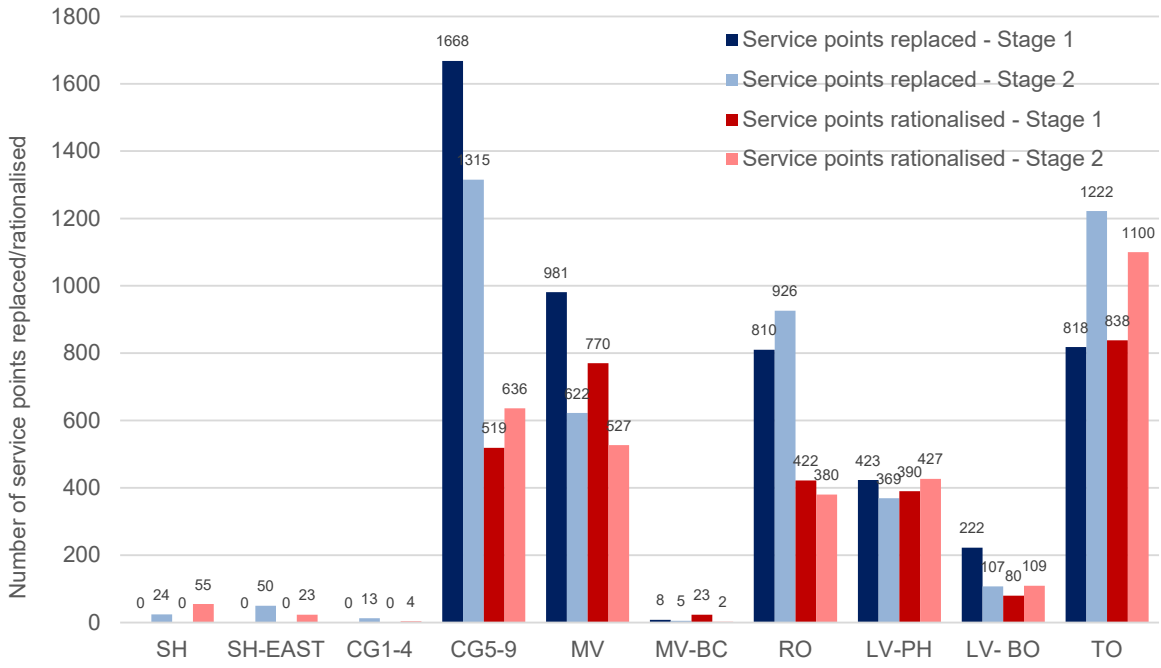
6.6 SAVINGS FROM SERVICE POINT REPLACEMENT AND REMOVAL

6.6.1 Scope of Service Point Replacement and Removal Works

A service point is a location where water is taken from the irrigation distribution system by a customer. Customers may have more than one service point, and service points may or may not be metered. Water savings are achieved when existing customer service points, usually Dethridge Wheels, are replaced with modern outlets. The modern designs are typically pipes with magflow meters or flume gates. Savings may also be achieved when existing service points are removed and not replaced (i.e., rationalised). The savings achieved are due to the improved construction of the service points, preventing leakage through and around the meter, as well as the increased accuracy of the new meters which better account for water use.

Service point replacement and rationalisation has been completed under the GMW Connections Project Stage 1 and Stage 2. Figure 6-3 shows the cumulative number of service points replaced and rationalised in each irrigation area.

Figure 6-3 Numbers of service points replaced and rationalised (Stage 1 and Stage 2)



6.6.2 Findings from trailing data and calculations

We have reviewed the input data and confirm that the parameters sourced from the technical manual Baseline Year Water Balance are correct. However, we noted the following issues which required some adjustments by GMW:

a) The irrigation season starting and ending dates had some calculation linking issues, consequently affecting total water savings summary. The calculation season dates were referenced to the previous irrigation operating season instead of the current audit 2021/22 season. This resulted in a 121.23 ML decrease of Phase 3 water saving.

b) RODS6628 (B&C) meters were wrongly referenced to neighboring cells. GMW found that they were D&S meters which did not contribute to the savings. To rectify, the saving was reduced by 5.66 ML.

GMW corrected these problems and Cardno, now Stantec, has reviewed and accepted the corrections. These issues resulted in the decrease of Phase 3 water saving of 126.89 ML

The following summary is a review of the inputs from the current operating year:

Customer Deliveries through Replaced Service Points (DMYearX) and in the Irrigation System (DYearX)

Customer deliveries through the replaced meters in each irrigation area are determined through IPM. These delivered volumes are used for customer billing and, as noted previously, we believe they will be reliable due to the scrutiny they are subject to by GMW and customers.

In the 2019/20 audit, GMW converted the total amount of customer delivery (Dyearx) measured by any replacement modern meters (since 2004/05), to what the equivalent customer delivery would be if the old meters were used. Cardno agrees with this practice - "Apples to apples". This method was also applied in the current audit.

Number of Service Points Replaced and Removed ($N_{replaced}$, $N_{rationalised}$)

The number of meters replaced and removed is determined from construction records. GMW demonstrated the process it undertakes for handling service point record data. This process includes collating data from different sources and then filtering this data and removing any duplicate or anomalous records. We are satisfied that this process is robust. GMW also achieves meter error savings where new meters have been installed as part of system removal works.

