

Queanbeyan-Palerang Regional Council

Water and Sewer Strategic Planning

Issues Paper update 2025



Report Number: P-FY20231576-PWO-WSP-RP-001-01

March 2025

Prepared for:



Report Number: P-FY20231576-PWO-WSP-RP-001-01

QPRC Water and Sewer Strategic Planning_2025_Final.docx

Document control

Version	Author(s)	Reviewer	Approved for issue	
			Name	Date
0 (preliminary)	T. Ravindiran S. Shashidharan M. Verceluz N. Joshi	Glenn Fernandes	Glenn Fernandes	22/03/2024
1 (draft)	T. Ravindiran S. Shashidharan M. Verceluz N. Joshi	Nicole Bailey Gordon Gunningham Jennifer Blaikie	Glenn Fernandes	6/02/2025
2 (final)	T. Ravindiran S. Shashidharan M. Verceluz N. Joshi	Nicole Bailey Gordon Gunningham Jennifer Blaikie	Glenn Fernandes	27/03/2025

Glenn Fernandes

Director, Water Resource Management

NSW Public Works, 4PSQ, 12 Darcy Street, Parramatta NSW 2150

Locked Bag 5022, Parramatta NSW 2124

T (02) 9769 9735 | **M** 0421 487 408

E glenn.fernandes@pwa.nsw.gov.au | **W** www.publicworks.nsw.gov.au

Cover photo: Lake George

Source: www.istockphoto.com

© State of New South Wales through Department of Primary Industries and Regional Development 2025

This publication is copyright and may incorporate material to which an individual maintains moral rights. Other than for the purposes of and subject to the conditions prescribed under the Copyright Act 1968, no part of it may, in any form or by any means, be reproduced, altered, manipulated, stored in a retrieval system or transmitted without prior written consent of the copyright owner or owner of moral rights. Any enquiries relating to consents and use of this publication, including by NSW Government agencies, must be addressed to NSW Public Works.

While this document has been formulated with all due care, the State of New South Wales does not warrant or represent that the document is free from errors or omissions, or that it is exhaustive. The State of NSW disclaims, to the extent permitted by law, all warranties, representations or endorsements, express or implied, with regard to this document including but not limited to, all implied warranties of merchantability, fitness for a particular purpose, or non-infringement. The State of NSW further does not warrant or accept any liability in relation to the quality or accuracy of this document and no responsibility is accepted by the State of NSW for the accuracy, currency, reliability and correctness of any information in this document provided by the client or third parties.

Executive Summary

The former Palerang Local Government Area (LGA) is in south-eastern New South Wales, immediately to the east of Canberra. The area is predominately rural, with some rural residential areas and several small towns and villages. The major town is Bungendore, followed by Braidwood and Captains Flat. In May 2016, Palerang Council amalgamated with the former Queanbeyan City Council to form the Queanbeyan-Palerang Regional Council (QPRC).

The former Palerang Council developed a water and sewerage strategic plan in 2018 (formerly known as the IWCM Strategy) to prepare a 30 year Total Asset Management Plan (TAMP) and a supporting financial plan to deal with the issues identified in the IWCM process. Principal amongst these were strategies for the augmentation of the Bungendore water supply and sewerage schemes in an effort to support the significant growth pressures in and around the town of Bungendore.

Since the last strategic plan was completed, there has been a significant drought (from 2017-2019), Council has been unable to secure the required licences and approvals to secure additional groundwater for Bungendore (leading to the development of alternate options) and the projected growth around Braidwood has increased significantly. Therefore, updated water demand assessments are required for Bungendore and Braidwood.

The growth expected in Captains Flat has not increased and is still very low and water security has not been identified as an issue. Therefore, the analysis for Captains Flat is limited to an updated non-revenue water analysis.

Water supply service

The Palerang community sits within three catchments, with the major townships in different catchments: Captains Flat in the Murrumbidgee Catchment, Braidwood in the Shoalhaven Catchment and Bungendore in the Lake George Catchment respectively. Each township has its own separate water supply scheme. The Bungendore and Braidwood schemes will need to supply water to an estimated serviced population of 14,430 in 2054.

Palerang has three sewerage schemes servicing townships of Bungendore, Braidwood and Captains Flat. The other much smaller rural villages, as well as the considerable rural residential and rural areas in the former Palerang LGA, are serviced by On-site Sewage Management Systems (OSSMS) including septic tanks and aerated wastewater treatment systems.

The serviced and un-serviced towns and villages in Council's area are outlined in Table S-1.

Table S-1: Serviced and Unserviced areas in the former Palerang LGA

Town / village	Water supply service	Sewerage service
Bungendore	Bungendore water supply scheme	Bungendore sewerage scheme
Braidwood	Braidwood water supply scheme	Braidwood sewerage scheme

Town / village	Water supply service	Sewerage service
Captains Flat	Captains Flat water supply	Captains Flat sewerage scheme with some On-site Sewerage Management Systems (OSSMS)
Major Creek	Nil	On-site Sewerage Management Systems (OSSMS)
Araluen	Nil	On-site Sewerage Management Systems (OSSMS)
Nerriga	Nil	On-site Sewerage Management Systems (OSSMS)

Water supply schemes

Bungendore water supply scheme

Bungendore water supply scheme extracts water from the Turallo and Currandooly bore fields, both subsets of the Bungendore Alluvial Groundwater Source. Water from the Turallo bore fields is aerated, chlorinated, and fluoridated before distribution to customers. Water from the Currandooly bore fields is treated through a conventional water treatment plant, chlorinated and fluoridated before distribution to customers.

The current water demands are very close to the water access licence allocation. Therefore, Council has been working on acquiring additional water for Bungendore and has placed a moratorium on the development of new subdivisions until the additional water is secured.

In 2024 additional water quality sampling was undertaken for Per- and polyfluoroalkyl substances (PFAS), the results showed that there were low levels of PFAS (between the current Australian Drinking Water Guidelines (ADWG) concentrations and the proposed ADWG) in two of the five town water supply bores.

Braidwood water supply

The Braidwood water supply scheme draws water from an off-stream storage dam which is filled by water extracted from the Shoalhaven River. Water is treated in a Dissolved Air Flotation Filtration (DAFF) plant and is chlorinated and fluoridated before distribution.

Captains Flat water supply

The Captains Flat water supply scheme draws water from a dam on the Molonglo River. Water is treated in a membrane ultra-filtration (20nm) plant and chlorinated and fluoridated before distribution.

Sewerage schemes

Bungendore sewerage scheme

The Bungendore sewerage scheme has a gravity reticulation system, incorporating 10 Sewage Pumping Stations (SPS). Bungendore Sewerage Treatment Plant (STP) has two IDEA reactors for secondary treatment. Effluent is disinfected by UV prior to discharge into Mill Post Creek. The plant has been recently upgraded to cater for a separate high quality recycled water stream complete with UF membranes, dedicated UV, NaOCL dosing and a 300 kL storage reservoir. This

treated effluent is used for onsite reuse, the truck fill, for irrigation of Mick Sherd Oval and will be used for the new Bungendore Sports Hub.

In addition to the 10 SPS discussed above, a new pump station has been added to service the Bungendore Sports Hub (SPS 11). This SPS pumps a short distance into the SPS 1 catchment. For the purposes of this project, the current loads are assigned to SPS 1. This will be updated in future projects.

Braidwood sewerage scheme

The Braidwood sewage collection system is a conventional gravity sewerage system with seven pumping stations. The STP receives sewage from SPS 1. Braidwood STP has one IDEA reactor. The effluent is disinfected via a UV unit prior to discharge to Flood Creek.

Captains Flat sewerage scheme

Captains Flat has a gravity reticulation system with one sewage pumping station. The Captains Flat STP comprises of a Pasveer channel for secondary treatment. Since the last IWCM Strategy was completed, the plant has undergone a complete upgrade with new inlet works (screen and grit removal), provision for chemical phosphorus treatment (Alphos) dosing into the Pasveer channel, new sludge lagoons, new drying beds and a new UV system prior to discharge. The maturation ponds are no longer routinely used but have been retained as an emergency storage if required.

Population and demographic projections

Growth

The major factor contributing to growth in the former Palerang LGA are proposed major Greenfield developments at Bungendore which is expected to more than double the population of Bungendore over the next 10 years. The population of Bungendore is projected to grow at 3.3% (from 2021 to 2054). The population in Braidwood is expected to grow at 0.8% per year from 2021 to 2026 and then 2.5% per year from then on. 2.5% per year respectively.

Table S-2: Bungendore and Braidwood serviced population projection

		2021	2024	2026	2031	2036	2041	2046	2051	2054
Bungendore	Water	3,935	4,338	4,629	5,444	6,404	7,533	8,860	10,422	11,488
	Sewerage	3,736	4,136	4,427	5,242	6,202	7,331	8,658	10,220	11,286
Braidwood	Water	1,416	1,450	1,474	1,667	1,886	2,134	2,415	2,732	2,942
	Sewerage	1,325	1,359	1,383	1,576	1,795	2,043	2,324	2,641	2,851

The population growth projected in the 2018 IWCM for Bungendore was based on Council quickly securing additional water to support growth. In 2019, Council undertook additional groundwater investigations in the district but was unable to secure the required water access licences and works approvals. Therefore, a moratorium on subdivision approvals has been in place and therefore the growth forecast in the 2018 IWCM has not occurred, and the 2021 census population is approximately equal to the previously projected 2018 population. The 2046 population projected in the 2018 IWCM (11,734) will now be reached in 2054, assuming that the issue of additional sources of water can be resolved.

Most of the new development areas in Bungendore are on the northern edge of the existing town, these will be serviced by the recently completed North Elmslea Reservoir. There will also be a development to the east of town, along Kings Highway, this will be serviced by North Elmslea Reservoir through a separate trunk main that crosses the railway, this service area has been designated as North Elmslea zone 2. The final development area is located to the south of Currandooly Water Treatment Plant, this area will not be required until after 2054, and will probably require a separate reservoir.

The ABS estimates that population in Braidwood grew by 140 people between the 2016 and 2021 Censuses, that the number of occupied houses increased by 46 (16 more than forecast) and that the number of occupied semi-detached properties increased by 43 (none were forecast), this occupied dwelling growth was accompanied by a population growth of 56 people in the detached dwellings and 56 people in the semi-detached dwellings. The average household size for both houses and semi-detached dwellings declined slightly between the censuses. At the time of the 2021 Census, the ABS estimated that there were 1,209 people in standard private dwellings (houses, semi-detached dwellings and units), 20 in other private dwellings (4 in caravans and 16 in homes attached to businesses), and about 187 in “other” dwellings. Based on other information sources there were 27 aged care beds in the multi-purpose service (and these were probably all occupied), there may have been up to about 30 people in visitor accommodation (though this is likely to be an over-estimate given the COVID-19 related restrictions on travel). This leaves about 130 people who were in some other form of accommodation not mentioned previously, there were a similar number of people in this category in the 2016 Census and they were excluded from the IWCM population estimates.

As projected in the previous IWCM, the growth will lead to the unrestricted yearly water demand in hot dry years exceeding the current allocation and the load on the sewage treatment plant reaching the current capacity imminently.

The increased growth in Braidwood will lead to a need for increased annual water allocation, secure yield, water treatment capacity and sewage treatment capacity within the next 30 years.

Water demand analysis and assessment

The historical water production and metered data was modelled to understand the impact of climate dependency, increase in number of active connections, price increase and water restrictions.

Non-Revenue Water (NRW) at Bungendore, Braidwood and Captains Flat has remained around 86, 259 and 119 L/connection/day respectively for 2021-22, though over the last few years the NRW at Braidwood has varied between 402 and 82 L/connection/day.

The unit demand per active residential assessment is provided in Table S-3, the per person demands were developed using the current average household size for occupied standard dwellings as listed in Table S-2. Note that the term unrestricted future year is used instead of the term dry year in this report as some demands vary due to heat (or in other towns, due to visitor numbers), therefore the peak annual demand may occur during a quite dry year with heat waves rather than a very dry year without heat waves.

Table S-3: Unit demand per active residential assessment

WSS	Average year (kL/year)	Average day (kL/day)	Unrestricted future year (kL/year)	Average Day Peak Week (kL/day)	Climate dependence	Climate independent (kL/day)	Climate independent (kL/person/day)	Approximate WELS* Rating
Bungendore	203	0.556	245	1.317	Irrigation	0.424	0.145	2 to 3
Braidwood	153	0.419	177	0.709	Irrigation	0.317	0.149	2 to 3

* WELS the national Water Efficiency Labelling Scheme

The unit demands in Bungendore and Braidwood are similar to those presented in the 2018 IWCM, in Bungendore average year demand decreased by 4.2% and the unrestricted future year decreased by 5.8%, in Braidwood the average year increased by 2.7% and the dry year decreased by 1.1%.

The unit water demands for the new dwellings in Bungendore and Braidwood have been developed using the requirements of Council's 2015 Development Control Plan, this requires the installation and connection of larger rainwater tanks than are required under BASIX (policy implementing water and energy standards for new dwellings in NSW). All the new dwellings in Bungendore are expected to be medium sized detached dwellings and to have an average household size of 3 people (based on the Bungendore Structure Plan). Most of the new dwellings in Braidwood will be medium sized detached dwellings with a household size of 2.2, there will also be a smaller number of attached dwellings, with an average household size of 1.5, these household sizes are based on the 2021 ABS Census results as the Braidwood Structure Plan is yet to be published. The unit demands for new dwellings are summarised in Table S-4. Note that separate unit demands were not developed for Braidwood in the 2018 IWCM as there was very little growth projected.

Table S-5: Unit water demands for new dwellings

Town	Dwelling type	Household size	Average year (kL/year)	Average day (kL/day)	Unrestricted future year (99th %ile) (kL/year)	Peak day (kL/day)
Bungendore	House	3.0	139	0.381	208	1.243
	2018 IWCM	2.9	180	0.493	240	1.243
Braidwood	House	2.2	115	0.316	209	1.875
	2018 IWCM	2.9	180	0.493	240	1.612
	Villa home	1.5	52	0.141	62	0.299

A summary of the water projections for Bungendore is given in Table S-5.

Table S-5: Summary of water supply projections – Bungendore WSS

Reservoir		2025	2030	2035	2040	2045	2050	2055
Days Hill	Average Year Demand (ML/year)	134	165	166	166	167	167	168
	Unrestricted Future Year Extraction (ML/year)	149	190	190	191	192	194	195
	Peak Day Production (ML/day)	0.64	0.85	0.86	0.86	0.87	0.87	0.88
Turallo	Average Year Demand (ML/year)	191	198	206	216	227	240	256
	Unrestricted Future Year Extraction (ML/year)	230	241	255	271	291	313	340
	Peak Day Production (ML/day)	1.05	1.11	1.19	1.29	1.39	1.52	1.68
North Elmslea	Average Year Demand (ML/year)	0	21	66	66	66	66	66
	Unrestricted Future Year Extraction (ML/year)	0	28	85	85	85	85	85
	Peak Day Production (ML/day)	0.00	0.14	0.43	0.43	0.43	0.43	0.43
North Elmslea Zone 2*	Average Year Demand (ML/year)	0	0	18	91	177	278	397
	Unrestricted Future Year Extraction (ML/year)	0	0	23	117	228	358	512
	Peak Day Production (ML/day)	0.00	0.00	0.12	0.60	1.17	1.84	2.62
Total of all zones (historical climate)	Average Year Demand (ML/year)	325	385	455	539	636	751	887
	Unrestricted Future Year Extraction (ML/year)	378	459	553	665	796	950	1131
	Peak Day Production (ML/day)	1.69	2.11	2.60	3.18	3.86	4.67	5.61

Reservoir		2025	2030	2035	2040	2045	2050	2055
Combined system	Average Year Demand (ML/year)	372	432	502	586	683	798	934
	Unrestricted Future Year Extraction (ML/year)	441	521	616	727	858	1,012	1,194
	Peak Day Production (ML/day)	2.40	2.82	3.32	3.90	4.58	5.38	6.33
Combined system with climate change	Average Year Demand (ML/year)	389	452	526	613	716	836	978
	Unrestricted Future Year Extraction (ML/year)	471	557	658	777	917	1,081	1,275
	Peak Day Production (ML/day)	2.50	2.93	3.44	4.05	4.75	5.59	6.57

* This is for a new subdivision to the east of Bungendore (parts of 4610 Kings Highway)

A summary of the water projections for Braidwood is given in Table S-6. The NRW water has varied significantly over recent years. Therefore, there is a projection based on the average NRW (the High NRW projection) and the minimum annual NRW (the Low NRW projection).

Table S-6: Summary of water supply projections with historical climate – Braidwood WSS

		2025	2030	2035	2040	2045	2050	2055
Historical climate	Braidwood (Low NRW)							
	Average Year Demand (ML/year)	151	162	181	209	240	275	315
	Unrestricted Future Year Extraction (ML/year)	192	206	232	272	317	368	425
	Peak Day Production (ML/day)	0.83	0.90	1.06	1.33	1.64	1.99	2.38
	Braidwood (High NRW)							
	Average Year Demand (ML/year)	240	254	279	314	354	398	449
	Unrestricted Future Year Extraction (ML/year)	281	298	330	378	431	491	559
	Peak Day Production (ML/day)	1.07	1.15	1.33	1.62	1.95	2.32	2.75
Climate	Braidwood (Low NRW)							
	Average Year Demand (ML/year)	164	175	195	224	256	293	335
	Unrestricted Future Year Extraction (ML/year)	192	206	232	272	317	368	425
	Peak Day Production (ML/day)	1.46	1.52	1.69	1.97	2.29	2.65	3.05

		2025	2030	2035	2040	2045	2050	2055
	Braidwood (High NRW)							
	Average Year Demand (ML/year)	249	264	290	326	366	412	464
	Unrestricted Future Year Extraction (ML/year)	281	298	330	378	431	491	559
	Peak Day Production (ML/day)	1.45	1.53	1.71	2.01	2.35	2.73	3.16

Demands in Bungendore are projected to exceed the water access licence allocation between 2025 and 2028.

Demands in Braidwood are expected to exceed the:

- water access licence allocation between 2039 and 2041 under the high NRW scenario, though this is pushed out to 2049 or further under the low NRW scenario
- secure yield between 2035 and 2036 under the high NRW scenario, though under the low NRW scenario this is pushed out to between 2045 and 2047.
- WTP capacity under both low and high NRW scenario by about 2040 and combined reservoir capacity by about 2050

Sewer load analysis and assessment

The estimated sewage load to each SPS in terms of Equivalent Tenements (ET), Average Dry Weather Flow (ADWF), Peak Dry Weather Flow (PDWF) and Peak Wet Weather Flow (PWWF) is given in Table S-7.

Table S-7: The average dry weather flows (ADWF) for each sewerage scheme

Sewer catchment	ET	ADWF (kL/day)	PDWF (L/s)	PWWF (L/s)
Bungendore	1,544	643	25.2	123.1
Braidwood	761	278	10.7	54.9

The current and projected sewer system nutrient loads in terms of Equivalent Population (EP) and hydraulic loads (in terms of ET as well as volumetric flows) for each sewerage scheme is provided in Table S-7. The EP projections include both residential and non-residential customers and are therefore higher than the populations projected earlier. The network modelling for the Bungendore sewerage scheme has been undertaken using a specialist software package, the model will be updated as part of the IWCM process. The Braidwood network is yet to be modelled as there was minimum growth forecast in the previous IWCM, therefore a simplified calculation method has been used to estimate the PWWF.

Table S-8: Projected STP flows

		2022	2025	2030	2035	2040	2045	2050	2055
Bungendore sewerage scheme	EP	4,565	4,907	5,810	6,873	8,122	9,591	11,321	13,355
	ET	1,544	1,657	1,957	2,310	2,725	3,214	3,788	4,464
	ADWF* (kL/day)	644	702	859	1,043	1,260	1,515	1,815	2,168
	ADWF** (kL/day)	1,004	1,080	1,278	1,512	1,787	2,110	2,491	2,938
	PDWF** (L/s)	25.2	26.9	31.2	36.2	41.9	48.6	56.3	65.3
	PWWF** (L/s)	The PWWF projections will be estimated from the sewer modelling for the nominated containment standard of 1 in 5 ARI.							
Braidwood sewerage scheme	EP	1,755	1,782	1,918	2,148	2,469	2,833	3,243	3,707
	ET	762	773	831	930	1,070	1,230	1,409	1,612
	ADWF* (kL/day)	278	283	308	351	410	478	553	639
	ADWF** (kL/day)	386	392	422	473	543	623	713	816
	PDWF** (L/s)	10.7	10.8	11.5	10.4	11.7	13.2	14.8	16.7
	PWWF** (L/s)	54.9	55.6	59.7	64.3	73.8	84.5	96.5	110.1

* ADWF based on current ADWF plus 180 L/EP/day for growth

** based on 220 L/EP/day for all users

The Bungendore STP currently has a capacity of 5,000 EP, Council has commissioned the design of an upgrade to the plant that will result in a total capacity of 12,000 EP, it is expected that the STP will reach this capacity in about 2052. The construction of this upgrade will be scheduled once additional water has been secured for the town.

The Braidwood STP was built in 2010, the civil works were built with a capacity of 3,000 EP and the initial mechanical and electrical equipment installed had a capacity of 2,000 EP with the expectation that they would be upgraded during the routine renewals scheduled in 2030. The increased growth in Braidwood will result in the mechanical and electrical upgrade being required by 2032 and a major plant upgrade being required by 2048.

Issues

The issues have been split between current issues and resolved issues. The resolved issues are in the final table in this section.

QPRC's general issues that have been identified through the analyses are outlined in Table S-9.

Table S-9: General water and sewer issues

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
Compliance	BASIX	N/A new issue	Council's 2015 DCP increases the minimum rain water tank size for new dwellings in the former Palerang Shire, this contravenes the NSW State Environmental Planning Policy (Building Sustainability Index: BASIX) 2004

The water supply system issues are outlined in Table S-10.

Table S-10: Water Supply System Issues

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
General water supply issues			
Level of Service	Minimum pressure with firefighting capability	Council have nominated 'positive residual head' as the target for compliance, the current performance needs to be better understood through modelling.	Council now has a calibrated hydraulic model for Bungendore through an engagement with Public Works (Source: Email correspondence)
Best Practice	Pricing	N/A new issue	Council's 2015 DCP increases the minimum rain water tank size for new dwellings in the former Palerang Shire, new dwellings will require significantly less water in average years and nearly as much in hot dry years, increasing the difficulty of achieving an average of 50% of revenue from usage
Regulatory	Fluoridation of Public Water Supplies	The requirement for periodic auditing of the fluoridation systems is not always being met.	Council has confirmed that the requirement for periodic auditing is still not being met. (Source: Email correspondence)

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
Regulatory	Drinking Water Management System	Several of the nominated CCPs in the DWMS are not considered CCPs, for example free chlorine in the reticulation is an operational control point.	Council is currently revising the DWMS
Bungendore water supply issues			
Water security	Licensed allocation	It is estimated that Bungendore water supply dry year extraction will exceed its licensed extraction limit from the Bungendore and Currandooley bores by 2018.	<p>Still the biggest issue for the Palerang Communities</p> <p>History of the past few years of groundwater investigation is now well known.</p> <p>Current strategy is to develop the Q2B proposal, which will transfer water from Queanbeyan to Bungendore. In the meantime, all greenfield development for Bungendore is stalled.</p> <p>(Source: Email correspondence)</p>
Water quality	ADWG (Australian Drinking Water Guidelines)	N/A new issue	Proposed ADWG concentration limits for Per- and Polyfluoroalkyl Substances (PFAS) are significantly lower than the current limits. In response to the expected change, Council has undertaken additional sampling. Two of the four Bungendore bores tested positive for PFAS and the concentration of Perfluorooctane sulfonic acid (PFOS) exceeds the proposed guidelines.

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
Level of Service	Headworks capacity	The peak day demand will exceed the combined capacity of the Bungendore and Currandooly WTPs around 2025. The WTP, and reservoir capacity would need to be reviewed to ensure that the required pressure can be maintained in the system.	The peak day demand will exceed the combined capacity of the Bungendore and Currandooly WTP soon, the exact timing is dependent on the time required to resolve the water security issue and the extent to which additional development is permitted. If one or two of the existing bores need to be removed from service due to PFAS contamination, this will become an immediate serious issue.
CCP1(a)-chlorination in reticulation	DWMS (Drinking Water Management System)	Bungendore WTP: The DWMS (and possibly the plant) needs to be updated so that CCP1(a) is between the tank and the pump, rather than before the dosing point.	Council had deduced that it was more operational than critical due to the fact that water from this plant essentially hits the reticulation (and therefore consumers) only 170m from the Bungendore WTP. Council had confirmed that this test will be added to the daily monitoring field sheets. Council understands the need for a free chlorine sensor between the 100kL collection tank and the pump to ensure that the water is correctly chlorinated before distribution. Longer term, the plan is to establish a direct rising main between this plant and the reservoirs thus improving the chlorine concentration times contact time (C.t).

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
Pathogen cross contamination	DWMS	Based on the DWMS [1] the Residual Risk with Preventative Measures continues to remain “Very High” for the following: potential pathogen contamination issues due to breach of pipeline and cross contamination due to backflow	Council is currently revising the DWMS
Minimum C.t. value	Local Water Utility (LWU) Circular 18 - ADWG	The total C.t from chlorination at Bungendore aeration tower to outflow is 6.2 mg.min/L, which is not above the recommended minimum value of 15 mg.min/L. Residual risk of chlorine sensitive pathogens: High .	Council to strictly monitor and document free chlorine concentration. Longer term, and as part of the Q2B project, the aim is to install a dedicated rising main from this plant to the service reservoirs. This will address any issues with C.t
Residual risk of chlorine resistant pathogens	Pathogen contamination	New issue	Residual risk of chlorine resistant pathogens Medium due to insufficient treatment. Disinfection barriers such as UV or Ozone are also effective at disabling chlorine resistant pathogens. However, Bungendore and Currandooly WTPs do not have UV or Ozone. UV or ozone treatment systems to be installed as part of either the next capacity upgrade or WTP replacement or when DCCEEW policy changes
Braidwood water supply issues			
Water security	Secure Yield	N/A new issue	The un-restricted annual demand will exceed the secure yield (320 ML/year with 1 degree warming) between 2039 and 2047*

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
Water security	Licensed allocation	N/A new issue	The un-restricted annual demand will exceed the licenced water entitlement (360 ML) between 2038 and 2052*
Capacity	WTP capacity	N/A new issue	The un-restricted peak day demand will exceed the WTP capacity (2 ML/day) between 2040 and 2042*
Performance - leaks	Non-Revenue Water	<p>The historical average unit water loss is estimated to be 249 L/connection/day, which is approximately 3.4 times the state median of 74 L/connection/day.</p> <p>The daily NRW calculated for the previous IWCM was 168 kL/day (2013/14), 154 kL/day (2014/15) and 183 kL/day (2015/16), about 35%. The NRW for the period used for the water balance averaged 127 kL/day, showing some improvement. Note that the period used for the water balance was also relatively wet, greatly reducing the overall demand for water, causing the percentage NRW to increase.</p>	This remains a significant problem for Council. Since last IWCM Council has taken advantage of a DCCEEW funded leak detection program. This was of only limited success. Another initiative is a program of revenue meter replacement. Currently Council has rolled out 130 NB-IoT meters with a further 500 to be deployed in 2024/25. Results are already promising with a number of letters already being issued for properties with persistent low flows. The intention is to completely change Braidwood revenue meters to NB-IoT by the end of 2025
Pathogen Contamination	DWMS	Based on the DWMS [1] the Residual Risk with Preventative Measures continues to remain "Very High" for the following: dead end in reticulation system leading to stagnation and loss of chlorine residual; breach of pipeline through breaks and service works; cross contamination due to backflow and growth of biofilms/ sludge causing degradation of water quality	Council is reviewing the DWMS.

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
Residual risk of chlorine sensitive pathogens	Pathogen contamination	New issue	<p>Residual risk of chlorine resistant pathogens Medium due to moderately protected catchment.</p> <p>Disinfection barriers such as UV or Ozone are also effective at disabling chlorine resistant pathogens. However, Braidwood WTP does not have UV or Ozone.</p> <p>UV treatment system to be installed as part of either the next WTP capacity upgrade or WTP replacement or when DCCEEW policy changes</p>
Captains Flat water supply system			
Water loss	Major Water Residential User	This residential property (Property ID – 340223) has been flagged for investigation. A flow restrictor was installed in September 2021. The property is currently carrying in excess of \$40,000 worth of unpaid rates and charges.	Council suspecting serious leakage issues and investigation is underway.
Water loss	Water Balance	The historical average unit water loss is estimated to be 106 L/connection/day, which is approximately 1.4 times the state median of 74 L/connection/day.	Network investigations are ongoing
Regulatory	Drinking Water Management System	The turbidity alert limit corrective action for Captains Flat WTP needs to include a membrane integrity test.	<p>Turbidity monitoring at Captains Flat is now continuous online and monitored by GeoSCADA.</p> <p>Membranes were replaced in May 2024. Regular membrane integrity testing still to be enacted and included in field sheets.</p>

* Range due to use of high and low NRW forecasts

The sewerage system issues are outlined in Table S-11.

Table S-11: Sewerage System Issues

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023 Updates
General sewerage system issues			
Unserviced communities	On-site sewage management systems	<p>Village of Majors Creek – potential issue due to the following reasons:</p> <p>Small lot sizes (some around 3,000 & several around 1,000 m²)</p> <p>Inadequate buffer distance from Majors Creek</p> <p>Moderately well to imperfectly drained soil</p> <p>Village of Nerriga – potential issue due to the following reasons:</p> <p>Small lot sizes (various sizes below 3,000 m²)</p> <p>Some properties may have inadequate buffer distance from Bindi Brook</p> <p>Village of Araluen – potential issue due to the following reasons:</p> <p>Small lot sizes (several properties less than 1,500 m² bordering each other)</p> <p>Moderately permeable, imperfectly drained soil.</p>	No action here

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023 Updates
Bungendore sewerage system issues			
Regulatory	EPA Licence non-compliance	The Bungendore STP exceeded the volumetric discharge limit (2.16 ML/day) in 2016, 2014, 2012 and 2011. Council needs to consider undertaking an inflow/infiltration study.	<p>Council has confirmed that they have undertaken several sewer relining projects since last IWCM. This was informed by precursor cleaning and CCTV work. Council also mentioned about carrying out targeted smoke testing for catchment 4 (Bungendore - a new development area) to try and resolved an emerging inflow problem.</p> <p>(Source: Email correspondence)</p> <p>Wet weather flows exceeded the licence limits more often during the recent wet years</p> <p>Licence is being reviewed as part of the upgrade process.</p>
Pump sizing at PWWF	Sewer catchment performance	The PWWF at catchment #2, #8 and #9 exceeds the capacity of a single pump. The PWWF at catchments #4 will exceed the capacity of a single pump by 2021. This is based on a PWWF calculated from the storm allowance which is twice the maximum flow recorded during the highest rainfall event in the last five years. Hence this is a conservative assessment.	<p>Catchment #2 has had pumps upgraded. Catchment #4 has had pumps upgraded. Catchments #8 & #9 to be upgraded in the future.</p> <p>(Source: Email correspondence)</p>
	Odour/septicity potential	Catchment #7 and #8 have a medium risk for odour/septicity potential with a detention time greater than 4 hours. This risk is expected to continue over the 30-year planning period.	No immediate action. Both SPS7 & SPS8 will increase both capacity and throughput at northern greenfield development progresses. This will lower rising main detention times.

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023 Updates
Capacity	Sewage Treatment Plant	<p>The EP load currently exceeds the 3,000 EP STP capacity and is expected to exceed the 5,000 EP capacity by 2020.</p> <p>For the assessed hydraulic loading of 200 L/EP/day in this study, the plant hydraulic and capacity will be exceeded by:</p> <p>2018 for the 3,000 EP STP, or 2023 when capacity is increased to 5,000 EP by commissioning the second IDEA reactor.</p>	<p>Design engagement currently underway with supporting SSWP funding for a tender ready package (+7,000 EP giving a total capacity of 12,000 EP) by 30 June 2025.</p> <p>The construction will commence once additional water for Bungendore has been secured</p> <p>The spare 2,000 EP IDEA was re-commissioned in March 2023.</p> <p>(Source: Email correspondence)</p>
STP inflow	ADWF compliance	STP inflow continues to be high, regardless of the time since the last rainfall	Council undertaking CCTV inspections and targeted relining.
STP Capacity	STP Capacity Compliance	The current estimated EP load for Bungendore sewerage scheme is 4,549 EP which is reaching the STP Design EP of 5,000,	Design engagement currently underway with supporting SSWP funding for a tender ready package (+7,000 EP giving a total capacity of 12,000 EP) by 30 June 2025.
Odour/septicity potential	WSAA Guidelines	Rising mains that have residence time greater than eight hours are potential to septicity for BU SPSs.	Council to monitor
Braidwood sewerage system issues			
Regulatory	EPA Licence non-compliance	The plant exceeded the volumetric discharge limit every year in the last five years. Council is currently undertaking an inflow/infiltration study.	<p>Inflow/Infiltration study completed. Large program of relining subsequently conducted. Inflow continues to be an issue over recent wet years.</p> <p>(Source: Email correspondence)</p>

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023 Updates
Odour/septicity potential	Sewer catchment performance	Catchment #3, and 5 have a medium risk for odour/septicity potential with a detention time greater than 4 hours. The risk for Catchment #5 is expected to drop to low risk by 2020, however Catchment #3 is expected to remain at medium risk.	No action (Source: Email correspondence)
Increased dry weather flow	Sewage inflow compliance	In winter, spring and early summer 2019, while the weather was extremely dry, the dry weather flows increased to over 400 kL/day. This is substantially higher than the dry weather flows in 2017/18 of 290 kL/day.	Council to investigate potential factors contributing to these high flows
PWWF	Pump rate	The PWWF from the catchments is estimated to be 54 L/s and likely to exceed SPS1 capacity when the fifty-six 2-to-3-bedroom units in the Summerfield - Braidwood Retirement village are completed. Pump rate lower than the combined capacity of the upstream pumps and local flow.	Current. Council to investigate and monitor
Captains Flat sewerage system issues			
Regulatory	EPA Licence non-compliance	The plant exceeded the volumetric discharge limit every year in the last five years. Council is currently undertaking an inflow/infiltration study.	Inflow/Infiltration study completed. Large program of relining subsequently conducted. Inflow continues to be an issue in the La Nina years. (Source: Email correspondence)

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023 Updates
Performance	Sewage Treatment Plant compliance	The plant needs to be upgraded to improve replace ageing infrastructure, improve treatment and enable enhanced phosphorus removal, enable screening and grit removal, improve sludge and sludge drying components and improve amenity and WHS.	Council has confirmed that the plant has been augmented. 2018 Issue now resolved an outcome of a significant investment of capital. (Source: Email correspondence)

Table S-12: Resolved issues

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
General water and sewer issues Work Health and Safety (WHS)	Management System	Council does not have a documented Work and Health and Safety system. Council undertakes periodic WHS reviews, but these are not documented	Council has HSEQ accreditation. (Source: Email correspondence) Issue resolved
General water and sewer issues Levels of Service	Description and performance	There is no centralised data management system in place to monitor and measure the system performance against the levels of service (LOS) The LOS need to be reviewed for the newly formed Queanbeyan-Palerang Regional Council.	Council has a centralised records management system in ECM where plant field sheets are scanned and imported. Key data is also transcribed into spreadsheets for use in regulatory reporting. GeoSCADA also records key plant data. (Source: Email correspondence) Customer Request Management system also in place. Issue resolved
General water supply issues Best Practice	Pricing	Council currently has a two-tier inclining block tariff structure for water supply. Council should consider moving towards a fixed rate tariff structure.	Council has implemented a single block tariff system for water charging (Source: Email correspondence and Council's publicly available revenue policy) Issue resolved

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
Bungendore water supply issues CCP2 Fluoridation in Bungendore	DWMS	From January 2015 and February 2023, there were recent exceedances below the lower critical limit of less than 0.9 mg/L for 72 hrs.	Fluoride levels started to decrease from February 2023 due to issues with the saturators causing bed caking. Council stated that they had replaced the beds of all four branded NaF saturators and recommissioned. Issue resolved
Bungendore water supply issues CCP2 Fluoridation in Currandooly	DWMS	From January 2015 and June 2023, there were recent exceedances below the lower critical limit of less than 0.9 mg/L for 72 hrs. Before July, were maintained to be within the target range.	Fluoride levels started to decrease from February 2023 due to issues with the saturators causing bed caking. Council stated that they had replaced the beds of all four branded NaF saturators and recommissioned. Issue resolved.
Bungendore water supply issues Performance	Non-revenue water	Non-revenue water at Bungendore has been fairly constant at 125 L/connection/day. This is higher than the statewide median of 92 L/connection/day for 2015/16.	Significant program of water meter replacement has been undertaken. Many Itron electronic meters deployed. Now moving to NB-IoT meters as the LGA wide standard. (Source: Email correspondence) Bungendore NRW has reduced significantly, from 125 L/connection/day to 86 L/connection/day in 2021/22. Council will continue to monitor NRW. Issue resolved
Braidwood water supply issues Main breaks	Non-Revenue Water	Main breaks every 1-3 months with some months have main breaks more than once. 26 out of 173 complaints was related to main bursts over 3 years from October 2019 to November 2022.	A program of water main replacement has been undertaken. Frequency of main breaks has reduced. Issue resolved

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
Captains Flat water supply issues Performance	Non-revenue water	Seasonal variations in the NRW for the Captains Flat system have been noticed which are due to a faulty meter at the Captains Flat swimming pool and the neighbouring fields which share a meter. This meter recently been replaced.	The pool site is now well metered although it still has a significant leak problem. The P&G section of Council remains committed to deal with similar issues that arise. (Email correspondence). Issue resolved
Bungendore sewerage issues Best Practice	Section 60 approval	Effluent from the Bungendore STP is reused on-site, for road works (truck filling) and for watering Bungendore oval. Council does not have a Recycled Water Management Plan and Section 60 approval for the off-site effluent reuse.	Bungendore has a Recycled Water Management System and has formal s.60 approval. (Source: Email correspondence) Issue resolved.
		The Log Reduction Value (LRV) required for effluent reuse may not be achieved through the current STP process. This will be reviewed during the preparation of the Recycled Water Management System (RWMS) for Section 60 approval.	Council has updated that this is completed. (Source: Email correspondence) Issue resolved.
Bungendore sewerage issues Performance	Effluent reuse flow balance	There is a mismatch in the effluent reuse flow balance. Potential reasons for the discrepancy could include uncalibrated meters, and on-site flows which may not be metered.	New RWP at the STP has incorporated a whole new system of metering. (Source: Email correspondence) Issue resolved
Braidwood sewerage issues Pump sizing	Sewer catchment performance	The PWWF at catchment #1 will exceed the capacity of a single pump by 2021. Council has funded an upgrade.	Pumps upgraded together with supporting electrical network. 2018 Issue resolved. (Source: Email correspondence)
Captains Flat sewerage issues Pump sizing	Sewer catchment performance	The PWWF at catchment #1 is expected to exceed the duty pump capacity.	Pumps have been upgraded since last IWCM. Both now capable of 15L/s which is sufficient. 2018 Issue now resolved (Source: Email correspondence)

Contents

Executive Summary	1
1 Introduction	35
1.1 Purpose.....	35
1.2 Process	35
1.3 Water and Sewer Strategic Planning Paper	35
1.4 Queanbeyan-Palerang Local Government Area.....	36
1.5 Water Supply and Sewerage Schemes	37
1.6 Un-serviced Communities	38
2 Operating environment and levels of service.....	39
2.1 Regulatory Compliance.....	39
2.2 Levels of Service	44
3 Financial performance and issues	48
3.1 Water supply services.....	48
3.1.1 Tariff structure.....	48
3.2 Sewerage services	48
3.2.1 Council's tariff structure	48
3.2.2 Liquid Trade Waste Policy	49
4 Population and development	51
4.1 Historical Population.....	51
4.2 Serviced Population and Dwellings.....	54
4.3 Visitor Contribution	56
4.3.1 Accommodation providers.....	56
4.3.2 Seasonal visitor statistics	57
4.4 Growth distribution	57
4.4.1 Timing of growth	57
4.4.2 Bungendore residential greenfield subdivisions.....	58
4.4.3 Bungendore residential infill	59
4.4.4 Bungendore non-residential growth.....	60
4.4.5 Braidwood residential growth.....	60
4.4.6 Major events.....	64
4.5 Projections.....	65
4.5.1 Population and dwelling projection.....	65
5 Bungendore water supply scheme	68
5.1 Raw water source	68
5.1.1 Water resource.....	68
5.1.2 Raw water extraction.....	68
5.1.3 Water access licences.....	69
5.1.4 Source water quality	70
5.2 Water treatment.....	71
5.2.1 Treatment process	71

5.2.2	Historical water production.....	73
5.2.3	Peak production analysis	74
5.2.4	Treated water quality.....	76
5.3	Distribution.....	81
5.3.1	Distribution system	81
5.3.2	Metered customer demand.....	82
5.3.3	Major non-residential users.....	84
5.3.4	Water balance.....	85
5.3.5	Non-Revenue Water.....	86
5.3.6	NSW Health independent verification	87
5.3.7	Risks identified from the DWMS Risk Register.....	88
5.4	Best practice compliance – LWU Circular 18.....	89
5.4.1	Barrier 1: Effective distribution	89
5.4.2	Barrier 2: Distribution system integrity.....	90
5.4.3	Barrier 3: Maintain a free chlorine residual in the distribution system.....	90
5.5	Analysis of production data	90
5.5.1	Trend correction	90
5.5.2	Production modelling	91
5.5.3	Effect of climate change.....	92
5.6	Analysis of customer usage.....	94
5.6.1	Modelling of customer usage.....	94
5.6.2	Unit residential demands.....	95
5.7	Projections.....	97
5.8	Water security assessment.....	99
5.9	System capacity assessment	100
5.10	Application of Health-Based Treatment Targets	100
5.10.1	HBT assessment of threats.....	101
5.10.2	Inherent risk.....	101
5.10.3	HBT assessment of treatment barriers	102
5.10.4	NSW Health preliminary cryptosporidium risk assessment	103
5.11	Work health and safety	103
6	Braidwood water supply scheme	104
6.1	Raw water source	104
6.1.1	Water resource.....	104
6.1.2	Raw water extraction.....	104
6.1.3	Water access licences.....	105
6.1.4	Source water quality	106
6.2	Water treatment.....	106
6.2.1	Treatment process	106
6.2.2	Historical water production.....	108
6.2.3	Peak production analysis	109
6.2.4	Treated water quality.....	111
6.3	Distribution.....	114

6.3.1	Distribution system	114
6.3.2	Metered customer demand.....	115
6.3.3	Major non-residential users.....	117
6.3.4	Water balance.....	118
6.3.5	Non-Revenue Water.....	119
6.3.6	NSW Health independent verification	121
6.3.7	Risks identified from the DWMS Risk Register.....	121
6.4	Best practice compliance – LWU Circular 18.....	122
6.4.1	Barrier 1: Effective distribution	122
6.4.2	Barrier 2: Distribution system integrity	123
6.4.3	Barrier 3: Maintain a free chlorine residual in the distribution system.....	123
6.5	Analysis of production data	123
6.5.1	Trend correction	124
6.5.2	Production modelling	124
6.5.3	Effect of climate change.....	126
6.6	Analysis of customer usage.....	127
6.6.1	Modelling of customer usage.....	127
6.6.2	Unit residential demands.....	128
6.7	Projections.....	129
6.8	Water security assessment.....	131
6.8.1	Licensed entitlement.....	131
6.8.2	Secure yield	132
6.9	System capacity assessment	132
6.10	Application of Health Based Treatment Targets.....	132
6.11	HBT assessment of threats.....	132
6.11.1	Inherent risk.....	132
6.11.2	HBT assessment of treatment barriers	133
6.11.3	NSW Health preliminary cryptosporidium risk assessment	134
6.12	Work health and safety	134
7	Captains Flat water supply scheme	135
7.1	Raw water source	135
7.1.1	Water resource.....	135
7.1.2	Raw water extraction.....	135
7.1.3	Water access licences.....	136
7.1.4	Source water quality	137
7.2	Water treatment.....	137
7.2.1	Treatment process	137
7.2.2	Historical water production.....	139
7.2.3	Peak production analysis	140
7.2.4	Treated water quality	142
7.3	Distribution.....	146
7.3.1	Distribution system	146
7.3.2	Metered customer demand.....	146

7.3.3	Major users.....	148
7.3.4	Water balance.....	149
7.3.5	Non-Revenue Water.....	150
7.3.6	NSW Health independent verification	151
7.3.7	Risks identified from the DWMS Risk Register.....	152
7.4	Best practice compliance – LWU Circular 18.....	153
7.4.1	Barrier 1: Effective distribution	153
7.4.2	Barrier 2: Distribution system integrity.....	154
7.4.3	Barrier 3: Maintain a free chlorine residual in the distribution system.....	154
7.5	Water cycle analysis.....	154
7.6	Application of Health-Based Treatment Targets	154
7.6.1	HBT assessment of threats.....	154
7.6.2	HBT assessment of treatment barriers	155
7.6.3	NSW Health preliminary cryptosporidium risk assessment	156
7.7	Work health and safety	156
8	Bungendore sewerage scheme	157
8.1	Sewage collection and transfer	157
8.2	Sewage treatment.....	158
8.2.1	STP description.....	158
8.2.2	Historical flows	160
8.3	STP inflow analysis	160
8.3.1	Average dry weather flow (ADWF) estimated from STP inflow data	160
8.3.2	ADWF estimated from customer billing data	162
8.3.3	Nominated ADWF and unit hydraulic loading.....	162
8.3.4	Estimated Peak dry weather flow (PDWF)	163
8.3.5	Peak wet weather flow (PWWF).....	164
8.3.6	Biological and nutrient loading.....	164
8.4	Bungendore Recycled Water Management System	165
8.5	EP and ET estimates	170
8.6	EP and ET projections	171
8.7	Sewer system flow projections.....	174
8.7.1	System ADWF projections	174
8.7.2	System PDWF projections	178
8.7.3	System PWWF projections	179
8.8	SPS current performance and projections	179
8.8.1	Pump run time in dry weather	179
8.8.2	Emergency storage time	180
8.8.3	Odour/septicity potential	180
8.9	STP current performance and projections.....	181
8.10	Section 61 inspections and recommendations.....	181
8.11	Work Health and Safety	181
9	Braidwood sewerage scheme	182
9.1	Sewage collection and transfer	182

9.2	Sewage treatment.....	183
9.2.1	STP description.....	183
9.2.2	Historical flows.....	185
9.3	STP inflow analysis.....	187
9.3.1	Average dry weather flow (ADWF) estimated from STP inflow data.....	187
9.3.2	ADWF estimated from customer billing data.....	187
9.3.3	Nominated ADWF and unit hydraulic loading.....	187
9.3.4	Estimated PDWF and PWWF.....	188
9.3.5	Biological and nutrient loading.....	189
9.4	EP and ET estimates.....	189
9.5	EP and ET projections.....	190
9.6	Sewer system flow projections.....	193
9.6.1	System ADWF projections.....	193
9.6.2	System PDWF projections.....	197
9.6.3	System PWWF projections.....	198
9.7	SPS current performance and projections.....	199
9.7.1	Pump run time in dry weather.....	199
9.7.2	Pump rate compared to PWWF.....	199
9.7.3	Emergency storage time.....	200
9.8	Odour/septicity potential.....	200
9.9	STP current performance and projections.....	201
9.10	Section 61 inspections and recommendations.....	201
9.11	Work Health and Safety.....	201
10	Captains Flat sewerage scheme.....	203
10.1	Sewage collection and transfer.....	203
10.2	Sewage treatment.....	204
10.2.1	STP description.....	204
10.2.2	Historical flows.....	205
10.3	STP inflow analysis.....	205
10.3.1	Average dry weather flow (ADWF) estimated from STP inflow data.....	205
10.3.2	Biological and nutrient loading.....	206
10.4	SPS current performance.....	207
10.4.1	Emergency storage time.....	207
10.4.2	Odour/septicity potential.....	207
10.5	STP current performance.....	207
10.6	Section 61 inspections and recommendations.....	207
10.7	Work Health and Safety.....	208
11	Unserviced communities.....	209
11.1	OSSMS Assessment.....	209

12	Water and sewer strategic planning issues	212
13	References.....	225

Appendix A	Raw Water quality
Appendix B	Captains Flat Keating Reservoir Flow
Appendix C	Water quality risk assessment
Appendix D	Water supply analysis
Appendix E	Water demand analysis – background
Appendix F	Climate change impact comparison
Appendix G	New dwelling demand sensitivity analysis
Appendix H	Sewerage process flow diagram
Appendix I	Detailed Bungendore STP Reuse flow diagram

Tables

Table 1-1: A summary of the serviced areas	38
Table 2-1: Palerang Community Council Legislative requirements	39
Table 2-2: QPRC water supply service objectives and targets	44
Table 2-3: QPRC sewerage service objectives and targets.....	46
Table 3-1: Fees and charges for water supply 2023/24 – Palerang Water Supply Schemes..	48
Table 3-2: Fees and charges for sewerage 2023/24- Palerang Water Supply Schemes.....	49
Table 3-3: Liquid Trade Waste charges.....	49
Table 4-1: Population growth since 2001 in Queanbeyan and surrounds.....	51
Table 4-2: Historical Urban Centre Population of Serviced Areas.....	52
Table 4-3: Historical Household Size and Occupancy Ratio.....	52
Table 4-4: Household size for detached dwellings	53
Table 4-5: ABS dwelling data comparison	53
Table 4-6: Historical residential assessments and serviced population Bungendore.....	54
Table 4-7: Historical residential assessments and serviced population Braidwood	55
Table 4-8: Historical residential assessments and serviced population Captains Flat.....	56
Table 4-9: Bungendore planned subdivisions and investigation areas.....	59
Table 4-10: Braidwood detached dwelling infill lots.....	61
Table 4-11: Braidwood long-term growth areas.....	63
Table 4-12: Bungendore and Braidwood population and dwelling growth projection	66
Table 4-13: Bungendore and Braidwood serviced population and residential assessments projection.....	67
Table 5-1: Bungendore raw water extraction asset's capacities.....	68
Table 5-2: WAL Licence numbers.....	69
Table 5-3: Historical annual water production – Bungendore WTP (ML/year).....	73
Table 5-4: Bungendore WSS – Aeration tower Critical Control Point summary	76

Table 5-5: Bungendore WSS –Currandooly WTP Critical Control Point Summary	78
Table 5-6: Historical number of meters – Bungendore Potable WSS.....	82
Table 5-7: Historical metered customer usage (ML/year) – Bungendore Potable WSS	83
Table 5-8: Major Water Users – Bungendore WSS	84
Table 5-9: Water Balance – Bungendore WSS.....	85
Table 5-10: Bungendore NRW Summary	87
Table 5-11: Bungendore modelled unrestricted production	92
Table 5-12: Climate change impact on system demand.....	93
Table 5-13: Estimated customer usage from climate correction – Bungendore WSS	94
Table 5-14: Unit demand per active residential assessment – Bungendore WSS	95
Table 5-15: Unit demands for new houses in Bungendore.....	97
Table 5-16: Summary of projected average year metered consumption (ML/year) – Bungendore	98
Table 5-17: Summary of water supply projections – Bungendore WSS.....	98
Table 6-1: Braidwood raw water extraction asset's capacities	104
Table 6-2: WAL Licence numbers.....	105
Table 6-3: Historical annual water production – Braidwood WTP (ML/year)	108
Table 6-4: Braidwood WSS - Critical Control Point Summary.....	111
Table 6-5: Historical number of meters – Braidwood Potable WSS	115
Table 6-6: Historical metered customer usage (ML/year) – Braidwood Potable WSS.....	116
Table 6-7: Major Water Users – Braidwood WSS	117
Table 6-8: Water Balance – Braidwood WSS (ML/year).....	118
Table 6-9: Braidwood NRW Summary.....	120
Table 6-10: Braidwood modelled unrestricted production.....	125
Table 6-11: Climate change impact on system demand.....	126
Table 6-12: Estimated customer usage from climate correction – Braidwood WSS	127
Table 6-13: Unit demand per active residential assessment – Braidwood WSS.....	128
Table 6-14: Unit demands for new houses in Braidwood	129
Table 6-15: Unit demands for villa homes in Braidwood.....	129
Table 6-16: Summary of water supply projections – Braidwood WSS.....	130
Table 7-1: Captains Flat raw water extraction asset's capacities.....	135
Table 7-2: WAL Licence numbers.....	136
Table 7-3: Historical annual water production – Captains Flat WTP (ML/year)	140
Table 7-4: Captains Flat WSS - Critical Control Point Summary	142
Table 7-5: Historical number of meters – Captains Flat Potable WSS	147
Table 7-6: Historical metered customer usage (ML/year) – Captains Flat Potable WSS	147
Table 7-7: Major Water Users – Captains Flat WSS.....	148
Table 7-8: Major Water Residential User – Captains Flat WSS.....	149
Table 7-9: Water Balance- Captains Flat WSS (ML/year)	149
Table 7-10: Captains Flat NRW Summary	151
Table 7-11: Captains Flat Risks with very high residual risks after mitigation	153
Table 8-1: Bungendore STP – ADWF estimated from STP inflow data	161
Table 8-2: Bungendore ADWF based on winter metered consumption.....	163
Table 8-3: Estimated ADWF, PDWF and PWWF - Bungendore sewerage scheme	164

Table 8-4: Bungendore Inflow Biological Loading Results	165
Table 8-5: Pollutant List - Sewage and Effluent for Bungendore STP.....	165
Table 8-6: Approved end users.....	166
Table 8-7: Catch Pond Effluent Quality-RWMS Bungendore.....	167
Table 8-8: Critical Control Points and Critical Limits	168
Table 8-9: Recycled water quality monitoring schedule	168
Table 8-10: End user water quality monitoring schedule.....	169
Table 8-11: LRV calculation for process.....	169
Table 8-12: Bungendore sewerage scheme – Estimated ET and EP for each sewer catchment	170
Table 8-13: Bungendore sewerage scheme ET projection.....	171
Table 8-14: Bungendore sewerage scheme EP projection.....	172
Table 8-15: Bungendore sewerage scheme ADWF projection (historical with 180L/EP for growth) (kL/day)	174
Table 8-16: Bungendore sewerage scheme ADWF projection (220 L/EP/day) (kL/day)	176
Table 8-17: Bungendore sewerage scheme PDWF projections (L/s).....	178
Table 8-18: SPS assessment - pump run time	179
Table 8-19: SPS Assessment - rising main detention time	180
Table 9-1: Braidwood STP – ADWF estimated from STP inflow data.....	187
Table 9-2: Estimated ADWF, PDWF and PWWF - Braidwood sewerage scheme.....	188
Table 9-3: Pollutant List - Sewage and Effluent for Braidwood STP.....	189
Table 9-4: Braidwood sewerage scheme – Estimated ET and EP for each sewer catchment.....	189
Table 9-5: Braidwood sewerage scheme ET projection	190
Table 9-6: Braidwood sewerage scheme EP projection.....	191
Table 9-7: Braidwood sewerage scheme ADWF projection (historical with 180L/EP for growth) (kL/day)	193
Table 9-8: Braidwood sewerage scheme ADWF projection (220 L/EP/day for all users) (kL/day)	195
Table 9-9: Braidwood sewerage scheme - PDWF projections (L/s)	197
Table 9-10: Braidwood sewerage scheme - PWWF projections (L/sec)	198
Table 9-11: Pump run time in dry weather	199
Table 9-12: SPS assessment - rising main detention time	201
Table 10-1: Captains Flat STP – ADWF estimated from STP inflow data	205
Table 10-2: Pollutant List - Sewage and Effluent for Braidwood STP.....	206
Table 11-1: Inherent risk categorisation for OSSMS	209
Table 11-2: Unsewered villages – risk score	210
Table 12-1: General water and sewer system issues.....	212
Table 12-2: Water Supply System Issues	212
Table 12-3: Sewerage System Issues.....	218
Table 12-4: Resolved issues.....	222

Appendix table

Appendix table A-1: Bungendore bores raw water quality

Appendix table A-2: Currandooly bores raw water quality	
Appendix table A-3: Braidwood raw water quality	
Appendix table A-4: Captains Flat raw water quality	
Appendix table A-5: Bungendore NSW Health Water Quality	
Appendix table A-6: Braidwood NSW Health Water Quality	
Appendix table A-7: Captains Flats NSW Health Water Quality	
Appendix table F-1: Bungendore change in climate dependent demand using method from previous IWCM	
Appendix table F-2: Bungendore demand change using method from previous IWCM	
Appendix table F-3: Braidwood change in climate dependent demand using method from previous IWCM	
Appendix table F-4: Braidwood demand change using method from previous IWCM	
Appendix table F-5: Braidwood change in climate dependent demand using SEACI data	
Appendix table F-6: Braidwood demand change using SEACI data	
Appendix table F-7: Bungendore – CCCma-CanESM2 – RCP 4.5	
Appendix table F-8: Bungendore – CCCma-CanESM2 – RCP 8.5	
Appendix table F-9: Bungendore – CSIRO-BOM-ACCESS1-0 – RCP 4.5	
Appendix table F-10: Bungendore – CSIRO-BOM-ACCESS1-0 – RCP 8.5	
Appendix table F-11: Bungendore – CSIRO-BOM-ACCESS1-3 – RCP 4.5	
Appendix table F-12: Bungendore – CSIRO-BOM-ACCESS1-3 – RCP 8.5	
Appendix table F-13: Braidwood (low NRW) – CCCma-CanESM2 – RCP 4.5	
Appendix table F-14: Braidwood (low NRW) – CCCma-CanESM2 – RCP 8.5	
Appendix table F-15: Braidwood (low NRW) – CSIRO-BOM-ACCESS1-0 – RCP 4.5	
Appendix table F-16: Braidwood (low NRW) – CSIRO-BOM-ACCESS1-0 – RCP 8.5	
Appendix table F-17: Braidwood (low NRW) – CSIRO-BOM-ACCESS1-3 – RCP 4.5	
Appendix table F-18: Braidwood (low NRW) – CSIRO-BOM-ACCESS1-3 – RCP 8.5	
Appendix table F-19: Braidwood (high NRW) – CCCma-CanESM2 – RCP 4.5	
Appendix table F-20: Braidwood (high NRW) – CCCma-CanESM2 – RCP 8.5	
Appendix table F-21: Braidwood (high NRW) – CSIRO-BOM-ACCESS1-0 – RCP 4.5	
Appendix table F-22: Braidwood (high NRW) – CSIRO-BOM-ACCESS1-0 – RCP 8.5	
Appendix table F-23: Braidwood (high NRW) – CSIRO-BOM-ACCESS1-3 – RCP 4.5	
Appendix table F-24: Braidwood (high NRW) – CSIRO-BOM-ACCESS1-3 – RCP 8.5	
Appendix table F-25: Climate change impact on system demand	
Appendix table F-26: Paleo-stochastic irrigation modelling results – Ainslie ACT	
Appendix Table G-1: Per person water demands – houses with two bedrooms	
Appendix Table G-2: Per person water demands – houses with three or more bedrooms	
Appendix table H-1: Bungendore STP's process units and capacities	
Appendix table H-2: Braidwood STP's process units and capacities	
Appendix table H-3: Captains Flat STP's process units and capacities	

Figures

Figure 1-1-1: Map of Queanbeyan – Palerang LGA	37
Figure 4-1: Historical Queanbeyan Palerang LGA estimated residential population.	51

Figure 4-2: Bungendore planned subdivisions and investigation areas	58
Figure 4-3: Braidwood residential infill	61
Figure 4-4: Braidwood long term growth areas	63
Figure 5-1: Location of raw water intake for Bungendore WTP.....	69
Figure 5-2: Schematic flow diagram of the Bungendore / Currandooly water supply scheme.....	72
Figure 5-3: Historical production data- Bungendore potable water production.....	73
Figure 5-4: Peak fortnightly production patterns – Bungendore aeration tower and Currandooly WTP	75
Figure 5-5: Peak week and peak fortnight production – Bungendore aeration tower and Currandooly WTP	76
Figure 5-6: CCP1(a) Chlorination – Historical free chlorine in reticulation of Bungendore	77
Figure 5-7: CCP2 Fluoridation- Historical fluoride in clean water tank in Bungendore	78
Figure 5-8: CCP1 Filtration- Historical turbidity of Currandooly WTP filtrate.....	79
Figure 5-9: CCP2(a) Chlorination – Historical free chlorine in clear water at Currandooly.....	80
Figure 5-10: CC3 Fluoridation – Historical fluoride in clear water tank in Currandooly.....	81
Figure 5-11: Bungendore WSS distribution.....	82
Figure 5-12: Historical metered customer usage by user category - Bungendore Potable WSS	84
Figure 5-13: Water Balance – Bungendore WSS (ML/year).....	86
Figure 5-14: Bungendore historical non-revenue water	87
Figure 5-15: Production model hindcast – Bungendore raw water supply.....	91
Figure 5-16: Projected unrestricted future extraction for Bungendore WSS compared to historical production (RCP 4.5 probable climate change scenario)	100
Figure 5-17: Bungendore/Currandooly water supply source	102
Figure 6-1: Location of raw water intake for Braidwood WTP	105
Figure 6-2: Schematic flow diagram of the Braidwood water supply scheme	107
Figure 6-3: Historical production data – Braidwood potable water production	108
Figure 6-4: Peak fortnightly production patterns – Braidwood WTP.....	109
Figure 6-5: Production and maximum temperature around peak day.....	110
Figure 6-6: Peak week and peak fortnight production – Braidwood WTP.....	111
Figure 6-7: CCP1 Filtration – Historical turbidity of Braidwood WTP filtrate.....	112
Figure 6-8: CCP2 (a) Chlorination – Historical free chlorine in clear water tank at Braidwood.....	113
Figure 6-9: CCP1 (b) Chlorination – Historical free chlorine in reticulation of Braidwood	113
Figure 6-10: CCP2 Fluoridation – Historical fluoride in clear water tank in Braidwood	114
Figure 6-11: Braidwood WSS distribution	115
Figure 6-12: Historical metered customer usage by user category – Braidwood Potable WSS.....	117
Figure 6-13: Water Balance – Braidwood WSS (ML/year)	119
Figure 6-14: Braidwood historical non-revenue water	120
Figure 6-15: Production model hindcast – Braidwood raw water supply	125
Figure 6-16: Projected unrestricted future extraction for Braidwood WSS compared to historical production (RCP 4.5 probable climate change scenario).....	131
Figure 6-17: Inner and outer catchment of Braidwood raw water source.....	133
Figure 7-1: Location of raw water intake for Captains Flat WTP.....	136
Figure 7-2: Schematic flow diagram of the Captains Flat water supply scheme	138

Figure 7-3: Historical production data – Captains Flat potable water production	139
Figure 7-4: Peak fortnightly production patterns – Captains Flat WTP	141
Figure 7-5: Peak week and peak fortnight production – Captains Flat WTP	142
Figure 7-6: CCP1 Filtration – Historical turbidity of Captains Flat WTP filtrate	143
Figure 7-7: CCP2 (a) Chlorination – Historical free chlorine at Captains Flat WTP - Old Chlorine shed (going up to reservoir)	144
Figure 7-8: CCP2 (c) Chlorination – Historical free chlorine in reticulation of Captains Flat	145
Figure 7-9: CCP3 Fluoridation – Historical fluoride at reservoir outlet in Captains Flat	145
Figure 7-10: Captains Flat WSS distribution	146
Figure 7-11: Historical metered customer usage by user category – Captains Flat Potable WTP	148
Figure 7-12: Water Balance – Captains Flat WSS (ML/year)	150
Figure 7-13: Captains Flat historical non-revenue water	151
Figure 7-14: Inner and outer catchment of Captains Flat raw water source	155
Figure 8-1: Bungendore sewerage scheme	157
Figure 8-2: Bungendore sewerage scheme SPS hierarchy	158
Figure 8-3: Process Flow Diagram – Bungendore STP	159
Figure 8-4: Bungendore STP historical inflow, rainfall and metered consumption	160
Figure 8-5: Bungendore STP historical inflow and Butmaroo Creek water levels – Jan 2017 to Feb 2023	162
Figure 8-6: Bungendore STP Reuse flow diagram	166
Figure 8-7: Bungendore Recycled Water Scheme	167
Figure 8-8: Bungendore projected hydraulic loading	178
Figure 9-1: Braidwood sewerage scheme	182
Figure 9-2: Braidwood sewerage scheme SPS hierarchy	183
Figure 9-3: Process Flow Diagram – Braidwood STP	184
Figure 9-4: Plan/ aerial view of the Braidwood below	185
Figure 9-5: Braidwood STP historical inflow, rainfall and metered consumption	186
Figure 9-6: Braidwood STP historical inflow up to 600 kL/day, rainfall and metered consumption	186
Figure 9-7: Braidwood projected hydraulic loading	197
Figure 9-8: Estimated PWWF to each SPS in Braidwood sewerage scheme	200
Figure 10-1: Captains Flat Sewerage Scheme	203
Figure 10-2: Captains Flat SS SPS hierarchy	204
Figure 10-3: Process Flow Diagram – Captains Flat STP	204
Figure 10-4: Captains Flat STP historical inflow, rainfall and metered consumption	205
Figure 10-5: Captains Flat STP historical inflow and Molonglo River at Kobada water levels – Mar 2020 to Feb 2023	206

Appendix Figure

Appendix figure B-1: Captains Flat Keating Reservoir Flow

Appendix figure C-1: HBT Assessment Tool Water quality risk assessment – Bungendore Bores, Bungendore WSS

Appendix figure C-2: HBT Assessment Tool Water quality risk assessment – Currandooly Bores, Bungendore WSS

Appendix figure C-3: HBT Assessment Tool Water quality risk assessment – Braidwood WSS

Appendix figure C-4: HBT Assessment Tool Water quality risk assessment – Captains Flat WSS

Appendix figure C-5: NSW Health Letter

Appendix figure H-1: Detailed Process Flow Schematic – Bungendore STP

Appendix figure H-2: Plan view of Bungendore STP

Appendix figure H-3: Detailed Process Flow Schematic – Braidwood STP

Appendix figure H-4: Detailed Process Flow Schematic – Captains Flat STP

Appendix figure H-5: Plan view of Braidwood STP

Appendix figure I-1: Detailed Bungendore STP Reuse flow diagram

1 Introduction

1.1 Purpose

The water and sewer strategic plan is a local water utility's (LWU's) 30-year strategy for the provision of appropriate, affordable, cost-effective, and sustainable urban water services that meet community needs and protect public health and the environment.

The water and sewer strategy:

- Identifies the water supply and sewerage needs of the LWU.
- 'Right sizes' any infrastructure projects and determines their priority.
- Provides an initial estimate of developer contributions
- Identifies the lowest level of stable Typical Residential Bill (TRB) to meet the levels of service; and
- Includes a 30-year Total Asset Management Plan and Financial Plan.

1.2 Process

The process of preparing the water and sewer strategy in conjunction with the Department of Climate Change Energy, the Environment and Water's (DCCEEW) supports the integration of state, regional and local water utility and includes the following steps:

- Preparation of a water and sewer strategy planning paper
- Evaluation of feasible options
- Creation of water and sewer strategy planning scenarios
- Triple bottom line assessment of the scenarios
- Developing the water and sewer strategy, and
- Preparation of a Total Asset Management Plan and Financial Plan.

1.3 Water and Sewer Strategic Planning Paper

The water and sewer strategic planning paper presents the analyses that have been undertaken and summarises the water and sewer issues that have been identified through the analysis. The following are inputs to the water and sewer strategic planning paper:

- Service Objectives and Targets
- Growth strategy
- Existing systems
- Water demand analysis
- Sewer loading analysis.
- Existing system performance assessment, and
- Assessment of unserviced areas.

This report presents the outcomes of the analysis.

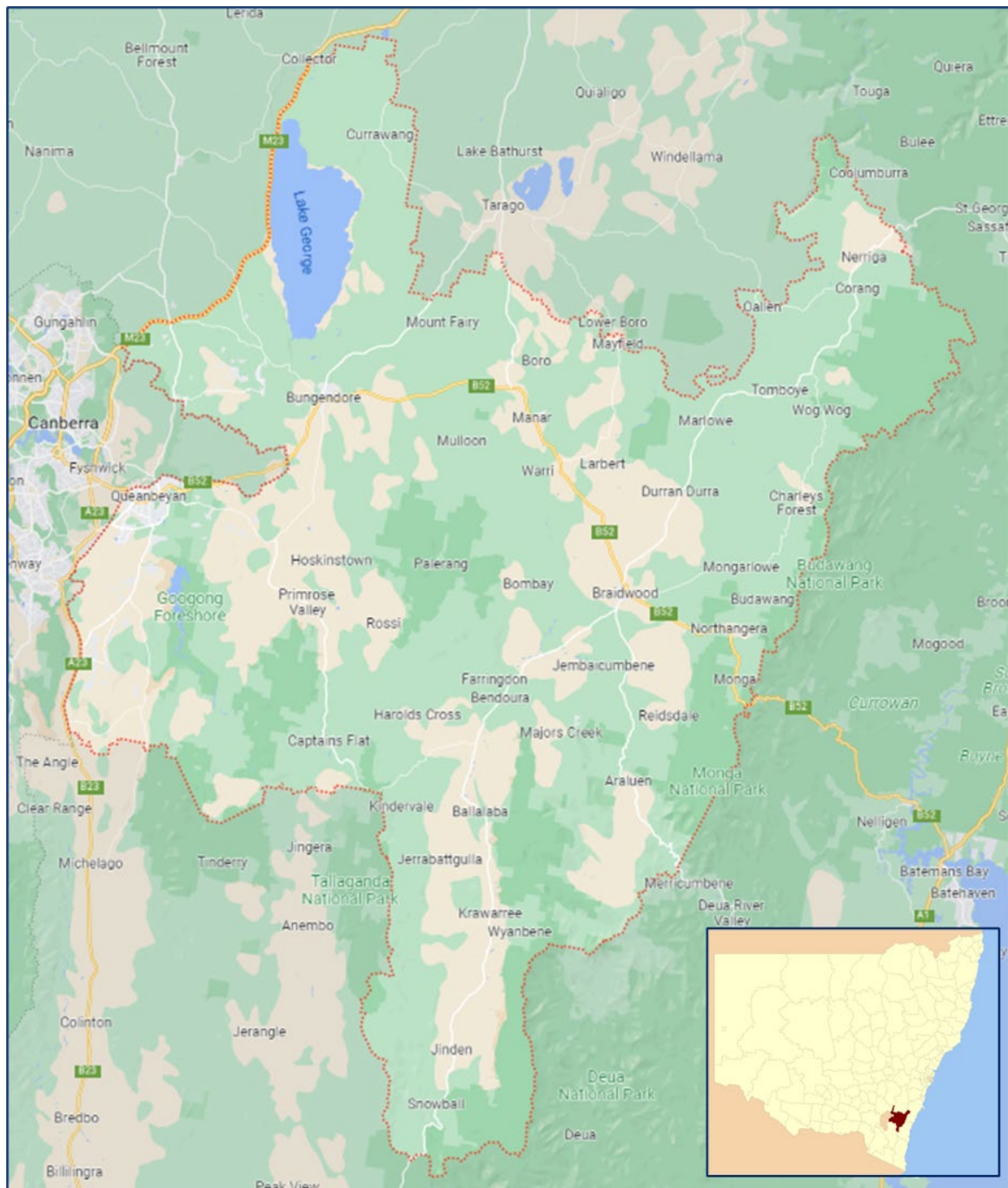
1.4 Queanbeyan-Palerang Local Government Area

The Queanbeyan-Palerang local government area (LGA) is located approximately 40 km East of Canberra. In May 2016, the former Palerang Council amalgamated with Queanbeyan City Council to form the Queanbeyan-Palerang Regional Council. QPRC supplies water and sewerage services to cities and towns in the LGA.

A map of the Queanbeyan-Palerang LGA from Google Maps is shown in Figure 1-1-1. This Issues Paper identifies the issues in the serviced areas covered by the former Palerang Council.

The combined serviced population of Bungendore, Braidwood and Captains Flat is about 10% of the LGA serviced population (the other 90% is in Queanbeyan, Googong, Jerrabomberra). Therefore, anything reported on a LGA wide basis does not necessarily reflect the three towns of interest.

It is expected that the next iteration of this planning process will see the amalgamation of the former Palerang and Queanbeyan Integrated Water Cycle Plans into a single strategic document.



Source: Google Maps

Figure 1-1-1: Map of Queanbeyan – Palerang LGA

1.5 Water Supply and Sewerage Schemes

A summary of the serviced areas is given in Table 1-1.

Table 1-1: A summary of the serviced areas

Town / village	Water supply service	Sewerage service
Bungendore	Bungendore water supply scheme	Bungendore sewerage scheme
Braidwood	Braidwood water supply scheme	Braidwood sewerage scheme
Captains Flat	Captains Flat water supply	Captains Flat sewerage scheme

1.6 Un-serviced Communities

In addition to the Bungendore, Braidwood and Captains Flat sewerage schemes, there are also schemes servicing Queanbeyan and Googong. Outside of these serviced areas the homes and businesses treat sewage using on-site sewage management systems (OSSMS), mostly septic tank systems. The villages of Majors Creek, Araluen and Nerriga have on-site sewage management systems. Some limited water supply areas in Captains Flat also utilise OSSMS – those properties on the Beverly Hills water main.

2 Operating environment and levels of service

2.1 Regulatory Compliance

The delivery of urban water services including water supply, sewerage and stormwater services is subject to many legislative and regulatory requirements, guidelines, contractual obligations for delivery of services and other external and internal factors, collectively referred to as the operating environment. A water and sewer strategic planning issue will arise if there is a failure to meet the legal obligations or agreed levels of service regarding provision of water supply and sewerage services including the following:

- Legislative and regulatory requirements (health requirements, WHS, EPA Licence)
- Levels of service targets (as agreed with customers)
- Contractual and agreed arrangements (for example Memorandum of Understanding (MoU))
- Regulatory assurance framework (RAF).

The operating environment compliance situation is analysed in this Section to identify the water and sewer strategic planning issues. The Local Government Act and a number of other pieces of legislation influence the way in which Council can provide the urban water and wastewater services and have specific implications for the operation of the schemes.

Table 2-1 provides the details of the status of compliance with the with the legislative and regulatory requirements by the Council.

Table 2-1: Palerang Community Council Legislative requirements

Key Legislative Framework and their main purposes	Council current performances and future targets
Local Government Act (1993)	
This Act aims to provide the legal framework for an effective, efficient, environmentally responsible, and open system of Local Government including the provision, management and operation of water supply and sewerage works and facilities. It covers:	Council operates three water supply schemes and three sewerage schemes under the authority of the Local Government Act 1993.

Key Legislative Framework and their main purposes	Council current performances and future targets
<p>Section 60 (S60) – Ministerial approval required for certain council works.</p> <p>A council must not, except in accordance with the approval of the Minister for Primary Industries, do any of the following:</p> <ul style="list-style-type: none"> • as to water treatment works – construct or extend any such works, • as to sewage – provide for sewage from its area to be discharged, treated or supplied to any person 	<p>Council has Section 60 approval for its water and wastewater system operations. Council has both a RWMP and formal s.60 approval for the recently constructed Bungendore reuse scheme.</p>
<p>Section 61 – Ministerial directions concerning certain works.</p> <p>The Minister for Primary Industries or a person authorised by the Minister may direct a council to take such measures as are specified in the direction to ensure the proper safety, maintenance and working of any of the following works:</p> <ul style="list-style-type: none"> • water treatment works, • sewage treatment works. 	<p>The WTPs and STPs in Bungendore, Braidwood and Captains Flat are inspected regularly by DCCEEW Water.</p> <p>The following issues were noted during the most recent inspections:</p> <ul style="list-style-type: none"> • Braidwood STP (18/4/23) – replacement of decant weir cables and boots required based on age even though condition appeared acceptable. An order to undertake this work has been placed with the relevant supplier • Braidwood WTP (2/3/22) - caustic dosing system had leaks, PAC shed required bird proofing, Issues resolved . • Bungendore WTPs (2/2/23) - softener off-line and fluoride saturator not operating correctly. All NaF saturators have since had their media changed and softeners serviced. • No issues were noted at Braidwood WTP or at Captains Flat
<p>Section 64 – Construction of works for developers.</p> <p>As a precondition to granting a certificate of compliance for development, a water supply authority may, by notice in writing served on the applicant, require the applicant to do either or both of the following:</p> <ul style="list-style-type: none"> • to pay a specified amount to the water supply authority by way of contribution towards the cost of such water management works as are specified in the notice, being existing works or projected works, or both, • to construct water management works to serve the development. 	<p>As part of the 2018 IWCM process a revised Development Contribution plan was developed and adopted by Council for the former Palerang Schemes (except Captains Flat). It is expected that these will be reviewed again as part of this current refresh along with the global tariff structure.</p>

Key Legislative Framework and their main purposes	Council current performances and future targets
<p>Section 68 – What activities require the approval of the council.</p> <ul style="list-style-type: none"> • A person may carry out operation of a system of sewage management (meaning to hold or process, or re-use or discharge, sewage or by-products of sewage) only with the prior approval of the council. • Council can manage the approval process under their liquid trade waste policy. 	<p>Council has a Liquid Trade Waste policy and has implemented the policy and associated charges.</p>
<p>Section 382 – Insurance against liability</p> <p>A Council must make arrangements for its adequate insurance against public liability and professional liability.</p>	<p>In accordance with Section 382 of the Local Government Act, Council is insured against public liability and professional indemnity claims. Councillors are included as a named insured on this Policy.</p>
<p>Environmental Planning and Assessment Act (1979) (incl. the EPA Regulation 2000).</p>	
<p>This Act aims to encourage proper management of resources, the orderly use of land, the provision of services, and the protection of the environment. It covers:</p> <ul style="list-style-type: none"> • Local Environmental Plans (LEP) • Environmental Impact Statement (EIS) • Reviews of Environmental Factors (REF) • State Environmental Planning Policy (SEPP) 	<p>These Legislative and regulatory requirements are met by Council.</p>

Key Legislative Framework and their main purposes	Council current performances and future targets
Public Health Act (2010)	
<p>This Act aims to promote, protect, and improve public health; by providing safe drinking water to the community.</p> <p>Section 25 - Quality assurance programs</p> <p>A supplier of drinking water must have a quality assurance program in place and must comply with its requirements.</p> <p>A Drinking Water Management System (DWMS) satisfies this requirement.</p> <p>The requirements of the DWMS are as follows:</p> <ul style="list-style-type: none"> • Produce an annual report to be made available to consumers, regulatory authorities, and stakeholders. • The DWMS will be internally reviewed. The review will assess Council's performance in relation to: • CCPs and their exceedances • Improvement Plan • Record keeping • NSW Health Database performance 	<p>A DWMS covering the three water supply schemes in QPRC was last updated in September 2017. This is currently being updated.</p> <p>The water quality performance for council has been measured against the current DWMS.</p>
Local Government Amendment (Planning and Reporting) Act 2009	
Sets out the integrated reporting requirements for local government in NSW, including the need to develop a Long-term Community Strategic Plan and Resourcing Strategy (which must include long-term financial planning, workforce management planning and asset management planning).	Council adheres to these requirements.
Seat of Government Acceptance Act 1909 – First Schedule	
The State shall not pollute and shall protect from pollution the waters of the Queanbeyan and Molonglo Rivers throughout their whole course above the Territory.	Council has an EPA licence for the Captains Flat (EPL1929) STP which discharges to waters upstream of the Territory.

