CWT WATER TREATMENT SPECIALISTS

Baradine Sewerage Scheme Upgrades – Scoping and Options Report

For Warrumbungle Shire Council

WBS1433-06-REP-B

28 September 2021

Baradine Sewerage Scheme Upgrades – Scoping and Options Report

For Warrumbungle Shire Council

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BESTPRACTICE CERTIFICATION ISO9001 QUALITY MANAGEMENT SYSTEM
BESTPRACTICE CERTIFICATION ISO14001 ENVIRONMENT MANAGEMENT SYSTEM
BESTPRACTICE CERTIFICATION AS4801 OH&S MANAGEMENT SYSTEM

Issue Date	Revision	Issued to	Prepared by	Reviewed by	Comments
23/12/2020	A	CW	NT/MMC	MMC	Draft for review
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1 Introduction

1.1 Overview

City Water Technology (CWT) was engaged by Warrumbungle Shire Council (WSC) to conduct a scoping study that will feed into the design and construction of Baradine Sewerage Treatment Plant (STP) inlet works to improve current treatment performance.

The Baradine STP provides sewerage treatment for the township of Baradine located on the Coonabarabran road, about midway between Coonabarabran and Pilliga in the central western area of New South Wales. Currently, the plant receives flows from the township of Baradine via a vacuum collection system. The treatment system is pond-based and consists of a pump station and lagoons. Sewage enters the first oxidative/facultative ponds before it flows to a maturation pond and subsequent storage lagoon. Effluent from the STP is reused by the neighbouring property for irrigation purposes. Reportedly, the oxidation/facultative ponds have not been desludged ever since commissioning in 1997.

Currently, the STP is configured with no inlet works, and as a result, rag build up has been a major concern for WSC. This causes a reduction in hydraulic and treatment capacity resulting in effluent quality issues and potentially sewage overflows directly to the surrounding environment. The current treatment capacity of the STP is also unknown – presenting challenges in planning for growth servicing and potential infrastructure development.

The study will also assess the current STP capacity in order to identify potential upgrades required to enable growth servicing and economic development within the community. Furthermore, the study will also review the previously identified options and identify any additional options for connection of Camp Cypress to the sewerage system including reviewing the loadings and assumptions used to develop the options, infrastructure sizing and cost estimates.

1.2 Description of the Existing STP System at Baradine

1.2.1 Process Description

The Baradine STP is a pond treatment-based system which consists of one pump station and ponds that receive flows from the township of Baradine via a vacuum collection system. Inflow to the Baradine STP is not monitored.

The STP has an "inlet box" with no screening which creates a major issue as rag build up in the lagoon reduces the lagoon capacity as well as affecting effluent quality and can lead to overflows directly into the surrounding environment. Effluent quality issues cause environmental and safety concerns in regard to the water released to the neighbouring private property for irrigation purposes.

A process flow diagram showing the major processes at Baradine STP is presented in Figure 1-1.

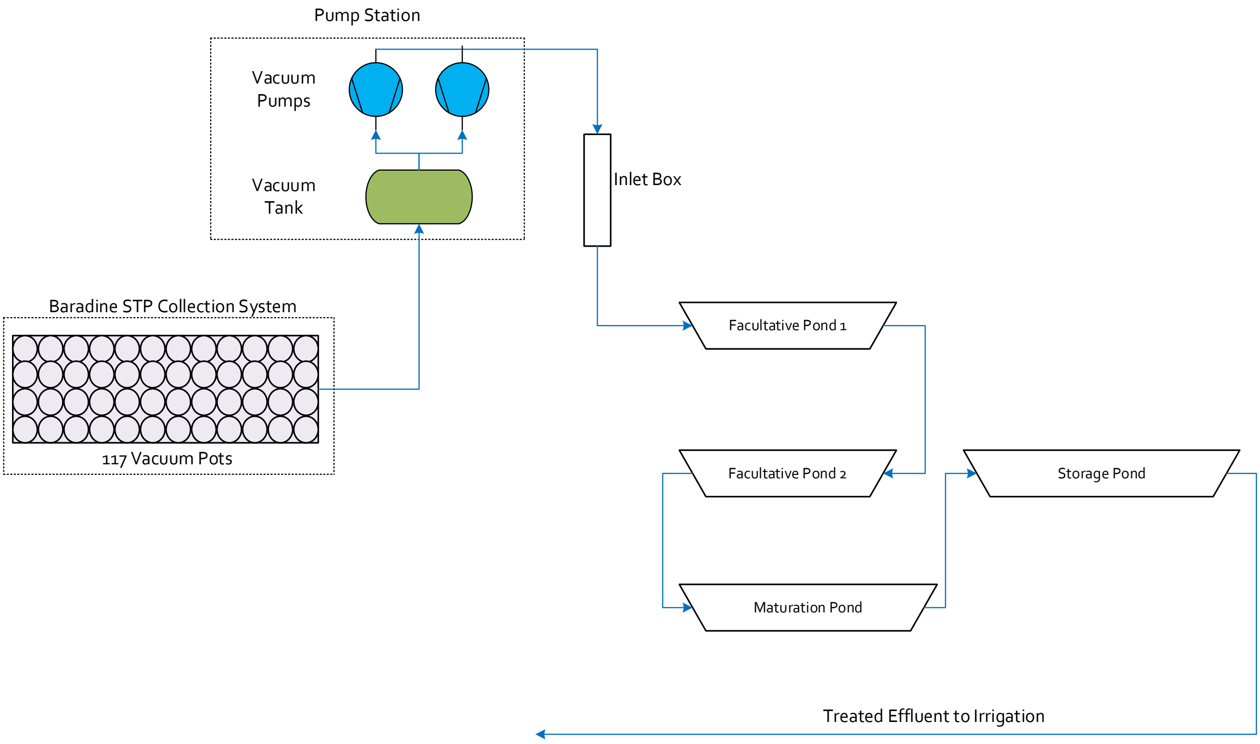

Figure 1-1: Baradine STP Process Flow Diagram

2 Design Basis and Plant Performance

2.1 Data Collection and Review

It is noted that no influent sewage monitoring is currently undertaken at Baradine STP. This presents challenges in capacity planning and design studies for the STP system. A gap analysis of data reviewed has identified several parameters for which additional sampling could be undertaken for determining operational limits on process performance. The following process streams and or sampling locations were identified.

Table 2-1: Baradine STP Sampling Points Proposed

Number	Description	Type of Monitoring	Sample Type
1	Influent	Quality and volume	Autosampler – or alternative
2	Pond Inlet (All Ponds)	Quality	Grab samples – twice daily for minimum of 2 weeks
3	Pond Outlet (All Ponds)	Quality	Grab samples – twice daily twice daily for minimum of 2 weeks

Effluent quality monitoring is conducted as per the Baradine STP licence requirements (Refer to Section 2.2.3).