We reviewed the commissioning certificates for a sample of service points under the GMW Connections Project Stage 1 and Stage 2, as outlined in Section 4.2.1. This review provided evidence that the sample of works claimed as complete by GMW had been completed.

Ratio of time Service Point in use compared to Baseline Year (t_m)

This factor is calculated by GMW based on the commissioning (or de-commissioning in the case of removal) dates for each service point. As the works have been in progress for a number of years, the t_m factor has limited impact on the calculated Phase 3 savings. We found that the tm factor has been calculated and applied correctly by GMW for service point replacements and removal (introduced in Version 5 of the Water Savings Protocol)

Our review of commissioning certificates for a sample of service points is outlined in Section 4.2.1

6.6.3 Results

The audited water savings due to service point replacement and removal are summarised in Table 6-4 and Table 6-5 for the GMW Connections Project Stage 1 and Stage 2. The fixed components are water savings derived from leakage through and around while the variable components are from meter error and unauthorised use. GMW performs these calculations on a meter-by-meter basis and not for an irrigation area nor as a whole system.

Table 6-4 Phase 3 Water Savings due to Service Point Replacement and Removal – GMW Connections Project Stage 1

	SH	SH-EAST	CG1-4	CG5-9	MV	MV-BC	RO	LV-PH	LV- BO	TO	Total
Service point replacement											
Phase 3 Water Savings											
Meter error (ML)	0.0	0.0	0.0	7,757.1	4,918.3	12.6	4,572.4	3,342.2	2,609.8	6,302.6	29,515.0
Leakage through service points (ML)	0.0	0.0	0.0	2,865.7	1,536.0	-0.4	1,264.6	718.6	363.6	1,347.0	8,095.2
Leakage around service points (ML)	0.0	0.0	0.0	624.2	334.0	0.0	272.5	152.5	77.4	292.6	1,753.2
Unauthorised Use (ML)	0.0	0.0	0.0	635.3	238.3	-0.4	314.3	138.5	110.1	257.1	1,693.3
Total (ML)	**0.0**	**0.0**	**0.0**	**11,882.3**	**7,026.6**	**11.9**	**6,423.9**	**4,351.7**	**3,161.0**	**8,199.3**	**41,056.6**
Service point removal											
Phase 3 Water Savings											
Meter error (ML)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leakage through service points (ML)	0.0	0.0	0.0	880.8	1,209.7	17.0	665.9	660.1	133.9	1,472.9	5,040.3
Leakage around service points (ML)	0.0	0.0	0.0	185.0	252.7	1.6	139.8	139.0	28.2	308.0	1,054.3
Unauthorised Use (ML)	0.0	0.0	0.0	237.0	235.2	3.3	204.1	159.4	50.6	349.1	1,238.7
Total (ML)	**0.0**	**0.0**	**0.0**	**1,302.8**	**1,697.5**	**21.9**	**1,009.8**	**958.5**	**212.7**	**2,130.0**	**7,333.2**
Total Phase 3 savings (Replacement and removal)	**0.0**	**0.0**	**0.0**	**13,185.1**	**8,724.1**	**33.8**	**7,433.6**	**5,310.2**	**3,373.7**	**10,329.3**	**48,389.8**

Note – Totals may not sum due to rounding

Table 6-5 Phase 3 Water Savings due to Service Point Replacement and Removal – GMW Connections Project Stage 2

	SH	SH-EAST	CG1-4	CG5-9	MV	MV-BC	RO	LV-PH	LV- BO	TO	Total
Service point replacement											
Phase 3 Water Savings											
Meter error (ML)	44.8	123.3	137.1	5,183.5	2,440.1	4.4	4,036.1	2,502.8	1,338.8	5,462.1	21,273.1
Leakage through service points (ML)	1.8	78.7	18.7	1,888.3	819.1	-0.6	956.6	502.8	154.1	1,481.7	5,901.3
Leakage around service points (ML)	0.4	18.3	4.0	409.4	176.9	0.0	209.3	107.2	33.0	321.0	1,279.5
Unauthorised Use (ML)	0.3	15.1	3.7	412.6	125.5	-0.5	241.3	91.7	45.9	276.4	1,212.0
Total (ML)	**47.3**	**235.4**	**163.5**	**7,893.8**	**3,561.7**	**3.3**	**5,443.4**	**3,204.6**	**1,571.7**	**7,541.2**	**29,665.8**
Service point removal											

	SH	SH-EAST	CG1-4	CG5-9	MV	MV-BC	RO	LV-PH	LV- BO	TO	Total
Phase 3 Water Savings											
Meter error (ML)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leakage through service points (ML)	52.5	39.8	7.5	1,044.9	802.6	1.9	589.4	731.8	201.8	1,898.9	5,371.2
Leakage around service points (ML)	11.0	7.2	1.6	219.2	169.0	0.4	124.1	154.1	42.5	399.4	1,128.4
Unauthorised Use (ML)	11.4	8.6	2.0	281.1	155.9	0.4	180.7	176.7	76.3	450.1	1,343.1
Total (ML)	**74.9**	**55.7**	**11.1**	**1,545.2**	**1,127.6**	**2.7**	**894.1**	**1,062.6**	**320.6**	**2,748.4**	**7,842.7**
Total Phase 3 savings (Replacement and removal)	**122.2**	**291.1**	**174.5**	**9,439.0**	**4,689.3**	**6.0**	**6,337.6**	**4,267.1**	**1,892.3**	**10,289.5**	**37,508.6**

