



# TWEED AND BRUNSWICK RIVER FLOOD WARNING IMPROVEMENTS

## RECOMMENDATIONS REPORT

Report MHL2978  
December 2024

Prepared for:

NSW Government Department of Climate Change, Energy, the Environment and  
Water, Biodiversity and Conservation Division

**Cover Photograph:** Murwillumbah aerial following February 2022 flood event. Taken from Tweed Shire Council media release (source: unknown).

# Tweed and Brunswick River Flood Warning Improvements

## Recommendations Report

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December 2024

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# Foreword

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Manly Hydraulics Laboratory (MHL) were commissioned by NSW Government Department of Climate Change, Energy, the Environment and Water (DCCEEW), Biodiversity and Conservation Division (BCD) to provide technical support on the improvement of flood warning within the Tweed and Brunswick River Valley catchment (the study area). This report documents the findings of review of existing flood warning service to identify gaps and improvements to support implementation.

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# 1 Introduction

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This Final literature review for Tweed and Brunswick River flood warning improvement project (the project) has been prepared by Manly Hydraulics Laboratory (MHL) for the NSW Government Department of Climate Change, Energy, the Environment and Water, Biodiversity and Conservation Division (BCD).

This document summarises all recommended improvements to flood warning arrangements within the Tweed and Brunswick Valley catchment (the study area) based on flood risk management studies and plans undertaken through the NSW floodplain risk management process, related studies, additional gap analysis and stakeholder feedback of the existing flood warning network. Additionally, flood behaviour and catchment characteristics, the existing rainfall and water level station network, and existing flood warning arrangements within the study area have been summarised.

The project is led by BCD and overseen by a project working group (PWG) consisting of representatives from the Commonwealth Bureau of Meteorology (the Bureau), NSW State Emergency Service (NSW SES) and BCD. It will be undertaken in four stages as follows:

- Development and support of delivery of a communication plan during the project with input from the Local Government Representative Group (LGRG) and the PWG.
- Review of existing flood warning service, identification of gaps and improvements to support implementation.
- Development of an implementation plan.
- Identification of key updates to the NSW Service level specification (SLS) and NSW SES requirements for and provision of flood warning by NSW SES.

This document aims to summarise all obtained information on the existing flood warning service, identification of gaps and recommended improvements to support their implementation.

## 1.1 Study objectives and scope

The overall objective is to identify options for the cost-effective improvement of the flood warning arrangements for the study area and investigate their feasibility, in response to the devastating impacts of the February/March 2022 floods. Once identified these will be prioritised for implementation.

The scope of this report includes the following:

- Review existing flood warning service for the study area, including existing flood warning arrangements and the existing station network.
- Review of published flood-related reports within the study area.
- Compilation of recommendations pertaining to improving flood warning within the study area.
- Identification of gaps and limitations with the existing flood warning network.

- Identification of local flood warning arrangements that are not part of the Bureau SLS or SES requirements and provision of flood warning.
- Development of a multi-criteria analysis (MCA) to prioritise options developed based on literature review and data gap analysis.
- Recommendation of a series of prioritised improvements to the flood warning network and service provision including new or upgraded infrastructure consistent with national infrastructure standards and total flood warning system.

## 2 Background

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### 2.1 Study area

#### 2.1.1 Tweed River catchment

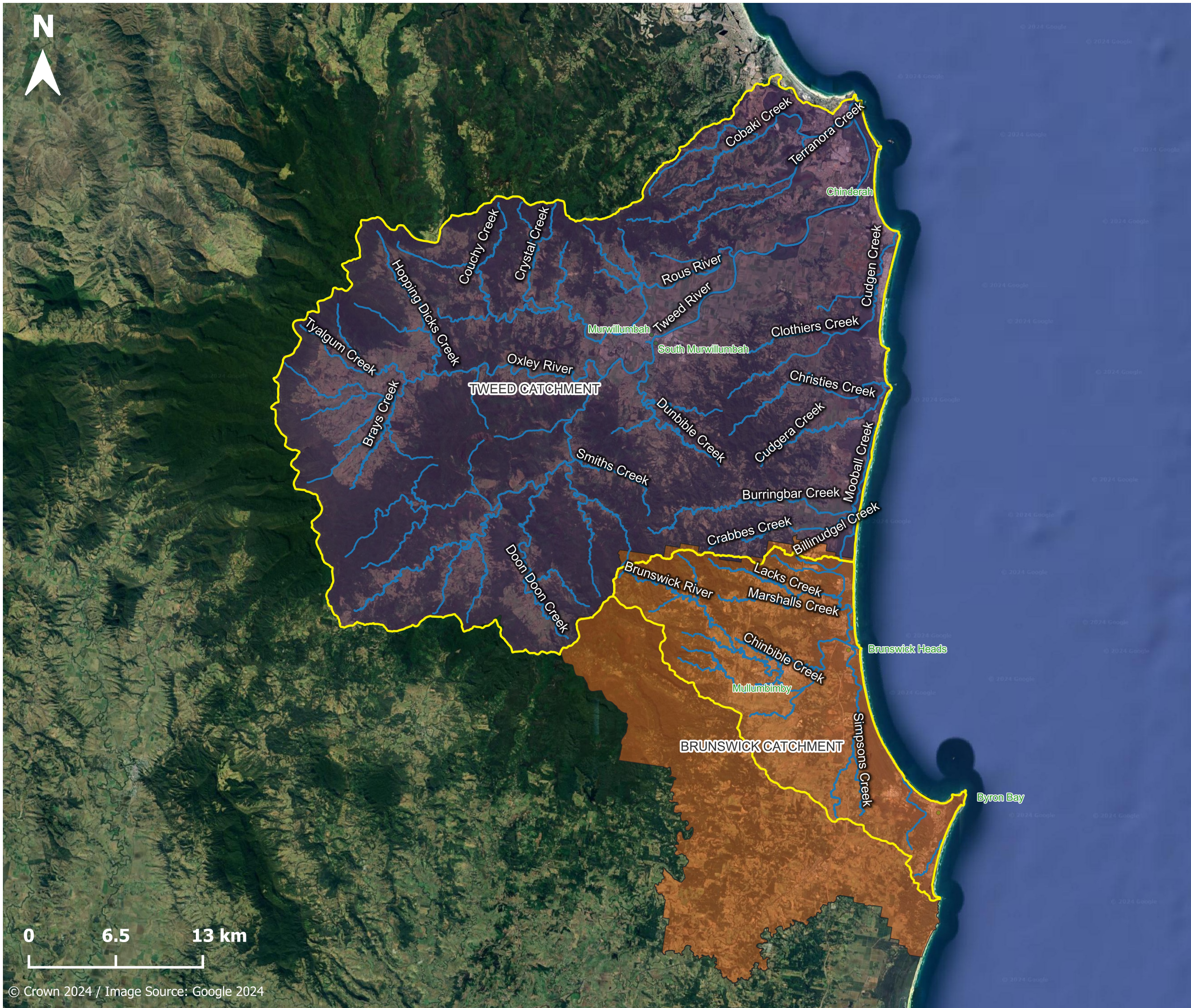
The Tweed catchment, situated in the far north-eastern part of New South Wales, is surrounded by the McPherson Range on the NSW-Queensland border, the Burringbar and Condong Ranges to the southeast, and the Tweed Range to the west (**Figure 2-1**). Encompassing an area of approximately 1,330 km<sup>2</sup>, Mount Warning stands as the highest point in the catchment at 1,156 m AHD, while much of the area has an elevation below 300 m AHD. Murwillumbah is centrally located within the catchment, while the major urban area of Tweed Heads surrounds the Tweed estuary. Roughly half of the catchment's population resides in the Tweed Heads area. The Tweed River originates near Mount Burrell in the southwestern part of the catchment, flowing approximately 80 kilometres until it reaches the ocean at Tweed Heads (BMT WBM, 2009). Flowing in a general northeast direction, the main arm of the river passes through the towns of Murwillumbah (approximately 28 km upstream) and Tweed Heads (at the river mouth), as well as the villages of Condong, Tumbulgum, Chinderah, and Fingal. Notable tributaries include the Oxley River, Rous River, Dunbible Creek, and Cobaki Creeks. The river meets the ocean just south of Point Danger, near the Queensland border.