Table 2-2: Suggested Monitoring Program for Baradine STP

Parameter	Influent	Ponds	Final Effluent
Soluble BOD/COD	x	x	x
Total BOD/COD	x		
Suspended Solids	x	x	x
Ammonia	x		x
Nitrate			x
TKN	x		x
Total phosphate	x		x
DO	x	x	x
pH	x	x	x
Temperature	x	x	x
E.Coli			x

Dissolved oxygen (DO), pH and temperature should be measured weekly by WSC operators beyond the intense sampling period described above. It should become normal practice for Council. Appropriate portable instruments may need to be purchased. Training should be provided on the use of those instruments, particularly the DO meter.

2.2 Current Influent and Effluent

2.2.1 Influent Flow

Influent flow is currently not measured. In typical sewage treatment systems, influent flow monitoring is required for license purposes, however as noted in section M6.1 of EPL 5950, the STP discharge flow is monitored by calculation method (pump capacity multiplied by operating time).

Sewage flow to Baradine STP is reportedly not influenced by wet weather events. Average dry weather flow (ADWF) has been estimated using current the number of sewer connections in Baradine and non-residential flows as estimated from Trade Waste Discharge water use data.

The ADWF to Baradine STP has been estimated to be approximately 205 kL/d.

There was no data available to determine diurnal flow patterns, however the following peaking factors size town were used to estimate the peak flows.

- Peak Wet Weather Flow PWWF) Peaking Factor – 4.0 (for vacuum sewer)
- Peak Dry Weather Flow (PDWF) Peaking Factor - 2.6

The historical Queensland approach was adopted for peaking factor estimation.

Peaking factor for PDWF = $4.7 \times (EP)^{-0.105}$

Peaking factor for PWWF= 3.5 to 5

2.2.2 Influent Composition

Appendix A shows the estimated volume contribution from the non-residential sources in the Baradine STP Catchment. The relative contribution of trade waste to the overall sewage flow and quality is relatively low in the Baradine catchment. Trade waste customers contribute less than 30% of the inflow to the plant. There is limited or no data relating to trade waste pollutant concentration (e.g. BOD, COD, TSS, Oil and Grease etc). As a result, it was assumed that the strength of the sewage from trade waste customers is the same as the residential flows.

While it is noted that no influent quality monitoring occurs at Baradine STP, the following table provides a summary of plant influent loading data (for 855 EP), based on typical domestic sewage characteristics at ADWF.

Table 2-3: Summary of Plant Influent Data

Analyte	Units	Typical Value	Basis
BOD	kg BOD/day	51.3	60g/EP/day BOD
TSS	kg TSS/day	51.3	60g/EP/day TSS
TN	kg TN/day	10.3	12g/EP/day TN
TP	kg TP/day	4.3	5g/EP/day P

2.2.3 Final Effluent

The results of monitoring of the Baradine STP treated effluent at the licence monitoring point are provided in Table 2-4. There are no concentration limits included in the licence. The EPL requires sampling quarterly during discharge.

Table 2-4: Treated effluent sampling results – Baradine STP EPA point 2 (Discharge to utilisation area)

Sample Date	pH	TSS (mg/L)	TN (mg/L)	TP (mg/L)	Oil and Grease (mg/L)	BOD (mg/L)
02/09/2015	9.0	66	9.2	10.	5	29
02/05/2017	9.2	126	15.2	11	2	18
28/03/2018	9.8	118	14.7	9	6	22

It is noted in the table above that the pH of the effluent is quite high (above 9). Furthermore, the TSS:BOD ratio is also quite high. This typically indicates potential algae overgrowth in the pond system.

3 Background Review

3.1 Summary of Previous Investigations

3.1.1 Connection of Camp Cypress to Baradine STP

The following options have been previously investigated by WSC with respect to connecting Camp Cypress to Baradine STP.

Option 1: Direct Connection to Baradine Sewerage System.

This option includes a direct connection from the facilities at Camp Cypress to the Baradine STP vacuum sewerage system. This would involve a new connection to and extension of the vacuum main at the corner of Lachlan and Naomi Streets where seven (7) new vacuum pots would receive the effluent from Camp Cypress. A schematic of the proposed option is shown in Figure 3-1.

Obtained cost estimates for this option are as follows:

Table 3-1: Cost Estimates for Direct Connection to Baradine STP

Item	Cost Estimate
A rising main and associated connections, including a tank, pumps and pressure line from Camp Cypress to the Lachlan/Naomi Street interface	$238,150
Vacuum Pots (×7) and branch line at the Lachlan/Naomi Street site	$300,000
Total Estimated Project Cost	$538,150

Under this option, the Showground Trust would be required to provide all internal sewerage collection systems, including pumps, tanks and pipework.