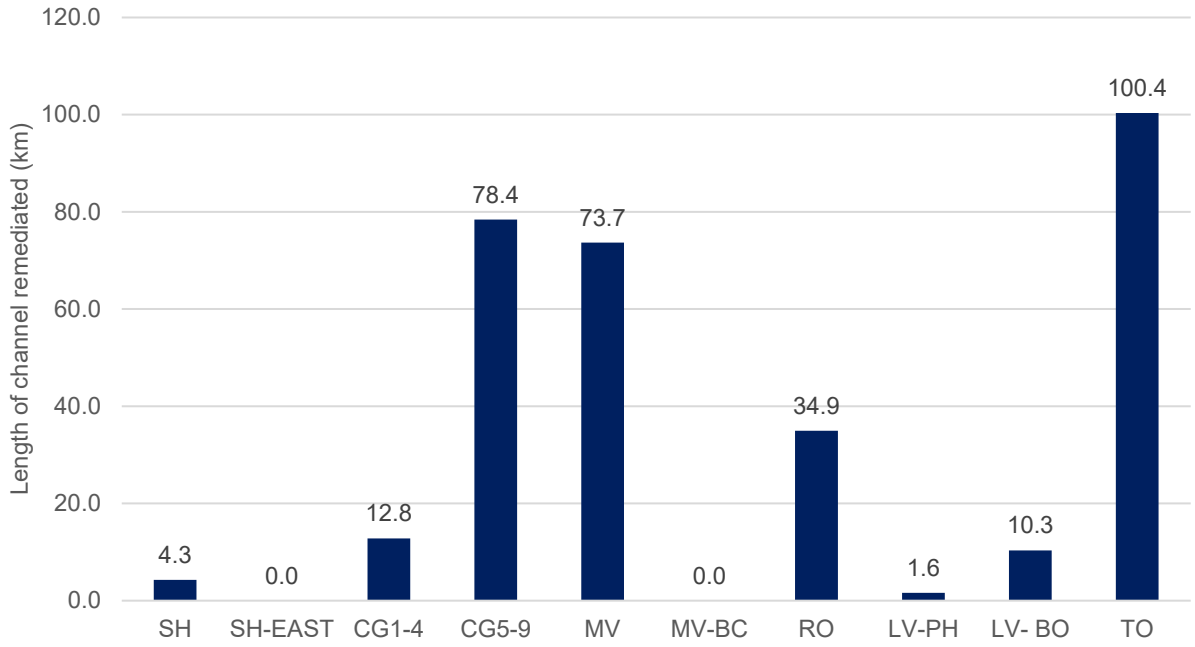
Note – Totals may not sum due to rounding

6.7 SAVINGS FROM CHANNEL REMEDIATION

6.7.1 Scope of Irrigation Channel Remediation Works

Channel remediation involves lining earthen channels, replacing channels with pipelines and bank remodeling. These works can generate irrigation water savings through reduced bank seepage and reduced bank leakage. A total of 316.3 km of channel lining has been completed to this audit 2021/22. The length of channel that has been remediated by irrigation area is shown in Figure 6-4

Figure 6-4 Length (km) of channel remediated by irrigation area



6.7.2 Findings from trailing data and calculations

For the remediation works completed in 2008 (5km), no pre or post works pondage test data is available. Therefore, the theoretical method has been used for these works. The inputs and method are unchanged from the 2009/10 audit report for these works from 2008.

For the works completed in 2009 pre-works pondage data is available for all sites except one. Post-works pondage testing data is available for 11 of the 15 sites. For the works completed in 2010, 40 of 43 sites have both pre and post works pondage testing data available. The sites for which post-works pondage testing is now available has been steadily increasing each year, enabling the preferred methodology using both pre and post works data to be used.

Through the course of the project, 75% of remediation water savings claims have been supported by pre and post remediation pondage test data. The Water Savings Protocol Version 5 does specifically allow for theoretical estimations to be used for later phases.

We have reviewed the input data and confirm that the fixed parameters sourced from the technical manual are correct, as are the deliveries in the Baseline Year sourced from the Baseline Year Water Balance.

The following summary is a review of the inputs from the current operating year:

Pre Works and Post Works bank Leakage and Seepage ($L^{PRE\ WORKS}$, $L^{POST\ WORKS}$, $S^{PRE\ WORKS}$, $S^{POST\ WORKS}$)

Where pondage testing data is available, pre and post works leakage and seepage are determined through evaluation of site testing results. We have reviewed the pondage testing methodology and results in previous audits and commented that we believe that the pre and post works seepage and leakage estimates, determined through site testing, are sound.

Customer Deliveries in the Current Year (D_{YearX})

Customer deliveries in each irrigation district are determined from IPM reports. The volumes used are sourced from the same reports used for GMW's annual reporting.

6.7.3 Results

Water savings due to channel remediation are calculated on a channel-by-channel basis as each channel has a different leakage and seepage rate. The meter error correction is applied to whole irrigation areas. The final water savings due to channel remediation are shown in Table 6-6.