In the recently experienced major flooding in February and March 2022, river level gauges located along the Tweed River recorded peak levels at Chinderah, Tumbulgum, and North Murwillumbah as 2.98 m, 4.77 m, and 6.51 m, respectively (WaterNSW, 2022). Submissions to the 2022 Flood Inquiry indicated that these measurements far exceeded the threshold for major flood events. The upper Tweed catchment area experienced significant impacts due to landslides, resulting in extensive damage to both road infrastructure (with repairs estimated at approximately \$80 million) and communication infrastructure (NSW Parliament 2022). Residents continue to experience the impact of access and communication challenges, which continues to affect them long after the floodwaters have receded.

#### 2.1.2 Brunswick River catchment (Byron Bay)

The study area (**Figure 2-1**) for the Byron catchment encompasses the towns of Mullumbimby, Brunswick Heads, and Billinudgel (BMT WBM, 2020). The study area comprises the Brunswick River, Marshalls Creek, and Simpsons Creek. Marshalls Creek is the northern major tributary of the Brunswick River, with a catchment area of approximately 42 km<sup>2</sup> and includes the town of Ocean Shores and the villages of Billinudgel, South Golden Beach and New Brighton. Marshalls Creek flows south parallel to the coastal dune system prior to joining the Brunswick River. The Brunswick River catchment covers an area of approximately 111 km<sup>2</sup> and includes the major towns of Mullumbimby and Brunswick Heads. To the south, the Simpsons Creek catchment, covers an area of approximately 66 km<sup>2</sup>.

The Byron Local Government Area (LGA) has experienced significant flash flooding, affecting approximately 1600 properties inundated with hundreds of additional properties within the flood extent (NSW Parliament 2022). Mullumbimby as well as South Golden Beach, Ocean Shores and New Brighton have experienced significant flooding. There is lack a of telecommunications services in these regions which prevents some of the flood warnings from being issued.



**Figure 2-1**

**Local government areas and key watercourses within the study area**

**Legend**

Tweed and Brunswick Valley catchments

**Local Government Areas**

- Tweed Shire Council
- Byron Shire Council
- Watercourses

**Report MHL2978**

**Tweed and Brunswick Rivers flood warning improvement**

**Recommendations Report**



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## 3 Existing flood warning arrangements

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The following subsections provide a brief outline of the existing rainfall and river station network, and the types of flood warning arrangements within the study area.

### 3.1 Existing rainfall and water level station network

A total of 69 rainfall and water level gauges were observed to be operating within the study area. 62 of those 69 are listed under the Bureau Service Level Specifications (SLS) arrangement, which are used as inputs to produce the Bureau flood warning products. The remaining 7 rainfall and water level stations that are not listed under the Bureau SLS arrangement may have different objectives such as informing local/flash flood warning systems, providing climate data to the Bureau, or being located outside the reaches of the SLS arrangements (i.e., Queensland). A list of all stations within the study area is presented in **Appendix A** and **Figure 3-1**.

### 3.2 Bureau of Meteorology flood forecasting services

The Bureau of Meteorology provides flood forecasting and warning services for several townships in the Tweed and Brunswick catchments along the Tweed River, Brunswick River, and Marshalls Creek. These services utilise rainfall-runoff models to forecast flood flows, and in certain cases, they incorporate pre-existing flood model results to enhance flood level predictions.

Currently, the Bureau offers flood forecasting and warning services to various townships within the catchments. These include:

- Tweed catchment:
  - North Murwillumbah
  - Tumbulgum
  - Chinderah
- Brunswick catchment:
  - Billinudgel
  - Mullumbimby

While the Bureau of Meteorology provides flood forecasting and warning services for townships in the Tweed and Brunswick catchments, it is important to note that the Bureau also issues various other weather-related warnings, such as severe weather warnings and severe thunderstorm warnings. These warnings serve to identify the potential for severe weather events, which can include heavy rainfall and thunderstorms, both of which are often associated with flash flooding. Severe weather and thunderstorm warnings serve a different purpose than the specialised flood forecasting and warning services provided by the Bureau of Meteorology, which offer highly specific and localised flood predictions for the safety of residents in vulnerable areas. All flood warnings provided by the Bureau are quantitative and include detailed information on predicted flood levels and timings. The residents of the aforementioned townships can rely on these flood forecasting and warning services to stay informed and prepared for potential flooding events in their areas.



**Figure 3-1**

Existing rainfall and water level station network within study area

**Legend**

Tweed and Brunswick Valley catchments

**Type of stations**

**Existing SLS stations and their schedules**

- Forecast locations
- ◆ River data locations
- Rainfall locations

**Existing stations outside the SLS network**

- Non-SLS gauges

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### 3.3 State Emergency Service flood advice

The Australian Warning System (AWS) is a nationally consistent, three-tiered approach designed to make warnings clear and lead people to take action ahead of severe weather events. The warning system comprises warning levels, action statements, hazard icons, colours and shapes.

The AWS flood warning products may be deployed to any township or station location within the study area based on flood predictions provided by the Bureau. The AWS flood warning products include:

- Advice: an incident has started, and the public should stay up to date in case the situation changes.
- Watch and Act: conditions are changing. The public needs to start taking action to protect themselves.
- Emergency Warning: the highest level of warning. The public may be in danger and immediate action must be taken.

Each warning comprises three components:

- Location and hazard: e.g., Murwillumbah flooding.
- Action statement: guiding protective action with statements such as 'stay informed', 'prepare to evacuate' and 'evacuate now'.
- Warning level: the severity of natural hazard event based on the consequence to the community.