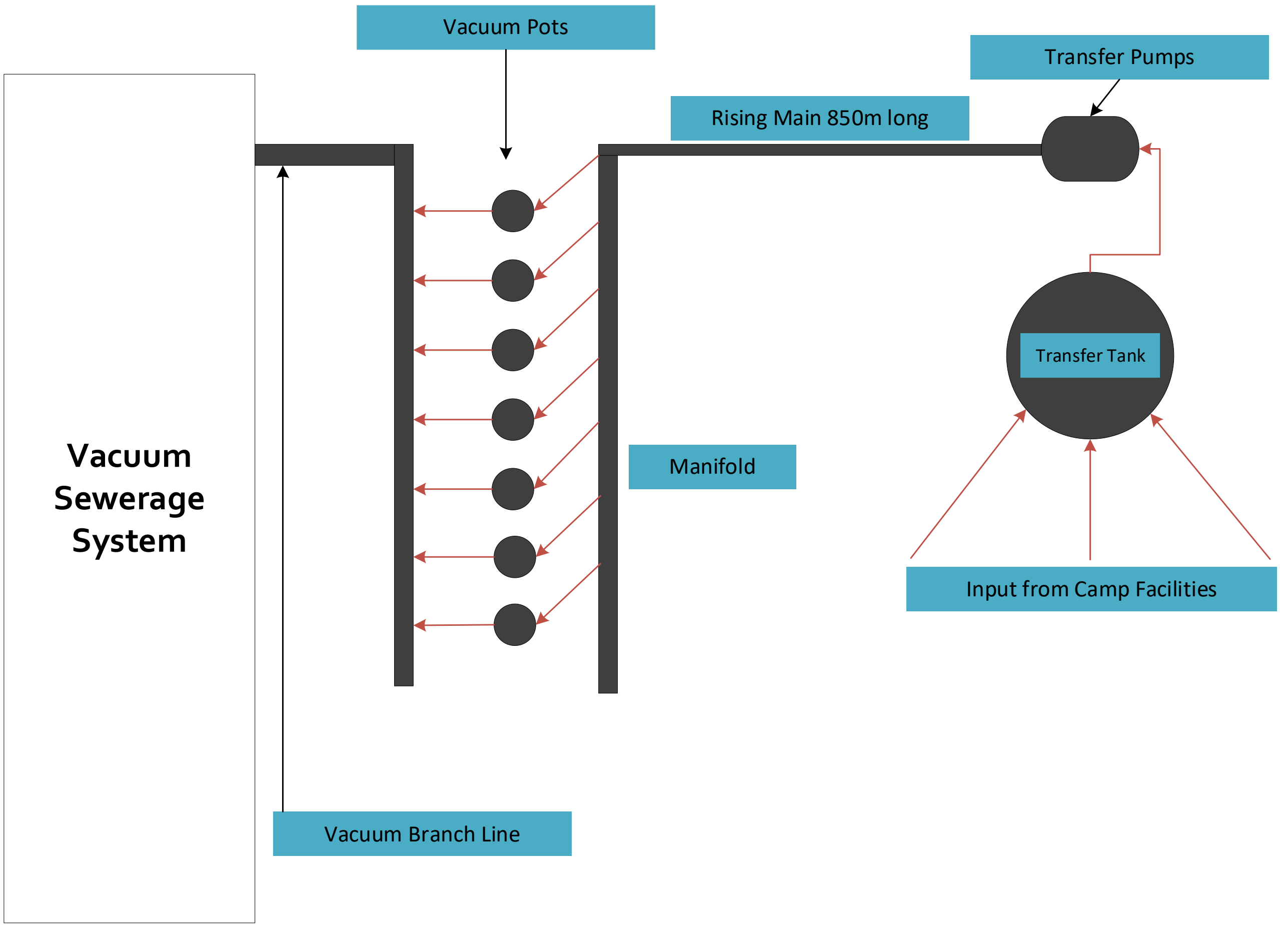

Figure 3-1: Camp Cypress – Proposed Sewer Connection Layout

Option 2: Construct a pipeline directly to the Sewerage Treatment Ponds

In this option, a direct pipeline from Camp Cypress to Baradine STP is proposed. WSC has conducted prior studies including an Ecological Assessment and an Aboriginal Due Diligence Assessment. Based on these prior investigations, it was noted that there are further restraints to be overcome.

The Ecological assessment identified a variety of threatened fauna species as potentially inhabiting or using the habitat along the proposed route – prompting further investigations. To address this issue, an option was to use Council's discretion in applying for an easement within Baradine Common. Another issue was on who would bear the Operating & Maintenance costs for the pipeline. A recommendation was made to apply for an easement. It is not clear whether this application went forward

The Aboriginal Due Diligence identified a few Aboriginal cultural heritage sites, however the site assessment resulted in the conclusion that the sites were not at risk from the proposed pipeline works if proposed management strategies would be followed.

The total project cost for this option was approximately $400,000. Under this option, the Showground Trust would be required to provide all internal sewerage collection systems, including pumps, tanks, and pipework.

Figure 3-2 shows the location of the proposed sewer pipeline connecting Camp Cypress to the Baradine STP.

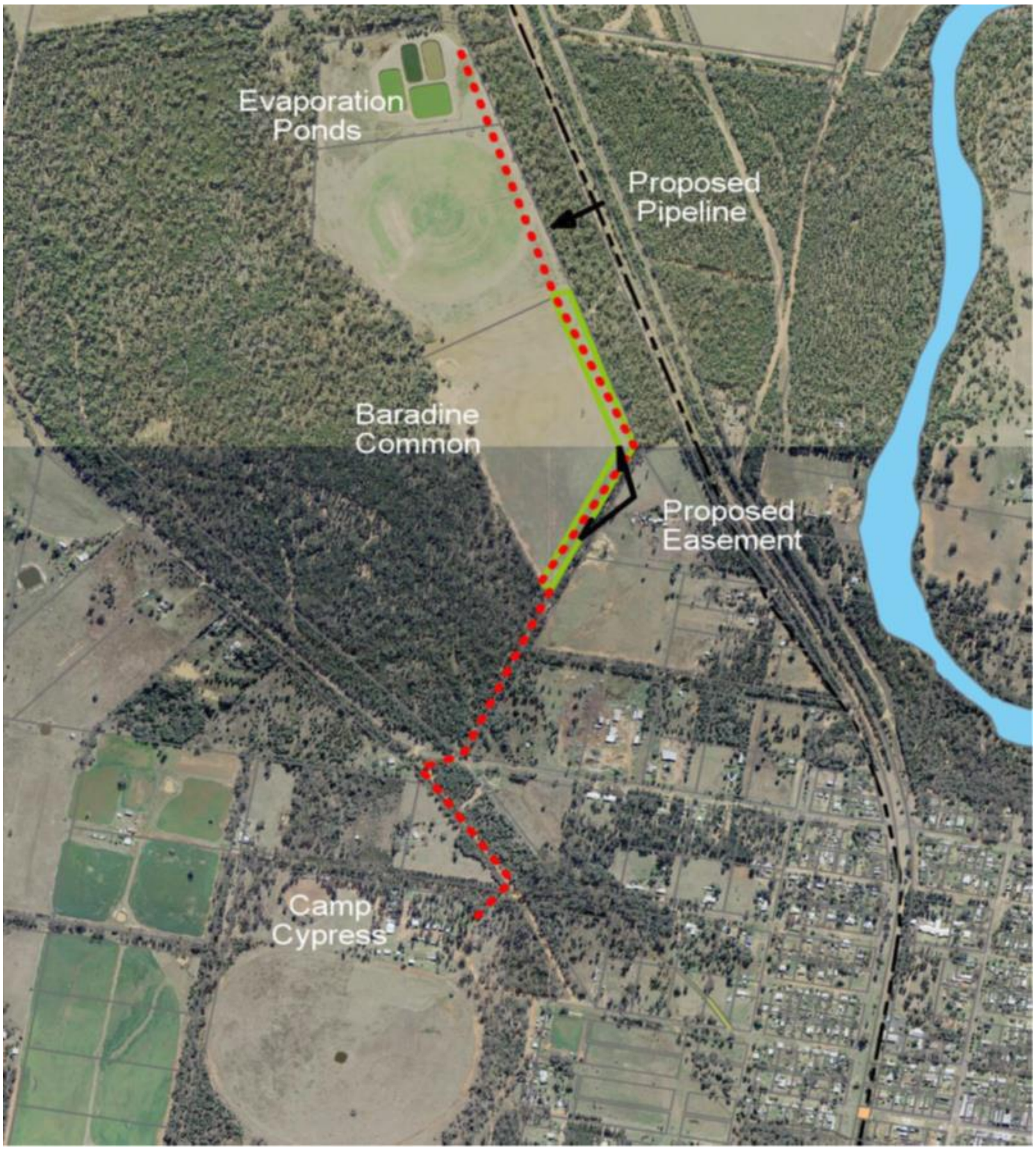

Figure 3-2: Location of Proposed Sewer Pipeline Connecting Camp Cypress to the Baradine STP

CWT is currently investigating typical and peak sewerage generation rates at the Camp and capacity of Baradine STP. This will determine the need to review connection options and update cost estimates.

3.1.2 Previous STP Capacity Assessments

Treatment Capacity

It has been noted that the current performance and capacity of Baradine STP are unknown. In 2019, a high-level assessment was conducted to review the ability of the treatment ponds at Baradine to accept additional loads from the proposed inland rail workers' camp. The assessment was conducted adopting the following dimensions, areas, and volumes for the ponds.

