ROUS
COUNTY COUNCIL

BULK WATER SUPPLY | WEED BIOSECURITY | FLOOD MITIGATION

Dungarubba Canal
Active Floodgate Management Plan

2021-2024

Management Plan operational summary

Dungarubba Canal is located four kilometres west of Broadwater in Northern NSW. The approximately seven-kilometre-long drain enters the Richmond River on its western bank. The system drains through the northern end of an extensive low-lying area that stretches from Dungarubba in the north, through Kilgin, and south to North Woodburn. Dungarubba Canal is one of the longest drainage systems on the Richmond floodplain.

The canal is floodgated at its junction with the Richmond River. A large concrete headwork structure has been constructed through the natural river levee and five floodgates installed on the downstream side. The central floodgate has been modified with a sluice window to allow tidal exchange. It is that modification to which this Plan applies. The term 'floodgate' within this Plan refers to the sluice window that is opened and closed to allow tidal exchange between the drain and the Richmond River.

Dungarubba Canal is a constructed drainage system that shows few natural characteristics and is surrounded by agricultural land used for grazing and sugar cane. However, the drainage system is a priority for active management as it can discharge large volumes of poor water quality into the Richmond River estuary and it holds a considerable volume of water in which fish can be present.

Active floodgate management commenced at Dungarubba Canal in 2010. Based on scientific understanding, it is known that tidal exchange (during non-flood periods) can improve water quality and reduce the risk of fish kills within the drain. However, this relies on the sluice window being open for frequent, long periods of time.

Tidal exchange can neutralise and dilute acid discharge from acid sulfate soils. During the warmer months, tidal exchange can also reduce stagnant conditions, which stabilises dissolved oxygen levels and reduces algal blooms within the drainage system. However, active floodgate management does not resolve all water quality issues in the system and does not reduce deoxygenated (blackwater) water after flooding.

While acknowledging the limitations, the environmental impact of Dungarubba Canal floodgates can be reduced through active management, and it continues to be an important on-going strategy. This Plan outlines how tidal exchange will continue and suggests additional management strategies to reduce the system's impact further.

Environmental goals and strategies

The goals and strategies listed here specifically relate to Dungarubba Canal and identify the desired outcome from actively managing the floodgates. Goals are listed in priority order.

Goals

1. Reduce acidic discharge from the drainage system into the Richmond River estuary.
2. Reduce stagnant conditions within the drainage system.
3. Reduce the risk of fish kills within the drainage system.

Strategies

1. Formalise the current opening strategy for the system's floodgate.
2. Encourage best management practices and additional remediation strategies to further reduce the impact of Dungarubba Canal on the Richmond River estuary.

Opening strategy for floodgate

Our understanding of the challenges involved with actively managing the Dungarubba Canal floodgates has improved in recent years. A drain invert survey was undertaken by Council in 2020, and following that, different openings of the sluice window were trialled and the impact monitored in the lowest lying areas adjacent to the canal. The review of this management plan is an opportunity to confirm how the sluice window will be managed into the future.

Active floodgate management at Dungarubba Canal must be controlled and carefully managed. The invert of the canal, the lack of fall in the lower section, along with the nearby land elevation, along with the large tidal range and high salinity experienced in this part of the estuary, means there is a risk of the canal overtopping and flooding low-lying land. The canal also has little freeboard through its middle section, which is very low lying. If drain water levels are elevated through this section from tidal exchange, the canal may not have adequate storage for heavy rain events.

The intention is to manage the sluice window to restrict tidal exchange to the first two kilometers of the drainage system where:

- the canal banks are higher, and overtopping will not occur
- surrounding land elevation is higher and tidal exchange will not influence drainage of land
- secondary, side drains are floodgated and tidal exchange can be restricted to within the main drain.

Restricting tidal exchange to the first two kilometers of Dungarubba Canal will:

- dilute or neutralise any runoff from acid sulfate soils before it is discharged into the Richmond River
- assist with reducing stagnant conditions and stabilising dissolved oxygen levels in the deepest body of water within the drain
- reduce the risk of fish kills within the drain
- reduce the buildup of vegetation within this section of drain, which can cause problems during floods by becoming lodged in the floodgates or culvert.

Depending on seasonal conditions (e.g., prolonged dry weather versus prolonged wet weather) the sluice will be opened 50mm, 75mm, 100mm, or closed. The sluice will be closed when drain water levels are above 0.1 on a flood gauge marker installed in the canal, three kilometres upstream of the floodgates. This gauge has been installed in the middle section of the canal, which is very low lying. The sluice will be reopened when drain water levels return to 0.1 or below on this flood gauge and there is no immediate risk of drain water levels rising from forecast rain or tides. How much the sluice is opened (50mm, 75mm or 100mm) will be determined by the landowner volunteer based on local conditions and risk. When drain water levels are at 0.1 on this flood gauge:

- the drain retains adequate storage for heavy rain events in the lowest lying area
- tidal exchange does not influence the drainage of the lowest lying land
- tidal exchange will be restricted to the first two kilometres of drain
- the risk of salinity impacting on low-lying land is greatly reduced
- there is sufficient water in the drain to assist with clearing growth of ribbon weed at the floodgate

Further, depending on prevailing weather conditions, landowners may rely on drain water to water in planted cane. In early July, Rous County Council (Council) and the cane growers on the system will decide whether the sluice window needs to be closed. This decision will be based on whether there is cane to plant in the coming months and the current weather and catchment conditions. If there is cane to plant and conditions are dry, the sluice will be closed to ensure the drain water is suitable to use. The sluice window will be reopened when water is no longer needed for watering in. The timing of this depends on adequate rainfall being received, which is usually in November or December.