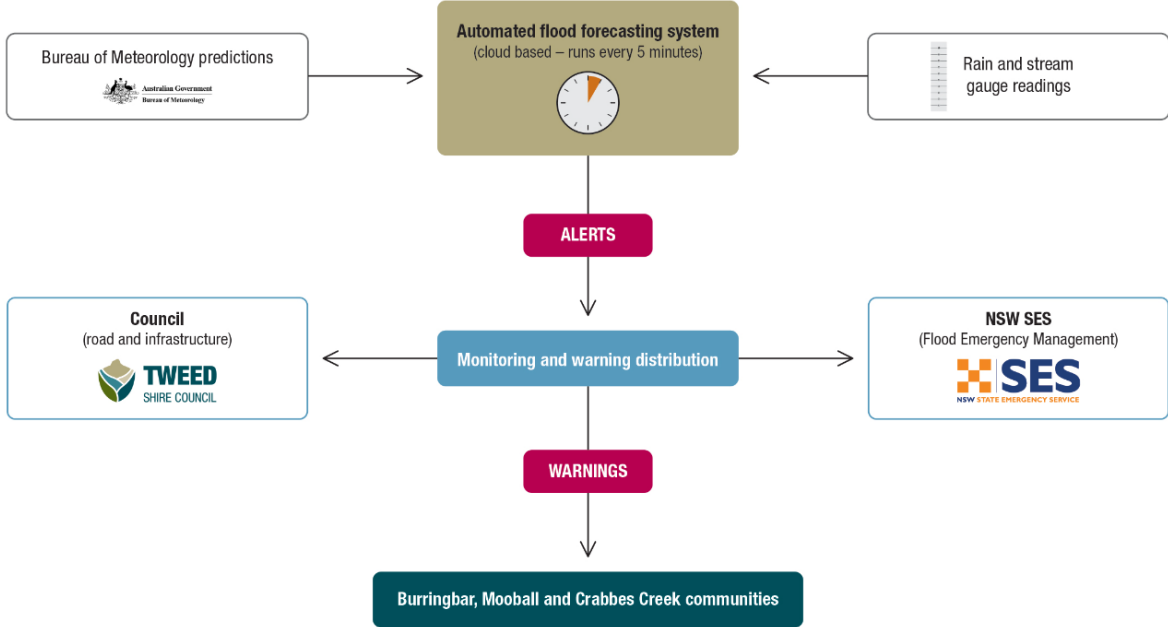
### 3.4 Burringbar and Crabbes Creeks Flash Flood warning network within the Tweed catchment

Previous studies on flood risk management have revealed that certain areas within the Burringbar, Mooball, and Crabbes Creek in the Tweed catchment are susceptible to sudden and unexpected flash flooding. Notable areas of concern include Dignan Street, Hunter Street, Tweed Valley Way, both the northern and southern sections of Mooball in proximity to the railway embankment, Crabbes Creek Village, and various rural road crossings like the Greenvale Court Culvert.

A key consideration for flooding in the area is the lack of amount of time available for warning. Heavy rainfall can trigger floods within a few hours, leaving residents with insufficient time to prepare or evacuate. Due to the short interval between rainfall and flooding in the small Burringbar Creek and Crabbes Creek catchments, the Bureau of Meteorology does not provide flood warnings for these areas. Consequently, the Tweed Shire Council, in collaboration with the NSW State Emergency Service (SES) and other government agencies, has developed an automated flash flood alert system to ensure timely notification for local residents about approaching floods.

The flash flood alert system has two main components (**Figure 3-2**): flood forecasting and alert distribution. The flood forecasting system involves a cloud-based computer system, running continuously, that accepts data from the local rain and water level gauges and combines this

with various Bureau of Meteorology prediction products to forecast flooding into the near future. The forecasting system is being monitored at all times. When predictions exceed certain thresholds, an alert will be distributed to the community. Then, SES and Council will be advised of approaching flooding, the expected timeframe and the magnitude at key locations.



**Figure 3-2 Schematic diagram of the flash flood alert system with two main components of flood forecasting and alert distribution (Tweed Shire Council website).**

### 3.5 Flood warning networks within the Brunswick catchment

Brunswick catchment faces flash flooding in numerous creeks and rivers, affecting low-lying towns and villages. Many of the Brunswick catchment’s population centres are only a few meters above sea level. On average, around half of the floods occur during the night and happen quickly, often unexpectedly. The upper reaches of the Shire's waterways experience flooding due to steep valleys, while the lower reaches are susceptible to flooding due to flat terrain, ocean levels, including storm surge, and the imminent sea level rise.

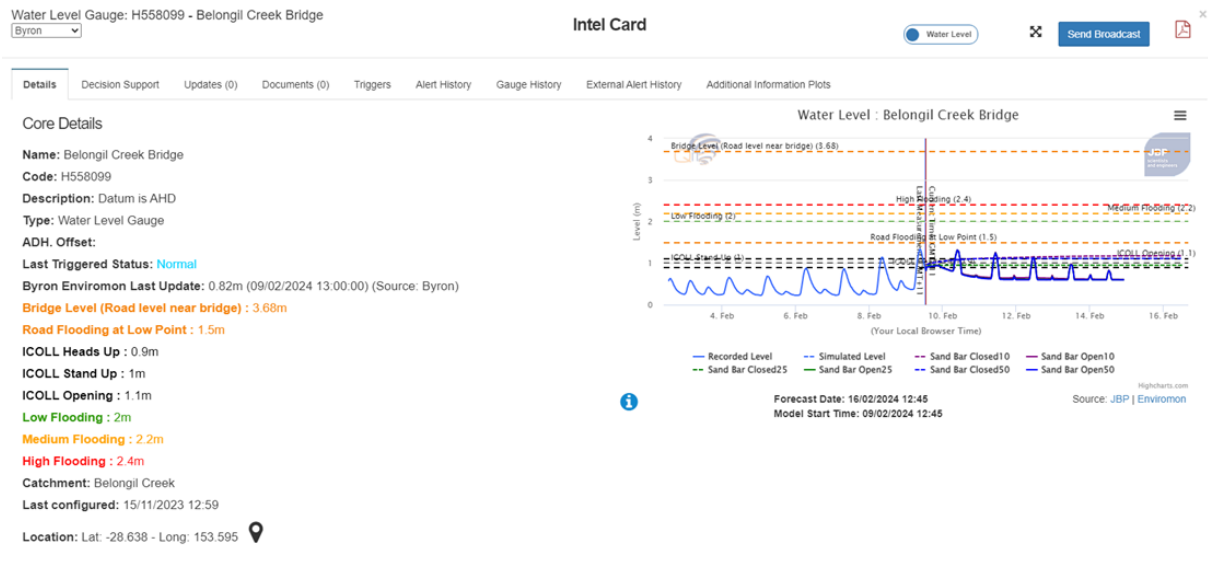
The resulting floods lead to damage in homes, businesses, and critical infrastructure. The lack of sufficient warning leaves people living in fear of flash flooding. Improving warning times can alleviate the psychological stress associated with living in flood-prone regions, providing residents with the time needed to prepare their homes and businesses for the impending flooding. Mullumbimby, Main Arm, and Upper Main Arm accommodate a population of 4,375 individuals, while Byron and Suffolk Park together house an additional 12,468 residents. A grand total of 24,343 people could potentially be impacted by flooding in the Shire and would benefit from an early warning system. These figures also escalate during holidays and events such as Splendour in the Grass, attracting tens of thousands of patrons to the area.