Table 6-6 Phase 3 Water Savings due to Channel Remediation

	SH	SH-EAST	CG1-4	CG 5-9	MV	MV-BC	RO	LV-PH	LV- BO	TO	Total
Phase 3 savings (ML)											
Stage 1	0.0	0.0	0.0	3,889.1	2,995.5	0.0	1,501.8	0.0	0.0	2,112.2	10,498.6
Stage 2	483.2	0.0	1,131.5	3,443.5	2,720.7	0.0	232.5	171.5	1,307.6	4,170.5	13,661.1
Total	**483.2**	**0.0**	**1,131.5**	**7,332.6**	**5,716.2**	**0.0**	**1,734.3**	**171.5**	**1,307.6**	**6,282.8**	**24,159.7**

Note – Totals may not sum due to rounding

7.0 RECOMMENDATIONS FOR IMPROVEMENT

The Audit Protocol requires that the water audit report include:

- Potential improvements to the data collection, data analysis, assumptions and methods used to estimate the water savings.
- Recommendation on changes to the Water Savings Protocol that will improve the useability and accuracy of water savings estimates.

We make the following recommendation regarding GMW's approach to estimating water savings for GMW to consider for implementation:

- Improve the audit trail when flow records are updated in SPM. This may be done by providing additional drop-down menus and/or reinforcing the requirement for operators to provide comments when updates are made.

This audit has not identified any need to change the Water Savings Protocol.

8.0 PROGRESS AGAINST PREVIOUS AUDIT RECOMMENDATIONS

The Audit Protocol requires the current year audit to report on the status of the suggested improvements made in previous audits. All recommendations prior to 2019/20 have now been closed out.

Table 8-1 details progress against the recommendations that were still open at the 2020/21 audit. This table also details the recommendations made at this year's audit for the purpose of tracking these recommendations in future audits.

Table 8-1 Schedule of progress against previous audit actions

Ref	Area	Comment	2020/21 Audit comment
2018/19-2	Construction Records – work packs	We recommend GMW consider if specific lines or entries marking beneficial completion should be included on ITPs so there is a clear link from site work completion to water saving claims	Based on the observations during the 2021 audit and information provided by GMW, this recommendation can be closed.
2019/20-1	Adjustment of flow data in SPM	GMW re-communicate the Outfall Loss Volume Data Management procedure and remind staff of their requirements.	This recommendation should stay open and be adjusted to "*Improve the audit trail when flow records are updated in SPM*"
2020/21-1	Date and time stamping on photos	Ensure all photographs used to support water savings are date and time-stamped	Based on the observations during the 2021 audit and information provided by GMW, this recommendation can be closed.

APPENDIX A

Calculations

Appendix A

Channel asset removal calculations

Overview

Water savings due to channel removal are the sum of the savings due to water no longer being lost in the channel to seepage, bank leakage, and evaporation:

Phase 3: $WS_{Yearx} = WS_{seepage} + WS_{bank\ leakage} + WS_{evaporation} - R$

Water savings calculations

Phase 3 Calculations

Phase 3 water savings have been calculated by GMW using the Phase 3 channel removal formulae from the technical manual:

$$WS_{Seepage} = S_{Base} \times CL \times t_r \times EF$$
$$WS_{bank\ leakage} = [(L_{Base} \times FL) + (L_{Base} \times VL \times (D_{YearX} / D_{Base})] \times CL \times t_r \times EF$$
$$WS_{evaporation} = E_{Base} \times CL \times t_r \times EF$$

Revisions to the baseline year water balance since 2011/12 have adjusted the baseline year losses for leakage, seepage, and evaporation losses. Seepage and evaporation losses are also now taken to occur over a full year rather than just the irrigation season.

As noted in Section 6.4, GMW uses a loss model approach for determining water savings from removal of spur channels. This approach has been approved by DELWP. The loss model approach is more granular than using area averages.

Input data

The inputs required to calculate Phase 3 water savings due to channel removal are summarised in Table A-1 and Table A-2.

The first table details the parameters that are fixed or have been previously audited, e.g., the baseline year parameters. The second table details the input data from the current year.

Table A-1 Fixed Parameters and Baseline Year Parameters for Channel Removal Water Savings Calculation

Parameter	Description	Source
S_{Base}	Seepage in Baseline Year	Baseline Year water balance
L_{Base}	Leakage in Baseline Year	Baseline Year water balance

E_{Base}	Evaporation in Baseline Year	Baseline Year water balance
D_{Base}	Deliveries in Baseline Year	Baseline Year water balance
FL	Proportion of bank leakage recognised as fixed	Technical manual
VL	Proportion of bank leakage recognised as variable	Technical manual
EF	Effectiveness Factor for channel removal	Technical manual
R	Residual losses if channel replaced by pipeline (0.4ML/km/year for Phase 3)	Technical manual, including a minor correction identified by the Connections Project and acknowledged by DELWP

Table A-2 Current Year Parameters for Channel Removal Water Savings Calculation

Parameter	Description	Source
CL	Ratio of length of spur channel length rationalised to total spur channel length in system	GIS and direct measurement
t_r	Ratio of the length of time a channel has been rationalised in the year in question relative to the irrigation season length in the baseline year	Construction records
$D_{Year\ x}$	Customer deliveries in the year in question to the irrigation system	IPM reports

Channel Automation Calculations

Overview

Water savings due to automation are the sum of the savings realised through reduced outfall volumes:

Phase 3: $WS_{YearX} = WS_{outfalls}$

In Version 5 of the Water Savings Protocol, outfalls in the current year and baseline year have been divided into fixed and variable components. The variable component relates to customer deliveries and is scaled by customer deliveries.