This approach, although conservative from a water quality improvement perspective, will see the sluice window open more often than it has been in recent years. It is recommended that this strategy be assessed when this Plan is reviewed in three years' time to determine its effectiveness.

The sluice window will be opened and closed in accordance with the details below by the nominated landowner volunteer. Before opening or closing the sluice window, the landowner volunteer will contact Council, to allow a record to be kept of how often and how long the sluice window is kept open under the arrangements described above.

This Plan will not restrict Council from taking emergency actions outside of those listed, taking into consideration safe work procedures. Council acknowledges there are many variables during flood events and will be guided by the details below.

Close sluice in floodgate

To allow adequate storage, the sluice will be closed if drain water levels are above 0.1 as marked on the gauge in the canal, 3km upstream of the floodgate. This will be determined by the landowner volunteer by monitoring the gauge in this section of the canal.

Landowners may rely on drain water to water in planted cane (Sep to Oct). In early July, Council and landowners will decide whether the sluice will be closed. It will be reopened when drain water is no longer required. This may be as early November or as late as January, depending on weather conditions.

Flood Watch or Warning issued by the Bureau of Meteorology for the Wilsons and Richmond rivers.

The landowner volunteer contacts Council and then closes the sluice window on the first available low, run-out tide, during daylight hours.

Open sluice in floodgate

Given the triggers for closing the sluice, it is expected that it will be often closed.
Outside of those times, the sluice window will be opened 50mm, 75mm, or 100mm.

- when drain water levels are at 0.1 or below on the flood gauge 3km upstream of the floodgates and there is no immediate risk of drain water levels rising from forecast rain or tides
- when drain water is not needed to water in planted cane
- the landowner volunteer will contact Council before opening the sluice.

Contingencies

Flood warning arrives quickly and without notice.

Sluice needs to be closed and it is a high or rising tide or river water levels are too high.

Landowner is away when sluice needs to be operated.

Sluice will remain open until safe (for volunteer and infrastructure) to close it.

Landowner volunteer will notify Council before leaving, and Council will manage the sluice in their absence.

- The landowner volunteer will contact Council before opening or closing the sluice window so a record can be kept on how often and how long tidal exchange occurs.
- If the nominated landowner volunteer requires assistance with the floodgate, or any associated infrastructure, they are to contact Council.
- Council is to be notified by either phone or email within 24 hours if the floodgate is opened or closed for any reason other than what is outlined above.
- If Council has not been notified of any action outside of what is outlined above, they will return the floodgate to the agreed state and aperture (open or closed) for the current conditions.

Rous County Council contact details

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council@rous.nsw.gov.au
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Authorisation

This Plan has been endorsed by the landowners within the immediate catchment, whose land is influenced by the management of floodgates. Those landowners have signed a letter of endorsement stating they understand the management strategy for the sluice windows, including the triggers for opening and closing them.

The nominated landowner volunteer has agreed to operate the sluice windows on behalf of Council, as outlined in this Active Floodgate Management Plan and in accordance with the Workplace Health and Safety advice and directions provided to them.

Disclaimer and copyright

Version control

Version	Description	By	Date
0.1	Draft developed before landowner consultation	Chrisy Clay	28/09/2021
0.2	Final draft incorporating landowner feedback	Chrisy Clay	13/10/2021
1.0	Final version – issued to landowners	Andrew Logan	22/10/2021

Rous County Council CM: D21/31280

Contents

1. Overview

The majority of coastal floodplains in NSW have been extensively modified for flood mitigation. Networks of drains have been constructed, natural water courses altered and floodgates installed to mitigate the impacts of floods and large rainfall events.

Constructed drains reduce inundation after flooding and floodgates prevent flood and tidal water from inundating low areas of the floodplain. This in many cases has converted prior wetlands and low-lying floodplain areas into dryland farming areas. While these developments have enhanced rural settlement and agricultural industries, they have also caused unintended adverse impacts to downstream water users, fisheries and the ecology of estuaries.

Rous County Council (Council) is the Flood Mitigation Authority operating across the local government areas of Ballina, Lismore and Richmond Valley. Council is responsible for the construction, replacement and routine maintenance of flood mitigation infrastructure, which includes floodgates, pipes, levees, drains and canals. Council's natural resource management function relates to the environmental consequence resulting from the operation of this infrastructure. Council is responsible for reducing the environmental impact of floodgates and other infrastructure, while retaining their benefits for flood mitigation.

The flood mitigation directive that Council operates under in the *Local Government Act 1993* is *'Prevent and mitigate menace to the safety of life or property from floods and natural resource management issues arising therefrom'.*

Purpose of a Floodgate Management Plan

Council has an Active Floodgate Management Plan (Plan) for each of its floodgates that are actively managed. Active management is the opening of floodgates during non-flood periods when the floodgate is otherwise operating passively. Opening floodgates and allowing tidal exchange can reduce their environmental impact by improving water quality and enhancing aquatic habitat and fish passage. Opening a floodgate for tidal exchange can occur by modifying a floodgate with a sluice window or an automatic, tidally operated float system or the floodgate can be winched opened.