After installation of additional gauges in the Brunswick catchment, a complete coverage of the area was achieved which enabled an automated system to have operational flood forecasting warnings.

Byron Shire Council, NSW SES, BCD, and the Bureau collaborated to create a fully automated flood warning system for Byron Shire Council and agencies such as SES. Three areas in the Brunswick catchment have operational flood forecasting warnings, including Brunswick River, Belongil Creek, and Tallow Creek. The systems aim to function as a dynamic hydrological and static 2D hydraulic surface forecast system. Key components include utilising the Bureau ADFD for advance forecasting and radar rainfall products for more accurate predictions near peak flood levels. The system accepts rainfields and STEPS products from the Bureau, leverages existing water level gauge locations for ratings, and introduces additional rating locations for storm magnitude consistency. Fine grid flood models are utilised for increased reliability and accuracy.

In the flood forecasting systems within the Brunswick catchment DELFT-FEWS software is used to continuously forecast flood extents using live data from EnviroMon and forecast weather / soil saturation data from Bureau. The system provides Byron Shire council with information such as live updates of gauge observations, real-time forecast data (at 10%, 25%, and 50% intervals), gauge forecasts, predicted flood extents, forecasts flood affected properties, as well as SMS and email alerts triggered by forecast or observation thresholds. Byron Shire council also has a public-facing Emergency Dashboard that is monitored and controlled by Byron Shire council staff.

The ability to notify the subscribing community of any warnings through text messages is also present. An agreement with SES is in place where warnings or evacuation orders are essentially reshared via SMS service. It is perceived as a backup/support system to the SES system. Examples of water level and rainfall gauge forecast are illustrated in **Figure 3-3** and **Figure 3-4**.



**Figure 3-3 An example of water level gauge for flood warning**

Rain Fall Gauge: R558099 - Belongil Ck Bridge  
Byron

### Intel Card

Rainfall



Send Broadcast



Details Decision Support Updates (0) Documents (0) Triggers Alert History Gauge History External Alert History Additional Information Plots

#### Core Details

**Name:** Belongil Ck Bridge  
**Code:** R558099  
**Description:**  
**Type:** Rain Fall Gauge  
**ADH. Offset:**  
**Last Triggered Status:** Normal  
**Byron Enviromon Last Update:** 0.5mm (09/02/2024 12:20:00) (Source: Byron)  
**Catchment:** Belongil Creek  
**Last configured:** 10/08/2022 21:00  
**Location:** Lat: -28.637400686637 - Long: 153.594593939126

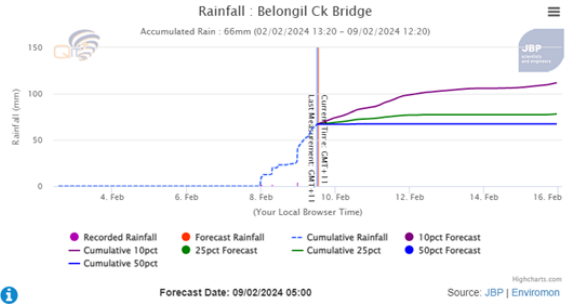


Figure 3-4 An example of rainfall gauge for flood warning

## 4 Review of existing studies/reports

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The following subsections summarise various flood risk management studies and plans undertaken through NSW floodplain risk management process, related studies, and additional flood warning recommendations within the study area. It should be noted that the majority of the below documents are floodplain risk management plans, which present recommendations on how to implement effective flood management strategies derived from the associated floodplain risk management studies. All other documents discussed below were identified by EHG (now BCD) in Table 3 of the project brief (EHG, 2023).

### 4.1 Murwillumbah CBD Levee and Drainage Study (Catchment Simulation Solutions, 2018)

Murwillumbah CBD Levee and Drainage Study report (Catchment Simulation Solutions, 2018) was produced on behalf of Tweed Shire Council to undertake a detailed flood study to define flooding and drainage behaviour when the Murwillumbah CBD Levee, the East Murwillumbah Levee and the Dorothy/William Streets Levee, and drainage behind the levees are overtopped. One of the main goals of the study was to assess the advantages of implementing various measures that could help improve the management of flood risk across the towns situated within the levee system. Recommendations relating to the improvement of flood warning were detailed, which are summarised in **Table 4-1**.

It was noted that 12 (1+11) residential and commercial properties were inundated in the 20% AEP flood event, 32 (2+30) were inundated in the 1% AEP flood event, and 117 (58+59) were inundated in the 0.2% AEP flood event. Total residential and commercial flood damages were approximately \$2.19 million (20% AEP), \$4.65 million (1% AEP), and \$59.31 million (0.2% AEP).

### 4.2 South Murwillumbah Floodplain Risk Management Study and Plan (Catchment Simulation Solutions, 2019)

South Murwillumbah Floodplain Risk Management Study and Plan was prepared for Tweed Shire Council to quantify the nature and extent of the existing flooding problem and evaluate options that could be potentially implemented to better manage the flood risk. Recommendations relating to the improvement of flood warning were detailed, which are summarised in **Table 4-1**.

It was shown that only a relatively small number of properties, 26 (5+18+3) residential, commercial, and industrial properties, can be exposed to above floor flooding during the 20% AEP flood events. However, the numbers of properties subject to the above floor inundation is predicted to increase significantly during the 1% AEP and 0.2% AEP floods to 158 (51+62+45) in the 1% AEP flood event and 275 (144+75+56) in the 0.2% AEP flood event. Total residential, commercial, and industrial flood damages were approximately \$6.90 million (20% AEP), \$45.1 million (1% AEP), and \$86.6 million (0.2% AEP).

### **4.3 Tweed Valley Floodplain Risk Management Plan (BMT WBM, 2014)**

The Tweed Valley Floodplain Risk Management Plan was prepared for Tweed Shire Council (BMT WBM, 2014). The Tweed Valley Floodplain Risk Management Plan is the result of detailed investigations and considerations of flood risk across the study area in the Tweed Valley Floodplain Risk Management Study and a prioritised plan to implement recommended measures. Most of the recommended measures in the report are non-structural, such as improved flood education, emergency planning and development planning. The major structural option recommended is raising the Tweed Heads South levee, which would provide increased protection to residents in the Dry Dock Road area. Further recommendations relating to the improvement of flood warning were detailed, which are summarised in **Table 4-1**.

It was noted that 51 (16+35) residential and commercial properties were inundated in the 20% AEP flood event, 1460 (1120 +340) were inundated in the 1% AEP flood event, and 6860 (6140+720) were inundated in the 0.2% AEP flood event. Total residential and commercial flood damages were approximately \$12 million (20% AEP), \$225 million (1% AEP), and \$986 million (0.2% AEP).