Key Legislative Framework and their main purposes	Council current performances and future targets
Water Management Act (2000) Section 66	
<p>This Act promotes the sharing of responsibility for the sustainable and efficient use of water between the NSW Government and water users and provides a legal basis to manage NSW water planning, allocation of water resources and water access entitlements.</p>	<p>Council has several water access licences issued under the Water Management Act 2000.</p> <p>Council's licensed allocation for Bungendore is barely sufficient for the current customers a will not support the growth forecast. Council is working on accessing additional water from ICON Water (ACT) via a pipeline from Queanbeyan.</p> <p>The licenced allocation for Braidwood will also need to be increased to service the forecast growth.</p> <p>Issue</p>
Protection of the Environment Operations Act (1997)	
<p>This Act introduces an approach to protect the environment. It is a powerful tool for regulating sewerage and trade waste by local water utilities and facilitating compliance with the utility's conditions of approval for liquid trade waste discharges to the sewerage system.</p>	<p>Council has EPA licences for the three STPs at Bungendore, Braidwood and Captains Flat; licence numbers 201, 1733 and 1929 respectively.</p> <p>Council has a single Pollution Incident Response Management Plan (PIRMP) that covers these schemes as well as the Googong and Queanbeyan City (reticulation only) schemes. The PIRMP is up to date.</p>
Dam Safety Act 2015	
<p>Under this act, the owner of any dam listed as a prescribed dam must meet the requirements of the Dams Safety NSW.</p> <p>Dams Safety NSW assigns dams a consequence category relative to their dam failure consequence, and this determines the level of reporting and type of actions required by the dam owner as part of their Safety Management System (SMS).</p>	<p>Captains Flat Dam is owned by Council and is a declared under the act.</p> <p>Council had engaged NSW Public Works (PW) to undertake a Dam Surveillance Report and PW are also Council's nominated dam experts.</p> <p>Council is required to maintain a Safety Management System (SMS), an Emergency Plan (EP) and an Operations and Maintenance Plant (O&M) for the dam. All three of these are current. In addition, 5 yearly precise surveys are required, 10 yearly post tension cable lift testing and thrice weekly status inspections are required. All of these requirements are currently being met.</p>
Work Health and Safety Act 2011 and WHS Regulation 2011	
<p>This Act has an objective to provide a consistent framework to secure the health and safety of workers and workplaces.</p>	<p>Council maintains HSEQ accreditation.</p>

Key Legislative Framework and their main purposes	Council current performances and future targets
Fluoridation of Public Water Supplies Act (1957)	
This Act covers the addition of fluoride to public water supply under the NSW Fluoridation Code of Practice.	The fluoridation systems at all water supply schemes comply with the code. Council advises that the requirement for periodic auditing is still not being met. Issue

2.2 Levels of Service

Levels of Service (LOS) are defined by local water utilities as the standards required from the water and sewerage systems from the perspective of the individual customer. The LOS are targets which the Council aims to meet and are not intended as a formal customer contract.

The provision of the agreed levels of service to customers is dependent upon the efficient and effective running of the water supply and sewerage operations. To this end, Council implements a program of works and appropriate operation and maintenance procedures to meet the levels of service for the current and future customers. Council also identifies additional works required to bridge any gap between the existing and desired services.

It should be noted that the objectives and targets would have a direct and significant influence on the future direction and management of the urban water services, hence allowing the identification of issues. Further it is noted that meeting agreed objectives and targets incurs cost, which needs to be recovered through typical residential bills and developer charges, and hence needs to be considered in the context of the community's preferences and ability to pay (i.e. affordability).

The LWU collects the data required to monitor the performance against the LOS, however there is no centralised system in place to managing the data appropriately when this project had commenced. Council now has a centralised records management system in ECM where plant field sheets are scanned and imported. Key data is also transcribed into spreadsheets for use in regulatory reporting. GeoSCADA also record key planned data.

Table 2-2: QPRC water supply service objectives and targets

DESCRIPTION	UNIT	LEVEL OF SERVICE	
		Target	Current Performance assessed by Council
Pressure:			
Minimum pressure when delivering 0.15L/s/tenement PID	Metres Head	12	Bungendore - 12 Braidwood - 40 Captains Flat - 40
Minimum pressure when delivering 0.10L/s/tenement with firefighting capability	Metres Head	Positive residual head throughout network	Bungendore - 12 Braidwood - 12 Captains Flat - 12

DESCRIPTION	UNIT	LEVEL OF SERVICE	
		Target	Current Performance assessed by Council
Max. static pressure	Metres head	80	90
Fire-Fighting:			
Compliance with The Water Supply Investigation Manual	% area served	95	100
Supply Interruptions to Consumers:			
Planned (95% of time):			
Notice given to domestic customers	Working Days	1	1
Notice given to commercial customers	Working Days	2	3
Notice given to industrial customers	Working Days	2	3
Maximum duration of interruption	Hours	8	2
Total number of interruptions	No./year/1000 tenements	8	5
Unplanned:			
Maximum duration	Hours	6	3
Total number of interruptions	No./year/1000 tenements	10	8
Response Times (Defined as time to have staff on-site to rectify problem)			
Note: Times apply for 95% of occasions			
Supply Failure (All Customers):			
During working hours	Hours	1	1
Out of working hours	Hours	2	2
Minor Problems & General Inquiries:			
Oral inquiry	Working Days	2	2
Written inquiry	Working Days	10	15
Service Provided			
Time to provide an individual connection to water supply in serviced area (90% of times)	Working days	5	5
Water Quality			
Number of boil water alerts	No./year	0	
Taste/odour complaints	No./year	0	
Non-compliance with DWMS	No./year	0	

Table 2-3: QPRC sewerage service objectives and targets

DESCRIPTION	UNIT	LEVEL OF SERVICE	
		Target	Current Performance assessed by Council
Frequency Of System Failures			
Category 1: Failure due to rainfall and deficient capacity (overflows)	Number/year	0	0
Category 2: Failures due to pump or other breakdown including power failure (overflows)	Number/year	0	0
Category 3: Failures due to main blockages and collapses (overflows)	Number/year	4	2
Response Times			
System Failure: (Defined as the maximum time to have staff on site to commence rectification after notification)			
Priority 1: (Major spill, significant environmental or health impact, or affecting large number of consumers i.e. a major main)			
During working hours	Hours	0.5	0.5
After hours	Hours	1	1
Priority 2: (Moderate spill, some environmental or health impact, or affecting small number of consumers i.e. other mains)			
During working hours	Hours	0.5	0.5
After hours	Hours	1	1
Priority 3: (Minor spill, little environmental or health impact, or affecting a couple of consumers)			
During working hours	Working Day	1	1
After hours	Working Day	1.5	1.5
Customer Complaints			
General Complaints and Inquiries:			
Note: Applies for 95% of complaints			
Oral complaints	Working Day	2	2
Written complaints	Working Day	10	15
Odour Complaints:			
Treatment works (outside designated buffer zone)	Number/year	2	1
Pumping Stations	Number/year	2	0
Reticulation system	Number/year	2	0

In addition to the water supply and sewerage specific objectives and targets, Council has additional strategies and policies that need to be considered, examples include:

- QPRC Council Operations Climate Change Action Plan commits Council to a 20% reduction in energy use by 2030 compared with 2017-18 baseline levels, and a 45% reduction in emissions by 2030 compared with 2017-18 levels.
- The Complaints Management Policy
- Enterprise Risk Management Policy.

3 Financial performance and issues

3.1 Water supply services

3.1.1 Tariff structure

Council's water supply fees and charges for 2023/24 are shown in Table 3-1.

Table 3-1: Fees and charges for water supply 2023/24 – Palerang Water Supply Schemes

Fee component	Unit	Potable water – Unit cost
Residential access		
20mm	\$/year	596.00
Non-Residential access		
20mm	\$/year	596.00
25mm	\$/year	931.00
32mm	\$/year	1,526.00
40mm	\$/year	2,385.00
50mm	\$/year	3,726.00
65mm	\$/year	6,297.00
80mm	\$/year	9,537.00
100mm	\$/year	14,903.00
150mm	\$/year	33,532.00
Usage		
Potable	\$/kL	3.81

The usage charge for the Googong and Queanbeyan supplies was \$4.48 in 2023/24, this is slightly higher than the charge for the communities in the former Palerang Shire of \$3.81.

3.2 Sewerage services

3.2.1 Council's tariff structure

All rateable land categorised as residential (including strata units) within the areas of Bungendore, Braidwood and Captains Flat sewerage supply schemes will be charged for each water supply service that is connected to the property. Land that is vacant with no existing premises connected to the Council water supply will be charged the equivalent to the annual sewerage access charge.

The sewerage fees and charges are shown in Table 3-2. The data was obtained from Council's 2023-2024 revenue policy.

Table 3-2: Fees and charges for sewerage 2023/24- Palerang Water Supply Schemes

Fee component	Unit	Unit cost
Residential	\$/year	1,214
Non-residential		
20mm	\$/year	1,399
25mm	\$/year	2,186
32mm	\$/year	3,581
40mm	\$/year	5,596
50mm	\$/year	8,744
65mm	\$/year	14,777
80mm	\$/year	22,384
100mm	\$/year	34,975
150mm	\$/year	78,694

The usage charge for non-residential users is calculated based on the water billing data and a discharge factor.

3.2.2 Liquid Trade Waste Policy

Council's current Liquid Trade Waste (LTW) Policy requires all individuals wishing to discharge liquid trade waste to obtain Council's approval. Fees and charges for liquid trade waste for 2023/24 is shown in Table 3-3.

Table 3-3: Liquid Trade Waste charges

Fee component	Unit	Unit cost
Application Fee- Category 1	\$ per year	102.51
Application Fee- Category 2	\$ per year	205.02
Application Fee- Category 3	\$ per year	685.13

Category 1 liquid trade waste dischargers are those conducting an activity deemed by Council as requiring nil or only minimal pre-treatment equipment and whose effluent is well defined and of a relatively low risk to the sewerage system. These users include food preparation (that do not generate oily/greasy waste), and other commercial activities such as animal wash, dental surgery etc. Some users are categorised to be '1A' dischargers, where pre-treatment is required, but overall impact on the sewerage system is low (examples include laundry, cooling tower, vehicle washing).

Category 2 liquid trade waste dischargers are those conducting an activity deemed by Council as requiring a prescribed type of liquid trade waste pre-treatment equipment and whose effluent is well characterised. These users include food preparation that serve hot food or foods that generate oily/greasy waste, and other commercial Classification A activities such as car

detailing, dental surgery with X-ray etc. Some users are categorised as Classification B activity, which includes users such as hospital, shopping complex, auto dismantler etc.

Category 3 dischargers are those conducting an activity which is of an industrial nature and/or which results in the discharge of large volumes (over 20 kL/d) of liquid trade waste to the sewerage system. Any Category 1 or 2 discharger whose volume exceeds 20 kL/d becomes a Category 3 discharger, except shopping complexes and institutions (for example hospitals, educational facilities, correctional facilities, etc). Users include abattoir, food processing, dairy processing etc.

4 Population and development

4.1 Historical Population

The Palerang Communities portion of the Queanbeyan-Palerang LGA consists of three main urban centres of Bungendore, Braidwood, and Captains Flat and surrounding rural areas. Council has advised that the Captains Flat growth has not changed much since the last IWCM Strategy, hence only the growth for just Bungendore and Braidwood was reviewed. The historical population of Historical Queanbeyan Palerang LGA have been obtained from the Australian Bureau of Statistics (ABS) Census data [2].

The historical Estimated Resident Population (ERP) for the Queanbeyan Palerang LGA is presented in Figure 4-1, split between Queanbeyan and surrounds and the rest of the LGA. The ABS ERP is released every year and uses data from several sources, including the Census and information provided by Council. [3] The 2023 population estimate was released on the 26 March 2024.

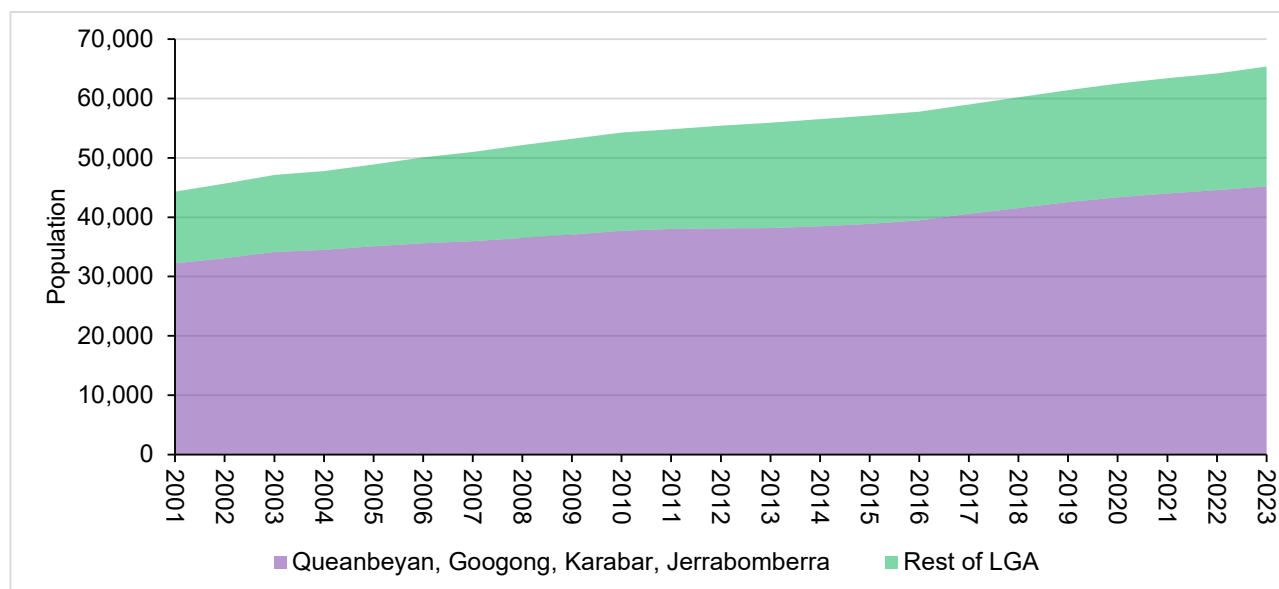


Figure 4-1: Historical Queanbeyan Palerang LGA estimated residential population.

Table 4-1: Population growth since 2001 in Queanbeyan and surrounds

		2001	2006	2011	2016	2021	2023
Queanbeyan, Googong, Karabar, Jerrabomberra	Population	32,222	35,614	38,032	39,494	44,022	45,227
	% annual growth		2.0%	1.3%	0.8%	2.2%	1.4%
Rest of LGA	Population	12,067	14,456	16,812	18,296	19,382	20,142
	% annual growth		3.7%	3.1%	1.7%	1.2%	1.9%
LGA	Population	44,289	50,070	54,844	57,790	63,404	65,369
	% annual growth		2.5%	1.8%	1.1%	1.9%	1.5%

The population growth in Queanbeyan and surrounds has been quite high, varying between 0.12% and 3.18% per year. The growth in the rest of the LGA has slowed from over 3% per year between 2001 and 2011 to an average of 1.9% over the last three years, this may be due to moratorium on the development of new subdivisions in Bungendore until additional water is secured

The historical population for the Urban Centres is presented in Figure 4-1. This data is obtained from the ABS census data releases [2].

Table 4-2: Historical Urban Centre Population of Serviced Areas

Area	Population					Growth Rate (% per year)				Historical Average Annual Growth Rate
	2001	2006	2011	2016	2021	2001 to 2006	2006 to 2011	2011 to 2016	2016 to 2021	
Bungendore	1,685	2,183	2,754	3,320	3,935	5.32	4.76	3.81	3.46	4.33
Braidwood	996	1,108	1,158	1,276	1,414	2.15	0.89	1.96	2.08	1.77
Captains Flat	419	447	436	449	473	1.30	-0.50	0.59	1.05	0.61

Table 4-3 outlines the historical household size and occupancy ratio recorded by ABS over the past five Censuses [2]. Household size is expressed in terms of occupants per occupied dwellings i.e. people per household. The following trends in household size are notable:

- Bungendore household size has remained close to 2.9.
- Braidwood household size was stable at about 2.3 until recently when it decreased to 2.12.
- Captains Flat household size has been generally close to 2.3.

Table 4-3: Historical Household Size and Occupancy Ratio

Area	Household Size *					% of dwellings occupied*				
	2001**	2006**	2011	2016	2021	2001**	2006**	2011	2016	2021
Bungendore	2.9	2.9	2.89	2.96	2.92	94%	92%	92.7%	93.6%	95.9%
Braidwood	2.3	2.3	2.28	2.28	2.12	80%	83%	84.5%	88.6%	86.3%
Captains Flat	2.3	2.3	2.29	2.22	2.33	83%	96%	88.3%	87.6%	87.1%

* Dwellings include houses, townhouses, semidetached, flats and units

** Sourced from the ABS QuickStats service, no additional decimal places available

Note that due to the percentage of dwellings occupied this is equivalent to 2.8 people per dwelling in Bungendore, 1.8 people per dwelling in Braidwood and 2.0 people per dwelling in Captains Flat.

The 2021 household size for detached dwellings is summarised in Table 4-5. This is important as a detached dwelling is the basis of the water and sewer developer charges.

Table 4-4: Household size for detached dwellings

Town	Bungendore	Braidwood	Captains Flat
Household size	2.94	2.21	2.34

The reported decline in the percentage of dwellings occupied in Braidwood (from 88.6% in 2016 to 86.3% in 2021) may be due to the residents having additional difficulty in completing the Census due to the reduces assistance available due to COVID-19 travel restrictions.

Council has adopted an assumed dwelling capacity of 3 people per lot for Bungendore (slightly higher than the current 2.92) in the structure plan.

In Bungendore, the percentage of dwellings occupied in 2021 was 95.9%, this indicates that there is likely to be significant housing stress as residents cannot easily find a new home when their needs change. Historically, 90% of dwellings occupied has been regarded as an optimum level of dwelling occupancy.

There are two main sources of Census data used in this analysis, the General Community Profile and a custom export from the table builder system. The General Community Profile provides the total population, the number of occupied dwellings by dwelling type, the total number of unoccupied dwellings (not split by type) and the number of people living in each dwelling type. The Table builder system provides the number of occupied, unoccupied and total dwellings, all by dwelling type. Unfortunately, the total occupied dwellings and total dwellings exported from each system is markedly different as summarised in Table 4-5. The difference between the two data sets is greater than that usually observed.

Table 4-5: ABS dwelling data comparison

	General community profile							Table Builder						
	Occupied dwellings					Un-occupied	Total	Occupied dwellings					Un-occupied	Total
	Detached	Semi-detached	Units	Other + not stated	Total			Detached	Semi-detached	Units	Other + not stated	Total		
Bungendore	1,215	50	19	5	1,301	79	1,367	1,259	56	17	9	1,341	67	1,408
Braidwood	498	66	6	16	579	99	672	542	68	3	19	632	86	718
Captains Flat	183	3	0	0	186	33	216	192	3	0	0	195	33	228

In general, data from the general community profile is used to estimate the population and household size, and the table builder data is used to estimate the percentage of dwellings

occupied as there is un-occupied dwelling data by dwelling type. It is very common for the percentage of dwellings occupied to vary significantly between houses, semi-detached dwellings and units.

4.2 Serviced Population and Dwellings

The service area private dwelling numbers were estimated using Council's water billing data.

The number of occupied dwellings connected to water or sewerage is approximately equal to the number of "active" residential assessments in the customer water billing data that are within the boundaries of the serviced area. An "active" residential assessment was one that had an average usage of at least 60 L/assessment/day. Most of the dwellings in blocks of flats and units (and businesses in commercial strata developments) have individual assessments and water meters.

The service area of each scheme is described in further detail in the relevant Sections 5 to 10.

The serviced area population was estimated by multiplying the number of "active" residential assessments by the estimated average household size for each community from the 2021 ABS Census [2] (see Table 4-3).

The historical residential active, inactive, and total assessments, along with the estimated private dwelling serviced population (calculated from the average detached dwelling household size multiplied by the number of assessments) is summarised for Bungendore in Table 4-6. The census occurred during August 2021 (read period 2022-1, the first read period of the 2021/22 financial year). For Bungendore, the ABS estimates that there were 1,289 occupied and 78 unoccupied (total 1,367) houses, semi-detached dwellings, flats and units. It is likely that there are some vacant residential assessments (contributing to there being more than twice the number of inactive residential assessments than there are vacant dwellings) and about 156 dwellings that are still on shared assessments.

Table 4-6: Historical residential assessments and serviced population Bungendore

Read periods			2018-2 to 2019-1	2019-2 to 2020-1	2020-2 to 2021-1	2021-2 to 2022-1	2022-2 to 2023-1
Water	Residential Assessments	Active	1,054	1,066	1,128	1,176	1,187
		Inactive	215	214	189	202	223
		Total	1,269	1,280	1,317	1,378	1,410
	Additional dwellings		156	156	156	156	156
	Serviced private dwelling population		3,533	3,568	3,749	3,889	3,921
	Population in other dwellings		46	46	46	46	46
	Serviced population		3,579	3,614	3,795	3,935	3,967

Read periods			2018-2 to 2019-1	2019-2 to 2020-1	2020-2 to 2021-1	2021-2 to 2022-1	2022-2 to 2023-1
Sewer	Residential Assessments	Active	997	1,006	1,060	1,107	1,118
		Inactive	199	199	179	191	211
		Total	1,196	1,205	1,239	1,298	1,329
	Additional dwellings		156	156	156	156	156
	Serviced private dwelling population		3,367	3,393	3,550	3,688	3,720
	Population in other dwellings		46	46	46	46	46
	Serviced Population		3,412	3,439	3,596	3,734	3,766

The historical residential active, inactive, and total assessments, along with the estimated private dwelling serviced population (calculated from the average detached dwelling household size multiplied by the number of assessments) is summarised for Braidwood in Table 4-7

Table 4-7: Historical residential assessments and serviced population Braidwood

Read periods			2018-2 to 2019-1	2019-2 to 2020-1	2020-2 to 2021-1	2021-2 to 2022-1	2022-2 to 2023-1
Water	Residential Assessments	Active	441	429	439	454	497
		Inactive	172	185	180	170	138
		Total	613	614	619	624	635
	Additional dwellings		116	116	116	116	116
	Serviced private dwelling population		1,181	1,156	1,177	1,209	1,300
	Population in other dwellings		205	205	205	205	205
	Serviced Population		1,386	1,361	1,382	1,414	1,505
Sewer	Residential Assessments	Active	397	387	396	413	454
		Inactive	157	168	162	149	119
		Total	554	555	558	562	573
	Additional dwellings		116	116	116	116	116
	Serviced private dwelling population		1,088	1,067	1,086	1,122	1,209
	Population in other dwellings		205	205	205	205	205

Read periods		2018-2 to 2019-1	2019-2 to 2020-1	2020-2 to 2021-1	2021-2 to 2022-1	2022-2 to 2023-1
	Serviced Population	1,293	1,272	1,291	1,327	1,414

The historical residential active, inactive, and total assessments, along with the estimated private dwelling serviced population (calculated from the average detached dwelling household size multiplied by the number of assessments) is summarised Captains Flat in Table 4-8. An extra 2-meter reading periods of data were provided for Captains Flat, therefore the time period used for the Captains Flat assessment is slightly different than that for Braidwood and Bungendore, as additional data was requested to assess the rectification of some problems identified during the project.

Table 4-8: Historical residential assessments and serviced population Captains Flat

Read periods			2019-1 to 2019-4	2020-1 to 2020-4	2021-1 to 2021-4	2022-1 to 2022-4	2023-1 to 2023-4
Water	Residential Assessments	Active	166	189	196	193	190
		Inactive	75	52	45	48	34
		Total	241	241	241	241	224
	Additional dwellings		7	7	7	7	7
	Serviced private dwelling population		403	456	473	466	459
	Population in other dwellings		7	7	7	7	7
	Serviced population		410	464	480	473	466
Sewer	Residential Assessments	Active	158	181	187	187	182
		Inactive	72	49	43	43	33
		Total	230	230	230	230	215
	Additional dwellings		7	7	7	7	7
	Serviced private dwelling population		384	438	452	452	440
	Population in other dwellings		7	7	7	7	7
	Serviced population		392	445	459	459	447

4.3 Visitor Contribution

4.3.1 Accommodation providers

Limited commercial visitor accommodation is available in Bungendore, Braidwood and Captains Flat. Council's 2017-2025 Tourism Plan states that:

- The major category of visitor accommodation is 'a friend's or relative's property'.
- There is a lack of a range of accommodation types and accommodation capacity.

The main commercial visitor accommodation in Bungendore is:

- Carrington Inn (22 rooms and 4 suites).
- Lake George Hotel (7 motel rooms and 1 cabin).
- The Showground provides powered and unpowered campsites although is outside of both the water and sewerage serviced areas

The main visitor accommodation in Braidwood is:

- Colonial Motel (10 rooms).
- Cedar Lodge Motel (10 rooms).
- Royal Mail Hotel (16 rooms).
- The Showground provides powered and unpowered campsites and does have access to reticulated town water but not sewerage.

Captains Flat:

- Captains Flat Hotel has 19 rooms, it reopened in June 2024 after being closed since 2020.
- Informal camping is available at Captains Flat Park.

The projections do not currently include an increase in visitor accommodation capacity.

4.3.2 Seasonal visitor statistics

Between 2012/13 and 2015/16, the Bureau of Statistics collected and published monthly visitor accommodation data from hotels, motels, and serviced apartment complexes with 15 or more rooms. No data was published for the Braidwood region (including Captains Flat) or the Queanbeyan Region (including Bungendore) as there were insufficient accommodation providers of the required size for the data to be published without breaking confidentiality. The area of interest is in “Capital Country” tourism region. There was comparatively little variability in the average room occupancy in the region, (between 0.74 and 1.22 people per room per night) with the highest occupancy in spring (especially in September), medium occupancy in autumn and lower occupancy in winter and summer.

Based on this data there is no evidence that the summer peak water demands are likely to be impacted significantly by higher-than-average visitor numbers.

4.4 Growth distribution

4.4.1 Timing of growth

Council has adopted a structure plan for Bungendore [4] and is in the process of developing the Structure Plan for Braidwood. The structure plans provide forecasts for population and dwelling growth in these communities. No growth is projected in Captains Flat.

The population of Bungendore is projected to grow at 3.3% per year. All the growth in Bungendore is expected to be housed in new detached dwellings. The new dwellings are expected to house 3 people per dwelling.

The population of Braidwood is expected to grow at 2.5% per year. The new houses in Braidwood are expected to house 2.2 people per dwelling, and the new villa homes or flats are expected to house 1.5 people per dwelling.

4.4.2 Bungendore residential greenfield subdivisions

The initial Bungendore Structure Plan 2048 contains a map of the proposed residential investigation areas. Since the structure plan was completed, Council has revised the growth expectations for these areas. The priority areas are mapped in Figure 4-2.

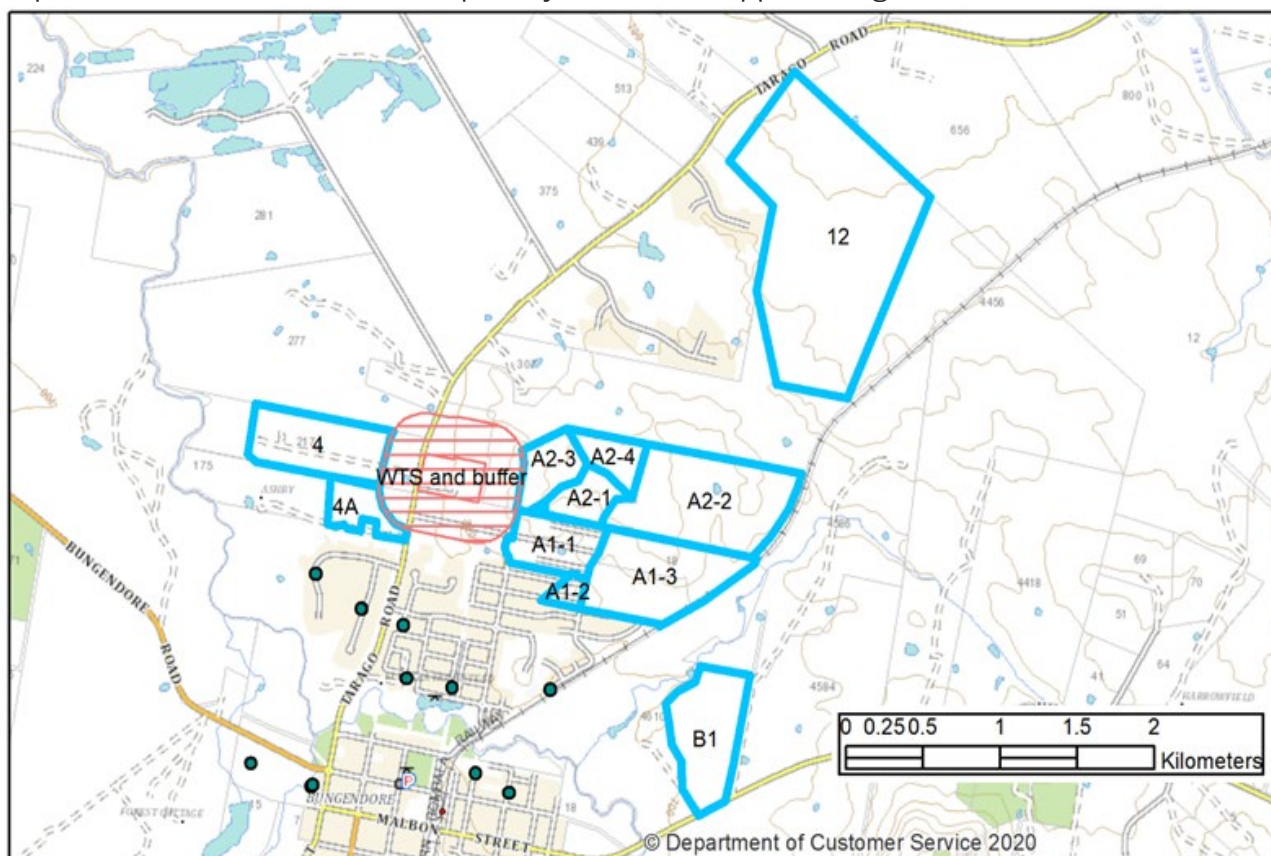


Figure 4-2: Bungendore planned subdivisions and investigation areas

Some of the development areas cannot be serviced using either existing reservoirs and/or sewage pumping stations (SPS). Development area 12 will require a new reservoir, its named New Currandooly Reservoir in this report. The new SPSs are designated New1 to New 5. The lot yields, reservoir zones and sewage pumping station catchments are summarised in Table 4-9. Note that only part of investigation area 4 and none of investigation area 12 are expected to be developed within the next 30 years, all other zones will be fully developed.

Table 4-9: Bungendore planned subdivisions and investigation areas

Investigation area or subdivision	Reservoir zone	SPS	Priority	Structure Plan (22/01/20)	Expected Growth in Bungendore (9/03/23)	Subdivision Plan	Total
A1 - Elm Grove Estate	North Elmslea Reservoir	SPS7	3	300	80	66	146
		SPS9	1		0	25	25
		SPS10	2		0	260	260
A2 - Elm Grove North	North Elmslea Reservoir	SPS7	7		789		95
		SPS10	8				118
		New3, Pumps to SPS7	9				95
		New4, Pumps to New3	10				481
B1	North Elmslea zone 2	New 1, Pumps to SPS2	5	327			327
4	North Elmslea Reservoir	New 2, Pumps to SPS6	6	1,148			1,148
4A	Days Hill	SPS6	4	117	250		250
12	New Currandooly Reservoir	New5, Pumps to New3	11	1,809			1,809
Total							4,754

4.4.3 Bungendore residential infill

In November 2022 Council estimated that there were 175 vacant subdivided lots within Bungendore suitable for infill development [4].

For the purposes of the projection NSW PW has assumed that 4 infill lots will be developed per year (120 over 30 years). Based on the 2024 aerial photos on Google Maps, it's estimated that:

- 60 lots are in SPS catchment 4 and Turallo reservoir zone.
- 32 lots are in SPS catchment 2 and Turallo reservoir zone.
- 5 lots are in SPS catchment 3 and Turallo reservoir zone.
- 8 lots are in SPS catchment 7 and Days Hill reservoir zone.

- 15 lots are in SPS catchment 1 and Turallo reservoir zone.

4.4.4 Bungendore non-residential growth

The Bungendore Structure Plan (22/01/20) [4] states that additional employment lands are required and that a separate plan needs to be developed to select suitable locations. Therefore, for the water and sewer projections, the non-residential growth has been assumed to occur at the same rate as the residential population growth and be distributed between service areas proportionally to the existing non-residential loads.

Council has completed stage 1 of the Bungendore Sports Hub. This consists of four hard surface netball courts, two turf fields (irrigated using treated effluent), and a facility building with public toilets, change rooms, a kiosk and a multi-use room. The facility building is sewered using a small sewage pumping station (SPS 11) that pumps into the SPS1 gravity catchment. Further stages of the hub are planned, including a Men's Shed, and an indoor aquatic centre (the aquatic centre is currently un-funded). When this occurs, Council will need to upgrade the pump in SPS11. The current projection includes a relatively generous sewage load for the current facilities and other minor users and these loads are assigned straight on SPS1.

Once the aquatic centre is built, it is expected to have a similar sewage load to the existing Bungendore Pool (which will close). The water demands for the new aquatic centre are expected to be slightly higher overall as it will operate all year round, though the peak summer demands may be slightly lower as there will be less evaporation.

SPS11 will be added to the analysis in future studies as will changes to the water demand and sewage loads due to the switch from the outdoor pool to the indoor pool.

4.4.5 Braidwood residential growth

Council released a discussion paper for the Braidwood Structure Plan In 30 January 2023 [5]. The plan includes a map of the infill development potential and a description of the dwelling capacity calculation method. The mapped lots were cross referenced with the current Google aerial photos to check whether any had already been developed. The potential number of dwellings on these lots were estimated using the same assumptions as listed in the zoned R2 (low density residential):

- The minimum lot size is 850 m² though there is a preference for lots of around 1,000 m² (based on the recent Braidwood Ridge development)
- Any lot under 1,900 m² will be developed into a single dwelling.
- Any lot between 1,700 m² and 2550 m² will be subdivided into 2 lots.
- Lots larger than 2,550 m² will be subdivided into lots with a minimum area of 1,000 m² with a 21% allowance for roads, drainage, and other communal uses.

The exemption to this is Maddrell Place, which has already been subdivided into 10 lots.

The only area zoned R1 (general residential) is 29-31 Coronation Ave, this lot is expected to be developed into 29 two-bedroom units. For the purpose of the projection, it is assumed that these dwellings will come online between 2031 and 2035 and will have separate water and sewer assessments (rather than a shared meter for the development).

The infill lots are mapped in Figure 4-3.

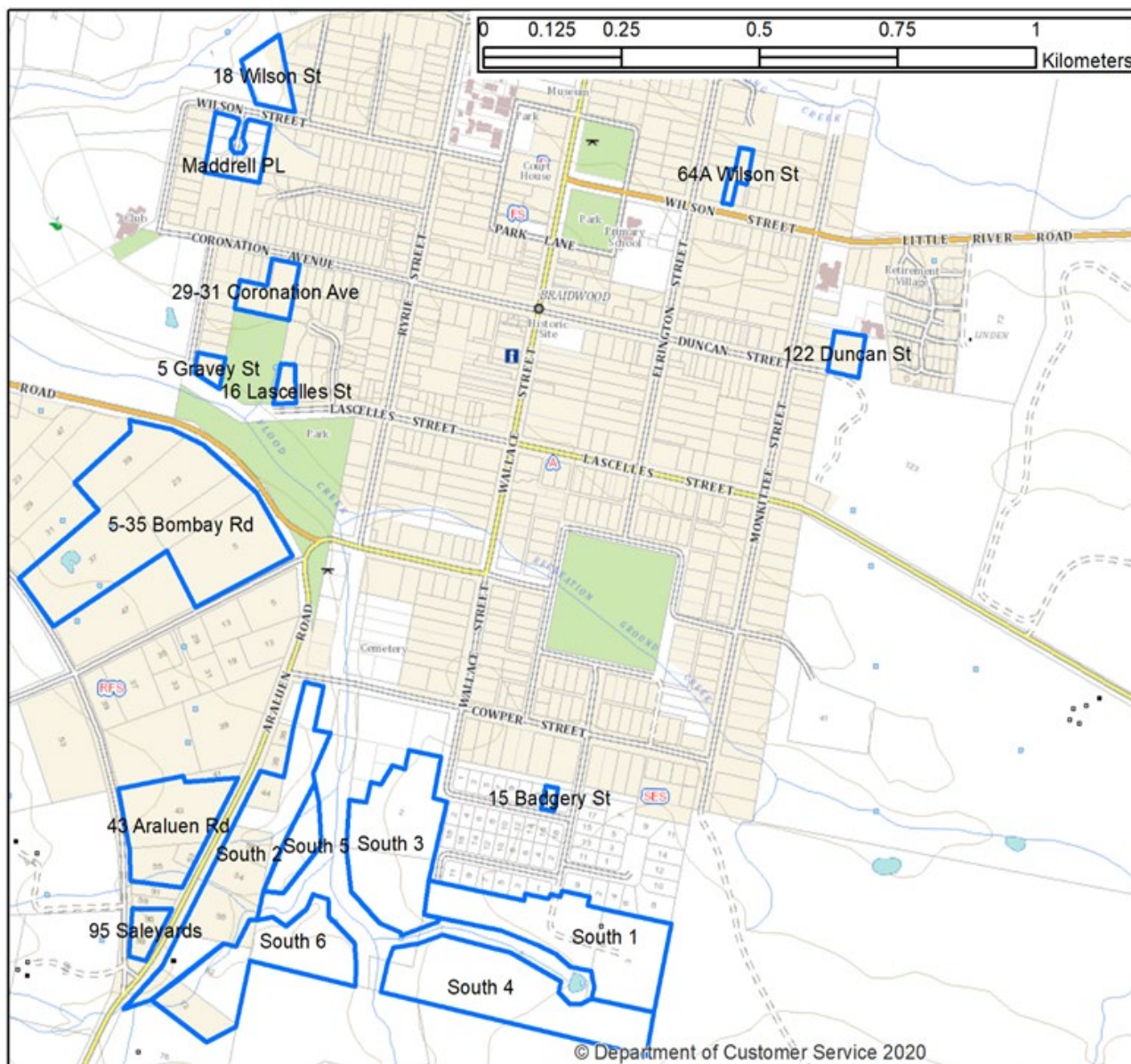


Figure 4-3: Braidwood residential infill

The area, capacity, and order of development for the Braidwood infill lots are summarised in Table 5.8. As with Bungendore, some of the development areas are unable to be serviced using existing SPSs, the new SPS are named New 1 and New 2.

Table 4-10: Braidwood detached dwelling infill lots

Name	SPS	Area (m2)	Capacity	Order of development
15 Badgery St	SPS1	928	1	1
5 Garvey St	SPS1	2,250	2	2
16 Lascelles St	SPS1	2,291	2	3
64A Wilson St	SPS1	2,418	2	4

Name	SPS	Area (m2)	Capacity	Order of development
122 Duncan St	SPS1	4,081	3	5
95 Saleyards	SPS6	4,514	3	6
18 Wilson St	SPS2	7,629	6	7
Maddrell PL (10 lots)**	SPS2	9,403	7	8
43 Araluen Rd	SPS6	27,248	21	9
5-35 Bombay Rd	SPS5	88,863	70	10
South 1	SPS1	44,004	34	11
South 2	SPS6	46,343	36	12
South 3	New1	40,001	31	13
South 4	New1	46,385	36	14
South 5	New2	8,365	6	15
South 6	New2	36,437	28	16
Total			317	

* this lot is zoned R1 and will be developed into 29 2-bedroom units

** this lot has already been subdivided

In addition to the infill lots, there are still some lots in Braidwood Ridge that are yet to be developed. Braidwood Ridge is a development area to the south of Braidwood including Badgery St, Nomchong St, Elrington St, and Coffey St. The first lots were released in about 2017. The development will end up with about 100 lots, of these lots 52 have already been subdivided and at least 28 have already had homes built (an average of more 4.6 dwellings per year). Of the subdivided lots, only one is marked for infill development, therefore it is assumed that the others have already been constructed or Council has received development applications.

For the purposes of the population and loading projection, it is assumed that between 2021/22 and 2023/24, 5 dwellings per year were built at Braidwood Ridge (15 over the three years).

The development of the Summerfield in Braidwood retirement village (70 Little River Rd) had just started when the data for this project was provided. The village will have 56 units and semi-detached villa homes with two or three bedrooms each and a range of community facilities including a swimming pool. For the projections, it has been assumed that these dwellings will house an average of 1.5 people, have two bedrooms and will be developed between 2023 and 2030. Braidwood SPS7 has been built to service this development.

Council has started planning for the additional growth expected. The areas currently being considered for long term growth are mapped in Figure 4-4.

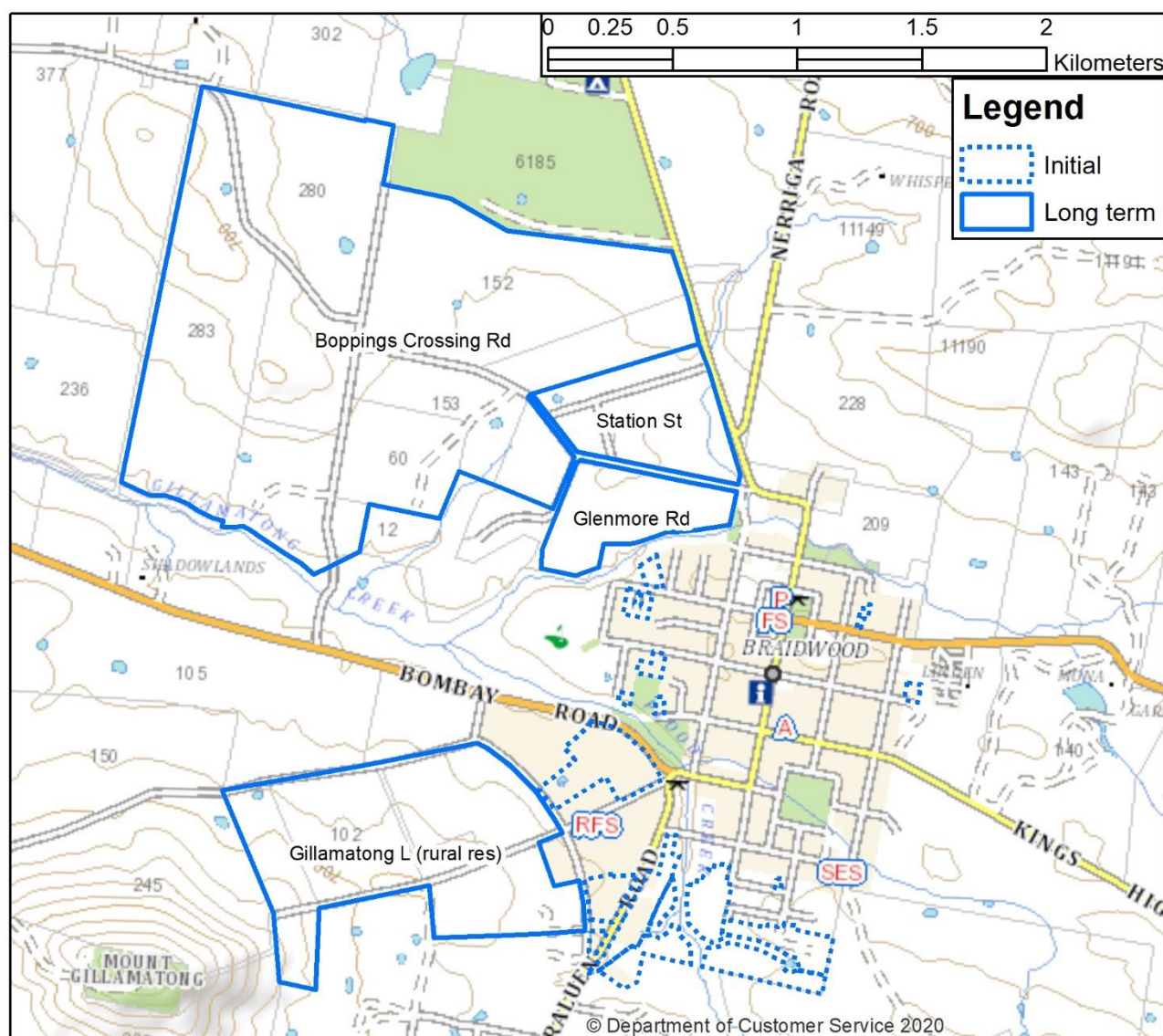


Figure 4-4: Braidwood long term growth areas

The area, capacity, and order of development for the Braidwood long term growth areas are summarised in Table 4-11. As with the initial growth, Boppings Crossing Road will be unable to be seweraged using the existing SPS, the new SPS is named New 3. Areas of Boppings Crossing Road will also need a separate water reservoir due to the elevation,

Table 4-11: Braidwood long-term growth areas

Name	SPS	Area (ha)	Capacity	Order of development
Station St	SPS 2	28	274	1
Gillamatong L (rural res)	SPS 5	80	32	Parallel with 1
Glenmore Rd	SPS 4	20	235	2
Boppings Crossing Rd	New 3	261	Unknown	4

Based on the 2.5% per year population growth rate for Braidwood (discussed in 4.4.1), 727 new dwellings are required between 2021 and 2054. These will consist of 15 new dwellings at Braidwood Ridge in the areas already subdivided, 317 infill dwellings, and an additional 399 dwellings in the long-term growth areas. Station St and Gillamatong are expected to be fully developed, these three areas can be serviced using existing the existing reservoir and existing sewage pumping stations.

The Glenmore Road development area is not required within the life of this study and can be served using the existing reservoir SPS pumping stations.

4.4.6 Major events

The QPRC 2018-2025 events strategy splits events into three categories:

1. Category 1 events have the primary purpose of enhancing community inclusion and social engagement within the Local Government Area. They also include events that are undertaken by Council to meet civic responsibility. These events include Australia Day, Seniors Week and the annual Reconciliation Walk. Based on the information provided, these events are not expected to draw significant numbers of visitors from outside the area.
2. Category 2 events include events or festivals with the primary purpose of:
 - a. celebrating local culture and/or promoting the liveability of the Local Government Area or
 - b. activating spaces and places in town and city centres; that inspire creativity and vivacity in public realm and contribute to economic and social activity in central business districts.

These events include community Christmas parties, the annual multicultural festival and Christmas in July Markets. This category of events is not expected to attract significant numbers of attendees from outside the area.

3. Category 3 events include events or festivals with a primary purpose to showcasing and attracting visitors to the region. These events focus on creating significant economic and/or visitor generation within the Local Government Area. These events include performances by the Canberra Symphony Orchestra and major sporting fixtures. The events listed appear to be mostly based in Queanbeyan.

None of the events listed in the strategy are expected to draw significant numbers of visitors to Bungendore, Braidwood or Captains Flat, though there may be some overflow from major events in Queanbeyan or Canberra.

There are also local events that are not listed in the events strategy including the:

- Braidwood Agricultural Show (held in March)
- Bungendore Agricultural Show (held in October).

Local agricultural shows typically attract many overnight visitors, though a large proportion camp at the show grounds.

Up until January 2020, Council published monthly event guides. These do not appear to have recommenced since the COVID-19 event restrictions were lifted. Therefore, it is difficult to assess which major events have continued.

4.5 Projections

4.5.1 Population and dwelling projection

The town population projection and the new dwelling projection are summarised in Table 4-12 and the serviced population and residential assessment projection is summarised in Table 4-13.

Table 4-12: Bungendore and Braidwood population and dwelling growth projection

		2021	2024	2026	2031	2036	2041	2046	2051	2054
Population growth rate	Bungendore		3.30%	3.30%	3.30%	3.30%	3.30%	3.30%	3.30%	3.30%
	Braidwood		0.80%	0.80%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%
Average population	Bungendore	3,935	4,338	4,629	5,444	6,404	7,533	8,860	10,422	11,488
	Braidwood	1,416	1,450	1,474	1,667	1,886	2,134	2,415	2,732	2,942
Additional people	Bungendore		403	694	1,509	2,469	3,598	4,925	6,487	7,553
	Braidwood		34	58	251	470	718	999	1,316	1,526
Household size for new dwellings	Bungendore		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	Braidwood (houses)		2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	Braidwood (flats & townhouses)		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
New dwellings required	Bungendore		134	231	503	823	1,199	1,642	2,162	2,518
	Braidwood		6	7	21	86	199	327	471	566
New Flats & townhouses	Bungendore		0	0	0	0	0	0	0	0
	Braidwood		6	13	62	85	85	85	85	85
New Detached Dwellings	Bungendore		134	231	503	823	1,199	1,642	2,162	2,518
	Braidwood		6	7	21	86	199	327	471	566

Table 4-13: Bungendore and Braidwood serviced population and residential assessments projection

		2021	2024	2026	2031	2036	2041	2046	2051	2054
Water serviced population	Bungendore	3,935	4,338	4,629	5,444	6,404	7,533	8,860	10,422	11,488
	Braidwood	1,416	1,450	1,474	1,667	1,886	2,134	2,415	2,732	2,942
Water serviced active residential assessments	Bungendore	1,128	1,233	1,330	1,602	1,922	2,298	2,741	3,261	3,617
	Braidwood	439	497	508	571	659	772	900	1,044	1,139
Water serviced inactive residential assessments	Bungendore	189	223	223	223	223	223	223	223	223
	Braidwood	179	211	211	211	211	211	211	211	211
Total water serviced residential assessments	Bungendore	1,317	1,456	1,553	1,825	2,145	2,521	2,964	3,484	3,840
	Braidwood	618	708	719	782	870	983	1,111	1,255	1,350
Sewer serviced population	Bungendore	3,736	4,136	4,427	5,242	6,202	7,331	8,658	10,220	11,286
	Braidwood	1,325	1,359	1,383	1,576	1,795	2,043	2,324	2,641	2,851
Sewer serviced active residential assessments	Bungendore	1,060	1,164	1,261	1,533	1,853	2,229	2,672	3,192	3,548
	Braidwood	396	454	465	528	616	729	857	1,001	1,096
Sewer serviced inactive residential assessments	Bungendore	179	211	211	211	211	211	211	211	211
	Braidwood	162	119	119	119	119	119	119	119	119
Total sewer residential assessments	Bungendore	1,239	1,375	1,472	1,744	2,064	2,440	2,883	3,403	3,759
	Braidwood	558	573	584	647	735	848	976	1,120	1,215

5 Bungendore water supply scheme

5.1 Raw water source

5.1.1 Water resource

Bungendore relies on groundwater sourced from alluvial paleo drainage channels in two sub-catchments for its water supply. These two are Turallo Creek and Butmaroo Creek. The Lake George Basin is to the north of the site area with associated channels and alluvial flats extending south. Groundwater is primarily recharged by local rainfall infiltration and runoff. In recent history, groundwater levels have a high Standing Water Level (SWL), however there have been low rainfall events in the past 10 to 15 years.

5.1.2 Raw water extraction

The main water source consists of four bores located at Turallo bore fields with NSW Office of Water approved entitlement of 322 ML. Currandooly consists of one bore at Butmaroo Creek with an approved entitlement of 150 ML, where raw water is transferred through a 1.8 km raw water rising main, a water treatment plant located on the Tarago Road about 5 km north of Bungendore.

Capacities of assets for raw water extraction for Bungendore and Currandooly are as follows:

Table 5-1: Bungendore raw water extraction asset's capacities

Asset	Capacity (L/s)
Bungendore	
Bore 1	11.5
Bore 2	14.6
Bore 3	6.5
Bore 6	16.25
Currandooly	
Bore	20.5

A map of the raw water bores and the Bungendore WTP is shown in Figure 5-1.

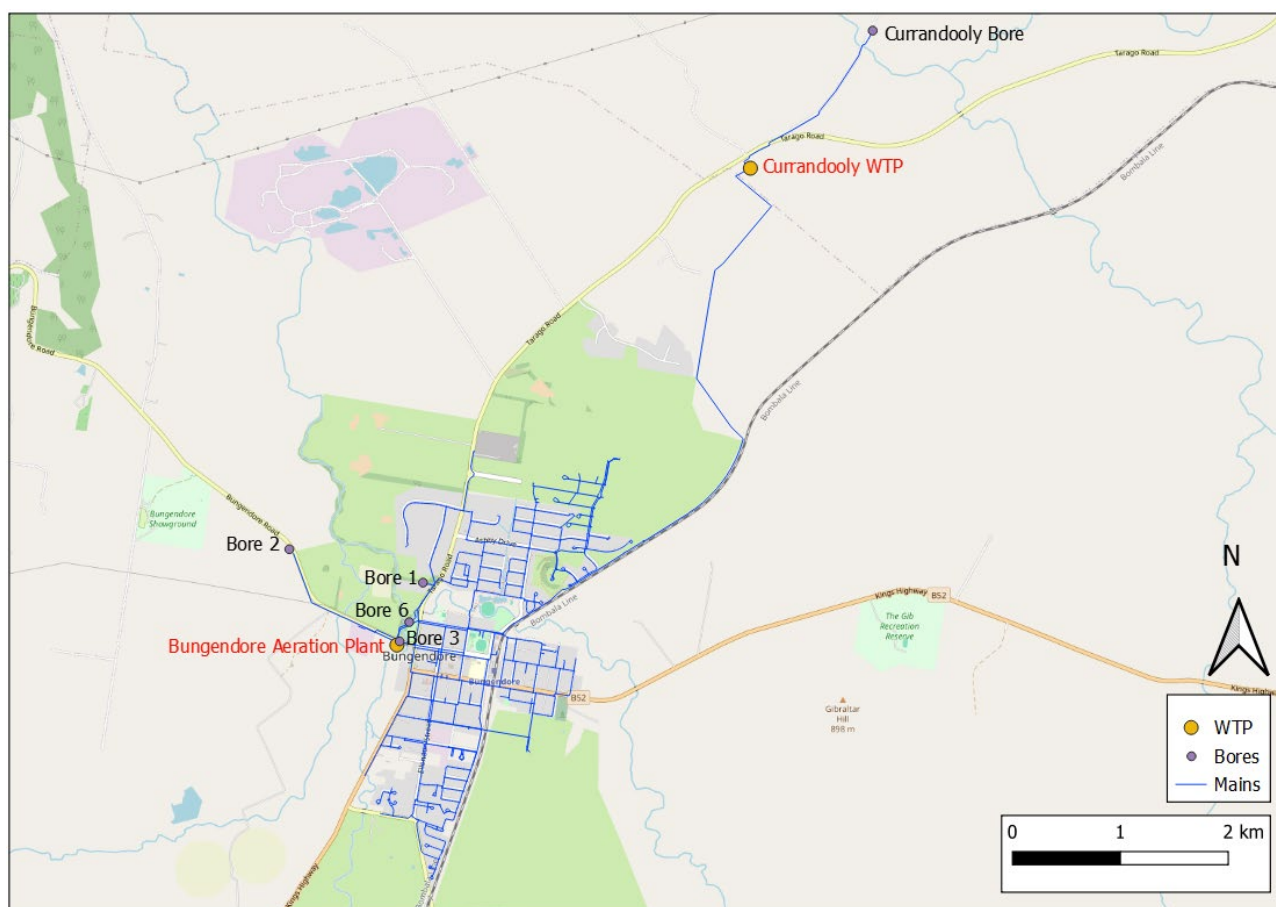


Figure 5-1: Location of raw water intake for Bungendore WTP

5.1.3 Water access licences

Council holds Local Water Utility Water Access Licenses (WAL32742 and WAL36260), issued under the Water Management Act 2000, which relate to the water supply to Bungendore. The following apply to the WALs:

Table 5-2: WAL Licence numbers

WAL license number	WAL32742	WAL36260
Category [Subcategory]	Local Water Utility	Local Water Utility
Entitlement	322.0 ML/year	150.0 ML/year
Water Source	Bungendore Alluvial Groundwater Source	Bungendore Alluvial Groundwater Source
Water Sharing Plan (WSP)	Murrumbidgee Alluvial Groundwater Sources 2020	Murrumbidgee Alluvial Groundwater Sources 2020
Works approval	40CA412631	40CA415918

WAL32742 is from the Bungendore alluvial source. It includes approvals to 4 town-based bores which all supply the aeration tower. WAL36260 is associated with the Currandooly bore and supplies the Currandooly WTP.

5.1.4 Source water quality

Raw water quality was sampled between March 2014 and March 2023 approximately once every quarter. The samples are collected both at the intake to the aeration plant and for the Currandooly bores.

Typical raw water quality for the Bungendore Bores and Currandooly Bore is shown in Appendix table A-1 and Appendix table A-2 respectively.

The main parameters of interest in the Bungendore bores raw water source are:

- Aluminium - About 18% of the samples contain aluminium in concentrations above the limit of reading.
- Copper - one sample contained relatively high concentrations of copper, it was collected in November 2015 (140 µg/L), this was not during drought, other than this, the samples have been relatively low in copper.
- pH - The pH was frequently quite high but below the ADWG (Australian Drinking Water Guidelines) of 8.5 pH units, 5 out of 37 (14%) samples had a pH of 8.2 pH and above.
- Sodium - Sodium is frequently high but within the ADWG (Australian Drinking Water Guidelines). The highest concentration recorded was 95.1 mg/L, 11 out of 38 of samples contained concentrations of more than 80 mg/L.
- PFAS – in response to a plan to lower the ADWG concentration limits for Polyfluoroalkyl Substances (PFAS) NSW Health funded additional testing for these substances. The testing showed that water extracted from bores 3 and 6 contains concentration of a particular PFAS substance (perfluorooctane sulfonic acid (PFOS)) that is below the current guideline but exceeds the proposed guideline. New **issue**

The main parameters of interest in the Currandooly raw water are:

- Aluminium – one sample collected on 9/12/2014 was exceptionally high in aluminium with a reading of 99.8 mg. Other than this sample, about 33% of the samples contain aluminium in concentrations above the limit of reading.
- Copper – two samples contained relatively high concentrations of copper, one was collected in August 2018 (60 µg/L) and the other in May 2019 (294 µg/L), both were collected during drought, other than this, the samples have been relatively low in copper.
- Iodide – two samples contained relatively high concentrations of iodide (0.24 and 0.17 mg/L), one was collected in December 2021 and the other in December 2022, both wet summers.

- Iron – 29 out of 33 (87%) samples contained above 20 mg/L.
- Lead – during the dry weather in 2017-2019, several samples contained more the 1 µg/L of lead with the highest concentration 36.1 µg/L (
- Manganese – samples generally contain around 500 µg/L.

Based on the results of the reticulation water quality testing undertaken as part of the NSW Health verification program (section 5.3.6), the current treatment systems are removing the aluminium, copper, iodide, iron, lead and manganese.

5.2 Water treatment

5.2.1 Treatment process

Water from the four Bungendore bores is treated at with the following processes:

- Aerated in the aeration towers
- Chlorine dosing in a 100 kL collection tank.
- Fluoride dosing

Water from the Currandooly bore is treated at the Currandooly WTP using a conventional treatment process:

- Pre-dosing with caustic soda, potassium permanganate and Aluminium Chlorohydrate (ACH)
- Clarification
- Filtration
- Post dosing using gas chlorine for disinfection, caustic soda for pH correction, and fluoride.

A schematic showing an overview of the Bungendore/ Currandooly water supply scheme is provided in Figure 5-2.

BUNGENDORE DRINKING WATER MANAGEMENT SCHEME

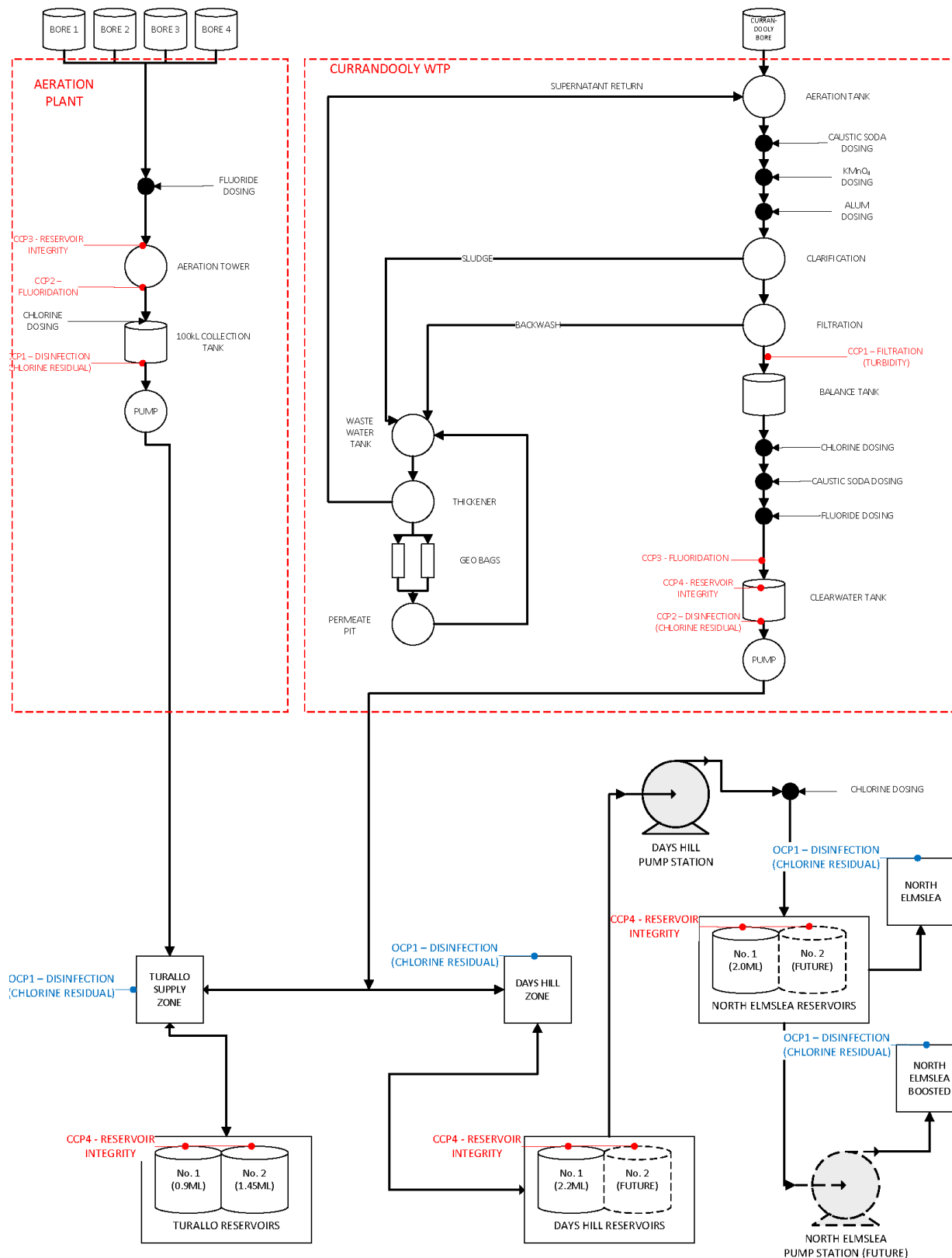


Figure 5-2: Schematic flow diagram of the Bungendore / Currandooly water supply scheme

5.2.2 Historical water production

Bungendore WSS supplies potable water to customers connected to the Bungendore and Elmslea Estate reticulation system. Council provided the potable water production records from July 2001 to February 2023 for both the Bungendore bore aeration plant and the Currandooly WTP. The potable water meters record flow being pumped out of the aeration tower and out of the Currandooly WTP. This data is summarised in Figure 5-3, which also show the stages of water restrictions that were implemented over this period.

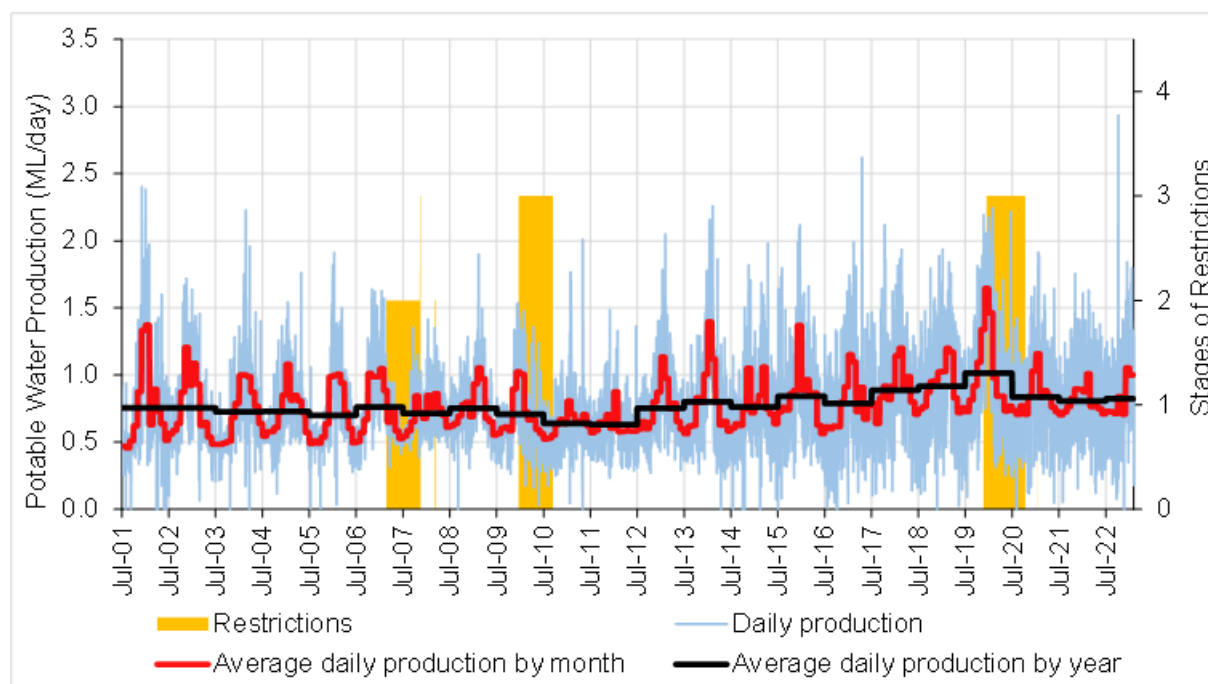


Figure 5-3: Historical production data- Bungendore potable water production

The annual summary of water production for the Bungendore WTP as shown in Table 5-3.

Table 5-3: Historical annual water production – Bungendore WTP (ML/year)

Financial Year	ML/year
2001/02	275.5
2002/03	276.2
2003/04	265.0
2004/05	265.1
2005/06	255.4
2006/07	277.8
2007/08	260.7
2008/09	274.9

Financial Year	ML/year
2009/10	258.6
2010/11	233.6
2011/12	230.0
2012/13	275.1
2013/14	291.9
2014/15	277.9
2015/16	307.6
2016/17	287.4
2017/18	332.1
2018/19	334.1
2019/20	371.3
2020/21	304.3
2021/22	294.0

The maximum production was 371.3 ML/year for the 2019/20 financial year.

5.2.3 Peak production analysis

The historical peak fortnight pattern for the Bungendore WSS is shown in Figure 5-4.

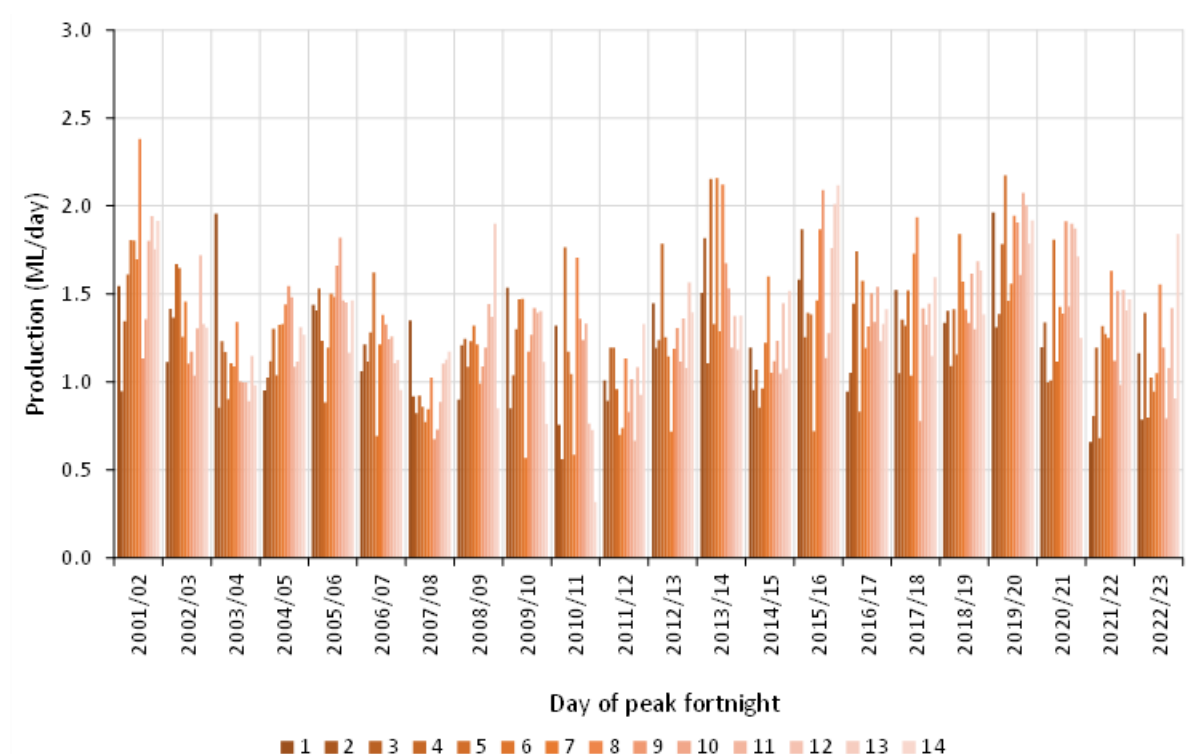


Figure 5-4: Peak fortnightly production patterns – Bungendore aeration tower and Currandooly WTP

The highest recorded daily production in Bungendore aeration tower and Currandooly WTP was 2.93 ML which occurred on 6 October 2022. However, as the temperature of this peak day is relatively low (15°C), this day is not considered to be the true peak production representative of the scheme demand.

The nominated peak day production is 2.24 ML which occurred on 31 January 2020. There was only 0.2mm of rainfall after 7 days of no rainfall. The maximum temperatures surrounding this day was high (ranged from 30°C to 41.9°C).

The average daily production over the peak week (ADPW) and peak fortnight (ADPF) was 1.89 ML/day of week starting 31 Dec 2019 and 1.78 ML/day of fortnight starting 24 December 2019 respectively. The ADPW and ADPF graphs are shown in Figure 5-5.

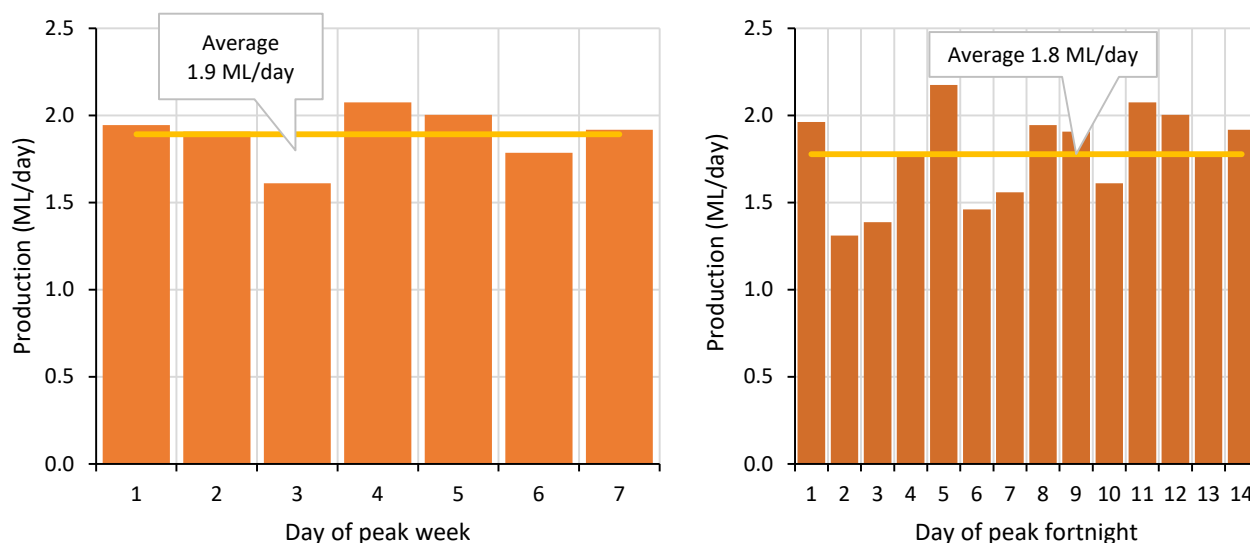


Figure 5-5: Peak week and peak fortnight production – Bungendore aeration tower and Currandooly WTP

The PD to ADPW ratio for Bungendore WSS is 1.19.

5.2.4 Treated water quality

According to Council's Drinking Water Management System (DWMS) [1], there are four Critical Control Points (CCP) adopted for Bungendore WTP, shown in Table 5-4. It is noted that the free chlorine residual in the reticulation is not a Critical Control Point.

Table 5-4: Bungendore WSS – Aeration tower Critical Control Point summary

CCP		Control parameter	Target	Alert Limit	Critical limit
Bungendore WTP	CCP1(a) Chlorination	Free clearwater daily chlorine tank residual	>1.2 mg/L	<0.9 mg/L or >2.0 mg/L	<0.7 mg/L or >5.0 mg/L
	CCP1(b) Chlorination	Free reticulation daily chlorine residual	>0.4 mg/L	<0.3 mg/L	<0.2 mg/L or >5.0 mg/L
	CCP2 Fluoridation	Fluoride clearwater daily tank weekly	0.95 – 1.05 mg/L	0.9 – 0.95 mg/L or 1.05-1.35 mg/L	<0.9 for 72 hrs or >1.5 mg/L
	CCP3 Reservoir	Reservoir Weekly Integrity	No gaps, vermin proof, secure, enclosed, locked	Breach of reservoir integrity	Evidence of vermin

5.2.4.1 Bungendore WTP

Council provided data for chlorine in Bungendore's reticulation and fluoride in the clear water tank. Data sets was provided for the period between January 2015 and June 2023. Data was not provided for chlorine in the aerator (CCP 1 (a)). The DWMS and the plant needs to be updated so that CCP1(a) is between the tank and the pump, rather than before the dosing point. Council had deduced that it was more operational than critical was due to the fact that water from this plant essentially hits the reticulation (and therefore consumers) only 170 m from the Bungendore WTP. Council had confirmed that this test will be added to the daily monitoring field sheets. Council understands the need for a free chlorine sensor between the 100 kL collection tank and the pump to ensure that the water is correctly chlorinated before distribution. The DWMS (and possibly the plant) needs to be updated so that CCP1(a) is between the tank and the pump, rather than before the dosing point. **Non-conformance issue.** Council plans to resolve the issue by installing rising mains from both Bungendore WTP and Currandooley WTP to all reservoirs as part of the Q2B project, thereby eliminating the C.t. issue.

CCP1(b) Chlorination based on free reticulation daily chlorine residual has been presented in Figure 5-6. It is noted that this is not a CCP.

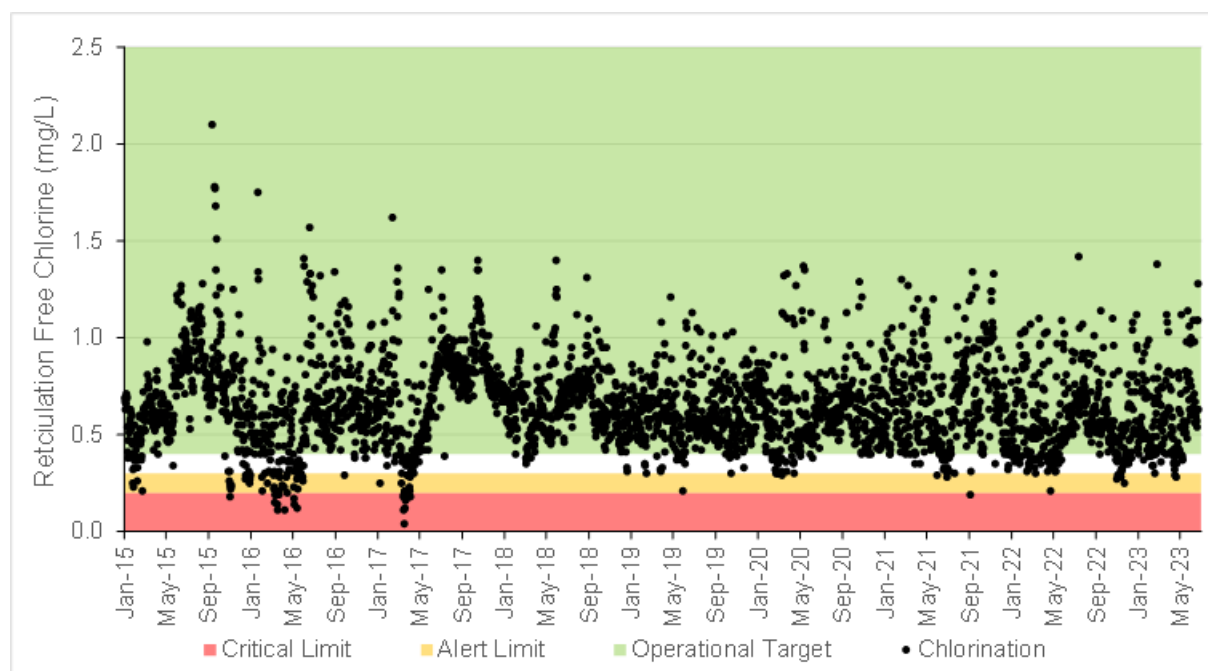


Figure 5-6: CCP1(a) Chlorination – Historical free chlorine in reticulation of Bungendore

Based on the data from January 2015 and February 2023, there were 20 out of 3088 records where chlorination levels were recorded to be lower than the 0.2 mg/L lower critical limit. Two recent records exceeded the lower critical limit occurring in September 2021 and December 2022. The reading of 0.19 mg/L on 4th September 2021 was at Simms Drive. It is a very low usage area; hence it was chosen to be a monitoring point. With typical low readings, lines are flushed to draw through higher chlorinated water. Council confirmed that when the reading is out the target range, lines are typically flushed with higher chlorinated water. Post the chlorine flush the reading was 0.55 mg/L at the same monitoring point. Majority of the records have maintained to be with the target range.

CCP2 Fluoridation has been presented in Figure 5-7.

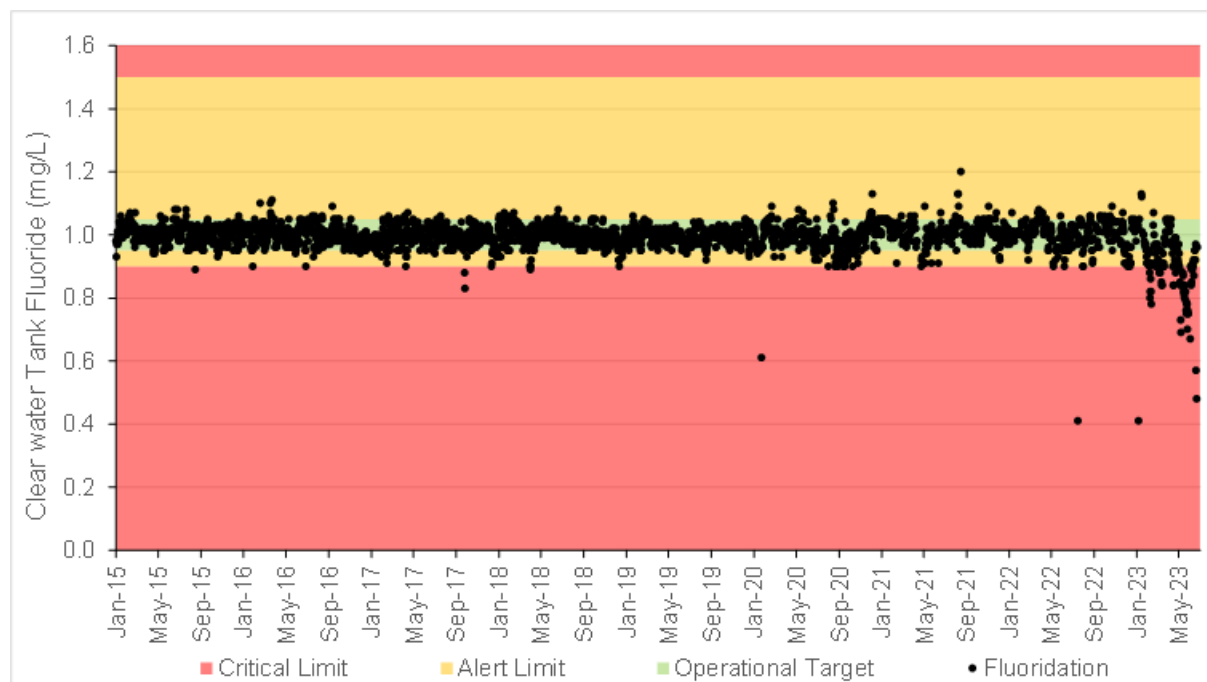


Figure 5-7: CCP2 Fluoridation- Historical fluoride in clean water tank in Bungendore

Based on the data from January 2015 and February 2023, there were recent exceedances below the lower critical limit of less than 0.9 mg/L for 72 hrs. Before July, fluoridation was maintained to be within the target range. Fluoride levels started to decrease from February 2023 due to issues with the saturators causing bed caking. Council stated that they had replaced and recommissioned the beds of all four sodium fluoride saturators. Email evidence from council to NSW Health was sighted.