These plans document and communicate:

- how active management can assist in reducing the environmental impact of the floodgate
- a strategy for how that will be monitored and achieved
- appropriate and consistent strategy for opening the floodgate and returning it to the operational position or state and by whom
- safe operating procedures for volunteers and Council staff
- how adverse effects on current land use will be identified and prevented, and
- additional management strategies for the drainage system that would further reduce the environmental impact of flood mitigation.

Each Plan is tailored for the system and its floodgates, considering their location, purpose and function.

Guiding principles for management

- Rous County Council is the Flood Mitigation Authority and acts in consultation with stakeholders on the management of its infrastructure.
- The primary function of Council's infrastructure is for flood mitigation.
- The intention of active floodgate management is to reduce environmental impact without causing adverse effects on current land use.
- All landowners behind the floodgate whose property may be impacted will be invited to participate in reviewing and updating the Plan and will be sent a final version of the Plan for their records. Where property ownership changes, the new landowner will be involved at the time the Plan is reviewed unless their location and role are critical to the management strategy.
- Active floodgate management is a cooperative exercise between Council, as the Flood Mitigation Authority, and the surrounding landowners. Council appreciates landowners' continued support of this important activity.

Stakeholder involvement

This Active Floodgate Management Plan is a formal agreement between Rous County Council and landowners on how tidal exchange will occur on the identified drainage system. The Plan has been developed in consultation with landowners whose property may be impacted from the floodgate's operation.

Rous County Council seeks the input and support of other stakeholders for their Active Floodgate Management program and its delivery.

Organisation	Role
Rous County Council	Owns, develops and uses individual Active Floodgate Management Plans.
Relevant landowners	Endorses and uses individual Active Floodgate Management Plans.
Lismore City Council Ballina Shire Council Richmond Valley Council	Supports active floodgate management and provides input on general program where relevant.
NSW Department of Primary Industries	Supports active floodgate management and provides input on general program where relevant. Regulatory role under *Fisheries Management Act 1994.*

Plan review frequency

The Plan will be formally reviewed every three years (from the date of adoption) and the effectiveness of the outlined strategy assessed.

Feedback on the Plan and active floodgate management matters

Feedback and comments should be referred to Council by telephone on (02) 6623 3800 or by email: council@rous.nsw.gov.au

2. Dungarubba Canal

Asset number and description

A reference in this section to ‘asset number’ is to a unique reference that Council has assigned to the specified asset.

Asset number 3390 – Dungarubba Canal

- Five floodgates, one with a sluice window operated with a winch.

Asset No.	Description	Number
3390-031-01 3390-031-02 3390-031-04 3390-031-05	Aluminium floodgate (2100mm square)	4
3390-031-03	Aluminium floodgate (2100mm square) with sluice window	1
3390-035	Steel lifting gear	1
3390-610	Handrail	2
3390-262	Canal	1
3390-290	Outlet	1
3400-031-01 3400-100 3410-031-01 3410-100 3420-031-01 3420-100 3430-031-01 3430-100 3472-030-01 3472-100 3480-031-01 3480-100 3490-031-01 3490-100 3500-031-01 3500-100	Secondary floodgates and pipes along canal	8 sets of pipes and gates
3440-720 3450-720 3470-720	Bridges	3
3480-120	Culvert	1

Aerial photograph of asset location and images of asset

1: Dungarubba Canal locality map.

2: Dungarubba Canal floodgates and headwork structure.

3: Dungarubba Canal looking downstream towards the floodgate headworks.

4: Dungarubba Canal as it travels through the lowest lying section, approximately 3 kilometres upstream from the floodgates, note the low bank heights in relation to the drain water level.

Drainage system characteristics

Location in estuary.	Mid-estuary.
Location in landscape.	Riverine natural levee and floodplain.
Land elevation.	0.1m – 1.9m AHD.
Land use.	Agriculture: grazing and sugar cane.
Vegetation.	Grasses and pastures. The canal drains and passes through *Swamp Sclerophyll Forest* and *Freshwater Wetlands* both identified as Endangered Ecological Communities under the *NSW Biodiversity Conservation Act 2016*.
Salinity levels and estuary dilution capacity.	Varies depending on rainfall, usually moderate.
Tidal range.	Moderate.
Land elevation adjacent to drains.	Very low in places. Graduating from natural levee along Richmond River to low-lying land upstream.
Soil type.	Likely to be alluvial sediment overlaying estuarine clay.
Acid sulfate soils.	High risk, areas of sulfuric sediments (actual sulfate soils), present in low-lying areas. MBOs present in drain.
Hydraulic conductivity.	High in places. An assessment conducted by DPI in 2009 (RRCC, 2009) located one kilometre from Dungarubba Canal determined hydraulic conductivity to be high. This equates to approximately 15 to 100 metres a day of potential groundwater movement toward the drain under favourable conditions.
Acid export.	System is known to export acid after heavy rain and for acidic conditions to persist for some time afterwards. Highly likely to be from groundwater discharge into the canal.
Water quality issues.	Prolonged acidification after rain. Can discharge deoxygenated water (blackwater) after flooding. In warmer months drain water can become stagnant, creating ideal conditions for algal blooms, and fluctuating dissolved oxygen levels.