### **4.4 Tweed Coastal Creeks Floodplain Risk Management Plan (BMT WBM, 2015)**

Tweed Coastal Creeks Floodplain Risk Management Plan (BMT WBM, 2015) aimed to manage and minimise (where practical and possible) flood risk in the Tweed Coastal Creeks area, by implementing a range of floodplain management measures which were assessed as part of the Tweed Coastal Creeks Floodplain Risk Management Study. The Plan provides practical information such as timing, priority, expense, and responsibility for all of the measures recommended for implementation. Recommendations relating to the improvement of flood warning were detailed, which are summarised in **Table 4-1**.

It was noted that 80 dwellings were inundated in the 20% AEP flood event, 537 were inundated in the 1% AEP flood event, and 1575 were inundated in the 0.2% AEP flood event. Total residential and commercial flood damages were approximately \$1.68 million (20% AEP), \$26.59 million (1% AEP), and \$65.29 million (0.2% AEP).

### **4.5 Belongil Creek Floodplain Risk Management Study and Plan (BMT WBM, 2015)**

Belongil Creek Floodplain Risk Management Study and Plan (BMT WBM, 2015) was prepared for Byron Shire Council to define a series of actions which, if implemented, help to reduce the impact of flooding in Byron Bay by controlling the flood risk and reducing flood damages. Council will use the Plan as a resource in implementing the selected options which briefly outlines the issues and details the recommended management actions to be implemented following formal adoption by Byron Shire Council. Recommendations relating to the improvement of flood warning were detailed, which are summarised in **Table 4-1**.

The number of properties inundated in the 20% AEP flood event were recorded as 131 properties. Property numbers inundated were jumped to 264 in the 1% AEP flood event, and

a total of 663 properties were inundated in the PMF flood event. Total residential and commercial flood damages were approximately \$2.52 million (20% AEP), \$7.44 million (1% AEP), and \$31.06 million (PMF).

#### **4.6 North Byron Floodplain Risk Management Study and Plan (WMA Water 2020)**

The North Byron Floodplain Risk Management Study and Plan (WMA Water 2020) was produced for Byron Shire Council to provide an understanding of the current and future flood risk within the catchment and a long-term path to manage flood risk in the North Byron floodplain. Management options recommended in the report were identified to reduce the flood hazard and risk to people and property in the existing community and to ensure future development is controlled in a manner consistent with the flood hazard and risk. Recommendations relating to the improvement of flood warning were detailed, which are summarised in **Table 4-1**.

It was noted that 5 properties were inundated in the 20% AEP flood event, 211 properties were inundated in the 1% AEP flood event, and 451 properties were inundated in the 0.2% AEP flood event. Total residential and commercial flood damages were approximately \$1.89 million (20% AEP), \$42.51 million (1% AEP), and \$106 million (0.2%).

#### **4.7 Tallow Creek Floodplain Risk Management Study and Plan (Sinclair Knight Merz, 2009)**

Tallow Creek Floodplain Risk Management Study and Plan was prepared for Byron Shire Council (Sinclair Knight Merz, 2009) to develop a Floodplain Risk Management Strategy for the Tallow Creek catchment. Based on the outcomes of the Floodplain Risk Management Study, the Tallow Creek catchment was identified as relatively small and steep, meaning the dominant flooding mechanism for the catchment is flash flooding from short duration rainfall events. Due to the limited warning time available during such events, there is not enough time for a controlled evacuation response. Consequently, recommendation on flood warning system and installation of flood gauges were needed to increase public awareness of the flooding potential in the catchment as well as to assist SES operations during a flood event response. Tallow Creek Floodplain Risk Management Strategy was devised to support Byron Shire Council and landowners in effectively managing flood risks within the Tallow Creek catchment. Recommendations relating to the improvement of flood warning were detailed, which are summarised in **Table 4-1**.

It was noted that 54 properties were inundated in the 20% AEP flood event, 93 properties were inundated in the 1% AEP flood event, and 114 properties were inundated in the 0.2% AEP flood event. The average annual damage for the Tallow Creek community was estimated at \$30,000 (i.e., \$30,000/annum), for floods up to and including the PMF event.

## 4.8 Recommendations for flood warning improvement from previous studies

Recommendations for the improvement of flood warning within the Tweed and Brunswick River Valley catchment are outlined in **Table 4-1** and presented in **Figure 4-1**. Items underlined in **Table 4-1** highlight recommendations that have already been implemented.