5.2.4.2 Currandooly WTP

According to Council's Drinking Water Management System (DWMS) [1], there are five Critical Control Points (CCP) adopted for Currandooly WTP, shown in Table 5-5.

Table 5-5: Bungendore WSS –Currandooly WTP Critical Control Point Summary

CCP		Control parameter	Target	Alert Limit	Critical limit
Currandooly WTP	CCP1 Turbidity Post filtration	Filtration and chemical dosing online continuous	<0.2 NTU	>0.3 NTU	>1.0 NTU
	CCP2(a) Chlorination	Free clear water online, chlorine tank continuous residual	1.0 – 1.5 mg/L	<1.0 mg/L or >2.0 mg/L	<0.5 mg/L or >5.0 mg/L
	CCP2(b) Chlorination	Free reticulation daily chlorine residual	>0.4 mg/L	<0.3 mg/L	<0.2 mg/L or >5.0 mg/L

CCP		Control parameter	Target	Alert Limit	Critical limit
	CCP3 Fluoridation	Fluoride clear water daily tank weekly	0.95 – 1.05 mg/L	0.9 – 0.95 mg/L or 1.05 – 1.35 mg/L	<0.9 mg/L for 72 hrs or >1.5 mg/L
	CCP4 Reservoir	Reservoir weekly integrity	No gaps, vermin proof, secure, enclosed, locked	Breach of reservoir integrity	Evidence of vermin

Council provided data for turbidity, chlorination, and fluoridation post filtration in the tank. Data sets was provided for the period between January 2015 and June 2023. Data was not provided for chlorine in reticulation as this is not a required CCP. Currandooly WTP is not run daily.

CCP1 Filtration recorded at the clear water tank has been presented in Figure 5-8.

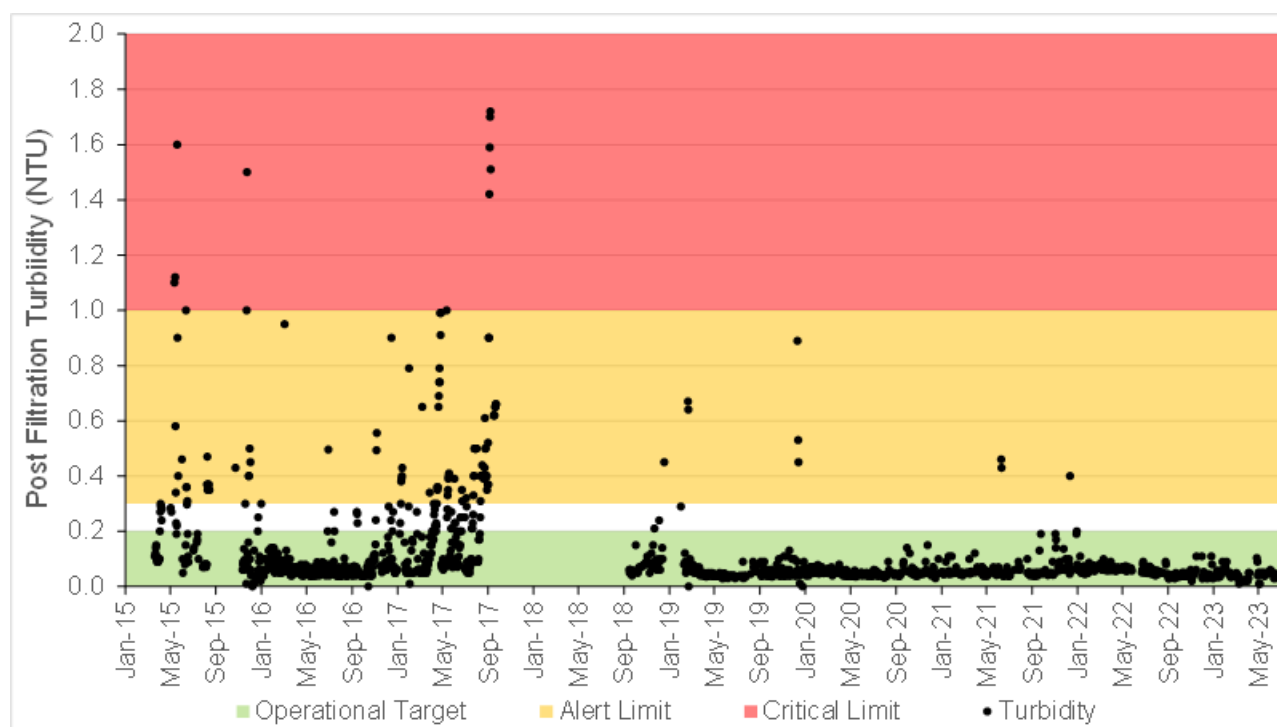


Figure 5-8: CCP1 Filtration- Historical turbidity of Currandooly WTP filtrate

Majority of the recent records have been within the target range. There was no data recorded from September 2017 to September 2018 and results prior to September 2017 are unreliable. Council has stated that the Currandooly WTP had a very difficult commissioning and the council decided to keep the principal contractor (Water Treatment Australia) on site until the WTP was rectified to run correctly. Council handed the plant back to WTA between September 2017 and September 2018 and water was not delivered to the town. On 6 September marks the onset of water delivery to town. Since then, it has been operational and run two to four times a week to the aeration tower (rarely in combination with the aeration plant).

CCP2 (a) Chlorination recorded at the clear water tank post filtration has been presented in Figure 5-9.

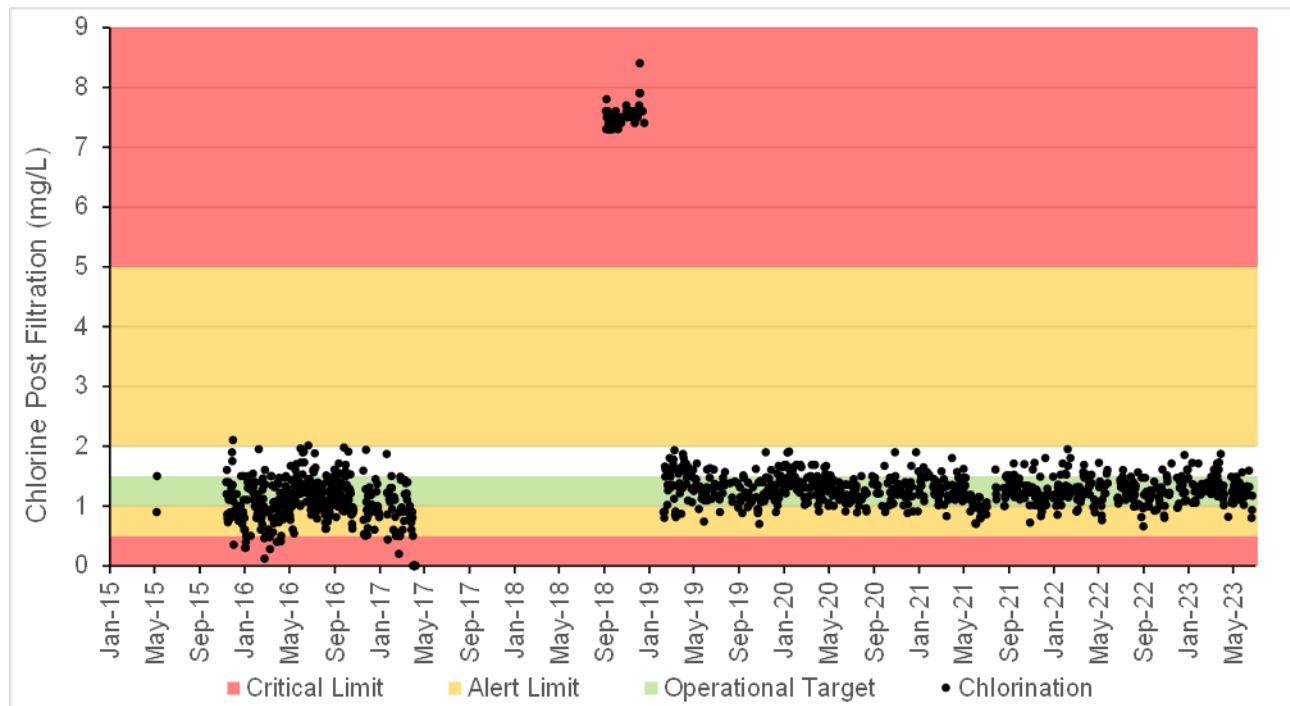


Figure 5-9: CCP2(a) Chlorination – Historical free chlorine in clear water at Currandooly.

One recent record exceeded the lower critical limit of 0.5 which occurring in July 2023. Between September to December in 2018, Chlorine levels exceeded the upper critical limit of 5.0 mg/L reaching level above 7.0 mg/L. This was because the entry for 0.053 mg/L was an error. The true reading for free chlorine was 1 mg/L.

CCP3 Fluoridation recorded at the clear water tank post filtration has been presented in Figure 5-10.

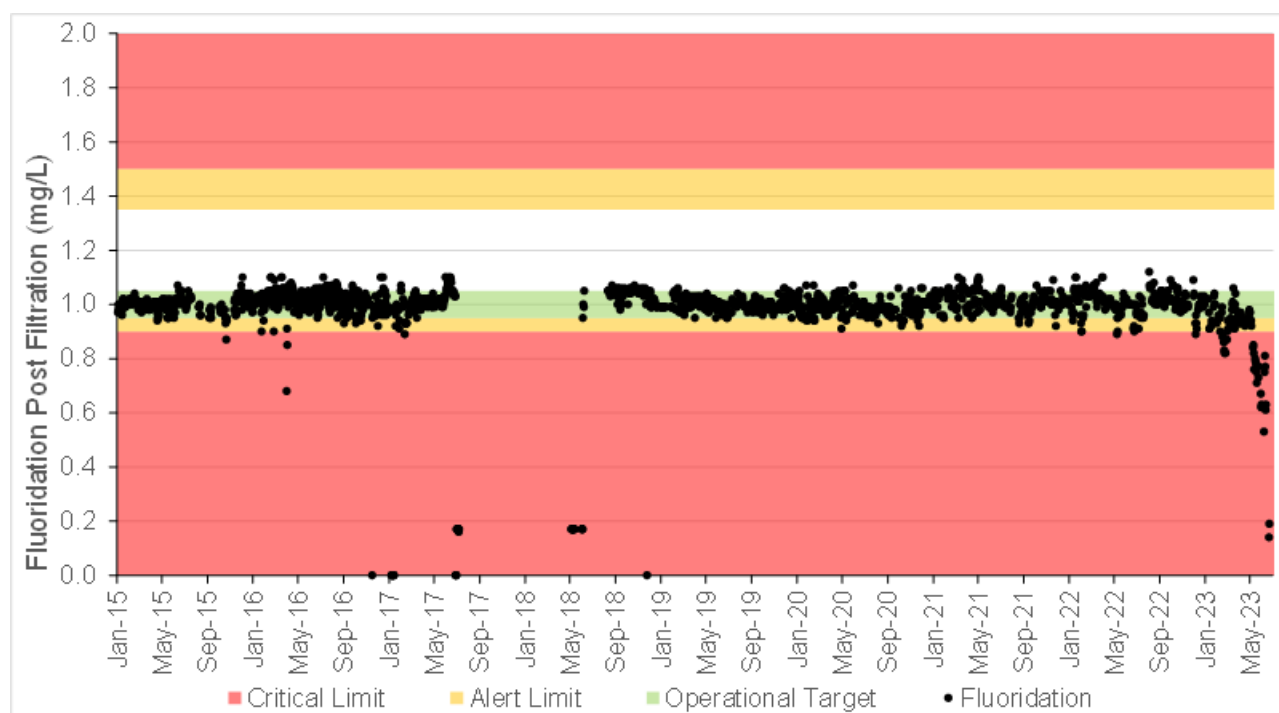


Figure 5-10: CC3 Fluoridation – Historical fluoride in clear water tank in Currandooly

Based on the data from January 2015 and June 2023, there were recent exceedances below the lower critical limit of less than 0.9 mg/L for 72 hrs. Before July 2023, concentrations were maintained to be within the target range. Fluoride levels started to decrease from February 2023 due to issues with the saturators causing bed caking. Council stated that they had replaced the beds of all four branded Sodium Fluoride (NaF) saturators and recommissioned. Email evidence from council to NSW Health was sighted.

5.3 Distribution

5.3.1 Distribution system

Treated water from the Bungendore aeration plant and Currandooly WTP is pumped to the Turallo Reservoirs (0.91 ML and 1.45 ML) and the Days Hill Reservoir (2.2ML) according to each site's requirements. From there, these reservoirs directly gravitate water to customers via the reticulation network. The Turallo Reservoirs operate in a lower pressure zone and typically service the older sections of the village south of Turallo Creek, this zone has the lowest pressure. Days Hill services the section of the town immediate north of Turallo Creek and the new North Elmslea Reservoir (2 ML) is filled from a pump station located at Days Hill and serves properties within the Elm Grove subdivision.

The layout of the distribution network for the Bungendore WSS is shown Figure 5-11.

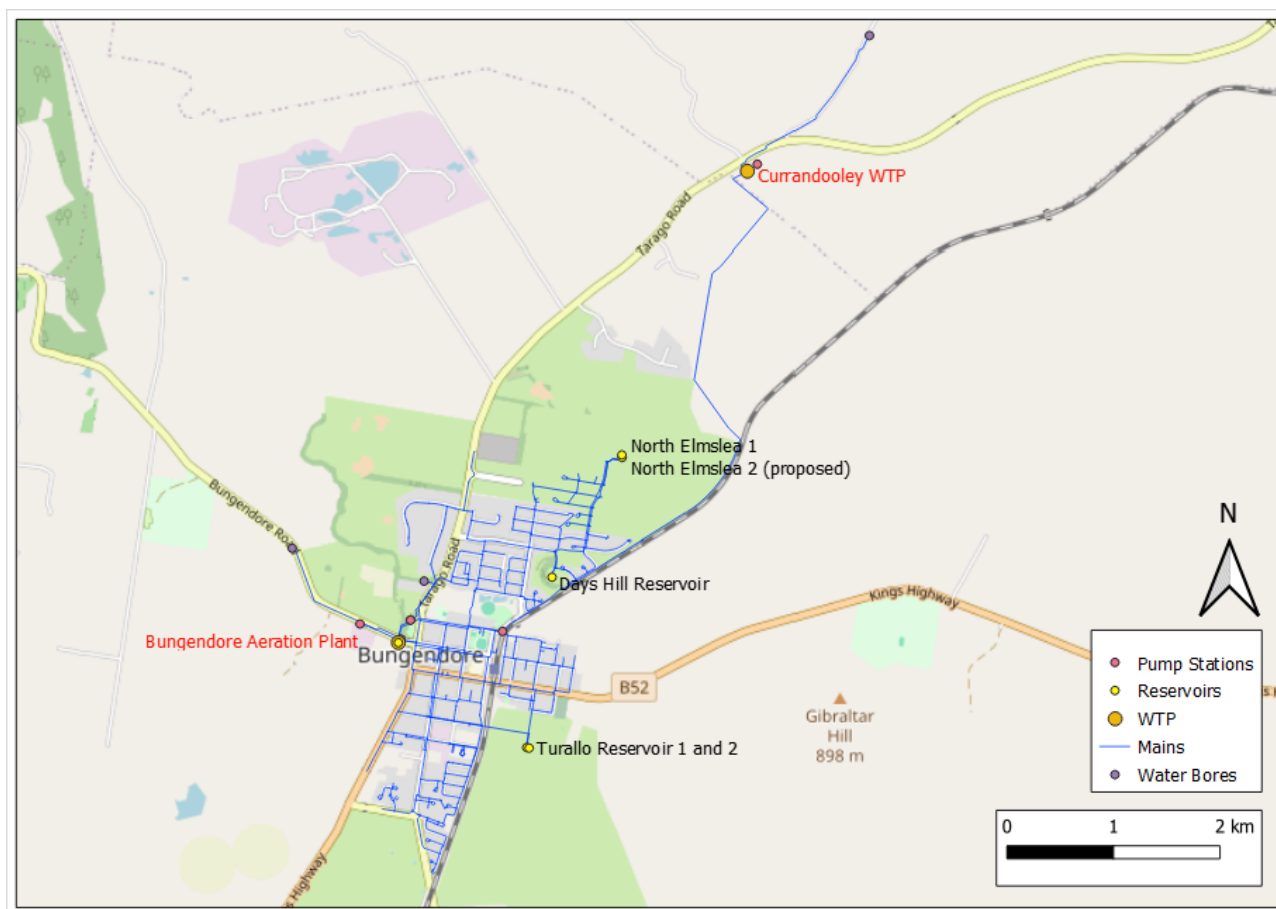


Figure 5-11: Bungendore WSS distribution

5.3.2 Metered customer demand

Council supplied billing data for all potable water customers from July 2017 to December 2022, with the water meters being read quarterly. User classes from the billing data were residential, commercial, mixed, municipal excluding parks, municipal public parks, rural and vacant.

The historical number of customer meters in the billing data and the historical metered customer usage of the last six years are shown in Table 5-6 and Table 5-7 respectively.

Table 5-6: Historical number of meters – Bungendore Potable WSS

User Types	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
Residential	1,190	1,218	1,263	1,302	1,320	1,304
Commercial	57	59	60	58	59	58
Mixed	1	1	1	1	1	1
Municipal - excluding parks	22	23	22	21	18	19
Municipal - public parks	3	4	4	5	5	5

User Types	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
Rural	1	1	1	1	1	1
Vacant	62	62	62	62	62	62
Total	1,336	1,368	1,413	1,450	1,466	1,450

Table 5-7: Historical metered customer usage (ML/year) – Bungendore Potable WSS

User Types	2017/18 reads 2 to 4*	2018/19	2019/20**	2020/21	2021/22	2022/23 read 1*
Residential	197	236	265	217	212	100
Commercial	20	20	21	17	15	7
Institutional	0	1	1	0	1	0
Farm	3	5	6	3	4	2
Vacant	2	6	20	9	5	5
Mixed	0	0	1	0	1	0
Education	9	11	11	9	8	4
Total	197	236	265	217	212	100

*Demand for the 2017/18 and 2022/23 financial years is included but not complete

** Level 1 water restrictions in place from 22/11/2019 to 5/03/2020

In 2021/22, the total customer usage in Bungendore was 212 ML. Customer usage was high during the very dry and hot conditions in 2019/20. Historical customer usage split has been on average around 85% residential to 15% non-residential.

The historical usage for all available billing periods for Bungendore is given in Figure 5-12.

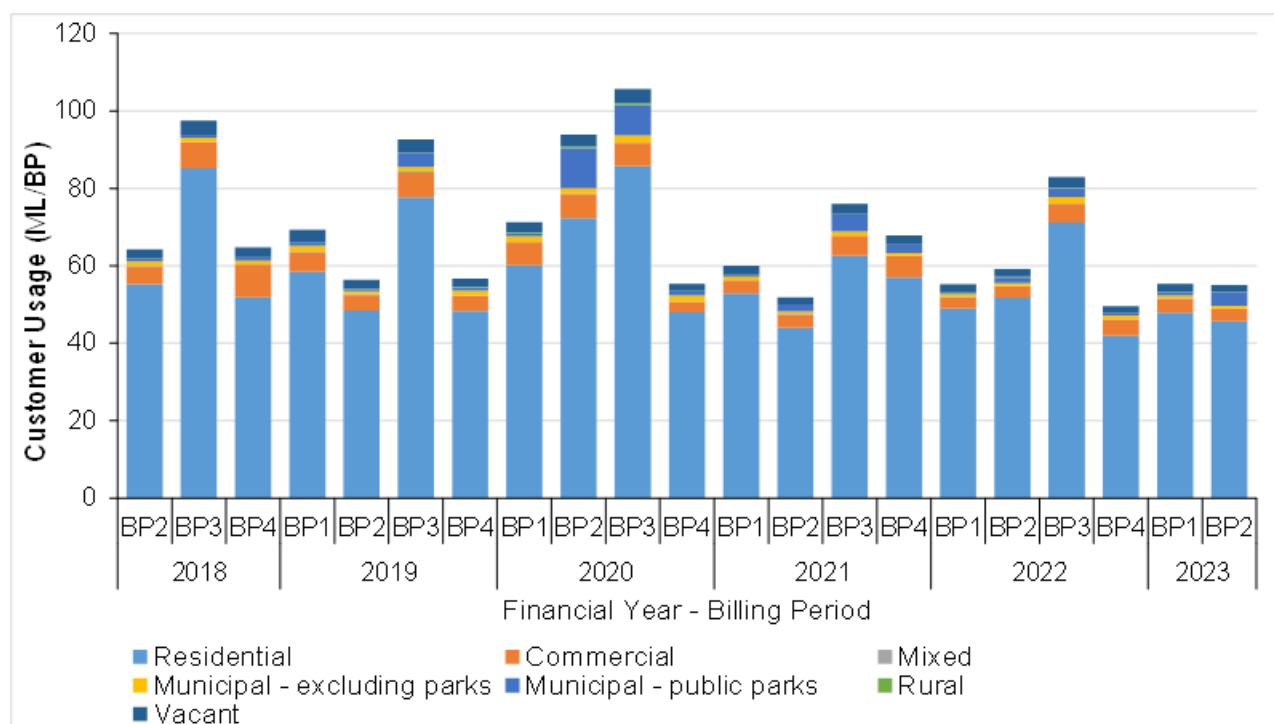


Figure 5-12: Historical metered customer usage by user category - Bungendore Potable WSS

5.3.3 Major non-residential users

The criteria used to identify major non-residential users was any non-residential customer that used more than 1% of the total metered customer usage for the Bungendore Potable WSS. This results in four major users. There is also a plant nursery growing seedlings in greenhouses, this has been added as a major user as the water consumption is nearly as high as the other major users and the expected sewer load is low and therefore, the site needs special consideration. The historical usage for the major users is shown in Table 5-8.

Table 5-8: Major Water Users – Bungendore WSS

Major User	Average Yearly Demand (ML/year)	Highest Yearly Demand (ML/year)
Bungendore Park	5.62	17.53
The Lake George Hotel	2.02	2.98
The Village Square	1.59	4.75
Bungendore Sports Hub	0.83	3.20
Nursery	1.56	2.28

The average yearly demand for Bungendore Sports Hub is higher than presented in the table because data was collated in its formative years. The average yearly demand for the Bungendore Park is less than the data presented in the table because potable water formally used for irrigation has been replaced by treated effluent from the STP.

5.3.4 Water balance

The historical water production from the WTP, and metered customer usage data were used to calculate a water balance over Bungendore WSS. The water balance used is the standard developed by the International Water Association (IWA) Water Loss Task Force. The method used to calculate the different components of the water balance is given in Appendix D.1.

The water balance for Bungendore WSS is shown in Table 5-9, and shown graphically in Figure 5-13.

The historical averages over eight billing periods 2020/21 Q2 (6/10/2020) and 2022/2023 Q1 (23/09/2022) were used in the water balance.

Table 5-9: Water Balance – Bungendore WSS

Raw water supplied to WTP 324 ML/year	Water supplied to Bungendore WSS (WTP production) 300 ML/year	Authorised consumption 255 ML/year	Billed authorised consumption 253 ML/year	Residential	226 ML/year
				Rural	0 ML/year
				Commercial	16 ML/year
				Municipal- excluding parks	4 ML/year
				Municipal- public parks	7 ML/year
		Unbilled authorised consumption			2 ML/year
		Water losses in distribution 45 ML/year	Apparent losses		1 ML/year
			Real losses 44 ML/year	Avoidable real losses	10 ML/year
				Unavoidable real losses from mains	16 ML/year
				Unavoidable real losses from service connections	18 ML/year
Losses at WTP 24 ML/year				24 ML/year	

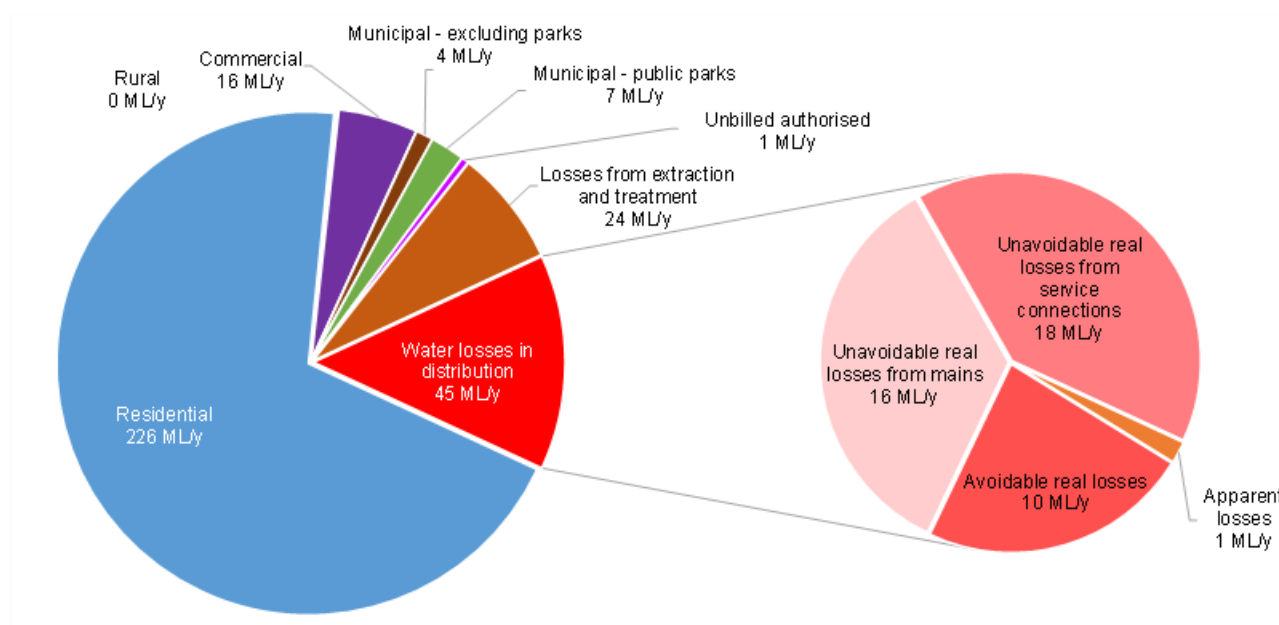


Figure 5-13: Water Balance – Bungendore WSS (ML/year)

Based on the above water balance, Bungendore WSS has an average Infrastructure Leakage Index (ILI) (the ratio of current annual real losses to unavoidable real losses) of around 1.3 which is categorised in the best performing leakage performance category (LPC A1) [6]. For Utilities with losses in this range it is not economically viable to reduce leakage further unless there are water shortages.

On average, authorised consumption made up around 85% of the water produced by the WTP in the billing data. This results in non-revenue water accounting for 15% of the total water produced. The historical average unit water loss is estimated to be 80 L/connection/day, which is approximately 1.08 times the state median of 74 L/connection/day.

5.3.5 Non-Revenue Water

Non-revenue water (NRW) is made up of several components including:

- unbilled authorised consumption which includes water used for fire-fighting and operational uses for example mains flushing.
- apparent losses including illegal connections and metering inaccuracies.
- real losses, mostly leakage from the network.

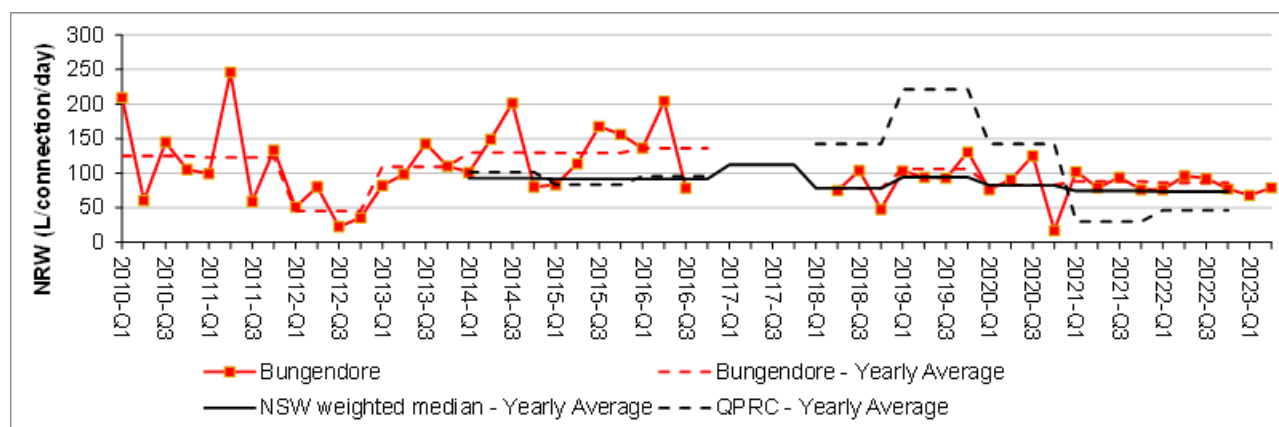
The NRW for the Bungendore schemes is given in Table 5-10. NRW is higher than the 2021-22 state-wide median of 73 L/connection/day and the LGA yearly average of 46 L/connection/day. The LGA yearly average is based on the combined service areas including Queanbeyan and adjacent suburbs and villages, who are served with water from ICON Water (ACT).

Table 5-10: Bungendore NRW Summary

	2017/18	2018/19	2019/20	2020/21	2021/22
Bungendore					
Average NRW (kL/day)	108	150	120	133	132
Number of Connections	1392	1418	1456	1509	1543
Average NRW (L/connections/day)	77	106	83	88	86

The water balance period used in Section 5.3.4 used the period from Q2 2021 to Q1 2023, the NRW in Q1 2023 was lower (78 L/connection/day) than in Q1 2021 (102 L/connection/day) bringing down the average reported (80 L/connection/day) when compared to the 2020/21 and 2021/22 financial years.

The average daily non-revenue water by quarter for Bungendore is graphed in Figure 5-14.

**Figure 5-14: Bungendore historical non-revenue water**

Overall, the NRW has improved since the previous IWCM analysis was completed. For the last two years, NRW has been reasonably stable and only varying between 68 and 102 L/connection/day). Since the last IWCM, the annual average NRW to decreased from 125 L/connection/day to range between 90 and 105 L/connection/day.

The historical average unit water loss for the water balance period is estimated to be 80 L/connection/day using the water balance methodology (see Section 5.3.4), this accounts for some meter losses not accounted for in the NRW calculation. The unit NRW for the water balance period is 82.4 L/connection/day. This will be used in the projection.

5.3.6 NSW Health independent verification

As of 2023 Council collects water quality samples for the NSW Health verification program from two points in the Bungendore.

NSW Health water quality data from the previous seven years (July 2016 to October 2023) were analysed. Typical water quality from the points in Bungendore in Appendix table A-5. The parameters that did not meet the guideline values were:

- pH exceeded 8.5 in January 2017 (two samples collected a fortnight apart) and January 2023 (a single sample). There have also been several periods when the pH has been between 8 and 8.5 for extended periods, including over six months between July 2016 and January 2017.
- Turbidity exceeded 5 NTU in for a single sample collected in January 2017.

While the following parameters complied with the ADWG, they are still of interest:

- A sample contained an arsenic concentration close to the guideline in August 2019 and samples regularly have concentrations over the limit of reading. Therefore, increased testing for arsenic in the raw water may be required.
- Sodium exceeds the concentration recommended for those on low sodium diets. Therefore, doctors and hospitals need to be informed of the sodium concentration so they can provide appropriate advice to their patients.

5.3.7 Risks identified from the DWMS Risk Register

According to the DWMS Risk register, for Bungendore WSS, the 'Very High' risks are identified below:

- STP overflows and leaks;
- OSSMS and other contaminants in the aquifer;
- Chlorine dose failure causing ineffective disinfection and alarm failures;
- Naturally occurring contaminants such as iron and manganese were found in the source water;
- Loss of trained operators;
- pH correction failure;
- Filters failure and ineffective backwash;
- Faecal contamination due to access by birds and rats;
- Dead end in reticulation leading to loss of chlorine residual, and contaminating the treated water due to back flow and cross connection;
- Aged water/short circuiting/thermal stratification/loss of chlorine residual;
- Breach of pipelines through breaks, inappropriate maintenance, new or service works.

Based on the DWMS [1] the Residual Risk with Preventative Measures continues to remain 'Very High' for the following: potential pathogen contamination issues due to breach of pipeline, and cross contamination due to backflow. **Issue.** Council is currently reviewing the DWMS including this risk assessment.

5.4 Best practice compliance – LWU Circular 18

This circular was prepared in 2014 to address local water utilities of a new protocol to ensure safety of drinking water supplies across regional NSW. LWUs were required to review and update their standard operating procedures to ensure three key barriers were achieved.

5.4.1 Barrier 1: Effective distribution

LWU Circular 18 states that disinfection is the single process that has had the greatest impact on drinking water safety. Two actions should be undertaken to achieve effective disinfection.

5.4.1.1 Action 1: Monitoring of factors which affect disinfection

LWU Circular 18 recommends LWUs to monitor the factors which affect effective disinfection including chlorine residual, turbidity and pH levels. These factors are monitored at Bungendore WTP as part of its CCP (see Section 5.2.4).

Circular 18 recommends keeping turbidity as low as practicable, aiming for less than 1 NTU. pH should be as low as possible and Circular 18 states that a level between 7.2 to 8.2 is desirable.

Turbidity is not a CCP or collected in Bungendore. The Currandooly WTP filtered water turbidity has been consistently below 1 NTU since 2018. (See Figure 5-8).

5.4.1.2 Action 2: Achieve minimum chlorine contact time (C.t)

Circular 18 recommends that a minimum C.t. value of 15 mg.min/L is achieved, as recommended by the ADWG.

C.t. is calculated for the 100-kL collection tank at Bungendore Aeration tower and the clear water tank at Currandooly WTP.

C.t. for water leaving collection tank at Bungendore Aeration tower:

- Aeration tower flow = 4.5 ML/day on a 22-hour basis
- Collection Tank = 100 kL
- Baffling factor of 0.3 used for contact tank assuming it has ‘single or multiple unbaffled inlets and outlets, no intra-basin baffles’ [7]
- Free chlorine concentration = 0.7 mg/L (Council’s CCP critical limit)
- C.t. = 6.2 mg.min/L

The total C.t from chlorination at Bungendore aeration tower to outflow is 6.2 mg.min/L, which is below the recommended minimum value of 15 mg.min/L. **Issue**

C.t for water leaving the Currandooly’s clear water tank.

- Plant flow = 2 ML/day on a 22-hour basis
- Clear water tank = 4.56 ML
- Baffling factor of 0.3 used for contact tank assuming it has ‘single or multiple unbaffled inlets and outlets, no intra-basin baffles’ [7]
- Free chlorine concentration = 0.5 mg/L (Council’s CCP critical limit)

- C.t. = 451.4 mg.min/L

The total C.t from chlorination at Currandooly WTP to outflow is 451.4 mg.min/L which is above the recommended minimum value of 15 mg.min/L.

5.4.2 Barrier 2: Distribution system integrity

Council's reservoirs are inspected each week which requires a check of perimeter security and a walk-around inspection and top inspection of the reservoir. Council uses Reservoir Integrity as a CCP in all three water supply schemes, however technically it is not a CCP.

Council provided the inspection reports recently for each reservoir. As of the last inspection no issues were identified, and no actions were required at any of the eight reservoirs.

5.4.3 Barrier 3: Maintain a free chlorine residual in the distribution system.

Circular 18 recommends a minimum chlorine residual of 0.2 mg/L in the distribution system. Council monitors free chlorine daily in the reticulation of each of the water supply schemes.

Refer to Section 5.3.6 for the reticulation water quality of Bungendore WSS. Most of the free chlorine measurements of the reticulation water were above the minimum requirements.

5.5 Analysis of production data

A water demand analysis is undertaken to calculate the unit demands, estimate the water losses and forecast the following demands:

- Average (rainfall) year demands – for revenue planning
- Unrestricted future year demands – to assess drought security
- Peak day demands – to assess system reliability.

The 30-year forecasts based on the nominated growth, are used to identify the issues in meeting the adopted water supply security, and reliability objectives of the urban water supply system. Further explanation on the water demand analysis can be found in Appendix E.

Analysis and modelling were undertaken on the water production data i.e. the water going into the reticulation system, recorded at the outlet of the treated water pumps.

5.5.1 Trend correction

Analysis and modelling were undertaken on the water production data i.e., the water going into the system.

Modelling was undertaken to understand the impact of various factors/trends (demographic, climatic, economic etc.) on the variability of town water demand.

The factors that were considered were:

- Historical water requirement for grass irrigation (lawns and public open spaces) obtained from the simulated water use model by PW. The model uses location-specific historical rainfall and evaporation data, soil type and grass type.
- Historical water requirement for use of evaporative coolers. The model uses location-specific historical maximum temperature data.

- Historical number of water connections.
- Non-revenue water.

The weather data (rainfall, temperature, synthetic pan evaporation, evapotranspiration) was all sourced from SILO (Scientific Information for Land Owners) data service (State of Queensland (Department of Environment and Science), 2023).

The aim was to develop models which, when input with historical factors/trends, would output a production that correlates well with the actual historic production.

Once the best model is selected, the production was hindcast to estimate the likely water production for a repeat of the historical climate from July 1889 to June 2023, with the current users and losses.

5.5.2 Production modelling

Water production records from July 2001 to February 2023 were analysed. The production data is the sum of the volume pumped out of the aeration tower at the bores and volume pumped from Currandooly WTP to the reservoirs.

The model showed that outdoor irrigation was the most significant contributor to Bungendore's demand variability. There was also an additional increase in demand during warm to hot weather that resembles evaporative cooler air conditioning water use when the maximum temperature was over 25°C as well as an increase in demand in line with customer growth.

The production model was then hindcast over a 133-year period of available climate data of historical temperature, rainfall and evaporation to estimate the annual demands if the current conditions of lot size, household size, number of connections, pricing and usage patterns were to prevail. The hindcast is shown in Figure 5-15.

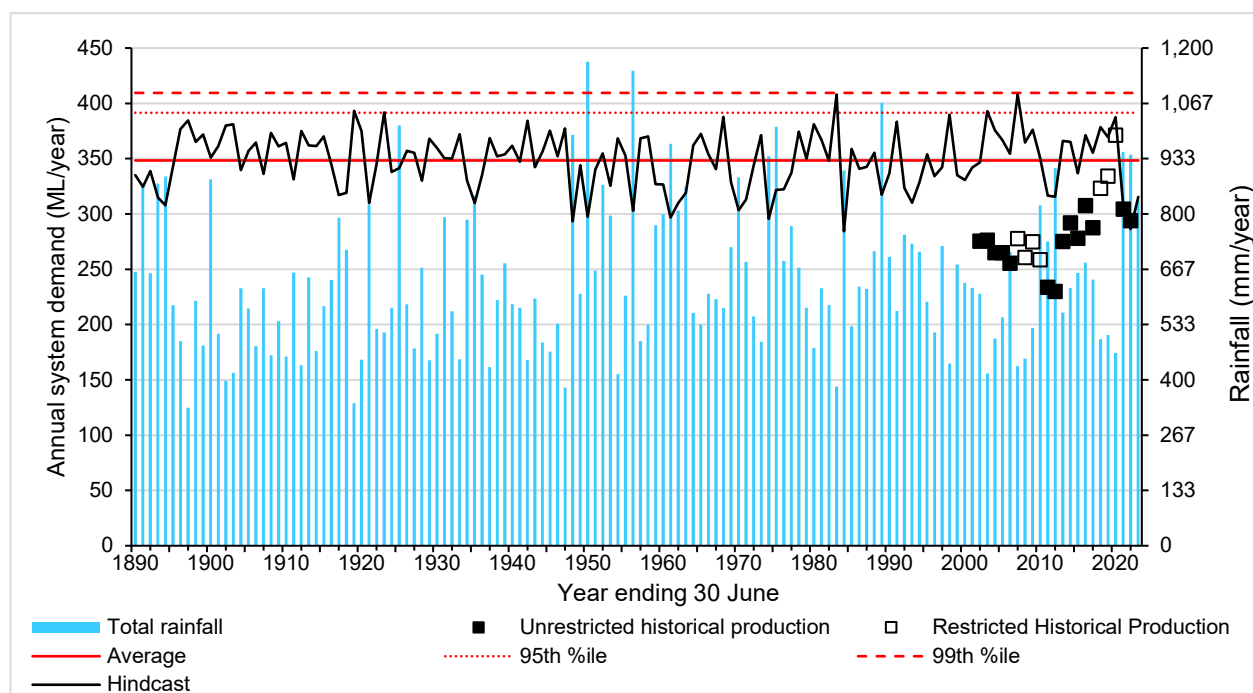


Figure 5-15: Production model hindcast – Bungendore raw water supply

The hindcast was also used to estimate the historical ADPW production. For the analysis the 99th%ile (1 in 100 year) unrestricted future production was selected from the hindcast as the starting points for the forecasts. The model results are presented in Table 5-11.

Table 5-11: Bungendore modelled unrestricted production

	From historical data	Modelled outcomes
Average year (ML/year)*	307	348
99th percentile unrestricted future year (ML/year)**	371	410
Average day peak fortnight (ML/day)	1.78	1.91
Average day peak week (ML/day)	1.89	2.09
Peak day (ML/day)	2.24	2.98

* Historical average from the 10 years 2012/13 and 2021/22, there were some water restrictions in this period

** Historical maximum was from 2019/20, there were severe water restrictions

Bungendore's peak day was estimated to be 2.8 ML/day in 2016 as per the previous IWCM. From the updated modelled unrestricted production, the modelled peak day is 2.98 ML/day. Between 2016 and 2022 there was a 20% increase in the number of water assessments consuming water. Therefore, the 6% increase in the peak day demand is lower than would be expected from assessment growth.

5.5.3 Effect of climate change

5.5.3.1 Previous IWCM methodology

Since the previous IWCM climate change analysis was completed, there have been two major revisions to the NSW Public Works climate change modelling method.

The previous IWCM methodology used seasonal changes to rainfall and evapotranspiration sourced from the CSIRO "Climate Change in Australia Report" and the maximum daily temperature increased by 1.25°C. The climate dependent use has been re-calculated using the current climate dependent consumption models, the current SILO Data and the weather data modified in the same way as was used in the previous IWCM. Refer to Appendix table F-1 and Appendix table F-2 for detailed calculation output.

5.5.3.2 NARClIM 1.5

More recently, DCCEE has started to recommend the use of data from the New South Wales (NSW) and Australian Capital Territory (ACT) regional climate modelling (NARClIM) version 1.5.

The NARClIM 1.5 dataset contains information for two future greenhouse gas concentration trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC). The trajectories are known as representative concentration pathways (RCPs). The RCPs for which data is available are:

- RCP 4.5, this is the most probable baseline scenario (no climate policies) considering the exhaustible character of non-renewable fuels. Under this scenario, the greenhouse gas concentration stabilise in 2080.
- RCP8.5, generally taken as the basis for worst-case climate change scenarios, was based on what proved to be overestimation of projected coal outputs. Under this scenario, the greenhouse gas concentration stabilises in 2250.

The data is available for:

- Three global climate models (GCMs), these models have a resolution of 100's of square kilometres.
 - CanESM2 produced by the Canadian Centre for Climate Modelling and Analysis (CCCMA)
 - ACCESS1.0 produced by a CSIRO and Bureau of Meteorology collaboration.
 - ACCESS1.3 produced by a CSIRO and Bureau of Meteorology collaboration.
- The ERA-Interim reanalysis data set, this is a global atmospheric reanalysis produced by the European Centre for Medium-Range Weather Forecasts (ECMWF). This dataset uses historical observations to create global data sets describing the recent history of the atmosphere, land surface, and oceans.

Each of these data sets is then downscaled using two separate regional climate models (RCMs).

The demand changes for Bungendore and Braidwood were estimated using the three GCMs, two RCMs, and two future time periods (before and after 2060). The results are summarised in Appendix table F-7 to Appendix table F-12. When there was a decrease in demand instead of an increase, the cells are shaded grey.

For the demand forecasts, the probable climate change forecasts have been calculated using the maximum increase from the RCP 4.5 models for the period between 2006/07 to 2058/59. The more severe climate change forecast uses the maximum increase from either the RCP 4.5 or 8.5 models and either time period. For Bungendore, the highest increase in the 99th percentile dry year demand was the maximum increase under RCP 4.5 between 2006/07 and 2058/59. The increase in system demand for Bungendore is summarised in Table 5-12.

Table 5-12: Climate change impact on system demand

Representative Concentration Pathway	RCP description	Average year	99th %ile dry year	Average day peak week	Average day peak fortnight
RCP4.5	Probable	4.77%	6.81%	3.86%	3.73%
RCP8.5	High severity	8.08%	6.81%	1.47%	3.68%

5.5.3.3 *Paleo-stochastic*

DCCEEW generated 10,000-year daily data sets of rainfall and potential evapotranspiration using observed data sets (at meteorological stations) combined with paleo climate data for use in the regional water strategies. Data is currently publicly available for selected weather stations in the NSW and ACT Murray Darling Basin catchments and will be released soon for the Nepean and Shoalhaven catchments. The closest site with the required parameters for irrigation modelling was Ainslie ACT in the Murrumbidgee Catchment.

The results from the paleo stochastic data were compared to the results from the SILO data for the same period. The results are summarised in Appendix table F-26.

Overall, based on the stochastic data, there is a very low probability (less than 0.1%) of more water being required for irrigation than was shown in the SILO data on a yearly basis. There is a chance that the average day peak week irrigation demand may be higher than estimated from the SILO data, using the SILO data, irrigation was required 4 days during the maximum week, using the stochastic data, irrigation was required 5 days during the maximum week, though this only occurred in 5 out of the 9,999 financial years.

5.6 Analysis of customer usage

The billing data was provided by assessment and meter. Some assessments had more than one meter, these are either major users (like the school) or properties where the meters were replaced. As each assessment was taken as a connected property, analysis was undertaken on an assessment basis.

5.6.1 Modelling of customer usage

Customer usage patterns were modelled in a similar way to production data.

The maximum and 99th percentile (1 in 100 year) unrestricted future year demands were selected as the starting points for the 30-year projections. The model results for user classes are given in table 6-12.

Table 5-13: Estimated customer usage from climate correction – Bungendore WSS

User Class	Average year demand (kL/year)	Unrestricted future year demand (kL/year)	Average day demand (kL/day)	Peak day demand (kL/day)
Business	14,496	17,669	39.7	83.9
Church	454	2,183	1.2	12.0
Community	939	1,455	2.6	9.6
Council General	873	1,319	2.4	7.3
Council Sewer	200	765	0.5	3.3
Council Water	15	65	0.0	0.8
Education	1,604	2,143	4.4	8.6

User Class	Average year demand (kL/year)	Unrestricted future year demand (kL/year)	Average day demand (kL/day)	Peak day demand (kL/day)
Farm	528	1,338	1.4	5.2
Government	440	617	1.2	2.4
Mixed	575	946	1.6	4.7
Major User	12,456	29,574	34.1	229.9
Public Parks and Gardens	1,497	2,410	4.1	11.3
Residential	220,147	239,090	602.7	907.0
Total	254,222	299,573	696.0	1,286.0

The residential, non-residential and total consumption were significantly climate dependent.

Overall, residential users were significantly climate dependent, whereas most non-residential user classes were climate independent.

5.6.2 Unit residential demands

5.6.2.1 Existing dwellings

The residential unit demands for each scheme were assessed by climate correcting historical data, using the modelled demand for lawn irrigation.

Using a threshold of 60 L/connection/day for an active connected residential property resulted in 94% of the assessments in Bungendore WSS being active in 2022/23, which corresponds reasonably well to the percentage of dwellings occupied from the 2021 ABS Census data. (See Table 4-3).

The unit demand per active residential connection is then estimated from the number of active assessments. The results are given in Table 5-14.

Table 5-14: Unit demand per active residential assessment – Bungendore WSS

	Average year (kL/year)	Average day (kL/day)	Unrestricted future year (kL/year)	ADPW (kL/day)	Climate dependence	Climate independent (kL/day)	Climate independent (kL/person/day)	Approximate WELS Rating
All	203	0.556	245	1.317	Irrigation	0.424	0.145	2 to 3
Unsewered	174	0.478	174	0.478	Irrigation	0.478	0.164	1 to 2
Sewered	202	0.554	245	1.324	Irrigation	0.421	0.144	2 to 3

The baseline internal demand per person was estimated by dividing the internal demand by the household size of standard private dwellings in Bungendore.

5.6.2.2 New dwellings

In July 2004 the NSW Government implemented the Building Sustainability Index (BASIX) with the purpose of reducing the use of potable water and to produce less greenhouse gas emissions.

Bungendore is in the BASIX 40% reduction target zone for water [8]. This means that the target average annual water demand for a resident in a BASIX dwelling is 54 kL/person/year. Using current the household size of 2.92 for Bungendore to provide a baseline, the target average annual water demand for a BASIX compliant dwelling is 158 kL/year. This is substantially less than the current average demand by sewerer dwellings of 202 kL/year.

Council has implemented the Palerang Development Control Plan 2015, it provides detailed development provisions for development in the former Palerang LGA and states that is “subject to overriding planning controls in State Environmental Planning Policies and legislation”. Section B17 requires all new dwellings in areas with reticulated water have rainwater tanks installed with a minimum tank size determined by Council, this contravenes the NSW State Environmental Planning Policy (Building Sustainability Index: BASIX) 2004 which states that it overrides provisions of other environmental planning instruments and development control plans that would otherwise add to, subtract from, or modify any obligations arising under the BASIX Scheme. **Issue.**

A sensitivity analysis was undertaken to assess the impact of these tank sizes for two and three bedrooms dwellings a range of household sizes. The results are discussed in Appendix G. The tanks are significantly more effective at reducing demand in average years than in hot dry years, increasing the demand variability and therefore increasing the variability in water sales. **Issue**

The unit demands for Bungendore were based on the following dwelling and household configuration: 3 (or more) bedroom house, 22.5 kL rainwater tank, 190 m² connected roof area, rainwater tank supplying water to the irrigated garden area, toilets and washing machine, 250 m² of lawn irrigated by the tank (the same area used in the 2018 IWCM), 3* WELS appliances, 3 person households.

The demands for new dwellings in Bungendore are summarised in Table 5-15.

Table 5-15: Unit demands for new houses in Bungendore

Tank	Household size	Average year (kL/year)	Average day (kL/day)	Unrestricted future year (99th %ile) (kL/year)	Peak day (kL/day)	Average day peak week (kL/day)	Average day peak fortnight (kL/day)
With tank	3.0	139	0.381	208	1.243	1.243	1.151
Without tank	3.0	233	0.637	269	1.243	1.243	1.151
66% with tank	3.0	171	0.468	229	1.243	1.243	1.151
95% with tank	3.0	230	0.629	267	1.243	1.243	1.151
Previous IWCM	2.9	180	0.493	240	1.612		

In June-July 2014 Hunter Water and Hunter Research Foundation carried out a study of rainwater tank functionality in 191 properties in the suburbs of Cameron Park and Fletcher (new suburbs in the west of the Newcastle LGA and Lake Macquarie LGA) built since BASIX was enacted [9]. This study found that

- 18% of the tanks had failed (tank leaking, gutter to tank plumbing not operational, switching device not operating, pump not operational)
- 16% of the systems had previously required pump or switch replacement
- 23% of systems were underperforming.

In 2018, Hunter Water commissioned the Institute for Sustainable Futures at University of Technology Sydney to review recent publications and case studies on potable rainwater substitution through household rainwater harvesting [10]. This study reported that it would be reasonable to assume that an average of 66% of rainwater tanks are functional at any time.

Therefore, the main projection will be undertaken on the basis that 33% of homes not using tanks. A sensitivity analysis will also be undertaken on the basis that 5% of homes are not using tanks to simulate the impact of Council assistance, subsidies or other incentives to residents to keep systems operating optimally.

5.7 Projections

Average year demand projection will be used for revenue requirement planning, un-restricted (dry) year demand for sizing of headworks and peak day production is used for sizing of water treatment works or pumping facilities.

Water demands for the Bungendore WSS are projected as follows:

- The initial unrestricted annual demands are based on the 99th percentile unrestricted demand and the peak day demands estimated from the 120-year hindcast.
- For each new residential dwelling the unit demand is developed from the data provided in Table 5-15, adjusted for the percentage of operating rainwater tanks assumed for the case.
- The unit NRW for existing and new customers is assumed to be 82.4 L/meter/day (see Section 5.3.5).
- For non-residential demand, the future demands are based on the initial demand multiplied by a population growth scaler. The population scaler is a ratio between average projected population (see Table 4-12) and average population in 2022.

A summary of the average year metered consumption projection is given in Table 5-16. The main projection is based on 66% of the residential rainwater tanks in new dwellings operating optimally. Sensitivity assessments were undertaken to assess the impact of tank failure on residential consumption.

Table 5-16: Summary of projected average year metered consumption (ML/year) – Bungendore

% of residential tanks operating	User category	2025	2030	2035	2040	2045	2050	2055
66%	Residential	236	281	334	396	469	555	656
	Non-residential	38	44	52	61	72	85	99
	Total	274	325	386	457	541	639	755
95%	Residential	234	272	316	369	430	503	588
0%	Residential	242	303	375	460	560	677	815

A summary of the water projections (based on 66% of the tanks operating) is given in Table 5-17.

Table 5-17: Summary of water supply projections – Bungendore WSS

Reservoir		2025	2030	2035	2040	2045	2050	2055
Days Hill	Average Year Demand (ML/year)	134	165	166	166	167	167	168
	Unrestricted Future Year Extraction (ML/year)	149	190	190	191	192	194	195
	Peak Day Production (ML/day)	0.64	0.85	0.86	0.86	0.87	0.87	0.88

Reservoir		2025	2030	2035	2040	2045	2050	2055
Turallo	Average Year Demand (ML/year)	191	198	206	216	227	240	256
	Unrestricted Future Year Extraction (ML/year)	230	241	255	271	291	313	340
	Peak Day Production (ML/day)	1.05	1.11	1.19	1.29	1.39	1.52	1.68
North Elmslea	Average Year Demand (ML/year)	0	21	66	66	66	66	66
	Unrestricted Future Year Extraction (ML/year)	0	28	85	85	85	85	85
	Peak Day Production (ML/day)	0.00	0.14	0.43	0.43	0.43	0.43	0.43
North Elmslea Zone 2	Average Year Demand (ML/year)	0	0	18	91	177	278	397
	Unrestricted Future Year Extraction (ML/year)	0	0	23	117	228	358	512
	Peak Day Production (ML/day)	0.00	0.00	0.12	0.60	1.17	1.84	2.62
Total of all zones (historical climate)	Average Year Demand (ML/year)	325	385	455	539	636	751	887
	Unrestricted Future Year Extraction (ML/year)	378	459	553	665	796	950	1131
	Peak Day Production (ML/day)	1.69	2.11	2.60	3.18	3.86	4.67	5.61
Combined system	Average Year Demand (ML/year)	372	432	502	586	683	798	934
	Unrestricted Future Year Extraction (ML/year)	441	521	616	727	858	1,012	1,194
	Peak Day Production (ML/day)	2.40	2.82	3.32	3.90	4.58	5.38	6.33
Combined system with climate change	Average Year Demand (ML/year)	389	452	526	613	716	836	978
	Unrestricted Future Year Extraction (ML/year)	471	557	658	777	917	1,081	1,275
	Peak Day Production (ML/day)	2.50	2.93	3.44	4.05	4.75	5.59	6.57

5.8 Water security assessment

Water for Bungendore WSS is supplied by four groundwater bores in Bungendore and one groundwater bore in Currandooly. An investigation into the sustainability and drought resilience of the groundwater source is being undertaken.

Council's WAL entitlement to extract water from the Bungendore Alluvial Groundwater bores is 472 ML/year. The water security assessment is done for the future unrestricted extraction which is based on the 99th percentile from the hindcast. RCP 4.5 was adopted as the probable climate change scenario for forecasting unrestricted future extraction shown in Figure 5-16, an additional projection was undertaken to assess the impact of keeping 95% of the rainwater tanks operating and this is included in the graph.

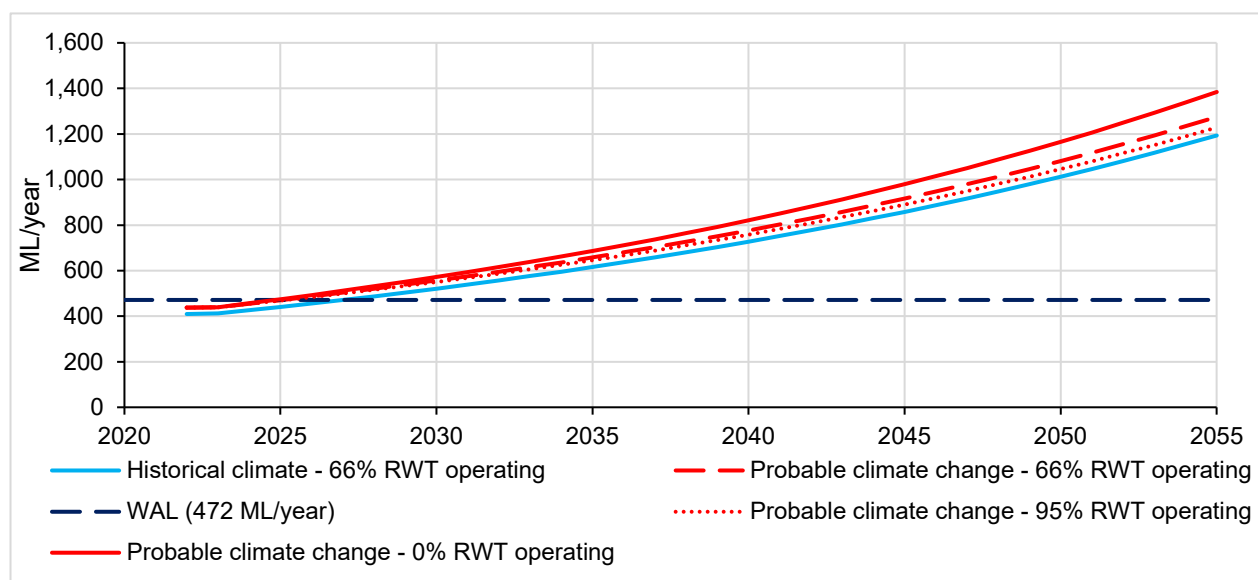


Figure 5-16: Projected unrestricted future extraction for Bungendore WSS compared to historical production (RCP 4.5 probable climate change scenario)

Projected unrestricted future extraction with the effect of climate change reaches between 1,107 and 1,260 ML/year by 2055 depending on the proportion of rainwater tanks operating correctly. The 99th percentile dry year extraction reaches the 472 ML/year WAL entitlement by 2028 (or soon after development resumes).

5.9 System capacity assessment

This will be undertaken through a review of the hydraulic model built by Public Works in the previous engagement.

5.10 Application of Health-Based Treatment Targets

Health-Based Target (HBT) have been introduced in the Australian Drinking Water Guidelines to determine the tolerably low level of microbial risk for drinking water. The HBT will provide the basis for determining the treatment requirements and will help define the performance standards that apply to treatment processes.

The application of HBTs requires that the source risk to a drinking water supply be assessed and quantified, and depending on the risk, a log-reduction in pathogens by treatment is required. If a system were not to meet the recommended Log Reduction Values (LRVs) then a potential issue would arise.

PW has developed an HBT Assessment tool which categorised catchments into vulnerability categories (See Appendix figure C-1 for Bungendore bores and Appendix figure C-2 for

Currandooly bores). The tool was used to assess the inherent microbial risk from each water source catchment, the performance of the treatment barriers, and the residual microbial risk after treatment.

5.10.1 HBT assessment of threats

Bungendore WSS sources water from four Bungendore bores and one Currandooly Bore. Since this water source is a groundwater, vulnerability assessment is not required.

5.10.2 Inherent risk

Based on the HBT assessment, the Bungendore groundwater source has an inherent risk of Medium (Vulnerability Class 2) (ADWG [11]) assuming:

- Bore caps and bore casing are in good condition and prevents surface water ingress.
- There is aquitard layer between the surface water and the water bearing aquifer.
 - Based on the bore drill logs, there are several clay layers between the surface water and the water bearing aquifer
 - Council's bores are screened in the deeper semi-confined Lachlan formation alluvium, which is not directly connected to surface water.
- there are no disused uncapped bores close to the town water supply bore allowing ingress of surface water into the aquifer.

The aerial view of the catchment of Bungendore/Currandooly water supply source is shown in Figure 5-17.

Overall inherent risk prior to the treatment is 'Medium' from Bungendore bores and Currandooly bore.

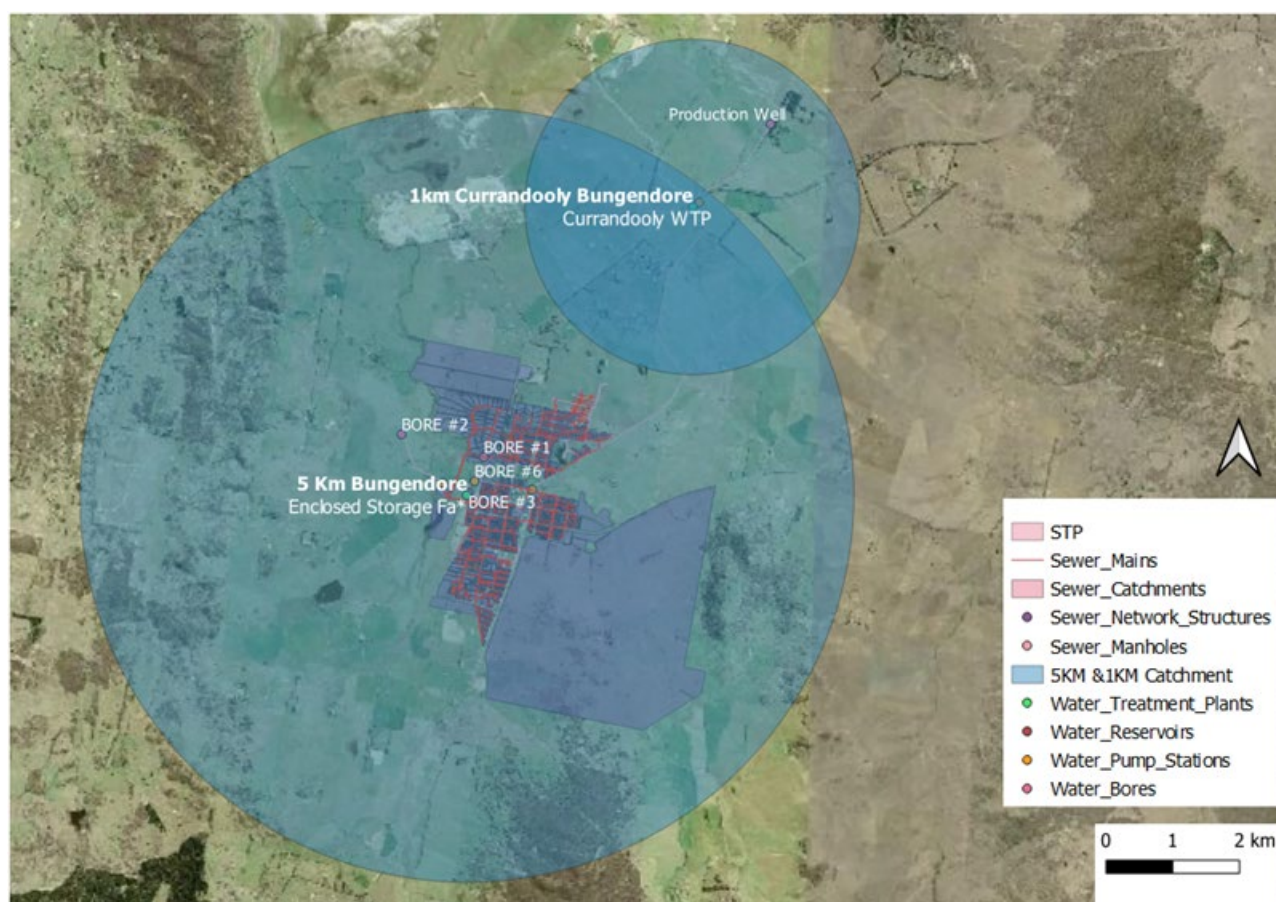


Figure 5-17: Bungendore/Currandooly water supply source

5.10.3 HBT assessment of treatment barriers

5.10.3.1 Treatment barriers for chlorine sensitive pathogens

Currandooly WTP is a conventional filtration plant with chlorine as the disinfection barrier. The criteria used for assessing the effectiveness of treatment barriers are as follows:

- Filtered water turbidity < 1 NTU
- Chlorine contact > 15 mg.min/L

Between 2015 and 2017, the filtered water turbidity from Currandooly exceeded 1 NTU on 13 occasions. Between 2018 and 2023 the turbidity has been consistently less than 1 NTU. Currandooly WTP does achieve a chlorine contact time of more than 15 mg.min/L. Therefore, the treatment barrier for chlorine sensitive pathogens is considered effective.

Bungendore WTP does not achieve a chlorine contact of 15 mg.min/L (see 5.4.1.2), therefore the treatment barrier for chlorine sensitive pathogens is not considered effective.

Residual risk of chlorine sensitive pathogens: Medium (Vulnerability Class 2) (ADWG [11]). **Issue**

5.10.3.2 Treatment barriers for chlorine resistant pathogens

There is Currandooly WTP monitoring turbidity after filtration, however no data is available for the Bungendore WTP turbidity as there is no filtration. The criteria used for assessing the effectiveness of the filters are:

- Highest individual filtered water turbidity recorded ≤ 0.3 NTU
- Highest monthly 95th percentile individual filtered water turbidity ≤ 0.15 NTU

From Section 5.2.4 using the most recent (2021) data, the highest filtered water turbidity exceeded 0.3 NTU, and the highest monthly 95th percentile turbidity was calculated to be 0.4 NTU.

Residual risk of chlorine resistant pathogens **Medium. Issue**

5.10.4 NSW Health preliminary cryptosporidium risk assessment

Based on NSW Health (letter sent to Council in November 2019), there is a '**Low**' risk rating of cryptosporidium in the raw water source for Bungendore (see Appendix figure C-5)

5.11 Work health and safety

No major WHS issues were noted from the condition assessment site visit.

6 Braidwood water supply scheme

6.1 Raw water source

6.1.1 Water resource

The Braidwood Water Supply Scheme sources raw water from an 80 ML off-stream dam built in the mid-1980s. The storage dam is filled from the Shoalhaven River which lies within the upper region of the Southern Rivers Catchment area and forms the upper regions of the Sydney Drinking Water Catchment. The catchment area above the intake is 1,114 km². The river intake pumps are operated manually as required. When in operation they run 24 hours per day at 1.38 to 1.68 ML/day (depending on which pump is in service).

6.1.2 Raw water extraction

After raw water extraction from the Shoalhaven River to the 80 ML off-stream dam, the water is then pumped from a submerged pipe in the off-stream dam to the Braidwood WTP.

Capacities of assets for raw water extraction for Braidwood are as follows:

Table 6-1: Braidwood raw water extraction asset's capacities

Asset	Capacity
Braidwood	
Shoalhaven River transfer pumps	16 -19.5 L/s
Braidwood WTP	2 ML/d (25 L/s) – 22 hours/day

The schematic arrangement of the raw water and Braidwood WTP is shown in Figure 6-1.

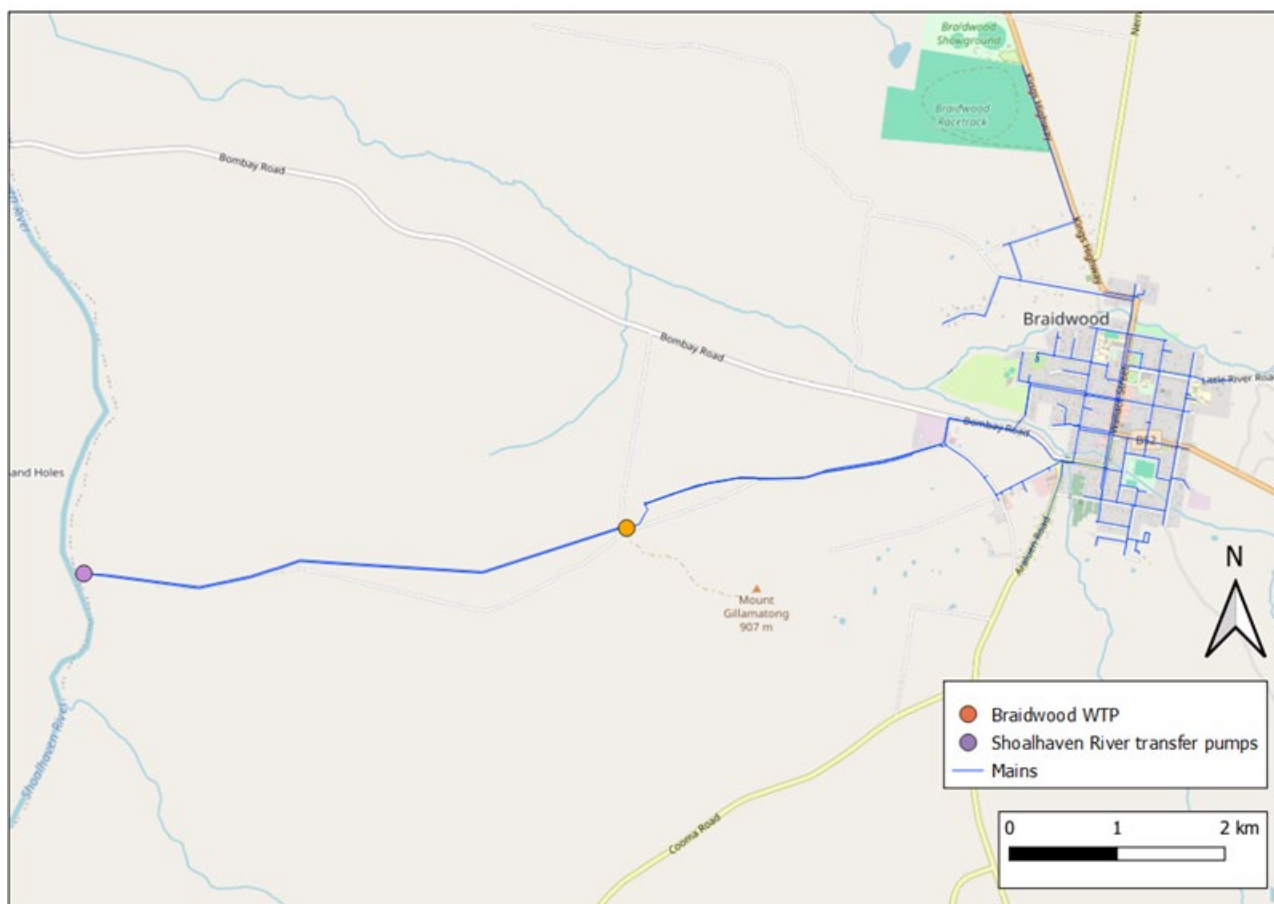


Figure 6-1: Location of raw water intake for Braidwood WTP

6.1.3 Water access licences

Council holds Local Water Utility Water Access License (WAL25376), issued under the Water Management Act 2000, which relates to the water supply to Braidwood. The following table summarises the key details of the WAL.

Table 6-2: WAL Licence numbers

WAL license number	WAL25376
Category [Subcategory]	Local Water Utility
Entitlement	360.0 ML/year
Water Source	Mid Shoalhaven River Water Source
Works approval	10CA102425

WAL25376 is sourced from Mid Shoalhaven River Water Source via two 100 mm centrifugal pump and one overshoot dam.

6.1.4 Source water quality

Raw water quality was sampled between March 2014 and March 2023 approximately once every quarter. The samples are collected at Shoalhaven River intake and from the off-stream storage dam (80 ML)

Typical raw water quality for the Shoalhaven River is shown in Appendix table A-3.

The main parameters of interest in the Braidwood raw water are:

- Aluminium – one sample collected on 30/11/2020 (1.3 mg/L) was exceptionally high in aluminium. Other than this sample, about 2 out of 38 (approximately 5%) of samples contain aluminium in concentrations above 0.2 mg/L.
- Blue-green algae – 298 cells/mL of Total Cyanophyta was detected in the off-stream storage dam (80 ML) on 13/11/2019.
- *Escherichia coli* (E. coli)– has been tested using a method that provides an estimate of the Most Probable Number (MPN), 26 out of 38 (68%) of samples were above 1 MPN/100 mL and 3 (less than 1%) of samples were above 100 MPN/100mL. The maximum E.coli recorded was 250 MPN/100 mL.
- pH – pH occasionally increases but remains below the ADWG (Australian Drinking Water Guidelines) of 8.5 pH Unit. 2 out of 38 (5%) samples are above 8.2 pH Unit.
- Iron – 4 out of 38 (11%) of the samples contained above 0.3 mg/L.
- Turbidity - one sample collected on 30/11/2020 (7.2 NTU) was above 5 NTU.

6.2 Water treatment

6.2.1 Treatment process

Water pumped from the Shoalhaven River is treated with the following Dissolved Air Flotation and Filtration treatment process at Braidwood WTP:

- Pre-dosing with optional power activated carbon, aluminium chlorohydrate (ACH) and caustic soda
- Flash Mixer to uniformly disperse the chemicals dosed
- Coagulation, flocculation, flotation and filtration
- Post dosing using gas chlorine for disinfection, caustic soda for pH correction, and fluoride.

The WTP has a capacity of 2 ML/day.

A schematic showing an overview of the Braidwood water supply scheme is provided in Figure 6-2.

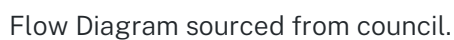


Figure 6-2: Schematic flow diagram of the Braidwood water supply scheme

6.2.2 Historical water production

Braidwood WSS supplies potable water to customers in Braidwood's reticulation system. Council provided the potable water data recording from July 2004 to February 2023. The potable water meter records flow being pumped out of the Braidwood WTP. The historical potable water volume supplied is summarised in Figure 6-3.

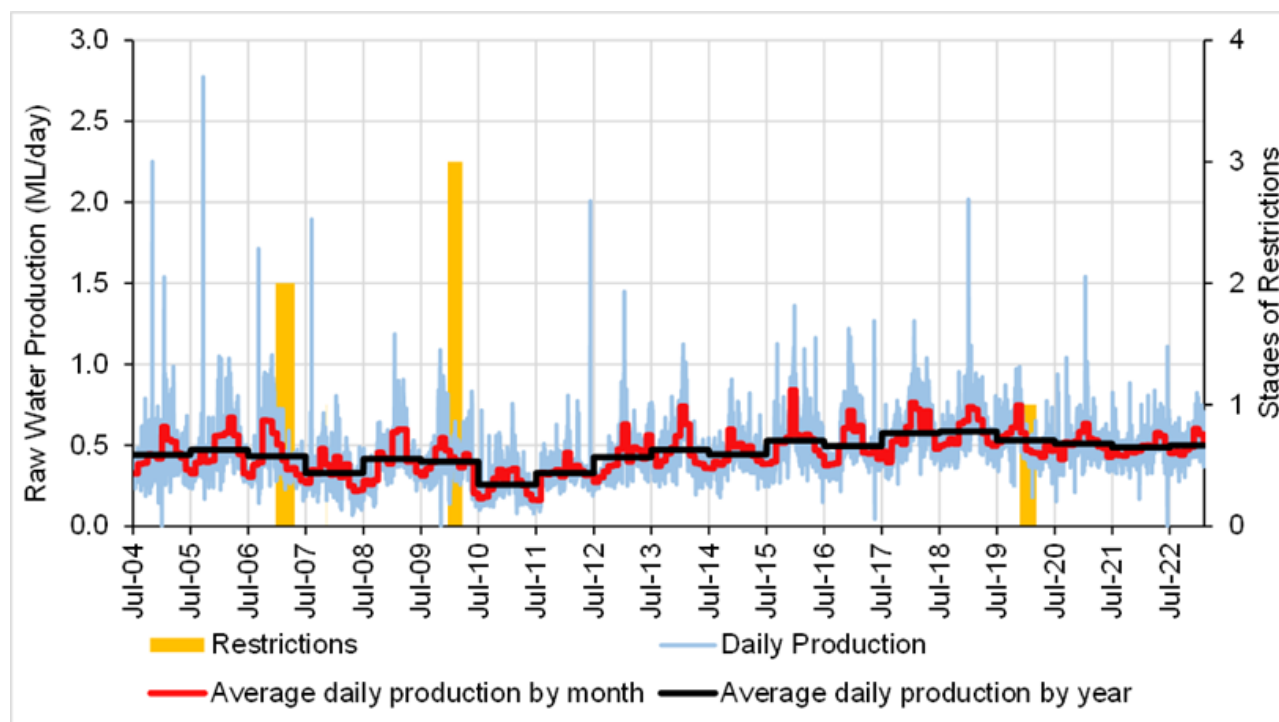


Figure 6-3: Historical production data – Braidwood potable water production

The annual summary of water production for the Braidwood WTP is shown in Table 6-3.

Table 6-3: Historical annual water production – Braidwood WTP (ML/year)

Financial Year	ML/year
2004/05	160.7
2005/06	172.1
2006/07	157.5
2007/08	119.7
2008/09	151.9
2009/10	145.7
2010/11	94.1
2011/12	120.3
2012/13	155.3

Financial Year	ML/year
2013/14	171.9
2014/15	161.7
2015/16	193.0
2016/17	180.6
2017/18	209.6
2018/19	213.5
2019/20	193.7
2020/21	186.1
2021/22	177.2

The maximum production was 213.5 kL/year for the 2018/19 financial year.

6.2.3 Peak production analysis

The historical peak fortnight pattern for the Braidwood WSS is shown in Figure 6-4.

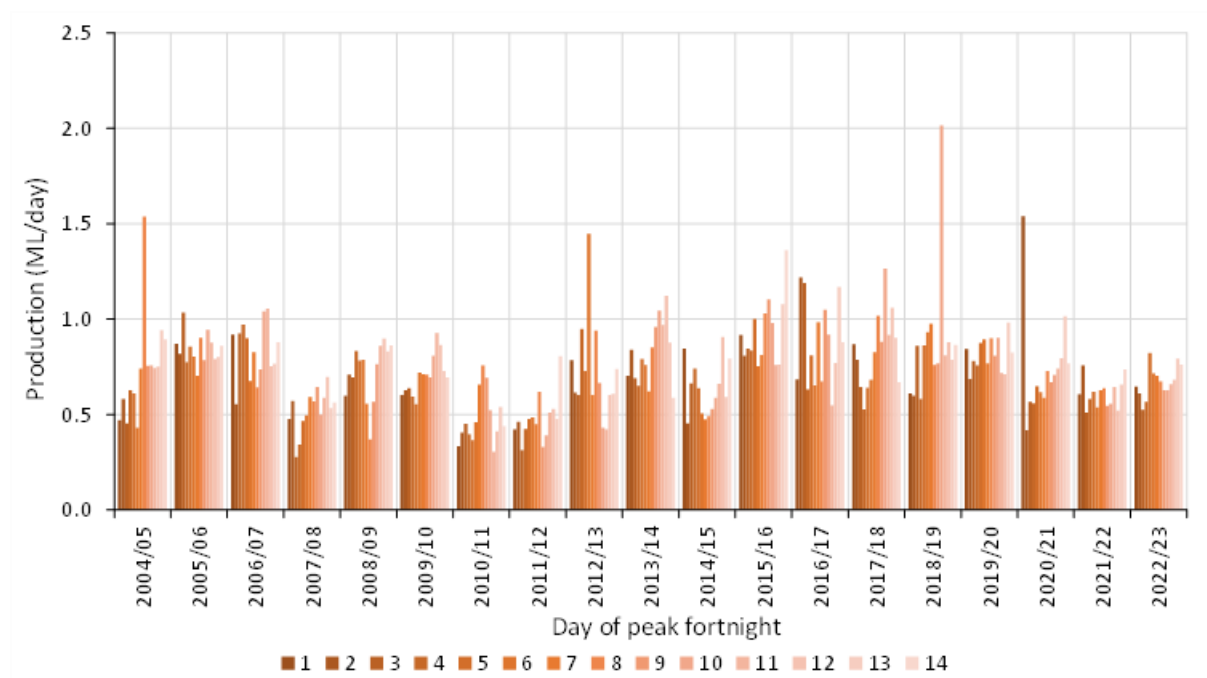


Figure 6-4: Peak fortnightly production patterns – Braidwood WTP

The highest recorded daily production in Braidwood WTP was 2.773ML which occurred on 19 September 2005. However, as the temperature of this peak day is relatively low (12.8°C), this day is not considered to be the true peak production representative of the scheme demand. It appears that this was probably a transcription error as the daily production in the week before

and the week after are all less than 0.5 ML/day. This is also likely to occurred on the 31st of October 2004, with a recorded daily production of 2.251 ML/day.