Water Savings Calculations

Phase 3 Calculations

Phase 3 water savings have been calculated by GMW Connections Project using the Phase 3 outfalls formula from the technical manual:

$$WS_{outfalls} = [(O_{base\ -\ variable} \times (D_{YearX} / D_{Base})) - (O_{YearX\ -\ variable})] + [O_{Base\text{-}Fixed} - O_{YearX\text{-}Fixed}]$$

Input Data

The inputs required to calculate Phase 3 water savings due to outfall automation are summarised in Table A-3 and Table A-4.

The first table details the parameters that are fixed or have been previously audited, i.e., the baseline year parameters. The second table details the input data from the current year.

Table A-3 Fixed parameters and baseline year parameters for automation water savings calculation

Parameter	Description	Source
$O_{Base\ -\ fixed}$	Fixed outfall loss in Baseline Year	Baseline Year water balance and analysis
$O_{Base\ -\ variable}$	Fixed outfall loss in Baseline Year	Baseline Year water balance and analysis
D_{base}	Customer Deliveries in the Baseline Year in the irrigation system	Baseline Year water balance

Table A-4 Current year parameters for automation water savings calculation

Parameter	Description	Source
$O_{yearX\ -\ Fixed}$	Fixed outfalls in Current Year	SCADA and analysis
$O_{yearX\ –\ Variable}$	Variable outfalls in Current Year	SCADA and analysis
D_{yearX}	Customer Deliveries in the Current Year in the irrigation system	IPM reports

Service Point Replacement and Removal

Overview

Water savings due to service point replacements and removal are the sum of the savings realised through reduced meter errors, lowered leakage through and around the old meter, previously unmetered volumes and reduced unauthorised use.

The high-level equation of Phase 3 savings:

$$WS_{YearX} = WS_{meter\ error} + WS_{leakage\ through} + WS_{leakage\ around} + WS_{unmetered} + WS_{unauthorised}$$

Water Savings Calculations

The components of the Phase 3 water savings calculations are detailed below. GMW does not include the component for savings due to unmetered volumes as it believes that these are negligible.

Phase 3 Calculations – Service Point Replacement

Phase 3 water savings have been calculated by GMW using the formula in the technical manual:

$$WS_{YearX} = WS_{meter\ error} + WS_{leakage\ through} + WS_{leakage\ around} + WS_{unmetered} + WS_{unauthorised}$$

where

$WS_{meter\ error} = D_{MYearx} \times (1/MCF) \times (MCF - 1) \times EF$

$WS_{leakage\ through} = N_{replaced} \times LTT \times EF \times t_m$

$WS_{leakage\ around} = N_{replaced} \times LTA \times EF \times t_m$

$WS_{unmetered} = D_{UBase} \times (MCF - 1) \times EF \times (D_{YearX}/D_{base}) \times t_m$ **(not used)**

$WS_{unauthorised} = N_{replaced} \times U_{base} \times EF \times (D_{YearX}/D_{base}) \times t_m$

In the cases where a new service point has been added into a channel previously serviced by less meters, GMW denotes these as a new-new meter. The new-new meter decreases water savings due to the leakage through and around the structure. Therefore, GMW has used a slightly different formula to calculate 'savings', which accounts for introduced losses that would not have been experienced before. The formulas only change in leakage through and unauthorised losses in Phase 3. This is a conservative approach that we feel is appropriate.

Phase 3 Calculations – Service Point Removal

Phase 3 water savings due to service point removal have been calculated by GMW using the formula in the *technical manual:*

$$WS_{YearX} = WS_{meter\ error} + WS_{leakage\ through} + WS_{leakage\ around} + WS_{unmetered} + WS_{unauthorised}$$

where

$WS_{meter\ error} = (D_{MBase} \times (MCF - 1) \times EF) \times (D_{YearX}/D_{base}) \times t_m$

$WS_{leakage\ through} = N_{rationalised} \times LTT \times EF \times t_m$

$WS_{leakage\ around} = N_{rationalised} \times LTA \times EF \times t_m$

$WS_{unmetered} = D_{UBase} \times (MCF - 1) \times EF \times (DYearX/Dbase) \times t_m$ **(not used)**

$WS_{unauthorised} = N_{rationalised} \times U_{Base} \times EF \times (D_{YearX}/D_{base}) \times t_m$

Input Data

The inputs required to calculate Phase 3 water savings due to service point replacement and removal are summarised in Table A-5 and Table A-6. Table A-5 details the parameters that are fixed or have been previously audited. Table A-6 details the input data from the current year.