**Table 4-1 Recommendations for flood warning system improvement from the literature**

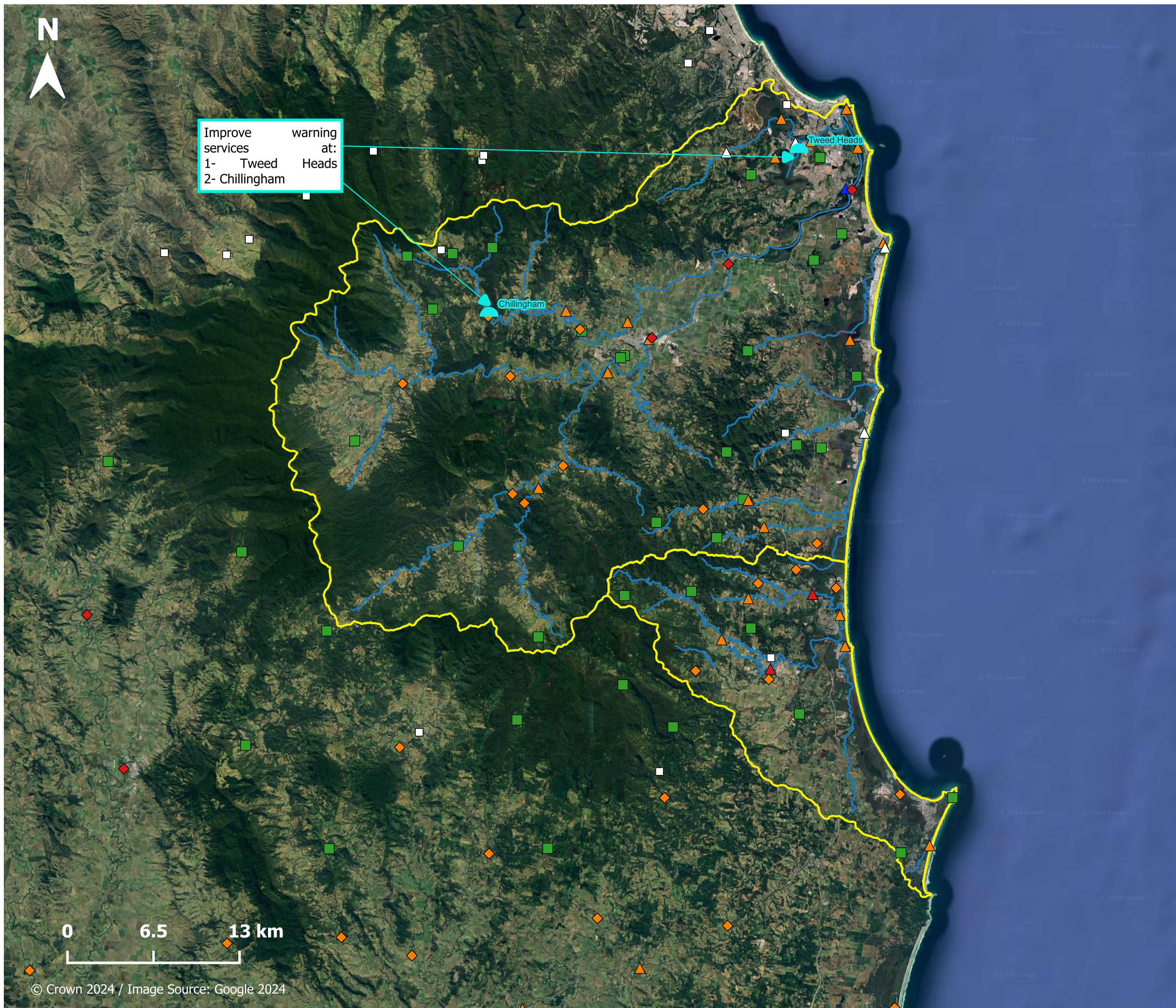
LGA	Study title	Author and date	Recommendations from literature	
			Flood infrastructure	Flood warning system
Tweed	Murwillumbah CBD Levee and Drainage Study	Catchment Simulation Solutions, (2018)	<ul style="list-style-type: none"> <li>Install “totem pole” flood marker near the intersection of Wharf Street and Commercial Road.</li> <li>Re-design the Commercial Road levee gates to allow them to “open” and release water back into the Tweed River during levee overtopping events.</li> </ul>	<ul style="list-style-type: none"> <li>Develop SMS Flood Messaging Service (potentially automated via linkages to water level gauges and established trigger levels).</li> <li>Develop a webpage or app for real time notifications of road closures in the Tweed Valley Way, Clothiers Creek, Tumbulgum and alternative routes.</li> </ul>
Tweed	South Murwillumbah Floodplain Risk Management Study and Plan	Catchment Simulation Solutions (2019)	<ul style="list-style-type: none"> <li>Install flood marker near the intersection of Alma Street and Tweed Valley Way.</li> <li>Introduce telemetered water level gauges or remote cameras at the Alma Street (<u>this recommendation has already been addressed with two gauges, one North Murwillumbah forecast location gauge and Murwillumbah Bridge water level data location</u>).</li> <li>Elevate the low point of Alma Street from ~4.35 m AHD to 4.65 m AHD.</li> </ul>	<ul style="list-style-type: none"> <li>Update Tweed Shire Flood Plan to incorporate new flood intelligence for South Murwillumbah.</li> <li>Establish revised river level triggers for Murwillumbah gauge to determine when evacuation routes will be cut (done with SES flood action cards. NRRRP tranche 2, by NSWRA, includes detailed evacuation planning project (currently in definition stage).</li> </ul>

LGA	Study title	Author and date	Recommendations from literature	
			Flood infrastructure	Flood warning system
			<ul style="list-style-type: none"> <li>• Raise South Murwillumbah Levee to 20%AEP Level.</li> <li>• Elevate sections of the South Murwillumbah levee that have settled over time to the original design elevations and construct dedicated spillway to allow for controlled levee overtopping.</li> <li>• Raise the height of existing Commercial Road/CBD levee.</li> </ul>	<ul style="list-style-type: none"> <li>• Investigate potential to incorporate SMS messaging into flood warning system.</li> </ul>
Tweed	Tweed Valley Floodplain Risk Management Plan	BMT WBM (2014)	<ul style="list-style-type: none"> <li>• Raise Tweed Heads South Levee from 2 m AHD to 2.8 m AHD</li> </ul>	<ul style="list-style-type: none"> <li>• Upgrade Tumbulgum water level gauge in the Bureau's formal warning system (<u>gauge became a forecast location in 2018</u>).</li> <li>• Develop flood information website for residents in the Tweed Valley to provide all the information in a single location such as flood warnings, predictions, evacuation information, road closures and interactive flood mapping.</li> <li>• Create a Flood Watch Network to make use of the knowledge and experience of Tweed Valley residents by collecting and incorporating real-time flood information. This system proves beneficial for monitoring rural roads in the Tweed Valley that are</li> </ul>

LGA	Study title	Author and date	Recommendations from literature	
			Flood infrastructure	Flood warning system
				challenging for the SES to observe during a flood situation.
Tweed	Tweed Coastal Creeks Floodplain Risk Management Plan	BMT WBM (2015)	<ul style="list-style-type: none"> <li>Install additional rainfall gauges upstream of Burringbar and Crabbes Creek (<u>two rainfall stations in Burringbar Creek and one rainfall station in Crabbes Creek have already been installed</u>).</li> <li>Install five additional water level gauges in the Burringbar, Mooball and Crabbes Creek area (<u>two water level gauges in Burringbar Creek, two water level gauges in Crabbes Creek, and one water level gauge in Mooball Creek have been installed</u>).</li> </ul>	<ul style="list-style-type: none"> <li>Install a network of audible flood sirens, connected to water level gauges in the regions of Burringbar, Mooball and Crabbes Creek as part of a flash flood warning system.</li> <li>SES actively promote the concept of Flood Watch Networks to contribute real-time flood information to the community, particularly in high-risk locations such as Burringbar, Mooball and Crabbes Creek.</li> <li>It is recommended that existing and new water level gauges in the Burringbar and Crabbes Creek flash flood alert system be classified so that definitions of minor / moderate / major floods can be established (such as likely road closures or evacuation). (<u>This is done as part of the Burringbar and Crabbes Creek flash flood alert project</u>).</li> <li>SES develop flood intelligence cards for the existing water level gauges and any new gauges installed to detail the relationship between flood gauge heights and flood consequences. No flood intelligence</li> </ul>

LGA	Study title	Author and date	Recommendations from literature	
			Flood infrastructure	Flood warning system
				cards exist for the Tweed Coastal Creek.
Tweed	New South Wales Strategic Flood Warning Infrastructure Plan	NSW/ACT Flood Warning Consultative Committee (2018)		<p>Flood warning services to be improved at:</p> <ul style="list-style-type: none"> <li>• Chillingham</li> <li>• Tweed Heads</li> <li>• Burringbar (<u>This is done as part of the Burringbar and Crabbes Creek flash flood alert project</u>).</li> <li>• Mooball (<u>This is done as part of the Burringbar and Crabbes Creek flash flood alert project</u>).</li> <li>• Crabbes Creek (<u>This is done as part of the Burringbar and Crabbes Creek flash flood alert project</u>).</li> </ul>
Byron	Belongil Creek Floodplain Risk Management Study and Plan	BMT WBM (2015)	<ul style="list-style-type: none"> <li>• Install additional data sources in the Belongil Creek catchment to provide real-time water level data in the catchment: <ul style="list-style-type: none"> <li>• Water level gauge station at the Ewingsdale Road Bridge (<u>this has already been addressed, there is a SLS water level gauge at the bridge</u>).</li> <li>• A rainfall gauge at St Helena (<u>This gauge has already been installed and called Coopers Shoot</u>).</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• For each flood level gauge, it is suggested that a “Flood Consequences” table be developed (e.g., evacuation route inundated at gauge level of 2.1m).</li> <li>• Create evacuation route maps.</li> </ul>