The second highest peak day production was 2.02 ML which occurred on 1 January 2019. There was no rainfall recorded leading up to the day for 8 days except 0.2 mm on the previous day and the maximum temperatures surrounding this day was high (ranged from 25°C to 35°C) as graphed in Figure 6-5. The demand was much higher than any of the days in the week before or week after even though the maximum temperature was similar. This pattern is usually seen as a response to an operational issue (for example a main break or treatment plant outage) rather than in response to customer demand. Similar peaks also occurred on 11/1/2021 (1.5 ML).

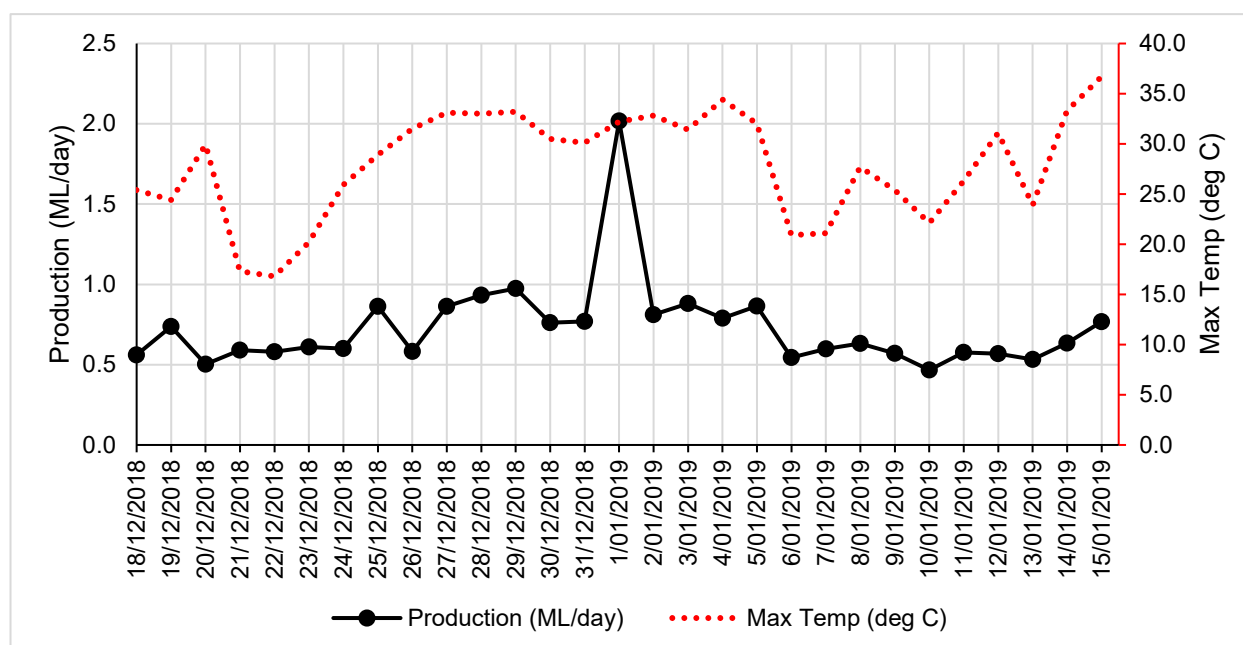


Figure 6-5: Production and maximum temperature around peak day

The average daily production over the peak week (ADPW) and peak fortnight (ADPF) was 1.01 ML/day of week starting 19 Dec 2015 and 0.93 ML/day of fortnight starting 12 December 2015 respectively. The ADPW and ADPF graphs are shown in Figure 6-6.

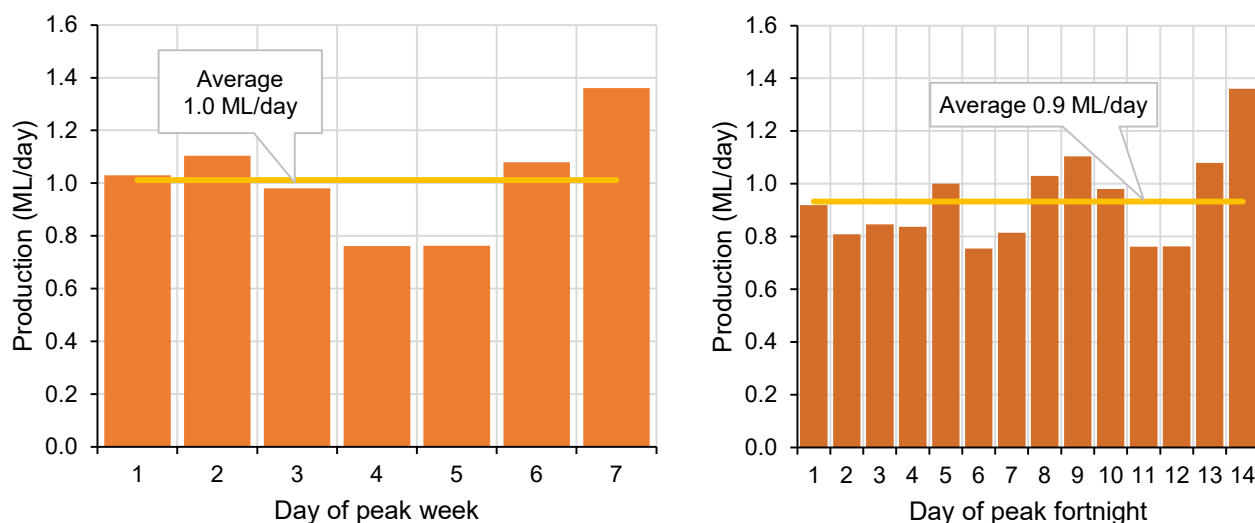


Figure 6-6: Peak week and peak fortnight production – Braidwood WTP

The PD to ADPW ratio for Braidwood WSS is **1.97**. Once the peak days of 2 ML/day are excluded, the PD to ADPW ratio is 1.36. this rounds to the PD to ADPW ratio of 1.4 observed in other systems of similar size in similar climates. a PD to ADPW ratio of **1.4** is adopted for Braidwood WSS.

A peak day production of 1.4 ML/day has been adopted for the starting point for the projection.

6.2.4 Treated water quality

According to Council's Drinking Water Management System (DWMS) [1], there are five critical control points (CCP) adopted for Braidwood WTP, shown in Table 6-4.

Table 6-4: Braidwood WSS - Critical Control Point Summary

CCP		Control parameter	Target	Alert Limit	Critical limit
Braidwood WTP	CCP1 Filtration	Filter turbidity in channel (after ripening up to 15 mins)	<0.1 NTU	>0.3 NTU	>0.5 NTU
	CCP2 Chlorination (a)	Free chlorine residual in clear water tank	1.0 to 2.0 mg/L	<0.8 mg/L or >2.0 mg/L	<0.5 mg/L or >5.0 mg/L
	CCP2 Chlorination (b)	Free chlorine residual in reticulation	>0.4 mg/L	<0.3 mg/L	<0.2 mg/L or 5.0 mg/L
	CCP3 Fluoridation	Fluoride in clearwater tank	0.95 – 1.05 mg/L	0.9 – 0.95 mg/L or 1.05-1.35 mg/L	<0.9 for 72 hrs or >1.5 mg/L

CCP		Control parameter	Target	Alert Limit	Critical limit
	CCP4 Reservoir	Reservoir Weekly Integrity	No gaps, vermin proof, secure, enclosed, locked	Breach of reservoir integrity	Evidence of vermin

6.2.4.1 Braidwood WTP

Council provided data for chlorine in Braidwood's reticulation and turbidity, chlorine, and fluorine in the clear water tank. Data sets was provided for the period between January 2015 and June 2023. All parameters increased in March/May 2020. Free chlorine in the reticulation is not considered to be a CCP.

CCP1 Filtration recorded at the clear water tank has been presented in Figure 6-7.

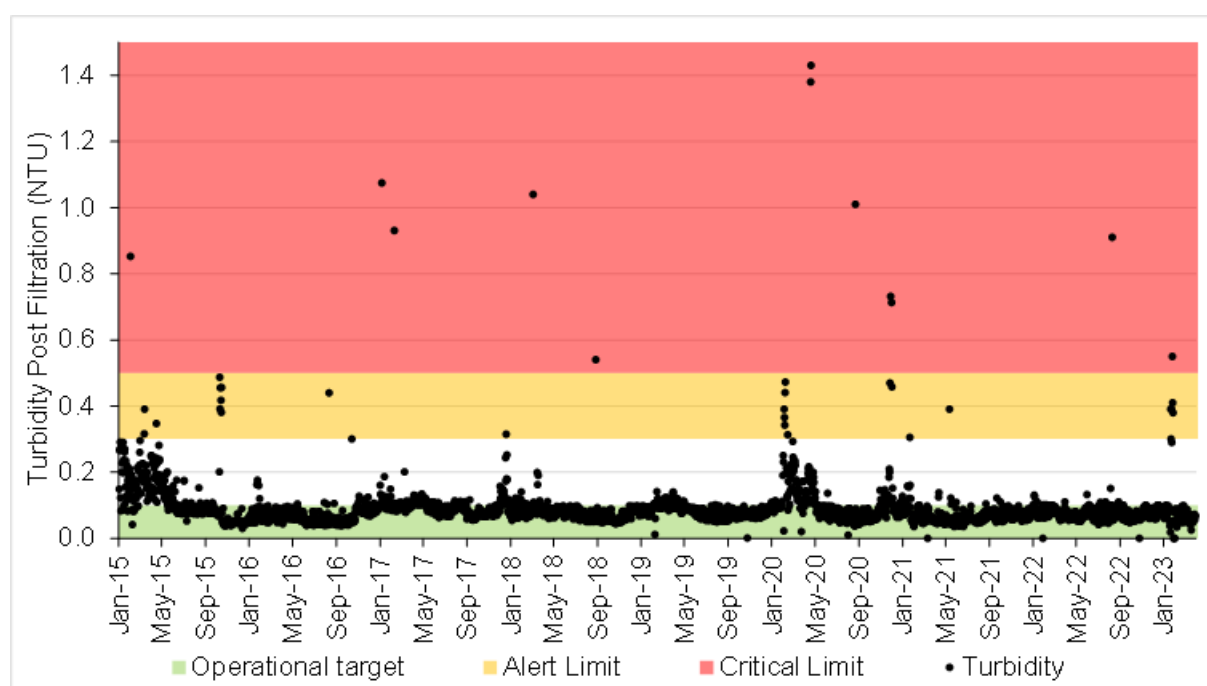


Figure 6-7: CCP1 Filtration – Historical turbidity of Braidwood WTP filtrate

Majority of the records have maintained to be around the target range. There have been 12 records which exceeded the critical limit of 0.5 NTU. Explanation from the council for the exceedances are listed below.

- Entries on 10/8/22 read 0.91 entered, however the actual result is 0.091 NTU. Master sheet modified to reflect the actual result.
- Entries on 22/8/20 read 1.01. It was noted by the supervisor as erroneous reading, field sheet shows this figure. Noted circled by supervisor. Suspect erroneous reading.

- Entries on 19/4/20 and 20/4/20 read 1.38 and 1.43 respectively. It was reviewed on the sheet for alum dosing.

CCP2 (a) Chlorination recorded at the clear water tank post filtration has been presented in Figure 6-8.

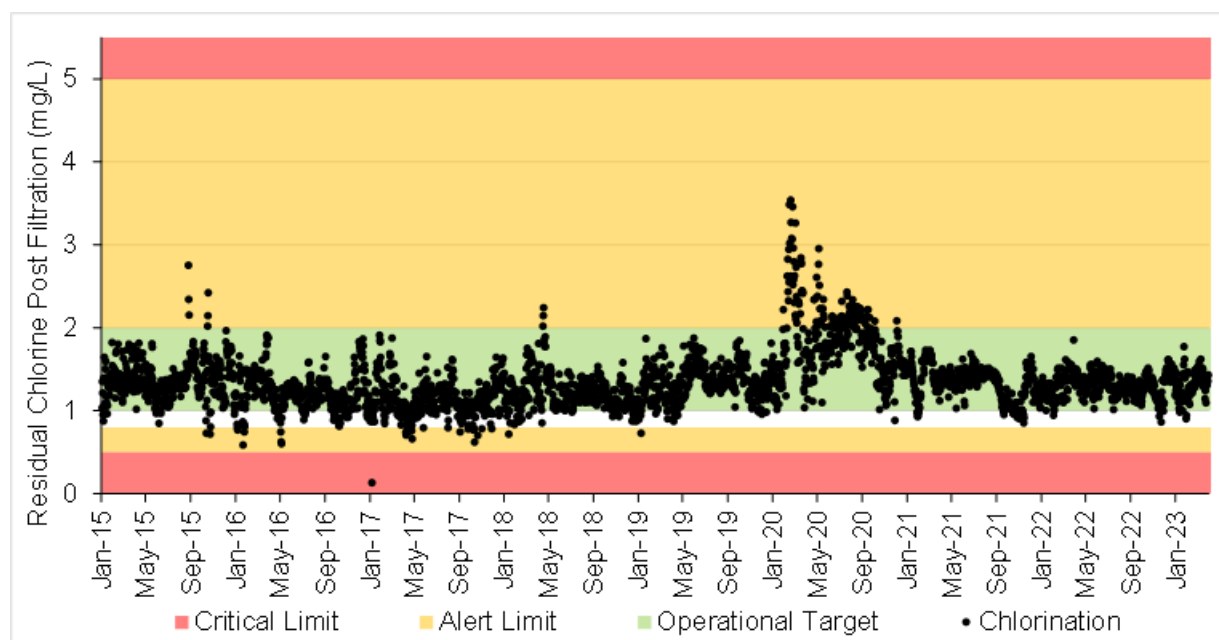


Figure 6-8: CCP2 (a) Chlorination – Historical free chlorine in clear water tank at Braidwood

Majority of the records have maintained to be around the target range.

CCP2 (b) Chlorination based on free reticulation chlorine residual has been presented in Figure 6-9

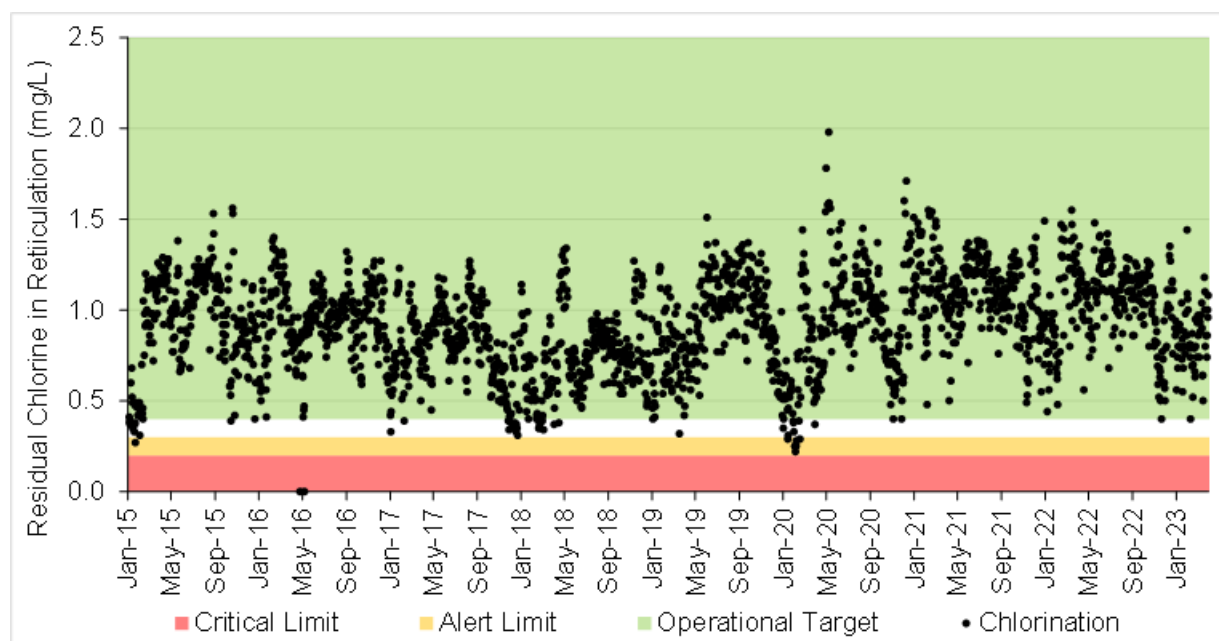


Figure 6-9: CCP1 (b) Chlorination – Historical free chlorine in reticulation of Braidwood

Majority of the records have maintained to be around the target range.

CCP3 Fluoridation recorded at the clear water tank post filtration has been presented in Figure 6-10.

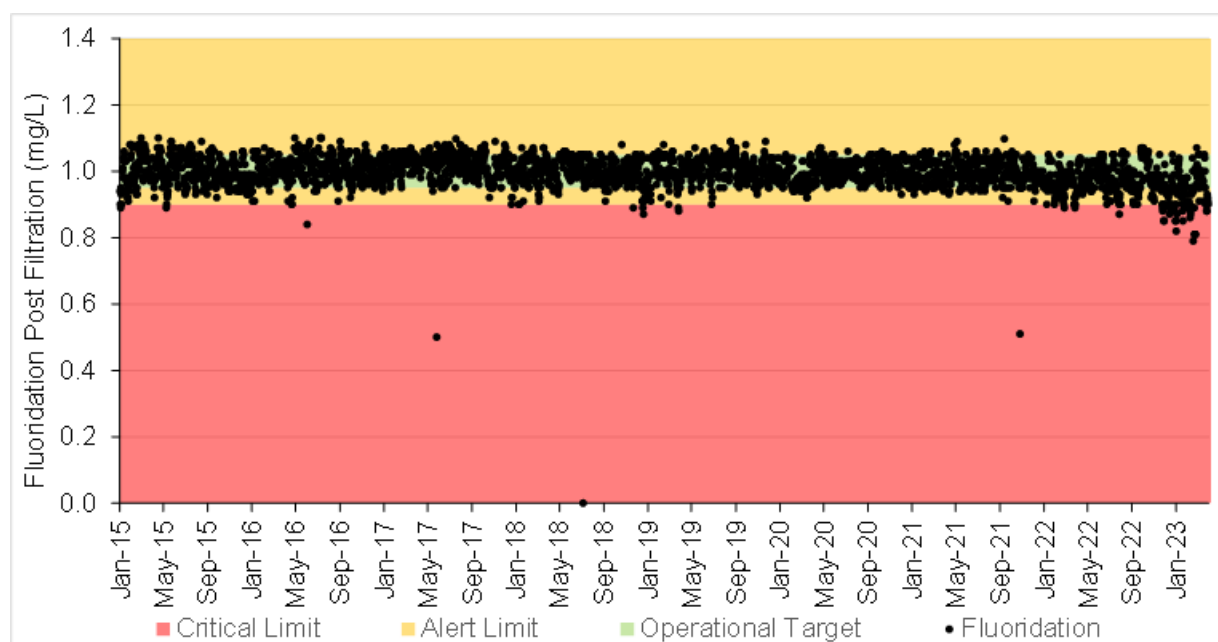


Figure 6-10: CCP2 Fluoridation – Historical fluoride in clear water tank in Braidwood

Based on the data from January 2015 and February 2023, there were recent exceedances below the lower critical limit of less than 0.9 mg/L for 72 hrs. Before July, were maintained to be within the target range. Fluoride levels started to decrease from February 2023 due to issues with the saturators causing bed caking. Council stated that they had replaced the beds of all four branded NaF saturators and recommissioned. Email evidence from council to NSW Health was sighted.

6.3 Distribution

6.3.1 Distribution system

Treated water stored at the reservoirs supply Braidwood via a 2.3 kilometre main, and gravity mains service the township. Reservoirs include two older reservoirs (0.55ML each – total 1.1ML) and a new reservoir (1.5 ML). The layout of the distribution network for the Braidwood WSS is shown Figure 6-11.

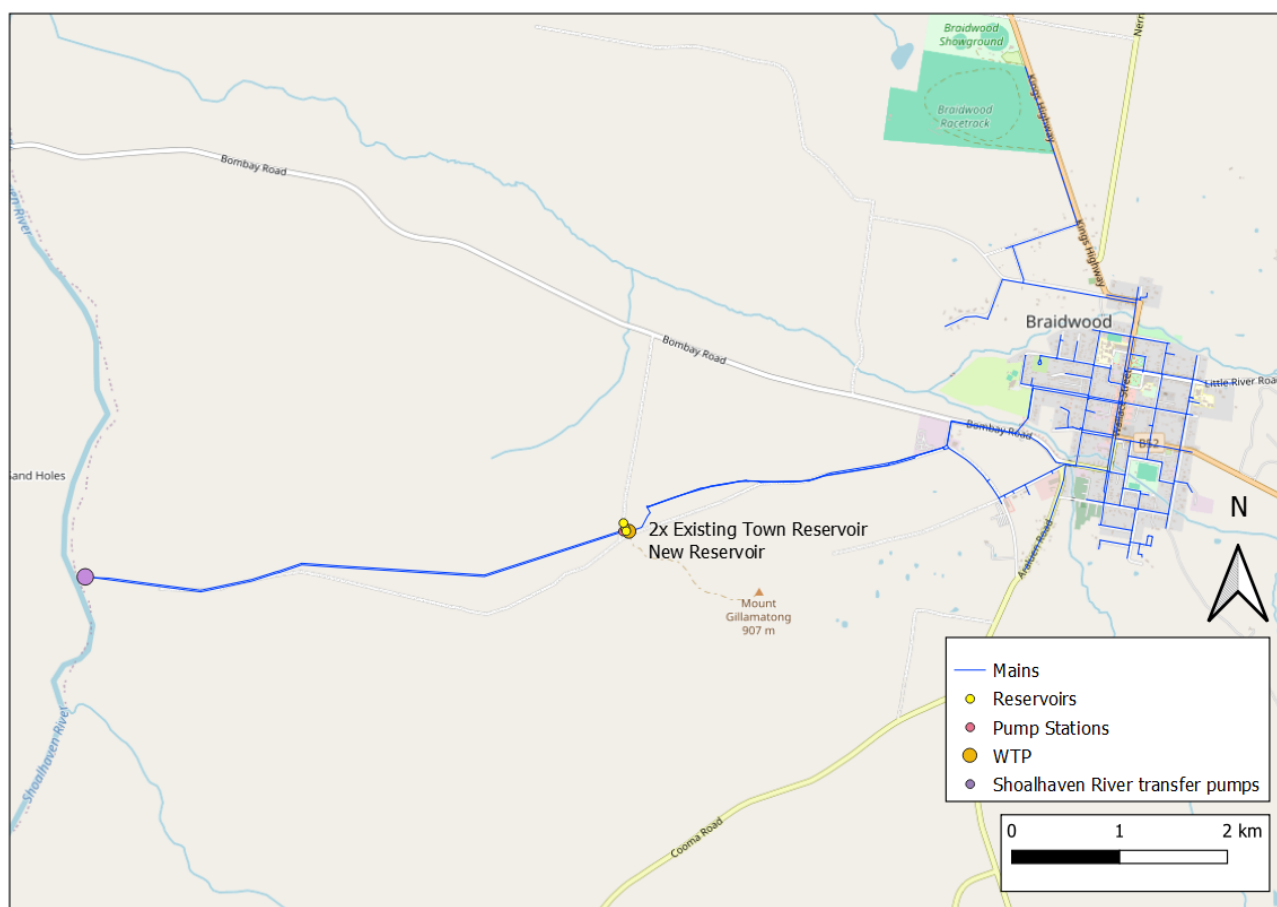


Figure 6-11: Braidwood WSS distribution

6.3.2 Metered customer demand

Council supplied billing data for all potable water customers from July 2017 to December 2022, with the water meters being read quarterly. User classes from the billing data were residential, commercial, mixed, municipal excluding parks, municipal public parks, rural and vacant.

The historical number of customer meters in the billing data and the historical metered customer usage of the last six years are shown in Table 6-5 and Table 6-6 respectively.

Table 6-5: Historical number of meters – Braidwood Potable WSS

	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
Residential	572	566	582	601	603	598
Commercial	49	49	50	49	50	47
Mixed	16	16	16	16	15	15
Municipal - excluding parks	26	27	27	25	26	25
Municipal - public parks	5	6	5	6	6	6
Rural	3	4	3	3	2	2

	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
Vacant	2	2	2	2	2	2
Total	673	670	685	702	704	695

Table 6-6: Historical metered customer usage (ML/year) – Braidwood Potable WSS

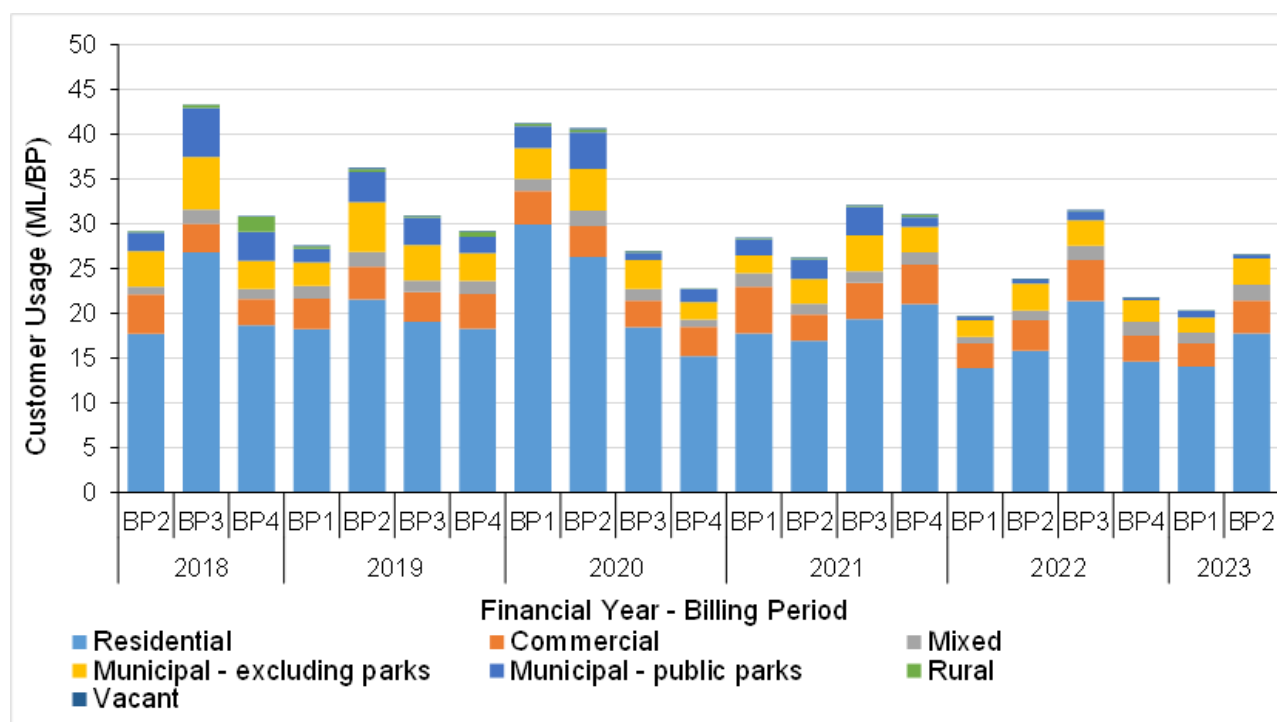
	2017/18 reads 2 to 4*	2018/19	2019/20**	2020/21	2021/22	2022/23 read 1*
Residential	70	76	91	73	69	30
Commercial	12	14	14	16	14	6
Institutional	4	6	5	5	5	3
Farm	14	15	13	11	11	4
Vacant	11	10	9	8	2	1
Mixed	2	1	1	1	0	0
Education	0	0	0	0	0	0
Total	112	123	133	115	102	44

*Demand for the 2017/18 and 2022/23 financial years is included but not complete

** Stage 2 to 4 water restrictions in place from 22/11/2019 to 5/03/2020

Customer usage was high during the dry and warm conditions in 2019/20. Historical customer usage split has been on average around 65% residential to 35% non-residential.

The historical usage for all available billing periods for Braidwood is given in Figure 6-12.



Note: Vacant are not shown in the column graph due to negligible consumption

Figure 6-12: Historical metered customer usage by user category – Braidwood Potable WSS

6.3.3 Major non-residential users

The criteria used to identify major non-residential users was any non-residential customer that used more than 3% of the total metered customer usage for the Braidwood WSS. This results in four major users; their historical usage is shown in Table 6-7.

Table 6-7: Major Water Users – Braidwood WSS

Major User	Average Yearly Demand (ML/year)	Highest Yearly Demand (ML/year)
Braidwood Recreation Grounds	2.76	5.34
Ryrie Park North (Inc Braidwood Memorial Pool)	2.44	4.63
Ryrie Park South	2.06	3.60
The Firewood King (Firewood Supplier) and TEGRA (Quarry)	2.74	3.07

There is not currently an effluent reuse scheme in Braidwood. Future capital works for the sewerage scheme may include an option for a recycled effluent scheme.

6.3.4 Water balance

The historical water production from the WTP, and metered customer usage data were used to calculate a water balance over Braidwood WSS. The water balance used is the standard developed by the International Water Association (IWA) Water Loss Task Force. The method used to calculate the different components of the water balance is given in Appendix D.1

The water balance for Braidwood WSS is shown in Table 6-8, and shown graphically in Figure 6-13.

The historical averages over eight billing periods 2020/21 Q1 (28/06/2020) and 2021/2022 Q4 (16/06/2022) were used in the water balance.

Table 6-8: Water Balance – Braidwood WSS (ML/year)

Raw water supplied to WTP 197 ML/year	Water supplied to Braidwood WSS (WTP production) 182 ML/year	Authorised consumption 110 ML/year	Billed authorised consumption 109 ML/year	Residential	77 ML/year
				Rural	0 ML/year
				Commercial	15 ML/year
				Municipal- excluding parks	11 ML/year
				Municipal- public parks	5 ML/year
			Unbilled authorised consumption		1 ML/year
		Water losses in distribution 72 ML/year	Apparent losses		1 ML/year
			Real losses 71 ML/year	Avoidable real losses	38 ML/year
				Unavoidable real losses from mains	17 ML/year
				Unavoidable real losses from service connections	16 ML/year
Losses at WTP 15 ML/year				15 ML/year	

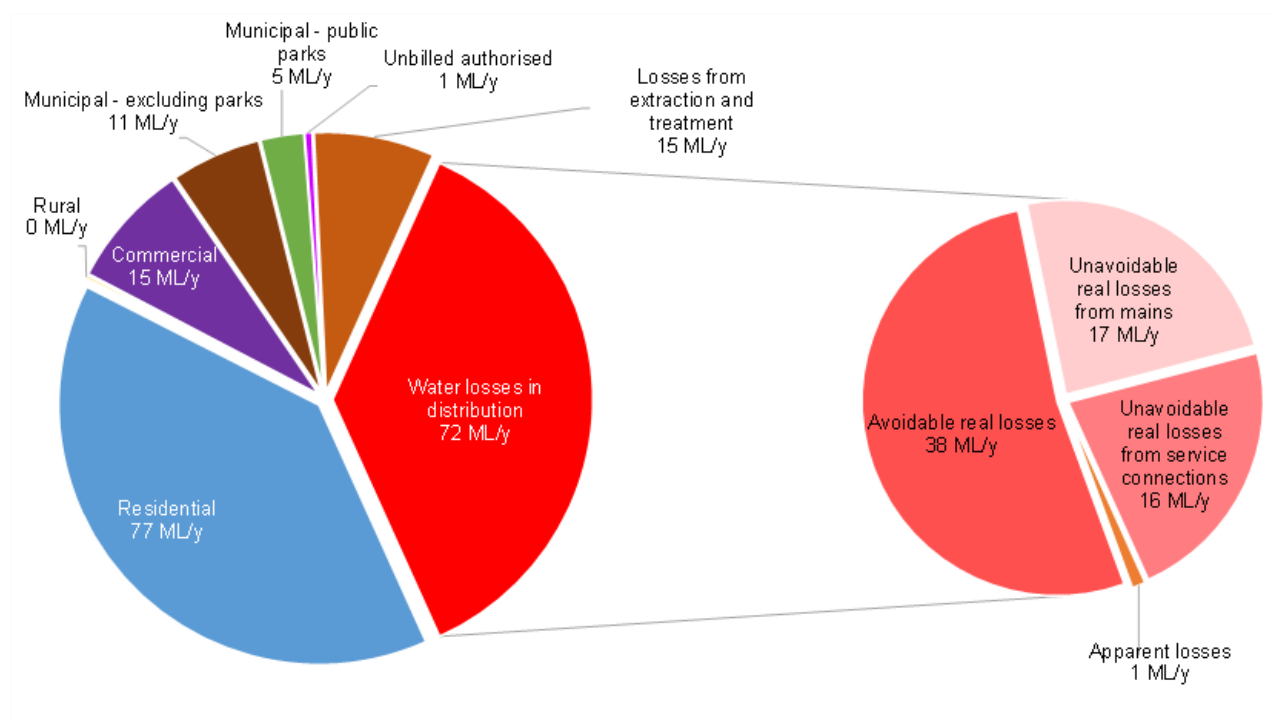


Figure 6-13: Water Balance – Braidwood WSS (ML/year)

Based on the above water balance, Braidwood WSS has an average ILI (current annual real losses / unavoidable real losses) of around 2.1 which is categorised in the third-best performing leakage performance category, B1 [12]. Utilities with losses in this range are expected to be able to make significant improvement using techniques including pressure management, active leakage control and better maintenance.

On average, authorised consumption made up around 61% of the water produced by the WTP in the billing data. This results in non-revenue water accounting for 39% of the total water produced. The historical average unit water loss is estimated to be 249 L/connection/day, which is approximately 3.4 times the state median of 74 L/connection/day. **Issue**

The daily NRW calculated for the previous IWCM was 168 kL/day (2013/14), 154 kL/day (2014/15) and 183 kL/day (2015/16), about 35%. The NRW for the period used for the water balance averaged 127 kL/day, showing some improvement. Note that the period used for the water balance was also relatively wet, greatly reducing the overall demand for water, causing the percentage NRW to increase.

6.3.5 Non-Revenue Water

Non-revenue water (NRW) is made up of several components including:

- unbilled authorised consumption which includes water used for fire-fighting and operational uses for example mains flushing.
- apparent losses including illegal connections and metering inaccuracies.
- real losses, mostly leakage from the network.

The NRW for the Braidwood schemes is given in Table 6-9 NRW is higher than the 2021-22 state-wide median of 73 L/connection/day and the LGA yearly average of 46 L/connection/day. The

LGA yearly average is based on the combined service areas including Queanbeyan and adjacent suburbs and villages, who are served with water from ICON Water (ACT).

Table 6-9: Braidwood NRW Summary

	2017/18	2018/19	2019/20	2020/21	2021/22
Average NRW (kL/day)	202	248	167	193	205
Number of Connections	709	763	772	781	792
Average NRW (L/connection/day)	285	325	216	247	259

The average daily non-revenue water by quarter for Braidwood is displayed in Figure 6-14

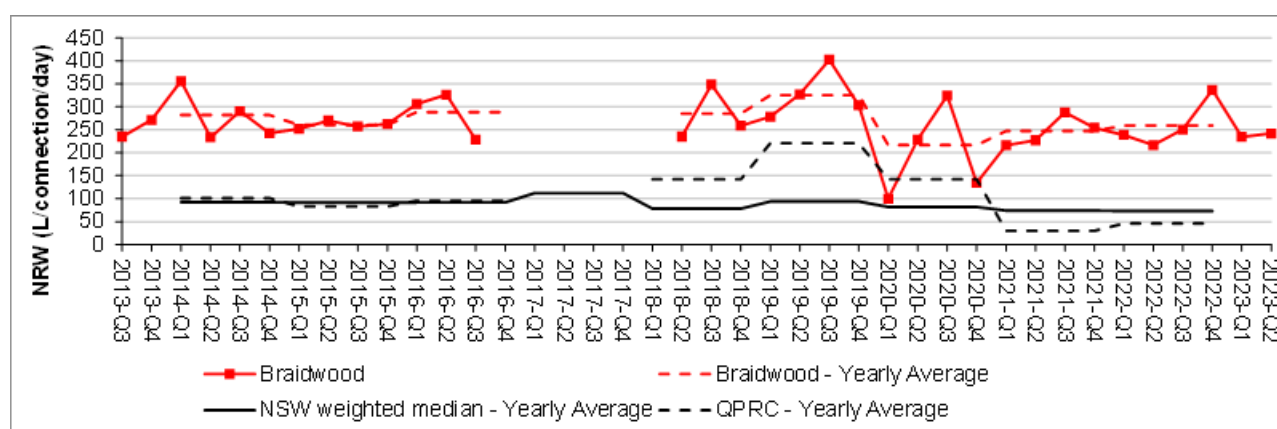


Figure 6-14: Braidwood historical non-revenue water

Braidwood has highest NRW of the Palerang water supplies as it is the oldest network. Approximately 12 km out of 19 km of Braidwood's network is 65 years old (sourced from water asset list provided by council). It has the highest number of main breaks. 26 out of 173 complaints was related to main bursts over 3 years from October 2019 to November 2022 (sourced from water complaints since 2019 provided by council). There have been main breaks every 1-3 months with some months have main breaks more than once. **Issue.**

Since the previous IWCM, council has replaced 2.2 km of trunk main connecting the reservoirs to the town and spent \$50,000 replacing old, galvanised water mains in town. These measures may have contributed to a decrease in NRW observed starting in Q1 2020.

In 2018/19, the NRW reached high values which have not been observed before. In 2019/20, the NRW values returned to the previously observed range. As seen in Figure 7-13, NRW is climate dependent. There may be a user that is not metered which uses water to irrigate and council may need to investigate.

The historical average unit water loss for the water balance period is estimated to be 249 L/connection/day using the water balance methodology (see Section 6.3.4), this accounts for some meter losses not accounted for in the NRW calculation below. The unit NRW for the water balance period is 253.2 L/connection/day, this will be used as the unit water loss in the high NRW projection for the new properties.

The minimum unit NRW was 99.8 L/connection/day for the quarter ending September 2019, this will be used as the unit water loss in the low NRW projection for the new properties.

6.3.6 NSW Health independent verification

Council collects water quality samples for the NSW Health verification program from four points in the Braidwood as of 2023.

NSW Health water quality data from the previous seven years (July 2016 to October 2023) were analysed. Typical water quality from the points in Braidwood in Appendix table A-6. The parameters that did not meet the guideline values were:

- Aluminium (0.2): 1 exception in February 2020.
- Fluoride weekly laboratory sampling (0.9 – 1.5): 23 exceptions, all with concentrations slightly below the recommended minimum concentration.
- Fluoride ratio (0.8 - 1.2) 1 exception in March 2018
- pH exceeded 8.5 in January 2017 (two samples collected a fortnight apart) and January 2023 (a single sample). There have also been several periods when the pH has been between 8 and 8.5 for extended periods, including over six months between July 2016 and January 2017.

While the following parameter did not comply the ADWG, though it is still of interest:

- Sodium exceeds the concentration recommended for those on low sodium diets. Therefore, doctors and hospitals need to be informed of the sodium concentration so they can provide advice to their patients.

6.3.7 Risks identified from the DWMS Risk Register

According to the DWMS Risk register [1], for Braidwood WSS, the 'Very High' risks are identified below:

- Onsite Sewage Management System discharges/failures;
- Unrestricted livestock/stockyards access;
- Flooding event, storm flows (and turbidity and colour);
- Turnover of dam leading to elevated pathogens and metals (e.g., manganese and iron);
- Cyanobacterial (blue green algae) outbreak;
- Alum dosing system failure (and turbidity, aluminium);
- Filtration and flocculation failure;
- Chlorine dose failure causing ineffective disinfection;
- Loss of trained operators;
- Faecal contamination due to access by birds and rats;
- Dead ends in reticulation leading to loss of chlorine residual;

- Breach of pipelines through breaks, inappropriate maintenance, new or service works.
- Contaminating the treated water due to back flow and cross connection;
- Growth of biofilms, sludge causing degradation of water quality;
- STP overflows/ leaks/ OSSMS contaminating aquifer due to discharges and failures;
- Aged water/short circuiting/thermal stratification/loss of chlorine residual;
- Unrestricted livestock access to water supply;
- Point sources (e.g., mines), Sedimentation in dam and leachate, stratification/turnover of dam leading to elevated pathogens and metals;
- Operator cross-over between water and sewer assets due to use of same tools leading to cross contamination error.

Based on the DWMS [1] the Residual Risk with Preventative Measures continues to remain ‘Very High’ for the following: dead end in reticulation system leading to stagnation and loss of chlorine residual; breach of pipeline through breaks and service works; cross contamination due to backflow and growth of biofilms/ sludge causing degradation of water quality. **Issue** Council is currently reviewing the DWMS including this risk assessment.

6.4 Best practice compliance – LWU Circular 18

This circular was prepared in 2014 to inform local water utilities of a new protocol being implemented to ensure the microbial safety of drinking water supplies across regional NSW. LWUs were required to review and update their standard operating procedures to ensure three key barriers were achieved.

6.4.1 Barrier 1: Effective distribution

LWU Circular 18 states that disinfection is the single process that has had the greatest impact on drinking water safety. Two actions should be undertaken to achieve effective disinfection.

6.4.1.1 Action 1: Monitoring of factors which affect disinfection

LWU Circular 18 recommends LWUs to monitor the factors which affect effective disinfection including chlorine residual, turbidity and pH levels. These factors are monitored at Braidwood WTP as part of its CCP (see Section 6.2.4)

Circular 18 recommends keeping turbidity as low as practicable, aiming for less than 1 NTU. pH should be as low as possible and Circular 18 states that a level between 7.2 to 8.2 is desirable.

The Braidwood WTP filtered water turbidity is predominantly below 1 NTU with few results that fall out of Circular 18 recommended range. (see Figure 6-7).

6.4.1.2 Action 2: Achieve minimum chlorine contact time (C.t)

Circular 18 recommends that a minimum C.t. value of 15 mg.min/L is achieved, as recommended by the ADWG.

C.t. is calculated only for the clear water tank at Braidwood WTP.

C.t. for water leaving clear water tank:

- Plant flow = 1.38 ML/day
- Clear water tank = 2.6 ML
- Baffling factor of 0.3 used for contact tank assuming it has 'single or multiple unbaffled inlets and outlets, no intra-basin baffles' [7]
- Free chlorine concentration = 0.5 mg/L (Council's CCP critical limit)
- C.t. = 407 mg.min/L

The total C.t from chlorination at Braidwood WTP to outflow is 407 mg.min/L, which is above the recommended minimum value of 15 mg.min/L.

6.4.2 Barrier 2: Distribution system integrity

Council's reservoirs are inspected each week which requires a check of perimeter security and a walk-around inspection and top inspection of the reservoir. Council uses Reservoir Integrity as a CCP in all three water supply schemes, however technically it is not a CCP.

Council provided the inspection reports recently for each reservoir. As of the last inspection no issues were identified, and no actions were required at any of the eight reservoirs.

6.4.3 Barrier 3: Maintain a free chlorine residual in the distribution system

Circular 18 recommends a minimum chlorine residual of 0.2 mg/L in the distribution system. Council monitors free chlorine daily in the reticulation of each of the water supply schemes.

6.5 Analysis of production data

A water demand analysis is undertaken to calculate the unit demands, estimate the water losses and forecast the following demands:

- Average (rainfall) year metered demands – for revenue planning
- Unrestricted future year system demands – to assess drought security
- Peak day system demands – to assess system reliability.

The 30-year forecasts based on the nominated growth, are used to identify the issues in meeting the adopted water supply security, and reliability objectives of the urban water supply system. Further explanation on the water demand analysis can be found in Appendix E.

Analysis and modelling were undertaken on the water production data i.e. the water going into the reticulation system, recorded at the outlet of the treated water pumps.

6.5.1 Trend correction

Analysis and modelling were undertaken on the water production data i.e., the water going into the system.

Modelling was undertaken to understand the impact of various factors/trends (demographic, climatic, economic etc.) on the variability of town water demand.

The factors that were considered were:

- Historical water requirement for grass irrigation (lawns and public open spaces) obtained from the simulated water use model by PW. The model uses location-specific historical rainfall and evaporation data, soil type and grass type.
- Historical water requirement for use of evaporative coolers. The model uses location-specific historical maximum temperature data.
- Historical number of connections.
- Non-revenue water.

The weather data (rainfall, temperature, synthetic pan evaporation, evapotranspiration) was sourced from SILO (State of Queensland (Department of Environment and Science), 2023).

The aim was to develop models which, when input with historical factors/trends, would output a production that correlates well with the actual historic production.

Once the best model is selected, the production was hindcast to estimate the likely water production for a repeat of the historical climate from July 1889 to June 2023, with the current users and losses.

6.5.2 Production modelling

Water production records from July 2004 to February 2023 provided by council were analysed. The model showed that the most significant contributors to Braidwood's demand variability were:

- outdoor irrigation
- an additional increase in demand during warm to hot weather that resembles evaporative cooler air conditioning water use when the maximum temperature was over 20°C.
- Non-revenue water.

The production model was then hindcast over a 133-year period of available climatic data of historical temperature, rainfall and evaporation to estimate the annual demands if the current conditions of lot size, household size, number of connections, pricing and usage patterns were to prevail. The Low NRW case is based on the lowest NRW per billing period from December 2017 to December 2022 and the High NRW case is based on the highest NRW per billing period from December 2017 to December 2022. The hindcast is shown in Figure 6-15.

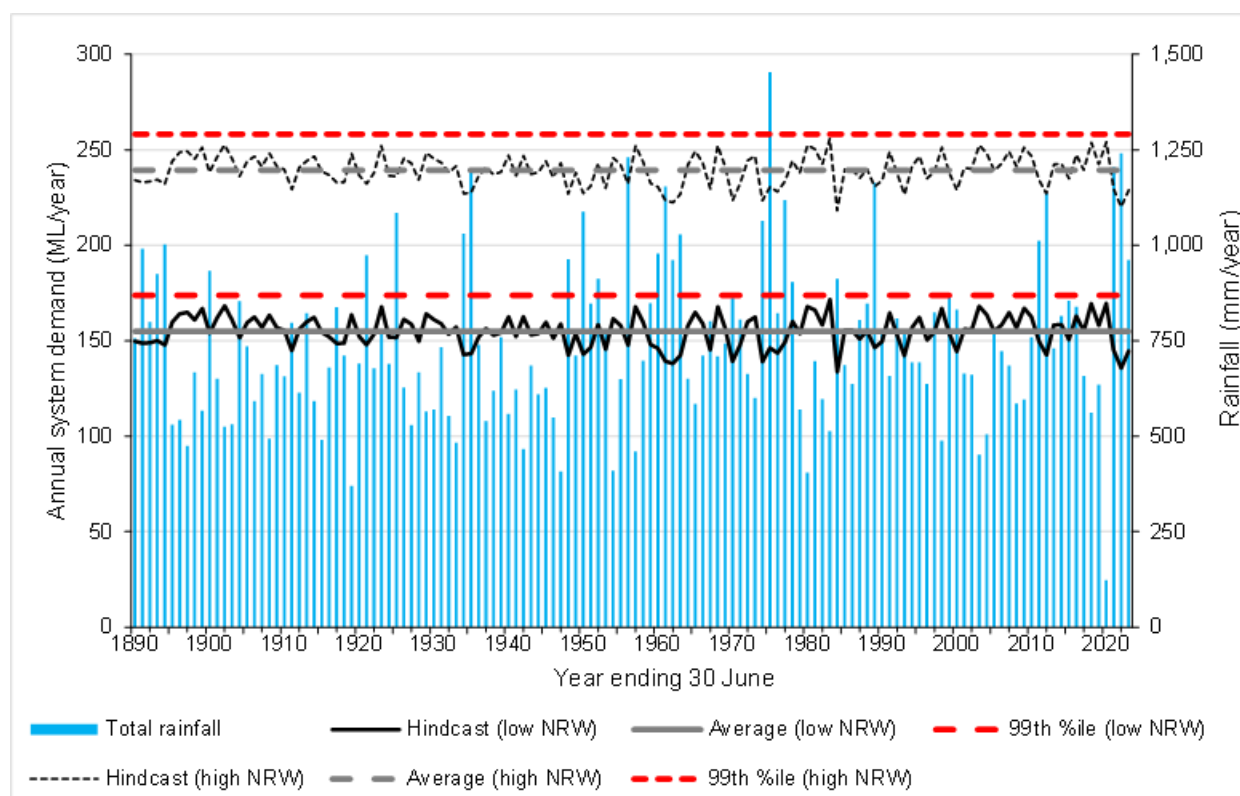


Figure 6-15: Production model hindcast – Braidwood raw water supply

The hindcast was also used to estimate the historical ADPW production. For the analysis the 99th%ile (1 in 100 year) unrestricted future production was selected from the hindcast as the starting points for the forecasts. The model results are presented in Table 6-10.

Table 6-10: Braidwood modelled unrestricted production

	From historical data	Modelled outcomes (High NRW)	Modelled outcomes (Low NRW)
Average year (ML/year)*	184	239	155
99th percentile unrestricted future year (ML/year)	214**	258	174
Average day peak fortnight (ML/day)	0.88	0.98	0.75
Average day peak week (ML/day)	1.02	1.02	0.79
Peak day (ML/day)**	1.4	1.38	1.15

* Historical average from the 10 years 2012/13 and 2021/22, there were some water restrictions in this period

** 2018/19 there were no water restrictions

*** See discussion in Section 6.2.3 on historical peak days

The historical recorded production is generally between the modelled outcomes for the high and low NRW scenarios as is expected from the historical variation in NRW.

In the previous IWCM, Braidwood's peak day production was estimated to be 1.5 ML/day (in 2016). From the modelled unrestricted production, the modelled peak day is 1.15 to 1.38 ML/day depending on the NRW scenario. This is much less than the peak days recorded on 1/1/2019 (2.02 ML) and 11/1/2021 (1.5 ML).

6.5.3 Effect of climate change

As with Bungendore, for comparison purposes, the impact of climate change on the 2023 demand was calculated using the method from the previous IWCM. Refer to Appendix table F-3 and Appendix table F-4 for detailed calculation output for Braidwood.

6.5.3.1 SEACI

Shortly after the previous IWCM analysis was completed, DCCEEW started providing the data sourced from the South Eastern Australian Climate Initiative (SEACI). This data included rainfall and evapotranspiration datasets for 1 historical dataset and 17 Global Climate Models (GCMs) and was based on a 1°C warming scenario from a 1990 baseline. The Daily maximum temperatures assumed to be 1°C higher. Data from this data set was used to calculate the secure yield of the surface water source at Braidwood and Captains Flat.

SEACI data was obtained for Braidwood.

Refer to Appendix table F-5 and Appendix table F-6 for detailed calculation output.

6.5.3.2 NARCIIM 1.5

The demand changes for Bungendore and Braidwood were estimated using the three GCMs, two RCMs, and two future time periods (before and after 2060). The results are summarised in Appendix table F-13 to Appendix table F-24. When there was a decrease in demand instead of an increase, the cells are shaded grey.

For the demand forecasts, the probable climate change forecasts have been calculated using the maximum increase from the RCP 4.5 models for the period between 2006/07 to 2058/59. The more severe climate change forecast uses the maximum increase from either the RCP 4.5 or 8.5 models and either time period. For both Braidwood and Bungendore, the highest increase in the 99th percentile dry year demand was the maximum increase under RCP 4.5 between 2006/07 and 2058/59. The increase in system demand for Braidwood is summarised in Table 6-11, note that as the NRW is assumed to be climate independent, the climate change impact on the low NRW scenario is more severe than on the high NRW scenario.

Table 6-11: Climate change impact on system demand

Projection	Climate change scenario	Average year	99th %ile dry year	Average day peak week	Average day peak fortnight
Low NRW	Probable	4.42%	5.75%	3.06%	3.52%
	High severity	7.02%	5.75%	3.86%	5.17%
High NRW	Probable	2.85%	3.85%	2.39%	2.70%
	High severity	4.56%	3.85%	3.01%	3.97%

6.5.3.3 *Paleo-stochastic*

Overall, based on the stochastic data, there is a very low probability (less than 0.1%) of more water being required for irrigation than was shown in the SILO data on a yearly basis.

6.6 Analysis of customer usage

The billing data was provided by assessment and meter. Some assessments had more than one meter, these are either major users (like the school) or properties where the meters were replaced. As each assessment was taken as a connected property, analysis was undertaken on an assessment basis.

6.6.1 Modelling of customer usage

Customer usage patterns were modelled in a similar way to production data.

The maximum and 99th percentile (1 in 100 year) unrestricted yearly demands were selected as the starting points for the 30-year projections. The model results for user classes are given in Table 6-12.

Table 6-12: Estimated customer usage from climate correction – Braidwood WSS

User Class	Average year demand (ML/year)	Unrestricted yearly demand (ML/year)	Average day demand (kL/day)	Peak day demand (kL/day)
Business	10,987	13,092	30.1	63.1
Church	272	348	0.7	1.2
Community	1,806	2,332	4.9	12.0
Council General	1,940	3,043	5.3	16.1
Council Sewer	1,621	2,346	4.4	8.2
Education	3,032	3,957	8.3	21.4
Farm	985	2,407	2.7	25.9
Government	314	704	0.9	6.5
Hospital	1,082	1,610	3.0	8.8
Mixed	5,055	5,953	13.8	21.3
Major User	12,361	18,384	33.8	114.8
Public Parks and Gardens	2,322	5,526	6.4	37.4
Residential	78,690	101,149	215.4	476.7
Total	120,468	160,851	329.8	813.3

The residential, non-residential, and total consumption were significantly climate dependent.

Overall, residential users were significantly climate dependent, whereas most non-residential user classes were climate independent.

6.6.2 Unit residential demands

6.6.2.1 Existing dwellings

The residential unit demands for each scheme were assessed by climate correcting historical data, using the modelled demand for lawn irrigation.

Using a threshold of 60L/connection/day for an active connected residential property resulted in 91% of the assessments in Braidwood WSS being active in 2022/23.

The unit demand per active residential connection is then estimated from the number of active assessments. The results are given in Table 7-11.

Table 6-13: Unit demand per active residential assessment – Braidwood WSS

	Average year (kL/year)	Average day (kL/day)	Unrestricted future year (kL/year)	ADPW (kL/day)	Climate dependence	Climate independent (kL/day)	Climate independent (kL/person/day)	Approximate WELS Rating
All	153	0.419	177	0.709	Irrigation	0.317	0.149	2 to 3
Unsewered	183	0.500	243	1.211	Irrigation	0.329	0.155	2 to 3
Sewered	150	0.410	171	0.659	Irrigation	0.321	0.152	2 to 3

The baseline internal demand per person was estimated by dividing the internal demand by the average household size of standard private dwellings in Braidwood.

6.6.2.2 New dwellings

In July 2004 the NSW Government implemented the Building Sustainability Index (BASIX) with the purpose of reducing the use of potable water and to produce less greenhouse gas emissions.

Braidwood is in the BASIX 40% reduction target zone for water [8]. This means that the target average annual water demand for a resident in a BASIX dwelling is 54 kL/person/year. Using the household size of 2.12 for Braidwood, the target average annual water demand for a BASIX compliant dwelling is 115 kL/year, this is substantially less than the current average demand by sewerer dwellings of 150 kL/year.

The unit demands for new houses in Braidwood were developed based same logic used for Bungendore: 3 or more bedroom house, 22.5 kL rainwater tank, 190 m² connected roof area, rainwater tank supplying water to the irrigated garden area, toilets and washing machine, 250 m² of lawn irrigated by the tank (same as for Bungendore as the new lots are currently projected to mostly be between 800 m² and 1200 m² and have larger watered gardens than most homes in the town currently appear to have), 3* WELS appliances, 2.2 person households. The demands for new dwellings in Braidwood are summarised in Table 6-14. For the previous IWCM there was little growth projected for Braidwood, therefore the same unit demands were used for Braidwood and Bungendore.

Table 6-14: Unit demands for new houses in Braidwood

Tank	Household size	Average year (kL/year)	Average day (kL/day)	Unrestricted future year (99th %ile) (kL/year)	Peak day (kL/day)	Average day peak week (kL/day)	Average day peak fortnight (kL/day)
With tank	2.2	115	0.316	209	1.875	1.875	1.677
Without tank	2.2	196	0.537	258	1.875	1.875	1.677
66% with tank	2.2	196	0.537	258	1.875	1.875	1.677
95% with tank	2.2	196	0.537	258	1.875	1.875	1.677
Previous IWCM	2.9	180	0.493	240	1.612		

The unit demands for new villa homes in Braidwood were developed based on the following assumptions: 2 bedroom house, 13 kL rainwater tank, 90 m² connected roof area, rainwater tank supplying water to the irrigated garden area, toilets and washing machine, 20 m² of lawn irrigated by the tank, 3* WELS appliances, 1.5 person households. The unit demands for these dwellings are summarised in Table 6-15.

Table 6-15: Unit demands for villa homes in Braidwood

Tank	Average year (kL/year)	Average day (kL/day)	Unrestricted future year (99th %ile) (kL/year)	Peak day (kL/day)	Average day peak week (kL/day)	Average day peak fortnight (kL/day)
With tank	39	0.107	52	0.299	0.299	0.267
Without tank	76	0.208	81	0.299	0.299	0.267
66% with tank	52	0.141	62	0.299	0.299	0.267
95% with tank	75	0.204	80	0.299	0.299	0.267

6.7 Projections

Average year demand projection will be used for revenue requirement planning, dry year demand for sizing of headworks and peak day production is used for sizing of water treatment works or pumping facilities. Water demands for the Braidwood WSS are projected as follows:

- The initial demands are based on the 99th percentile unrestricted demand and the peak day demands estimated from the 120-year hindcast.

- For each new residential dwelling the unit demand is developed from the data provided in Section 6.6.2.2, adjusted for the percentage of operating rainwater tanks assumed for the case.
- For the low NRW scenario the unit NRW for existing and new customers is assumed to be 100 L/meter/day (see Section 6.3.5).
- For the high NRW scenario the unit NRW for existing customers is assumed to be 402 L/meter/day and for new customers 253 L/meter/day (see Section 6.3.5).
- For non-residential demand, future demands are based on the initial demand multiplied by a population scaler. The population scaler is a ratio between average projected population (see Table 4-12) and average population in 2022.

A summary of the water projections is given in Table 6-16. This projection is based on 66% of the residential rainwater tanks in new dwellings operating optimally.

Table 6-16: Summary of water supply projections – Braidwood WSS

		2025	2030	2035	2040	2045	2050	2055
Historical climate	Braidwood (Low NRW)							
	Average Year Demand (ML/year)	157	168	187	214	245	281	320
	Unrestricted Future Year Extraction (ML/year)	177	190	216	256	301	352	409
	Peak Day Production (ML/day)	1.41	1.48	1.64	1.91	2.22	2.57	2.96
	Braidwood (High NRW)							
	Average Year Demand (ML/year)	242	257	281	317	356	401	451
	Unrestricted Future Year Extraction (ML/year)	262	279	311	358	412	472	540
	Peak Day Production (ML/day)	1.41	1.49	1.67	1.96	2.29	2.67	3.09
Climate change	Braidwood (Low NRW)							
	Average Year Demand (ML/year)	164	175	195	224	256	293	335
	Unrestricted Future Year Extraction (ML/year)	192	206	232	272	317	368	425
	Peak Day Production (ML/day)	1.46	1.52	1.69	1.97	2.29	2.65	3.05
	Braidwood (High NRW)							
	Average Year Demand (ML/year)	249	264	290	326	366	412	464
	Unrestricted Future Year Extraction (ML/year)	281	298	330	378	431	491	559
	Peak Day Production (ML/day)	1.45	1.53	1.71	2.01	2.35	2.73	3.16

6.8 Water security assessment

6.8.1 Licensed entitlement

Council's WAL entitlement to extract water from the Shoalhaven River off stream dam Bungendore Alluvial Groundwater bores is 360 ML/year. The water security assessment is done for the future unrestricted extraction which is based on the 99th percentile from the hindcast. RCP 4.5 was adopted as the probable climate change scenario for forecasting unrestricted future extraction shown in Figure 6-16 for the Low NRW and the High NRW case.

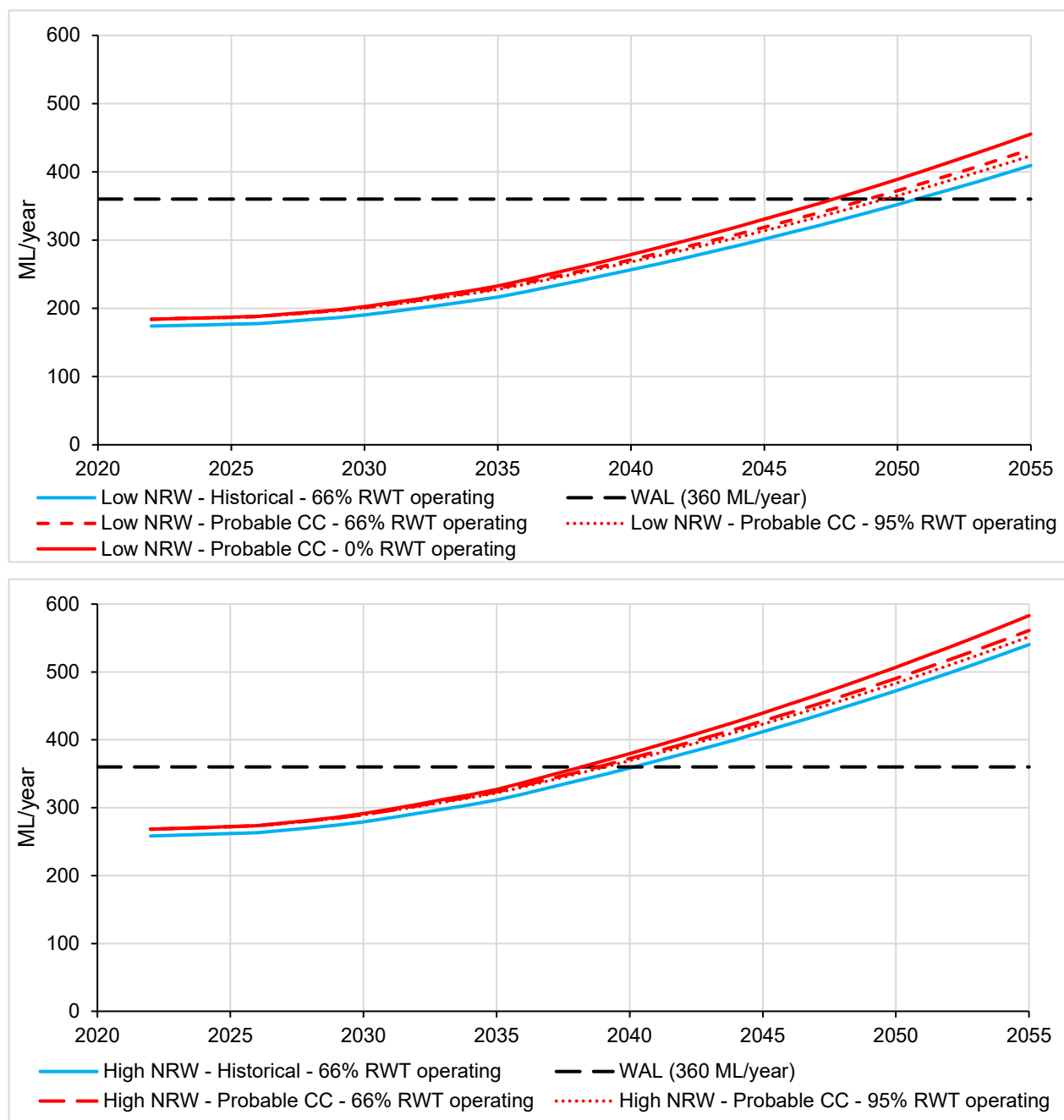


Figure 6-16: Projected unrestricted future extraction for Braidwood WSS compared to historical production (RCP 4.5 probable climate change scenario)

This 99th percentile dry year extraction reaches the 360 ML/y WAL entitlement between 2041 and 2043 under the high NRW scenario (**ISSUE**) and not until after 2048 under the low NRW scenario. While Council will probably be able to significantly decrease the NRW, there is a moderate chance that some of the NRW is un-metered demand and therefore will become revenue water, therefore the most probable future demand is between the two sets of projections.

6.8.2 Secure yield

Secure yield analysis was undertaken for Braidwood in 2020. The estimated secure yield under the 5/10/10 rule is 320 ML/year. Under the high NRW scenarios, this will be exceeded between 2039 and 2041 under the high NRW scenario and under the low NRW scenarios, this will be exceeded between 2045 and 2047.

6.9 System capacity assessment

The peak day demand is expected to exceed the WTP capacity (2 ML/day) between 2040 and 2042 and the reservoir capacity (2.6 ML/day) between 2049 and 2051. **Issue**

While persistence analysis can be used to optimise the reservoir and WTP capacities, the peak day production is expected to reach between 3.1 and 3.2 ML/day and therefore, upgrades to the WTP and/or reservoir capacities are likely to be required.

6.10 Application of Health Based Treatment Targets

See Appendix figure C-3 for Braidwood's HBT tool.

6.11 HBT assessment of threats

Braidwood WTP sources water from Shoalhaven River. Since this water source is a surface water source, vulnerability assessment is required.

6.11.1 Inherent risk

The assessed is undertaken for an inner catchment and outer catchment:

- Inner catchment – 1 km radius from the extraction point in Shoalhaven River
- Outer catchment – 5 km radius from the extraction point in Shoalhaven River

The likelihood of the threat occurring in the outer catchment is considered to be lower than the inner catchment, therefore risk ratings within the outer catchment is reduced.

The aerial view of the catchment of Braidwood water supply source is shown in Figure 6-17.

The threats within the catchment are as follows:

- Sewage entering the water source
 - There are very few OSSMS within the inner or outer catchment
- Contamination by stock – around 80% of the catchment is grazing land
- Stormwater runoff from roads, drains within the catchment

The risk from stock is partly mitigated by the fencing of the perennial waterways and presence of riparian vegetation.

Based on the assessment, Braidwood catchment has an **inherent risk of 'Medium'**.

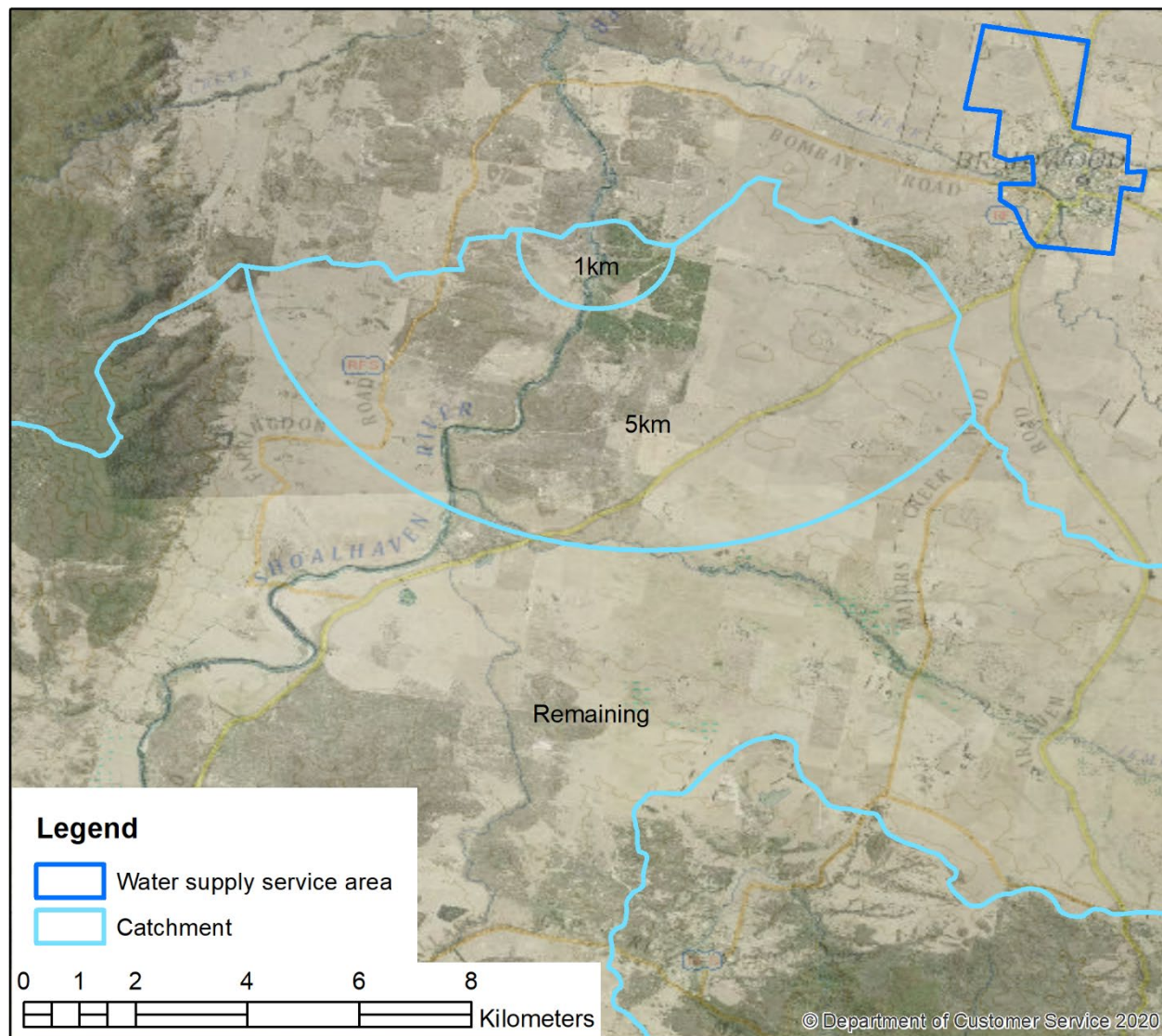


Figure 6-17: Inner and outer catchment of Braidwood raw water source

6.11.2 HBT assessment of treatment barriers

6.11.2.1 Treatment barriers for chlorine sensitive pathogens

Braidwood WTP is a conventional filtration plant with chlorine as the disinfection barrier. The criteria used for assessing the effectiveness of treatment barriers are as follows:

- Filtrate turbidity < 1 NTU
- Chlorine contact > 15 mg.min/L

Historically, there were 6 cases when filtered water turbidity from Braidwood WTP exceeded 1 NTU.

Braidwood WTP achieves a chlorine contact of 15 mg.min/L (see 6.4.1.2), therefore the treatment barrier for chlorine sensitive pathogens is considered effective.

Residual risk of chlorine sensitive pathogens: **Low**.

6.11.2.2 Treatment barriers for chlorine resistant pathogens

Braidwood WTP has individual monitoring of turbidity at each filter. The criteria used for assessing the effectiveness of the filters are:

- Highest individual filtered water turbidity recorded ≤ 0.3 NTU
- Highest monthly 95th percentile individual filtered water turbidity ≤ 0.15 NTU

From Section 6.2.4, using the most recent (2021) data, the highest filtered water turbidity exceeded 0.3 NTU, and the highest monthly 95th percentile turbidity was calculated to be 0.17 NTU.

Residual risk of chlorine resistant pathogens **Medium** due to partly protected catchment. **Issue**

Disinfection barriers such as UV or Ozone are also effective at disabling chlorine resistant pathogens. However, Braidwood WTP does not have UV or Ozone.

6.11.3 NSW Health preliminary cryptosporidium risk assessment

Based on NSW Health (letter sent to Council in November 2019), there is a '**Low**' risk rating of cryptosporidium in the raw water source for Braidwood (see Appendix figure C-5)

6.12 Work health and safety

No major WHS issues were noted from the condition assessment site visit.

7 Captains Flat water supply scheme

7.1 Raw water source

7.1.1 Water resource

Raw water is sourced from the Molonglo River which is part of the Murrumbidgee catchment within the Murray–Darling basin. The dam’s catchment has an area of 33 square kilometres, with land use dominated by extensive agriculture and grazing occupying 64 per cent of the catchment.

7.1.2 Raw water extraction

The Captains Flat Water Supply Scheme sources raw water from an 820 ML dam on the Molonglo River. The capacity of the booster pump is equivalent to the WTP capacity of 0.7 ML/day.

Capacities of assets for raw water extraction for Captains Flat are as follows:

Table 7-1: Captains Flat raw water extraction asset’s capacities

Asset	Capacity
Captains Flat	
Captains Flat Dam (Molonglo River)	820 ML
Captains Flat WTP	0.7ML/d (8.83 L/s)

The schematic arrangement of the raw water and Captains Flat WTP is shown in Figure 7-1.

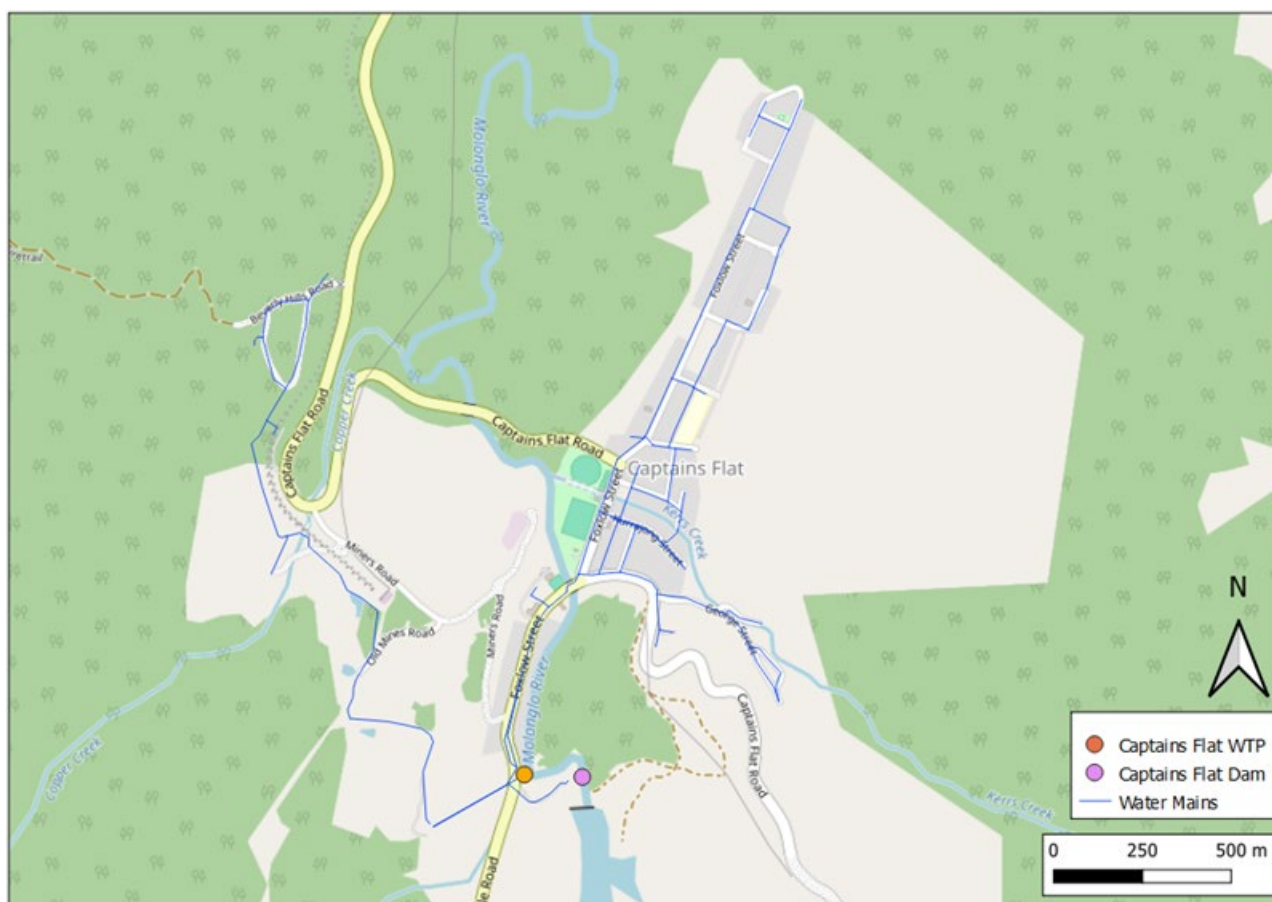


Figure 7-1: Location of raw water intake for Captains Flat WTP

7.1.3 Water access licences

Council holds Local Water Utility Water Access License (WAL36281), issued under the Water Management Act 2000, which relates to the water supply to Captains Flat. The following table summarises the key details of the WAL:

Table 7-2: WAL Licence numbers

WAL license number	WAL36281
Category [Subcategory]	Local Water Utility
Entitlement	250.0 ML/year
Water Source	Molonglo Water Source
Works approval	40CA415962

WAL25376 is sourced from Molonglo Water Source via one diversion pipe, one 80 mm centrifugal pump and one overshot dam.

7.1.4 Source water quality

Raw water quality was sampled between March 2014 and March 2023 approximately once every quarter. The samples are collected both at the Captains Flat Dam.

Typical raw water quality for the Molonglo River is shown in Appendix table A-4.

The main parameters of interest in the Captains Flat raw water are:

- Aluminium – one sample collected on 30/03/2021 was exceptionally high in aluminium. 19 out of 37 (51%) samples contain aluminium in concentrations above 0.2 mg/L.
- *Escherichia coli* (E. coli) – 29 out of 37 (78%) samples was above 1 MPN/100mL and 5 out of 37 (14%) sample was above 100 MPN/100mL. The maximum E.coli recorded is 390 MPN/100mL.
- Iron – All records are above 0.3 mg/L.
- pH – pH occasionally reaches quite low values but remains above the ADWG (Australian Drinking Water Guidelines) of 6.5 pH Unit. 3 out of 37 (14%) samples are below 6.5 pH Unit.
- Turbidity – 22 out of 32 (69%) samples are above 5 NTU and 9 out of 32 (28%) samples are above 10 NTU.

7.2 Water treatment

7.2.1 Treatment process

Water from the Molonglo River is treated with the following conventional treatment process at Captains Flat WTP:

- Raw water filtered through a coarse screen.
- Pre-dosing with aluminium chlorohydrate and caustic soda.
- Membrane Ultra-filtration
- Post dosing using sodium fluoride and sodium hypochlorite (disinfection).

A schematic showing an overview of the Captains Flat water supply scheme is provided in Figure 7-2.