Table 3-2: Pond Description and Dimensions at Baradine STP

Description	L (m)	W (m)	D (m)	A (m^2)	V (m^3)
Facultative Pond 1	100	38	2.1	3,800	7,980

Description	L (m)	W (m)	D (m)	A (m^2)	V (m^3)
Facultative Pond 2	100	38	1.9	3,800	7,220
Maturation Pond	110	52	1.75	5,720	10,000

The following assumptions were adopted in the previous capacity assessment:

- The storage pond was not included in the capacity assessment
- Residential load was based on the 2016 census figures resulting in an Equivalent Population (EP) of 760
- A non-residential EP of 138 was used for non-residential load
- Hydraulic loading was taken as 240 L/EP/day
- BOD loading was taken as 60 g/EP/day
- Using the residential and non-residential EP estimates, the Average Dry Weather Flow (ADWF) was calculated to be 216 m^3/d
- Additional load from the planned inland rail workers camp was taken as 500 EP. This resulted in a total ADWF of 336 m^3/d.
- Current volumetric loading rate (2019) was taken as 20 $g/m^3/d$
- Proposed volumetric loading rate was taken as 31 $g/m^3/d$
- Faecal Coliform concentration in the influent was taken 1x10^6 cfu/100 mL
- The minimum average monthly temperature was taken 9.5°C.

The results from the previous capacity assessments are summarised in Table 3-3 below. These results were based on modelling of the system using methodologies developed by Mara and Marais.

Table 3-3: Results from the previous Capacity Assessment (Hunter H2O, 2019)

Parameter	Value	Comment
Modelled performance under current loads		
Combined Surface Area	7,600 m^2	Greater than the minimum requirement of 5,735 m^2 for the minimum average monthly temperature 9.5°C
Retention Time	70 days (facultative) 46 days (maturation)	Good
Facultative Pond 1 effluent unfiltered BOD	Approx. 20 mg/L	This indicates a moderate load on the second oxidation pond
Predicted facultative Pond 2 effluent BOD	Less than 5 mg/L	Acceptable
Maturation pond BOD surface loading rate	Less than 1 kg/ha/d	Acceptable

Parameter	Value	Comment
Modelled performance under proposed loads		
Combined Surface Area	7,600 m^2	Less than the minimum requirement of 8,921 m^2 for the minimum average monthly temperature of 9.5°C
Retention Time	51 days (facultative) 30 days (maturation)	Good
Facultative Pond 1 effluent unfiltered BOD	Approx. 35 mg/L	This indicates a moderate load on the second oxidation pond
Predicted facultative pond 2 effluent BOD	Less than 5 mg/L	Acceptable
Maturation Pond BOD surface loading rate (kg/ha/d)	2.5 kg/ha/d	Acceptable

First order modelling of faecal coliform destruction was undertaken. Based on an influent concentration of 1x10^6 org/100 mL and the retention time in the three ponds, the winter median concentration of ~350 org/100 mL for the current load increased to a median of <1000 org/100 mL. Nematode removal through sedimentation of >25 days was achieved in both the current and proposed conditions.

Based on the modelling performed in the previous investigations, Hunter H2O concluded the following:

- Additional load associated with the inland rail workers' camp would be manageable if connected to the Baradine STP.
- Additional refuse and detritus will increase crust and solids build up at the inlet to the works.
- Any commercial cooking (grease and fats) or laundry operations (detergents, caustic material) associated with the camp may exceed assimilative capacity of impact on the biology of the pond system.
- Sludge and inerts that have accumulated in the ponds over time will reduce the retention time and treatment effectiveness compared to that modelled. As sludge accumulates in the pond system, regular desludging of the inlet zone of ponds 1 and 2 should be undertaken to maintain treatment effectiveness.

3.1.3 Previous Baradine STP Sludge Survey

In 2014, WSC commissioned Oceanic Bio Innovative Water Solutions to conduct a sludge survey at the Baradine Sewerage Ponds . The results obtained are presented below.

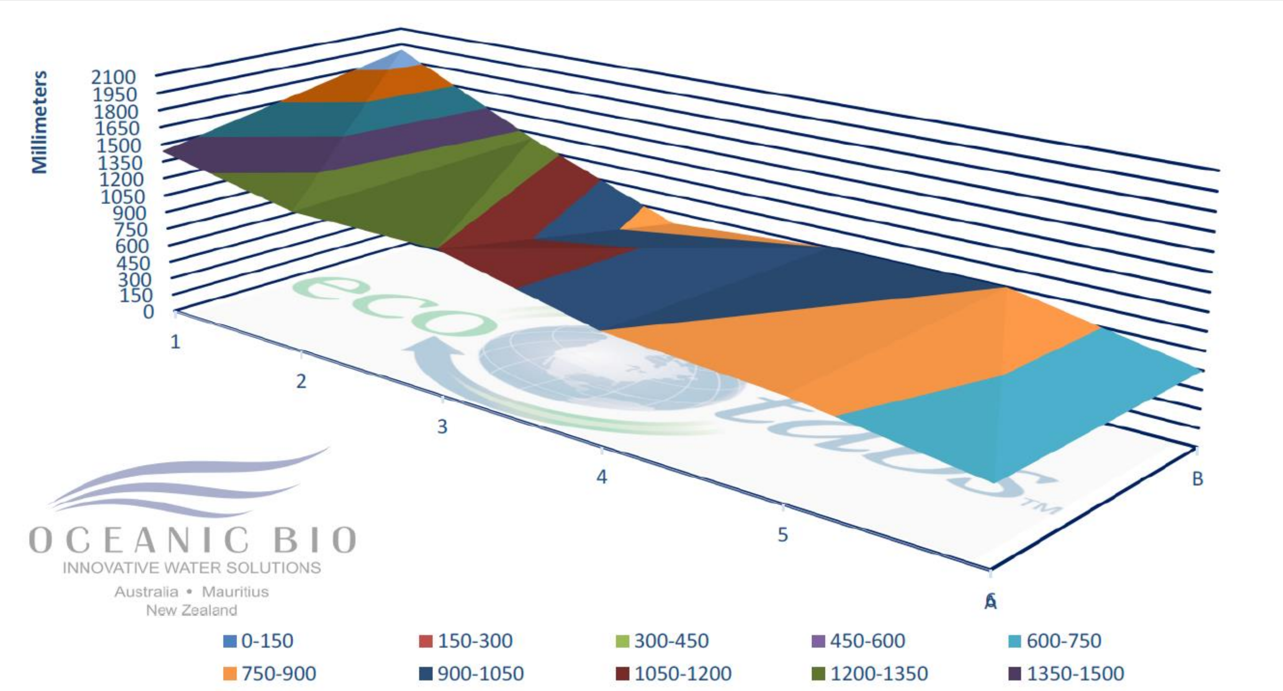

Figure 3-3: Baradine Sludge Survey 28 May 2014

Table 3-4: Baradine STP Sludge Survey 28 May 2014

	1	2	3	4	5	6	Average
Section A							
Pond Depth	**2,500**	**2,500**	**2,400**	**2,400**	**2,100**	**2,100**	**2,333**
Sludge Depth (mm)	1,060	1,300	1,200	1,500	1,300	1,500	1,310
Sludge Thickness (mm)	1,440	1,200	1,200	900	800	600	1,023
Section B							
Pond Depth	**2,500**	**2,500**	**2,400**	**2,400**	**2,100**	**2,100**	**2,333**
Sludge Depth (mm)	600	1,200	1,600	1,500	1,200	1,500	1,267
Sludge Thickness (mm)	1,900	1,300	800	900	900	600	1,067

From the results in Table 3-4, the average total depth was approximately 2,333 mm and the average sludge thickness was 970 mm, indicating that sludge occupied about 41% of the pond depth. It is noted that for optimum operation of waste stabilisation ponds, the volume of sludge in the primary facultative pond should typically represent 15 – 30% of the total volume of the basin. A filling rate above 30% necessitates desludging[1].