Table A-5 Fixed Parameters and Baseline Year Parameters for Service Point Replacement and Removal Water Savings Calculation

Parameter	Description	Source
MCF	Adopted Meter Correction Factor for Dethridge Meter Service Points or associated with deemed Service Points	Technical manual
$EF_{meter\ error}$	Effectiveness Factor for reducing measurement error	Technical manual
$EF_{leakage\ through}$	Effectiveness Factor for reducing leakage through the meter	Technical manual
$EF_{leakage\ around}$	Effectiveness Factor for reducing leakage around the meter	Technical manual
$EF_{unauthorised}$	Effectiveness Factor for reducing unauthorised use	Technical manual
LTA	Defined Fixed Leakage Rate (ML/year/service point) around service points	Technical manual
LTT	Defined Fixed Leakage Rate (ML/year/service point) through service points	Technical manual
U_{base}	Unauthorised use loss in the Baseline Year	Technical manual
D_{base}	Customer Deliveries in the Baseline Year	Baseline Year water balance
DM_{base}	Customer deliveries through the Rationalised meters in the Baseline Year	Baseline Year water balance

Table A-6 Current Year Parameters for Service Point Replacement and Removal Water Savings Calculation

Parameter	Description	Source
D_{MYearX}	Customer deliveries through the replaced meters for the year in question	IPM reports
D_{YearX}	Customer deliveries in the year in question to the irrigation system	IPM reports
t_m	Ratio of time service point in use compared to Baseline Year	Construction records
$N_{replaced}$	Number of meters replaced	Construction records
$N_{rationalised}$	Number of meters rationalised	Construction records

Channel Remediation

Overview

The type of calculation employed for determining water savings due to channel remediation depends on the availability of pre and post works pondage data as detailed in Table A-7.

Table A-7 Calculation methods for Channel remediation works

Data availability	Calculation method
No pre or post remediation pondage testing data available	Theoretical method (No pre-works pondage test data) using technical manual Phase 2 calculations
Pre remediation pondage testing only available	Theoretical method (using pre-works pondage test data)
Both pre and post remediation pondage testing data available	Direct method

GMW has historically omitted the evaporation component from its savings as it assumes that there is likely to be negligible change in surface area of a channel pre and post remediation. Version 5 of the technical manual no longer includes an evaporation component.

Both direct and theoretical equations have the same high-level form:

$$WS_{YearX} = WS_{bank\ leakage} + WS_{seepage}$$

Water Savings Calculations

The calculations for remediation in Version 5 of the technical manual have been revised to reflect the amended approach which has been accepted in 2015/16 by DELWP and the Water Savings Protocol Implementation Review Committee.

Theoretical Phase 3 calculations, where no pre-works pondage testing data is available, are not discussed as these only apply to the 2008 works. These were reviewed in 2009/10 and there has been no change since then. The equations in the updated technical manual for determining savings due to channel remediation have been revised with the length and time discounting factors being removed.

Theoretical Method - Phase 3 Calculations– Pre-works pondage test data available

$$WS_{bank\ leakage} = [((PT^{PRE\ WORKS} \times F(PA)) - S^{PRE\ WORKS}) \times (VL \times (D_{YearX}/D_{Base}) + FL)] \times EF$$

$$WS_{seepage} = S^{PRE\ WORKS} \times EF$$

Direct Method - Phase 3 Calculations– Measured pre-works and post-works pondage test data is available

$$WS_{bank\ leakage} = [(((PT^{PRE\ WORKS} - PT^{POST\ WORKS}) \times F(PA)) - (S^{PRE\ WORKS} - S^{POST\ WORKS})) \times (VL \times (D_{YearX}/D_{Base}) + FL)]$$

$$WS_{seepage} = S^{PRE\ WORKS} - S^{POST\ WORKS}$$

The revised baseline year water balance[5] has removed the concept of system fill. System fill was treated as operational flows that were not impacted by improved irrigation infrastructure because they occurred outside of the irrigation season. However, it has now been recognised that most channels that have been lined will hold water over the full year, including the non-irrigation season, and therefore water savings occur across the full year. In particular, there is reduced seepage in both the irrigation and non-irrigation seasons. As a result, the interpretation of the seepage calculation has been updated to be applied across the full 365 days of the year of operation, instead of only the irrigation season as previously calculated.

GMW has adjusted the water savings estimated due to channel remediation downwards for old leaking outlets existing when pondage tests were carried out. This is to avoid any possibility of double counting savings on both the remediation program and from service point upgrade works.

Input Data

The inputs required to calculate Phase 3 water savings due to channel remediation are summarised in Table A-8 and Table A-9. The first table details the parameters that are fixed or have been previously audited. The second table details the input data from the current year.

Table A-8 Fixed Parameters and Baseline Year Parameters for Channel Remediation Water Savings Calculation

Parameter	Description	Source
VL	Proportion of bank leakage recognised as variable	Technical manual
FL	Proportion of bank leakage recognised as fixed	Technical manual
D_{base}	Customer deliveries in the baseline year	Baseline Year water balance
EF	Effectiveness Factor for channel remediation	Technical manual
F(PA)	Pondage Testing Adjustment Factor to account for dynamic losses in addition to static losses	Technical manual

Table A-9 Current Year Parameters for Channel Remediation Water Savings Calculation

Parameter	Description	Source
$PT^{PRE\ WORKS}$	Pre works total seepage and bank leakage	Pondage testing
$PT^{POST\ WORKS}$	Post works total seepage and bank leakage	Pondage testing
$D_{Year\ X}$	Customer deliveries in the year in question to the irrigation system	IPM reports
$S^{PRE\ WORKS}$	Pre works seepage	Pondage testing
$S^{POST\ WORKS}$	Post works seepage	Pondage testing

[5] The revised baseline year water balance was independently audited in 2011/12

APPENDIX B

Document Register

Appendix B

Document titles – as received

Calculations

Summary

- v3 summary Connections phase 3 21 22 updateA4502733 (A4514553).xlsx
- v4 automation 2021 22 (A4510080).xlsx