LGA	Study title	Author and date	Recommendations from literature	
			Flood infrastructure	Flood warning system
Byron	North Byron Floodplain Risk Management Study and Draft Plan	WMA Water (2020)	<ul style="list-style-type: none"> <li>Construct Billinudgel levee.</li> <li>Raise the entire length of Wilfred Street (approximately 450m) to provide 1% AEP flood immunity for properties in Billinudgel.</li> <li>Raise River Street from the corner of Casons Road to past the corner of Oceans Avenue to provide flood immunity up to and including the 1% AEP flood event. This involved raising the road by approximately 0.5 m to up to 1.5 m depending on the location.</li> </ul>	<ul style="list-style-type: none"> <li>Automatic warning signs and depth indicators for the Pocket Road, Sherry's Bridge on Main Arm Road, Myocum Road, Coolamon Scenic Drive, Wilsons Creek Road, Gulgan Road and Left Bank Road.</li> <li>Council to consider development of an automated emergency SMS system.</li> <li>NSW SES and Byron Shire Council to consider development of an online system where flood warning can be easily accessed.</li> </ul>
Byron	Tallow Creek Floodplain Risk Management Study and Plan	Sinclair Knight Merz (2009)	<ul style="list-style-type: none"> <li>Install a water level gauge along Broken Head Road near the BP service station (<u>This gauge has already been installed</u>).</li> <li>Install rainfall monitoring station on Tallow Lake and connect to Council's flood warning system (<u>This gauge has been installed</u>).</li> </ul>	<ul style="list-style-type: none"> <li>Support SES in inclusion of Suffolk Park in Flood Response Plan.</li> <li>Establish relationship between flood return period, sand bar levels and flooding conditions in Tallow Lake to assist in SES flood evacuation planning.</li> </ul>
Byron	New South Wales Strategic Flood Warning Infrastructure Plan	NSW/ACT Flood Warning Consultative Committee (2018)	<ul style="list-style-type: none"> <li>Install additional water level gauges.</li> <li>Install additional rainfall gauges.</li> </ul>	<p>Improve warning services at:</p> <ul style="list-style-type: none"> <li>South Golden Beach (<u>This is done</u>).</li> <li>Ocean Shore (Bay) (<u>This is done</u>).</li> </ul>



Improve warning services at:  
 1- Tweed Heads  
 2- Chillingham

**Figure 4-1**

**Recommendations for flood warning improvement within the study area**

**Legend**

Tweed and Brunswick Valley catchments

**Type of station**

- Rainfall
- River
- River/ Rainfall
- Flood Forecast

**Existing SLS gauges**

- Forecast locations
- River data locations
- Rainfall locations

**Existing stations outside the SLS network**

- Non-SLS gauges

**Reference Studies**

- NSW/ACT Flood Warning Consultative Committee (2018)

**Recommendation type**

- Flood forecast locations

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**Manly Hydraulics Laboratory**

## 4.9 Summary of recommendations from previous studies

The literature review summarised in **Section 4.8** identified a number of recommendations pertaining to the improvement of flood infrastructure and flood warning systems in the study area, these are summarised in **Table 4-2** and **Table 4-3**.

**Table 4-2 Summarised recommendations for flood infrastructure improvement from the literature**

Recommendations related to flood infrastructure	Implemented?	Riverine or flash	Available warning times (based on rainfall to flood peak)
A water level gauge in Crabbes Creek	✓	Flash flooding	< 6 hrs
A rainfall gauge station at St Helena	✓	Flash flooding	< 3 hrs
A water level gauge along Broken Head Road near the BP service station	✓	Flash flooding	< 3 hrs
A rainfall monitoring station on Tallow Lake	✓	Flash flooding	< 3 hrs
Two rainfall gauges in Burringbar Creek	✓	Flash flooding	< 6 hrs
Two water level gauges in Burringbar Creek	✓	Flash flooding	< 6 hrs
One rainfall station in Crabbes Creek	✓	Flash flooding	< 6 hrs
A water level gauge at Mooball Creek	✓	Riverine	> 6 hrs
A water level gauge station at the Ewingsdale Road Bridge (Belongil Creek)	✓	Flash flooding	< 3 hrs

**Table 4-3 Summarised recommendations for flood warning system improvement from the literature**

Recommendations related to flood warning arrangements	Implemented?	Riverine or flash	Available warning times (based on rainfall to flood peak)
Improve warning services at Tweed Heads	x	Riverine	> 6 hrs
Improve warning services at Chillingham	x	Flash flooding	< 6 hrs
Improve warning services at Ocean Shores and South Golden Beach	✓	Flash flooding	< 3 hrs
Upgrading Tumbulgum water level gauge	✓	Riverine	> 6 hrs
A flood forecast location in Billinudgel	✓	Flash flooding	< 3 hrs

Recommendations related to flood warning arrangements include:

- Improve warning services at Tweed Heads. Tweed Heads has a geography position with both riverine and flash flooding characteristics, with riverine flooding risk from Tweed River to the east and potential hazards of flash flooding from multiple creeks including Cobaki, Piggabeen, Bilambil, Duroby and Terranora Creeks to the west.
- Improve warning services at Chillingham. The area is susceptible to flash flooding.
- Establishing revised river level triggers for Murwillumbah gauge to determine when evacuation routes will be cut.

It is important to clarify that developing local flash flood warning services is not within the scope of this project. The present project focuses on improving flood warning services in alignment with the SLS network. Any consideration for additional funding for local flash flood warning services will be revisited once all SLS priorities are adequately addressed.

Comparing the recommendation from the literature review discussed in **Section 4.8** with the existing gauges revealed that a number of recommendations have already been addressed by local Council and government agencies which are summarised as below:

- A rainfall gauge station at St Helena has been installed, called Coopers Shoot. The gauge recommendation needed to move to the current location for various reason (e.g. installation requirements) as noted by council.
- A water level gauge along Broken Head Road near the BP service station is being installed as indicated by council during the preparation of the report.
- A rainfall gauge near Tallow Lake has been installed on Byron Bay (Tallow Creek Bridge) water level gauge.
- Two rainfall gauges and two water level gauges have been installed in Burringbar Creek.

- A rainfall station has been installed in Crabbes Creek.
- Two water level gauges have been installed in Crabbes Creek
- A water level gauge has been installed in Mooball Creek.
- (North) Murwillumbah and Murwillumbah Bridge gauges were installed to monitor Alma Street overtopping/closure.
- One water level gauge station was installed at the Ewingsdale Road Bridge (Belongil Creek).
- Tumbulgum water level gauge was upgraded to a flood forecast location (Bureau's formal warning system).
- Flood warning services have been improved at Burringbar, Crabbes, and Mooball Creeks.
- Flood warning services have been improved at Ocean Shores and South Golden Beach as noted by council.