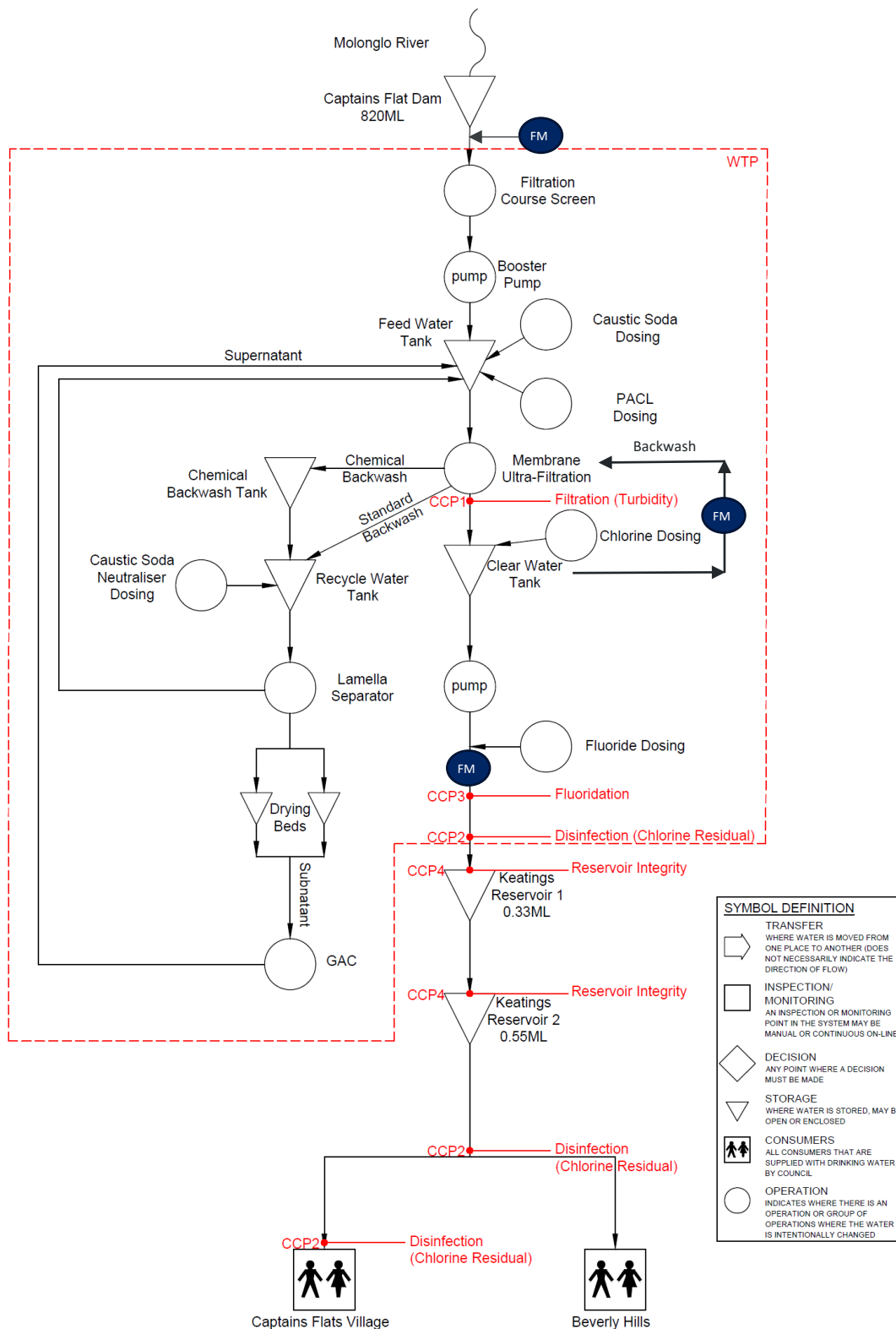


Figure 7-2: Schematic flow diagram of the Captains Flat water supply scheme

7.2.2 Historical water production

Captain Flat WSS supplies potable water to customers in Captains Flat Village and Beverly Hills through the reticulation system. Water sourced from the Captains Flat Dam (on the Molonglo River) is treated at the Captains Flat WTP. Council provided the potable water production data records from July 2003 to February 2023. The potable water meter records flow being pumped out of the Captains Flat WTP to the reservoirs. The historical potable water volume supplied is summarised in Figure 7-3.

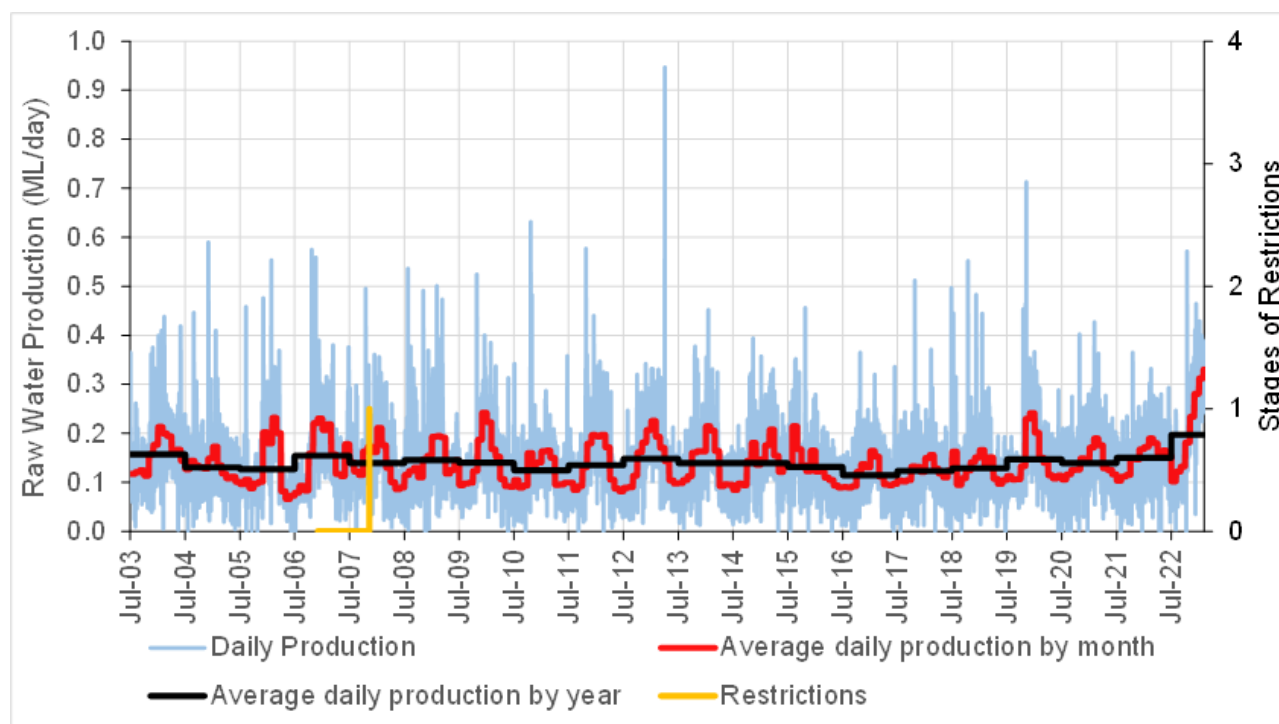


Figure 7-3: Historical production data – Captains Flat potable water production

Council is still investigating the January 2023 rise in production. Council is aware of an undetected leak just before July 2022 which corresponds to the decline in the total volume of Keatings Reservoir in Captains Flat. They advise that the high use of water between October 2022 to March 2023 is most likely related to leakage of Captains Flat pool because the drop in usage coincided with pool closure even if it doesn't appear to be explained by the pool's water meter data. See Appendix figure B-1.

The annual summary of water production for the Captains Flat WTP is shown in Table 7-3.

Table 7-3: Historical annual water production – Captains Flat WTP (ML/year)

Financial Year	ML/year
2003/04	57
2004/05	47
2005/06	46
2006/07	56
2007/08	51
2008/09	52
2009/10	51
2010/11	45
2011/12	49
2012/13	54
2013/14	51
2014/15	51
2015/16	48
2016/17	42
2017/18	45
2018/19	47
2019/20	53
2020/21	51
2021/22	54
2022/23	65

The maximum production was 65 ML/year for the 2022/23 financial year.

7.2.3 Peak production analysis

The historical peak fortnight pattern for the Captains Flat WSS is shown in Figure 7-4.

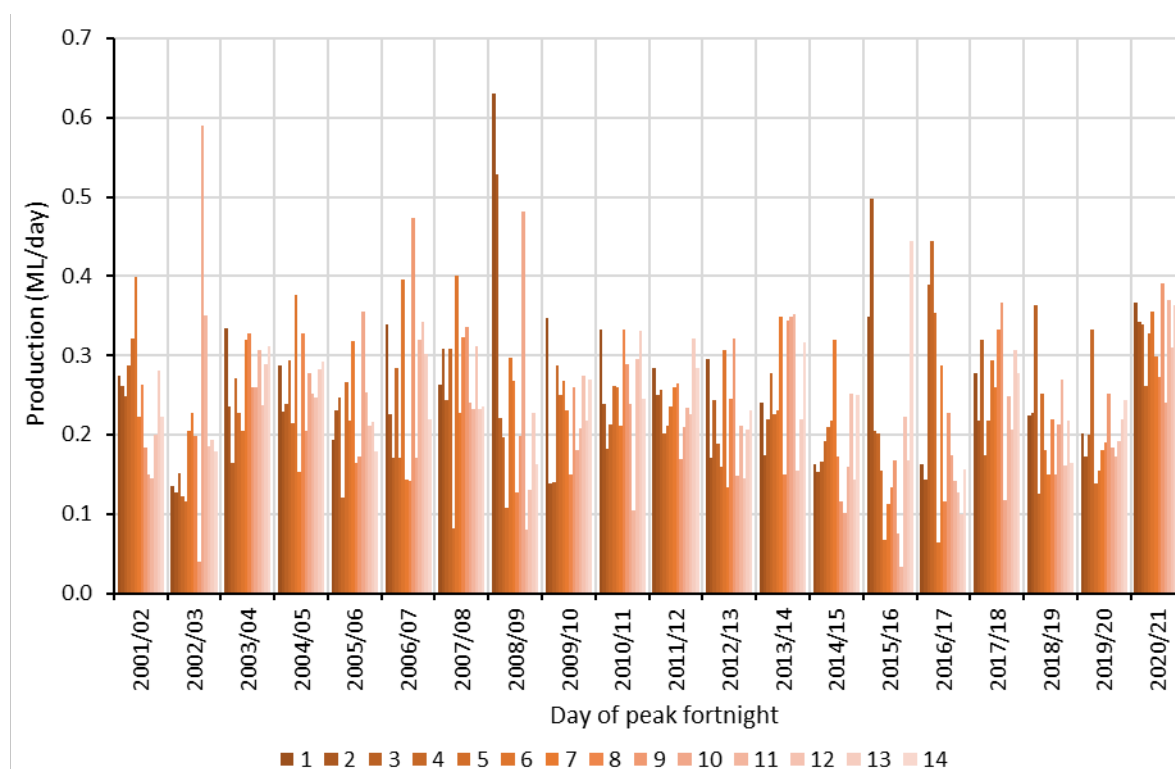


Figure 7-4: Peak fortnightly production patterns – Captains Flat WTP

As discussed in Section 7.2.2, there have been unexpected rises in production post July 2022.

A number of reasons that could have caused this rise in production were investigated. There was no evidence found about weather related affects such as extremely high temperature or bushfires post July 2022. The number of connections did not suddenly increase. Captains Flat is not known to experience tourism related population increases, and tourism generally causes spikes for short periods which is not the case in Captains Flat. None of the above reasons can explain that rise in production. Council has explained that there was an undetected leak before July 2022 which was related to the leakage of Captains Flat pool. The reason for spike is still unclear, but it seems more recent data shows production has decreased. Hence, data prior to June 2022 has been used for peak production analysis.

The highest recorded daily production in Captains Flat WTP was 0.95 ML which occurred on 2 April 2013. However, as the temperature of this peak day is relatively low (20.8°C), this day is not considered to be the true peak production representative of the scheme demand.

The nominated peak day production is 0.48 ML which occurred on 8 December 2018. There was no rainfall recorded leading up to the day and the maximum temperatures surrounding this day was high (ranged from 20°C to 30.5°C).

The average daily production over the peak week (ADPW) and peak fortnight (ADPF) was 0.28 ML/day for the week starting 25 Dec 2019 and 0.26 ML/day of fortnight starting 23 December 2019 respectively. The ADPW and ADPF graphs are shown in Figure 7-5.

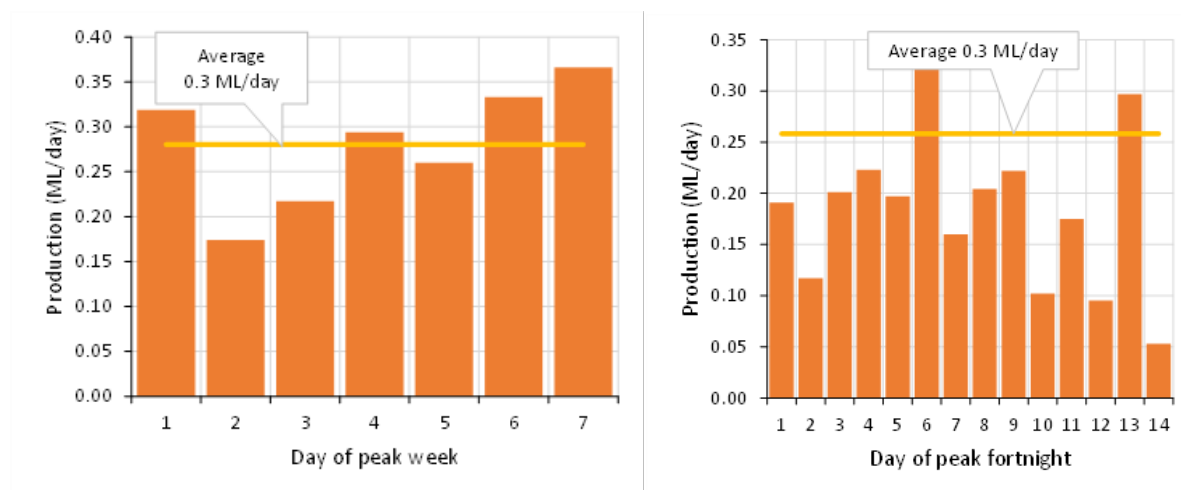


Figure 7-5: Peak week and peak fortnight production – Captains Flat WTP

The PD to ADPW ratio for Captains Flat WSS is **1.72**

From PW's experience, this high ratio is not normally seen and could be partially due to operational errors, for example, the meter being read at different times. Based on to other similar sized water utilities in similar climate zones, a PD to ADPW ratio of **1.4** is adopted for Captains Flat WSS.

7.2.4 Treated water quality

According to Council's Drinking Water Management System (DWMS) [1], there are six critical control points (CCP) adopted for Captains Flat WTP, shown in Table 7-4.

Table 7-4: Captains Flat WSS - Critical Control Point Summary

CCP		Control parameter	Target	Alert Limit	Critical limit
Captains Flat WTP	CCP1 Filtration	Filter turbidity	<0.2 NTU	>0.5 NTU	>1.0 NTU
	Interim CCP2*(a) Chlorination at WTP – Old Chlorine Shed (going up to reservoir)	Free chlorine residual at WTP	5.0 – 8.0 mg/L	<4.0 mg/L or >8.8 mg/L	<3.0 mg/L or >10 mg/L
	Interim CCP2*(b) Chlorination at reservoir outlet – Old Chlorine Shed (coming from reservoir)	Free chlorine residual at reservoir outlet	>1.0 mg/L	<0.8 mg/L or >3.0 mg/L	<0.2 mg/L or >5.0 mg/L

CCP		Control parameter	Target	Alert Limit	Critical limit
	Interim CCP2*(c) Chlorination at reticulation	Free chlorine residual at reticulation	>0.3 mg/L	<0.3 mg/L	<0.2 mg/L or >5.0 mg/L
	CCP3 Fluoridation	Fluoridation post filtration at reservoir outlet	0.95 – 1.05 mg/L	0.9 – 0.95 mg/L or 1.05-1.35 mg/L	<0.9 for 72 hrs or >1.5 mg/L
	CCP4 Reservoir	Reservoir Weekly Integrity	No gaps, vermin proof, secure, enclosed, locked	Breach of reservoir integrity	Evidence of vermin

***Note:** Limits are based on the high chlorine demand from the chlorine reservoir. Limits are to be reviewed following the replacement of reservoir.

7.2.4.1 Captains Flat WTP

Council provided data for turbidity, fluoride and chlorine in Captains Flats reservoir outlet post filtration, and data for chlorine at the WTP and in the reticulation. Data sets was provided for the period between January 2015 and June 2023.

CCP1 Filtration has been presented in Figure 7-6.

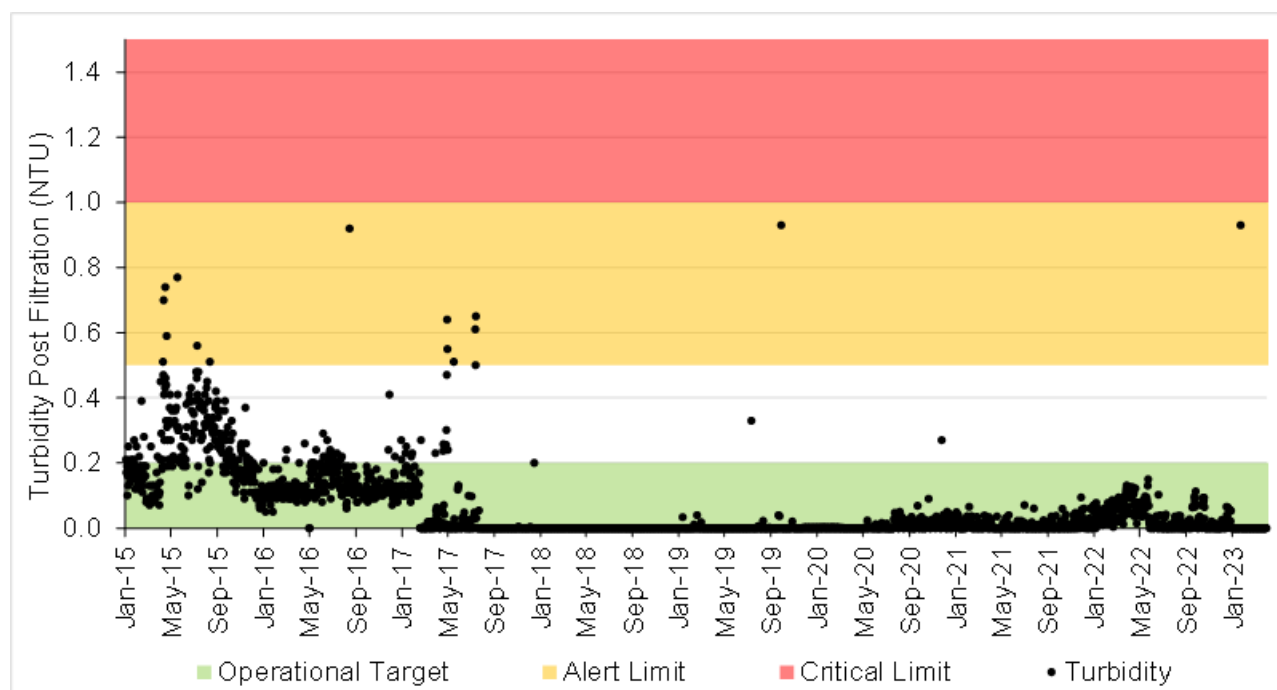


Figure 7-6: CCP1 Filtration – Historical turbidity of Captains Flat WTP filtrate

Majority of the recent records have maintained to be within the target range. Turbidity readings prior to January 2017 are scattered, because they were recorded on working days on a desk top analyser that had low range reading errors. Post January 2017, in tank continuous WTW analysers were installed commissioned by Xylem. It was also realised that these too needed

further adjustment to better read very low ranges, which was in effect from May 2020. In May 2020 Xylem again adjusted the sensitivity. Subsequently, failure occurred in the centralised system for these turbidity units in early 2023. The units failed and read zero for a majority of early 2023. It has been fixed now.

CCP2 (a) Chlorination recorded at the WTP has been presented in Figure 7-7.

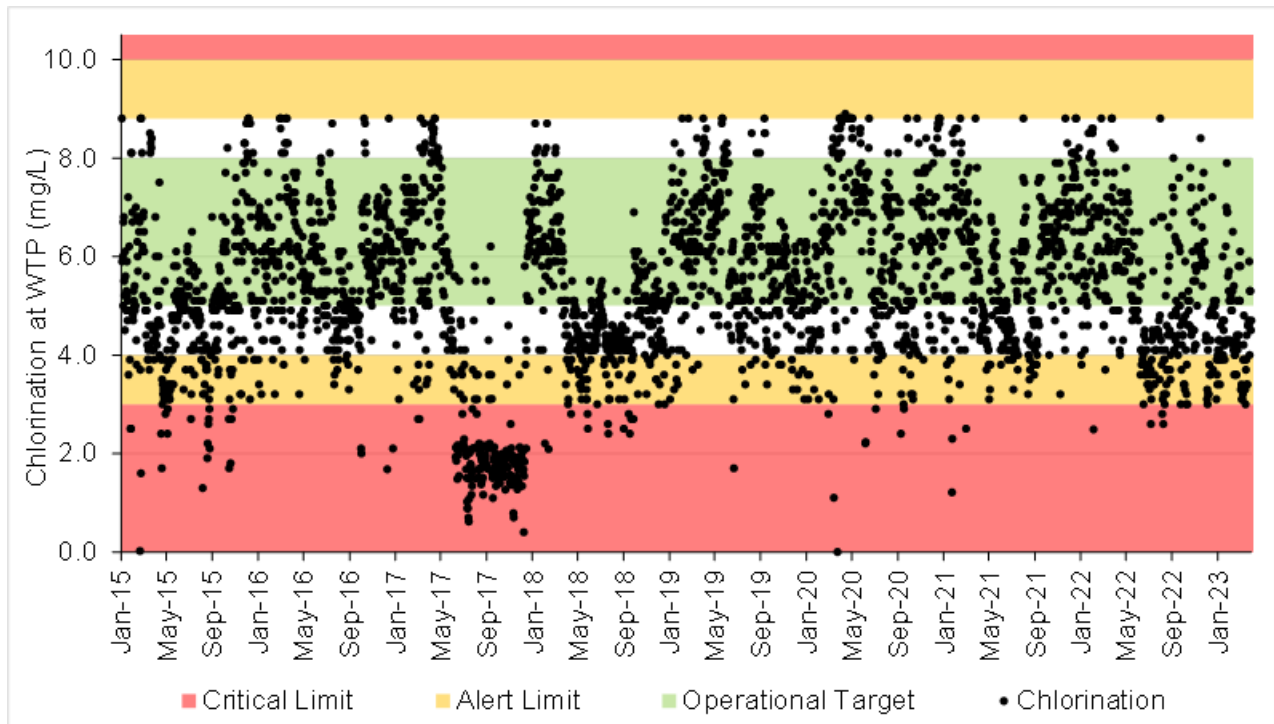


Figure 7-7: CCP2 (a) Chlorination – Historical free chlorine at Captains Flat WTP - Old Chlorine shed (going up to reservoir)

There have been 15 records cases exceeded the lower critical limit of 3.0 mg/L since 2019.

CCP2 (c) Chlorination recorded in reticulation of Captains Flat has been presented in Figure 7-8.

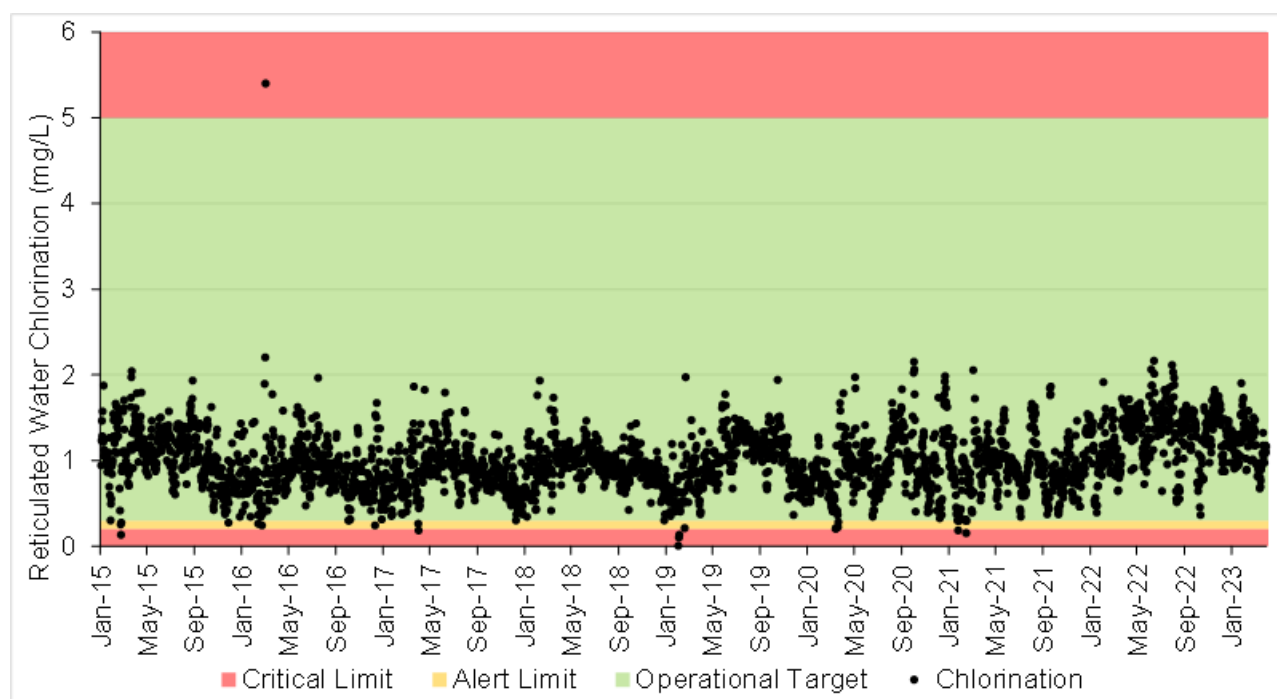


Figure 7-8: CCP2 (c) Chlorination – Historical free chlorine in reticulation of Captains Flat

Majority of the recent records have been within the target range. There have been 2 recent records that have exceeded the lower critical limit of 0.2 mg/L in January and February of 2021. Supervisor observed the readings on the field sheet, and it was rectified.

CCP3 Fluoridation post filtration recorded has been presented in Figure 7-9.

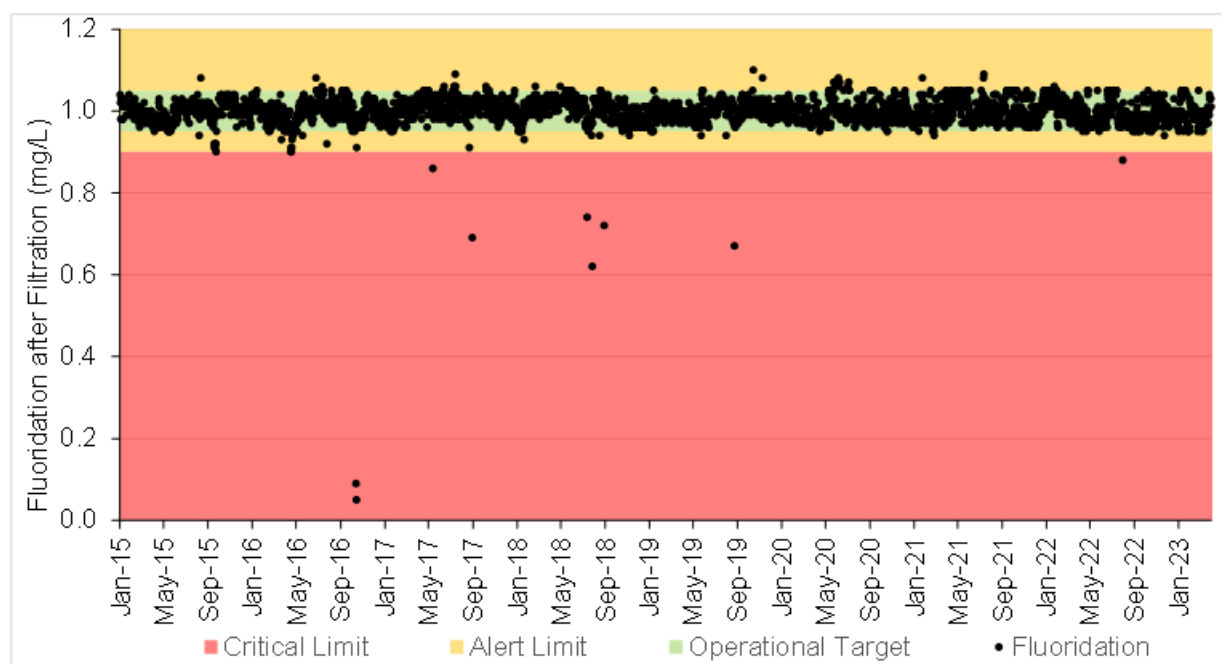


Figure 7-9: CCP3 Fluoridation – Historical fluoride at reservoir outlet in Captains Flat

Majority of the recent records have been around the target range. There was a recent record that was below the lower critical limit of 0.9 mg/L on 30th July 2022. Readings on the 29th and 31st July were 0.97 mg/L, therefore it is likely to be a sampling error.

7.3 Distribution

7.3.1 Distribution system

Treated water is pumped to Keating's Reservoirs 1 and 2 (capacities 0.33 ML and 0.55 ML respectively) before being distributed via gravity to Captains Flat Village and Beverly Hills. Treated water from both reservoirs can be distributed to both reticulated systems; therefore, this is considered a single supply zone system. The layout of the distribution network for the Captains Flat WSS is shown Figure 7-10.



Figure 7-10: Captains Flat WSS distribution

7.3.2 Metered customer demand

Council supplied billing data for all potable water customers from July 2017 to December 2022, with the water meters being read quarterly. User classes from the billing data were residential, commercial, mixed, municipal excluding parks, municipal public parks, rural and vacant.

The historical number of customer meters in the billing data and the historical metered customer usage of the last six years are shown in Table 7-5 and Table 7-6.

Table 7-5: Historical number of meters – Captains Flat Potable WSS

	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
Residential	229	231	231	231	231	227
Commercial	4	5	5	6	6	6
Mixed	0	0	0	0	0	0
Municipal - excluding parks	15	16	14	15	15	13
Municipal - public parks	1	1	1	1	1	1
Rural	0	0	0	0	0	0
Vacant	0	0	1	1	1	1
Total	249	253	252	254	254	248

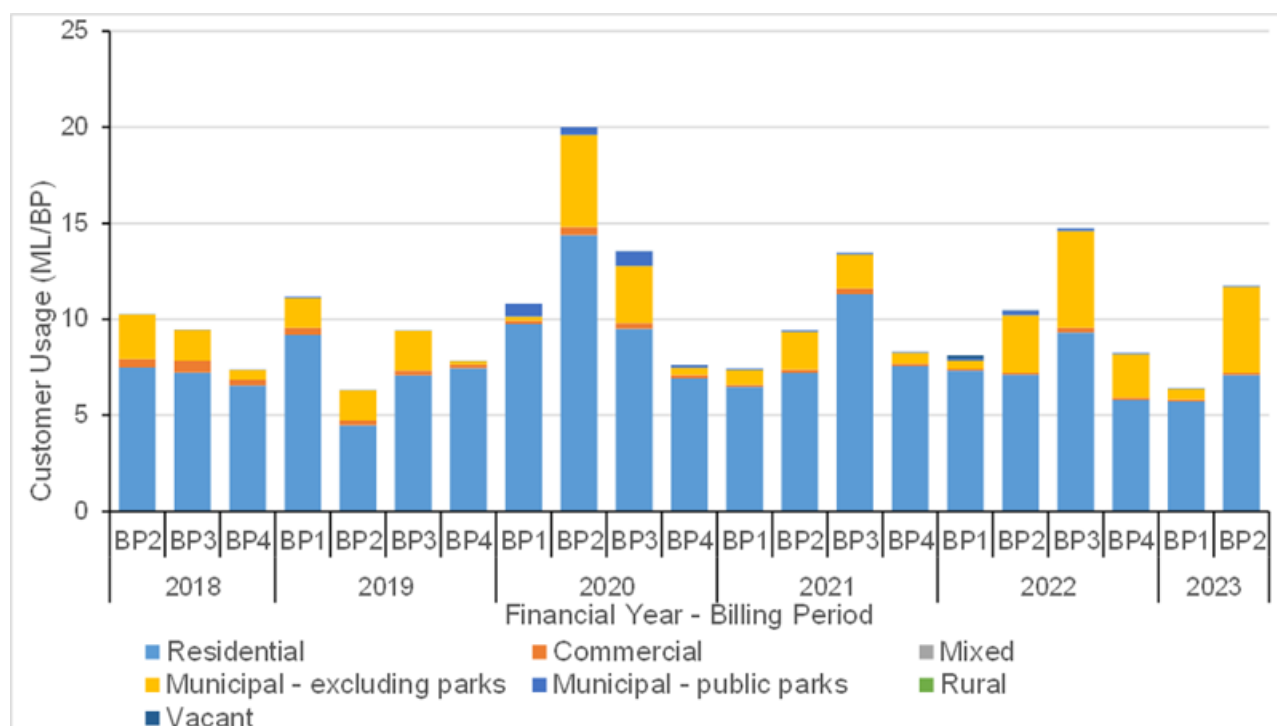
Table 7-6: Historical metered customer usage (ML/year) – Captains Flat Potable WSS

	2017/18*	2018/19	2019/20**	2020/21	2021/22	2022/23*
Residential	197	236	265	217	212	100
Commercial	20	20	21	17	15	7
Institutional	0	1	1	0	1	0
Farm	3	5	6	3	4	2
Vacant	2	6	20	9	5	5
Mixed	0	0	1	0	1	0
Education	9	11	11	9	8	4
Total	197	236	265	217	212	100

*Demand for the 2017/18 and 2022/23 financial years is included but not complete

Customer usage was high during the dry and warm conditions in 2019/20. Captains Flat water has been unrestricted since 2010. Historical customer usage split has been on average around 77% residential to 23% non-residential, this is on the high side for communities of this size.

The historical usage for all available billing periods for Captains Flat is given in Figure 7-11.



Note: Mixed, rural vacant are not shown in the column graph due to negligible numbers.

Figure 7-11: Historical metered customer usage by user category – Captains Flat Potable WTP

7.3.3 Major users

7.3.3.1 Major non-residential users

The criteria used to identify major non-residential users was any non-residential customer that used more than 2% of the total metered customer usage for the Captains Flat WSS. This results in four major users; their historical usage is shown in Table 7-7.

Table 7-7: Major Water Users – Captains Flat WSS

Major User	Average Yearly Demand (ML/year)	Highest Yearly Demand (ML/year)
Colin Winchester Oval and Captains Flat Pool	3.97	7.86
Sewer Works	1.50	3.32
Wilkins Park	0.48	1.96
Captains Flat Public School	0.34	0.85

7.3.3.2 Major residential user

A single property with exceptionally high consumption was identified, the consumption is summarised in Table 7-8.

Table 7-8: Major Water Residential User – Captains Flat WSS

Major Residential User	Average Yearly Demand (ML/year)	Highest Yearly Demand (ML/year)
Residential Property ID - 340223	2.06	5.49

This residential property has been flagged for investigation. A flow restrictor was installed in September 2021. The property is currently carrying in excess of \$40,000 worth of unpaid rates and charges. Council suspects that there is a serious leak and investigation is underway. **Issue.**

7.3.4 Water balance

The historical water production from the WTP, and metered customer usage data were used to calculate a water balance over Captains Flat WSS. The water balance used is the standard developed by the International Water Association (IWA) Water Loss Task Force. The method used to calculate the different components of the water balance is given in Appendix D.1

The water balance for Captains Flat WSS is shown Table 7-9, and shown graphically in Figure 7-12.

The historical averages over eight billing periods 2020/21 Q1 (15/07/2020) and 2021/2022 Q4 (07/06/2022) were used in the water balance.

Table 7-9: Water Balance- Captains Flat WSS (ML/year)

Raw water supplied to WTP 57 ML/year	Water supplied to Captains Flat WSS (WTP production) 53 ML/year	Authorised consumption 43 ML/year	Billed authorised consumption 42 ML/year	Residential	33 ML/year	
				Rural	0 ML/year	
				Commercial	1 ML/year	
				Municipal- excluding parks	8 ML/year	
				Municipal- public parks	0 ML/year	
				Unbilled authorised consumption		1 ML/year
		Water losses in distribution 10 ML/year	Apparent losses		0 ML/year	
			Real losses 10 ML/year	Avoidable real losses	-1 ML/year	
				Unavoidable real losses from mains	5 ML/year	
				Unavoidable real losses from service connections	6 ML/year	
Losses at WTP 4 ML/year				4 ML/year		

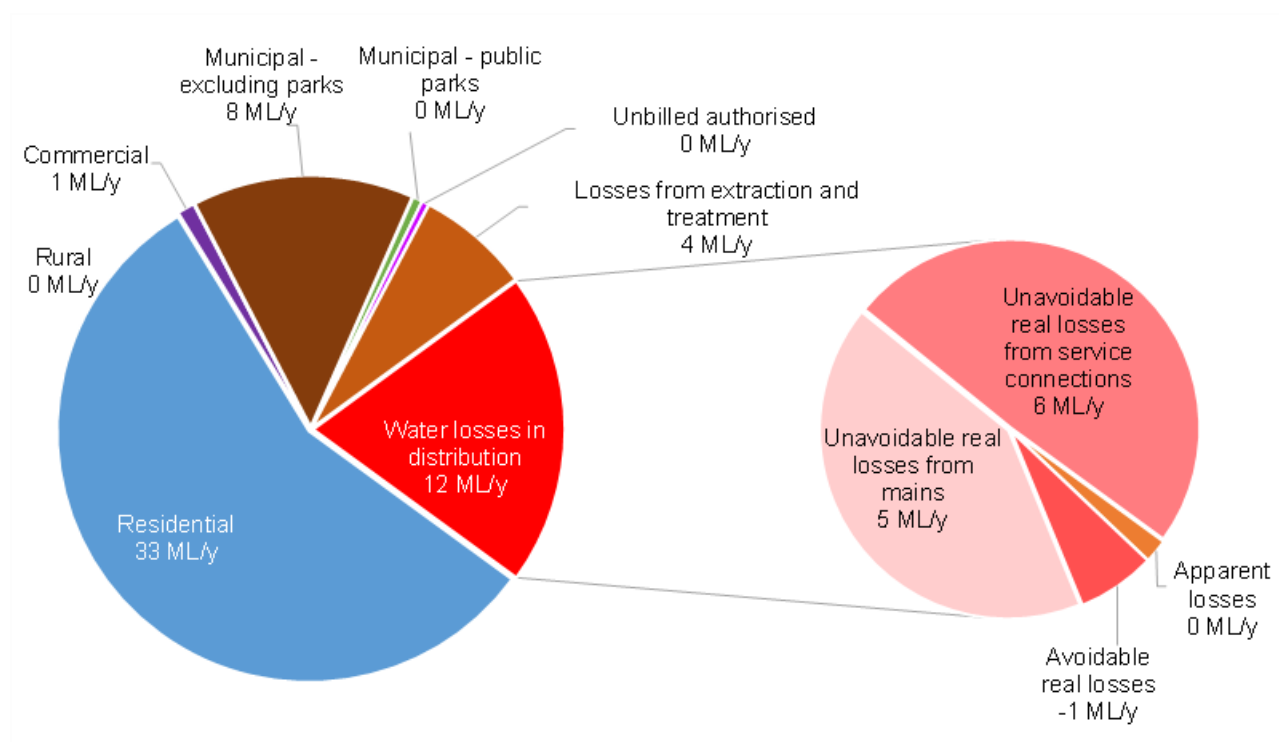


Figure 7-12: Water Balance – Captains Flat WSS (ML/year)

Based on the above water balance, Captains Flat WSS has an average ILI (current annual real losses / unavoidable real losses) of around 1.3 which is categorised in the best performing leakage performance category (LPC A1) [12] Utilities with losses in this range are expected to have difficulty economically reducing leakage further unless there are water shortages.

On average, authorised consumption made up around 81% of the water produced by the WTP in the billing data. This results in non-revenue water accounting for 19% of the total water produced. The historical average unit water loss is estimated to be 106 L/connection/day, which is approximately 1.4 times the state median of 74 L/connection/day. **Issue**

7.3.5 Non-Revenue Water

Non-revenue water (NRW) is made up of a number of components including:

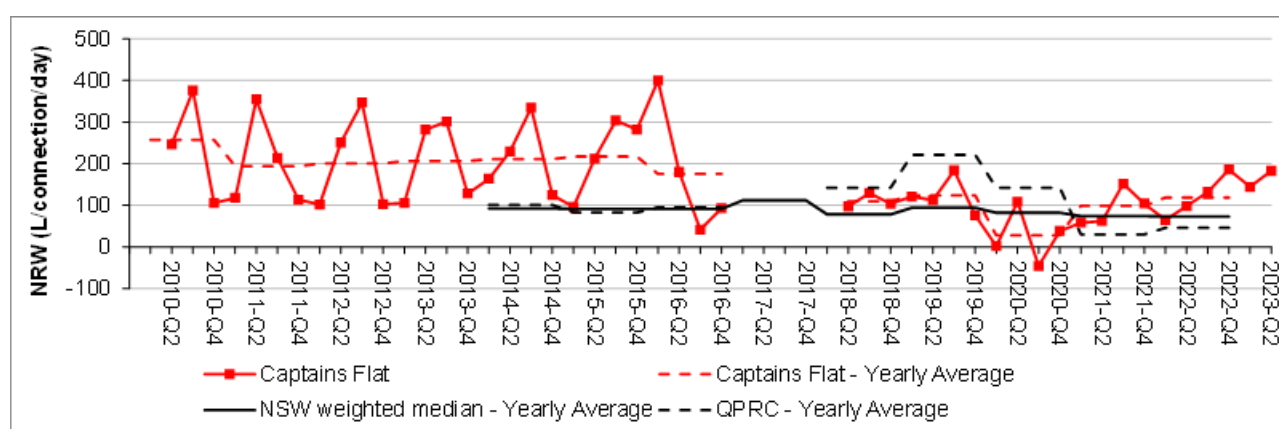
- unbilled authorised consumption which includes water used for fire-fighting and operational uses for example mains flushing.
- apparent losses including illegal connections and metering inaccuracies.
- real losses, mostly leakage from the network.

The NRW for the Captains Flat schemes is given in Table 7-10 For all schemes, NRW is higher than the 2021-22 state-wide median of 74 L/connection/day and the LGA yearly average of 46 L/connection/day. The LGA yearly average is based on the combined service areas including Queanbeyan and adjacent suburbs and villages, who are served with water from ICON Water (ACT).

Table 7-10: Captains Flat NRW Summary

	2017/18	2018/19	2019/20	2020/21	2021/22
Captains Flat					
Average NRW (kL/day)	29	35	8	26	31
Number of Connections	261	282	276	262	262
Average NRW (L/connections/day)	110	124	28	99	119

The average daily non-revenue water by quarter for Captains Flat is displayed in Figure 7-13.

**Figure 7-13: Captains Flat historical non-revenue water**

Captains Flat had data issues in 2019/20. The NRW has been trending upwards since mid-2020. Overall, it has improved since the previous IWCM analysis was done. With the exception of 2016 Q1, the maximum NRW was generally during Q3 in Summer, and quite high in Q2 in Spring. As discussed in the previous IWCM, the meter to the pool and neighbouring parks has been replaced, and there has also been a major project converting all customer meters to smart meters, these are likely to be the main factors contributing to the decrease in NRW.

7.3.6 NSW Health independent verification

Council collects water quality samples for the NSW Health verification program from two points in the Captains Flat as of 2023.

NSW Health water quality data from the previous seven years (July 2016 to October 2023) were analysed. Typical water quality from the points in Captains Flat in Appendix table A-7. The parameters that exceeded the guideline values were:

- Fluoride weekly laboratory sampling (0.9 – 1.5): 4 exceptions in June and July 2023, two exceptions in February 2021 and two exceptions in November 2017, all when the fluoridation system was off-line, resulting in fluoride concentrations slightly below the recommended minimum concentration.
- pH between July 2016 and October 2019 the pH was frequently over 8.5, since February 2019, the pH has only exceeded 8.5 on 6 occasions and has not exceeded 8.7.

While the following parameter did not exceed the ADWG, it is still of interest:

- Sodium exceeds the concentration recommended for those on low sodium diets. Therefore, doctors and hospitals need to be informed of the sodium concentration so they can provide advice to their patients.

7.3.7 Risks identified from the DWMS Risk Register

According to the DWMS Risk register [1], for Captains Flat WSS, the 'Very High' risks are identified below:

- OSSMS discharges and failures;
- Unrestricted livestock access to water supply;
- Point sources (e.g., mines);
- Stratification/turnover of dam leading to elevated pathogens and metals;
- Filters failure and ineffective backwash;
- Chlorine dose failure causing ineffective disinfection;
- Loss of trained operators;
- Faecal contamination due to access by birds and rats;
- High chlorine take-up within reservoir;
- Dead end in reticulation leading to loss of chlorine residual, and contaminating the treated water due to back flow and cross connection;
- Breach of pipelines through breaks, inappropriate maintenance, new or service works.
- Growth of biofilms, sludge causing degradation of water quality;
- Operator cross-over between water and sewer assets due to use of same tools leading to cross contamination error;

Based on the DWMS [1] the Residual Risk with Preventative Measures continues to remain 'Very High' for the hazardous events summarised in Table 7-11.

Table 7-11: Captains Flat Risks with very high residual risks after mitigation

Location	Hazard	Hazardous Event	Preventative measures
Service Reservoirs	Pathogens	Faecal contamination (access by birds, rats)	Fortnightly visual inspection; vermin proofing; covered reservoirs; chlorine residual in treated water
Service Reservoirs	Pathogens	High chlorine take-up within reservoir	Chlorine test inflow and outflow
Reticulation system	Pathogens or chemicals	Contaminating the treated water due to back flow & cross connection (e.g. water carters)	Chlorine residual; metered standpipe (top fill airgap) for hire from Council; Double check valve on meters (RPZ on critical users - SPS, STP, hospital, pool etc); backflow prevention training; Plumbing Code of Australia; spring loaded fire hydrants maintain pressure
Reticulation system	Pathogens or chemicals	Growth of biofilms, sludge causing degradation of water quality (includes metals)	Chlorine residual; operational monitoring at point of supply; deadend flushing; WTP process control (also for removal of nutrients); reactive mains replacement
Reticulation system	Pathogens	Use of same tools between sewage and water treatment systems	Well-trained operators; disinfect/ wash tools, clothes etc; chlorine residual; flush; pressure in system

There are other risks that have High residual risk including: OSSMs in the catchment failing and contaminating the raw water (mitigated by inspecting the OSSMs every two years and WTP process control; unrestricted livestock access to the raw water (mitigated by WTP process control), primary and secondary contact recreation in the dam (mitigated by WTP process control) and several others.

Council is currently reviewing the DWMS including this risk assessment.

7.4 Best practice compliance – LWU Circular 18

This circular was prepared in 2014 to address local water utilities of a new protocol to ensure safety of drinking water supplies across regional NSW. LWUs were required to review and update their standard operating procedures to ensure three key barriers were achieved.

7.4.1 Barrier 1: Effective distribution

LWU Circular 18 states that disinfection is the single process that has had the greatest impact on drinking water safety. Two actions should be undertaken to achieve effective disinfection.

7.4.1.1 Action 1: Monitoring of factors which affect disinfection

LWU Circular 18 recommends LWUs to monitor the factors which affect effective disinfection including chlorine residual, turbidity and pH levels. These factors are monitored at Captains Flat WTP as part of its CCPs (see Section 7.2.4).

Circular 18 recommends keeping turbidity as low as practicable, aiming for less than 1 NTU. pH should be as low as possible and Circular 18 states that a level between 7.2 to 8.2 is desirable.

The Captains Flat WTP filtered water turbidity has been consistently below 1 NTU (see Figure 7-6).

7.4.1.2 Action 2: Achieve minimum chlorine contact time (C.t)

Circular 18 recommends that a minimum C.t. value of 15 mg.min/L is achieved, as recommended by the ADWG.

C.t. is calculated only for the Keating's Reservoirs 1 and 2 (capacities 0.33 ML and 0.55 ML respectively)

C.t. for water leaving reservoirs:

- Plant flow = 0.7 ML/day
- Reservoirs = 0.88 ML
- Baffling factor of 0.3 used for contact tank assuming it has 'single or multiple unbaffled inlets and outlets, no intra-basin baffles' [source]
- Free chlorine concentration = 0.7 mg/L (Council's CCP critical limit)
- C.t. = 108.6 mg.min/L

The total C.t from chlorination at Captains Flat WTP to outflow is 108.6 mg.min/L, which is above the recommended minimum value of 15 mg.min/L.

7.4.2 Barrier 2: Distribution system integrity

Council's reservoirs are inspected each week which requires a check of perimeter security and a walk-around inspection and top inspection of the reservoir. Council uses Reservoir Integrity as a CCP in all three water supply schemes, however technically it is not a CCP.

Council provided the inspection reports recently for each reservoir. As of the last inspection no issues were identified, and no actions were required at any of the eight reservoirs.

7.4.3 Barrier 3: Maintain a free chlorine residual in the distribution system

Circular 18 recommends a minimum chlorine residual of 0.2 mg/L in the distribution system. Council monitors free chlorine daily in the reticulation of each of the water supply schemes.

7.5 Water cycle analysis

This was not undertaken as there has not been much growth in Captains Flat since the last IWCM. Hence it was not included in the scope.

7.6 Application of Health-Based Treatment Targets

See Appendix figure C-4 for Captains Flat's HBT tool.

7.6.1 HBT assessment of threats

Captains Flat WTP sources water from Molonglo River. Since this water source is a river source, a catchment vulnerability assessment is required.

7.6.1.1 Inherent risk

The assessed is undertaken for an inner catchment and outer catchment:

- Inner catchment – 1 km radius from the extraction point in Molonglo River
- Outer catchment – 5 km radius from the extraction point in Molonglo River

The likelihood of the threat occurring in the outer catchment and impacting the water quality at the intake is considered to be lower than the inner catchment, therefore risk ratings within the outer catchment is reduced.

The aerial view of the catchment of Captains Flat water supply source is shown in Figure 7-14.

Based on the assessment, Captains Flat catchment has an **inherent risk of 'Medium'** because of free roaming livestock within the catchment (grazing animals).

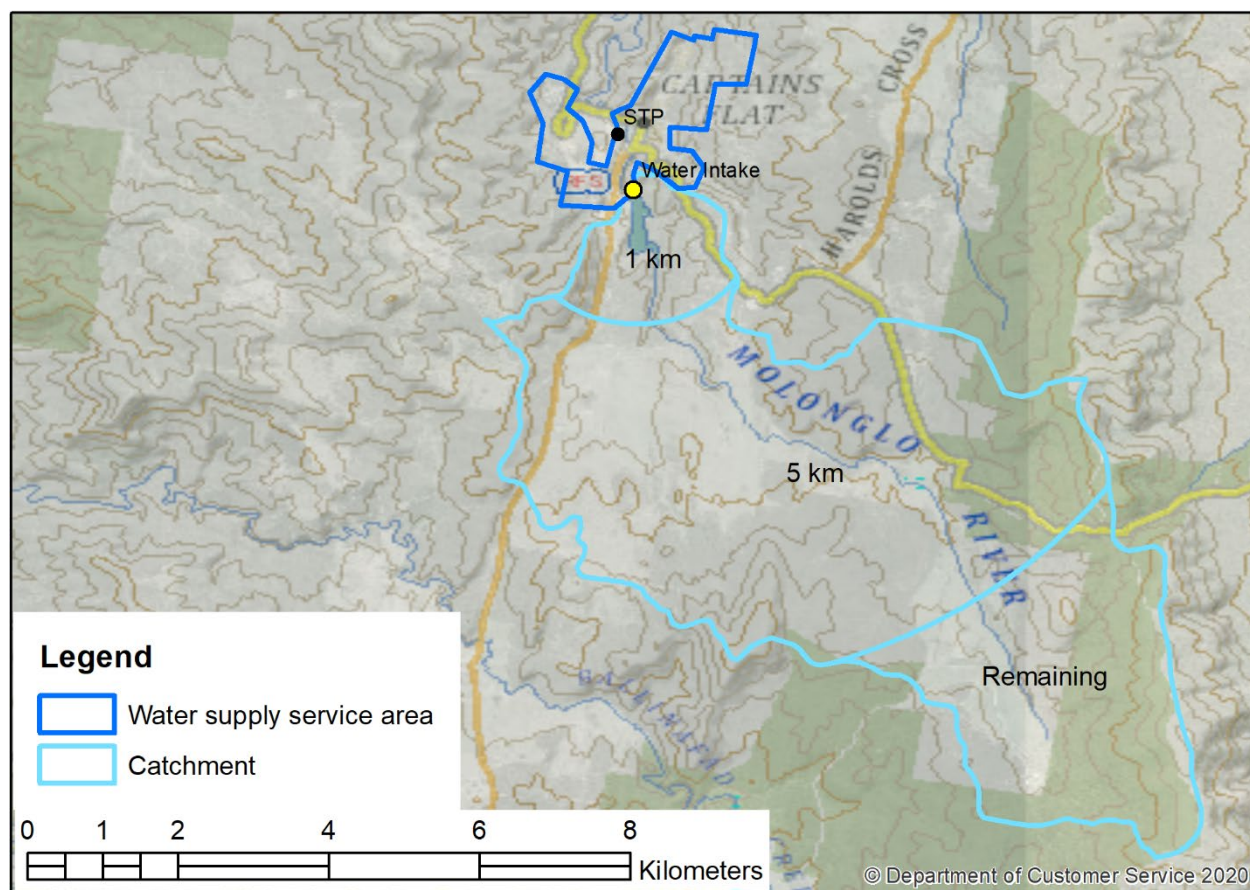


Figure 7-14: Inner and outer catchment of Captains Flat raw water source

7.6.2 HBT assessment of treatment barriers

7.6.2.1 Treatment barriers for chlorine sensitive pathogens

Captains Flat WTP is an ultra-filtration membrane filtration plant with chlorine as the disinfection barrier. Refer to Section 7.4.3 for the CCP results. The criteria used for assessing the effectiveness of treatment barriers are:

- Filtrate turbidity < 1 NTU
- Chlorine contact > 15 mg.min/L

Historically, there is only one case where filtered water turbidity from Captains Flat WTP exceeded 1 NTU.

Captains Flat WTP achieves a chlorine contact of 15 mg.min/L (see 7.4.1.2), therefore the treatment barrier for chlorine sensitive pathogens is considered effective.

Residual risk of chlorine sensitive pathogens: **Low**.

7.6.2.2 Treatment barriers for chlorine resistant pathogens

Captains Flat WTP has individual monitoring of turbidity at each filter. The criteria used for assessing the effectiveness of the filters are:

- Highest individual filtered water turbidity recorded ≤ 0.3 NTU
- Highest monthly 95th percentile individual filtered water turbidity ≤ 0.15 NTU

From Section 7.2.4, using the most recent (2021) data, the highest filtered water turbidity exceeded 0.3 NTU and the highest monthly 95th percentile turbidity was calculated to be 0.23 NTU.

Residual risk of chlorine resistant pathogens **Very Low**.

7.6.3 NSW Health preliminary cryptosporidium risk assessment

Based on NSW Health (letter sent to Council in November 2019), there is a '**Medium**' risk rating of cryptosporidium in the raw water source for Captains Flat (see Appendix figure C-5).

7.7 Work health and safety

No major WHS issues were noted from the condition assessment site visit.

No major WHS issues were noted from NSW PW staff site visit.

8 Bungendore sewerage scheme

8.1 Sewage collection and transfer

The Bungendore sewerage scheme consists of 10 sewage pumping stations, 8 km of rising sewer mains and 44 km of gravity sewer mains.

Figure 8-1 shows an overview of Bungendore sewerage scheme with the inclusion of the new growth zones.

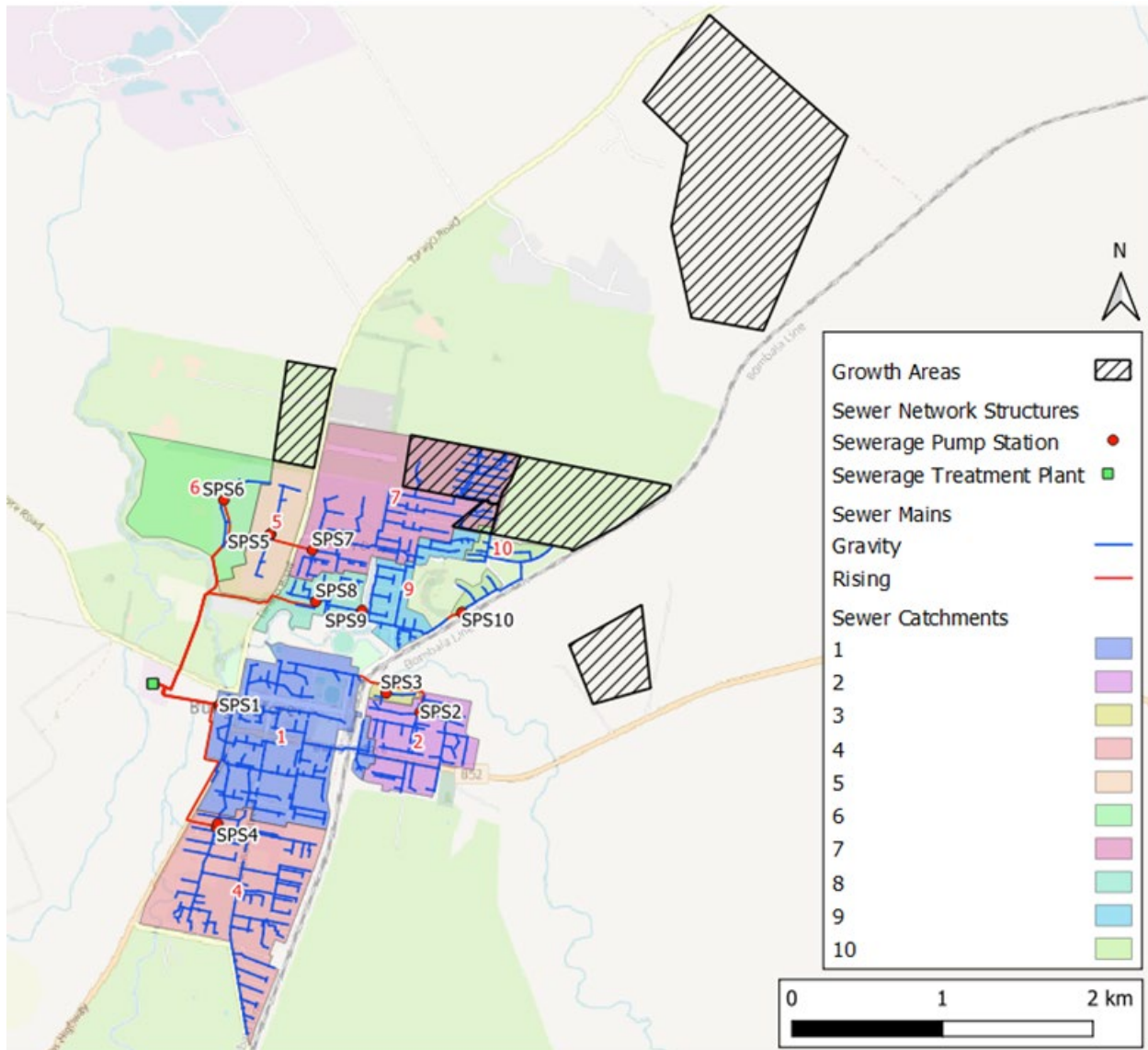


Figure 8-1: Bungendore sewerage scheme

A pump hierarchy diagram of Bungendore sewerage scheme with pump rates is shown in Figure 8-2.

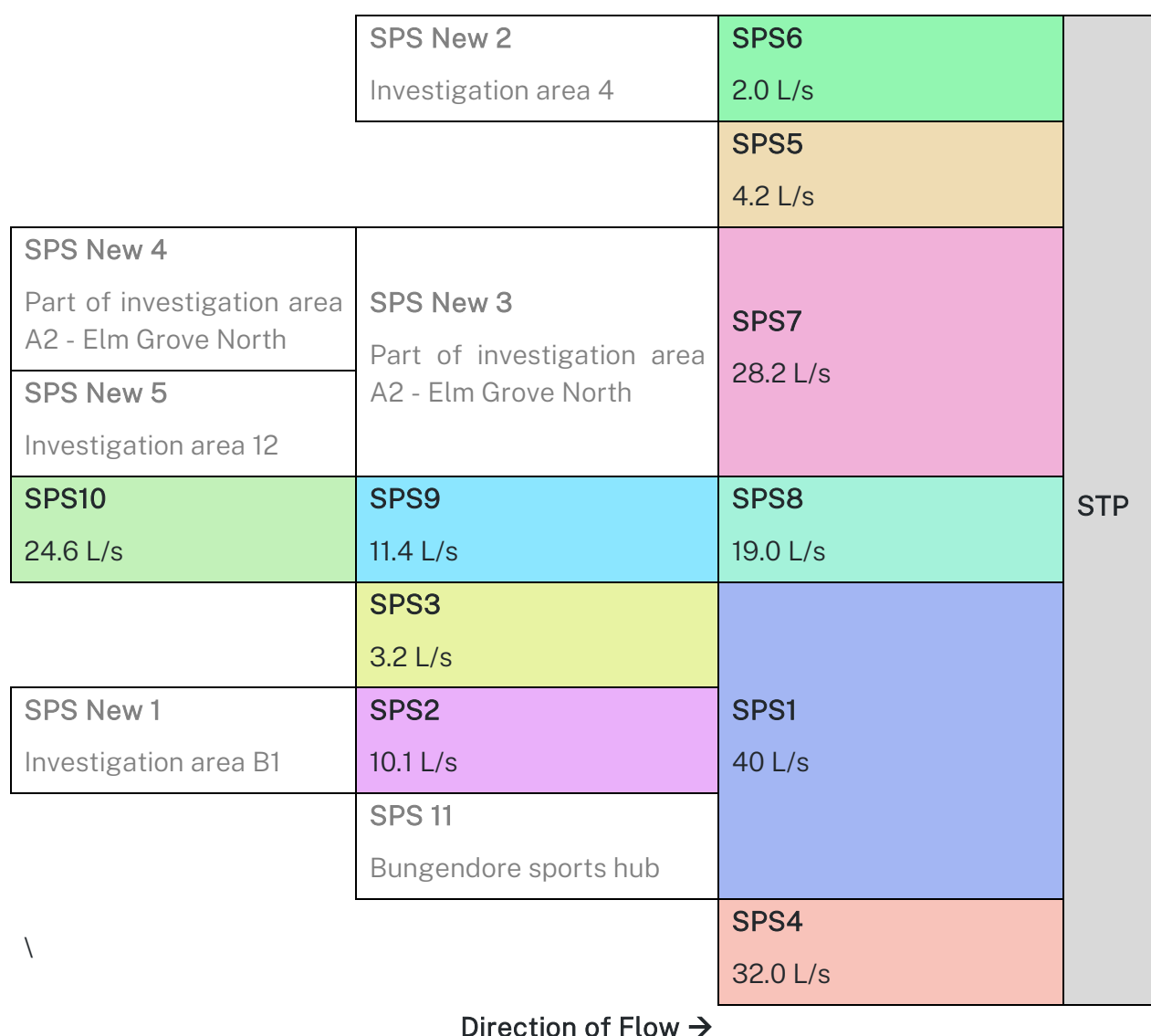


Figure 8-2: Bungendore sewerage scheme SPS hierarchy

A new pump station has been added to service the Bungendore Sports Hub (SPS 11). This SPS pumps a short distance into the SPS 1 catchment. For the purposes of this project, the current loads are assigned to SPS 1. This will be updated in future projects.

SPS 1's design pump capacity was 61.5 L/s, based on recent Council checks, it appears that the actual pump capacity installed is 40 L/s.

8.2 Sewage treatment

8.2.1 STP description

Bungendore STP was first constructed in 1976 with a 1,000 EP Pasveer Channel, and in 1993 a 2,000 EP capacity IDEA tank was constructed. The STP was re-augmented in 2012 with the demolition of the Pasveer channel and the construction of a new 3,000 EP IDEA reactor on the same footprint. Due to the high growth rates expected in Bungendore, the 1993 IDEA tank has been refurbished and was recommissioned in March 2023, bringing the total capacity of the plant to 5,000 EP.

The Bungendore STP consists of the following process units:

- Inlet works Inflow reception, screening, grit removal, flow measurement, and flow division;
- 2 x IDEA reactors (a 3,000 EP (new), a 2,000 EP (old))
- Catch/balance pond;
- Effluent ponds;
- Alum dosing facilities;
- Sludge Lagoons;
- Sludge drying beds;
- UV disinfection system and
- Chlorination system.

A summary of the Bungendore STP design capacities for each process unit is given in Appendix table H-1.

Figure 8-3 shows the process flow diagram of the Bungendore STP. See Appendix figure H-1 for the detailed process flow schematic.

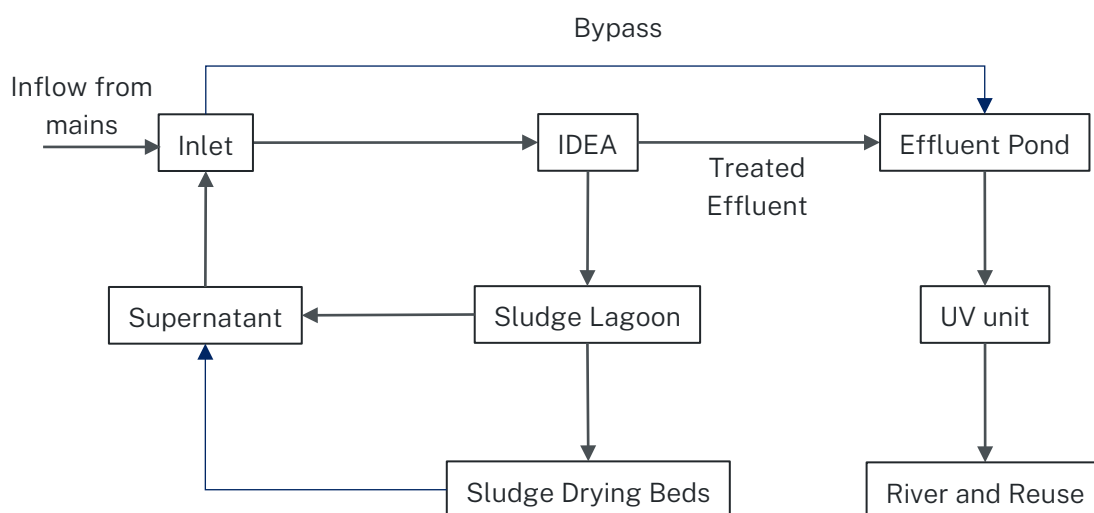


Figure 8-3: Process Flow Diagram – Bungendore STP

See the plan view of the Bungendore STP in Appendix figure H-2.

8.2.2 Historical flows

STP inflow daily data was available from July 2012 to February 2023. Daily rainfall data is available at the STP site over the period as well. Rainfall data were obtained from the Bureau of Meteorology (BOM weather station number 70011 – Bungendore Post Office).

The historical sewage inflow to the Bungendore STP is shown in Figure 8-4.

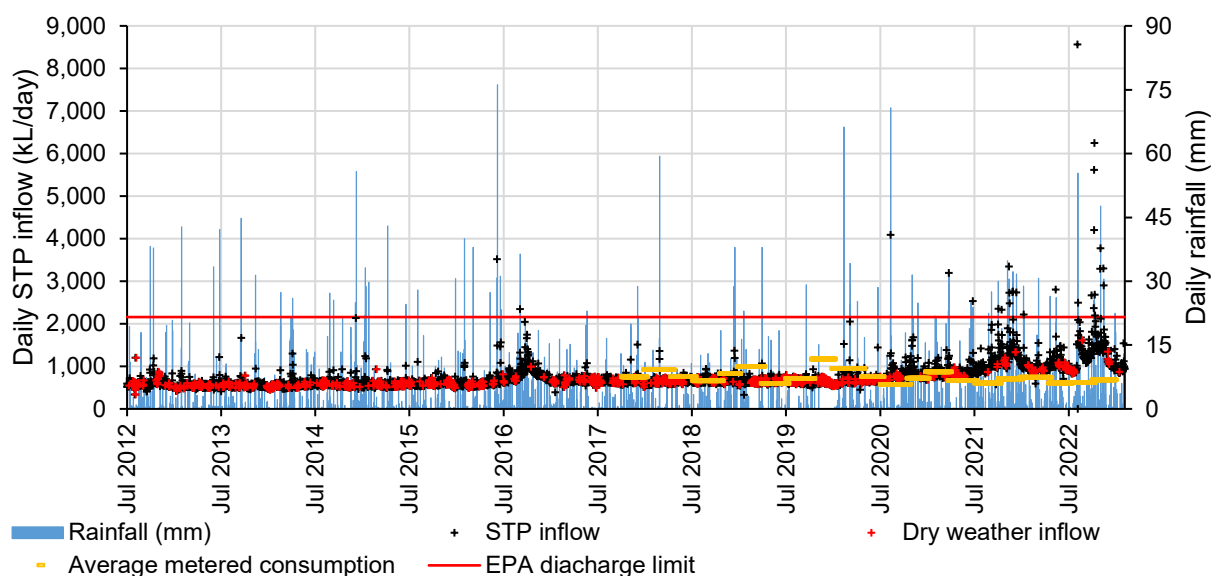


Figure 8-4: Bungendore STP historical inflow, rainfall and metered consumption

The dry weather inflow exceeded the volume of metered consumption during the winter of 2019, a very dry period. It was also observed that during the extended wet weather from 2020 to 2022, the STP inflow is persistently high, even after 14 to 16 dry days in a row. Between July 2012 and July 2021, the STP inflow very rarely exceeded the EPA licence outflow limit (2,160 kL/day) and it is likely that the storage at the STP could buffer these flows to keep daily releases below the limit, in 2021/22 and 2022/23 the climate was significantly wetter leading to months when the average daily inflow was over 1,500 kL/day and it is likely that the outflow exceeded the licence limit during these periods. This is examined further in Section 8.3.1.1.

8.3 STP inflow analysis

8.3.1 Average dry weather flow (ADWF) estimated from STP inflow data

STP daily inflow data was analysed to estimate the average dry weather flow (ADWF). To estimate historical ADWF, a dry day was taken as a day with less than 3 mm of rainfall on that day, any of the eight preceding days and one day following. All historical rainfall data was obtained from the Bureau of Meteorology (BOM).

The historical annual ADWF from 2012/13 to 2017/18 is shown in Table 8-1.

Table 8-1: Bungendore STP – ADWF estimated from STP inflow data

Financial Year	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
ADWF (kL/day)	566	537	567	583	662	639	642	639

There have been some trends in changes to the recorded ADWF: between and May 2016 the ADWF averaged 563 kL/day, there was then a wet weather period from June 2016 to May 2017 after this period there was a mostly quite dry period between May 2017 to early July 2020, over this drier period the ADWF was 641 kL/day, with the monthly average only below 600 kL/day in January 2020. This 14% increase in ADWF after the wet weather in 2016/17 indicate that there may have been a change in the STP flow meter calibration.

The 2020/21 and 2021/22 data has been excluded from the ADWF calculation due to the impact of the extremely wet weather. Therefore, on the STP inflow data from 2017/18 to 2019/20, the ADWF for the Bungendore STP is around 640 kL/day.

8.3.1.1 Average Dry Weather Flow (ADWF) comparison with river level data

From July 2020 to February 2023 STP inflow has been almost continuously above 660 kL/day, and almost all of 2021/22 over 800 kL/day. It appears that the infiltration to the system is likely due to continued high water levels in the local groundwater system and local waterways. There are three monitoring bores in Bungendore, though there were no readings available between August 2021 and December 2023 (as of 6 December 2023). Therefore, the closest environmental water level data monitoring available is from the river gauge at Butmaroo Creek, Butmaroo (station number 411003, about 9 km east of Bungendore in an adjacent Lake George sub-catchment). The creek levels and STP inflow from July 2017 to February 2023 are shown in Figure 9 6 and show that when the creek levels are over 500 mm for an extended period, the STP inflow continues to be high, regardless of the time since the last rainfall. **Issue**

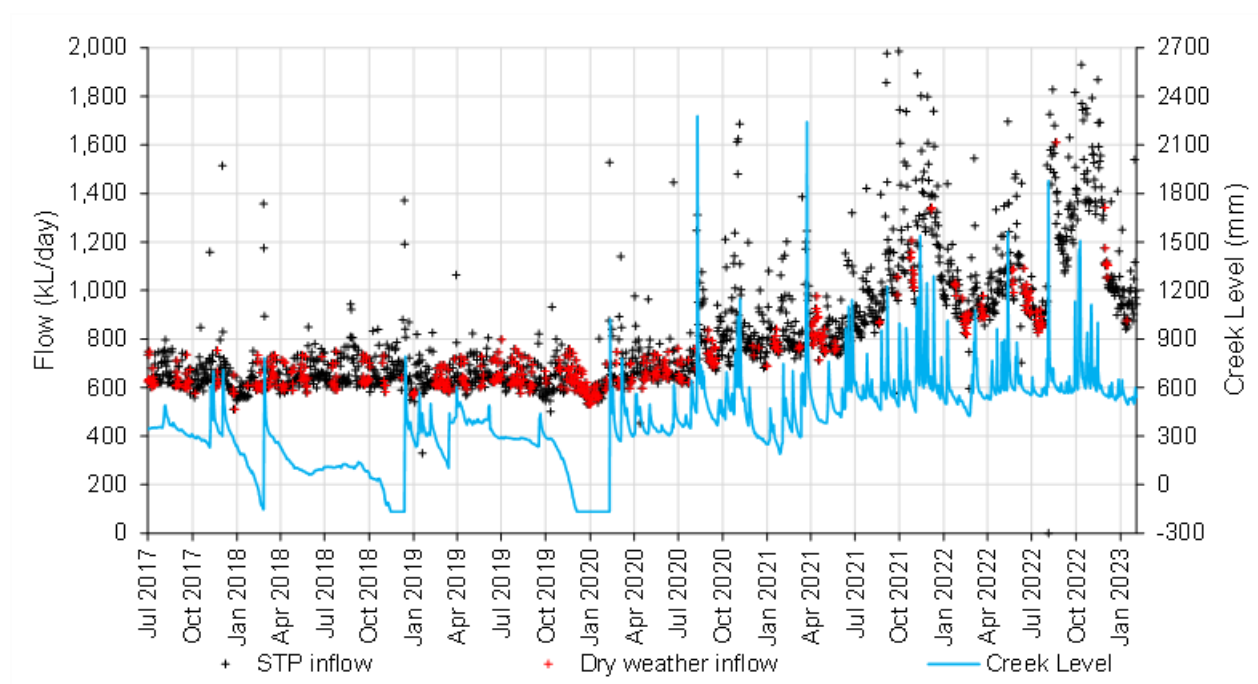


Figure 8-5: Bungendore STP historical inflow and Butmaroo Creek water levels – Jan 2017 to Feb 2023

8.3.2 ADWF estimated from customer billing data

The unit climate independent demand for the sewered Bungendore residential properties was 421 L/property/day, or 144 L/person/day.

In general, most winter water consumption by sewered properties is expected to become dry weather sewage flow. Between 2018 and 2022 the winter metered water consumption (generally using the billing periods running between March or April to September or October) by sewered properties has varied between 614 and 801 kL/day, averaging 693 kL/day over the entire period and 659 kL/day for 2021 and 2022.

An alternate method to estimating the average dry weather flow is to assume that the climate independent flow (for properties with climate dependent use) is approximately equal to the sewer flow and then to use the average winter metered demand for the properties with climate dependent consumption. Using this method, the estimated average dry weather flow was 623 kL/day.

8.3.3 Nominated ADWF and unit hydraulic loading

The ADWF measured from the STP inflow data (refer to Figure 8-5 and Table 8-1) recorded an average of **600 kL/day** from year 2013 to year 2019. At year 2019, STP inflow has recorded **640 kL/day** followed by significant increase reaching to **959 kL/day** in year 2022 due to extreme wet weather events in year 2021 and year 2022 as shown on Figure 8-8.

The ADWF calculated from customer billing data analysis was **643 kL/day** (the average winter water consumption by sewered customers during winter 2018, 2019 and 2022 (skipping the COVID-19 lockdown winters), with the exception of SPS 4 where 2022 was used as there has

been significant development in this catchment) and this has been nominated ADWF for the Bungendore sewerage scheme, as it is close to the ADWF from the inflow data (640 kL/day) and the meter data can be easily assigned to the individual SPS catchments.

Table 8-2: Bungendore ADWF based on winter metered consumption

Sewer catchment	ADWF (local catchment) (kL/day)	ADWF (local and upstream catchments) (kL/day)
BU SPS1	196.9	289.9
BU SPS2	88.8	88.8
BU SPS3	4.1	4.1
BU SPS4	95.8	95.8
BU SPS5	10.1	10.1
BU SPS6	9.5	9.5
BU SPS7	114.6	114.6
BU SPS8	44.5	123.7
BU SPS9	57.4	79.1
BU SPS10	21.7	21.7
STP	643	643

The total Equivalent Person (EP) for the Bungendore sewerage scheme has been estimated as **4,540 EP**, which is explained in more detail in Section 8.5. Using this EP, the unit hydraulic loading is calculated to be **142 L/EP/day**. This is very low compared to the standard design load for sewerage systems of 240 L/EP/day developed in the 1980s, and significantly lower than the 180 L/EP/day used for some modern designs. This is likely due to the widespread use of water efficient appliances and moderate climate (evaporative air-conditioner waste water contributes to dry weather flows in some communities with high temperatures and low humidity).

8.3.4 Estimated Peak dry weather flow (PDWF)

The PDWF in each SPS catchment are calculated using the method in the Public Works Sewer Design Manual [13]. The total Equivalent Tenement (ET) for the Bungendore sewerage scheme has been estimated as 1568 ET, explained in more detail in Section 8.5.

The estimated sewage load to each SPS in terms of Average Dry Weather Flow (ADWF), Peak Dry Weather Flow (PDWF) and Peak Wet Weather Flow (PWWF) is shown in Table 8-3.

Table 8-3: Estimated ADWF, PDWF and PWWF - Bungendore sewerage scheme

Sewer catchment	ET	Local catchment flow				Cumulative		
		ADWF (kL/day)	ADWF (L/s)	PDWF (L/s)	PWWF (L/s)	ADWF (kL/day)	ADWF (L/s)	PWWF (L/s)
BU SPS1	518	198.7	2.3	5.8	35.8	290.4	3.4	49.1
BU SPS2	207	87.5	1.0	2.9	14.9	87.5	1.0	14.9
BU SPS3	12	4.1	0.0	0.3	1.0	4.1	0.0	1.0
BU SPS4	281	95.8	1.1	3.1	19.4	95.8	1.1	19.4
BU SPS5	21	10.1	0.1	0.5	1.8	10.1	0.1	1.8
BU SPS6	24	9.5	0.1	0.5	1.9	9.5	0.1	1.9
BU SPS7	210	114.6	1.3	3.8	16.0	114.6	1.3	16.0
BU SPS8	93	44.5	0.5	1.7	7.1	123.7	1.4	19.0
BU SPS9	123	57.4	0.7	2.1	9.2	79.1	0.9	35.6
BU SPS10	55	21.7	0.3	0.9	4.1	21.7	0.3	4.1
Total	1,544	643.9	7.5	16.1	105.6	643.9	7.5	107.1

Note that the PDWF and PWWF do not add up to the total of the STP because not every catchment is expected to experience peak flows at the same time.

The peaking factor ('r') for the whole sewerage scheme was calculated to be 2.2. Using the number of ET, the PDWF was estimated to be **16 L/s**. The PWWF from all catchments in Bungendore sewerage scheme is further discussed in Section 8.3.5.

8.3.5 Peak wet weather flow (PWWF)

A hydraulic model for Bungendore was completed by NSW PW in 2018. In the model, a 1 in 5-year 1 hour duration rainfall event was selected so that there will be no overflows during that event. Simulations predicted that no upgrades are required at sewage load of 1,368 ET for Bungendore sewerage scheme. The estimated equivalent tenement in year 2022 for Bungendore is 1,568 ET, a increase of about 14.6% from the ET used in the model. An update and recalibration of this model for current equivalent tenement of 1,568 ET will be undertaken separately. Hence, the PWWF in each SPS catchment are calculated using the method in the Public Works Sewer Design Manual [13].

The design hydraulic capacity of the inlet works needs to be sufficient to receive the pumped flow from all of the SPS immediately upstream.