Water quality

Dungarubba Canal experiences several different water quality issues.

After major summer floods, Dungarubba Canal can discharge large volumes of deoxygenated water or blackwater into the Richmond River estuary. Blackwater is generated when low-lying areas are inundated and the flooded vegetation rots. The canal drains a very large low-lying basin, which is a meter above average sea level (1m AHD) and below. This area can be inundated for lengthy periods of time. After flooding in February 2020, blackwater was recorded discharging from the canal with dissolved oxygen levels ranging from 0.1 to 1.9 mg/L, which are lethal for aquatic life.

5: Deoxygenated water or blackwater discharging from the Dungarubba floodgates after flooding in February 2020.

Dungarubba Canal can also be chronically acidified from acid sulfate soils for many months of the year. Acidity, iron and aluminium enters the canal when drain water levels are low and groundwater from the surrounding paddocks and land enters the drainage system. Mono-sulfidic Black Ooze (MBOs) have also been recorded in the canal by Southern Cross University (Bush, et al, 2004).

Finally, during extended dry and hot weather, Dungarubba Canal can become stagnant. During these times, drain water temperatures can be very high. In February 2019, water temperatures of up to 35 degrees Celsius were recorded in the first two kilometres upstream of the floodgates. This, together with no flow and a build-up of nutrients and organic matter in the canal, provides ideal conditions for algal blooms. In February 2010, Richmond River County Council recorded extremely high levels (75,000 cells/ml) of *Microcytis* a type of blue-green algae. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) says there is an increased risk to stock when levels exceed 11,500 cells/ml. Excessive algae in drainage systems can cause dissolved oxygen levels to fluctuate putting any fish trapped in the canal at considerable risk.

Water quality in Dungarubba Canal was monitored as part of a 3.5 year sugar cane industry study funded by the Sugar Research and Development Corporate and the Cooperative Research Centre for Sugar. The project commenced in 1999 and monitored chemical, nutrients and pesticides. Dungarubba Canal was one of the two drainage systems monitored in the Richmond floodplain with a datalogger installed just upstream of the floodgates and monthly grab samples collected for laboratory analysis. Their analysis confirmed periodic pulses of acidity in the drain and traced this back to the lowest lying land in the system (Beatie et al 2004).

Aquatic habitat values

The former freshwater wetland that historically stretched from Dungarubba in the north, through Kilgin, and south to North Woodburn would have had aquatic habitat value. Historical newspapers provide an indication of what the area was like before extensive drainage. Reports refer to ‘a thick growth of ti-trees’ and an area of near permanent inundation referred to as the Coraki swamp, or the ‘Duck Hole’

Although the canal has little or no natural features and provides little aquatic habitat, the system does hold a large volume of water in which fish can be present. Fish trapped in a drainage system with deteriorating water quality are at considerable risk. One of the aims of active floodgate management at Dungarubba Canal is to reduce the risk of fish kills in the system. In April 2021, such a fish kill occurred in the canal upstream of the floodgate. After prolonged wet weather and flooding, hundreds of European Carp died in the canal. Spot water quality readings taken by Council at the time, showed that 700m upstream from the floodgates the pH was 3.41 and dissolved oxygen was 1.4mg/L in the canal - these conditions are lethal for aquatic life.

Another aim of active floodgate management at Dungarubba Canal is to reduce the system's impact on the Richmond River estuary. As described, the drainage system can discharge poor water quality and tidal exchange can reduce the system's impact upon downstream aquatic habitat.

Aquatic vegetation

Associated with the canal having low flows and limited tidal exchange, allowing nutrients and organic matter to accumulate, is excessive vegetation growth. These conditions allow aquatic vegetation to proliferate, including a species locally called ribbon weed or eel grass. Excessive aquatic vegetation causes problems when it is pushed downstream in large quantities where it can block the floodgate cells and prop open floodgates, preventing them from closing properly. Pictured below is Council removing a build-up of vegetation from behind the floodgates with an excavator in 2013. Council has also previously mechanically cleaned sections of the canal to remove excessive vegetation, which can block and prohibit flow. Again, active floodgate management and increasing tidal exchange can reduce these risks by limiting the amount of vegetation that grows in the canal in the lower sections.

6: Council removing a build-up of vegetation from behind the floodgates.

Whole of system management

The following table outlines what management changes have already been made within Dungarubba Canal and what could be explored in the future. A cooperative approach that balances the needs of current land use and environmental benefits is promoted by Council. Dungarubba Canal has benefitted from the willingness of previous landowners to trial and adopt different management strategies to improve its environmental condition and Council acknowledges their efforts.

Council provides this information for landowners and other organisations that are responsible for promoting and facilitating natural resource management on private freehold land. This information identifies a range of relevant strategies for improving water quality based on the characteristics of the system and are consistent with current best management practice.