Supporting calculations

Meter outlets

- v4 phase 3 meter savings 21 22 (A4510161).xlsx

Channel decommissioning

- phase 3 channel decom 21 22 (A4499689).xlsx

Channel remediation

- resid pipe losses 2021 21 (A4499837).xlsx
- phase 3 est channel remediat 21 22 (A4500355).xlsb

Supporting documents

Automation outfalls

- Copy of CENTRAL GOULBURN OUTFALL REPORT - 2021-22 (A4387363).xlsm
- Copy of LODDON VALLEY OUTFALL REPORT - 2021-22 (A4387357).xlsm
- Copy of MURRAY VALLEY OUTFALL REPORT - 2021-22 (A4387361).xlsm
- Copy of ROCHESTER OUTFALL REPORT -2021-22 (A4387359).xlsm
- Copy of SHEPPARTON OUTFALL REPORT - 2021-22 (A4387355).xlsm
- Copy of TORRUMBARRY OUTFALL REPORT - 2021-22 (A4387365).xlsm

Outfall data follow-ups

- SCADA & SPM data PH895.xlsx
- SCADA data SH209A.xlsx

- SPM outfall data TN820.xlsx
- SPM outfall data TO663.xlsx

Delivery Data

- Copy of summary cust deliv 21 22 (A4496278).xlsx
- Copy of v8 cust deliveries 21 22 (A4496272).xlsx
- first and last day of irrigation season in the areas 21 22 _SEC_OFFICIAL_.msg
- she_authnode_all (A4496984).csv
- tat_authnode_all (A4496991).csv

PWC Audits

- Feb-22 GMW WEP Finalisation Letter.pdf (April 2021 to September 2021)

Procedures

- GENERAL WATER SAVINGS PROCEDURES 2021 22 update 21 22 (A4515333).docx

Work pack documents

Regulator works

MV325A

- FW_ MV325A old Connections Project reg data sample _SEC_OFFICIAL_.msg
- CivilConstruction.pdf
- Environmental.pdf
- MV325A_WP_PHOTO_DS.jpg
- MV325A_WP_PHOTO_LEFT.jpg
- MV325A_WP_PHOTO_RIGHT.jpg

MV342

- FW_ MV342 old Connections Project reag dataset sample _SEC_OFFICIAL_.msg
- CivilConstruction.pdf
- Environmental.pdf
- MV342_WP_PHOTO_DS.jpg
- MV342_WP_PHOTO_LEFT.jpg
- MV342_WP_PHOTO_RIGHT.jpg
- MV342_WP_PHOTO_US.jpg

MV470

- MV470 old Connections 20_21 regs extra sample _SEC_OFFICIAL_.msg
- CivilConstruction.pdf
- Environmental.pdf
- MV470_WP_PHOTO_DS.jpg
- MV470_WP_PHOTO_LEFT.jpg
- MV470_WP_PHOTO_RIGHT.jpg
- MV470_WP_PHOTO_US.jpg

MV877

- MV877 old Connections reg 2021 data sample _SEC_OFFICIAL_.msg
- CivilConstruction.pdf
- Environmental.pdf
- MV877_WP_PHOTO_DS.JPG
- MV877_WP_PHOTO_LEFT.JPG
- MV877_WP_PHOTO_RIGHT.JPG
- MV877_WP_PHOTO_US.JPG

SH409

- SH409 old Connections Project 20_21 reg data sample _SEC_OFFICIAL_.msg
- CivilConstruction.pdf
- Environmental.pdf
- SH409_WP_PHOTO_DS.JPG
- SH409_WP_PHOTO_LEFT.JPG
- SH409_WP_PHOTO_RIGHT.JPG
- SH409_WP_PHOTO_US.JPG

TN798

- TN798 Connections reg sample - ex 20_21 _SEC_OFFICIAL_.msg
- CivilConstruction.pdf
- Environmental.pdf
- TN798_WP_PHOTO_DS.JPG
- TN798_WP_PHOTO_LEFT.JPG
- TN798_WP_PHOTO_RIGHT.JPG
- TN798_WP_PHOTO_US.JPG

TO95

- FW_ TO95 Connections old regs 20_21 datset sampke _SEC_OFFICIAL_ (1).msg
- CivilConstruction.pdf
- Environmental.pdf
- Thumbs.db
- TO95_WP_PHOTO_DS.jpg
- TO95_WP_PHOTO_LEFT.jpg
- TO95_WP_PHOTO_RIGHT.jpg
- TO95_WP_PHOTO_US.jpg

TO960

- TO960 - old Connections Project 20_21 reg data sample _SEC_OFFICIAL_.msg
- TO960 regulator pics _SEC_OFFICIAL_.msg
- TO960 regulator workpack _SEC_OFFICIAL_.msg
- CivilConstruction.pdf
- TO960_WP_PHOTO_DS.jpg
- TO960_WP_PHOTO_LEFT.jpg
- TO960_WP_PHOTO_RIGHT.jpg
- TO960_WP_PHOTO_US.jpg

Asset Removal Works

CH000250

- CH000250_DS_BLOCK_LOCATION_MAP84ef0562-5b8a-4085-b982-d18a567b8ac3.png
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- CH000250_WP_BEFORE_PHOTO_SRf976cbf8-90c0-4a04-a45e-86f9758f15c2.jfif
- CH000250_WP_ITP_BLOCK_SRf7e45464-d142-4a0c-b8bb-49630cd98cae.pdf