8.3.6 Biological and nutrient loading

Council undertakes regular sampling and testing of effluent concentrations at Bungendore as required under the EPL. Council doesn't test raw sewage concentrations. Standard biological allowances that are commonly adopted as typical for sewage that is essentially domestic in origin as shown on Table 8-4. These are adopted in the absence of other data in the option study done by NSW PW in June 2016 for Bungendore STP Augmentation (from 5,000 EP to 12,000 EP capacity). [14]

Table 8-4: Bungendore Inflow Biological Loading Results

Parameter	Standard Allowances (Unit Loading)	
Biochemical Oxygen Demand (BOD ₅)	70	g/EP.d
Suspended Solids (SS)	65	g/EP.d
Total Nitrogen (TN)	12	g/EP.d
Total Phosphorus (TP)	2.7	g/EP.d

The STP and the collection system operate under EPL No. 201 granted by the NSW EPA that is renewed annually.

Effluent quality limitations on EPA licence are summarized in Table 8-5.

Table 8-5: Pollutant List - Sewage and Effluent for Bungendore STP

Parameter	Typical Raw Sewage	Effluent (90 percentile) *	Effluent (100 percentile) *
Biochemical Oxygen Demand (BOD ₅)	270 mg/L	<5 mg/L	<10 mg/L
Suspended Solids (SS)	270 mg/L	<10 mg/L	<15 mg/L
Total Nitrogen (TN)	53 mg/L	<8 mg/L	<10 mg/L
Ammonia	12 mg/L	<2 mg/L	<5 mg/L
Total Phosphorus (TP)	11 mg/L	<0.5 mg/L	<1 mg/L
Oil and grease (O&G)	< 10 mg/L	<2 mg/L	<10 mg/L
Faecal coliforms (FC)	1,000,000 cfu/100 mL	<100 cfu/100 mL	<200 cfu/100 mL
pH	6.5 – 8.5		6.5 – 8.5

Note: *Licence Conditions

Source: PIRMP, V2 [15]

8.4 Bungendore Recycled Water Management System

The Bungendore STP includes a recycled water component that treats effluent from the Bungendore STP's catch pond to a suitable standard. The sewage inflow is treated by screening, grit removal, biological and chemical treatment before flowing to the catch pond. [16]

The recycled water plant includes the following:

- A pumping system for the catch pond to the recycled water treatment
- A disc filter for pre-screening
- An ultra-filtration (UF) membrane system
- An ultraviolet (UV) disinfection system
- A liquid chlorine storage and dosing disinfection system

- An on-site recycled water storage tank
- A pump station to transport the water to the irrigation sites and the tanker fill station.
- Rising mains to the irrigation sites
- A schematic of the Recycled Water Management System (RWMS) is in Figure 8-6.

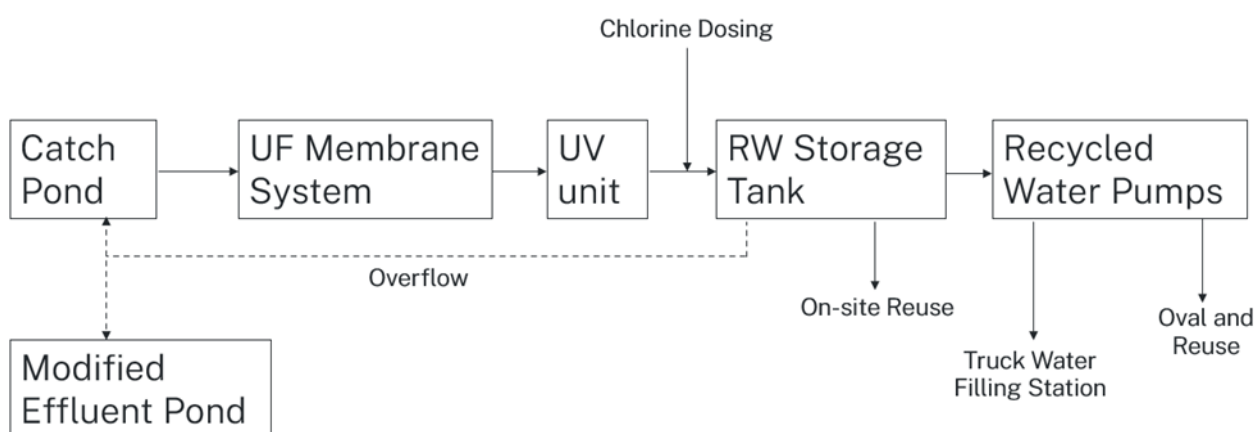


Figure 8-6: Bungendore STP Reuse flow diagram

The detailed Bungendore STP reuse flow diagram is shown in Appendix figure I-1.

The new recycled water scheme will provide recycled water to the following users:

- Dust suppression for road construction (current user)
- On site STP reuse (current user)
- Mick Sherd Oval (MS Oval)
- The future Bungendore Sports Hub Area (currently under construction)
- Other potential future users.

Table 8-6: Approved end users

Users	Purpose	Quantity
Ad hoc	Dust suppression for road construction	240 kl/d
Mick Sherd Oval	Municipal irrigation of sporting grounds including golf, horse racing and lawn bowls but excluding wet synthetic hockey fields	28 kl/d
Bungendore Sports Hub Area (Bungendore West)	Municipal irrigation of sporting excluding wet synthetic hockey fields	134 kl/d

The recycled water scheme is shown in Figure 8-7.



Figure 8-7: Bungendore Recycled Water Scheme

Council monitors the outflow quality from the catch pond (EPA Identification point 2 - Discharge Point Catch Pond). Results from June 2013 to May 2018, a total of 64 samples, is shown below in Table 8-7. This quality has been used as the basis of design for the RWP feed.

Table 8-7: Catch Pond Effluent Quality-RWMS Bungendore

	Max	95th %ile	Average	5th %ile	Min
Ammonia (mg/L N)	8	4.9	1	0.5	0
Biochemical Oxygen Demand (mg/L)	10	7	1.91	0	0
Faecal Coliforms (CFU/100 ml)	490,000	123,000	18,000	1,500	20
Total Nitrogen (mg/L N)	12	8.2	4.6	4.5	0.1
Oil & Grease (mg/L)	0	0	0	0	0
Phosphorus (mg/L P)	2.85	0.48	0.23	0.17	0.06
Total Suspended Solids (mg/L)	38	20	9.83	9	0
pH	8	7.9	7.6	7.7	7.1

The catch pond is an open structure which could encourage algae growth. Algae tests were completed in March 2019. The maximum algae count was 11,000 cells/ml. The RWP is designed to handle up to 400,000 cells/ml.

Four CCPs have been identified for the Bungendore RWP:

- CCP 1 – Membrane system

- CCP 2 – UV system
- CCP 3 and 4 – Chlorine systems

The design operating target, adjustment and critical limits for each CCP are shown in Table 8-8. Each CCP with the limits as well as the required actions are displayed at the STP.

Once CCP data for Bungendore RWMS is provided to NSW Public Works it can be graphically represented and analysed whether values fall within limits in the next report.

Table 8-8: Critical Control Points and Critical Limits

Critical Control Point	Description	Monitoring Process/Type	Operational Target	Adjustment Limit	Critical Limit
CCP1	Membrane treatment	Turbidity and pressure decay test (PDT)	Turbidity <0.1 NTU PDT <2.7 kPa/min	Turbidity >0.1 NTU PDT >2.7 kPa/min	PDT >3.2 kPa/min
CCP2	UV system	Lamp age, ultra-violet transmittance (UVT) and Reduced Equivalent Dose (RED)	Age <10,000 h UVT > 50% RED > 43 mJ/cm ²	Age >10,000 h UVT <50% RED <43 mJ/cm ²	Age >12,000 h UVT <43.6% RED <39 mJ/cm ²
CCP3	Chlorination System	Free Residual chlorine after contact time and pH	Residual between 1.0 - 4.5 mg/L pH between 6.5-8.5	Residual <1.0 mg/L pH < 6.5 or >8.5	Residual <0.8 mg/L pH < 6.0 or >9.0
CCP4	Chlorination System	Free Residual chlorine after contact time and pH	Residual between 1.0 - 4.5 mg/L pH between 6.5-8.5	Residual <1.0 mg/L pH < 6.5 or >8.5	Residual <0.8 mg/L pH < 6.0 or >9.0

Table 8-9 and Table 8-10 details the monitoring plan. These results will be kept with the STP operational logs.

Table 8-9: Recycled water quality monitoring schedule

Parameter	Location	Frequency	Limit/Range	Responsibility
E. coli	Recycled Water Pumps	Weekly	<1 CFU per 100 mL	Plant operator
Audit of calibration activities	STP and RWP	Monthly	Monitoring equipment stays accurate	Manager, Utilities

Parameter	Location	Frequency	Limit/Range	Responsibility
Audit of preventative maintenance activities	STP and RWP	Annually	No unforeseen breakdowns	Manager, Utilities
Audit of operational monitoring activities	STP and RWP	Monthly	Safe recycled water scheme	Manager, Utilities

Table 8-10: End user water quality monitoring schedule

Parameter	Location	Frequency	Limit/Range	Responsibility
E. coli	Recycled Water Storages	Monthly	<1 CFU per 100 mL	Plant operator
Residual Chlorine	Recycled Water Storages	Monthly	0.5 mg/L	Plant operator
Phosphorus in soil	Irrigation Sites	Annually	As per site specific irrigation plan	End User

Table 8-11 shows the LRV for this process. A validated membrane filtration and UV unit will be installed, and chlorination will be required to ensure that the LRV for adenovirus is achieved.

Table 8-11: LRV calculation for process

Treatment process	Protozoa	Virus	Bacteria
Membrane filtration (validated unit)	2	2	2
UV disinfection (validated unit)	2	0.5	1
Chlorination (C.t calculation)	0	2.7	1
Scheme Requirement	4	5.2	4

The C.t requirements for disinfection have been based on the USEPA Guidance manual for compliance with the filtration and disinfection requirements for public works systems using surface water sources (USEPA (1991)). The treated wastewater is essentially free of suspended solids having been through ultrafiltration membranes. It is therefore considered reasonable to apply the design guidance from this document. For a pH range of 6-9, a C.t of 3.7 mg.min/L is required for 2.7 log virus disinfection. A pipe contactor has been selected as it allows the use of a baffling factor of 1, which minimises the detention volume required, and avoids mixing and recirculation issues. This is generally considered an acceptable assumption provided L/d > 40 (length is at least 40 times the diameter). The following equation shows that the C.t target will be met in the contact pipe if the chlorine residual is above 0.8 mg/L.

$$C.t \text{ (Calculated)} = \left(0.395^2 \times \frac{\pi}{4} \times 30\right) kL \times 1 \times \frac{s}{11.5 L} \times \frac{0.8 mg}{L} \times \frac{1000L}{kL} \times \frac{min}{60s} = 4.3 mg \cdot \frac{min}{L}$$

8.5 EP and ET estimates

An Equivalent Person (EP) is defined as the quantity of sewage discharge for a resident in a detached house. For a non-residential establishment, the EP represents the number of persons who would contribute the same quantity and/or quality of domestic sewage as the establishment being considered. An Equivalent Tenement (ET) is similar to EP, but instead of a person used in the definition, an occupied detached house is used.

The residential sewer ET in each sewer catchment is equal to the number of occupied private residential dwellings, estimated from customer billing data. The non-residential ET is calculated by dividing the non-residential sewer load by the unit residential sewage load. Note that other ET definitions may be used for other purposes).

EP is then calculated by multiplying the ET by the current household size for Bungendore of 2.92 people per household, see Table 4-3.

Using the unit residential water consumption analysis undertaken in 5.6.2.1, EP unit flow is 144 L/EP/day and the ET unit flow is 421 L/ET/day.

The estimated EP and ET for each sewer catchment is given in Table 8-12.

Table 8-12: Bungendore sewerage scheme – Estimated ET and EP for each sewer catchment

Sewer catchment	ET			EP		
	Residential	Non-res	Total	Residential	Non-res	Total
BU SPS1	351	164	515	1032	482	1514
BU SPS2	205	5	210	603	14	617
BU SPS3	12	0	12	35	0	35
BU SPS4	266	15	281	782	45	827
BU SPS5	21	0	21	62	0	62
BU SPS6	20	4	24	59	11	70
BU SPS7	210	0	210	617	0	617
BU SPS8	92	1	93	270	4	275
BU SPS9	122	1	123	359	3	361
BU SPS10	55	0	55	162	0	162
Total	1,354	190	1,544	3,981	559	4,540

The estimated residential EP of 3,981 is slightly higher than the estimated serviced private dwelling population of 3,720 in Table 4-6.

8.6 EP and ET projections

The growth strategy for Bungendore is discussed in Section 4.4 and Section 4.5. Dwelling growth and priority areas are mapped on Figure 4-2 and the lot yields and receiving sewage pumping station catchments are summarised in Table 4-9. Bungendore residential infill and non-residential growth are discussed in 4.4.3 and Section 4.4.4 respectively.

Using the growth rates as discussed in Section 4 the ET projections for each SPS catchment are given in Table 8-13 and the EP projection is summarised in Table 8-14.

Table 8-13: Bungendore sewerage scheme ET projection

	SPS	2022	2025	2030	2035	2040	2045	2050	2055
Residential	BU SPS1	351	351	351	351	351	351	351	351
	BU SPS2	205	205	205	205	205	205	205	205
	BU SPS3	12	12	12	12	12	12	12	12
	BU SPS4	266	266	266	266	266	266	266	266
	BU SPS5	21	21	21	21	21	21	21	21
	BU SPS6	20	114	270	270	270	270	270	270
	BU SPS7	210	210	210	210	379	451	451	451
	BU SPS8	92	92	92	92	92	92	92	92
	BU SPS9	122	122	122	147	147	147	147	147
	BU SPS10	55	55	55	120	315	433	433	433
	BU New1	0	0	107	327	327	327	327	327
	BU New2	0	0	0	0	0	95	95	95
	BU New3	0	0	0	0	0	143	481	481
	BU New4	0	0	0	0	0	0	166	759
	BU New5	0	0	0	0	0	0	0	0
	Total	1,354	1,448	1,711	2,021	2,385	2,813	3,317	3,910
Non-residential	BU SPS1	167	184	216	254	299	351	413	486
	BU SPS2	2	2	2	3	3	4	5	5
	BU SPS3	0	0	0	0	0	0	0	0
	BU SPS4	15	17	20	23	27	32	38	44
	BU SPS5	0	0	0	0	0	0	0	0
	BU SPS6	4	4	5	6	7	8	9	11
	BU SPS7	0	0	0	0	0	0	0	0
	BU SPS8	1	2	2	2	3	3	4	4
	BU SPS9	1	1	1	1	2	2	2	3

	SPS	2022	2025	2030	2035	2040	2045	2050	2055
	BU SPS10	0	0	0	0	0	0	0	0
	BU New1	0	0	0	0	0	0	0	0
	BU New2	0	0	0	0	0	0	0	0
	BU New3	0	0	0	0	0	0	0	0
	BU New4	0	0	0	0	0	0	0	0
	BU New5	0	0	0	0	0	0	0	0
	Total	190	209	246	289	340	401	471	554
Total	BU SPS1	518	535	567	605	650	702	764	837
	BU SPS2	207	207	207	208	208	209	210	210
	BU SPS3	12	12	12	12	12	12	12	12
	BU SPS4	281	283	286	289	293	298	304	310
	BU SPS5	21	21	21	21	21	21	21	21
	BU SPS6	24	118	275	276	277	278	279	281
	BU SPS7	210	210	210	210	379	451	451	451
	BU SPS8	93	94	94	94	95	95	96	96
	BU SPS9	123	123	123	148	149	149	149	150
	BU SPS10	55	55	55	120	315	433	433	433
	BU New1	0	0	107	327	327	327	327	327
	BU New2	0	0	0	0	0	95	95	95
	BU New3	0	0	0	0	0	143	481	481
	BU New4	0	0	0	0	0	0	166	759
	BU New5	0	0	0	0	0	0	0	0
	Total	1,544	1,657	1,957	2,310	2,725	3,214	3,788	4,464

Table 8-14: Bungendore sewerage scheme EP projection

	SPS	2022	2025	2030	2035	2040	2045	2050	2055
Residential	BU SPS1	1,032	1,032	1,032	1,032	1,032	1,032	1,032	1,032
	BU SPS2	603	603	603	603	603	603	603	603
	BU SPS3	35	35	35	35	35	35	35	35
	BU SPS4	782	782	782	782	782	782	782	782
	BU SPS5	62	62	62	62	62	62	62	62
	BU SPS6	59	341	809	809	809	809	809	809

	SPS	2022	2025	2030	2035	2040	2045	2050	2055
	BU SPS7	617	617	617	617	1,124	1,340	1,340	1,340
	BU SPS8	270	270	270	270	270	270	270	270
	BU SPS9	359	359	359	434	434	434	434	434
	BU SPS10	162	162	162	357	942	1,296	1,296	1,296
	BU New1	0	0	321	981	981	981	981	981
	BU New2	0	0	0	0	0	285	285	285
	BU New3	0	0	0	0	0	429	1,443	1,443
	BU New4	0	0	0	0	0	0	498	2,277
	BU New5	0	0	0	0	0	0	0	0
	Total	3,981	4,263	5,052	5,982	7,074	8,358	9,870	11,649
Non-residential	BU SPS1	515	568	668	785	924	1,087	1,278	1,503
	BU SPS2	6	7	8	10	12	14	16	19
	BU SPS3	0	0	0	0	0	0	0	0
	BU SPS4	45	49	58	68	80	94	111	131
	BU SPS5	0	0	0	0	0	0	0	0
	BU SPS6	11	12	15	17	20	24	28	33
	BU SPS7	0	0	0	0	0	0	0	0
	BU SPS8	4	5	6	7	8	9	11	13
	BU SPS9	3	3	4	4	5	6	7	8
	BU SPS10	0	0	0	0	0	0	0	0
	BU New1	0	0	0	0	0	0	0	0
	BU New2	0	0	0	0	0	0	0	0
	BU New3	0	0	0	0	0	0	0	0
	BU New4	0	0	0	0	0	0	0	0
	BU New5	0	0	0	0	0	0	0	0
	Total	585	644	758	891	1,049	1,233	1,451	1,707
Total	BU SPS1	1,547	1,600	1,700	1,817	1,956	2,119	2,310	2,535
	BU SPS2	609	610	611	612	614	616	619	621
	BU SPS3	35	35	35	35	35	35	35	35
	BU SPS4	827	831	840	850	862	877	893	913
	BU SPS5	62	62	62	62	62	62	62	62
	BU SPS6	70	353	823	826	829	832	837	842

	SPS	2022	2025	2030	2035	2040	2045	2050	2055
	BU SPS7	617	617	617	617	1,124	1,340	1,340	1,340
	BU SPS8	275	275	276	277	278	280	281	283
	BU SPS9	361	362	362	438	439	439	441	442
	BU SPS10	162	162	162	357	942	1,296	1,296	1,296
	BU New1	0	0	321	981	981	981	981	981
	BU New2	0	0	0	0	0	285	285	285
	BU New3	0	0	0	0	0	429	1,443	1,443
	BU New4	0	0	0	0	0	0	498	2,277
	BU New5	0	0	0	0	0	0	0	0
	Total	4,565	4,907	5,810	6,873	8,122	9,591	11,321	13,355

The EP load will reach the STP design in about 2026, **Issue**. Council has commissioned a detailed design for an upgrade to the STP to bring the design capacity to 12,000 EP. The construction of the upgrade will commence once additional water has been secured for Bungendore.

8.7 Sewer system flow projections

8.7.1 System ADWF projections

The estimated ADWF projections for Bungendore sewerage scheme are shown in Table 8-15. The ADWF has been projected using the unit hydraulic loading of 180 L/EP/day for new residential developments and current loads for existing users and non-residential growth, the existing hydraulic load as discussed in Section 8.3.3.

The 220 L/EP/day used for some modern designs has been projected and plotted as shown in Figure 8-8, this graph shows that the current hydraulic capacity will not be reached until well after the nutrient treatment (EP) capacity is reached in 2026 (as discussed in Section 8.6).

The current STP Design ADWF is based on STP design criteria of 5000EP and ADWF of 240 L/EP/day. The projected sewage loading is plotted against the hydraulic capacity of the STP in Figure 8-8.

Table 8-15: Bungendore sewerage scheme ADWF projection (historical with 180L/EP for growth) (kL/day)

	SPS	2022	2025	2030	2035	2040	2045	2050	2055
Residential	BU SPS1	132.5	132.5	132.5	132.5	132.5	132.5	132.5	132.5
	BU SPS2	86.8	86.8	86.8	86.8	86.8	86.8	86.8	86.8
	BU SPS3	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
	BU SPS4	90.6	90.6	90.6	90.6	90.6	90.6	90.6	90.6
	BU SPS5	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1

	SPS	2022	2025	2030	2035	2040	2045	2050	2055
	BU SPS6	7.9	58.6	142.9	142.9	142.9	142.9	142.9	142.9
	BU SPS7	114.6	114.6	114.6	114.6	205.9	244.7	244.7	244.7
	BU SPS8	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9
	BU SPS9	57.0	57.0	57.0	70.5	70.5	70.5	70.5	70.5
	BU SPS10	21.7	21.7	21.7	56.8	162.1	225.8	225.8	225.8
	BU New1	0.0	0.0	57.8	176.6	176.6	176.6	176.6	176.6
	BU New2	0.0	0.0	0.0	0.0	0.0	51.3	51.3	51.3
	BU New3	0.0	0.0	0.0	0.0	0.0	77.2	259.7	259.7
	BU New4	0.0	0.0	0.0	0.0	0.0	0.0	89.6	409.9
	BU New5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	569.2	620.0	762.0	929.4	1,125.9	1,357.1	1,629.2	1,949.4
Non-residential	BU SPS1	66.2	72.9	85.8	100.9	118.7	139.6	164.2	193.2
	BU SPS2	0.8	0.8	1.0	1.2	1.4	1.6	1.9	2.2
	BU SPS3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BU SPS4	5.2	5.7	6.7	7.9	9.3	10.9	12.8	15.1
	BU SPS5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BU SPS6	1.6	1.8	2.1	2.5	2.9	3.4	4.0	4.7
	BU SPS7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BU SPS8	0.6	0.7	0.8	1.0	1.1	1.3	1.6	1.8
	BU SPS9	0.4	0.4	0.5	0.6	0.7	0.8	1.0	1.2
	BU SPS10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BU New1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BU New2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BU New3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BU New4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BU New5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	74.7	82.4	96.9	114.0	134.1	157.7	185.5	218.2
Total	BU SPS1	198.7	205.4	218.3	233.4	251.2	272.1	296.7	325.7
	BU SPS2	87.5	87.6	87.8	87.9	88.1	88.4	88.7	89.0
	BU SPS3	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
	BU SPS4	95.8	96.3	97.3	98.5	99.9	101.5	103.4	105.7
	BU SPS5	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1

	SPS	2022	2025	2030	2035	2040	2045	2050	2055
	BU SPS6	9.5	60.4	145.0	145.3	145.8	146.3	146.9	147.6
	BU SPS7	114.6	114.6	114.6	114.6	205.9	244.7	244.7	244.7
	BU SPS8	44.5	44.6	44.7	44.9	45.0	45.2	45.5	45.7
	BU SPS9	57.4	57.4	57.5	71.1	71.2	71.3	71.5	71.7
	BU SPS10	21.7	21.7	21.7	56.8	162.1	225.8	225.8	225.8
	BU New1	0.0	0.0	57.8	176.6	176.6	176.6	176.6	176.6
	BU New2	0.0	0.0	0.0	0.0	0.0	51.3	51.3	51.3
	BU New3	0.0	0.0	0.0	0.0	0.0	77.2	259.7	259.7
	BU New4	0.0	0.0	0.0	0.0	0.0	0.0	89.6	409.9
	BU New5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	643.9	702.3	858.9	1,043.4	1,260.0	1,514.8	1,814.7	2,167.6

Table 8-16: Bungendore sewerage scheme ADFW projection (220 L/EP/day) (kL/day)

	SPS	2022	2025	2030	2035	2040	2045	2050	2055
Residential	BU SPS1	227.0	227.0	227.0	227.0	227.0	227.0	227.0	227.0
	BU SPS2	132.6	132.6	132.6	132.6	132.6	132.6	132.6	132.6
	BU SPS3	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
	BU SPS4	172.0	172.0	172.0	172.0	172.0	172.0	172.0	172.0
	BU SPS5	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6
	BU SPS6	12.9	75.0	177.9	177.9	177.9	177.9	177.9	177.9
	BU SPS7	135.8	135.8	135.8	135.8	247.4	294.9	294.9	294.9
	BU SPS8	59.5	59.5	59.5	59.5	59.5	59.5	59.5	59.5
	BU SPS9	78.9	78.9	78.9	95.4	95.4	95.4	95.4	95.4
	BU SPS10	35.6	35.6	35.6	78.5	207.2	285.1	285.1	285.1
	BU New1	0.0	0.0	70.6	215.8	215.8	215.8	215.8	215.8
	BU New2	0.0	0.0	0.0	0.0	0.0	62.7	62.7	62.7
	BU New3	0.0	0.0	0.0	0.0	0.0	94.4	317.5	317.5
	BU New4	0.0	0.0	0.0	0.0	0.0	0.0	109.6	500.9
	BU New5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	875.8	937.8	1,111.4	1,316.0	1,556.2	1,838.7	2,171.3	2,562.7

	SPS	2022	2025	2030	2035	2040	2045	2050	2055
Non-residential	BU SPS1	113.3	124.9	146.9	172.8	203.2	239.1	281.2	330.8
	BU SPS2	1.4	1.6	1.8	2.2	2.5	3.0	3.5	4.1
	BU SPS3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BU SPS4	9.9	10.9	12.8	15.0	17.7	20.8	24.4	28.8
	BU SPS5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BU SPS6	2.5	2.7	3.2	3.8	4.4	5.2	6.1	7.2
	BU SPS7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BU SPS8	1.0	1.1	1.2	1.5	1.7	2.0	2.4	2.8
	BU SPS9	0.6	0.7	0.8	0.9	1.1	1.3	1.5	1.8
	BU SPS10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BU New1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BU New2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BU New3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BU New4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BU New5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	128.6	141.8	166.7	196.1	230.7	271.4	319.2	375.4
Total	BU SPS1	340.3	351.9	373.9	399.8	430.3	466.1	508.2	557.8
	BU SPS2	134.0	134.2	134.4	134.7	135.1	135.6	136.1	136.7
	BU SPS3	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
	BU SPS4	181.9	182.9	184.8	187.1	189.7	192.8	196.5	200.8
	BU SPS5	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6
	BU SPS6	15.4	77.7	181.1	181.7	182.4	183.1	184.1	185.1
	BU SPS7	135.8	135.8	135.8	135.8	247.4	294.9	294.9	294.9
	BU SPS8	60.5	60.6	60.8	61.0	61.2	61.5	61.9	62.3
	BU SPS9	79.5	79.6	79.7	96.3	96.5	96.7	96.9	97.2
	BU SPS10	35.6	35.6	35.6	78.5	207.2	285.1	285.1	285.1
	BU New1	0.0	0.0	70.6	215.8	215.8	215.8	215.8	215.8
	BU New2	0.0	0.0	0.0	0.0	0.0	62.7	62.7	62.7
	BU New3	0.0	0.0	0.0	0.0	0.0	94.4	317.5	317.5
	BU New4	0.0	0.0	0.0	0.0	0.0	0.0	109.6	500.9
	BU New5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	1,004.4	1,079.6	1,278.1	1,512.1	1,786.9	2,110.1	2,490.5	2,938.2

The forecast sewer loads compared to the STP capacity is shown in Figure 8-8.

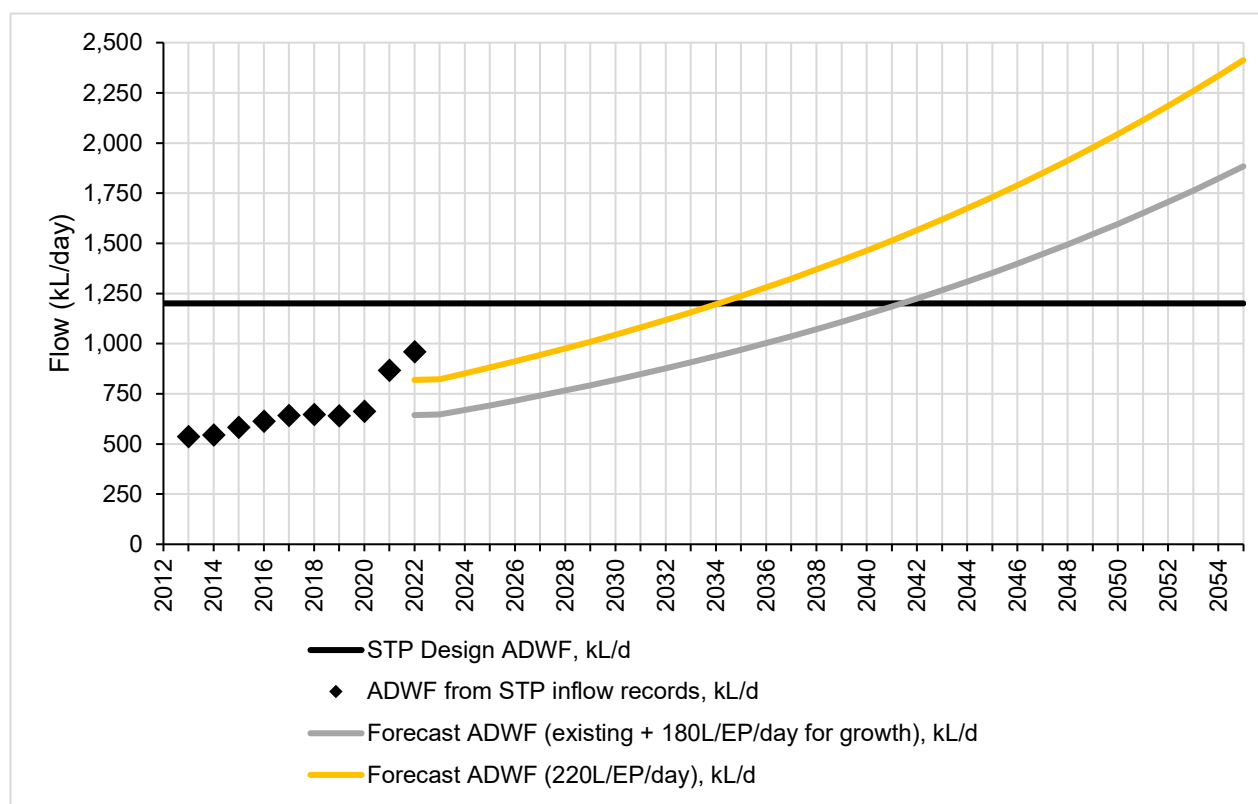


Figure 8-8: Bungendore projected hydraulic loading

8.7.2 System PDWF projections

The projected PDWF for the Bungendore sewerage scheme is shown in Table 8-17. The projected PDWF was calculated using the Public Works Sewer Design Manual [17] where the total ETs (residential and non-residential) were taken from Table 8-13, a unit EP flow of 220 L/EP/day was used for all customers.

Table 8-17: Bungendore sewerage scheme PDWF projections (L/s)

	SPS	2022	2025	2030	2035	2040	2045	2050	2055
Local catchment inflow	BU SPS1	9.9	10.2	10.8	11.4	12.1	13.0	14.0	15.2
	BU SPS2	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.6
	BU SPS3	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	BU SPS4	5.8	5.8	5.9	5.9	6.0	6.1	6.2	6.3
	BU SPS5	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	BU SPS6	0.8	2.8	5.8	5.8	5.8	5.9	5.9	5.9
	BU SPS7	4.5	4.5	4.5	4.5	7.5	8.8	8.8	8.8
	BU SPS8	2.3	2.3	2.3	2.3	2.3	2.3	2.4	2.4

	SPS	2022	2025	2030	2035	2040	2045	2050	2055
	BU SPS9	2.9	2.9	2.9	3.4	3.4	3.4	3.4	3.4
	BU SPS10	1.5	1.5	1.5	2.9	6.5	8.5	8.5	8.5
	BU New1			2.6	6.7	6.7	6.7	6.7	6.7
	BU New2						2.4	2.4	2.4
	BU New3						3.4	9.3	9.3
	BU New4							3.8	13.8
	BU New5								
	STP	25.2	26.9	31.2	36.2	41.9	48.6	56.3	65.3
	Total	9.9	10.2	10.8	11.4	12.1	13.0	14.0	15.2

8.7.3 System PWWF projections

The PWWF projections will be estimated from the sewer modelling for the nominated containment standard of 1 in 5 ARI.

8.8 SPS current performance and projections

The current SPS performance is assessed with respect to the following factors:

- The pump run time in dry weather – to assess the capacity
- The emergency storage volume – to assess if the response time is adequate
- The odour/septicity potential in the rising main

8.8.1 Pump run time in dry weather

As a rule of thumb PWWF is around seven times ADWF for a gravity system, therefore if a pump is running more than three hours at ADWF it may indicate that the SPS may not have the capacity to pump out the excess flow during wet weather, and sewage overflow may occur.

The results for Bungendore sewerage scheme are given in Table 8-18. Using the ADWF from customer billing data, there were no Instances where the average day pump run time exceeds three hours.

Table 8-18: SPS assessment - pump run time

SPS Catchment	ADWF (local catchment) (kL/day)	ADWF (inc. upstream catchments) (kL/day)	Pump Capacity (L/s)	Pump run time (hours/day)
BU SPS1	196.9	196.9	40.0	2.0
BU SPS2	88.8	88.8	10.1	2.4
BU SPS3	4.1	4.1	3.2	0.4
BU SPS4	95.8	95.8	32.0	0.8

SPS Catchment	ADWF (local catchment) (kL/day)	ADWF (inc. upstream catchments) (kL/day)	Pump Capacity (L/s)	Pump run time (hours/day)
BU SPS5	10.1	10.1	4.2	0.7
BU SPS6	9.5	9.5	2.0	1.3
BU SPS7	114.6	114.6	28.2	1.1
BU SPS8	44.5	123.7	19.0	1.8
BU SPS9	57.4	79.1	11.4	1.9
BU SPS10	21.7	21.7	24.6	0.2
Total	643.5	643.5		

8.8.2 Emergency storage time

If a technical issue causes a pump to stop working, extended mechanical breakdown or electrical failures for examples, the emergency storage volume in the pump well should be able to store the incoming volume of sewage without overflow until Council can restore the operation of the pump.

Each of the SPSs' in the sewerage system is designed to have 8 hours of ADWF emergency storage from the inflows from its immediate catchment.

All SPS have ability to detect and respond to abnormal operating conditions via telemetry system in the events of power failure, pump failure, etc.

As per the past records kept by Council, there are no major overflow events have occurred in the reticulation system in the recent past. [15]

8.8.3 Odour/septicity potential

Septicity potential is generally assessed by reviewing sewage detention times in SPS rising mains. According to WSAA Guidelines, sewage [18] with a detention time between four and eight hours has a medium risk of septicity, and above eight hours has a high risk of septicity.

The assessed rising main detention time is shown in Table 8-19. Detention times greater than eight hours are highlighted in red. **Issue**. The ADWF is based on the metered water consumption as discussed earlier. The detention for the SPS 4 rising main is calculated for the section from SPS 4 to SPS 1 because the rising main from SPS 1 to the STP carries effluent from both SPS 1 and SPS 4.

Table 8-19: SPS Assessment - rising main detention time

SPS	ADWF kL/d	Rising main			Residence time	
		Diameter (mm)	Length (m)	Volume (m ³)	Day	Hours
BU SPS1	290.4	200	461.3	14.5	0.076	1.82
BU SPS2	87.5	80	564	2.8	0.032	0.78

SPS	ADWF kL/d	Rising main			Residence time	
		Diameter (mm)	Length (m)	Volume (m ³)	Day	Hours
BU SPS3	4.1	80	255	1.3	0.309	7.43
BU SPS4*	95.8	150	1126.6	19.9	0.208	4.99
BU SPS5	10.1	80	1455.7	7.3	0.726	17.43
BU SPS6	9.5	50	238	0.5	0.049	1.18
BU SPS7	114.6	150	1758.9	31.1	0.271	6.51
BU SPS8	123.7	150	1517.8	26.8	0.217	5.21
BU SPS9	79.1	100	18.2	0.1	0.002	0.04
BU SPS10	21.7	150	104.2	1.8	0.085	2.03

* Section from SPS 4 to SPS 1

There are no odour treatment units used at Bungendore STP.

Within the reticulation system, odours are generated in the network and are treated by an activated carbon unit installed on each SPSs.

Source: PIRMP, V2 [15]

8.9 STP current performance and projections

Based on inspection done at Bungendore STP in year 2022, its performance is found satisfactory as discussed in more details on Section 8.10.

The Bungendore STP Design ADWF is based on STP design criteria of 5000 EP and ADWF of 240 L/EP/day. This upgrade is expected to be required as soon as the moratorium on residential subdivisions is lifted and the new homes are completed.

The hydraulic capacity of the upgrade is based on the same unit flow as the existing of 240 L/EP/day. Therefore, given the very low current unit EP flow for the customers already connected to the system and the use of water efficient appliances in new homes, the hydraulic capacity of the plant is expected to be significantly above the nutrient treatment capacity of the plant. There are some mechanical and electrical upgrades that will be able to slightly increase the nutrient treatment capacity of the plant beyond the 12,000 EP.

8.10 Section 61 inspections and recommendations

Bungendore STP was inspected on 19/12/2023 and found the plant was performing satisfactorily and appeared well maintained and operated. Sampling analysis results showed the treatment process was well managed and operating as expected.

8.11 Work Health and Safety

No major WHS issues were noted/found from NSW PW staff site visit.

9 Braidwood sewerage scheme

9.1 Sewage collection and transfer

The Braidwood sewerage scheme consists of 7 sewage pumping stations, 3km of rising sewer mains and 20km of gravity sewer mains.

Figure 9-1 shows an overview of Braidwood sewerage scheme.

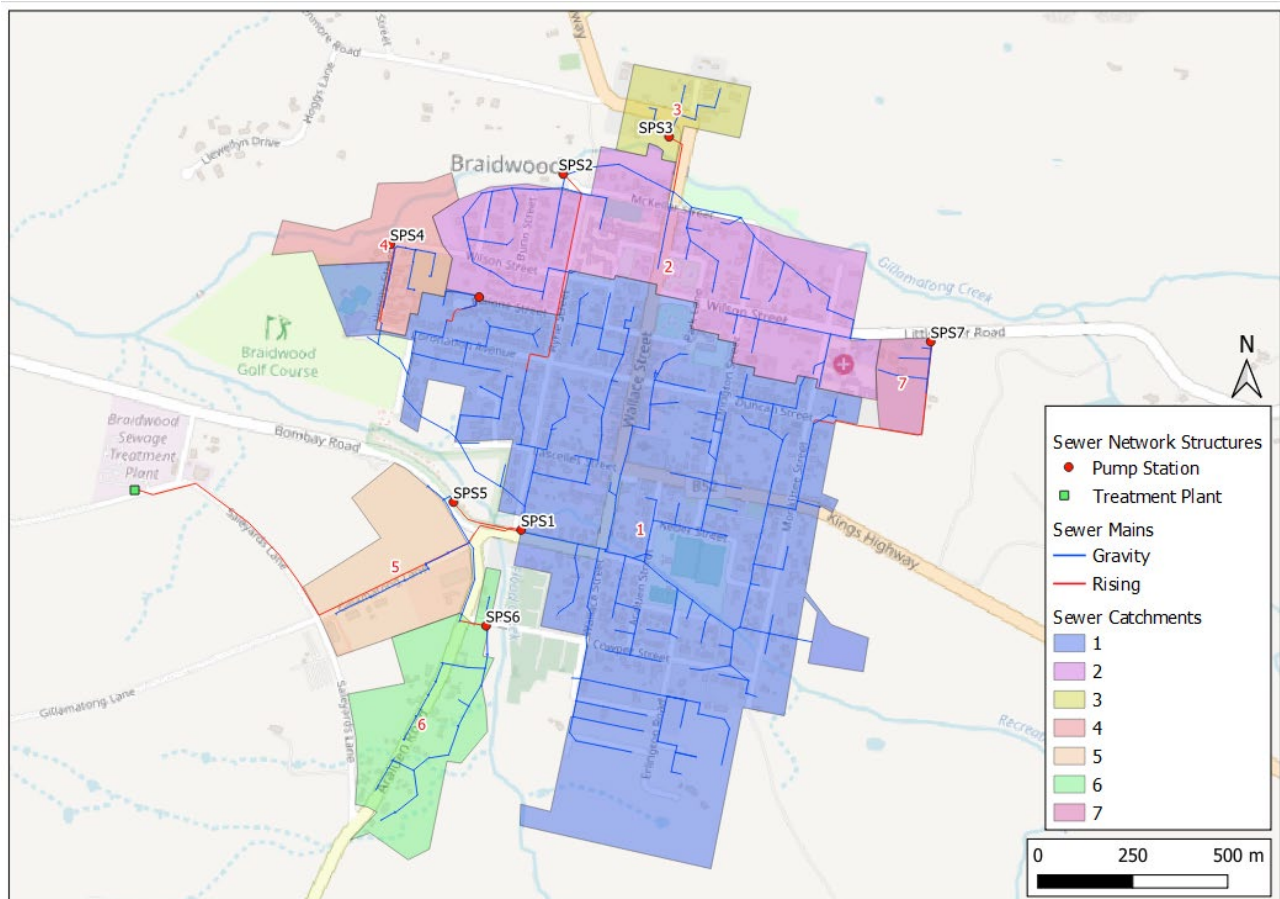
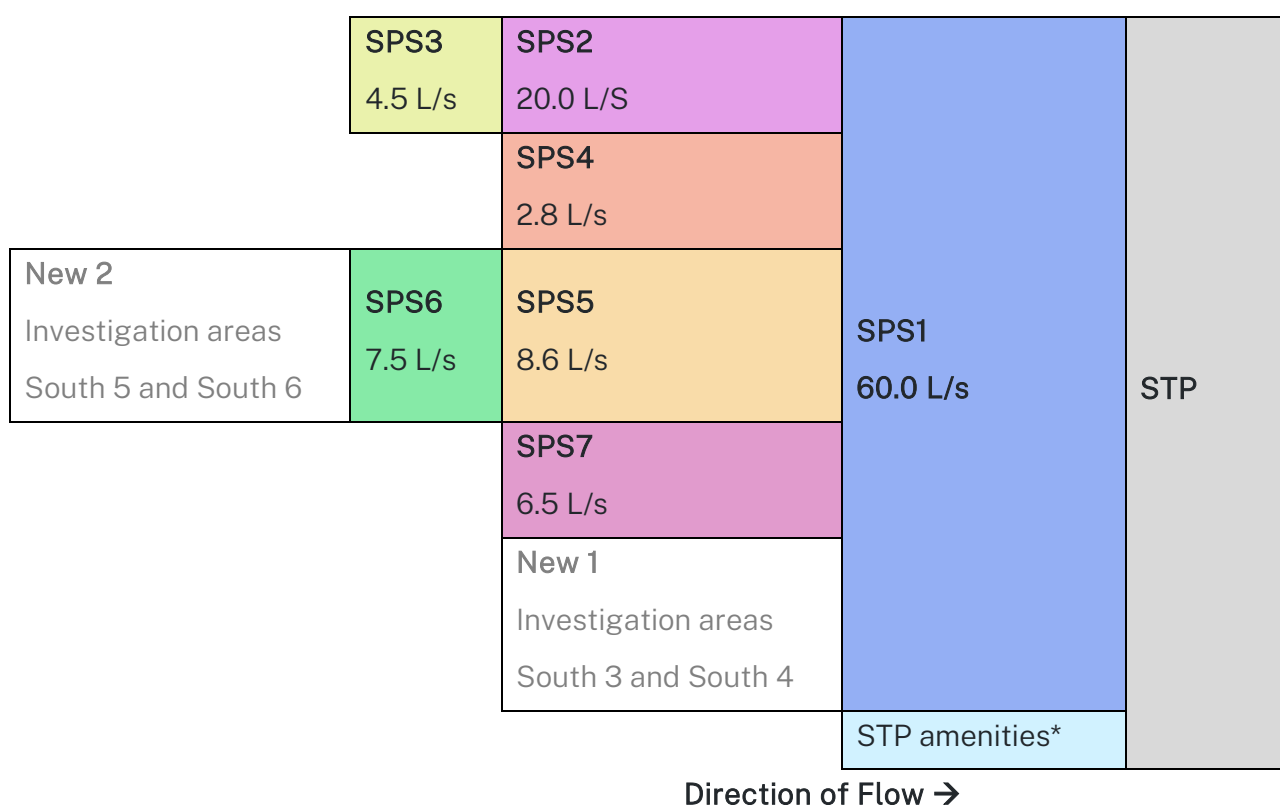


Figure 9-1: Braidwood sewerage scheme

The Braidwood sewage collection system comprises of the following:

- Gravity mains;
- Main SPS 1;
- 6 other sewage pumping stations, the arrangement of all SPSs is shown in Figure 9-1;
- Rising mains (from each SPS); and
- Saleyard tank.

A pump hierarchy diagram of Braidwood sewerage scheme with pump rates is shown in Figure 9-2.



* a small pumping station is used to transfer effluent from the STP amenities to the inlet works

Figure 9-2: Braidwood sewerage scheme SPS hierarchy

Based on the records in Councils telemetry system, it is possible that SPS 2 may have a capacity of 15 L/d and SPS 1 may have a capacity of 51 L/s.

9.2 Sewage treatment

9.2.1 STP description

Braidwood sewage treatment plant was commissioned in 2010. This was an entire replacement of a trickling filter plant built in 1966. The new treatment plant has a civil and hydraulic capacity of 3,000 equivalent persons (EP) and electrical and mechanical equipment capacity for 2,000 EP.

The Braidwood STP with design capacity of 2,000 EP consists of the following process units:

- A septage receival facility with screens receiving septage wastes delivered to the plant via tanker truck;
- A packaged waste pump station receiving sewage from the plant amenities building;
- Inlet works including a mechanical fine screen with bypass channel fitted with manually raked bar screen, grit removal, storm bypass, flow measurement unit and flow divider;

- An emergency overflow/ storage pond receiving inflow in excess of 64 L/s from the overflow chamber of the inlet works and draining to the plant supernatant pump station;
- An intermittently decanted extended aeration (IDEA) reactor with surface aeration systems to accommodate a peak load of 2,000 EP;
- Alum dosing system for two-stage chemical phosphorus removal (using Alphos);
- A catch/balance pond, located downstream of the IDEA reactor to attenuate IDEA effluent flows and capture second stage chemical (alum) sludge;
- An effluent UV disinfection system;
- A reclaimed water storage tank and two on-site reuse pressure pumps;
- Biosolids treatment and handling facilities, including sludge lagoons, sludge drying beds and sludge storage area;
- A supernatant and storm return pumping station; and
- Site works including amenities building, site drainage and lighting, etc.

A summary of the Braidwood STP design capacities for each process unit is given in Appendix table H-2.

Figure 9-3 shows the process flow diagram of the Braidwood STP. See Appendix figure H-3 for the detailed process flow schematic.

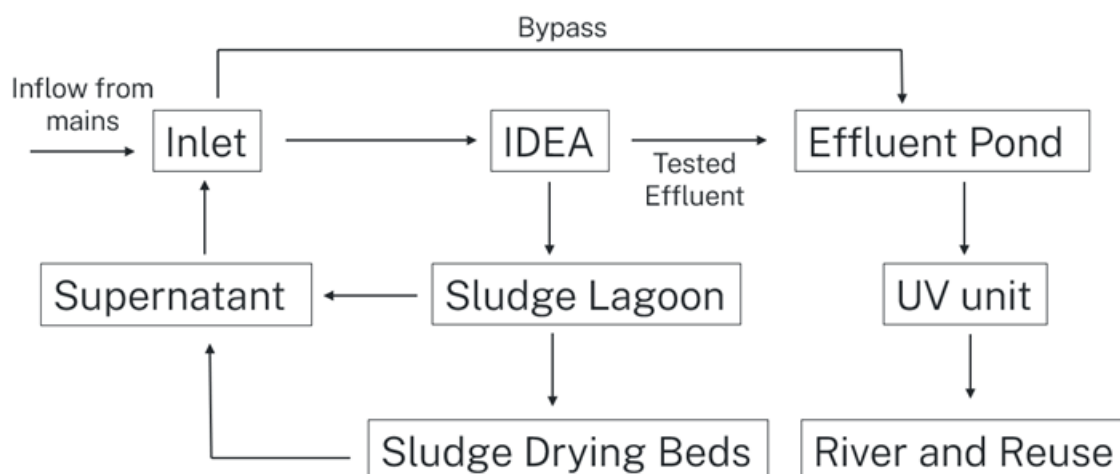


Figure 9-3: Process Flow Diagram – Braidwood STP

See the plan/aerial view of the Braidwood in Figure 9-4.



Figure 9-4: Plan/ aerial view of the Braidwood below

9.2.2 Historical flows

Daily STP inflow data and was provided for the period from July 2012 to February 2023. Rainfall data was obtained from the Bureau of Meteorology (BOM weather station number 69132 – Braidwood Racecourse).

The historical sewage inflow to the Braidwood STP is shown in Figure 9-5.

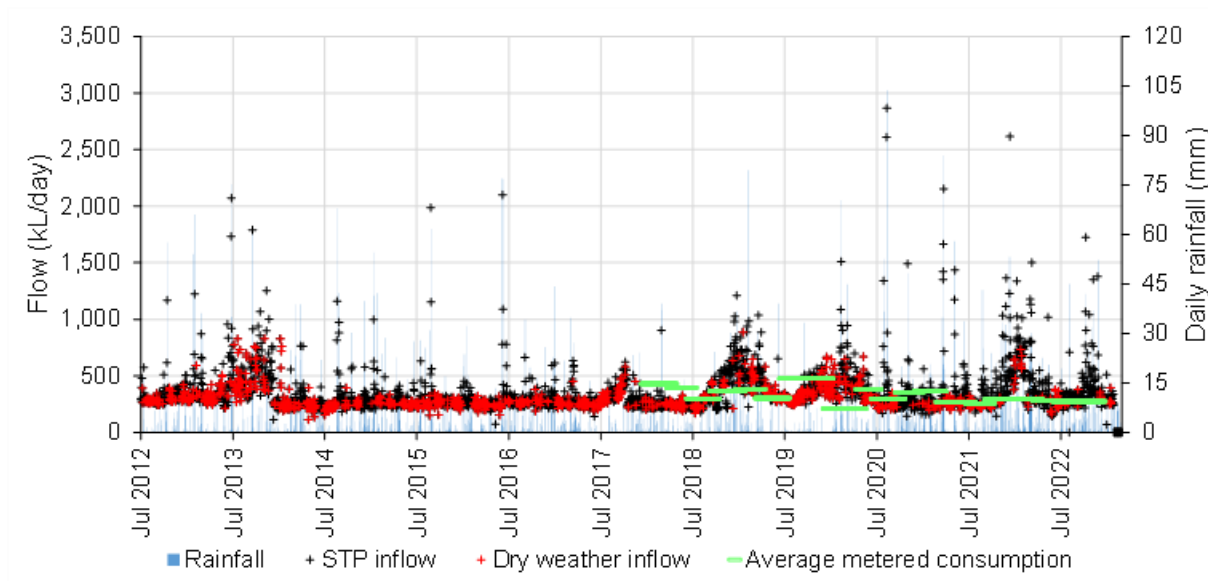


Figure 9-5: Braidwood STP historical inflow, rainfall and metered consumption

From the figure above, the STP inflow increases after rainfall. This indicates that there is some infiltration into the sewerage system. The maximum wet weather inflow is 2.9 ML/day.

In wet years, the network takes a long time to dry out with some years having flows over 350 kL/day for most of the year. This can be seen more easily in Figure 9-6 where only the lower flows are graphed.

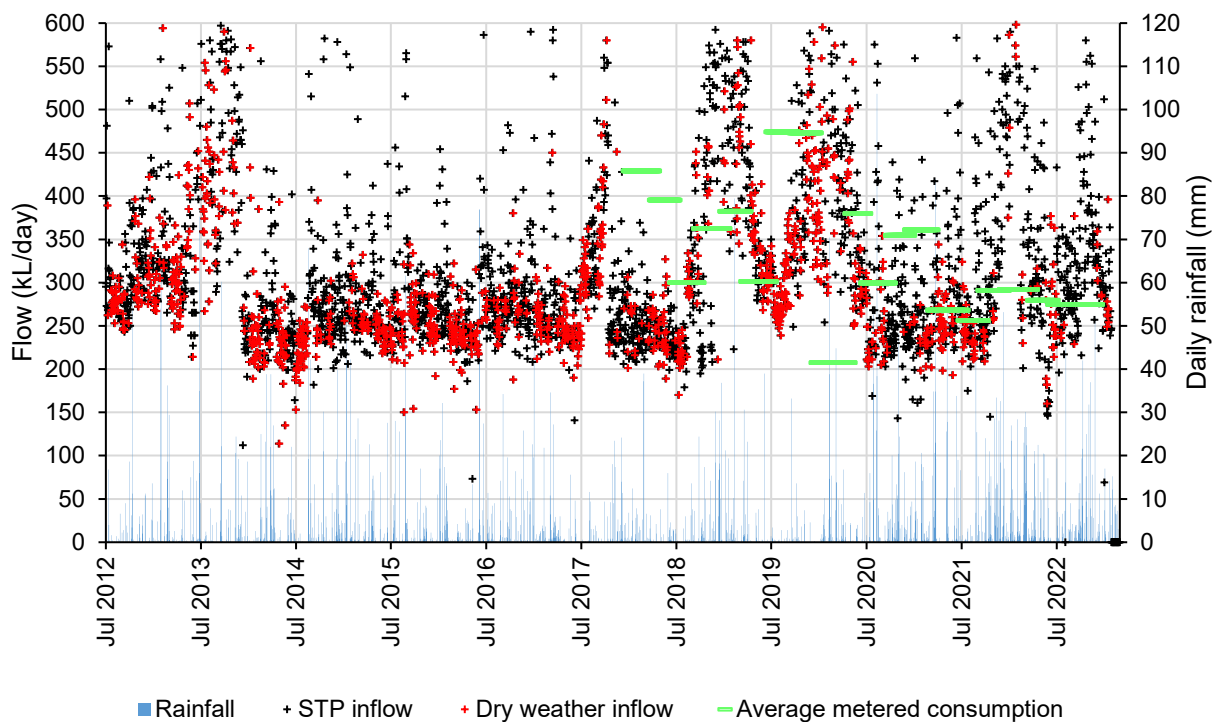


Figure 9-6: Braidwood STP historical inflow up to 600 kL/day, rainfall and metered consumption

Figure 9-6 also shows that in winter, spring and early summer 2019, while the weather was extremely dry, the dry weather flows increased to over 400 kL/day, this is substantially higher than the dry weather flows in 2017/18 of 290 kL/day. Council suspects that this was due to an issue with the STP inflow meter (noticeable because the daily flows were very inconsistent even during extremely dry periods), therefore, on 29 February 2020 Council switched to using the recorded flow data from the SPS 1 magflow meter to collect the STP inflow data.

9.3 STP inflow analysis

9.3.1 Average dry weather flow (ADWF) estimated from STP inflow data

STP daily inflow data was analysed to estimate the average dry weather flow (ADWF). To estimate historical ADWF, a dry day was taken as a day with less than 3 mm of rainfall on that day, any of the eight preceding days and one day following..

The historical ADWF from 2012/13 to 2017/18 is shown in Table 9-1.

Table 9-1: Braidwood STP – ADWF estimated from STP inflow data

Financial Year	2012/ 13	2013/ 14	2014/ 15	2015/ 16	2016/ 17	2017/ 18	2018/ 19	2019/ 20	2020/ 21	2021/ 22
ADWF (kL/day)	310	350	245	249	258	291	355	362	250	296
Annual rainfall (mm)	730	815	854	840	658	562	635	124	1,205	1,241
Wet weather impact	High	High	Low	Low	Low	High	High	*	Low	High

*very dry weather, dry weather flows very high

Since March 2020 (after the flow records started to be taken from the SPS 1 pump flows), the ADWF has averaged 286 kL/day.

9.3.2 ADWF estimated from customer billing data

The unit climate independent demand for the sewered Braidwood residential properties was 321 L/property/day, or 152 L/person/day.

The ADWF calculated from customer billing data analysis was **278 kL/day** (the average winter water consumption by sewered customers during winter 2018, 2019 and 2022 (skipping the COVID-19 lockdown winters), and this has been nominated ADWF for the Braidwood sewerage scheme, as it is close to the ADWF from the inflow data (286 kL/day) and the meter data can be easily assigned to the individual SPS catchments.

An alternate method to estimating the average dry weather flow is to assume that the climate independent flow (for properties with climate dependent use) is approximately equal to the sewer flow and then to use the average winter metered demand for the properties with climate independent consumption. Using this method, the estimated average dry weather flow was 253 kL/day.

9.3.3 Nominated ADWF and unit hydraulic loading

The ADWF measured from the recent STP inflow data is 286 kL/day.

The ADWF measured from customer billing data analysis was **278 kL/day** and this has been nominated ADWF for the Braidwood sewerage scheme, as it is close (within 3%) to the ADWF estimated from the inflow data, and the meter data can be easily assigned to the individual SPS catchments.

The total Equivalent Person (EP) for the Braidwood sewerage scheme has been estimated as **1,755 EP**, which is explained in more detail in Section 9.4. Using this EP, the unit hydraulic loading is calculated to be **158 L/EP/day**. This is very low compared to the standard design load for sewerage systems of 240 L/EP/day developed in the 1980s, and significantly lower than the 180 L/EP/day used for some modern designs. This is likely due to the widespread use of water efficient appliances and moderate climate.

9.3.4 Estimated PDWF and PWWF

The Peak Dry Weather Flow (PDWF) and Peak Wet Weather Flow (PWWF) in each SPS catchment are calculated using the method in the Public Works Sewer Design Manual [17]. The total Equivalent Tenement (ET) for the Braidwood sewerage scheme has been estimated as 762 ET, explained in more detail in Section 9.4.

The estimated sewage load to each SPS in terms of Average Dry Weather Flow (ADWF), Peak Dry Weather Flow (PDWF) and Peak Wet Weather Flow (PWWF) is given in Table 9-2. SPS 7 is not included as there was insufficient water consumption data available.

Table 9-2: Estimated ADWF, PDWF and PWWF - Braidwood sewerage scheme

Sewer catchment	ET	Cumulative ADWF (kL/day)	PDWF (L/s)	PWWF (L/s)
BR SPS1	469	261.9	5.3	70.4
BR SPS2	219	73.0	2.4	15.1
BR SPS3	27	9.8	0.5	2.0
BR SPS4	20	6.1	0.3	1.5
BR SPS5	11	4.5	0.4	8.5
BR SPS6	16	282.6	0.3	1.2
STP amenities	2		0.2	0.2
Total*	762	277.8	7.7	60.2

* Note that the PDWF and PWWF do not add up to the total of the STP because not every catchment is expected to experience peak flows at the same time.

The peaking factor ('r') for the whole sewerage scheme was calculated to be 2.4 using the number of ET, and the PDWF was estimated to be **6.9 L/s**. The PWWF from all catchments in Braidwood sewerage scheme is estimated to be **54 L/s**.

9.3.5 Biological and nutrient loading

The STP and the collection system operate under EPL No. 1733 granted by the NSW EPA that is renewed annually.

Effluent quality limitations on EPA licence are summarized in Table 9-3.

Table 9-3: Pollutant List - Sewage and Effluent for Braidwood STP

Parameter	Typical Raw Sewage	Effluent (90 percentile) *	Effluent (100 percentile) *
Biochemical Oxygen Demand (BOD5)	270 mg/L	<5 mg/L	<10 mg/L
Suspended Solids (SS)	270 mg/L	<10 mg/L	<15 mg/L
Total Nitrogen (TN)	53 mg/L	<8 mg/L	<10 mg/L
Ammonia	12 mg/L	<2 mg/L	<5 mg/L
Total Phosphorus (TP)	11 mg/L	<0.5 mg/L	<1 mg/L
Oil and grease (O&G)	< 10 mg/L	<2 mg/L	<10 mg/L
Faecal coliforms (FC)	1,000,000 cfu/100 mL	<100 cfu/100 mL	<200 cfu/100 mL
pH	6.5 – 8.5		6.5 – 8.5

Note: *Licence Conditions

Source: PIRMP, V2 [15]

9.4 EP and ET estimates

EP is calculated by multiplying the ET by the average detached dwelling household for Braidwood of 2.21 people per household, see Table 4-4. Using the unit residential water consumption analysis undertaken in 6.6.2.1, EP unit flow is 180 L/EP/day and the ET unit flow is 398 L/ET/day.

The estimated EP and ET for each sewer catchment is given in Table 9-4.

Table 9-4: Braidwood sewerage scheme – Estimated ET and EP for each sewer catchment

Sewer catchment	ET			EP		
	Residential	Non-res	Total	Residential	Non-res	Total
BR SPS1	391	78	469	864	185	1,049
BR SPS2	131	88	219	290	252	542
BR SPS3	18	9	27	40	19	59
BR SPS4	20	0	20	44	0	44
BR SPS5	7	4	11	15	8	23
BR SPS6	16	0	16	35	0	35
STP amenities	0	2	2	0	3	3
Total	583	179	762	1,288	467	1,755

The residential EP (1,288) is quite close to the estimated serviced private dwelling population of 1,209 in Table 4-7.

9.5 EP and ET projections

The growth strategy for Braidwood is discussed in Section 4.4.5 and Section 4.5. Dwelling growth and order of development are mapped on Figure 4-3 and the lot yields and sewage pumping station catchments are summarised in Table 4-10. Using the growth rates as discussed in Section 4.5.1, the ET projections for each SPS catchment are given in Table 9-5 and the EP projection is summarised in Table 9-6.

Table 9-5: Braidwood sewerage scheme ET projection

		2022	2025	2030	2035	2040	2045	2050	2055
Residential	BR SPS1	391	391	397	420	449	454	454	454
	BR SPS2	131	131	131	144	144	147	258	417
	BR SPS3	18	18	18	18	18	18	18	18
	BR SPS4	20	20	20	20	20	20	20	20
	BR SPS5	7	7	7	19	69	92	109	109
	BR SPS6	16	16	16	40	71	76	76	76
	BR SPS7	0	7	37	37	37	37	37	37
	STP amenities	0	0	0	0	0	0	0	0
	BR New1	0	0	0	0	0	55	67	67
	BR New2	0	0	0	0	0	34	34	34
	BR New3	0	0	0	0	0	0	0	0
	Total	583	590	626	699	809	934	1,074	1,233
Non-residential	BR SPS1	78	79	88	100	113	128	145	164
	BR SPS2	88	90	101	114	129	146	165	187
	BR SPS3	9	9	10	11	12	14	16	18
	BR SPS4	0	0	0	0	0	0	0	0
	BR SPS5	4	4	4	5	5	6	7	7

		2022	2025	2030	2035	2040	2045	2050	2055
	BR SPS6	0	0	0	0	0	0	0	0
	BR SPS7	0	0	0	0	0	0	0	0
	STP amenities	2	2	2	2	2	2	3	3
	BR New1	0	0	0	0	0	0	0	0
	BR New2	0	0	0	0	0	0	0	0
	BR New3	0	0	0	0	0	0	0	0
	Total	179	184	204	231	262	296	335	379
Total	BR SPS1	469	470	485	520	562	582	599	618
	BR SPS2	219	221	232	258	273	293	423	604
	BR SPS3	27	27	28	29	30	32	34	36
	BR SPS4	20	20	20	20	20	20	20	20
	BR SPS5	11	11	11	24	74	98	116	116
	BR SPS6	16	16	16	40	71	76	76	76
	BR SPS7	0	7	37	37	37	37	37	37
	STP amenities	2	2	2	2	2	2	3	3
	BR New1	0	0	0	0	0	55	67	67
	BR New2	0	0	0	0	0	34	34	34
	BR New3	0	0	0	0	0	0	0	0
	Total	762	773	831	930	1,070	1,230	1,409	1,612

Table 9-6: Braidwood sewerage scheme EP projection

		2022	2025	2030	2035	2040	2045	2050	2055
Residential	BR SPS1	864	864	877	930	993	1,004	1,004	1,004
	BR SPS2	290	290	290	318	318	325	569	919
	BR SPS3	40	40	40	40	40	40	40	40

		2022	2025	2030	2035	2040	2045	2050	2055
	BR SPS4	44	44	44	44	44	44	44	44
	BR SPS5	15	15	15	42	152	202	240	240
	BR SPS6	35	35	35	88	156	167	167	167
	BR SPS7	0	15	84	84	84	84	84	84
	STP amenities	0	0	0	0	0	0	0	0
	BR New1	0	0	0	0	0	121	147	147
	BR New2	0	0	0	0	0	75	75	75
	BR New3	0	0	0	0	0	0	0	0
	Total	1,288	1,303	1,386	1,546	1,788	2,063	2,371	2,721
Non-residential	BR SPS1	185	189	211	238	270	305	345	391
	BR SPS2	252	258	287	325	368	416	471	533
	BR SPS3	19	19	21	24	27	31	35	40
	BR SPS4	0	0	0	0	0	0	0	0
	BR SPS5	8	8	9	10	11	13	15	16
	BR SPS6	0	0	0	0	0	0	0	0
	BR SPS7	0	0	0	0	0	0	0	0
	STP amenities	3	3	4	4	5	5	6	7
	BR New1	0	0	0	0	0	0	0	0
	BR New2	0	0	0	0	0	0	0	0
	BR New3	0	0	0	0	0	0	0	0
	Total	467	478	532	602	681	771	872	987
Total	BR SPS1	1,049	1,054	1,088	1,168	1,263	1,310	1,350	1,395
	BR SPS2	542	548	577	643	686	741	1,040	1,451
	BR SPS3	59	59	61	64	67	71	75	80

		2022	2025	2030	2035	2040	2045	2050	2055
	BR SPS4	44	44	44	44	44	44	44	44
	BR SPS5	23	23	24	52	163	215	254	256
	BR SPS6	35	35	35	88	156	167	167	167
	BR SPS7	0	15	84	84	84	84	84	84
	STP amenities	3	3	4	4	5	5	6	7
	BR New1	0	0	0	0	0	121	147	147
	BR New2	0	0	0	0	0	75	75	75
	BR New3	0	0	0	0	0	0	0	0
	Total	1,755	1,782	1,918	2,148	2,469	2,833	3,243	3,707

The STP EP load will reach the current treatment capacity with the installed aeration system (2,000 EP) in 2032 and the design capacity of 3,000 EP in 2048.

9.6 Sewer system flow projections

9.6.1 System ADWF projections

The ADWF has been projected using both the current ADWF plus 180 L/EP/day for growth (Table 9-7) and 220 L/EP/day for all users (Table 9-8). Using the first method, the hydraulic capacity of the plant will be reached in about 2047 (slightly before the nutrient capacity is reached in 2048), using the second method, the hydraulic capacity will be reached in 2043.

Table 9-7: Braidwood sewerage scheme ADWF projection (historical with 180L/EP for growth) (kL/day)

		2022	2025	2030	2035	2040	2045	2050	2055
Residential	BR SPS1	119.3	119.3	121.6	131.0	142.5	144.5	144.5	144.5
	BR SPS2	46.6	46.6	46.6	51.7	51.7	52.9	96.9	159.9
	BR SPS3	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	BR SPS4	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
	BR SPS5	2.1	2.1	2.1	6.9	26.7	35.8	42.5	42.5
	BR SPS6	4.8	4.8	4.8	14.3	26.6	28.6	28.6	28.6
	BR SPS7	0.0	2.7	15.1	15.1	15.1	15.1	15.1	15.1

		2022	2025	2030	2035	2040	2045	2050	2055
	STP amenities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BR New1	0.0	0.0	0.0	0.0	0.0	21.8	26.5	26.5
	BR New2	0.0	0.0	0.0	0.0	0.0	13.5	13.5	13.5
	BR New3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	184.6	187.3	202.1	230.9	274.5	324.0	379.4	442.4
Non-residential	BR SPS1	59.8	61.3	68.2	77.1	87.3	98.7	111.7	126.4
	BR SPS2	26.4	27.0	30.1	34.0	38.5	43.6	49.3	55.8
	BR SPS3	4.1	4.2	4.7	5.3	6.0	6.8	7.7	8.7
	BR SPS4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BR SPS5	2.4	2.5	2.7	3.1	3.5	4.0	4.5	5.1
	BR SPS6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BR SPS7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	STP amenities	0.5	0.5	0.6	0.6	0.7	0.8	0.9	1.0
	BR New1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BR New2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BR New3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	93.2	95.5	106.2	120.2	136.0	153.9	174.1	197.0
Total	BR SPS1	179.1	180.5	189.8	208.2	229.8	243.2	256.2	270.9
	BR SPS2	73.0	73.6	76.7	85.8	90.3	96.5	146.2	215.6
	BR SPS3	9.8	9.9	10.4	11.0	11.7	12.5	13.4	14.4
	BR SPS4	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
	BR SPS5	4.5	4.6	4.8	10.0	30.2	39.7	47.0	47.6
	BR SPS6	4.8	4.8	4.8	14.3	26.6	28.6	28.6	28.6
	BR SPS7	0.0	2.7	15.1	15.1	15.1	15.1	15.1	15.1

		2022	2025	2030	2035	2040	2045	2050	2055
	STP amenities	0.5	0.5	0.6	0.6	0.7	0.8	0.9	1.0
	BR New1	0.0	0.0	0.0	0.0	0.0	21.8	26.5	26.5
	BR New2	0.0	0.0	0.0	0.0	0.0	13.5	13.5	13.5
	BR New3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	277.8	282.8	308.3	351.1	410.4	477.8	553.5	639.3

Table 9-8: Braidwood sewerage scheme ADWF projection (220 L/EP/day for all users) (kL/day)

		2022	2025	2030	2035	2040	2045	2050	2055
Residential	BR SPS1	190.1	190.1	193.0	204.5	218.6	221.0	221.0	221.0
	BR SPS2	63.7	63.7	63.7	70.0	70.0	71.4	125.2	202.1
	BR SPS3	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8
	BR SPS4	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7
	BR SPS5	3.4	3.4	3.4	9.2	33.4	44.5	52.8	52.8
	BR SPS6	7.8	7.8	7.8	19.4	34.4	36.8	36.8	36.8
	BR SPS7	0.0	3.3	18.5	18.5	18.5	18.5	18.5	18.5
	STP amenities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BR New1	0.0	0.0	0.0	0.0	0.0	26.6	32.4	32.4
	BR New2	0.0	0.0	0.0	0.0	0.0	16.5	16.5	16.5
	BR New3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	283.5	286.8	304.8	340.1	393.3	453.8	521.6	598.5
Non-residential	BR SPS1	40.7	41.7	46.4	52.5	59.4	67.2	76.0	86.0
	BR SPS2	55.5	56.8	63.2	71.5	80.9	91.5	103.6	117.2
	BR SPS3	4.1	4.2	4.7	5.3	6.0	6.8	7.7	8.8
	BR SPS4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BR SPS5	1.7	1.8	2.0	2.2	2.5	2.8	3.2	3.6

		2022	2025	2030	2035	2040	2045	2050	2055
	BR SPS6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BR SPS7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	STP amenities	0.7	0.8	0.8	0.9	1.1	1.2	1.4	1.5
	BR New1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BR New2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	BR New3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	102.7	105.2	117.1	132.5	149.9	169.6	191.8	217.1
Total	BR SPS1	230.8	231.8	239.4	257.0	277.9	288.1	296.9	306.9
	BR SPS2	119.2	120.5	126.9	141.5	150.9	163.0	228.7	319.3
	BR SPS3	12.9	13.0	13.5	14.1	14.8	15.6	16.5	17.5
	BR SPS4	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7
	BR SPS5	5.1	5.2	5.4	11.4	35.9	47.4	56.0	56.4
	BR SPS6	7.8	7.8	7.8	19.4	34.4	36.8	36.8	36.8
	BR SPS7	0.0	3.3	18.5	18.5	18.5	18.5	18.5	18.5
	STP amenities	0.7	0.8	0.8	0.9	1.1	1.2	1.4	1.5
	BR New1	0.0	0.0	0.0	0.0	0.0	26.6	32.4	32.4
	BR New2	0.0	0.0	0.0	0.0	0.0	16.5	16.5	16.5
	BR New3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	386.2	392.0	421.9	472.5	543.2	623.4	713.4	815.6

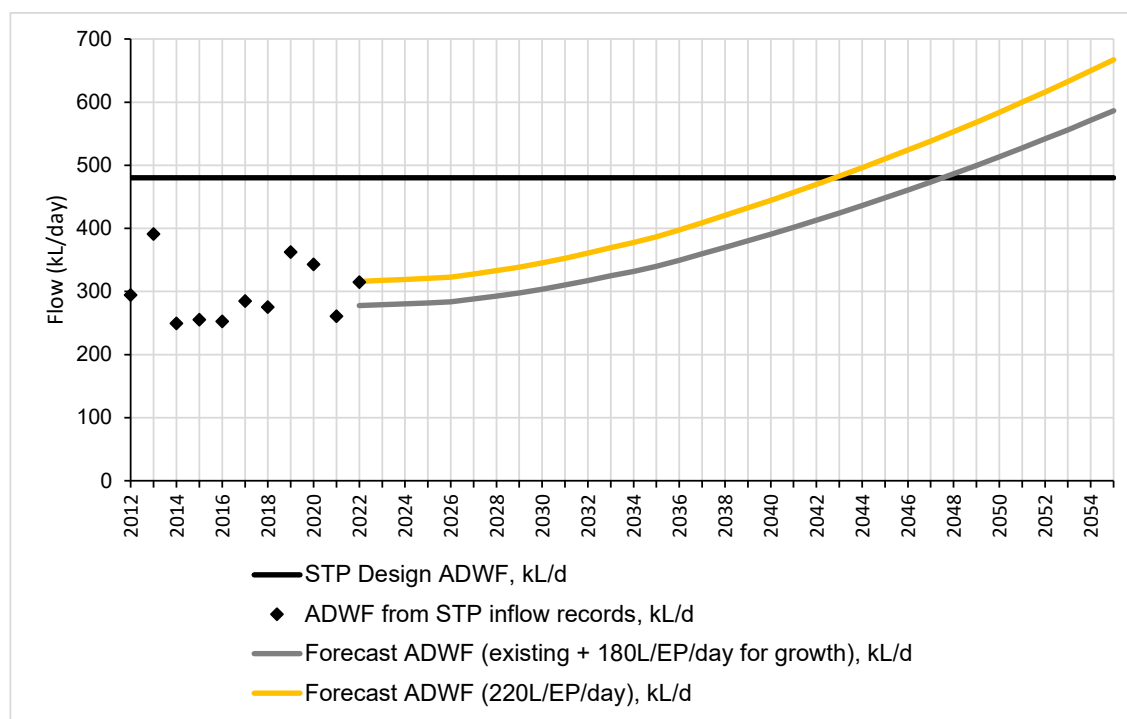


Figure 9-7: Braidwood projected hydraulic loading

9.6.2 System PDWF projections

The projected PDWF for the Braidwood sewerage scheme is shown in Table 9-9. The projected PDWF was calculated using the Public Works Sewer Design Manual [13] where the total ETs (residential and non-residential) were taken from Table 9-5.

Table 9-9: Braidwood sewerage scheme - PDWF projections (L/s)

SPS Catchment	2022	2026	2031	2036	2041	2046	2051	2053
BR SPS1	34.0	34.1	35.2	37.7	40.6	42.0	43.2	44.6
BR SPS2	16.7	16.8	17.6	19.5	20.7	22.2	31.4	44.1
BR SPS3	2.2	2.2	2.3	2.3	2.5	2.6	2.7	2.9
BR SPS4	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
BR SPS5	1.0	1.0	1.0	2.0	5.7	7.5	8.8	8.8
BR SPS6	1.4	1.4	1.4	3.2	5.5	5.9	5.9	5.9
BR SPS7		0.7	3.0	3.0	3.0	3.0	3.0	3.0
STP amenities	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5
BR New1						4.3	5.2	5.2
BR New2						2.7	2.7	2.7
BR New3								
Total	54.9	55.6	59.7	64.3	73.8	84.5	96.5	110.1

9.6.3 System PWWF projections

The projected PWWF for Braidwood is shown on Table 9-10. The projected PWWF was calculated using the Public Works Sewer Design Manual where the total ETs were taken from Table 9-5. It should be noted that the PWWF reported here is the combined PWWF from all sewer catchments and does not account for the SPS pump rates. The PWWF to each SPS catchment is assessed in Section 9.7.2.

Table 9-10: Braidwood sewerage scheme - PWWF projections (L/sec)

	SPS Catchment	2022	2026	2031	2036	2041	2046	2051	2053
Local catchment	BR SPS1	34.0	34.1	35.2	37.7	40.6	42.0	43.2	44.6
	BR SPS2	16.7	16.8	17.6	19.5	20.7	22.2	31.4	44.1
	BR SPS3	2.2	2.2	2.3	2.3	2.5	2.6	2.7	2.9
	BR SPS4	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
	BR SPS5	1.0	1.0	1.0	2.0	5.7	7.5	8.8	8.8
	BR SPS6	1.4	1.4	1.4	3.2	5.5	5.9	5.9	5.9
	BR SPS7		0.7	3.0	3.0	3.0	3.0	3.0	3.0
	STP amenities	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5
	BR New1						4.3	5.2	5.2
	BR New2						2.7	2.7	2.7
	Total	54.9	55.6	59.7	64.3	73.8	84.5	96.5	110.1
Cumulative	BR SPS1	71.9	74.0	76.1	82.0	95.4	98.8	111.0	125.4
	BR SPS2	16.7	16.8	17.6	19.5	20.7	22.2	31.4	44.1
	BR SPS3	2.2	2.2	2.3	2.3	2.5	2.6	2.7	2.9
	BR SPS4	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
	BR SPS5	8.5	8.5	8.5	9.5	13.2	15.0	16.3	16.3
	BR SPS6	1.4	1.4	1.4	3.2	5.5	5.9	5.9	5.9
	BR SPS7	0.0	0.7	3.0	3.0	3.0	3.0	3.0	3.0
	STP amenities	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5
	BR New1	0.0	0.0	0.0	0.0	0.0	4.3	5.2	5.2
	BR New2	0.0	0.0	0.0	0.0	0.0	2.7	2.7	2.7
	Total	60.3	75.3	77.3	82.4	96.4	99.4	112.4	126.5

9.7 SPS current performance and projections

9.7.1 Pump run time in dry weather

As a rule of thumb PWWF is around seven times ADWF for a gravity system, therefore if a pump is running more than three hours at ADWF it may indicate that the SPS may not have the capacity to pump out the excess flow during wet weather, and sewage overflow may occur.

The results for Braidwood sewerage scheme are given in Table 9-11. Using the ADWF from billing data, there were no instances where the average day pump run time exceeds three hours.

Table 9-11: Pump run time in dry weather

SPS Catchment	ADWF (kL/d)	Pump Capacity (L/s)	Pump run time (hours)
BR SPS1	261.9	60.0	1.2
BR SPS2	73.0	20.0	1.0
BR SPS3	9.8	4.5	0.6
BR SPS4	6.1	2.8	0.6
BR SPS5	4.5	8.6	0.1
BR SPS6	4.8	7.5	0.2

9.7.2 Pump rate compared to PWWF

The PWWF in each SPS catchment is calculated using the method in the Public Works sewer design manual [13], also presented in Section 9.6.3. A PDWF and storm allowance (0.058 L/s per ET) is calculated for each catchment based on the estimate ET, which combined give the PWWF. The pump rate of any SPS that are directly upstream of the catchment also contribute to the estimated PWWF. The SPS 7 has nil ET at the time of study but will service the Under Development (U/D) Summerfield in Braidwood retirement village.

The PWWF in each SPS catchment in Braidwood is shown in red text in Figure 9-8.