3.2 Site Visit Observations

On 6th October 2020, CWT's Senior Process Engineer – Neville Tawona visited Baradine STP and conducted a site tour of the pump station and the lagoon system. The following issues were noted during the site visit.

Table 3-5: Site Visit Issues

Issue/Item	Description
Baradine STP Pump Station	
Data Collection	During the site visit, it was observed that currently, operational data at the pump station is recorded on paper logs – no digital cataloguing and storage. It is thus difficult to track operational trends of pump cycles.
Control System	There is an onsite control system including a wall mounted PLC for the vacuum tank and vacuum pump systems. There is a current proposed project to install a SCADA system.
Vacuum System	There is a vacuum tank and two vacuum pumps. There are two duty submersible pumps for sewage at the pump station with a duty point of 20L/s each. The capacity of the vacuum system (including vacuum pots, pumps and tank) will need to be assessed for their ability to service potential / future flows and loads in this study.
Odour Issues	There have been numerous odour complaints from the neighbouring residential properties WSC have confirmed that a project to install a new odour bed is currently underway.
Baradine STP Lagoon/Pond System	
Configuration	There are currently four (4) ponds, which include two (2) facultative ponds (Pond 1 and Pond 2), a maturation pond (Pond 3) and a Storage Pond (Pond 4). These ponds are configured in series. Effluent from the storage pond is irrigated at an adjacent site.
Inlet Structure	Some trash was seen at the inlet box. Visual inspection of the inlet structure indicated potential sulphate and chloride attack on the concrete wall. Refurbishing and/or replacement could be required.
Pond Appearance	Sewage appeared to have a green colour in all ponds except Pond 1. This typically indicates an algal bloom potentially due to long detention times. pH and TSS:BOD ratio will likely be high (this will be verified through tests). Old sludge which has built up over the years will need to be removed. Tall weeds were also observed in Pond 2 and Pond 3. Pond maintenance is thus critical because tall weeds can stop the wave action when wind is blowing, which would limit treatment capacity.
Effluent Irrigation	It was noted that effluent is irrigated on adjacent land. Irrigation schedules and irrigation pump capacity need to be understood to determine overall detention time of sewage in the ponds.
Environmental Compliance	There are currently no concentration / load limits imposed by the EPL (EPL No. 5950) with respect to effluent irrigation at Baradine STP discharge location. There is a volume limit

[1] Picot B et al., 2005

	only. Furthermore, we understand that WSC and the EPA have had prior discussions regarding surrendering the EPL 5950. For sustainable effluent management, WSC would need to have internal targets based on best practice sewage treatment practices. Classification of effluent as low, medium or high strength could be conducted as part of an ongoing irrigation management plan to mitigate environmental risks associated with effluent irrigation, runoff and establish sustainable discharge controls.
Camp Cypress	
Existing Sewerage System	Currently, Camp Cypress has a septic tank system to manage sewage onsite. Based on discussions with Camp Management, there are numerous occasions whereby the septic tank storage does not cope with sewage generation. The current storage capacity is unknown. The interim strategy implemented at Camp Cypress to cope with overflows is to use a liquid waste contractor to pump out the septic tanks for transport of sewage to an offsite disposal facility.
Number of Visitors	The number of visitors at the Camp provided to CWT is quite variable. This presents a major data gap which creates problems in assessing additional treatment capacity required. Furthermore, growth in the number of visitors to Camp Cypress is anticipated in the future and as a result, sewage treatment capacity is a limiting factor that needs to be addressed. There is a need for more data collected over at least 5 years to determine visitor trends and peak periods. It was proposed during the workshop to analyse water usage data at the Camp from Council records to estimate sewage generation rates.
Inland Rail Project	
Number of Employees	Available data indicates that the inland rail project will attract around 500 employees for the duration of the project.
Duration of project	The duration of the project will need to be confirmed. There are still some uncertainties regarding details for the inland rail project. For example, at the time of workshop 1, the identity of the proposed contractor was still unknown. Assumptions for assessing the ability of Baradine STP to accept additional wastewater loads will be confirmed with WSC.

4 Assessment of STP Capacity

The assessment of Baradine STP capacity included the following key steps:

- Detail current demand and forecast future demand
- Assess asset capacity (current and planned) to treat loads ensuring compliance to regulated product specifications and licenses (where applicable)
- Identify shortfalls in treatment capacity to service growth while maintaining compliance including the timing of these shortfalls.
- Identify the required treatment plant augmentations and provide cost estimates where applicable

4.1 Population and Load Projections

Growth demand assessment was assessed for Baradine catchment and was derived by projecting:

- Growth in residential population

- Change in existing non-residential sources where applicable
- Future additional non-residential demand.

This was used to develop the following scenarios that were further assessed:

Table 4-1: Growth Scenarios Assessed

Scenario	Description
Scenario 1	This is a business as usual (BAU) scenario whereby current sewage treatment will continue, and the only growth in the Baradine catchment will be from additional residential connections as per Council's planning priorities (as forecast in the IWCM strategy).
Scenario 2	This scenario will include: - Current sewage treatment - Growth from future additional residential connections as per Council's planning priorities (as forecast in the IWCM strategy) - Additional wastewater from Camp Cypress
Scenario 3	This scenario will include: - Current sewage treatment - Growth from future additional residential connections as per Council's planning priorities (as forecast in the IWCM strategy) - Additional wastewater from the Inland Rail Project
Scenario 4	This scenario will include: - Current sewage treatment - Growth from future additional residential connections as per Council's planning priorities (as forecast in the IWCM strategy) - Additional wastewater from Camp Cypress - Additional wastewater from the Inland Rail Project

4.1.1 Scenario 1 – BAU Sewage Treatment at Baradine

Residential growth was defined as the increase in the numbers of sewer connections in the Baradine Catchment. Number of sewer connections were provided in the IWCM Strategy for 2018, 2028, 2038 and 2048. These were used in conjunction with a household occupancy ratio of 2.4 to determine the equivalent population served.

Non-residential growth was based on data provided by WSC on Trade Waste Dischargers.

The total sewage flows calculated is presented in Table 4-2 below.

Table 4-2: Baradine Catchment Growth Projection

Parameter	Units	2020	2024	2028	2038	2048
Equivalent Population (Total)	EP	855	862	869	886	905
ADWF	m³/d	205	207	209	213	217
PDWF	m³/d	506	507	513	522	532
PWWF	m³/d	821	828	834	851	869

Based on the total flows to the STP presented in Table 4-2, the following table shows the biological loads to the Baradine STP with respect to BOD.