Management strategy	Works	Undertaken	Location	Recommendation	Responsibility
Further information to understand the drainage system.	Drain invert survey.	Yes, by RCC in 2020.	Entire drainage system.	The drain invert survey identified opportunities and challenges for further tidal flushing. The invert survey may also guide future options such as reshaping of the canal.	Local government: Rous County Council.
Acidic groundwater containment.	Reducing drainage density – removing drains or reshaping so shallow and wide to only drain surface water.	No.	Could apply to both private drains entering the canal and the main canal itself.	Explore possibility with relevant landowners.	Private landowners. Local government: • Rous County Council. • Lismore City Council. State government: • North Coast Local Land Services. • Department of Primary Industries. • Department of Planning, Industry and Environment. • Marine Estate Management Authority.
	Laser levelling of paddocks to enhance drainage of surface water and remove the need for field drains that can drain groundwater.	Likely to have been completed on cane farms as this is a widespread industry practice.	Land growing sugar cane.	Explore with landowners whether laser levelling and reduction of field drains can occur.	Private landowners. Local government: • Lismore City Council. State government: • North Coast Local Land Services. • Department of Primary Industries. • Department of Planning, Industry and Environment. • Marine Estate Management Authority.

Tidal flushing for dilution and buffering of acidification and reducing stagnant conditions.	Actively manage floodgates.	Yes, by RRCC in 2010.	Sluice window installed on main floodgate.	Continue with outlined management strategy. Review in three years.	Private landowners. Local government: Rous County Council.
Reduce impact of deoxygenation events.	Return low-lying grazing areas to a more natural water regime, i.e., wet pasture grazing.	No.	Private drains in low-lying areas.	Explore possibility with relevant landowners.	Private landowners. Local government: • Rous County Council. • Lismore City Council. State government: • North Coast Local Land Services. • Department of Primary Industries. • Department of Planning, Industry and Environment. • Marine Estate Management Authority.
	Explore further management strategies for lowest lying areas.	No.	All drains in grazing land.	Explore possibility with relevant landowners.	
Water quality monitoring.	Monitoring program to identify any water quality issues and confirm benefits of managing floodgate.	No, only spot samples and observations.	Main floodgates.	That a program be developed to determine success of Active Floodgate Management Plan. Identify resources required and assess cost versus benefit.	Local government: Rous County Council.

RRCC = Richmond River County Council, former Flood Mitigation Authority on the Richmond.

3. Risks of actively managing floodgates

Work Health and Safety

- The sluice window is fitted with a winch and large forces can be involved in winch systems.
- The sluice window should only be opened on a low or falling tide. This will reduce the risk of the wire rope breaking and the floodgate deforming.
- The sluice windows are opened and closed by the nominated landowner volunteer or Council operator, who should consult and follow the approved Safe Work Procedure and Floodgate Fact Sheet relevant for the activity and undertake their own risk assessment before operating the floodgate.
- Operating the sluice window during and after heavy rain or flooding can require working in wet and slippery conditions. Safe access to the site should be assessed after events.

Environmental / Agricultural

Flooding

There is a risk of flooding land upstream of the floodgate and surrounding areas if the sluice window is not closed before a flood arrives and floodwater from the Richmond River enters the drainage system.

There is also concern of increased flooding from elevated drain water levels caused by tidal exchange. This increases the risk of prolonged inundation after rain events. To reduce this risk,

active floodgate management will occur cautiously, and the sluice will not be opened if drain water levels are considered too high to maintain storage capacity (air space) in the drainage system for heavy rain events.

Saline water overtopping

Landowners have identified that if tidal exchange is not carefully managed there is a risk of saline water overtopping the drain and inundating areas. There can be little freeboard between elevated drain water levels and surrounding land and the operational strategy outlined in this Plan will reduce this risk.

Increased salt levels in drainage system

Salinity levels can be high in this part of the Richmond River estuary, especially during dry periods. Increased salinity levels in the drainage system are a risk as the landowners rely on the drain to water in planted cane. To reduce this risk, if drain water is needed, the sluice will be closed in July before cane is planted to reduce the salinity within the drain and reopened once the cane is planted and established.

4. Monitoring, evaluation and reporting

Council will explore whether programmed and longer-term water quality monitoring can occur at Dungarubba Canal. However, if resources are not available for monitoring, scientific principles and visual observations support the assumption that implementing the outlined management strategy will improve water quality.

An evaluation of the success of the Plan will be made at the 3 yearly review, and a report provided by Council to landowners and relevant stakeholders.

5. Drain invert survey

To better understand how Dungarubba Canal functions, and identify risks with increasing tidal exchange, Council had the drainage system surveyed. A drain invert survey was conducted to determine the height of the bottom of the drain and the drain banks, along its entire length. Some of the lowest lying land adjacent to the canal was also surveyed.

This information has been very useful in understanding how the system functions, but importantly for tidal flushing, where any hazards exist. This is only the second drain survey conducted by Council. The survey was conducted by a local contractor in June 2020 and a summary of the results follows.

The survey showed there are three distinct sections along the drain, each with different characteristics.

<u>The section closest to the floodgates</u>

- This is the first 2.5km of the canal where the invert (height of the bottom of the drain) is at the same level or below that of the bottom of the floodgates.
- There is no fall in the canal through this section (ie. it is flat).
- The banks are relatively high, ranging between 1.1m-2m above average sea level (AHD). The surrounding land is also high.
- This area is cropped with sugar cane.

7: Showing the characteristics of the section closest to the floodgates.