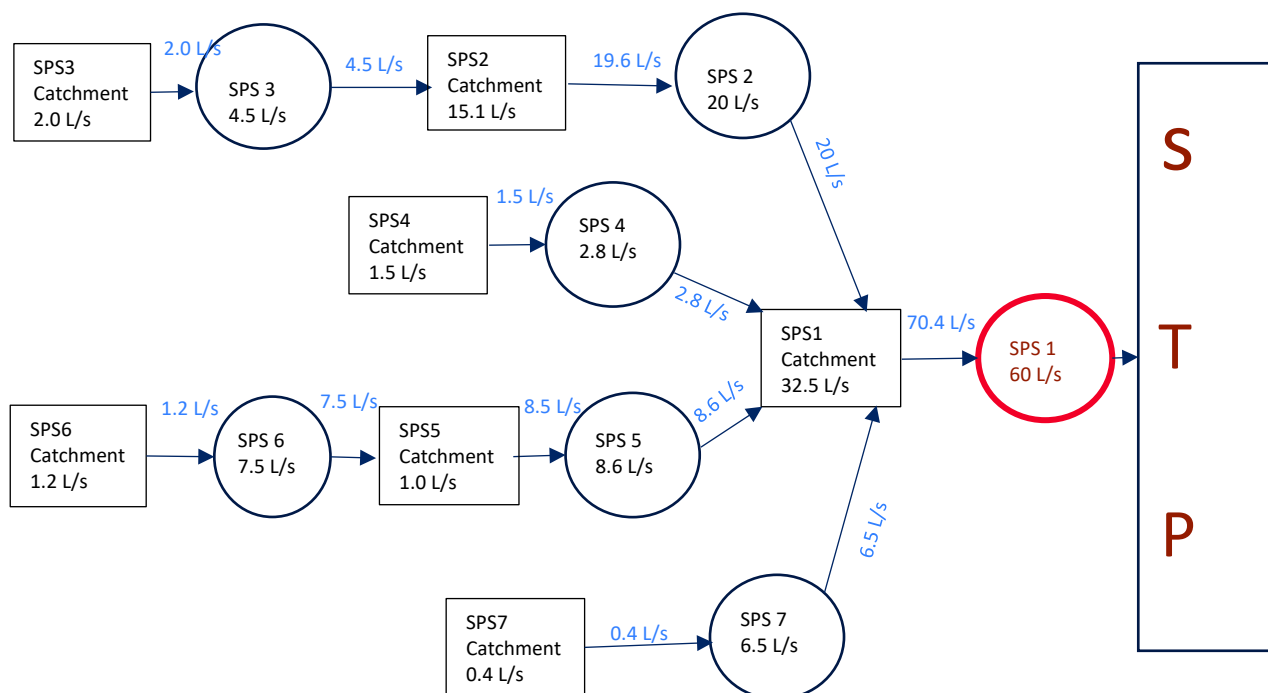


Figure 9-8: Estimated PWWF to each SPS in Braidwood sewerage scheme

BR SPS1 (60 L/s) is undersized to pump wet weather flows. **Issue**

SPS pump rate imbalance is also identified for BR SPS6. It has a pumping rate more than five times the estimated catchment PWWF. Therefore, SPS 5 may need to be upgraded sooner than expected.

9.7.3 Emergency storage time

If a technical issue causes a pump to stop working, extended mechanical breakdown or electrical failures for examples, the emergency storage volume in the pump well should be able to store the incoming volume of sewage without overflow until Council can restore the operation of the pump.

Each of the SPSs in the sewerage system is designed to have 8 hours of ADWF emergency storage from the inflows from its immediate catchment.

All SPS have ability to detect and respond to abnormal operating conditions via telemetry system in the event of power failure, pump failure, etc.

9.8 Odour/septicity potential

Septicity potential is generally assessed by reviewing sewage detention times in SPS rising mains. According to WSAA Guidelines [18], sewage with a detention time between four and eight hours has a medium risk of septicity, and above eight hours has a high risk of septicity.

The assessed rising main detention time is shown in Table 9-12. Detention times greater than eight hours are highlighted in **red. Issue.**

Table 9-12: SPS assessment - rising main detention time

SPS	ADWF (kL/d)	Rising main			Residence time	
		Diameter,(mm)	Length (m)	Volume (kL)	Day	Hours
BR SPS1	261.9	200	1239.541	38.9	0.2	3.57
BR SPS2	73.0	150	604.37	10.7	0.2	3.51
BR SPS3	9.8	100	168.703	1.3	0.2	3.24
BR SPS4	6.1	63	216.062	0.7	0.1	2.65
BR SPS5	4.5	110	210.412	2.0	0.3	10.64
BR SPS6	282.6	110	70.482	0.7	0.1	3.35
BR SPS7*	0.0					

*Note: The SPS 7 has nil value at the time of study data provision as construction of the Summerfield - Braidwood Retirement village had barely commenced

At Braidwood STP, odour is not an issue.

At reticulation system, odours are generated in the sewerage system and treated by an activated carbon unit installed on each SPSs. Source: PIRMP, V2 [15]

9.9 STP current performance and projections

Based on inspections done at Braidwood STP in 2021 and 2023, its performance is found satisfactory as discussed in more details on Section 9.10.

The Braidwood STP Design ADWF is based on STP design criteria of 2000 EP and ADWF of 240 L/EP/day. The STP design ADWF will be reached during year 2049 based on nominated flow of 253 kL/d, a hydraulic loading of 147L/EP/d. If based on hydraulic loading of 180 L/EP/day is used, the STP design ADWF will be reached earlier (in year 2041), as shown in Figure 9-7.

9.10 Section 61 inspections and recommendations

Inspection records on 01/03/2021 and 18/04/2023 found the Braidwood STP plant was performing satisfactorily. There was a recommendation made for the replacement of the decant weir cables and boots every five years as part of preventative maintenance on the risk of major operational disruption and damage to decant equipment, Council has scheduled these works.

9.11 Work Health and Safety

No major WHS issues were noted/found from NSW PW staff site visit.

However, Pollution Incident Response Management Plan (PIRMP) [15] report done by NSW PW states that for the following incidents and injuries must be reported to SafeWork NSW:

- Notifiable incidents involving a fatality or a serious injury or illness,

- Notifiable incidents involving a fatality or serious injury or illness to other people at your workplace.
- Notifiable incidents that present a serious risk to health and safety at your workplace (dangerous incidents), and
- Other incidents involving an injury or illness where workers compensation is payable.

Council's WHS policies and procedures do exist to be followed.

10 Captains Flat sewerage scheme

10.1 Sewage collection and transfer

The Captains Flat Sewerage Scheme (Captains Flat SS) consists of 1 sewage pumping station, 0.2 km of sewer rising main and 7km of sewer gravity mains.

Figure 10-1 shows an overview of Captains Flat Sewerage Scheme (Captains Flat SS) with the inclusion of the new growth zones.

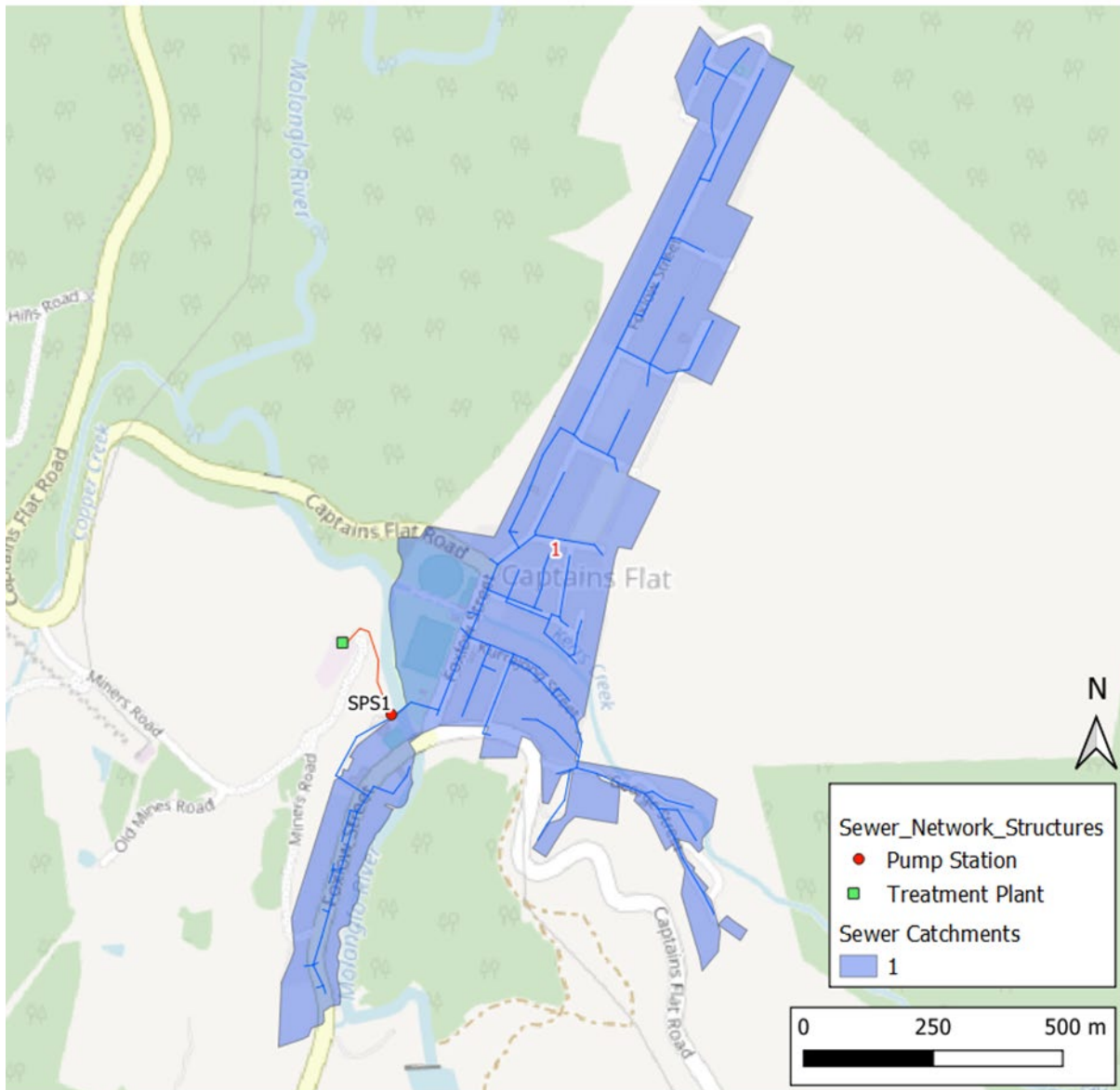


Figure 10-1: Captains Flat Sewerage Scheme

A pump hierarchy diagram of Captains Flat SS with pump rates is shown in Figure 10-2.

SPS1	STP
15.0 L/s	

Figure 10-2: Captains Flat SS SPS hierarchy

10.2 Sewage treatment

10.2.1 STP description

Captains Flat STP is the oldest STP in Palerang Sewerage Systems. This STP was built in mid 1980s and it has a capacity of 500 EP.

The Captains Flat STP consists of the following process units and discharges to Molonglo River:

- Inlet works - Inflow reception, screening, grit removal, flow measurement and flow division;
- Pasveer channel;
- Chemical dosing unit;
- UV disinfection unit;
- On-site reuse unit;
- Emergency storage ponds;
- Sludge lagoons; and
- Sludge drying beds.

A summary of the Captains Flat STP design capacities for each process unit is given in Appendix table H-3

Figure 10-3 shows the process flow diagram of the Captains Flat STP. See Appendix figure H-4 for the detailed process flow schematic.

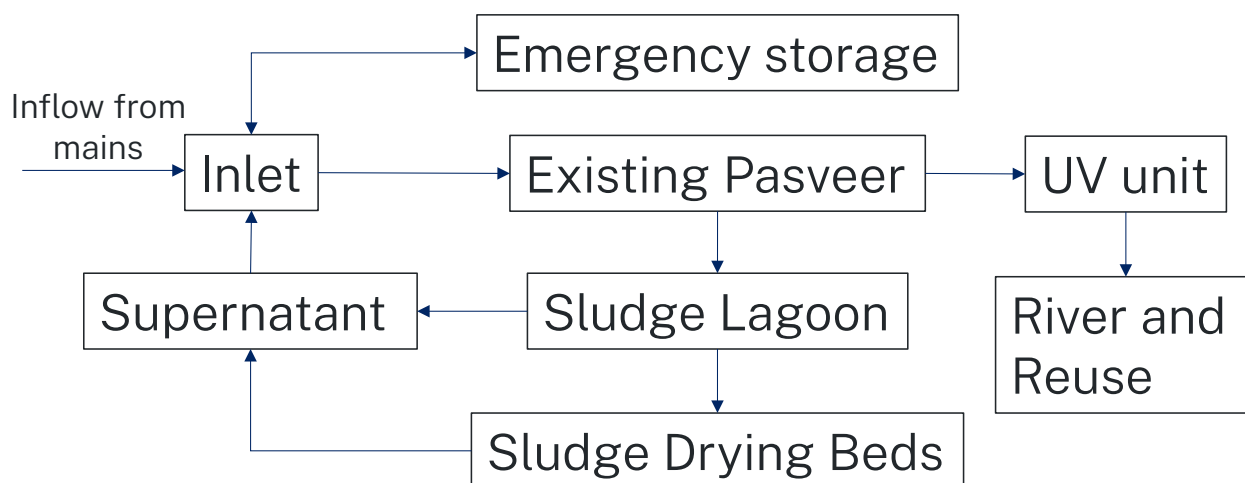


Figure 10-3: Process Flow Diagram – Captains Flat STP

10.2.2 Historical flows

STP inflow daily data was available from July 2012 to February 2023. Rainfall data was obtained from the Bureau of Meteorology (BOM weather station number 70016 – Foxlow St Captains Flat).

The historical sewage inflow to the Captains Flat STP is shown in Figure 10-4.

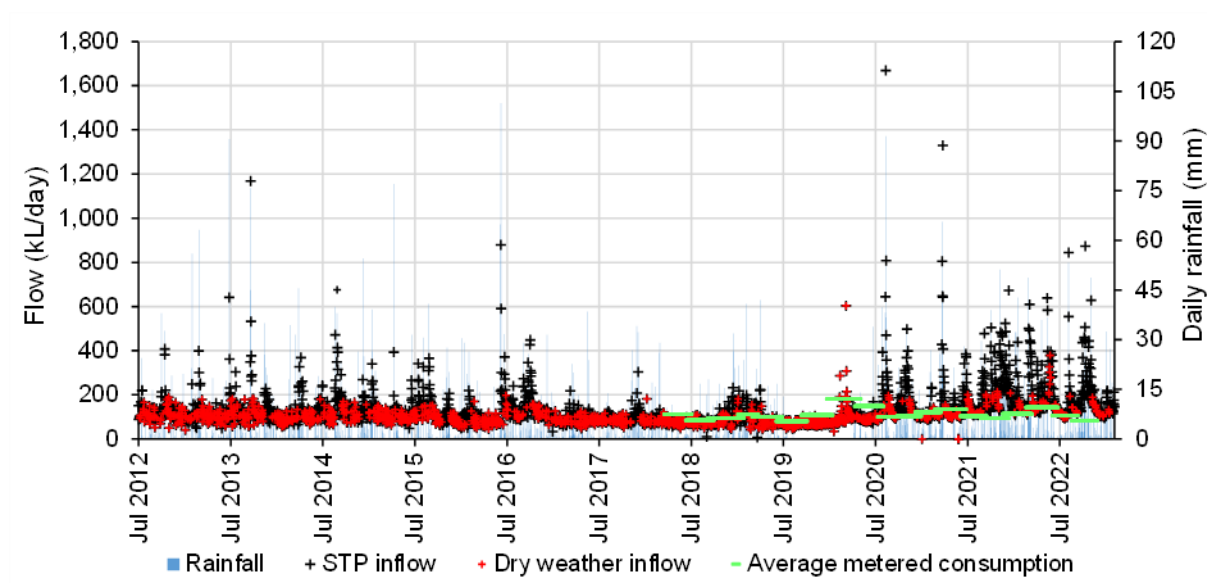


Figure 10-4: Captains Flat STP historical inflow, rainfall and metered consumption

From the figure above, the STP inflow increases after rainfall. This indicates that there is inflow and infiltration into the sewerage system.

It was also observed that during the extended wet weather in 2020 to 2022, the STP inflow is continuing to decrease after 10 dry days in a row. This is examined further in Section 10.3.1.1.

10.3 STP inflow analysis

10.3.1 Average dry weather flow (ADWF) estimated from STP inflow data

STP daily inflow data was analysed to estimate the average dry weather flow (ADWF). To estimate historical ADWF, a dry day was taken as a day with less than 4 mm of rainfall on that day, any of the seven preceding days and one day following. All historical rainfall data was obtained from the Bureau of Meteorology (BOM).

The historical ADWF from 2012/13 to 2017/18 is shown in Table 10-1.

Table 10-1: Captains Flat STP – ADWF estimated from STP inflow data

Financial Year	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22
ADWF (kL/day)	107	103	104	91	95	81	81	84	112	155

Based on the STP inflow data, the ADWF for the Captains Flat STP is around 95 kL/day.

10.3.1.1 Average Dry Weather Flow (ADWF) comparison with river level data

From September 2021 to June 2022 the STP inflow was almost continuously over 150 kL/day. It appears that the infiltration to the system is likely due to continued high water levels in the local aquifers and waterways. The closest environmental water level data monitoring available is from the river gauge at Molonglo River, Kobada (station number 4100208, about 2 km upstream of Captains Flat Dam). The creek levels and STP inflow from March 2020 to February 2023 are shown in Figure 10-5 and show that when the creek levels are over 450 mm continuously, the STP inflow continues to be high even after several “dry days”.

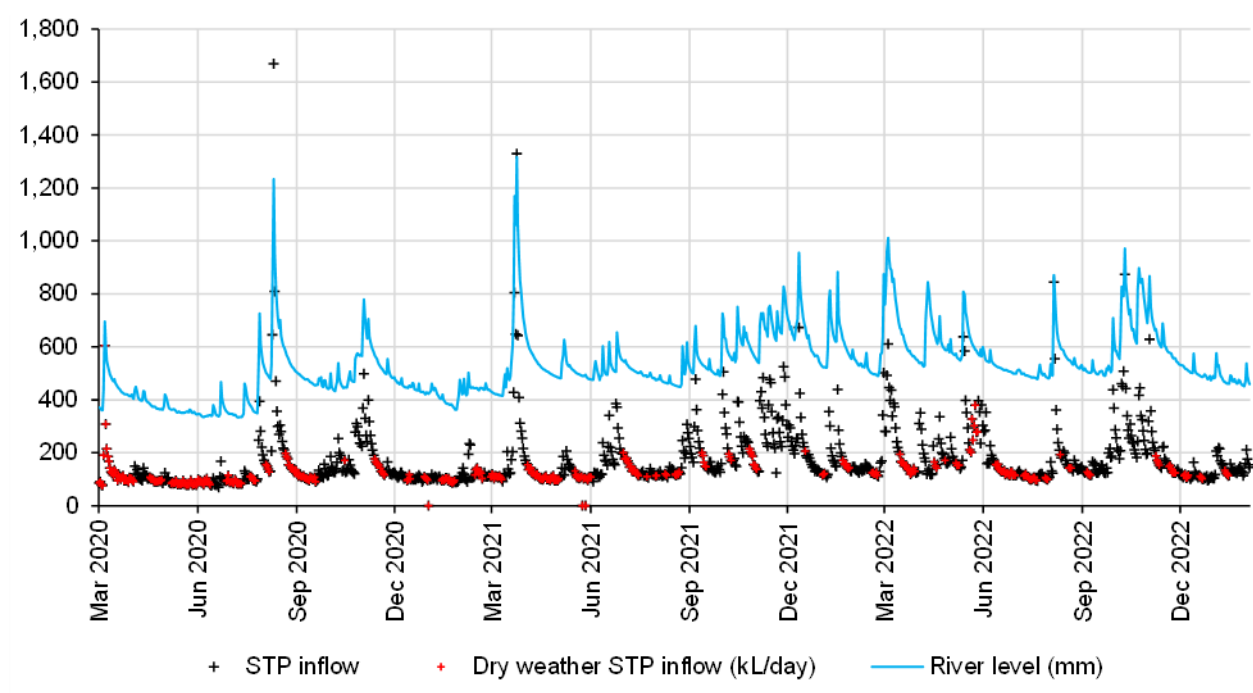


Figure 10-5: Captains Flat STP historical inflow and Molonglo River at Kobada water levels – Mar 2020 to Feb 2023

10.3.2 Biological and nutrient loading

The STP and the collection system operate under EPL No. 1929 granted by the NSW EPA that is renewed annually.

Effluent quality limitations on EPA licence are summarized in Table 10-2.

Table 10-2: Pollutant List - Sewage and Effluent for Braidwood STP

Parameter	Typical Raw Sewage	Effluent (90 percentile) *	Effluent (100 percentile) *
Biochemical Oxygen Demand (BOD5)	270 mg/L	<10 mg/L	<20 mg/L
Suspended Solids (SS)	270 mg/L	<10 mg/L	<15 mg/L

Parameter	Typical Raw Sewage	Effluent (90 percentile) *	Effluent (100 percentile) *
Total Nitrogen (TN)	53 mg/L	<8 mg/L	<10 mg/L
Ammonia	12 mg/L	<2 mg/L	<5 mg/L
Total Phosphorus (TP)	11 mg/L	<0.5 mg/L	<1 mg/L
Oil and grease (O&G)	< 10 mg/L	<2 mg/L	<10 mg/L
Faecal coliforms (FC)	1,000,000 cfu/100 mL	<100 cfu/100 mL	<200 cfu/100 mL
pH	6.5 – 8.5		6.5 – 8.5

Note: *Licence Conditions

Source: PIRMP, V2 [15]

10.4 SPS current performance

10.4.1 Emergency storage time

If a technical issue causes a pump to stop working, extended mechanical breakdown or electrical failures for examples, the emergency storage volume in the pump well should be able to store the incoming volume of sewage without overflow until Council can restore the operation of the pump.

There is only one SPS in the sewerage system and it is designed to have 8 hours of ADWF emergency storage before an overflow occurs.

The SPS has the ability to detect and respond to abnormal operating conditions via the telemetry system in the event of power failure, pump failure, etc.

10.4.2 Odour/septicity potential

Septicity potential is generally assessed by reviewing sewage detention times in SPS rising mains. According to WSAA Guidelines [18], sewage with a detention time between four and eight hours has a medium risk of septicity, and above eight hours has a high risk of septicity. The sewer rising is very short and the septicity risk is correspondingly low.

At Captains Flat STP, there is no odour treatment unit used.

At reticulation system, there is no odour treatment unit used for the SPS.

10.5 STP current performance

From recent inspections of the STP, as detailed in Section 10.6, it is performing satisfactorily.

10.6 Section 61 inspections and recommendations

Captain Flat STP was inspected on 02/03/2021 and the report states that the plant was performing satisfactorily. There was concern on the proximity of the inlet to decant weir. Baffles were installed to mitigate this. There were signs of corrosion on the decant scum baffles and

some gaps. It was recommended that maintenance of this equipment should be carried out. Results of sampling tests showed treatment process was being well managed and operating as expected.

The inspection on 27/04/2022 found the STP was performing satisfactorily. Sampling test analysis results showed treatment process was being well managed and operating as expected.

10.7 Work Health and Safety

No major WHS issues were noted/found from NSW PW staff site visit.

Council's WHS policies and procedures do exist and are followed.

11 Unserviced communities

There are numerous remote small villages and rural localities throughout the LGA without sewerage service. These residents treat wastewater using on-site sewage management systems (OSSMS) (typically septic tanks or aerated wastewater treatment systems).

11.1 OSSMS Assessment

A desktop assessment was undertaken for the villages that use OSSMS. The villages where potential issues have been identified are Nerriga, Majors Creek, Araluen and some unsewered properties on the edges of Captains flat. To assess the risk and impact for these unsewered villages, a prioritisation assessment was developed (based on the Safe and Secure Risk Prioritisation Framework by DCCEE). An inherent risk score was assigned to each village based on potable water source, lot sizes for effective effluent disposal, access to reticulated water supply, proximity to water course and population growth. The inherent risk score is categorised based on the criteria shown in Table 11-1.

Table 11-1: Inherent risk categorisation for OSSMS

Risk outcomes	Risk score
Widespread high-risk properties: Wastewater from on-site wastewater management facilities has potential for direct impact on drinking water supply source and/or with widespread direct primary contact impact to resident population and/or high impact on waterway uses and values Criteria: Large percentage (>70%) of properties with insufficient lot sizes for effluent disposal for well-drained soil, under 2,000 m ² or less is considered insufficient for poorly drained soil, under 4,000 m ² is considered insufficient AND reticulated water (potential to overload existing septic tanks) OR residents using private bores for potable water OR greater than 40 properties within 100 m buffer distance to surface waterway	4
Localised high-risk properties: Wastewater from on-site wastewater management facilities has potential for localised direct primary contact impact to resident population and/or medium impact on waterway uses and values Criteria: Smaller percentage (<70%) of properties with insufficient lot sizes for effluent disposal for well-drained soil, under 2,000 m ² or less is considered insufficient for poorly drained soil, under 4,000 m ² is considered insufficient AND reticulated water (potential to overload existing septic tanks) OR residents using private bores for potable water OR greater than 30 properties within 100 m buffer distance to surface waterway	3

Risk outcomes	Risk score
Medium risk properties (lot sizes 2,000 – 4,000 m ² with well drained soils). Potential direct health impact due to: Direct primary contact caused by overloading or ineffective effluent disposal Environmental: Low number (<20) of properties within 100 m buffer distance to surface waterway	2
Low risk properties (lot size greater than 4,000 m ²). Potential direct health impact due to: Direct primary contact caused by overloading or ineffective effluent disposal Environmental: Less than five properties within 100 m buffer distance to surface waterway	1

Table 11-2: Unsewered villages – risk score

	Soil drainage	% of properties with insufficient lot size	Potable water source	Number of properties close to waterway	Risk score
Requirement	Ideally well drained soils	<u>Well drained soil:</u> minimum 2,000 m ² Poorly/imperfectly drained soil: 2,000 to 4,000 m ² Practically impervious soil: minimum 4,000 m ²	No private bores are used for potable water. Reticulated water can also be an issue as there are risks of overloading septic tanks	Minimum 100 m away from surface waterway	
Risk if requirements not met	Resurfacing hazard (leading to potential human contact)	Public health risk: Insufficient area for effluent disposal leading to potential human contact	Bores – possible contamination Reticulated – increases loading	Contamination of surface water	
Village assessment					
Nerriga ~7 properties [1]	Profile is Well drained [2]	< 5 properties less than 4,000 m ² Minimum lot size from LSC LEP is 4,000 m ² .	Reticulated non-potable water supply.	No surface water nearby	1
Majors Creek ~100 properties [1]	Profile is imperfectly drained [2]	< 20 properties less than 4,000 m ² Minimum lot size from LSC LEP is 4,000 m ² .	Reticulated non-potable water supply.	No surface water nearby	1

	Soil drainage	% of properties with insufficient lot size	Potable water source	Number of properties close to waterway	Risk score
Araluen ~65 properties [1]	Profile is Well drained [2]	< 20 properties less than 4,000 m ² Minimum lot size from LSC LEP is 4,000 m ² .	Reticulated non-potable water supply.	No surface water nearby	1
Captains flat ~30 properties [1]	Profile imperfectly drained [2]	< 10 properties less than 4,000 m ² Minimum lot size from LSC LEP is 4,000 m ² .	Reticulated non-potable water supply.	No surface water nearby	1

[1] Counted from aerial map

[2] Soil Profile is from eSpade2 [19]

All villages have a risk score of 1 as they have suitable lot sizes, well-drained soil and no surface water is located nearby area.

12 Water and sewer strategic planning issues

Table 12-1: General water and sewer system issues

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
Compliance	BASIX	N/A new issue	Council's 2015 DCP increases the minimum rain water tank size for new dwellings in the former Palerang Shire, this contravenes the NSW State Environmental Planning Policy (Building Sustainability Index: BASIX) 2004

Table 12-2: Water Supply System Issues

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
General water supply issues			
Level of Service	Minimum pressure with firefighting capability	Council have nominated 'positive residual head' as the target for compliance, the current performance needs to be better understood through modelling.	Council now has a calibrated hydraulic model for Bungendore through an engagement with Public Works (Source: Email correspondence)
Best Practice	Pricing	N/A new issue	Council's 2015 DCP increases the minimum rain water tank size for new dwellings in the former Palerang Shire, new dwellings will require significantly less water in average years and nearly as much in hot dry years, increasing the difficulty of achieving an average of 50% of revenue from usage
Regulatory	Fluoridation of Public Water Supplies	The requirement for periodic auditing of the fluoridation systems is not always being met.	Council has confirmed that the requirement for periodic auditing is still not being met. (Source: Email correspondence)

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
Regulatory	Drinking Water Management System	Several of the nominated CCPs in the DWMS are not considered CCPs, for example free chlorine in the reticulation is an operational control point.	Council is currently revising the DWMS
Bungendore water supply issues			
Water security	Licensed allocation	It is estimated that Bungendore water supply dry year extraction will exceed its licensed extraction limit from the Bungendore and Currandooley bores by 2018.	<p>Still the biggest issue for the Palerang Communities</p> <p>History of the past few years of groundwater investigation is now well known.</p> <p>Current strategy is to develop the Q2B proposal, which will transfer water from Queanbeyan to Bungendore. In the meantime, all greenfield development for Bungendore is stalled.</p> <p>(Source: Email correspondence)</p>
Water quality	ADWG (Australian Drinking Water Guidelines)	N/A new issue	Proposed ADWG concentration limits for Per- and Polyfluoroalkyl Substances (PFAS) are significantly lower than the current limits. In response to the expected change, Council has undertaken additional sampling. Two of the four Bungendore bores tested positive for PFAS and the concentration of Perfluorooctane sulfonic acid (PFOS) exceeds the proposed guidelines.

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
Level of Service	Headworks capacity	The peak day demand will exceed the combined capacity of the Bungendore and Currandooly WTPs around 2025. The WTP, and reservoir capacity would need to be reviewed to ensure that the required pressure can be maintained in the system.	The peak day demand will exceed the combined capacity of the Bungendore and Currandooly WTP soon, the exact timing is dependent on the time required to resolve the water security issue. If one or two of the existing bores need to be removed from service due to PFAS contamination, this will become an immediate serious issue.
CCP1(a)-chlorination in reticulation	DWMS (Drinking Water Management System)	Bungendore WTP: The DWMS (and possibly the plant) needs to be updated so that CCP1(a) is between the tank and the pump, rather than before the dosing point.	Council had deduced that it was more operational than critical due to the fact that water from this plant essentially hits the reticulation (and therefore consumers) only 170m from the Bungendore WTP. Council had confirmed that this test will be added to the daily monitoring field sheets. Council understands the need for a free chlorine sensor between the 100kL collection tank and the pump to ensure that the water is correctly chlorinated before distribution. Longer term, the plan is to establish a direct rising main between this plant and the reservoirs thus improving the chlorine concentration times contact time (C.t).

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
Pathogen cross contamination	DWMS	Based on the DWMS [1] the Residual Risk with Preventative Measures continues to remain “Very High” for the following: potential pathogen contamination issues due to breach of pipeline and cross contamination due to backflow	Council is currently revising the DWMS
Minimum C.t. value	Local Water Utility (LWU) Circular 18 - ADWG	The total C.t from chlorination at Bungendore aeration tower to outflow is 6.2 mg.min/L, which is not above the recommended minimum value of 15 mg.min/L. Residual risk of chlorine sensitive pathogens: High .	Council to strictly monitor and document free chlorine concentration. Longer term, and as part of the Q2B project, the aim is to install a dedicated rising main from this plant to the service reservoirs. This will address any issues with C.t
Residual risk of chlorine resistant pathogens	Pathogen contamination	New issue	Residual risk of chlorine resistant pathogens Medium due to insufficient treatment. Disinfection barriers such as UV or Ozone are also effective at disabling chlorine resistant pathogens. However, Bungendore and Currandooly WTPs do not have UV or Ozone. UV or ozone treatment systems to be installed as part of either the next capacity upgrade or WTP replacement or when DCCEEW policy changes
Braidwood water supply issues			
Water security	Secure Yield	N/A new issue	The un-restricted annual demand will exceed the secure yield (320 ML/year with 1 degree warming) between 2039 and 2047*

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
Water security	Licensed allocation	N/A new issue	The un-restricted annual demand will exceed the licenced water entitlement (360 ML) between 2038 and 2052*
Capacity	WTP capacity	N/A new issue	The un-restricted peak day demand will exceed the WTP capacity (2 ML/day) between 2040 and 2042*
Performance - leaks	Non-Revenue Water	<p>The historical average unit water loss is estimated to be 249 L/connection/day, which is approximately 3.4 times the state median of 74 L/connection/day.</p> <p>The daily NRW calculated for the previous IWCM was 168 kL/day (2013/14), 154 kL/day (2014/15) and 183 kL/day (2015/16), about 35%. The NRW for the period used for the water balance averaged 127 kL/day, showing some improvement. Note that the period used for the water balance was also relatively wet, greatly reducing the overall demand for water, causing the percentage NRW to increase.</p>	This remains a significant problem for Council. Since last IWCM Council has taken advantage of a DCCEEW funded leak detection program. This was of only limited success. Another initiative is a program of revenue meter replacement. Currently Council has rolled out 130 NB-IoT meters with a further 500 to be deployed in 2024/25. Results are already promising with a number of letters already being issued for properties with persistent low flows. The intention is to completely change Braidwood revenue meters to NB-IoT by the end of 2025
Pathogen Contamination	DWMS	Based on the DWMS [1] the Residual Risk with Preventative Measures continues to remain ‘Very High’ for the following: dead end in reticulation system leading to stagnation and loss of chlorine residual; breach of pipeline through breaks and service works; cross contamination due to backflow and growth of biofilms/ sludge causing degradation of water quality	Council is reviewing the DWMS.

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
Residual risk of chlorine sensitive pathogens	Pathogen contamination	New issue	<p>Residual risk of chlorine resistant pathogens Medium due to moderately protected catchment.</p> <p>Disinfection barriers such as UV or Ozone are also effective at disabling chlorine resistant pathogens. However, Braidwood WTP does not have UV or Ozone.</p> <p>UV treatment system to be installed as part of either the next WTP capacity upgrade or WTP replacement or when DCCEEW policy changes</p>
Captains Flat water supply system			
Water loss	Major Water Residential User	This residential property (Property ID – 340223) has been flagged for investigation. A flow restrictor was installed in September 2021. The property is currently carrying in excess of \$40,000 worth of unpaid rates and charges.	Council suspecting serious leakage issues and investigation is underway.
Water loss	Water Balance	The historical average unit water loss is estimated to be 106 L/connection/day, which is approximately 1.4 times the state median of 74 L/connection/day.	Network investigations are ongoing
Regulatory	Drinking Water Management System	The turbidity alert limit corrective action for Captains Flat WTP needs to include a membrane integrity test.	<p>Turbidity monitoring at Captains Flat is now continuous online and monitored by GeoSCADA.</p> <p>Membranes were replaced in May 2024. Regular membrane integrity testing still to be enacted and included in field sheets.</p>

* Range due to use of high and low NRW forecasts

Table 12-3: Sewerage System Issues

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023 Updates
General sewerage system issues			
Unserviced communities	On-site sewage management systems	<p>Village of Majors Creek – potential issue due to the following reasons:</p> <p>Small lot sizes (some around 3,000 & several around 1,000 m²)</p> <p>Inadequate buffer distance from Majors Creek</p> <p>Moderately well to imperfectly drained soil</p> <p>Village of Nerriga – potential issue due to the following reasons:</p> <p>Small lot sizes (various sizes below 3,000 m²)</p> <p>Some properties may have inadequate buffer distance from Bindi Brook</p> <p>Village of Araluen – potential issue due to the following reasons:</p> <p>Small lot sizes (several properties less than 1,500 m² bordering each other)</p> <p>Moderately permeable, imperfectly drained soil.</p>	No action here

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023 Updates
Bungendore sewerage system issues			
Regulatory	EPA Licence non-compliance	The Bungendore STP exceeded the volumetric discharge limit (2.16 ML/day) in 2016, 2014, 2012 and 2011. Council needs to consider undertaking an inflow/infiltration study.	<p>Council has confirmed that they have undertaken several sewer relining projects since last IWCM. This was informed by precursor cleaning and CCTV work. Council also mentioned about carrying out targeted smoke testing for catchment 4 (Bungendore - a new development area) to try and resolved an emerging inflow problem.</p> <p>(Source: Email correspondence)</p> <p>Wet weather flows exceeded the licence limits more often during the recent wet years</p> <p>Licence is being reviewed as part of the upgrade process.</p>
Pump sizing at PWWF	Sewer catchment performance	The PWWF at catchment #2, #8 and #9 exceeds the capacity of a single pump. The PWWF at catchments #4 will exceed the capacity of a single pump by 2021. This is based on a PWWF calculated from the storm allowance which is twice the maximum flow recorded during the highest rainfall event in the last five years. Hence this is a conservative assessment.	<p>Catchment #2 has had pumps upgraded. Catchment #4 has had pumps upgraded. Catchments #8 & #9 to be upgraded in the future.</p> <p>(Source: Email correspondence)</p>
	Odour/septicity potential	Catchment #7 and #8 have a medium risk for odour/septicity potential with a detention time greater than 4 hours. This risk is expected to continue over the 30-year planning period.	No immediate action. Both SPS7 & SPS8 will increase both capacity and throughput at northern greenfield development progresses. This will lower rising main detention times.

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023 Updates
Capacity	Sewage Treatment Plant	<p>The EP load currently exceeds the 3,000 EP STP capacity and is expected to exceed the 5,000 EP capacity by 2020.</p> <p>For the assessed hydraulic loading of 200 L/EP/day in this study, the plant hydraulic and capacity will be exceeded by:</p> <p>2018 for the 3,000 EP STP, or 2023 when capacity is increased to 5,000 EP by commissioning the second IDEA reactor.</p>	<p>Design engagement currently underway with supporting SSWP funding for a tender ready package (+7,000 EP giving a total capacity of 12,000 EP) by 30 June 2025.</p> <p>The construction will commence once additional water for Bungendore has been secured</p> <p>The spare 2,000 EP IDEA was re-commissioned in March 2023.</p> <p>(Source: Email correspondence)</p>
STP inflow	ADWF compliance	STP inflow continues to be high, regardless of the time since the last rainfall	Council undertaking CCTV inspections and targeted relining.
STP Capacity	STP Capacity Compliance	The current estimated EP load for Bungendore sewerage scheme is 4,549 EP which is reaching the STP Design EP of 5,000,	Design engagement currently underway with supporting SSWP funding for a tender ready package (+7,000 EP giving a total capacity of 12,000 EP) by 30 June 2025.
Odour/septicity potential	WSAA Guidelines	Rising mains that have residence time greater than eight hours are potential to septicity for BU SPSs.	Council to monitor
Braidwood sewerage system issues			
Regulatory	EPA Licence non-compliance	The plant exceeded the volumetric discharge limit every year in the last five years. Council is currently undertaking an inflow/infiltration study.	<p>Inflow/Infiltration study completed. Large program of relining subsequently conducted. Inflow continues to be an issue over recent wet years.</p> <p>(Source: Email correspondence)</p>

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023 Updates
Odour/septicity potential	Sewer catchment performance	Catchment #3, and 5 have a medium risk for odour/septicity potential with a detention time greater than 4 hours. The risk for Catchment #5 is expected to drop to low risk by 2020, however Catchment #3 is expected to remain at medium risk.	No action (Source: Email correspondence)
Increased dry weather flow	Sewage inflow compliance	In winter, spring and early summer 2019, while the weather was extremely dry, the dry weather flows increased to over 400 kL/day. This is substantially higher than the dry weather flows in 2017/18 of 290 kL/day.	Council to investigate potential factors contributing to these high flows
PWWF	Pump rate	The PWWF from the catchments is estimated to be 54 L/s and likely to exceed SPS1 capacity when the fifty-six 2-to-3-bedroom units in the Summerfield - Braidwood Retirement village are completed. Pump rate lower than the combined capacity of the upstream pumps and local flow.	Current. Council to investigate and monitor
Captains Flat sewerage system issues			
Regulatory	EPA Licence non-compliance	The plant exceeded the volumetric discharge limit every year in the last five years. Council is currently undertaking an inflow/infiltration study.	Inflow/Infiltration study completed. Large program of relining subsequently conducted. Inflow continues to be an issue in the La Nina years. (Source: Email correspondence)

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023 Updates
Performance	Sewage Treatment Plant compliance	The plant needs to be upgraded to improve replace ageing infrastructure, improve treatment and enable enhanced phosphorus removal, enable screening and grit removal, improve sludge and sludge drying components and improve amenity and WHS.	Council has confirmed that the plant has been augmented. 2018 Issue now resolved an outcome of a significant investment of capital. (Source: Email correspondence)

Table 12-4: Resolved issues

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
General water and sewer issues Work Health and Safety (WHS)	Management System	Council does not have a documented Work and Health and Safety system. Council undertakes periodic WHS reviews, but these are not documented	Council has HSEQ accreditation. (Source: Email correspondence) Issue resolved
General water and sewer issues Levels of Service	Description and performance	There is no centralised data management system in place to monitor and measure the system performance against the levels of service (LOS) The LOS need to be reviewed for the newly formed Queanbeyan-Palerang Regional Council.	Council has a centralised records management system in ECM where plant field sheets are scanned and imported. Key data is also transcribed into spreadsheets for use in regulatory reporting. GeoSCADA also records key plant data. (Source: Email correspondence) Customer Request Management system also in place. Issue resolved
General water supply issues Best Practice	Pricing	Council currently has a two-tier inclining block tariff structure for water supply. Council should consider moving towards a fixed rate tariff structure.	Council has implemented a single block tariff system for water charging (Source: Email correspondence and Council's publicly available revenue policy) Issue resolved

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
Bungendore water supply issues CCP2 Fluoridation in Bungendore	DWMS	From January 2015 and February 2023, there were recent exceedances below the lower critical limit of less than 0.9 mg/L for 72 hrs.	Fluoride levels started to decrease from February 2023 due to issues with the saturators causing bed caking. Council stated that they had replaced the beds of all four branded NaF saturators and recommissioned. Issue resolved
Bungendore water supply issues CCP2 Fluoridation in Currandooly	DWMS	From January 2015 and June 2023, there were recent exceedances below the lower critical limit of less than 0.9 mg/L for 72 hrs. Before July, were maintained to be within the target range.	Fluoride levels started to decrease from February 2023 due to issues with the saturators causing bed caking. Council stated that they had replaced the beds of all four branded NaF saturators and recommissioned. Issue resolved.
Bungendore water supply issues Performance	Non-revenue water	Non-revenue water at Bungendore has been fairly constant at 125 L/connection/day. This is higher than the statewide median of 92 L/connection/day for 2015/16.	Significant program of water meter replacement has been undertaken. Many Itron electronic meters deployed. Now moving to NB-IoT meters as the LGA wide standard. (Source: Email correspondence) Bungendore NRW has reduced significantly, from 125 L/connection/day to 86 L/connection/day in 2021/22. Council will continue to monitor NRW. Issue resolved
Braidwood water supply issues Main breaks	Non-Revenue Water	Main breaks every 1-3 months with some months have main breaks more than once. 26 out of 173 complaints was related to main bursts over 3 years from October 2019 to November 2022.	A program of water main replacement has been undertaken. Frequency of main breaks has reduced. Issue resolved

Issue Type	Target for Compliance	Issue (2015-2019 IWCM)	2023-25 Council Updates
Captains Flat water supply issues Performance	Non-revenue water	Seasonal variations in the NRW for the Captains Flat system have been noticed which are due to a faulty meter at the Captains Flat swimming pool and the neighbouring fields which share a meter. This meter recently been replaced.	The pool site is now well metered although it still has a significant leak problem. The P&G section of Council remains committed to deal with similar issues that arise. (Email correspondence). Issue resolved
Bungendore sewerage issues Best Practice	Section 60 approval	Effluent from the Bungendore STP is reused on-site, for road works (truck filling) and for watering Bungendore oval. Council does not have a Recycled Water Management Plan and Section 60 approval for the off-site effluent reuse.	Bungendore has a Recycled Water Management System and has formal s.60 approval. (Source: Email correspondence) Issue resolved.
		The Log Reduction Value (LRV) required for effluent reuse may not be achieved through the current STP process. This will be reviewed during the preparation of the Recycled Water Management System (RWMS) for Section 60 approval.	Council has updated that this is completed. (Source: Email correspondence) Issue resolved.
Bungendore sewerage issues Performance	Effluent reuse flow balance	There is a mismatch in the effluent reuse flow balance. Potential reasons for the discrepancy could include uncalibrated meters, and on-site flows which may not be metered.	New RWP at the STP has incorporated a whole new system of metering. (Source: Email correspondence) Issue resolved
Braidwood sewerage issues Pump sizing	Sewer catchment performance	The PWWF at catchment #1 will exceed the capacity of a single pump by 2021. Council has funded an upgrade.	Pumps upgraded together with supporting electrical network. 2018 Issue resolved. (Source: Email correspondence)
Captains Flat sewerage issues Pump sizing	Sewer catchment performance	The PWWF at catchment #1 is expected to exceed the duty pump capacity.	Pumps have been upgraded since last IWCM. Both now capable of 15L/s which is sufficient. 2018 Issue now resolved (Source: Email correspondence)

13 References

- [1] "Drinking Water Management System, Queanbeyan-Palerang Regional Council," Viridis Consultants Pty Ltd, Bulimba QLD, 2017.
- [2] Australian Bureau of Statistics, "Census," [Online]. Available: <https://www.abs.gov.au/census>. [Accessed 15 October 2023].
- [3] Australian Bureau of Statistics, "Estimated Residential Population (ERP)," [Online]. Available: <https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2901.0Chapter31602016>. [Accessed 15 October 2023].
- [4] "Bungendore Structure Plan 2048," Queanbeyan-Palerang Regional Council, 2020.
- [5] Land-Use Planning Branch, "Discussion Paper For the Braidwood Structure Plan," Queanbeyan-Palerang Regional Council, 2023.
- [6] Water Loss Research & Analysis Ltd, "Unavoidable Annual Real Losses & Infrastructure Leakage Index," 16 July 2020. [Online]. Available: <https://www.leakssuitelibrary.com/uarl-and-ili/>.
- [7] A. Lanchbery, "Guide to the measurement and use of Ct," WIOA Occasional Publication, 2019.
- [8] NSW Government, "About BASIX (Building Sustainability Index) - Water target zones," [Online]. Available: <https://www.basix.nsw.gov.au/iframe/water-help/water-targets/water-target-zones.html>. [Accessed 20 January 2024].
- [9] NSW Department of Primary Industries Water, "Lower Hunter Water Plan: MERI Annual Evaluation 2015," Metropolitan Water Directorate, Newcastle, 2016.
- [10] M. Retamal, P. Mukheibir, A. Schlunke and E. Prentice, "Work Package 4: Rainwater," The Institute for Sustainable Futures (University of Technology Sydney), 2018.
- [11] Natural Resource Management Ministerial Council, National Health and Medical Research Council. Australian Government, "Australian Drinking Water Guidelines 6," Commonwealth of Australia, Canberra, 2011.
- [12] NSW Department of Industry, "Local water utility performance," 2024. [Online]. Available: <https://water.dpie.nsw.gov.au/our-work/local-water-utilities/local-water-utility-performance>. [Accessed 10 January 2024].
- [13] DPWS, "Department of Public Works, Manual of Practice: Sewer Design," 1984.
- [14] Public Works, "Bungendore Sewage Treatment Plant Augmentation Options Study," 2016.
- [15] Public Works Advisory, "Queanbeyan-Palerang Regional Council Googong, Bungendore, Braidwood, Captains Flat and Queanbeyan (Reticulation) Sewerage Scheme - Pollution Incident Response Plan," 2022.
- [16] Public Works Advisory, "Bungendore Recycled Water Scheme, Recycled Water Management System," 2022.
- [17] Public Works, "Manual of Practice Sewer Design," Public Works, 1987.
- [18] WSAA, "Water Services Association of Australia," [Online]. Available: <https://www.wsaa.asn.au/>. [Accessed 15 February 2024].
- [19] NSW Department of Planning, Industry and Environment, "eSPADE," [Online]. Available: <https://www.environment.nsw.gov.au/eSpade2Webapp>. [Accessed 20 January 2024].
- [20] Australian Government, "National Performance Framework: 2013-14 urban performance reporting indicators and definitions handbook," National Water Commission, 2014.
- [21] T. B. M. T. D. W. A. O. Lambert, "A Review of Performance Indicators for Real Losses from Water Supply Systems," 1999.
- [22] Queanbeyan-Palerang Regional Council, "QPRC," 30 June 2022. [Online]. Available: <https://yourvoice.qprc.nsw.gov.au/qprc-financial-statement-2021-22>.
- [23] Queanbeyan Palerang Regional Council, "Bungendore Structure Plan 2048," 2020.
- [24] Australian Bureau of Statistics, "Quickstats," [Online]. Available: <https://www.abs.gov.au/census/guide-census-data/about-census-tools/quickstats>. [Accessed 15 October 2023].

Appendix A Raw Water quality

A.1 Raw Water quality

Appendix table A-1: Bungendore bores raw water quality

Parameter	Units	Number of samples	Samples below LOR	Max LOR	Min LOR	Average above LOR	Max above LOR
Acid Soluble Aluminium	µg/L	38	25	5	5	17	40
Aluminium	mg/L	28	23	0.02	0.02	0.06	0.13
Aluminium	µg/L	9	8	9	9	14	14
Antimony	µg/L	36	36	3	1		
Arsenic	µg/L	36	27	1	1	1	2
Barium	µg/L	36	0	0	0	38	56.6
Bicarbonate Alkalinity as CaCO ₃	mg/L	37	0	0	0	169	331
Boron	mg/L	37	4	0.02	0.01	0.02	0.03
Cadmium	µg/L	36	36	0.05	0.05		
Calcium	mg/L	37	0	0	0	24	26.4
Calcium Hardness as CaCO ₃	mg/L	37	0	0	0	61	66
Carbonate Alkalinity as CaCO ₃	mg/L	37	36	0.1	0.1	8	8.4
Chloride	mg/L	38	0	0	0	87	111
Chromium	mg/L	28	20	0.002	0.001	0.002	0.003
Chromium	µg/L	9	8	2	2	2	2
Colour (True)	PCU	36	21	1	1	2	3
Combined Chlorine	mg/L	59	31	0.03	0.03	0.05	0.15
Copper	µg/L	58	2	1	1	6	140
Dissolved Organic Carbon (as NPOC)	mg/L	12	7	1	1	2	3

Parameter	Units	Number of samples	Samples below LOR	Max LOR	Min LOR	Average above LOR	Max above LOR
E.coli (Colilert)	MPN/100 mL	37	37	1	1		
Fluoride	mg/L	36	0	0	0	0.9	1.1
Free Chlorine	mg/L	60	0	0	0	0.8	1.34
Hexavalent Chromium	mg/L	1	1	0.01	0.01		
Hydroxide Alkalinity as CaCO ₃	mg/L	37	37	0.1	0.1		
Iodide	mg/L	37	37	0.05	0.01		
Iron	mg/L	38	12	0.02	0.01	0.07	0.35
Lead	µg/L	36	25	0.2	0.2	0.5	1.6
Magnesium	mg/L	37	0	0	0	21	23.2
Manganese	mg/L	37	22	0.001	0.001	0.002	0.006
Manganese	µg/L	21	5	0.5	0.5	1	5.4
Mercury	µg/L	35	35	0.1	0.1		
Mercury	mg/L	1	1	0.0001	0.0001		
Molybdenum	µg/L	35	32	1	1	9	20
Nickel	µg/L	36	0	0	0	3	6
Nitrate as N	mg/L N	36	0	0	0	2	3.16
Nitrite + Nitrate as N	mg/L N	36	0	0	0	2	3.16
Nitrite as N	mg/L N	36	36	0.01	0.01		
pH	pH Unit	37	0	0	0	8	8.24
Selenium	µg/L	36	5	1	1	3	8
Silver	µg/L	36	36	1	1		
Sodium	mg/L	38	0	0	0	77	95.1
Sulfate	mg/L	59	0	0	0	29	38.7
Total Alkalinity as CaCO ₃	mg/L	37	0	0	0	170	331
Total Chlorine	mg/L	59	0	0	0	0.8	1.34
Total Coliforms (Colilert)	MPN/100 mL	37	37	1	1		

Parameter	Units	Number of samples	Samples below LOR	Max LOR	Min LOR	Average above LOR	Max above LOR
Total Cyanide	mg/L	37	37	0.004	0.004		
Total Dissolved Solids	mg/L	36	0	0	0	368	445
Total Hardness as CaCO ₃	mg/L	12	0	0	0	151	160
Total Residual Chlorine	mg/L	1	1	0.03	0.03		
Turbidity	NTU	38	0	0	0	0.7	2.3
Zinc	mg/L	29	4	0.005	0.005	0.009	0.013
Zinc	µg/L	9	1	5	5	8	18

Appendix table A-2: Currandooly bores raw water quality

Parameter	Units	Number of samples	Samples below LOR	Max LOR	Min LOR	Average above LOR	Max above LOR
Acid Soluble Aluminium	µg/L	33	26	5	5	14266.57	99800
Aluminium	µg/L	9	3	9	9	19021	114000
Aluminium	mg/L	24	19	0.02	0.02	0.08	0.24
Antimony	µg/L	33	32	3	1	0	0
Arsenic	µg/L	33	22	1	1	0.909091	1
Barium	µg/L	33	0	0	0	81.04242	97.9
Bicarbonate Alkalinity as CaCO ₃	mg/L	33	0	0	0	116.0939	163
Boron	mg/L	33	20	0.02	0.01	0.012308	0.02
Cadmium	µg/L	33	32	0.05	0.05	0	0
Calcium	mg/L	33	0	0	0	15.42848	42.6
Calcium Hardness as CaCO ₃	mg/L	33	0	0	0	38.54545	106
Carbonate Alkalinity as CaCO ₃	mg/L	33	33	0.1	0.1		
Chloride	mg/L	33	0	0	0	38.32727	112

Parameter	Units	Number of samples	Samples below LOR	Max LOR	Min LOR	Average above LOR	Max above LOR
Chromium	µg/L	9	9	2	2		
Chromium	mg/L	24	22	0.002	0.001	0.001	0.001
Colour (True)	PCU	33	0	0	0	209.2727	460
Copper	µg/L	53	35	1	1	42.44444	294
Dissolved Organic Carbon (as NPOC)	mg/L	12	0	0	0	3.166667	6
E.coli (Colilert)	MPN/100 mL	34	34	1	1		
Fluoride	mg/L	33	9	0.1	0.05	0.188333	0.93
Hexavalent Chromium	mg/L	1	1	0.01	0.01		
Hydroxide Alkalinity as CaCO ₃	mg/L	33	33	0.1	0.1		
Iodide	mg/L	33	13	0.05	0.01	0.0525	0.24
Iron	mg/L	33	1	0.02	0.02	25.71375	31.9
Lead	µg/L	33	22	0.2	0.2	4.727273	36.1
Magnesium	mg/L	33	0	0	0	11.28242	12.4
Manganese	µg/L	22	0	0	0	433.9636	551
Manganese	mg/L	31	0	0	0	0.450742	0.514
Mercury	mg/L	1	1	0.0001	0.0001		
Mercury	µg/L	33	32	0.1	0.1	0	0
Molybdenum	µg/L	33	19	1	1	1	2
Nickel	µg/L	33	25	1	1	2.375	8
Nitrate as N	mg/L	9	9	0.05	0.01		
Nitrate as N	mg/L N	24	16	0.01	0.01	0.2675	1.44
Nitrite + Nitrate as N	mg/L	9	9	0.05	0.05		
Nitrite + Nitrate as N	mg/L N	24	16	0.05	0.05	0.2725	1.44
Nitrite as N	mg/L	9	9	0.01	0.01		

Parameter	Units	Number of samples	Samples below LOR	Max LOR	Min LOR	Average above LOR	Max above LOR
Nitrite as N	mg/L N	24	21	0.01	0.01	0.013333	0.03
pH	pH Unit	33	0	0	0	6.948788	7.35
Selenium	µg/L	33	23	1	1	1.6	3
Silver	µg/L	33	32	1	1	0	0
Sodium	mg/L	33	0	0	0	33.49394	70.4
Sulfate	mg/L	54	0	0	0	8.285185	17.1
Total Alkalinity as CaCO ₃	mg/L	33	0	0	0	116.1212	163
Total Coliforms (Colilert)	MPN/100 mL	34	30	1	1	5.25	8
Total Cyanide	mg/L	33	33	0.004	0.004		
Total Dissolved Solids	mg/L	33	0	0	0	209.2727	376
Total Hardness as CaCO ₃	mg/L	12	0	0	0	84.91667	98
Turbidity	NTU	33	0	0	0	197.1939	369
Zinc	µg/L	9	6	5	5	19	30
Zinc	mg/L	24	13	0.005	0.005	0.026	0.164

Appendix table A-3: Braidwood raw water quality

Parameter	Units	Number of samples	Samples below LOR	Max LOR	Min LOR	Average above LOR	Max above LOR
Acid Soluble Aluminium	µg/L	38	6	5	5	90	1330
Aluminium	µg/L	6	1	9	9	28	63
Aluminium	mg/L	29	8	0.02	0.02	0.2	1.33
Anabaena	cells/mL	1	0	0	0	0	0
Anabaenopsis	cells/mL	1	0	0	0	0	0
Anathece	cells/mL	1	0	0	0	0	0
Antimony	µg/L	38	37	3	1	0	0
Aphanizomenon	cells/mL	1	0	0	0	0	0
Aphanocapsa	cells/mL	1	0	0	0	106	106

Parameter	Units	Number of samples	Samples below LOR	Max LOR	Min LOR	Average above LOR	Max above LOR
Aphanothece	cells/mL	1	0	0	0	0	0
Arsenic	µg/L	38	37	1	1	0	0
Bacillariophyceae	cells/mL	2	0	0	0	22445	44697
Barium	µg/L	38	0	0	0	14	34.6
Bicarbonate Alkalinity as CaCO ₃	mg/L	38	0	0	0	39	61.3
Boron	mg/L	38	33	0.02	0.01	0.01	0.01
Cadmium	µg/L	38	37	0.05	0.05	0	0
Calcium	mg/L	38	0	0	0	6	10.5
Calcium Hardness as CaCO ₃	mg/L	38	0	0	0	16	26
Carbonate Alkalinity as CaCO ₃	mg/L	38	38	0.1	0.1		
Chloride	mg/L	38	0	0	0	10	20
Chlorophyta	cells/mL	2	0	0	0	201	210
Chromium	µg/L	9	9	2	2		
Chromium	mg/L	29	26	0.002	0.001	0.002	0.003
Chroococcus	cells/mL	1	0	0	0	0	0
Chrysophyceae	cells/mL	2	0	0	0	24	48
Chrysosporum	cells/mL	1	0	0	0	0	0
Colour (True)	PCU	38	0	0	0	13	33
Copper	µg/L	45	39	1	1	1	2
Cryptophyceae	cells/mL	2	0	0	0	475	844
Cuspidothrix	cells/mL	1	0	0	0	0	0
Cyanophyta	cells/mL	2	0	0	0	1354	2410
Cylindrospermopsis	cells/mL	1	0	0	0	0	0
Dissolved Organic Carbon (as NPOC)	mg/L	1	0	0	0	8	8
Dolichospermum	cells/mL	1	0	0	0	0	0
E.coli (Colilert)	MPN/100 mL	38	12	1	1	31	250
Euglenophyta	cells/mL	2	0	0	0	0	0
Fluoride	mg/L	38	0	0	0	0.3	1.1

Parameter	Units	Number of samples	Samples below LOR	Max LOR	Min LOR	Average above LOR	Max above LOR
Hexavalent Chromium	mg/L	1	1	0.01	0.01		
Hydroxide Alkalinity as CaCO ₃	mg/L	38	38	0.1	0.1		
Iodide	mg/L	38	35	0.05	0.01	0.01	0.01
Iron	mg/L	38	1	0.01	0.01	0.2	0.76
Lead	µg/L	38	36	0.2	0.2	0.2	0.4
Magnesium	mg/L	38	0	0	0	3	4.85
Manganese	µg/L	16	0	0	0	7	22.4
Manganese	mg/L	29	0	0	0	0.02	0.184
Mercury	mg/L	1	1	0.000 1	0.000 1		
Mercury	µg/L	37	36	0.1	0.1	0	0
Merismopedia	cells/mL	1	0	0	0	0	0
Microcystis	cells/mL	1	0	0	0	192	192
Molybdenum	µg/L	38	37	1	1	0	0
Nickel	µg/L	38	34	1	1	1	2
Nitrate as N	mg/L N	38	36	0.05	0	0.08	0.15
Nitrite + Nitrate as N	mg/L N	38	36	0.05	0.05	0.08	0.15
Nitrite as N	mg/L N	38	36	0.01	0.01	0.005	0.01
Nodularia	cells/mL	1	0	0	0	0	0
Oscillatoria	cells/mL	1	0	0	0	0	0
Other	cells/mL	1	0	0	0	0	0
pH	pH Unit	38	0	0	0	8	8.33
Phormidium	cells/mL	1	0	0	0	0	0
Planktolyngbya	cells/mL	1	0	0	0	0	0
Planktothricoides	cells/mL	1	0	0	0	0	0
Planktothrix	cells/mL	1	0	0	0	0	0
Pseudanabaena	cells/mL	1	0	0	0	0	0
Pyrrophyta	cells/mL	2	0	0	0	0	0
Radiocystis	cells/mL	1	0	0	0	0	0
Selenium	µg/L	38	35	1	1	0.7	1

Parameter	Units	Number of samples	Samples below LOR	Max LOR	Min LOR	Average above LOR	Max above LOR
Silver	µg/L	38	37	1	1	0	0
Sodium	mg/L	38	0	0	0	10	14.5
Sphaerospermopsis	cells/mL	1	0	0	0	0	0
Spirulina	cells/mL	1	0	0	0	0	0
Sulfate	mg/L	45	0	0	0	7	17.2
Tot. Algae	cells/mL	2	0	0	0	24485	47400
Total Alkalinity as CaCO ₃	mg/L	38	0	0	0	39	61
Total Coliforms (Colilert)	MPN/100 mL	38	5	1	1	608	2400
Total Cyanide	mg/L	38	38	0.004	0.004		
Total Cyanophyta	cells/mL	1	0	0	0	298	298
Total Dissolved Solids	mg/L	38	0	0	0	75	111
Total Hardness as CaCO ₃	mg/L	13	0	0	0	28	42
Turbidity	NTU	38	0	0	0	1	7.2
Tychonema	cells/mL	1	0	0	0	0	0
Unknown	cells/mL	2	0	0	0	0	0
Xanthophyceae	cells/mL	2	0	0	0	0	0
Zinc	µg/L	9	9	5	5		
Zinc	mg/L	29	27	0.005	0.005	0.007	0.007

Appendix table A-4: Captains Flat raw water quality

Parameter	Units	Number of samples	Samples below LOR	Max LOR	Min LOR	Average above LOR	Max above LOR
Acid Soluble Aluminium	µg/L	37	0	0	0	75	501
Aluminium	µg/L	9	0	0	0	290	557
Aluminium	mg/L	28	0	3	1	0.3	2.08
Antimony	µg/L	37	36	1	1	0	0
Arsenic	µg/L	37	18	0	0	1	2
Barium	µg/L	37	0	0	0	14	21.8
Bicarbonate Alkalinity as CaCO ₃	mg/L	37	0	0.02	0.01	28	71.5

Parameter	Units	Number of samples	Samples below LOR	Max LOR	Min LOR	Average above LOR	Max above LOR
Boron	mg/L	37	36	0.05	0.05	0.01	0.01
Cadmium	µg/L	37	30	0	0	0.05	0.08
Calcium	mg/L	37	0	0	0	4	4.99
Calcium Hardness as CaCO ₃	mg/L	35	0	0.1	0.1	9	12
Carbonate Alkalinity as CaCO ₃	mg/L	37	37	0	0		
Chloride	mg/L	37	0	2	0.001	6	14.6
Chromium	µg/L	9	9	0	0		
Chromium	mg/L	28	22	1	1	0.002	0.003
Colour (True)	PCU	37	0	0	0	49	90
Copper	µg/L	44	1	1	1	3	4
Dissolved Organic Carbon (as NPOC)	mg/L	11	0	0.1	0.05	8	15
E.coli (Colilert)	MPN/100 mL	37	2	0.01	0.01	47	390
Fluoride	mg/L	41	28	0.1	0.1	0.07	0.12
Hexavalent Chromium	mg/L	1	1	0.05	0.01		
Hydroxide Alkalinity as CaCO ₃	mg/L	37	37	0	0		
Iodide	mg/L	37	34	0	0	0.01	0.01
Iron	mg/L	37	0	0	0	0.8	1.34
Lead	µg/L	38	0	0	0	8	27.4
Magnesium	mg/L	37	0	0.1	0.0001	4	5.19
Manganese	µg/L	16	0	1	1	42	82.9
Manganese	mg/L	28	0	1	1	0.09	0.242
Mercury	mg/L	1	1	0.05	0		
Mercury	µg/L	36	35	0.05	0.05	0	0
Molybdenum	µg/L	37	36	0.01	0.01	0	0

Parameter	Units	Number of samples	Samples below LOR	Max LOR	Min LOR	Average above LOR	Max above LOR
Nickel	µg/L	37	2	0	0	2	4
Nitrate as N	mg/L	9	9	1	1		
Nitrate as N	mg/L N	28	25	1	1	0.1	0.24
Nitrite + Nitrate as N	mg/L	9	9	0	0		
Nitrite + Nitrate as N	mg/L N	28	25	0	0	0.1	0.24
Nitrite as N	mg/L	9	9	0	0		
Nitrite as N	mg/L N	28	25	1	1	0.007	0.01
pH	pH Unit	37	0	0.004	0.004	7	7.65
Selenium	µg/L	37	35	0	0	0.5	1
Silver	µg/L	37	36	0	0	0	0
Sodium	mg/L	37	0	0	0	6	7.6
Sulfate	mg/L	44	0	0	0	11	25.8
Total Alkalinity as CaCO ₃	mg/L	37	0	0	0	28	71
Total Coliforms (Colilert)	MPN/100 mL	37	8	0	0	670	2800
Total Cyanide	mg/L	37	37	0	0		
Total Dissolved Solids	mg/L	37	0	0	0	402	12500
Total Hardness as CaCO ₃	mg/L	12	0	0	0	21	28
Turbidity	NTU	37	0	0	0	8	32
Zinc	µg/L	9	0	0	0	77	144
Zinc	mg/L	28	0	0	0	0.05	0.098

A.2 NSW Health Water Quality Monitoring Analysis

Appendix table A-5: Bungendore NSW Health Water Quality

Characteristic	First sample	Last Sample	Samples	Guideline	Number non-compliant	Minimum Concentration (if ADWG has min)	Maximum Concentration	Average Concentration	% of samples non-compliant	% of samples above limit of reading
Aluminium	4/10/16	20/02/23	13	0.2 mg/L			0.020	0.011	0%	54%
Antimony	4/10/16	20/02/23	13	0.003 mg/L			<LOR		0%	0%
Arsenic	4/10/16	20/02/23	13	0.01 mg/L			0.009	0.002	0%	85%
Barium	4/10/16	20/02/23	13	2 mg/L			0.048	0.031	0%	100%
Boron	4/10/16	20/02/23	13	4 mg/L			0.012	0.010	0%	31%
Cadmium	4/10/16	20/02/23	13	0.002 mg/L			<LOR		0%	0%
Calcium	4/10/16	20/02/23	13	10000 mg/L			26	22	0%	100%
Chloride	4/10/16	20/02/23	13	250 mg/L			114	85	0%	100%
Chromium	4/10/16	20/02/23	13	0.05 mg/L			<LOR		0%	0%
Copper	4/10/16	20/02/23	13	2 mg/L			0.033	0.013	0%	77%
E. coli	5/07/16	3/10/23	249	0 mpn/100 mL			<LOR		0%	0%
Fluoride	5/07/16	5/09/23	93	1.5 mg/L			1.10	0.96	0%	100%
Fluoride (weekly WU)	6/07/16	6/09/23	749	0.9 / 1.5 mg/L	19	0.47	1.11	0.99	3%	100%
Fluoride (WU result)	5/07/16	5/09/23	86	1.5 mg/L			1.06	0.99	0%	100%

Characteristic	First sample	Last Sample	Samples	Guideline	Number non-compliant	Minimum Concentration (if ADWG has min)	Maximum Concentration	Average Concentration	% of samples non-compliant	% of samples above limit of reading
Fluoride Ratio	5/07/16	5/09/23	86	0.8 / 1.2	1	0.87	1.21	1.03	1%	100%
Free Chlorine	5/07/16	3/10/23	249	0.2 / 5 mg/L	1	0.10	1.99	1.09	0%	100%
Iodine	4/10/16	20/02/23	13	0.5 mg/L			0.080	0.062	0%	92%
Iron	4/10/16	20/02/23	13	0.3 mg/L			0.010	0.010	0%	15%
Lead	4/10/16	20/02/23	13	0.01 mg/L			0.002	0.001	0%	38%
Magnesium	4/10/16	20/02/23	13	10000 mg/L			24	19	0%	100%
Manganese	4/10/16	20/02/23	13	0.5 mg/L			0.006	0.002	0%	31%
Mercury	4/10/16	20/02/23	13	0.001 mg/L			0.0002	0.0001 2	0%	38%
Molybdenum	4/10/16	20/02/23	13	0.05 mg/L			0.0011	0.0009	0%	31%
Nickel	4/10/16	20/02/23	13	0.02 mg/L			0.0006	0.0005 5	0%	15%
Nitrate	4/10/16	20/02/23	13	50 mg/L			12.50	7.42	0%	92%
Nitrite	4/10/16	20/02/23	13	3 mg/L			<LOR		0%	0%
pH	5/07/16	3/10/23	258	6.5 / 8.5	5	6.50	8.79	7.91	2%	100%
Selenium	4/10/16	20/02/23	13	0.01 mg/L			0.003	0.003	0%	15%
Silver	4/10/16	20/02/23	13	0.1 mg/L			<LOR		0%	0%
Sodium	4/10/16	20/02/23	13	180 mg/L			81	72	0%	100%

Characteristic	First sample	Last Sample	Samples	Guideline	Number non-compliant	Minimum Concentration (if ADWG has min)	Maximum Concentration	Average Concentration	% of samples non-compliant	% of samples above limit of reading
Sulfate	4/10/16	20/02/23	13	250 mg/L			36	24	0%	100%
Total Chlorine	5/07/16	3/10/23	249	5 mg/L			2.08	1.20	0%	100%
Total Coliforms	5/07/16	3/10/23	249	0 mpn/100 mL			<LOR		0%	0%
Total Dissolved Solids (TDS)	4/10/16	20/02/23	13	10000 mg/L			348	298	0%	100%
Total Hardness as CaCO ₃	4/10/16	20/02/23	13	200 mg/L			164	131	0%	100%
True Colour	4/10/16	20/02/23	13	15 Hazen Units (HU)			3.00	1.50	0%	31%
Turbidity	4/10/16	3/10/23	236	5 NTU	1		7.62	0.07	0%	97%
Uranium	7/08/17	20/02/23	10	0.017 mg/L			0.0001	0.0001	0%	10%
Zinc	4/10/16	20/02/23	13	3 mg/L			0.060	0.026	0%	85%

Appendix table A-6: Braidwood NSW Health Water Quality

Characteristic	First sample	Last Sample	Samples	Guideline	Number non/compliant	Minimum Concentration (if ADWG has min)	Maximum Concentration	Average Concentration	% of samples non/compliant	% of samples above limit of reading
Aluminium	4/10/16	1/08/23	18	0.2 mg/L	1		0.250	0.052	6%	100%
Antimony	4/10/16	1/08/23	18	0.003 mg/L			0	0.0001	0%	6%
Arsenic	4/10/16	1/08/23	18	0.01 mg/L			0.004	0.001	0%	50%
Barium	4/10/16	1/08/23	18	2 mg/L			0.063	0.021	0%	100%
Boron	4/10/16	1/08/23	18	4 mg/L			0.011	0.007	0%	44%
Cadmium	4/10/16	1/08/23	18	0.002 mg/L			0.0005	0.0005	0%	6%
Calcium	4/10/16	1/08/23	18	10000 mg/L			14	8	0%	100%
Chloride	4/10/16	1/08/23	18	250 mg/L			33	16	0%	100%
Chromium	4/10/16	1/08/23	18	0.05 mg/L			0.001	0.001	0%	6%
Copper	4/10/16	1/08/23	18	2 mg/L			0.542	0.057	0%	78%
E. coli	5/07/16	3/10/23	367	0 mpn/100 mL			<LOR		0%	0%
Fluoride	5/07/16	5/09/23	97	1.5 mg/L			1.20	1.00	0%	100%
Fluoride (weekly WU)	6/07/16	6/09/23	737	0.9 / 1.5 mg/L	23	0.68	1.10	1.00	3%	100%
Fluoride (WU result)	5/07/16	5/09/23	85	1.5 mg/L			1.09	0.99	0%	100%
Fluoride Ratio	5/07/16	5/09/23	85	0.8 / 1.2	1	0.46	1.17	0.99	1%	100%
Free Chlorine	5/07/16	3/10/23	368	0.2 / 5 mg/L		0.20	1.90	1.05	0%	100%

Characteristic	First sample	Last Sample	Samples	Guideline	Number non/compliant	Minimum Concentration (if ADWG has min)	Maximum Concentration	Average Concentration	% of samples non/compliant	% of samples above limit of reading
Iodine	4/10/16	1/08/23	18	0.5 mg/L			<LOR		0%	0%
Iron	4/10/16	1/08/23	18	0.3 mg/L			0.050	0.014	0%	72%
Lead	4/10/16	1/08/23	18	0.01 mg/L			0.002	0.001	0%	39%
Magnesium	4/10/16	1/08/23	18	10000 mg/L			5	3	0%	100%
Manganese	4/10/16	1/08/23	18	0.5 mg/L			0.018	0.005	0%	56%
Mercury	4/10/16	1/08/23	18	0.001 mg/L			0.0001	0.0001	0%	11%
Molybdenum	4/10/16	1/08/23	18	0.05 mg/L			0.0004	0.0001 78	0%	50%
Nickel	4/10/16	1/08/23	18	0.02 mg/L			0.0015	0.0009	0%	22%
Nitrate	4/10/16	1/08/23	18	50 mg/L			9.00	9.00	0%	6%
Nitrite	4/10/16	1/08/23	18	3 mg/L			<LOR		0%	0%
pH	5/07/16	3/10/23	383	6.5 / 8.5	32	6.55	9.23	8.03	8%	100%
Selenium	4/10/16	1/08/23	18	0.01 mg/L			<LOR		0%	0%
Silver	4/10/16	1/08/23	18	0.1 mg/L			<LOR		0%	0%
Sodium	4/10/16	1/08/23	18	180 mg/L			27	16	0%	100%
Sulfate	4/10/16	1/08/23	18	250 mg/L			28	16	0%	94%
Total Chlorine	5/07/16	3/10/23	368	5 mg/L			2.12	1.22	0%	100%

Characteristic	First sample	Last Sample	Samples	Guideline	Number non/compliant	Minimum Concentration (if ADWG has min)	Maximum Concentration	Average Concentration	% of samples non/compliant	% of samples above limit of reading
Total Coliforms	5/07/16	3/10/23	367	0 mpn/100 mL	2		16	16	1%	0%
Total Dissolved Solids (TDS)	4/10/16	1/08/23	18	10000 mg/L			116	71	0%	100%
Total Hardness as CaCO ₃	4/10/16	1/08/23	18	200 mg/L			56	32	0%	100%
True Colour	4/10/16	1/08/23	18	15 Hazen Units (HU)			8.00	1.64	0%	61%
Turbidity	4/10/16	3/10/23	357	5 NTU			2.00	0.04	0%	99%
Uranium	1/08/17	1/08/23	15	0.017 mg/L			0.0001	0.0001	0%	7%
Zinc	4/10/16	1/08/23	18	3 mg/L			0.240	0.034	0%	89%

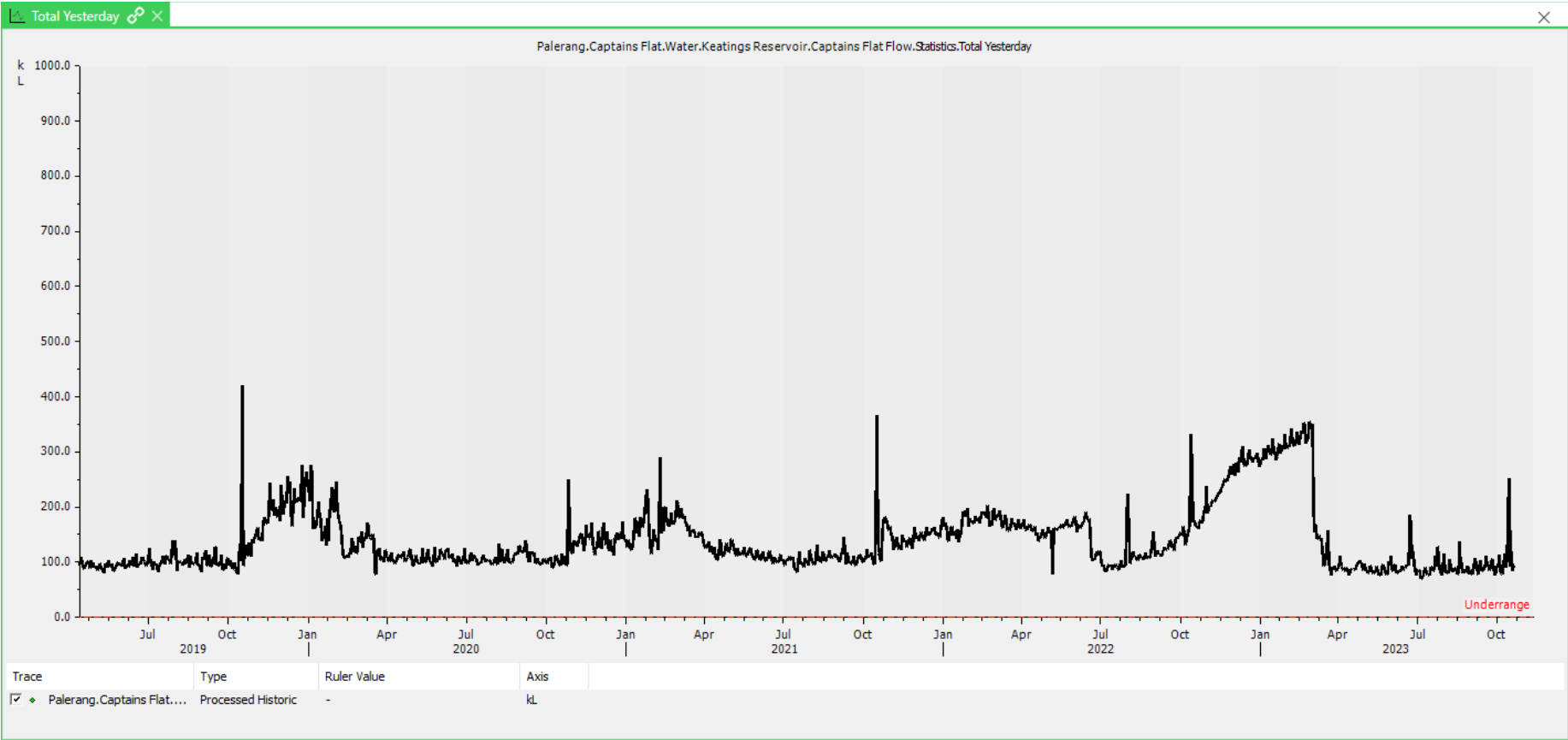
Appendix table A-7: Captains Flats NSW Health Water Quality