Parameter	Units	2020	2024	2028	2038	2048
BOD	kg/d	51	52	52	53	54

4.1.2 Scenario 2 – BAU + Growth from Camp Cypress

This scenario will still include flows and loads to Baradine STP based on current and future additional connections as presented in section 4.1.1 and additional flows and loads from Camp Cypress.

Appendix B presents the estimated maximum daily wastewater flow from the Camp Cypress.

Table 4-3 BAU + Camp Cypress Growth Projection

Parameter	Units	2020	2024	2028	2038	2048
Equivalent Population (Total)	EP	1054	1061	1068	1085	1104
ADWF	m^3/d	253	255	256	260	265
PDWF	m^3/d	697	698	704	713	723
PWWF	m^3/d	950	956	963	980	998

4.1.3 Scenario 3 – BAU + Growth from Inland Rail Project

This scenario will still include flows and loads to Baradine STP based on current and future additional connections as presented in section 4.1.1 and additional flows and loads from the proposed inland rail project. The timing for the inland rail project is currently not known, however for purposes of this study, it was assumed that the project will commence in 2021 and end in 2024.

Table 4-4 BAU + Inland Rail Project Growth Projection

Parameter	Units	2020	2024	2028	2038	2048
Equivalent Population (Total)	EP	1355	1362	869	886	905
ADWF	m^3/d	325	327	209	213	217
PDWF	m^3/d	986	987	513	522	532
PWWF	m^3/d	1121	1128	834	851	869

4.1.4 Scenario 4 – BAU + Growth from Camp Cypress and Inland Rail Project

This scenario will still include flows and loads to Baradine STP based on current and future additional connections as presented in section 4.1.1 and additional flows and loads from Camp Cypress and the proposed inland rail project.

Table 4-5 BAU+ Camp Cypress + Inland Rail Project Growth Projection

Parameter	Units	2020	2024	2028	2038	2048
Equivalent Population (Total)	EP	1554	1561	1068	1085	1104
ADWF	m³/d	373	375	256	260	265
PDWF	m³/d	1177	1178	704	713	723
PWWF	m³/d	1250	1256	963	980	998

4.2 Estimated STP Capacity Vs Different Growth Scenarios

The Baradine STP has an assessed treatment capacity of 1268 EP (See Appendix C for Capacity Assessment Calculation). Assessment uses the mean temperature of the air in the coldest month. Higher temperatures will improve the STP's capacity to handle the higher organic loadings.

Following Figure 4-1 indicated that the STP has enough capacity to treat the wastewater from Baradine under different growth scenarios until 2048.

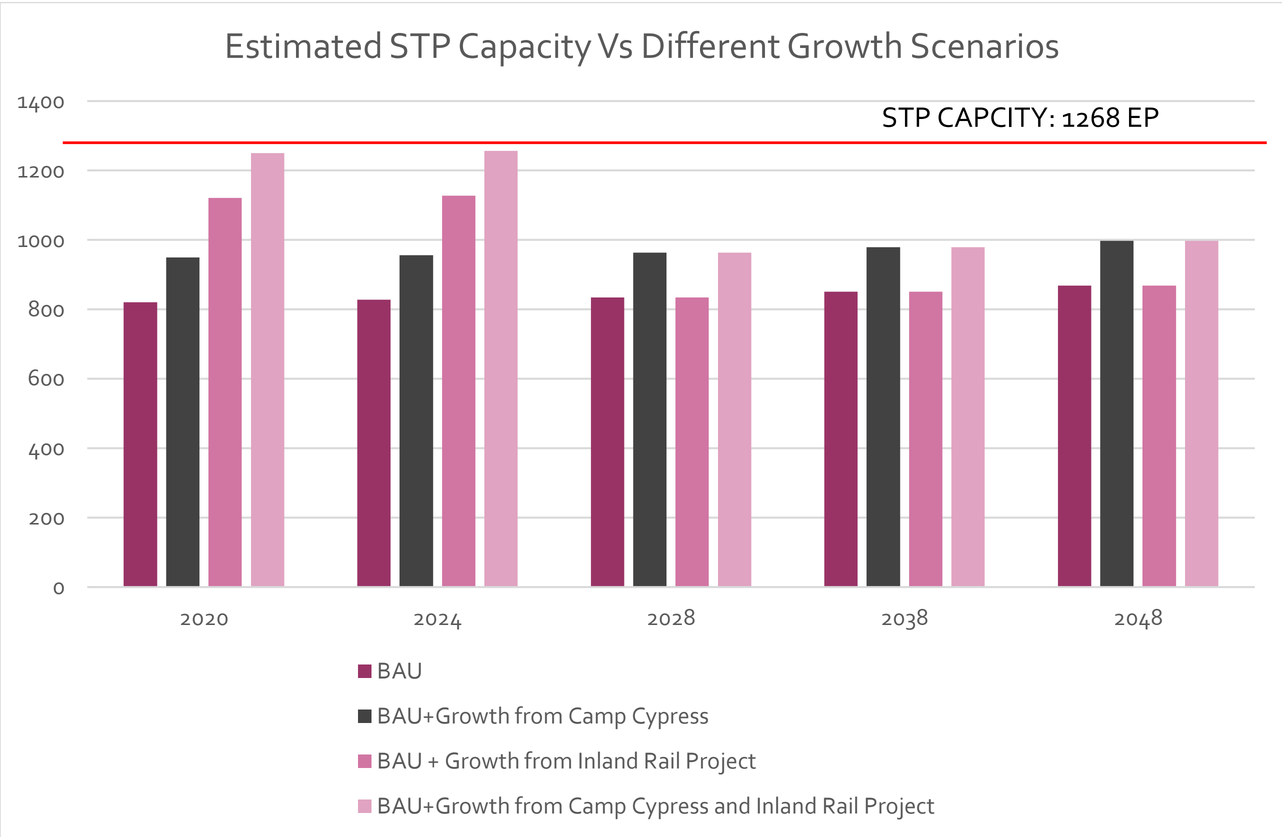

Figure 4-1 Estimated STP Capacity Vs Different Growth Scenarios

5 Discussion and Recommendations

The Baradine STP has an assessed treatment capacity of 1268 EP. Assessment uses the mean temperature of the air in the coldest month. Higher temperatures will improve the STP's capacity to handle the higher organic loadings.

The total wastewater generation per day from the non-residential sources (see Appendix A) is estimated to be 58.1 kL (242 EP).

The maximum wastewater generation on Showground Day from the Camp Cypress (see Appendix B) is estimated to be 47.7 kL (199 EP).

The Camp Cypress water meter readings (from 2006-2020) indicate that the average daily water usage at Camp Cypress is 3.75 kL/d (Note: usage can be significantly high on Showground Day). Annual wastewater generation from the Camp Cypress is estimated to be 1,027 kL assuming 75% of water ends up in sewer. With the annual net evaporation rate of 1500 mm, if suitable land size and location are available, existing septic tanks followed by an evaporation pond is a low maintenance option that should be considered for zero liquid discharge.