The middle section

- The middle 2.5km section is characterised by very low banks and the surrounding land is also very low.
- The surrounding land adjacent to the canal ranges from 0.08m – 0.96m above average sea level (AHD) with large areas between 0.10m-0.40m above average sea level.
- The banks of the canal through this section range from 0.40m-0.88m above average sea level.
- There is a rise (ie. a hump) in the canal's floor 3.5km up the drain from the floodgate in the lowest lying section. The rise is 795m long and at its highest sits 0.25m higher than the invert of the floodgate. This rise is thought to be an accumulation of silt, where the drain flow slows down and suspended sediment in the water is allowed to drop out to the invert of drain.
- Upstream of this rise, the invert of the drain is lower than the floodgate.

8: Showing the characteristics of the low-lying middle section of the canal.

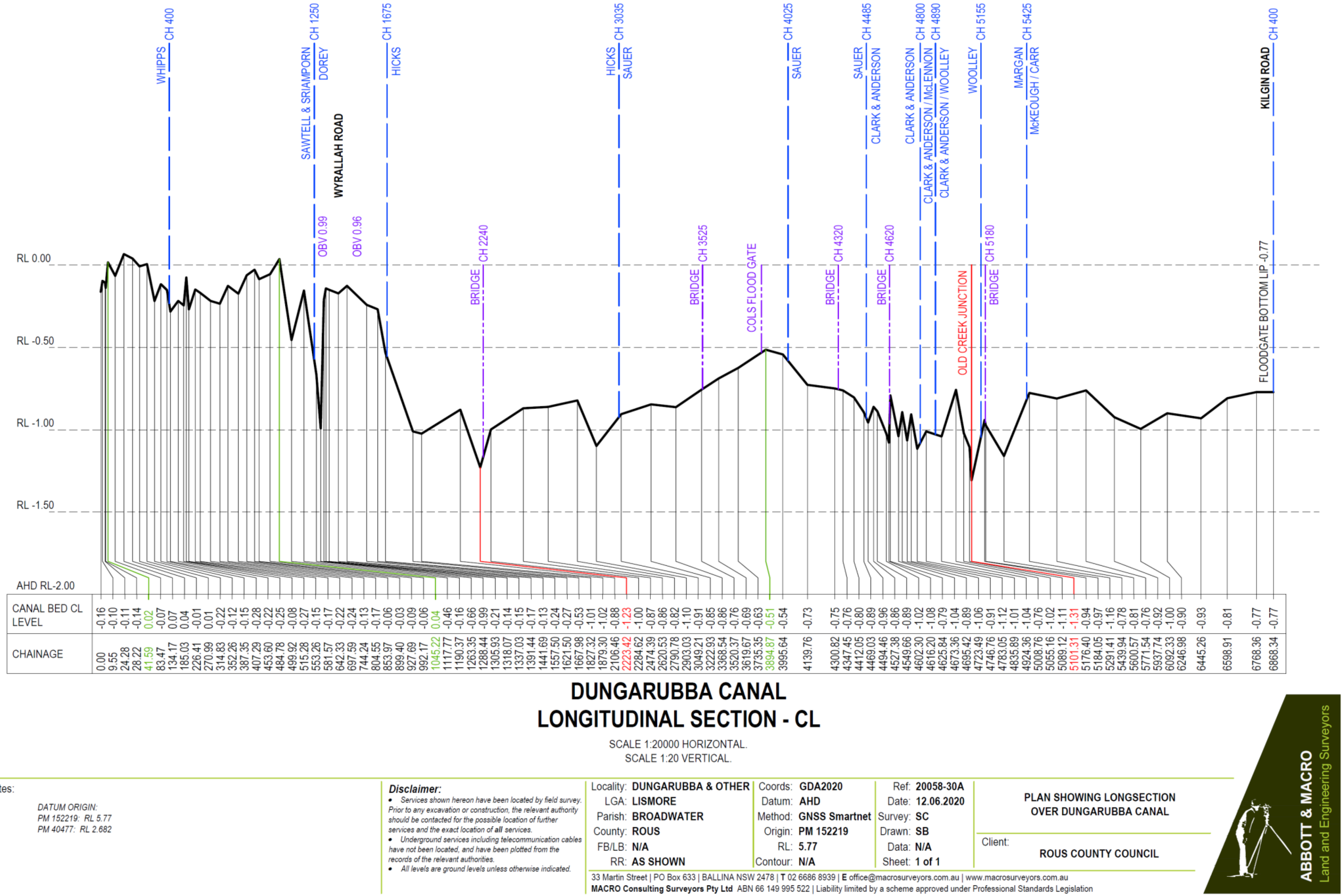
The top section

- The height of the bottom of the canal rises dramatically in the final 2km.
- The drain invert is now 0.50m-0.75m higher than the invert of the floodgates, which are now between 5-7km away.
- The canal banks are also higher, ranging between 1.44m and 1.9m higher than average sea level (AHD).
- This rise mirrors the step up in the height of the surrounding land.
- The drain invert survey recorded a deep hole downstream of the Wyrallah Road bridge, which is 75cm deep.

The characteristics of the three sections gives the Dungarubba Canal a bathtub effect, with higher banks and land elevation above and below the very low-lying middle section.

The survey confirmed there are challenges in keeping the sluice window open for continuous tidal flushing. Trials that followed the survey were conducted with landowners in the lowest lying areas and showed that opening the sluice window, even conservatively, can significantly increase drain water levels in the middle section. That increase in drain water levels, together with unfavourable tides or heavy rain, can result in low-lying land adjacent to the drain being inundated.