CH003040

- CH003040_WP_AFTER_PHOTO525c23ff-41a7-4bae-bbc3-af3b4e8e68bd.jfif
- CH003040_WP_AFTER_PHOTO_SR3b265cbf-156c-43a8-9111-a26b71631b30.png
- CH003040_WP_CON_PHOTO72b93b4c-6dc4-420f-9ed1-af64dc23a353.png
- CH003040_WP_ITP_BLOCK_SR9289d936-6cab-4698-b742-4a13cc4ccd1c.pdf
- PH227_WP_AFTER_PHOTO.png

- PH227_WP_BEFORE_PHOTO.jfif
- PH227_WP_ITP_RATIO.pdf

CH004033

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- CH017104_WP_BEFORE_PHOTO65499da8-a735-4e0b-8675-8cbcc1066e69.jpg
- CH017104_WP_BEFORE_PHOTO839ac69e-9561-47ce-b6c1-49dc4f1b910a.jpg
- CH017104_WP_BEFORE_PHOTOf10b4404-e2ad-486c-bc78-fd0a323734b0.jpg
- Location map.pdf
- ST052636_IMG_BEFORE.jpg

CH006334

- 2022-10-19 11_14_31-GMW Locations.png
- CH003161_WP_AFTER_PHOTO.jpg
- CH003161_WP_BLOCK_LOCATION_MAPf0aeca8e-2e5e-47d8-9cb7-38332e4115e7.pdf
- CH003161_WP_ITP_BLOCK39f01543-eec4-4489-9ea4-961a44952eed.pdf

CH009046

- 2022-10-19 13_35_35-GMW Locations.png
- PH665_EN_SECM.pdf
- PH665_WP_AFTER_PHOTO.jfif
- PH665_WP_ITP_RATIO.pdf

CN011634

- CH011634_WP_AFTER_PHOTOc08df618-5499-459f-8ba0-610632c4e320.jpg
- CH011634_WP_BLOCK_LOCATION_MAP89ceb454-d4f2-40c8-b2dc-26180a3a2cea.pdf
- CH011634_WP_ITP_BLOCK4c594c8e-ae5d-4851-9ae6-2880ddee369f.pdf
- CH011634_WP_ITP_DECOM6c76384b-50b7-4deb-994e-729b43d63d93.pdf
- TN3843_WP_HANDOVER_Remote Operate.zip
- CH012611

CH012609_WP_AFTER_PHOTO81bc0296-2e37-4b0c-b61f-f5a4740f9760.jpg

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- CH012609_WP_BLOCK_LOCATION_MAP7ddcb7de-e609-46a6-af3d-62659affa6ca.pdf
- CH012609_WP_ITP_BLOCK817a0950-b28f-486f-88ab-0228d377184a.pdf

CH014496

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- TN500_WP_PHOTO_RIGHT.jfif

CH018124

- 2-6-4 offtake.jfif
- CH000392_WP_ITP_BLOCKba9cd360-09e3-44b4-af87-e5c8b9d28c35.pdf
- CH018124 decom-2.png
- CH018124 decom.png

Meters

RN1740

- RN1740_Commissionning.pdf
- RN1740_Workpack.pdf
- RN1740_WP_PHOTO_DS.JPG
- RN1740_WP_PHOTO_LEFT.JPG
- RN1740_WP_PHOTO_RIGHT.JPG
- RN1740_WP_PHOTO_SP.JPG
- RN1740_WP_PHOTO_US.JPG

RN2134A

- RN2134A_Workpack.pdf
- RN2134A_WP_RATIO_PHOTO2bdefdd9-b0b0-4500-bcbb-0d6c7280411d.jpg

RN2293

- RN2293_Commissionning.pdf
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- RN2293_WP_PHOTO_RIGHT.JPG
- RN2293_WP_PHOTO_SP.JPG
- RN2293_WP_PHOTO_US.JPG

RO5512

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- RO5512_WP_RATIO_PHOTO328a530a-3fd5-404f-a55c-312fc8bd1a52.jpg

RO6647

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SH6835

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TN3843

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- TN3843_WP_PHOTO_SP.jpg
- TN3843_WP_PHOTO_US.jpg

TN4065

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TO5078

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- TO5078_WP_PHOTO_SP.jpg
- TO5078_WP_PHOTO_US.jpg

TO6044

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- TO6044_WP_RATIO_PHOTO1a586ca9-48f1-4de1-809d-2c8565d63725.jpg

APPENDIX C

Site Photos (provided by GMW)

Appendix C

Site Photographs

Table C-1 Site Photos

Automation - New regulator (pre works) **TO95** **From construction pack (TO95 Civil Construction.pdf)**	
Automation - New regulator (post works) **TO95** **TO95_WP_PHOTO_DS.jpg**	

Meter – rationalisation (pre works) **RO5512** **RO5512_BEFORE_PHOTO-2.jfif**	
Meter – rationalisation (post works) **R05512** **RO5512_WP_RATIO_PHOTOe90a4059-0703-4d72-b9f6-2895094b1096.jpeg**	

Meter – replacement (post works) **TO5078** **TO5078_WP_PHOTO_DS.jpg**	
Channel Decommissioning (post works) **CH011634** **CH011634_WP_AFTER_PHOTOc08df618-5499-459f-8ba0-610632c4e320.jpg**