The Scenario 1- Baradine catchment growth projection Table 4-2 suggests that the STP has enough capacity to treat the wastewater from Baradine until 2048.

The Scenario 2- BAU+ Camp Cypress growth projection Table 4-3 suggests that the STP has enough capacity to treat the combined wastewater from Baradine and Camp Cypress until 2048. This Scenario assumed the maximum wastewater generation per day from Camp Cypress is 47.7 kL (199 EP) and remain unchanged until 2048.

The Scenario 3- BAU + Inland Rail Project growth projection Table 4-4 suggests that the STP has enough capacity to treat the combined wastewater from Baradine and Inland Rail Project camp.

The Scenario 4- BAU + Camp Cypress+ Inland Rail Project growth projection Table 4-5 suggests that the STP has enough capacity to treat the combined wastewater from Baradine, Camp Cypress, and Inland Rail Project camp. However, there is a chance of STP overloading during inland rail project period.

The immediate solution for the Scenario 4 is to increase organic treatment capacity by placing the aerator(s) close to the inlet zone of the primary facultative pond, where the oxygen demand is higher to maintain a minimum of 1 mg/L DO throughout the pond at the heaviest loading periods. Aerator/mixer can also reduce the odour and algae issues. However, the manufacturers' data should be consulted with relation to the recommended pond depth, area covered by each aerator, oxygen transfer efficiency, etc. Typical 7.5 kW aerator/mixer can cover approximately 1,500-2,000 m^2 aera for oxygenation. 2 (Two) aerators x 7.5 kW ($50,000 each) will be required to cover the primary facultative pond. Design, supply and install cost for the stand-alone automatic aeration system including 2 x aerators and a DO sensor is estimated to be $150,000 assuming power is readily available onsite. Hire option is available ($920/week/aerator) but not economically feasible for the long-term use. In the long term, a pre-treatment program with collection system monitoring of the areas suspected of introducing high organic shock loads should be developed and implemented.

Because of the number of assumptions necessary in determining the Baradine STP capacity and the likely required EP for the town growth, and inclusion of Camp Cypress and the Inland Rail Project sewage, a staged approach to the problem(s) is recommended.

- The primary facultative pond sludge survey indicated that the net pond volume is substantially reduced. It is recommended that the accumulated sludge from the primary facultative pond must be removed. (Note: The sludge should be removed when the sludge reaches a thickness that can be affected by the aerators, or usually when the sludge reaches 1/3 of the pond depth.)
- Install inlet flowmeter, manually raked coarse bar screen (15 mm openings between each bar) and the grit channel at the inlet to prevent future sludge accumulation.
- Implement a weekly monitoring program as described in Table 2-2 Use the data to determine how the plant is performing and whether it is approaching being overloaded. At the same time, once the data becomes available, repeat the analysis of the current capacity.
- Investigate options for in situ treatment of Camp Cypress waste.
- Trial recirculation of algal laden, DO rich water from the maturation or storage pond and monitor the performance of the first facultative pond including the generation of odour.
- Establish contact with a company that can provide aerators at short notice.
- Increase existing EPL limit of 85 kL/d to 250 kL/d to match the potential discharge volume of STP

Appendix A Wastewater Flowrates from Non-Residential Sources

Name of Business	Facility Type	Unit	Value	Flow, L/Unit/day		Daily Wastewater Generation (L)
				Range	Typical	
Ahmedi's IGA	Shopping Center	Employee	8	26-49	38	304
PharmaSave Baradine Pharmacy	Office	Employee	2	26-61	49	98
The Lott	Retail	Employee	2	26-61	49	98
The Embassy Baradine	coffee shop	Customer	30	15-30	23	690
		Employee	3	30-45	38	114
Baradine Rural Supplies	Shopping Center	Employee	5	26-49	38	190
Baradine Surgery	Hospital, Medical	Employee	2	19-57	38	76
Pilliga Forest Discovery Centre	Visitor Center	Visitor	20	15-30	19	380
Baradine Hotel	Hotel	Guest	15	150-230	190	2850
		Employee	5	30-49	38	190
TAB	Office	Employee	2	26-61	49	98
Baradine Multi-Purpose Service	Hospital, Medical	Bed	45	470-910	630	28350
		Employee	10	19-57	38	380
Baradine Central School	School, day-only with canteen	Student	120	38-76	57	6840
		staff	30	26-61	49	1470
Warrigal Gardens Bed and Breakfast	Hotel	Guest	4	150-230	190	760
Casey's Corner	coffee shop	Customer	50	15-30	23	1150
		Employee	2	30-45	38	76
Baradine Police Station	Office	Employee	5	26-61	49	245

Bowling Club & Squash Courts	Bowling alley	alley	7	570-950	760	5320
St John's Catholic Primary School	School, day-only with canteen	Student	38	38-76	57	2166
		staff	12	26-61	49	588
Australia Post	Office	Employee	2	26-61	49	98
Tattersalls Hotel	Hotel	Guest	10	150-230	190	1900
		Employee	3	30-49	38	114
NSW AMBULANCE	Office	Employee	2	26-61	49	98
ASM mechanical	Automobile service station	Vehicle served	3	30-57	45	135
		Employee	3	34-57	49	147
Forestry corporation of NSW	Office	Employee	5	26-61	49	245
Baradine library		Employee	1	30-45	38	38
Memorial swimming pool		Customer	10	19-45	38	380
		Employee	1	30-45	38	38
Emmy Lou's Eatery	coffee shop	Customer	50	15-30	23	1150
		Employee	2	30-45	38	76
The Embassy	coffee shop	Customer	50	15-30	23	1150
		Employee	2	30-45	38	76
			Total Wastewater Generation (L/d)			58,078
				Equivalent Population		242

Appendix B Estimated Wastewater Flowrates from Camp Cypress during Showground Day

Name of Business	Facility Type	Unit	Value	Flow, L/Unit/day		Daily Wastewater Generation (L)
				Range	Typical	
Camp Cypress Accommodation and Facilities	Cabin, Resort	Person	92	30-190	150	13800
	Dining hall	meal served	200	15-38	26	5200
	Trailer camp	Trailer	50	280-570	470	23500
	Fairground	Visitor	600	4-8	8	4800
		Employee	10	30-45	38	380
				Total Wastewater Generation (L/d)		47,680
				Equivalent Population		199

Appendix C Capacity Assessment Calculation

Assumptions

The following assumptions are adopted in the capacity assessment:

- Hydraulic loading: 240 L/EP/day
- BOD loading: 60 g/EP/day
- Influent total BOD: 250 mg/L
- Faecal Coliform concentration in the influent: 1x10^6 cfu/100 mL
- Helminth eggs concentration in the influent: 100 eggs/L
- The lowest monthly mean air temperature: 10°C
- Flow regime: Dispersed
- Annual rainfall: 500 mm
- Annual evaporation: 2000 mm
- All ponds are completely de-sludged.

Facultative & Maturation Ponds

Proposed by Mara (1997) the pond sizing equation uses the mean temperature of the air in the coldest month. The reason for using the mean temperature of the air is that, in the cold period, a safe value is obtained since the temperature of the water will be slightly higher.