9: Drain overtopping that has previously occurred in the lowest lying section adjacent to the canal from uncontrolled tidal exchange in 2009.



10: Results of the drain invert survey, showing the height of the bottom of the canal from the floodgates on the right of the graph, to the end of the canal, west of Wyrallah Road on the left of the graph.

6. Historical context

History of when and why asset was installed

Construction of the Dungarubba Canal commenced in 1909. The canal was cut using a dredge from the head of Dungarubba Creek westward. The newspapers at the time reported on its progress.

> **The Richmond River Herald and Northern District Advertiser 13 Nov 1908**
> DUNGARUBBA
> Where the dredge 52 is now working is all solid cutting. There is no water on the surface, and how she cuts her way through with a great bucket is astounding. She is leaving a splendid canal, studded on either side with a thick growth of ti-trees, behind her. This canal should be carried right lip to the Duck Hole, where it would have the effect of rendering that and adjoining areas the most valuable on the river. If the landowners are alive to their own interests, there is no reason why this should not be done. The work now in progress proves that the cost would not be prohibitive. The cost, when spread over numbers of years, as under the Water and Drainage Act, would not be felt, and the benefits would be incalculable.

> **The Richmond River Herald and Northern District Advertiser 19 March 1909**
> DUNGARUBBA
> March 16th. — In a few weeks the dredge will have completed the canal at the head of the creek. She is now almost opposite Mr Arthur Whipps residence. Skipper Mason and his crew have proved themselves thoroughly capable men in cutting the canal through a thick growth of ti-trees in such an incredibly short space of time. To the uninitiated the task appeared, at the outset, an impossible one.

> **The Richmond River Herald and Northern District Advertiser 19 April 1909**
> DUNGARUBBA.
> April 9th. — It is rumored the dredge is about to be removed from Dungarubba Creek. There are now only five chains to be out to meet the drain opened by the Shire Council, and it will be a pity if the dredge is not allowed to complete the work. If she is taken, it is about up to the landholders to provide the money necessary for the Shire Council to extend the drain. The canal cut by the dredge, and also the drain opened by the Council, will drain thousands of acres of private property, and, so far, owners have not been asked to contribute a copper towards the cost.

The idea of Dungarubba Canal connecting directly to the Richmond River was raised in 1944 as a post-war construction project, by the then Gundurimba Shire Council. This would mean the canal would discharge separately from Dungarubba Creek (as it currently does). Again, the newspaper at the time reported on this.

> **The Norther Star 9 March 1944**
> *Drainage Union at Dungarubba*
> At a meeting at Dungarubba, convened by Gundurimba Shire Council, to discuss drainage matters, it was decided to form a drainage union to include all the present drainage areas. This was reported by the Clerk (Mr. N. E. Fiford) at the monthly meeting of the Gundurimba Shire Council yesterday.
> Mr. Fiford said it was recommended that the council should apply to the Government for the immediate dredging of Dungarubba Creek. The proposed Drainage Union would undertake the task of carrying out the Stibbard's Creek and an enlarged Dungarubba Creek drainage schemes as post-war reconstruction works. A further resolution was carried that the Woodburn Shire Council be supported in its efforts to have the Tuckombil flood escape canal cleaned out. Mr. Fiford said Cr. C. M. Mitchell had presided at a later meeting, when it was deeded that the proposed drainage union be known as the Gundurimba Shire C Riding Drainage Union. It was also decided that the union should be managed by four local directors, exclusive of a Government nominee, if any. Mr. F. Paff was appointed Secretary pro tem. Mr. Fiford said he had written to the Lands Department for an application form for the formation of the proposed drainage union.

Historic aerial photography confirms Dungarubba Canal was eventually connected directly to the Richmond River between 1964 and 1966.

11: Historical aerial photograph of Dungarubba Creek and canal in 1964.

12: Historical aerial photograph from 1966 of Dungarubba Creek and canal after the canal was connected independently to the Richmond River.

History of active floodgate management

Consideration of active floodgate management was first raised by NSW Department of Primary Industries as a permit condition in 2010 when the floodgates on Dungarubba Canal were upgraded from steel to aluminium. Council's records show that the landowners have always been concerned of the possible risks involved.

The former Richmond River County Council undertook lengthy consultation with the then 15 different landowners on the canal for more than 12 months. Eventually, all landowners signed off on an Active Floodgate Management Plan in July 2010, but then later that month the sluice window was closed because of concerns of overtopping.

Repeated attempts have been made to retrofit the drainage system with secondary floodgates and pipes to restrict tidal water to the main canal. This has included seven secondary floodgates on mostly private secondary drains in the lowest lying land over the past ten years. These have not been able to control the tidal water to the satisfaction of the landowners.

13: Secondary pipes and floodgates being installed in 2014 to restrict tidal water to the main canal.

14: An example of the secondary pipes and floodgates installed along Dungarubba Canal, note the abundant flocculated iron in the drain water from acid sulfate soils.

Since that time the sluice window on Dungarubba Canal has been opened very rarely. There remains limited opportunity for active floodgate management because of the fundamental characteristics of the drainage system as outlined in this Plan. Landowners' concerns of elevated drain water levels, inundation of land and salinity levels continue.