Characteristic	First sample	Last Sample	Samples	Guideline	Number non/compliant	Minimum Concentration (if ADWG has min)	Maximum Concentration	Average Concentration	% of samples non/compliant	% of samples above limit of reading
Aluminium	4/10/16	20/02/23	16	0.2 mg/L			0.080	0.029	0%	94%
Antimony	4/10/16	20/02/23	16	0.003 mg/L			0	0.00025	0%	25%
Arsenic	4/10/16	20/02/23	16	0.01 mg/L			0.004	0.001	0%	56%
Barium	4/10/16	20/02/23	16	2 mg/L			0.018	0.010	0%	100%
Boron	4/10/16	20/02/23	16	4 mg/L			0.006	0.004	0%	38%
Cadmium	4/10/16	20/02/23	16	0.002 mg/L			0.0001	0.0001	0%	6%
Calcium	4/10/16	20/02/23	16	10000 mg/L			7	5	0%	94%
Chloride	4/10/16	20/02/23	16	250 mg/L			20	13	0%	100%
Chromium	4/10/16	20/02/23	16	0.05 mg/L			<LOR		0%	0%
Copper	4/10/16	20/02/23	16	2 mg/L			0.051	0.012	0%	81%
E. coli	12/07/16	3/10/23	304	0 mpn/100 mL			<LOR		0%	0%
Fluoride	5/07/16	5/09/23	97	1.5 mg/L			1.11	0.99	0%	100%
Fluoride (weekly WU)	6/07/16	6/09/23	749	0.9 / 1.5 mg/L	10	0.78	1.07	0.99	1%	100%
Fluoride (WU result)	5/07/16	5/09/23	87	1.5 mg/L			1.05	0.99	0%	100%

Characteristic	First sample	Last Sample	Samples	Guideline	Number non/compliant	Minimum Concentration (if ADWG has min)	Maximum Concentration	Average Concentration	% of samples non/compliant	% of samples above limit of reading
Fluoride Ratio	5/07/16	5/09/23	87	0.8 / 1.2		0.91	1.16	1.01	0%	100%
Free Chlorine	12/07/16	3/10/23	304	0.2 / 5 mg/L		0.22	4.59	1.16	0%	100%
Iodine	4/10/16	20/02/23	16	0.5 mg/L			<LOR		0%	0%
Iron	4/10/16	20/02/23	16	0.3 mg/L			0.030	0.014	0%	44%
Lead	4/10/16	20/02/23	16	0.01 mg/L	1		0.025	0.005	6%	38%
Magnesium	4/10/16	20/02/23	16	10000 mg/L			6	4	0%	100%
Manganese	4/10/16	20/02/23	16	0.5 mg/L			0.016	0.007	0%	75%
Mercury	4/10/16	20/02/23	16	0.001 mg/L			0.0001	0.0001	0%	13%
Molybdenum	4/10/16	20/02/23	16	0.05 mg/L			0.0002	0.0001 33	0%	19%
Nickel	4/10/16	20/02/23	16	0.02 mg/L			0.01	0.0019	0%	50%
Nitrate	4/10/16	20/02/23	16	50 mg/L			14.00	5.76	0%	88%
Nitrite	4/10/16	20/02/23	16	3 mg/L			<LOR		0%	0%
pH	12/07/16	3/10/23	318	6.5 / 8.5	29	7.02	9.04	8.05	9%	100%
Selenium	4/10/16	20/02/23	16	0.01 mg/L			<LOR		0%	0%
Silver	4/10/16	20/02/23	16	0.1 mg/L			<LOR		0%	0%

Characteristic	First sample	Last Sample	Samples	Guideline	Number non/compliant	Minimum Concentration (if ADWG has min)	Maximum Concentration	Average Concentration	% of samples non/compliant	% of samples above limit of reading
Sodium	4/10/16	20/02/23	16	180 mg/L			20	15	0%	100%
Sulfate	4/10/16	20/02/23	16	250 mg/L			23	11	0%	100%
Total Chlorine	12/07/16	3/10/23	303	5 mg/L	2		5.33	1.33	1%	100%
Total Coliforms	12/07/16	3/10/23	304	0 mpn/100 mL	1		2	2	0%	0%
Total Dissolved Solids (TDS)	4/10/16	20/02/23	16	10000 mg/L			80	63	0%	100%
Total Hardness as CaCO ₃	4/10/16	20/02/23	16	200 mg/L			38	28	0%	100%
True Colour	4/10/16	20/02/23	16	15 Hazen Units (HU)			3.00	1.56	0%	100%
Turbidity	4/10/16	3/10/23	305	5 NTU	3		49.00	0.34	1%	98%
Uranium	1/08/17	20/02/23	13	0.017 mg/L			0.0001	0.0001	0%	8%
Zinc	4/10/16	20/02/23	16	3 mg/L			0.130	0.033	0%	88%

Appendix B Captains Flat Keating Reservoir Flow



Appendix figure B-1: Captains Flat Keating Reservoir Flow

Appendix C Water quality risk assessment

C.1 HBT Assessment Tool Water quality risk assessment – Bungendore WSS

HBT Assessment Tool		Reset Form	
Question	Answer		
Catchment Assessment			
1.1 Name of water supply	Bungendore Drinking water supply system		Catchment characteristics
1.2 Name of water source	Bungendore-Bore 1, Bore 2, Bore 3 and Bore 6		15 Average slope
1.3 Is this a primary or secondary source	Primary Source		16 Average annual rainfall (mm)
1.4 Is the water source groundwater or surface water	Groundwater		17 Area NSW
			18 Soil drainage
			19 Land use grazing (%)
Groundwater Assessment			
3.1 Are there disused uncapped bores allowing ingress of surface water into aquifer?	No		
3.2 Can surface water ingress into aquifer through bore casing?	No		
3.3 Type of aquifer water is being extracted (where the screens are located)?	Alluvial		
3.4 Is there an aquitard (impervious) layer between surface and water-bearing aquifer (where screens are located)?	No		
3.5 Is Aquifer level directly influenced by surface water?	No		
3.6 What is the depth of the water-bearing aquifer (m)?	37		
3.7 Any change in turbidity? e.g. linked to rain events	No		
Vulnerability Assessment Required?			
No			
Vulnerability Assessment			
Question	Answer - Inner Catchment	Answer - Outer Catchment	Inherent Risk Rating - Inner Catchment
Definition: 1km radius from bore in direction of 5km radius from bore in direction of			
Urban Areas			
No of properties with OSSMS in catchment	0	0	Low
Threats			
Are there STPs in catchment	Yes	Yes	Very High
Are there possibilities of sewer overflows in catchment	Yes	Yes	High
Are there biosolids reuse in catchment	No	No	Low
Are there industrial WWTs in catchment	No	No	Low
Are there landfill type facilities in catchment	No	No	Low
Are there urban stormwater discharges in catchment	No	No	Low
Is there aquifer recharge with stormwater or effluent	No	No	Low
Effluent Reuse			
Any effluent reuse in catchment	No	No	
Stock animals			
Are dairies, feedlots or other intensive farming operations in catchment	Yes	No	Very High
Are there free-roaming livestock within catchment	Yes	No	Low
Is number of calves and lambs in catchment known?	Yes		
Number of calves / Ha grazing land			
Number of lambs / Ha grazing land			
% of perennial waterways fenced off	>90%	>90%	
% of perennial waterways with riparian vegetation	>90%	>90%	
Weighted risk from livestock			Low
Highest catchment rating	Very High		
Inherent Risk	Moderate		
Note: There is not an aquitard (impervious) layer between surface and water-bearing aquifer, however aquifer level is not directly influenced by surface water - moderate risk			

Appendix figure C-1: HBT Assessment Tool Water quality risk assessment – Bungendore Bores, Bungendore WSS

HBT Assessment Tool Reset Form

Question	Answer	Question	Answer	
Catchment Assessment		Catchment characteristics		
1.1 Name of water supply	Bungendore Drinking water supply system	15 Average slope	2%	
1.2 Name of water source	Bungendore-WTP Currandooly Bore	16 Average annual rainfall (mm)	640	
1.3 Is this a primary or secondary source	Primary Source	17 Area NSW	South East NSW	
1.4 Is the water source groundwater or surface water	Groundwater	18 Soil drainage	Poorly drained	
		19 Land use grazing (%)	80%	
Groundwater Assessment				
3.1 Are there disused uncapped bores allowing ingress of surface water into aquifer?	No			
3.2 Can surface water ingress into aquifer through bore casing?	No			
3.3 Type of aquifer water is being extracted (where the screens are located)?	Alluvial			
3.4 Is there an aquitard (impervious) layer between surface and water-bearing aquifer (where screens are located)?	No			
3.5 Is Aquifer level directly influenced by surface water?	No			
3.6 What is the depth of the water-bearing aquifer (m)?	30			
3.7 Any change in turbidity? e.g. linked to rain events	No			
Vulnerability Assessment Required?				
	No			
Vulnerability Assessment				
Question	Answer - Inner Catchment Definition: 1km radius from bore in direction of	Answer - Outer Catchment 5km radius from bore in direction of	Inherent Risk Rating - Inner Catchment	Inherent Risk Rating - Outer Catchment
Urban Areas				
No of properties with OSSMS in catchment	0	0	Low	Low
Threats				
Are there STPs in catchment	Yes	Yes	Very High	High
Are there possibilities of sewer overflows in catchment	No	No	Low	Low
Are there biosolids reuse in catchment	No	No	Low	Low
Are there industrial WWTs in catchment	No	No	Low	Low
Are there landfill type facilities in catchment	No	No	Low	Low
Are there urban stormwater discharges in catchment	No	No	Low	Low
Is there aquifer recharge with stormwater or effluent	No	No	Low	Low
Effluent Reuse				
Any effluent reuse in catchment	No	No		
Stock animals				
Are dairies, feedlots or other intensive farming operations in catchment	Yes	Yes	Very High	High
Are there free-roaming livestock within catchment	Yes	Yes		
Is number of calves and lambs in catchment known?				
% of perennial waterways fenced off	>90%	>90%		
% of perennial waterways with riparian vegetation	>90%	>90%		
Weighted risk from livestock			Low	Low
Highest catchment rating				
	Very High			
Inherent Risk				
	Moderate			
Note: There is not an aquitard (impervious) layer between surface and water-bearing aquifer, however aquifer level is not directly influenced by surface water - moderate risk				

Appendix figure C-2: HBT Assessment Tool Water quality risk assessment – Currandooly Bores, Bungendore WSS

C.2 HBT Assessment Tool Water quality risk assessment – Braidwood WSS

Catchment Assessment		Catchment characteristics	
1.1 Name of water supply	Braidwood Drinking Water Supply System	1.5 Average slope	2%
1.2 Name of water source	Shoalhaven River	1.6 Average annual rainfall (mm)	658
1.3 Is this a primary or secondary source	Primary Source	1.7 Area NSW	South East NSW
1.4 Is the water source groundwater or surface water	Surface Water	1.8 Soil drainage	Moderately well drained
		1.9 Land use grazing (%)	80%
Surface Water Assessment 2.1 Is extraction from a storage or dam? <input type="text" value="No"/> Assessment is for the river not the storage.			
Vulnerability Assessment Required? <input type="text" value="Yes"/>			
Vulnerability Assessment			
Question	Answer - Inner Catchment	Answer - Outer Catchment	Inherent Risk Rating - Inner Catchment / Inherent Risk Rating - Outer Catchment
Definition: 1km radius upstream from surface intake (only land that slopes towards water body) / 5km radius upstream from surface intake (only land that slopes towards water body)			
Urban Areas			
No of properties with OSSMS in catchment	2	5	Low / Low
Threats			
Are there STPs in catchment	No	No	Low / Low
Are there possibilities of sewer overflows in catchment	No	No	Low / Low
Are there biosolids reuse in catchment	No	No	Low / Low
Are there industrial WWTs in catchment	No	No	Low / Low
Are there landfill type facilities in catchment	No	No	Low / Low
Are there urban stormwater discharges in catchment	No	No	Low / Low
Effluent Reuse			
Any effluent reuse in catchment	No	No	
Stock animals			
Are dairies, feedlots or other intensive farming operations in catchment	No	No	Low / Low
Are there free-roaming livestock within catchment	Yes	Yes	
Is number of calves and lambs in catchment known?	No	No	
% of perennial waterways fenced off	>90%	>90%	
% of perennial waterways with riparian vegetation	%65 to 90%	%65 to 90%	
Weighted risk from livestock			Medium / Medium
Highest catchment rating		Medium	
Inherent Risk		Medium	
Note: Extraction is from a surface water intake - requires catchment vulnerability assessment			

Appendix figure C-3: HBT Assessment Tool Water quality risk assessment – Braidwood WSS

C.3 HBT Assessment Tool Water quality risk assessment – Captains Flat WSS

Catchment Assessment		Catchment characteristics	
1.1 Name of water supply	Captains Flat water supply scheme	1.5 Average slope	7%
1.2 Name of water source	Molonglo River	1.6 Average annual rainfall (mm)	747
1.3 Is this a primary or secondary source	Primary Source	1.7 Area NSW	South East NSW
1.4 Is the water source groundwater or surface water	Surface water	1.8 Soil drainage	Imperfectly drained
		1.9 Land use grazing (%)	90%

Surface Water Assessment	
2.1 Is extraction from a storage or dam?	Yes
2.2 Is water pumped to storage from a different water source?	No
2.3 What is the storage volume at full supply level (FSL)? (in ML)	820
2.4 Does the storage have a variable off-take?	No
2.5 Is the storage used for primary contact recreation? I.e. where full body is submergible?	No
2.6 Is the storage used for secondary contact recreation? I.e. where chance of swallowing water is possible?	No
2.7 Is water extracted daily from the storage?	Yes
2.8 Can the storage filling be controlled based on water quality?	No
2.9 What is the maximum monthly demand? (in ML/month)	7.5
2.10 What is the average annual demand? (in ML/year)	4.14
2.11 Is there local runoff to storage?	Yes
2.12 Is the storage adequately secured? (Or can it be easily secured?)	Fenced

Vulnerability Assessment Required? Yes

Question	Answer - Inner Catchment Definition: 1km radius from edge of storage at full storage volume (FSL) (only land that slopes towards water body)	Answer - Outer Catchment Definition: 5km radius from edge of storage at full storage volume (FSL) (only land that slopes towards water body)	Inherent Risk Rating - Inner Catchment	Inherent Risk Rating - Outer Catchment
Urban Areas				
No of properties with OSSMS in catchment	0	0	Low	Low
Threats				
Are there STPs in catchment	No	No	Low	Low
Are there possibilities of sewer overflows in catchment	No	No	Low	Low
Are there biosolids reuse in catchment			Not assessed	Not assessed
Are there industrial WWTs in catchment	No	No	Low	Low
Are there landfill type facilities in catchment	No	No	Low	Low
Are there urban stormwater discharges in catchment	No	No	Low	Low
Effluent Reuse				
Any effluent reuse in catchment	No	No		
Stock animals				
Are dairies, feedlots or other intensive farming operations in catchment	No	No	Low	Low
Are there free-roaming livestock within catchment	Yes	Yes		
Is number of calves and lambs in catchment known?	No	No		
% of perennial waterways fenced off	>90%	>90%		
% of perennial waterways with riparian vegetation	>90%	>90%		
Weighted risk from livestock			Medium	Medium
Highest catchment rating	Medium			
Inherent Risk	Low			

Note: Water is extracted daily from the storage, but the storage is large enough that settlement reduces pathogens. However there is local runoff to storage - requires catchment vulnerability assessment, however risk is

Appendix figure C-4: HBT Assessment Tool Water quality risk assessment – Captains Flat WSS

C.4 NSW Health Letter



22 November 2019

Mr Peter Tegart
General Manager
Queanbeyan-Palerang Regional Council
PO Box 90
QUEANBEYAN NSW 2620

RECEIVED IN Records Queanbeyan-Palerang Regional Council	
- 3 DEC 2019	
Document No.	12-1-4-02
Document Scanned?	☐ Yes

Dear Mr Tegart

I am writing to share the preliminary outcomes of NSW Health's recent *Cryptosporidium* risk assessment of drinking water supplies operated by Queanbeyan-Palerang Regional Council.

Cryptosporidium

Cryptosporidium is a microorganism found in water that can cause serious gastrointestinal disease. Livestock and sewage can be sources of *Cryptosporidium* that can infect humans. *Cryptosporidium* is of particular concern for water supplies because it is not controlled by normal doses of chlorine. A high standard of filtration or an alternative disinfection, such as ultraviolet light, is needed to control *Cryptosporidium*.

Preliminary risk assessment for *Cryptosporidium*

The risk assessment used a model that considered potential *Cryptosporidium* sources in the catchment(s) and any existing controls, such as catchment management and water treatment. The Public Health Unit can provide the detailed report on the model. The assessment was based on information provided by Queanbeyan-Palerang Regional Council, with a preliminary *Cryptosporidium* risk rating determined as high, medium or low, as shown in the following table and attachment 1. The table also identifies potential improvements to better control *Cryptosporidium*. NSW Health will advise Department of Planning, Industry and Environment - Water of the risk ratings of drinking water supplies, to be prioritised for investigation through the Safe and Secure Water Program, where upgrades are not already approved.

Supply system	Preliminary <i>Cryptosporidium</i> risk rating	Potential action and/or improvement
Captains Flat	Medium	Maintaining the operation and monitoring (ideally continuously) of membranes to identify any breakdown of integrity and assessing the need for further treatment that can control <i>Cryptosporidium</i> .
Bungendore	Low	Confirming the aquifer is protected from surface water and confirming the integrity of the bore (including head and bore casing).
Braidwood	Low	Maintaining the operation and monitoring (ideally continuously) of processes to consistently reduce turbidity of individual filters to <0.2 NTU and identify any reduction in process quality.

Public Health Unit
Murrumbidgee and Southern NSW Local Health District
PO Box 3095 Albury NSW 2640
Tel 02 6080 8900 Fax 02 6080 8999
Website www.mihd.health.nsw.gov.au

Appendix figure C-5: NSW Health Letter

Appendix D Water supply analysis

D.1 Water Balance Method

The historical water production data and customer usage data were used to calculate a water balance over the system. The water losses represent the difference between the volume of water delivered into a network and the metered customer usage. The water balance used is the standard developed by the International Water Association (IWA) Water Loss Task Force.

The system losses can be estimated through finding the differences of water produced and water consumed. Assumptions were made to further categorise water losses into apparent losses (such as unauthorised consumption – theft/illegal use and customer meter under-registration) and real losses (such as leakages).

Unbilled authorised consumption was estimated as 0.5% of water supplied. Apparent losses are estimated as customer meter under-registration (2% of metered consumption) plus theft (0.1% of water supplied). These assumptions are from the Australian Government National Performance Framework [20]. Unavoidable real losses are calculated using the average pressure, length of main and number connections using equations from the IWA paper titled 'A Review of Performance Indicators for Real Losses from Water Supply Systems' [21]. As these losses are calculated using assumptions, actual volumes may differ, however they are a useful indicator of where losses are occurring.

Appendix E Water demand analysis – background

The water demand analysis is described below.

Outcomes of water demand analysis

A water demand analysis is undertaken to calculate the unit demands, estimate the non-revenue water and forecast the following demands:

- Average (rainfall) year demands – for revenue planning
- Unrestricted future year demands – to assess drought security
- Peak day demands – to assess system reliability.

The 30-year forecasts based on the nominated growth, are used to identify the issues in meeting the adopted water supply security, and reliability objectives of the urban water supply system.

The analysis uses the water production data (that is the water delivered into the system), and the customer billing data (metered consumption by users in the system).

The billing data was provided by assessment with every assessment taken as a connected property. Therefore, analysis has been undertaken on an assessment basis.

Peak usage analysis

Weather patterns in summer that result in prolonged periods of high demand can stress systems more than a large but isolated peak day demand. Historical daily production data is analysed to understand water usage patterns during these periods of peak usage.

The first aim of the analysis is to obtain a ratio of the peak day to the average day in the peak week, which is used to estimate peak day demands from the production model hindcast. The second aim is to obtain a demand “persistence pattern” during the peak period, which can be used to estimate whether the existing reservoirs and WTP capacity can supply demand during the peak period. The persistence pattern can also be used in simulating a peak demand period in a hydraulic model simulation.

Water production and customer usage modelling

Modelling of water production data (that is the water delivered into the system), and the customer billing data (metered consumption by users in the system) is undertaken to understand the impact of various factors/trends (demographic, climatic, economic etc.) on the variability of town water demand.

The aim is to develop a model which, when input with historical factors/trends, will output a production that co-relates well with the actual historic production or customer usage.

The model is then hind-cast over a period of available climatic data of temperature and rainfall to estimate the annual demands if the current conditions of lot size, household size, number of connections, pricing and usage patterns were to prevail. The average year and dry year demand over the 120-year period are then determined and these demands are used as the starting point for the forecasts.

Appendix F Climate change impact comparison

Since the previous IWCM climate change analysis was completed, there have been two major revisions to the NSW Public Works climate change modelling method.

F.1 Method used in previous IWCM

The previous IWCM methodology used seasonal changes to rainfall and evapotranspiration sourced from the CSIRO “Climate Change in Australia Report” and the maximum daily temperature increased by 1.25°C. The climate dependent use has been re-calculated using the current climate dependent consumption models, the current SILO Data and the weather data modified in the same way as was used in the previous IWCM.

Appendix table F-1: Bungendore change in climate dependent demand using method from previous IWCM

		Airconditioning - 25°C trigger (kL/dwelling)			Irrigation (ML/ha)		
		Annual Total (ML/day)	Average day peak week (kL/day)	Average day peak fortnight (kL/day)	Annual Total (ML/day)	Average day peak week (kL/day)	Average day peak fortnight (kL/day)
2023 SILO	Average	31	672	534	4.27	0.054	0.047
	99th %ile	58	1076	908	7.62	0.074	0.063
	Maximum	63	1086	926	7.44	0.063	0.056
2023 SILO adjusted using 2018 method	Average	42	769	634	4.80	0.058	0.050
	99th %ile	73	1145	990	8.33	0.077	0.067
	Maximum	76	1120	1011	8.11	0.079	0.063
% increase due to climate change	Average	38.06%	14.44%	18.70%	12.52%	6.99%	6.00%
	99th %ile	25.04%	6.39%	9.07%	9.30%	3.54%	5.19%
	Maximum	21.07%	3.16%	9.26%	8.96%	25.00%	14.29%

Appendix table F-2: Bungendore demand change using method from previous IWCM

		Annual Total (ML/day)	Average day peak week (kL/day)	Average day peak fortnight (kL/day)
2023 SILO	Average	346	1532	1427
	99th %ile	388	1817	1671
	Maximum	387	1723	1601

		Annual Total (ML/day)	Average day peak week (kL/day)	Average day peak fortnight (kL/day)
2023 SILO adjusted using 2018 method	Average	354	1594	1477
	99th %ile	399	1861	1720
	Maximum	397	1906	1699
% increase due to climate change	Average	2.41%	4.07%	3.49%
	99th %ile	2.83%	2.42%	2.96%
	Maximum	2.66%	10.62%	6.13%

Appendix table F-3: Braidwood change in climate dependent demand using method from previous IWCM

		Airconditioning - 25°C trigger (kL/dwelling)			Irrigation (ML/ha)		
		Annual Total (ML/day)	Average day peak week (kL/day)	Average day peak fortnight (kL/day)	Annual Total (ML/day)	Average day peak week (kL/day)	Average day peak fortnight (kL/day)
2023 SILO	Average	90	1.07	0.94	3.63	0.049	0.043
	99th %ile	130	1.44	1.28	6.83	0.069	0.062
	Maximum	130	1.53	1.35	6.44	0.063	0.056
2023 SILO adjusted using 2018 method	Average	112	1.16	1.04	4.13	0.053	0.046
	99th %ile	153	1.51	1.36	7.46	0.073	0.064
	Maximum	151	1.58	1.42	7.00	0.063	0.056
% increase due to climate change	Average	24.42%	8.15%	10.37%	13.55%	8.41%	7.41%
	99th %ile	17.56%	4.82%	5.88%	9.24%	7.01%	3.18%
	Maximum	16.07%	2.99%	5.08%	8.62%	0.00%	0.00%

Appendix table F-4: Braidwood demand change using method from previous IWCM

		Annual Total (ML/day)		Average day peak week (kL/day)		Average day peak fortnight (kL/day)	
NRW scenario		Low	High	Low	High	Low	High
2023 SILO	Average	155	239	670	901	631	862
	99th %ile	174	258	787	1018	746	977
	Maximum	172	256	769	1000	715	946
2023 SILO adjusted using 2018 method	Average	159	243	696	927	652	883
	99th %ile	178	263	816	1047	759	990
	Maximum	175	260	770	1001	718	949
% increase due to climate change	Average	2.27%	1.47%	3.85%	2.86%	3.29%	2.41%
	99th %ile	2.49%	1.68%	3.69%	2.85%	1.72%	1.31%
	Maximum	2.20%	1.48%	0.21%	0.16%	0.36%	0.27%

F.2 SEACI

Shortly after previous IWCM analysis was completed, DCCEEW started providing the data sourced from the from South Eastern Australian Climate Initiative (SEACI). This data included rainfall and evapotranspiration datasets for 1 historical dataset and 17 Global Climate Models (GCMs) and was based on a 1°C warming scenario from a 1990 baseline. The Daily maximum temperatures assumed to be 1°C higher. Data from this data set was used to calculate the secure yield of the surface water source at Braidwood and Captains Flat.

SEACI data was obtained for Braidwood.

Appendix table F-5: Braidwood change in climate dependent demand using SEACI data

		Airconditioning - 25°C trigger (kL/dwelling)			Irrigation (ML/ha)		
		Annual Total (ML/day)	Average day peak week (kL/day)	Average day peak fortnight (kL/day)	Annual Total (ML/day)	Average day peak week (kL/day)	Average day peak fortnight (kL/day)
SEACI Historical	Average	92	1.07	0.95	3.72	0.047	0.042
	99th %ile	129	1.39	1.25	6.54	0.055	0.056
	Maximum	128	1.38	1.32	6.00	0.063	0.048

		Airconditioning - 25°C trigger (kL/dwelling)			Irrigation (ML/ha)		
		Annual Total (ML/day)	Average day peak week (kL/day)	Average day peak fortnight (kL/day)	Annual Total (ML/day)	Average day peak week (kL/day)	Average day peak fortnight (kL/day)
SEACI 1°C warming	Average	109	1.14	1.03	4.50	0.048	0.044
	99th %ile	148	1.44	1.31	7.18	0.058	0.056
	Maximum	147	1.46	1.29	6.56	0.063	0.056
% increase due to climate change	Average	18.74%	6.56%	8.07%	20.90%	1.72%	5.60%
	99th %ile	14.92%	3.79%	4.79%	9.77%	6.72%	-0.64%
	Maximum	14.78%	5.79%	-2.16%	9.26%	0.00%	16.67%

Appendix table F-6: Braidwood demand change using SEACI data

		Annual Total (ML/day)		Average day peak week (kL/day)		Average day peak fortnight (kL/day)	
NRW scenario		Low	High	Low	High	Low	High
SEACI Historical	Average	156	240	659	890	624	855
	99th %ile	172	257	711	942	711	942
	Maximum	169	253	761	992	666	897
SEACI 1°C warming	Average	160	245	666	897	640	871
	99th %ile	176	261	730	961	713	944
	Maximum	172	257	763	994	711	942
% increase due to climate change	Average	3.18%	2.06%	1.14%	0.84%	2.60%	1.90%
	99th %ile	2.46%	1.65%	2.69%	2.03%	0.19%	0.14%
	Maximum	2.23%	1.49%	0.16%	0.12%	6.87%	5.10%

F.3 NARClIM 1.5

More recently, DCCEE has started to recommend the use of data from the New South Wales (NSW) and Australian Capital Territory (ACT) regional climate modelling (NARClIM) version 1.5.

The NARClIM 1.5 dataset contains information for two future greenhouse gas concentration trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC). The trajectories

are known as representative concentration pathways (RCPs). The RCPs for which data is available are:

- RCP 4.5, this is the most probable baseline scenario (no climate policies) considering the exhaustible character of non-renewable fuels. RCP8.5, generally taken as the basis for worst-case climate change scenarios, was based on what proved to be overestimation of projected coal outputs. Under this scenario, the greenhouse gas concentration stabilises in 2080.
- RCP8.5, generally taken as the basis for worst-case climate change scenarios, was based on what proved to be overestimation of projected coal outputs.

The data is available for:

- Three global climate models, these models have a resolution of 100's of square kilometres
 - CanESM2 produced by the Canadian Centre for Climate Modelling and Analysis (CCCMA)
 - ACCESS1.0 produced by a CSIRO and Bureau of Meteorology collaboration
 - ACCESS1.3 produced by a CSIRO and Bureau of Meteorology collaboration.
- The ERA-Interim reanalysis data set, this is a global atmospheric reanalysis produced by the European Centre for Medium-Range Weather Forecasts (ECMWF). This dataset uses historical observations to create global data sets describing the recent history of the atmosphere, land surface, and oceans.

Each of these data sets is then downscaled using two separate regional climate models.

The demand changes for Bungendore and Braidwood were estimated using the three GCMs, two RCMs, and two future time periods (before and after 2060). The results are summarised in the following tables. When there was a decrease in demand instead of an increase, the cells are shaded grey.

Appendix table F-7: Bungendore – CCCma-CanESM2 – RCP 4.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	335	1.53	1.40	343	1.53	1.42
		99th %ile	371	1.78	1.62	382	1.75	1.61
		Maximum	375	1.67	1.56	379	1.68	1.56
2006/07 to 2058/59 RCP 4.5	Modelled production	Average	335	1.54	1.41	343	1.56	1.44
		99th %ile	367	1.78	1.65	378	1.80	1.67
		Maximum	366	1.71	1.59	381	1.71	1.64
	% increase compared to 1951/52 to 2004/05	Average	-0.19%	0.92%	0.65%	0.21%	1.91%	1.44%
		99th %ile	-1.10%	0.02%	2.01%	-1.06%	2.88%	4.00%
		Maximum	-2.44%	1.99%	1.74%	0.58%	1.71%	5.52%
2059/60 to 2099/100 RCP 4.5	Modelled production	Average	351	1.56	1.44	359	1.59	1.48
		99th %ile	392	1.83	1.68	395	1.78	1.65
		Maximum	387	1.70	1.58	386	1.72	1.59
	% increase compared to 1951/52 to 2004/05	Average	4.77%	1.38%	2.14%	4.64%	2.06%	2.95%
		99th %ile	6.81%	2.83%	1.43%	4.43%	-0.94%	-1.28%
		Maximum	5.76%	-0.13%	-0.94%	1.32%	0.39%	-3.41%

Appendix table F-8: Bungendore – CCCma-CanESM2 – RCP 8.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	335	1.53	1.40	343	1.53	1.42
		99th %ile	371	1.78	1.62	382	1.75	1.61
		Maximum	375	1.67	1.56	342	1.55	1.42
2006/07 to 2058/59 RCP 8.5	Modelled production	Average	336	1.51	1.39	342	1.55	1.42
		99th %ile	369	1.75	1.62	380	1.81	1.70
		Maximum	362	1.68	1.63	373	1.71	1.65
	% increase compared to 1951/52 to 2004/05	Average	0.28%	-1.18%	-0.60%	-0.10%	0.90%	-0.16%
		99th %ile	-0.69%	-1.67%	0.30%	-0.69%	3.28%	6.20%
		Maximum	-3.37%	0.40%	4.08%	-1.45%	1.71%	5.94%
2059/60 to 2099/100 RCP 8.5	Modelled production	Average	353	1.57	1.44	359	1.59	1.48
		99th %ile	392	1.75	1.64	395	1.80	1.65
		Maximum	387	1.69	1.58	386	1.72	1.59
	% increase compared to 1951/52 to 2004/05	Average	5.03%	4.04%	3.28%	4.94%	2.91%	4.58%
		99th %ile	6.40%	0.31%	1.17%	4.11%	-0.52%	-3.25%
		Maximum	6.78%	0.40%	-3.17%	3.41%	0.39%	-3.80%

Appendix table F-9: Bungendore – CSIRO-BOM-ACCESS1-0 – RCP 4.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	330	1.52	1.40	327	1.47	1.36
		99th %ile	367	1.87	1.72	366	1.79	1.69
		Maximum	371	1.70	1.59	364	1.66	1.56
2006/07 to 2058/59 RCP 4.5	Modelled production	Average	332	1.54	1.40	335	1.54	1.40
		99th %ile	375	1.82	1.68	377	1.83	1.69
		Maximum	381	1.69	1.61	378	1.70	1.58
	% increase compared to 1951/52 to 2004/05	Average	0.59%	1.27%	-0.36%	2.48%	4.31%	3.02%
		99th %ile	2.20%	-3.17%	-1.96%	2.91%	2.14%	0.43%
		Maximum	2.66%	-0.26%	1.51%	3.80%	2.54%	0.92%
2059/60 to 2099/100 RCP 4.5	Modelled production	Average	335	1.54	1.39	337	1.53	1.42
		99th %ile	375	1.78	1.66	373	1.79	1.70
		Maximum	381	1.72	1.70	370	1.72	1.67
	% increase compared to 1951/52 to 2004/05	Average	0.76%	-0.39%	-0.28%	0.50%	-0.67%	1.82%
		99th %ile	0.05%	-2.10%	-1.25%	-0.92%	-1.85%	0.50%
		Maximum	-0.11%	1.57%	5.36%	-2.11%	1.04%	5.80%

Appendix table F-10: Bungendore – CSIRO-BOM-ACCESS1-0 – RCP 8.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	330	1.52	1.40	366	1.79	1.69
		99th %ile	367	1.87	1.72	364	1.66	1.56
		Maximum	371	1.70	1.59	339	1.53	1.40
2006/07 to 2058/59 RCP 8.5	Modelled production	Average	333	1.54	1.39	339	1.53	1.40
		99th %ile	376	1.85	1.69	385	1.88	1.70
		Maximum	377	1.92	1.72	374	1.70	1.56
	% increase compared to 1951/52 to 2004/05	Average	0.83%	0.98%	-0.92%	3.59%	4.01%	3.03%
		99th %ile	2.52%	-1.56%	-1.37%	5.09%	5.17%	0.50%
		Maximum	1.50%	13.14%	8.35%	2.75%	2.41%	-0.21%
2059/60 to 2099/100 RCP 8.5	Modelled production	Average	345	1.59	1.45	348	1.59	1.47
		99th %ile	385	1.82	1.69	390	1.82	1.67
		Maximum	392	1.72	1.68	392	1.73	1.63
	% increase compared to 1951/52 to 2004/05	Average	3.61%	3.12%	4.45%	2.66%	3.83%	5.03%
		99th %ile	2.40%	-1.21%	0.01%	1.49%	-3.14%	-1.70%
		Maximum	4.08%	-10.23%	-2.06%	4.74%	1.96%	4.84%

Appendix table F-11: Bungendore – CSIRO-BOM-ACCESS1-3 – RCP 4.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	338	1.57	1.44	346	1.56	1.44
		99th %ile	377	1.80	1.69	392	1.82	1.71
		Maximum	377	1.70	1.68	390	1.70	1.66
2006/07 to 2058/59 RCP 4.5	Modelled production	Average	345	1.58	1.45	351	1.60	1.47
		99th %ile	383	1.82	1.72	392	1.86	1.70
		Maximum	384	1.71	1.66	389	1.73	1.63
	% increase compared to 1951/52 to 2004/05	Average	1.92%	0.22%	0.47%	1.39%	2.26%	2.24%
		99th %ile	1.59%	1.11%	1.80%	0.08%	2.20%	-0.22%
		Maximum	1.79%	0.26%	-0.99%	-0.33%	1.96%	-1.47%
2059/60 to 2099/100 RCP 4.5	Modelled production	Average	354	1.60	1.47	356	1.61	1.48
		99th %ile	409	1.89	1.78	405	1.85	1.72
		Maximum	404	1.75	1.64	408	1.75	1.67
	% increase compared to 1951/52 to 2004/05	Average	2.75%	1.58%	1.43%	1.51%	0.54%	0.97%
		99th %ile	6.76%	3.86%	3.73%	3.07%	-0.65%	0.84%
		Maximum	5.39%	2.21%	-1.20%	4.93%	1.28%	2.44%

Appendix table F-12: Bungendore – CSIRO-BOM-ACCESS1-3 – RCP 8.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	338	1.57	1.44	346	1.56	1.44
		99th %ile	377	1.80	1.69	392	1.82	1.71
		Maximum	377	1.70	1.68	390	1.70	1.66
2006/07 to 2058/59 RCP 8.5	Modelled production	Average	344	1.57	1.45	358	1.60	1.49
		99th %ile	396	1.81	1.75	410	1.82	1.71
		Maximum	398	1.70	1.66	403	1.72	1.67
	% increase compared to 1951/52 to 2004/05	Average	1.84%	-0.01%	0.53%	3.57%	2.76%	3.68%
		99th %ile	4.92%	0.67%	3.68%	4.59%	-0.17%	0.06%
		Maximum	5.69%	0.00%	-1.19%	3.35%	1.31%	0.80%
2059/60 to 2099/100 RCP 8.5	Modelled production	Average	372	1.66	1.56	381	1.66	1.56
		99th %ile	422	1.84	1.77	426	1.82	1.77
		Maximum	415	1.92	1.74	419	1.76	1.71
	% increase compared to 1951/52 to 2004/05	Average	8.08%	5.37%	7.57%	6.26%	3.60%	4.62%
		99th %ile	6.63%	1.47%	1.09%	3.87%	0.30%	3.48%
		Maximum	4.30%	12.44%	4.54%	3.94%	2.19%	2.26%

Appendix table F-13: Braidwood (low NRW) – CCCma-CanESM2 – RCP 4.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	154	0.70	0.64	160	0.71	0.66
		99th %ile	171	0.82	0.75	179	0.82	0.76
		Maximum	172	0.76	0.71	179	0.76	0.71
2006/07 to 2058/59 RCP 4.5	Modelled production	Average	153	0.69	0.63	159	0.71	0.65
		99th %ile	171	0.84	0.76	179	0.82	0.76
		Maximum	175	0.76	0.71	175	0.76	0.71
	% increase compared to 1951/52 to 2004/05	Average	-0.43%	-0.85%	-1.44%	-0.40%	0.02%	-0.78%
		99th %ile	0.07%	2.32%	1.31%	-0.10%	-0.39%	-0.42%
		Maximum	1.44%	0.00%	-0.23%	-2.13%	0.16%	0.31%
2059/60 to 2099/100 RCP 4.5	Modelled production	Average	160	0.70	0.64	166	0.74	0.68
		99th %ile	181	0.83	0.77	184	0.82	0.76
		Maximum	175	0.77	0.72	182	0.77	0.72
	% increase compared to 1951/52 to 2004/05	Average	4.42%	1.46%	0.81%	4.48%	3.34%	3.60%
		99th %ile	5.75%	-1.00%	0.59%	2.79%	-0.32%	-0.63%
		Maximum	0.40%	0.05%	1.30%	4.06%	0.42%	0.84%

Appendix table F-14: Braidwood (low NRW) – CCCma-CanESM2 – RCP 8.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	154	0.70	0.64	160	0.71	0.66
		99th %ile	171	0.82	0.75	179	0.82	0.76
		Maximum	172	0.76	0.71	162	0.72	0.66
2006/07 to 2058/59 RCP 8.5	Modelled production	Average	155	0.70	0.64	162	0.72	0.66
		99th %ile	179	0.85	0.78	187	0.84	0.78
		Maximum	182	0.76	0.75	186	0.77	0.75
	% increase compared to 1951/52 to 2004/05	Average	1.02%	-0.10%	-0.04%	1.41%	1.32%	0.10%
		99th %ile	4.63%	3.86%	4.18%	4.29%	1.40%	2.03%
		Maximum	5.91%	-0.05%	6.14%	3.63%	0.73%	6.24%
2059/60 to 2099/100 RCP 8.5	Modelled production	Average	161	0.71	0.65	168	0.74	0.69
		99th %ile	179	0.83	0.77	186	0.81	0.75
		Maximum	184	0.77	0.72	180	0.77	0.72
	% increase compared to 1951/52 to 2004/05	Average	3.61%	1.73%	1.92%	3.74%	3.08%	3.93%
		99th %ile	-0.29%	-2.01%	-1.27%	-0.70%	-3.07%	-3.18%
		Maximum	0.84%	0.37%	-4.80%	-2.84%	0.42%	-4.74%

Appendix table F-15: Braidwood (low NRW) – CSIRO-BOM-ACCESS1-0 – RCP 4.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	146	0.67	0.61	149	0.68	0.62
		99th %ile	162	0.84	0.78	168	0.85	0.79
		Maximum	168	0.76	0.71	170	0.76	0.71
2006/07 to 2058/59 RCP 4.5	Modelled production	Average	147	0.67	0.60	153	0.70	0.65
		99th %ile	168	0.85	0.78	174	0.87	0.80
		Maximum	171	0.76	0.71	176	0.76	0.71
	% increase compared to 1951/52 to 2004/05	Average	0.91%	-0.67%	-1.59%	2.63%	2.87%	4.11%
		99th %ile	3.44%	0.13%	-0.47%	3.67%	2.49%	1.16%
		Maximum	1.33%	-0.16%	0.28%	3.53%	0.79%	-0.06%
2059/60 to 2099/100 RCP 4.5	Modelled production	Average	148	0.66	0.60	154	0.70	0.64
		99th %ile	167	0.86	0.77	173	0.83	0.78
		Maximum	171	0.77	0.76	171	0.77	0.75
	% increase compared to 1951/52 to 2004/05	Average	0.71%	-1.68%	-0.29%	0.27%	-0.33%	-0.74%
		99th %ile	-0.34%	1.81%	-0.39%	-0.62%	-4.40%	-1.83%
		Maximum	0.27%	0.26%	6.82%	-3.15%	0.16%	6.19%

Appendix table F-16: Braidwood (low NRW) – CSIRO-BOM-ACCESS1-0 – RCP 8.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	146	0.67	0.61	168	0.85	0.79
		99th %ile	162	0.84	0.78	170	0.76	0.71
		Maximum	168	0.76	0.71	155	0.70	0.65
2006/07 to 2058/59 RCP 8.5	Modelled production	Average	146	0.66	0.60	155	0.70	0.65
		99th %ile	163	0.86	0.77	176	0.83	0.78
		Maximum	168	0.77	0.71	172	0.76	0.71
	% increase compared to 1951/52 to 2004/05	Average	0.28%	-1.58%	-2.82%	3.73%	2.12%	4.41%
		99th %ile	0.62%	1.31%	-1.49%	4.84%	-2.34%	-1.32%
		Maximum	-0.17%	0.73%	-0.45%	1.33%	0.63%	0.51%
2059/60 to 2099/100 RCP 8.5	Modelled production	Average	152	0.68	0.62	158	0.72	0.66
		99th %ile	169	0.85	0.77	177	0.83	0.76
		Maximum	165	0.77	0.72	177	0.77	0.72
	% increase compared to 1951/52 to 2004/05	Average	3.88%	2.64%	4.22%	1.79%	3.27%	2.03%
		99th %ile	3.35%	-0.65%	0.48%	0.45%	-0.58%	-1.85%
		Maximum	-1.91%	0.10%	2.32%	2.59%	1.21%	1.29%

Appendix table F-17: Braidwood (low NRW) – CSIRO-BOM-ACCESS1-3 – RCP 4.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	154	0.71	0.65	161	0.73	0.67
		99th %ile	174	0.83	0.76	184	0.83	0.77
		Maximum	177	0.76	0.72	182	0.77	0.72
2006/07 to 2058/59 RCP 4.5	Modelled production	Average	156	0.70	0.64	161	0.73	0.67
		99th %ile	176	0.86	0.79	184	0.85	0.77
		Maximum	175	0.77	0.76	183	0.77	0.72
	% increase compared to 1951/52 to 2004/05	Average	0.77%	-0.50%	-0.21%	0.03%	-0.12%	0.56%
		99th %ile	1.24%	3.06%	3.52%	-0.16%	1.66%	-0.14%
		Maximum	-0.89%	0.63%	5.48%	0.34%	0.63%	0.20%
2059/60 to 2099/100 RCP 4.5	Modelled production	Average	159	0.72	0.65	164	0.73	0.68
		99th %ile	184	0.85	0.78	187	0.83	0.77
		Maximum	182	0.77	0.72	187	0.77	0.76
	% increase compared to 1951/52 to 2004/05	Average	2.05%	1.78%	1.17%	1.64%	1.19%	1.71%
		99th %ile	4.92%	-0.74%	-1.63%	1.93%	-2.38%	-0.03%
		Maximum	3.94%	0.52%	-5.30%	2.32%	0.21%	6.39%

Appendix table F-18: Braidwood (low NRW) – CSIRO-BOM-ACCESS1-3 – RCP 8.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	154	0.71	0.65	161	0.73	0.67
		99th %ile	174	0.83	0.76	184	0.83	0.77
		Maximum	177	0.76	0.72	182	0.77	0.72
2006/07 to 2058/59 RCP 8.5	Modelled production	Average	156	0.70	0.64	165	0.73	0.68
		99th %ile	182	0.84	0.80	190	0.83	0.77
		Maximum	186	0.77	0.76	190	0.77	0.76
	% increase compared to 1951/52 to 2004/05	Average	1.14%	-1.40%	-0.90%	2.31%	1.07%	2.54%
		99th %ile	4.88%	1.61%	5.17%	3.46%	-0.37%	0.40%
		Maximum	5.25%	1.00%	5.59%	3.94%	0.21%	5.32%
2059/60 to 2099/100 RCP 8.5	Modelled production	Average	167	0.75	0.69	174	0.75	0.70
		99th %ile	192	0.85	0.78	196	0.82	0.77
		Maximum	189	0.86	0.77	192	0.78	0.77
	% increase compared to 1951/52 to 2004/05	Average	7.02%	7.15%	8.08%	5.54%	2.03%	2.46%
		99th %ile	5.39%	0.66%	-2.33%	2.73%	-1.35%	-0.15%
		Maximum	1.61%	11.45%	1.40%	1.18%	0.99%	1.75%

Appendix table F-19: Braidwood (high NRW) – CCCma-CanESM2 – RCP 4.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	238	0.93	0.87	244	0.94	0.89
		99th %ile	255	1.05	0.98	264	1.06	0.99
		Maximum	256	1.00	0.94	263	0.99	0.94
2006/07 to 2058/59 RCP 4.5	Modelled production	Average	237	0.92	0.86	243	0.94	0.89
		99th %ile	256	1.07	0.99	263	1.05	0.99
		Maximum	259	1.00	0.94	260	1.00	0.94
	% increase compared to 1951/52 to 2004/05	Average	-0.28%	-0.64%	-1.06%	-0.26%	0.01%	-0.58%
		99th %ile	0.05%	1.81%	1.00%	-0.06%	-0.31%	-0.32%
		Maximum	0.97%	0.00%	-0.17%	-1.45%	0.12%	0.23%
2059/60 to 2099/100 RCP 4.5	Modelled production	Average	244	0.93	0.87	250	0.97	0.91
		99th %ile	265	1.06	1.00	268	1.05	0.99
		Maximum	260	1.00	0.95	267	1.00	0.95
	% increase compared to 1951/52 to 2004/05	Average	2.85%	1.10%	0.59%	2.93%	2.52%	2.66%
		99th %ile	3.85%	-0.78%	0.46%	1.90%	-0.25%	-0.49%
		Maximum	0.27%	0.04%	0.98%	2.74%	0.32%	0.64%

Appendix table F-20: Braidwood (high NRW) – CCCma-CanESM2 – RCP 8.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	238	0.93	0.87	244	0.94	0.89
		99th %ile	255	1.05	0.98	264	1.06	0.99
		Maximum	256	1.00	0.94	246	0.95	0.89
2006/07 to 2058/59 RCP 8.5	Modelled production	Average	239	0.93	0.87	246	0.95	0.89
		99th %ile	263	1.08	1.01	271	1.07	1.01
		Maximum	267	1.00	0.98	270	1.00	0.99
	% increase compared to 1951/52 to 2004/05	Average	0.66%	-0.08%	-0.03%	0.92%	0.99%	0.07%
		99th %ile	3.10%	3.01%	3.20%	2.92%	1.10%	1.56%
		Maximum	3.97%	-0.04%	4.63%	2.47%	0.56%	4.71%
2059/60 to 2099/100 RCP 8.5	Modelled production	Average	245	0.94	0.88	252	0.97	0.92
		99th %ile	263	1.06	1.00	270	1.04	0.99
		Maximum	268	1.00	0.95	265	1.00	0.95
	% increase compared to 1951/52 to 2004/05	Average	2.34%	1.30%	1.41%	2.46%	2.33%	2.91%
		99th %ile	-0.20%	-1.58%	-0.98%	-0.48%	-2.41%	-2.45%
		Maximum	0.57%	0.28%	-3.68%	-1.95%	0.32%	-3.63%

Appendix table F-21: Braidwood (high NRW) – CSIRO-BOM-ACCESS1-0 – RCP 4.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	230	0.91	0.85	234	0.91	0.85
		99th %ile	247	1.08	1.01	252	1.08	1.02
		Maximum	253	1.00	0.94	255	0.99	0.94
2006/07 to 2058/59 RCP 4.5	Modelled production	Average	232	0.90	0.84	238	0.93	0.88
		99th %ile	252	1.08	1.01	259	1.10	1.03
		Maximum	255	0.99	0.94	261	1.00	0.94
	% increase compared to 1951/52 to 2004/05	Average	0.57%	-0.50%	-1.16%	1.68%	2.14%	3.00%
		99th %ile	2.27%	0.10%	-0.36%	2.46%	1.96%	0.90%
		Maximum	0.79%	-0.12%	0.21%	2.36%	0.61%	-0.04%
2059/60 to 2099/100 RCP 4.5	Modelled production	Average	233	0.89	0.83	238	0.93	0.88
		99th %ile	252	1.09	1.01	257	1.06	1.01
		Maximum	255	1.00	0.99	255	1.00	0.98
	% increase compared to 1951/52 to 2004/05	Average	0.45%	-1.25%	-0.21%	0.18%	-0.25%	-0.55%
		99th %ile	-0.25%	1.42%	-0.30%	-0.44%	-3.48%	-1.42%
		Maximum	0.18%	0.20%	5.15%	-2.22%	0.12%	4.67%

Appendix table F-22: Braidwood (high NRW) – CSIRO-BOM-ACCESS1-0 – RCP 8.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	230	0.91	0.85	252	1.08	1.02
		99th %ile	247	1.08	1.01	255	0.99	0.94
		Maximum	253	1.00	0.94	239	0.93	0.88
2006/07 to 2058/59 RCP 8.5	Modelled production	Average	231	0.89	0.83	239	0.93	0.88
		99th %ile	248	1.09	1.00	261	1.06	1.01
		Maximum	252	1.00	0.94	257	0.99	0.94
	% increase compared to 1951/52 to 2004/05	Average	0.18%	-1.18%	-2.05%	2.38%	1.58%	3.22%
		99th %ile	0.38%	1.03%	-1.15%	3.22%	-1.84%	-1.02%
		Maximum	-0.20%	0.56%	-0.34%	0.80%	0.49%	0.38%
2059/60 to 2099/100 RCP 8.5	Modelled production	Average	237	0.91	0.85	242	0.95	0.89
		99th %ile	253	1.08	1.00	261	1.06	0.99
		Maximum	249	1.00	0.95	261	1.00	0.95
	% increase compared to 1951/52 to 2004/05	Average	2.46%	1.96%	3.05%	1.16%	2.46%	1.50%
		99th %ile	2.23%	-0.51%	0.37%	0.31%	-0.46%	-1.43%
		Maximum	-1.27%	0.08%	1.75%	1.74%	0.93%	0.97%

Appendix table F-23: Braidwood (high NRW) – CSIRO-BOM-ACCESS1-3 – RCP 4.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	239	0.94	0.88	246	0.96	0.90
		99th %ile	258	1.06	0.99	268	1.06	1.00
		Maximum	261	0.99	0.95	267	1.00	0.95
2006/07 to 2058/59 RCP 4.5	Modelled production	Average	240	0.93	0.88	246	0.96	0.90
		99th %ile	260	1.09	1.02	268	1.08	1.00
		Maximum	259	1.00	0.99	267	1.00	0.95
	% increase compared to 1951/52 to 2004/05	Average	0.50%	-0.38%	-0.16%	0.02%	-0.09%	0.41%
		99th %ile	0.82%	2.39%	2.70%	-0.10%	1.30%	-0.11%
		Maximum	-0.69%	0.48%	4.15%	0.23%	0.48%	0.15%
2059/60 to 2099/100 RCP 4.5	Modelled production	Average	243	0.95	0.88	248	0.97	0.91
		99th %ile	269	1.08	1.01	272	1.06	1.00
		Maximum	266	1.00	0.95	272	1.00	1.00
	% increase compared to 1951/52 to 2004/05	Average	1.33%	1.34%	0.86%	1.07%	0.90%	1.27%
		99th %ile	3.33%	-0.58%	-1.26%	1.32%	-1.87%	-0.02%
		Maximum	2.66%	0.40%	-4.06%	1.59%	0.16%	4.84%

Appendix table F-24:Braidwood (high NRW) – CSIRO-BOM-ACCESS1-3 – RCP 8.5

			RCM J			RCM K		
			Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)	Annual total (ML/year)	Average day peak week (ML/day)	Average day peak fortnight (ML/day)
1951/52 to 2004/05	Modelled production	Average	239	0.94	0.88	246	0.96	0.90
		99th %ile	258	1.06	0.99	268	1.06	1.00
		Maximum	261	0.99	0.95	267	1.00	0.95
2006/07 to 2058/59 RCP 8.5	Modelled production	Average	241	0.93	0.87	249	0.97	0.91
		99th %ile	266	1.07	1.03	275	1.06	1.00
		Maximum	270	1.00	0.99	274	1.00	0.99
	% increase compared to 1951/52 to 2004/05	Average	0.74%	-1.05%	-0.66%	1.52%	0.81%	1.89%
		99th %ile	3.27%	1.26%	3.97%	2.38%	-0.29%	0.30%
		Maximum	3.47%	0.76%	4.23%	2.69%	0.16%	4.02%
2059/60 to 2099/100 RCP 8.5	Modelled production	Average	252	0.98	0.92	259	0.98	0.93
		99th %ile	276	1.08	1.01	280	1.05	1.00
		Maximum	273	1.09	1.00	276	1.01	1.00
	% increase compared to 1951/52 to 2004/05	Average	4.56%	5.37%	5.94%	3.67%	1.54%	1.84%
		99th %ile	3.71%	0.52%	-1.81%	1.94%	-1.06%	-0.12%
		Maximum	1.11%	8.81%	1.07%	0.81%	0.76%	1.34%

For the demand forecasts, the probable climate change forecasts have been calculated using the maximum increase from the RCP 4.5 models for the period between 2006/07 to 2058/59. The more severe climate change forecast uses the maximum increase from either the RCP 4.5 or 8.5 models and either time period. For both Braidwood and Bungendore, the highest increase in the 99th percentile dry year demand was the maximum increase under RCP 4.5 between 2006/07 and 2058/59.

Appendix table F-25: Climate change impact on system demand

Projection	Climate change scenario	Average year	99th %ile dry year	Average day peak week	Average day peak fortnight
Braidwood Low NRW	Probable	4.42%	5.75%	3.06%	3.52%
	High severity	7.02%	5.75%	3.86%	5.17%
Braidwood High NRW	Probable	2.85%	3.85%	2.39%	2.70%
	High severity	4.56%	3.85%	3.01%	3.97%
Bungendore	Probable	4.77%	6.81%	3.86%	3.73%
	High severity	8.08%	6.81%	1.47%	3.68%

F.4 Paleo-stochastic

DCCEEW generated 10,000-year daily data sets of rainfall and potential evapotranspiration using observed data sets (at meteorological stations) combined with palaeo climate data for use in the regional water strategies. Data is currently publicly available for selected weather stations in the NSW and ACT Murray Darling Basin catchments and will be released soon for the Nepean and Shoalhaven catchments. The closest site with the required parameters for irrigation modelling was Ainslie ACT in the Murrumbidgee Catchment.

The results from the paleo stochastic data were compared to the results from the SILO data for the same period. The results are summarised in Appendix table F-26.

Appendix table F-26: Paleo-stochastic irrigation modelling results – Ainslie ACT

		Irrigation (ML/ha)		
		Annual Total	Average day peak week	Average day peak fortnight
2023 SILO (Ainslie ACT)	Average	4.76	0.058	0.050
	99th %ile	8.18	0.075	0.066
	Maximum	8.00	0.063	0.063
	% of years with maximum	0.75%	62.69%	3.73%

		Irrigation (ML/ha)		
		Annual Total	Average day peak week	Average day peak fortnight
Paleo- stochastic (Ainslie ACT)	Average	4.32	0.055	0.051
	99th %ile	7.29	0.074	0.065
	Maximum	8.33	0.079	0.063
	% of years greater than or equal to SILO maximum	0.07%	47.34%	3.90%
Stochastic SILO	Average	90.84%	95.67%	100.77%
	99th %ile	89.05%	97.86%	99.52%
	Maximum	104.17%	125.00%	100.00%

Overall, based on the stochastic data, there is a very low probability of more water being required for irrigation than was shown in the SILO data on a yearly basis. There is a chance that the average day peak week irrigation demand may be higher than estimated from the SILO data, using the SILO data, irrigation was required 4 days during the maximum week, using the stochastic data, irrigation was required 5 days during the maximum week, though this only occurred in 5 out of the 9,999 financial years.

Appendix G New dwelling demand sensitivity analysis

The sensitivity analysis was undertaken for dwellings with rainwater tanks in Bungendore. The internal demands are based on dwellings having 3-star wells rated fittings and appliances, using an average 65.5 L/person/day of water from the potable supply and 59.6 L/person/day from the rainwater tanks.

G.1 Dwellings with 2 bedrooms

Dwellings with 2 bedrooms were assumed to have

- 13 kL rainwater tanks, as per Council's 2015 DCP
- 90 m² of roof area draining into the tank
- a household size of 1, 2, or 3 people
- irrigated garden areas of 10, 20 and 40 m².

Appendix Table G-1: Per person water demands – houses with two bedrooms

Irrigation area (m ²)	Household size	With Tank			Without Tank			With Tank Without Tank	
		Average year (KL/person/year)	Unrestricted future year (99th %ile)	Peak Average	Average year (KL/person/year)	Unrestricted future year (99th %ile)	Peak Average	Average year	Unrestricted future year (99th %ile)
10	1	24.1	25.6	1.06	50.0	53.3	1.07	0.48	0.48
10	2	26.5	33.8	1.28	47.8	49.5	1.04	0.55	0.68
10	3	30.8	40.0	1.30	47.1	48.3	1.02	0.65	0.83
20	1	24.8	29.8	1.20	54.2	61.0	1.12	0.46	0.49
20	2	28.2	38.1	1.35	50.0	53.3	1.07	0.56	0.71
20	3	32.2	42.6	1.32	48.6	50.8	1.05	0.66	0.84
40	1	28.5	43.4	1.52	62.8	76.2	1.21	0.45	0.57
40	2	31.9	46.3	1.45	54.2	61.0	1.12	0.59	0.76
40	3	35.0	47.8	1.36	51.4	55.9	1.09	0.68	0.85

The key observations that can be made from Appendix Table G-1 are:

- the 9 kL tanks are highly effective at providing a large proportion of the water required for lone person households, with very small gardens

- the unrestricted future year demand per person is quite sensitive to the irrigated area, therefore, variations in the design of villa home estates can have a significant impact on the water demand
- Unless the dwellings have only one resident and the irrigation area is very small (10 m²), the relative increase in unrestricted future year demands is significantly higher for the dwellings with tanks
- Unless the dwellings have only one resident and the irrigation area is very small (10 m²), the relative savings due to the tank are much lower in unrestricted future years.

G.2 Dwellings with 3 or more bedrooms

Dwellings with 3 bedrooms were assumed to have:

- 22.5 kL rainwater tanks, as per Council's 2015 DCP
- 200 m² of roof area draining into the tank
- a household size of 1, 2, 3, 4 or 5 people
- irrigated garden areas of 117 m² (selected based on the analysis undertaken for existing homes in Bungendore).

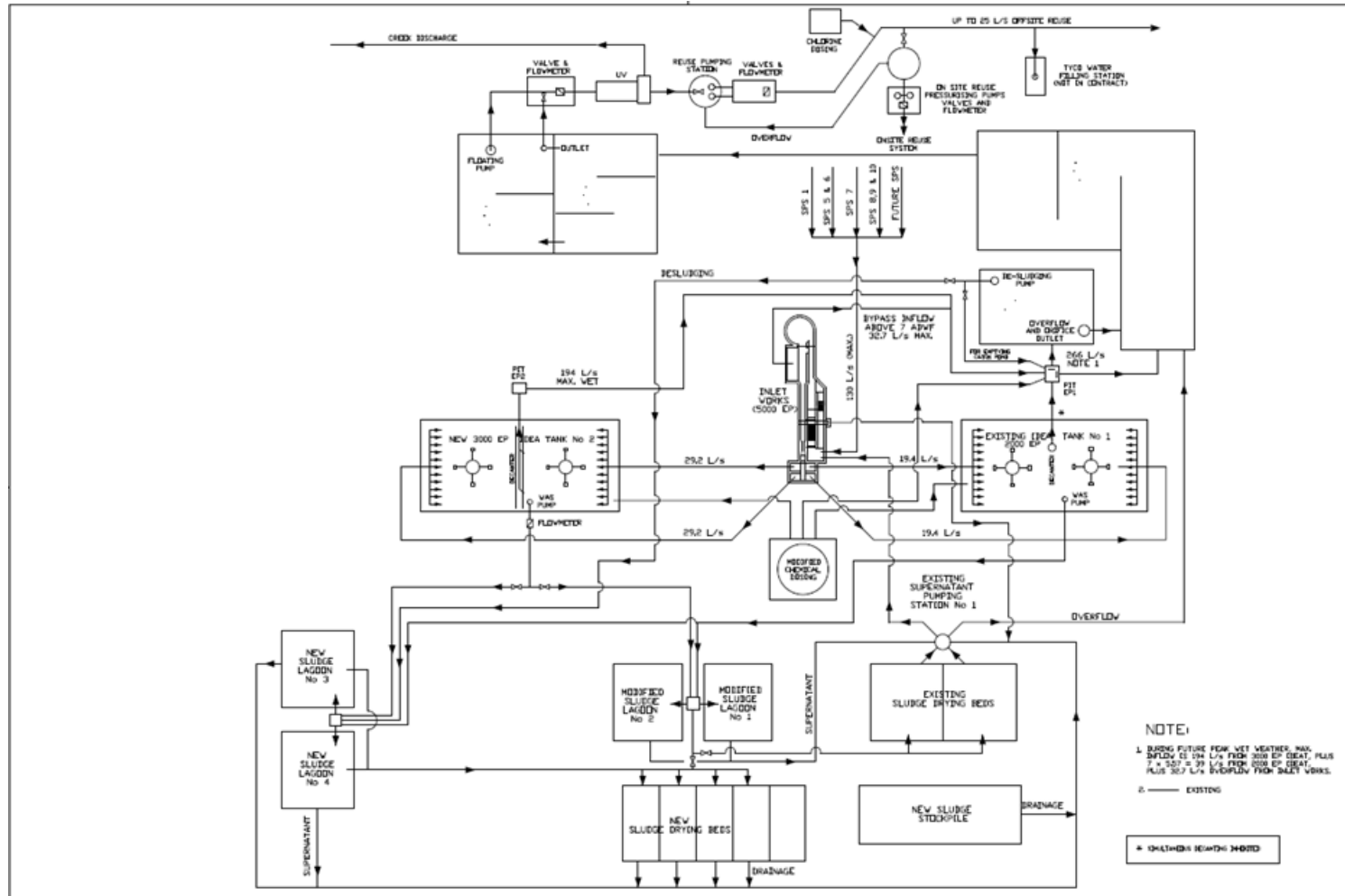
Appendix Table G-2: Per person water demands – houses with three or more bedrooms

Household size	With Tank			Without Tank			With Tank Without Tank	
	Average year (kL/person/year)	Unrestricted future year (99th %ile) (kL/person/year)		Average year (kL/person/year)	Unrestricted future year (99th %ile) (kL/person/year)	Peak Average	Average year	Unrestricted future year (99th %ile)
1	37.1	72.6	1.96	95.6	134.9	1.41	0.39	0.54
2	34.3	57.4	1.67	70.7	90.3	1.28	0.49	0.64
3	34.3	53.3	1.56	62.3	75.4	1.21	0.55	0.71
4	34.8	51.8	1.49	58.2	68.0	1.17	0.60	0.76
5	35.6	51.3	1.44	55.7	63.5	1.14	0.64	0.81

The key observations that can be made from Appendix Table G-1 and Appendix Table G-2 are:

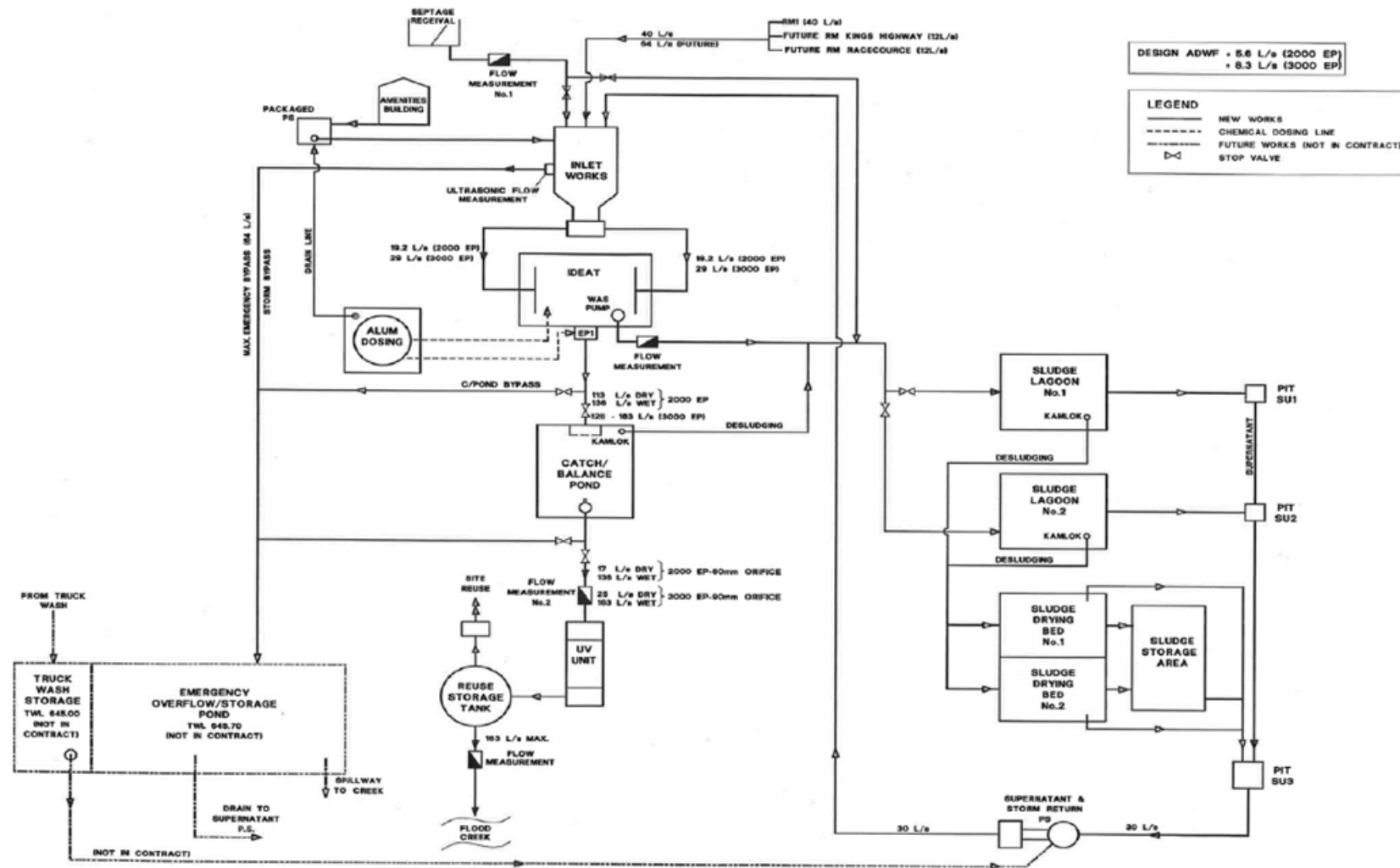
- The tanks are highly effective at reducing the per-capita annual demand for smaller households, though the effectiveness decreases for larger households.
- The demands per person for the homes with three or more bedrooms are significantly higher than for two bedroom homes of the same household size due to the larger irrigated area.
- the relative increase in unrestricted future year demands is significantly higher for the dwellings with tanks.
- the relative savings due to the tank are much lower in unrestricted future years.

Appendix H Sewerage process flow diagram

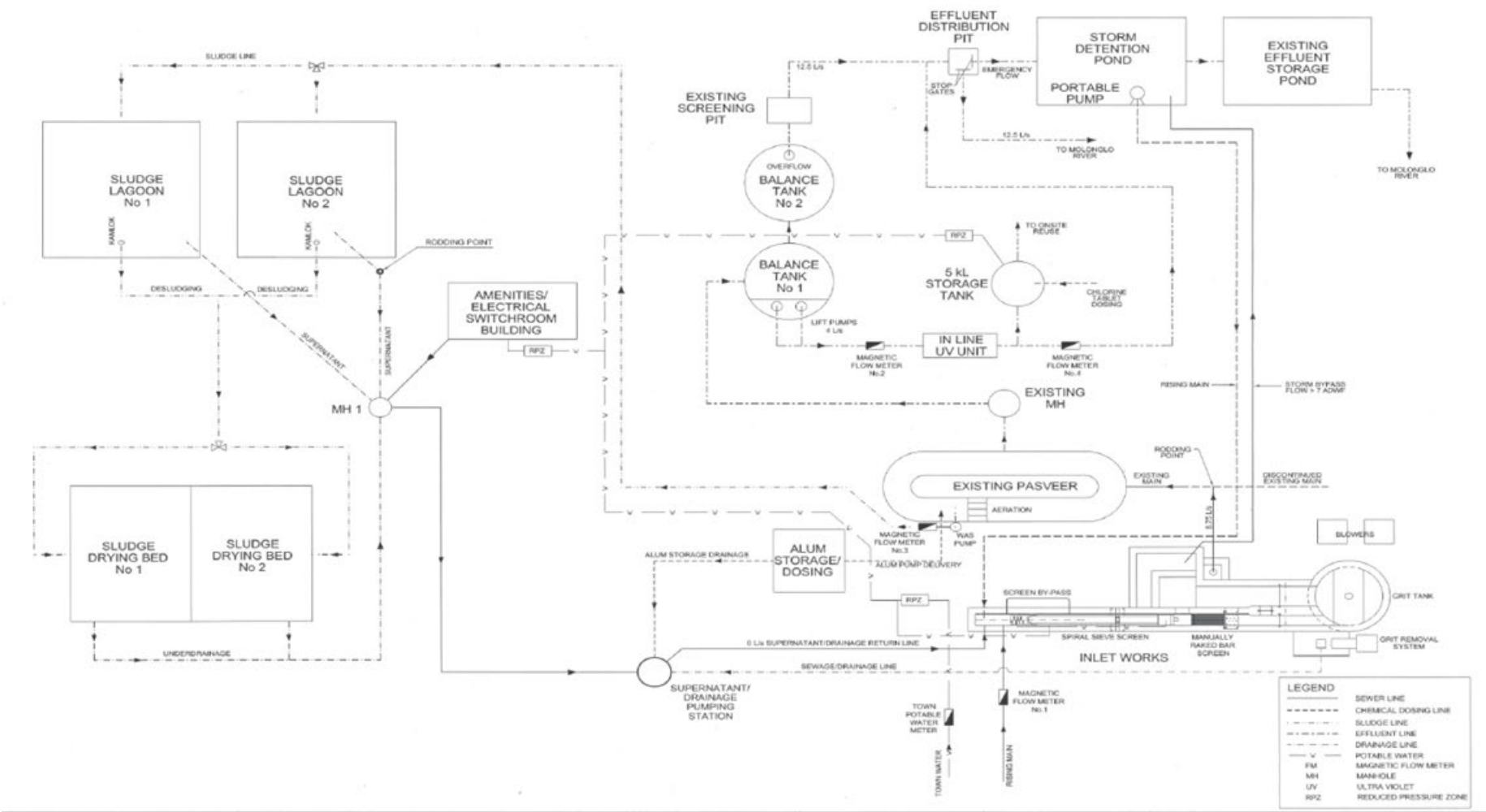


Appendix figure H-1: Detailed Process Flow Schematic – Bungendore STP





Appendix figure H-3: Detailed Process Flow Schematic – Braidwood STP



Appendix figure H-4: Detailed Process Flow Schematic – Captains Flat STP



Appendix table H-1: Bungendore STP's process units and capacities

Process	Design Criteria	Capacity
STP Design Capacity		
Average Dry Weather Flow (ADWF)	240 L/EP/day 3,000 EP IDEA Tank 2,000 EP IDEA Tank when required	720 kL/day 480 kL/day Total: 1,200 kL/day
Peak Wet Weather Flow (PWWF)	7 x ADWF 3,000 EP 5,000 EP	58.3 L/s 97.3 L/s
Process Units Capacities		
Primary Treatment		
Inlet works (including screening and grit removal)	5,000 EP	Bypass inflows in excess of PWWF
Emergency Overflow Storage		
None		
Secondary Treatment		
2 x IDEA tank	1 x 3,000 EP (in use) 1 x 2,000 EP (ready to commission)	
BOD ₅	70 g/EP/day ¹ 3,000 EP 5,000 EP	210 kg/day 350 kg/day
TKN	12 g/EP/day ¹ 3,000 EP 5,000 EP	36 kg/day 60 kg/day
Chemical Dosing		
1 x Liquid alum storage tank	For P removal	25 kL
Sludge Management		
4 x Sludge lagoons	5,000 EP	2 x 929 m ³ Total 2 x 2,150 m ³ Total
7 x Sludge drying beds	5,000 EP	Not available
Disinfection		
Ultraviolet disinfection system	5,000 EP	42 L/s for full disinfection

Process	Design Criteria	Capacity
Effluent Management	Discharge to Mill Post Creek	
3 x Effluent storage ponds	Not available	
1 x Reuse storage tank	For on-site and off-site use	Pump max capacity 25 L/s

Appendix table H-2: Braidwood STP's process units and capacities

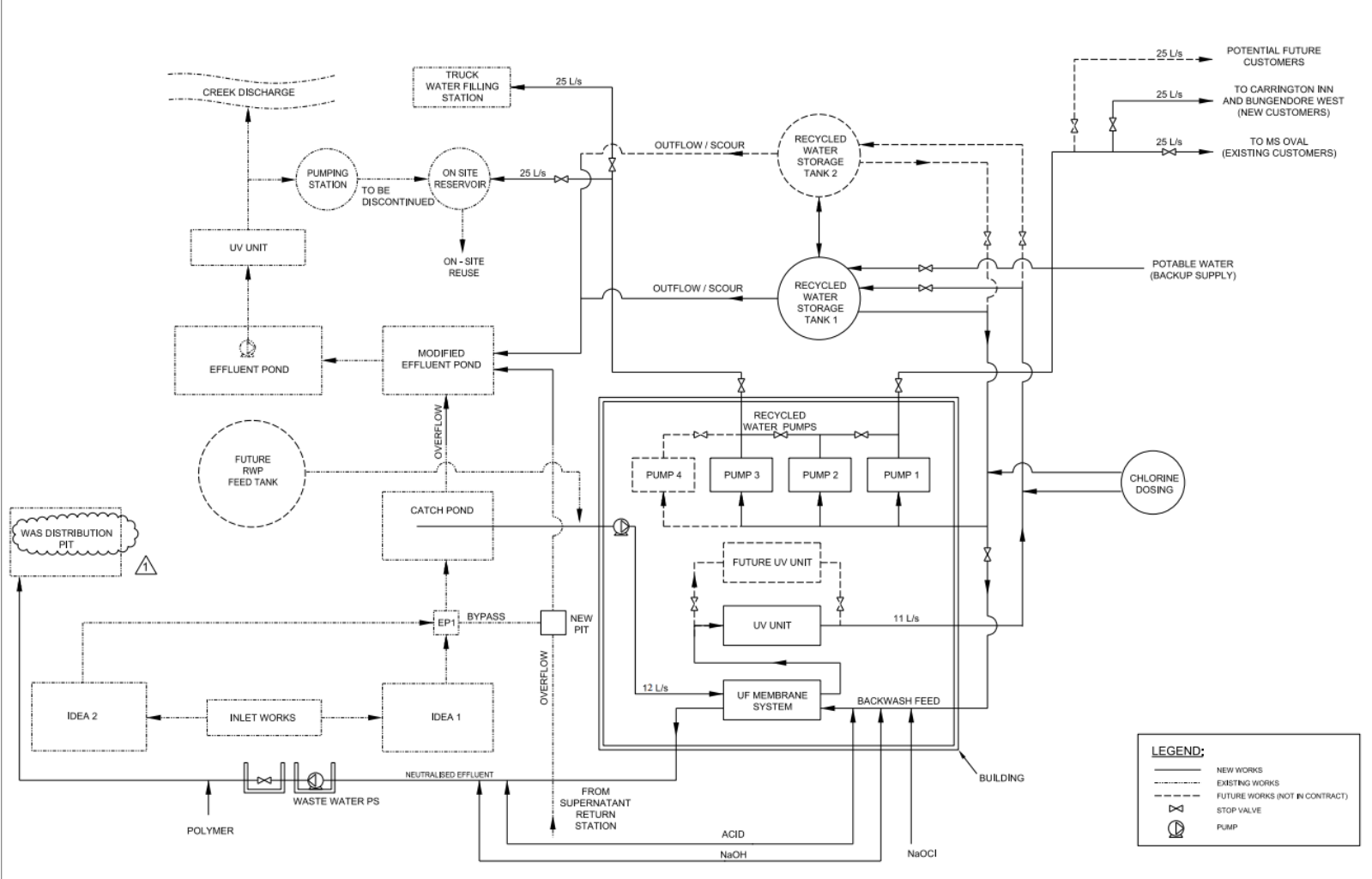
Process	Design Criteria	Capacity
STP Design Capacity		
Average Dry Weather Flow (ADWF)	2,000 EP @ 240 L/EP/day	480 kL/day
Peak Wet Weather Flow (PWWF)	7 x ADWF	39 L/s
Process Units Capacities		
Primary Treatment		
Inlet works (including screening and grit removal)	2,000 EP	Receive inflows up to 64 L/s Bypass flows in excess of 39 L/s during wet weather
Vortex Grit Arrestor	2,000 EP	Max 120 m ³ /m ² /hour
Emergency Overflow Storage		
Emergency overflow storage pond	28 days at ADWF 4 days at PWWF	13.8 ML
Secondary Treatment		
1 x IDEA tank	Treatment of flows up to PWWF	
BOD ₅	70 g/EP/day ¹	140 kg/day
NH ₃	12 g/EP/day ¹	24 kg/day
TP	2 g/EP/day	4 kg/day
1 x Catch / balance pond		101 m ³
Chemical Dosing		
1 x Liquid alum storage tank	For P removal	20 kL
Sludge Management		
2 x Sludge lagoons	Detention time 7 month	1,150 m ³ per lagoon
2 x Sludge drying beds		440 m ² per bed
Disinfection		
Ultraviolet disinfection system	2,000 EP	25 L/s for full disinfection
Effluent Management	Discharge to Flood Creek	

Process	Design Criteria	Capacity
1 x Reuse storage tank	For on-site use	

Appendix table H-3: Captains Flat STP's process units and capacities

Process	Design Criteria	Capacity
STP Design Capacity		
Average Dry Weather Flow (ADWF)	500 EP @ 240 L/EP/day	120 kL/day
Peak Wet Weather Flow (PWWF)	7 x ADWF	9.7 L/s
Process Units Capacities		
Primary Treatment		
None		
Emergency Overflow Storage		
None		
Secondary Treatment		
1 x Pasveer Channel	1 x 500 EP	
BOD ₅	70 g/EP/day ¹	210 kg/day
NH ₃	12.5 g/EP/day ¹	36 kg/day
TP	2.7 g/EP/day	6 kg/day
Chemical Dosing		
None		
Sludge Management		
2 x Sludge lagoons	Unknown	143 m ³ total
1 x Sludge drying bed	Unknown	Unknown
Disinfection		
None		
Effluent Management	Discharge to Molonglo River	
2 x Effluent Ponds	Unknown	900 m ³ total

Appendix I Detailed Bungendore STP Reuse flow diagram



Appendix figure I-1: Detailed Bungendore STP Reuse flow diagram