The temperature data for the period of 2009-2020 indicated that the lowest monthly mean air temperature at Baradine was 10 °C in July 2011,2014 & 2015[2].

Equivalent Population

The surface loading rate of the facultative pond can be estimated using following equation.

$$L_s = 350 \times (1.107 - 0.002 \times T)^{(T-25)}$$

Where:

L_s=Surface loading rate (kgBOD$_5$/ha.d)

T=Mean air temperature in the coldest month (°C)

$$L_s = 350 \times (1.107 - 0.002 \times T)^{(T-25)}$$

$$L_s = 350 \times (1.107 - 0.002 \times 10)^{(10-25)}$$

$$L_s = 100.14$$

The area required for the facultative pond can be calculated as a function of the surface loading rate L_s.

$$A = \frac{L}{L_s}$$

[2] *https://www.worldweatheronline.com/lang/en-au/baradine-weather-averages/new-south-wales/au.aspx*

Where:

A= Area required for the pond (ha)

L= Influent total BOD (kgBOD$_5$/d)

L_s=Surface loading rate (kgBOD$_5$/ha.d)

The total area of existing facultative ponds is 7,600 m^2 (0.76 ha). Hence., the influent total BOD of the facultative ponds can be estimated as follows:

$$L = A \times L_S = 0.76 \times 100.14 = 76.1$$

The estimated equivalent population (EP) is:

$$EP = \frac{L \times 1000 \frac{g}{kg}}{60 \frac{g}{EP.d}} = \frac{76{,}109}{60} = 1268$$

Detention Time

The detention time of the facultative ponds can be estimated as follows:

$$t = \frac{V}{Q} = \frac{V}{EP \times 0.24} = \frac{(7980 + 7220)}{1268 \times 0.24} = 49.9\ d$$

The detention time required for the oxidation of the organic matter varies with the local conditions, especially the temperature. The lower detention time required in the area where the influent temperature is higher. Typical design detention time for facultative pond is 15-45 days.

The detention time of the maturation pond can be estimated as follows:

$$t = \frac{V}{Q} = \frac{V}{EP \times 0.24} = \frac{10000}{1268 \times 0.24} = 32.9\ d$$

The detention time in a maturation pond is a function of the pond shape and the required coliform removal efficiency. Minimum detention time of 3 days is required to avoid short circuiting and the washing-out of algae. Typical design detention time for maturation pond is 10-20 days.

Where:

t = Detention time (d)

V = Pond volume (m^3)

Q = Influent flow (m^3/d)

Hydraulic loading = 240 L/EP/day = 0.24 m^3/EP/day

BOD Removal in Facultative Ponds

Dispersed flow regime adopted in the following calculation.

Dispersion number $d = \frac{1}{\frac{L}{B}} = \frac{1}{\frac{100}{38}} = 0.38$

Where:

d= Dispersion number

L= Length of the facultative pond (m)

B= Breath of the facultative pond (m)

The value of BOD removal coefficient at 20 °C can be obtained using following equation.

K(dispersed flow) $= 0.091 + 2.05 \times 10^{-4} \times L_s = 0.091 + 2.05 \times 10^{-4} \times 100.14 = 0.11 d^{-1}$

Where:

L_s= Surface loading rate (kgBOD$_5$/ha.d)

The value of BOD removal coefficient at 10 °C can be calculated as follows:

Correcting K for 10 °C:

$$K_{10} = K_{20} \times \theta^{(T-20)} = 0.11 \times 1.07^{(10-20)} = 0.22 d^{-1}$$

Where:

θ= Temperature coefficient[3] = 1.07

The effluent BOD concentration from the facultative ponds is:

$$a = \sqrt{1 + 4 \times K_{10} \times t \times d} = \sqrt{1 + 4 \times 0.22 \times 49.9 \times 0.38} = 4.2$$

$$S_e = S_i \cdot \frac{4 \times a \times e^{\frac{1}{2d}}}{(1+a)^2 \times e^{\frac{a}{2d}} - (1-a)^2 \times e^{-\frac{a}{2d}}} = 250 \frac{4 \times 4.2 \times e^{\frac{1}{2 \times 0.38}}}{(1+4.2)^2 \times e^{\frac{4.2}{2 \times 0.38}} - (1-4.2)^2 \times e^{-\frac{4.2}{2 \times 0.38}}} = 2\, mg/L$$

Actual effluent BOD is expected to be higher than calculated value because of presence of algae. Each 1 mg of algae generates a BOD5 around 0.45 mg. The suspended solids from facultative ponds are about 60-90% algae. The effluent BOD from the facultative ponds is the influent concentration to the maturation pond.

The BOD removal efficiency in the facultative ponds is:

$$E = \frac{S_i - S_e}{S_i} \times 100 = \frac{250 - 2}{250} \times 100 = 99.1\%$$

BOD Removal in Maturation Pond

The main objective of maturation pond is the removal of pathogens. However, maturation pond can provide additional polishing of BOD, although this is usually limited to only 10-25%.

Helminth Eggs Removal

The concentration of Helminth Eggs (HE) in the effluent from the waste stabilisation pond system will be estimated with the following assumptions:

Equivalent Population = 1268 inhab

Influent flow = 304 m³/d

Concentration of HE in the raw sewage, C_i = 100 eggs/L

Hydraulic detention time in facultative ponds, t = 49.9 day

Hydraulic detention time in maturation ponds, t = 32.9 day

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[3] *Sperling, M. V., "Waste Stabilisation Ponds: Biological Wastewater Treatment Series, Volume 3", 1st Edition, IWA publishing (2007)*

The HE removal efficiency in the facultative ponds can be estimated as follows:

$$E = 100 \times \left[1 - 0.41e^{\left(-0.49t + 0.0085t^2\right)}\right] = 100 \times \left[1 - 0.41e^{\left(-0.49 \times 49.9 + 0.0085 \times 49.9^2\right)}\right] = 98.47\%$$

The concentration of HE in the effluent of facultative ponds is:

$$C_e = C_i \times \left(1 - \frac{E}{100}\right) = 100 \times \left(1 - \frac{98.47}{100}\right) = 1.53\ eggs/L$$

The effluent from the facultative ponds do not comply with the national *guideline for sewerage systems-use of reclaimed water* quality of less than or equal to 1 egg per litre to protects crop consumers.

The HE removal efficiency in the maturation pond can be estimated as follows:

$$E = 100 \times \left[1 - 0.41e^{\left(-0.49t + 0.0085t^2\right)}\right] = 100 \times \left[1 - 0.41e^{\left(-0.49 \times 32.9 + 0.0085 \times 32.9^2\right)}\right] = 99.96\%$$

The concentration of HE in the effluent of maturation pond is:

$$C_e = C_i \times \left(1 - \frac{E}{100}\right) = 1.53 \times \left(1 - \frac{99.96}{100}\right) = 6.12 \times 10^{-4}\ eggs/L$$

In practical terms, this value corresponds to a HE concentration of zero in the maturation pond effluent.