The review of this Plan is an opportunity to clearly document the opportunity for tidal exchange, along with the constraints and challenges. This new Plan confirms how the sluice window will be managed into the future. Council appreciates landowners' continued cooperation and support of this important activity.

7. Future considerations

The drain invert survey conducted by Council, and the observations of landowners indicates that drainage of the lowest lying areas can be difficult and slow. This is because of the invert of the drain and floodgate, the lack of fall and length of the canal. These are the same characteristics making active floodgate management difficult. It is likely that this experience will continue into the future and may be exacerbated by climate change driven sea level rise.

Scientific advice indicates that the current conditions experienced across the Dungarubba floodplain of the Richmond River estuary will be significantly affected by climate change. It is likely that sea level rise will impact on floodplain drainage and the function of floodgates. Harrison et al (2021) determined that floodplain areas with an elevation below 0.9m above average sea level (AHD) is at risk of reduced drainage due to sea level in the near future (2050). The function of floodgates is also likely to be affected, by reducing how frequently they can freely drain based on downstream water levels and the invert of the floodgates.

Harrison et al (2021) indicates that the floodgates on Dungarubba Canal are 'moderately vulnerable' now, meaning they can drain effectively between 50% – 95% of an average day but in the near future (2050), this may change to being considered 'most vulnerable' where the floodgate will effectively only drain for less than 50% of an average day.

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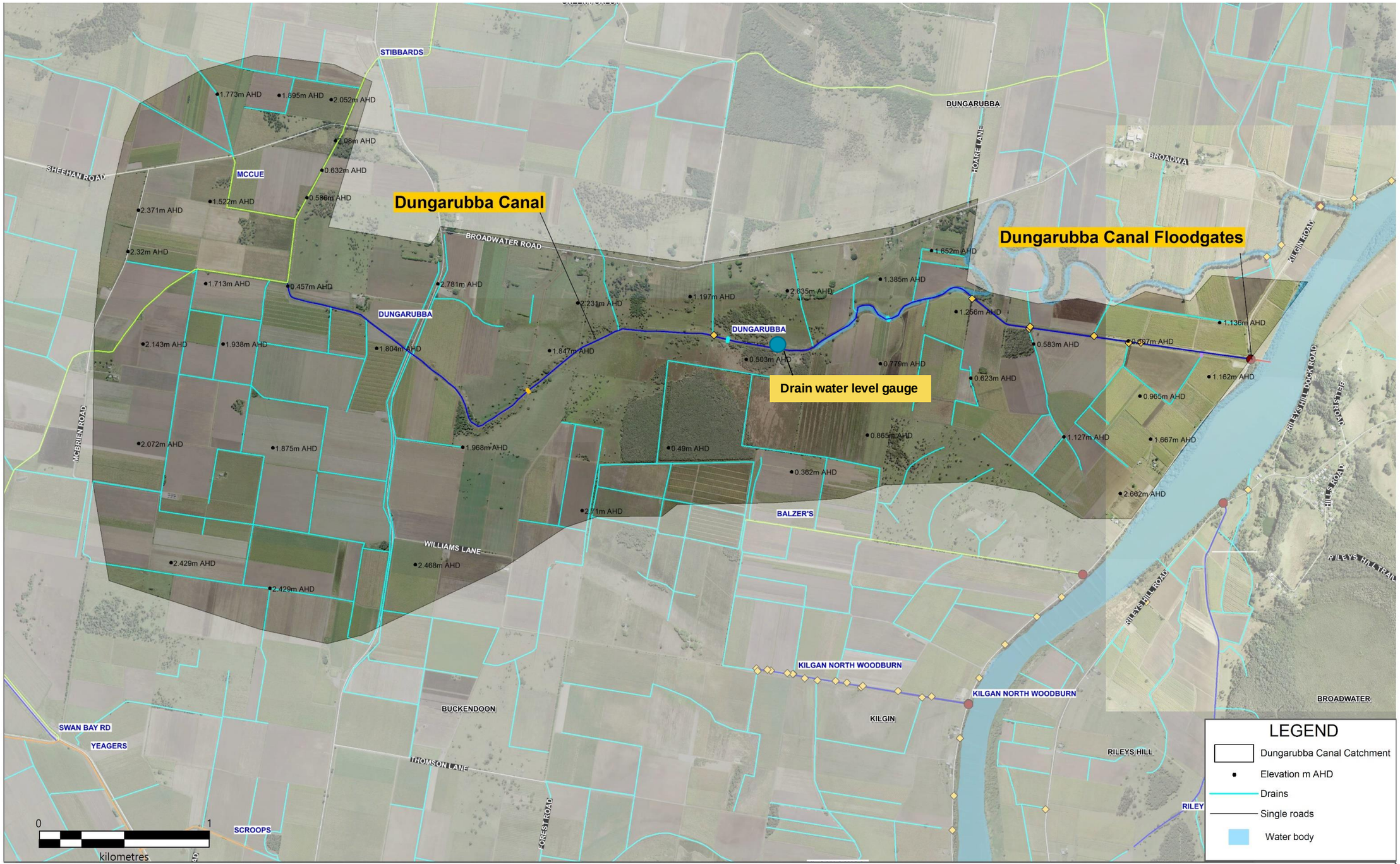
Appendix: Dungarubba Canal



Dungarubba Canal Catchment

THE INFORMATION ON THIS MAP MAY NOT BE ACCURATE.

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