Considering the focus of this study on upgrading/new flood infrastructure (water level and/or rainfall stations), a tabulated summary of recommendations for new infrastructure is presented in **Table 4-4**. It should be noted that broad recommendations such as constructing or raising levees have not been included in **Table 4-4**.

**Table 4-4 Number of new flood infrastructure recommended to be installed in the study area.**

Catchment	Number of new flood infrastructure recommended to be installed			
	Rainfall	River	Flood forecast	Total
Tweed	-	-	2	<b>2</b>
Brunswick	-	-	-	-
<b>Total</b>	-	-	<b>2</b>	<b>2</b>

## 5 Flood warning network Gap analysis

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In addition to the literature review component (refer **Section 4**), the following subsections outline a gap analysis of broader gap regions in the flood warning network, as well as specific gaps identified by stakeholders such as the local councils throughout the consultation process. Possible strategies for filling flood warning network gaps are outlined in **Table 5-1**.

### 5.1 Gap regions

Considering the existing river/rainfall stations within the study area and the recommendations derived from the literature described in **Section 4**, some potential gaps in the flood warning infrastructure within the study area were identified. These gaps represent areas where the existing network of river and rainfall monitoring stations may be insufficient to provide accurate and timely flood warnings. While the literature-based recommendations may not specifically address these specific gaps, a more generalised need for an enhanced flood warning system becomes evident through evaluation of both the existing SLS gauges and non-SLS gauges. Local councils are acknowledged the necessity for additional gauges to fill in these gaps, recognising them as a crucial supplement to the existing flood infrastructure within the study area.

To effectively improve the flood warning system, it is imperative to identify and fill these gaps with strategically placed river or rainfall monitoring stations, while also considering the responsibility of flood warning system by councils as outlined in the intergovernmental agreement (IGA). These stations play a crucial role in collecting real-time data, which, when integrated into the overall forecasting system, can significantly enhance the accuracy and reliability of flood predictions. This is a critical step toward achieving a more robust and responsive flood warning system that can better protect communities and infrastructure from the impacts of flooding. The location of the data gaps in relation to the existing gauge network is illustrated in **Figure 5-1**. Further information related to potential gaps and their improvement to the existing flood infrastructure for Tweed catchment are presented in **Table 5-1**. It is noted that no riverine gaps were identified in the Brunswick catchment as most of this catchment is subject to flash flooding which is considered outside the scope of this project.

**Table 5-1 Potential improvements to the existing Tweed catchment flood infrastructure**

Gap location	Type	Description (benefit and potential impacts)
Tyalgum Creek	RF	<p>There is currently no rainfall gauge installed on Tyalgum Creek. The addition of a rainfall gauge in Tyalgum Creek enhances redundancy and accuracy in the existing flood forecasting system operated by the Bureau at Murwillumbah. With increased rainfall gauge density, particularly in hinterland areas like Tyalgum, forecasts and response to potential flood events can be better anticipated. While improving redundancy and accuracy, the addition of a rainfall gauge in Tyalgum Creek is not expected to change the lead time for flood forecasting. Instead, it ensures that forecasts remain reliable and consistent.</p> <p>The Tyalgum area has also been identified as a potential flash flooding flood warning location by the local council. While development of such flash flooding warning location is outside the scope of this project and would require alternative funding avenues, it can be noted that the presence of a rainfall gauge in Tyalgum Creek would support the establishment of any potential future flash flood alert system at Tyalgum.</p>
Dunbible Creek	RF/WL	<p>There is currently no water level or rainfall gauge installed in the Dunbible Creek catchment.</p> <p>A water level and/or rainfall gauge on Dunbible Creek may improve the accuracy of the existing Bureau flood forecast at Murwillumbah. It should be noted that target warning lead time for North Murwillumbah gauges is reported as 6 -12 hrs.</p>
Cobaki Creek and Duroby Creek	RF	<p>Although there is adequate coverage of SLS river data locations in the north-eastern portion of the Tweed catchment, this part of catchment has inadequate rainfall gauges. There is currently one rainfall gauge close to Bilambil Creek. Rainfall gauges can be installed on Cobaki Creek and Duroby Creek.</p> <p>It is noted that this recommendation is dependent on the development of a potential new flood forecast location at Tweed Heads as proposed in this report. Should this new forecast location be established at Tweed Heads, the addition of rainfall gauges will enhance redundancy and improve the accuracy of the flood forecast in the downstream area from Cobaki Creek and Duroby Creek to Tweed Heads.</p>

## 5.2 Stakeholder identified gaps

In anticipation of future flood risks in the Tweed catchment, several flood warning improvements were proposed by Tweed Shire Council post-2022 flood event in the locations at the risk of riverine and flash flooding. There are plans for:

- 1- Cabarita/Bogangar (Cudgen Creek) flood warning service (riverine flooding)
- 2- Pottsville flood warning service (riverine flooding)
- 3- Cudgera Creek (riverine flooding)
- 4- Hinterland Villages, including Uki (riverine flooding), Chillingham (flash flooding), and Tyalgum (riverine flooding) flood warning services
- 5- Tweed Broadwater Creeks (Piggabeen, Cobaki, Bilambil, Duroby) flash flood warning service (flash flooding)

The location of the stakeholder identified gaps are shown in **Figure 5-2**. Although these upcoming projects have been considered in the Multi-Criteria Analysis (MCA) in this report (**Section 6**) to provide a more detailed discussion on all catchments identified by Tweed Shire Council that are at risk of flooding, small catchments and local flash flood warning systems are considered out of scope in this report. Additionally, it should be noted that the absence of a formal evaluation through the flood risk management study and plan process underscores the need for detailed assessment as these projects progress. The identification of potential new forecast locations during the floodplain risk management process signifies the importance of local insights and expertise in addressing the unique challenges posed by Tweed's specific geography and community needs.

It is noted that recommendations from this report will be considered for implementation in the Bureau's national prioritisation process to ensure ongoing sustainability and quality of the National Flood Warning Service. The national demand for flood service enhancements is currently significant and therefore specialist capacity of resources to deliver these enhancements also remains a limitation, requiring requests to be prioritised and sequenced as capacity allows. Hence, more complex flood warning systems requiring bespoke arrangements rather than more standard systems may be considered as lower priority in the national prioritisation process.

As indicated by Byron Shire Council, collaboration is underway among the council, SES, and consultants to install additional rainfall and water level gauges in the Brunswick catchment. The specific sites for these proposed new gauges will be determined following additional investigation. Initially, Tallow footbridge, Belongil Road Bridge, and Orana Road Bridge are being considered as the first three locations for these gauges. Additional measures are recommended by Byron Shire Council to enhance the precision of the flood forecasting network. These actions are outlined as follows:

- 1- Rating all gauges and update intel cards to improve support to SES
- 2- Reviewing / auditing system operation to see how successful flood predictions have been
- 3- Bringing improved Bureau forecasting products into the system, such as rain radar to help improve live forecasting

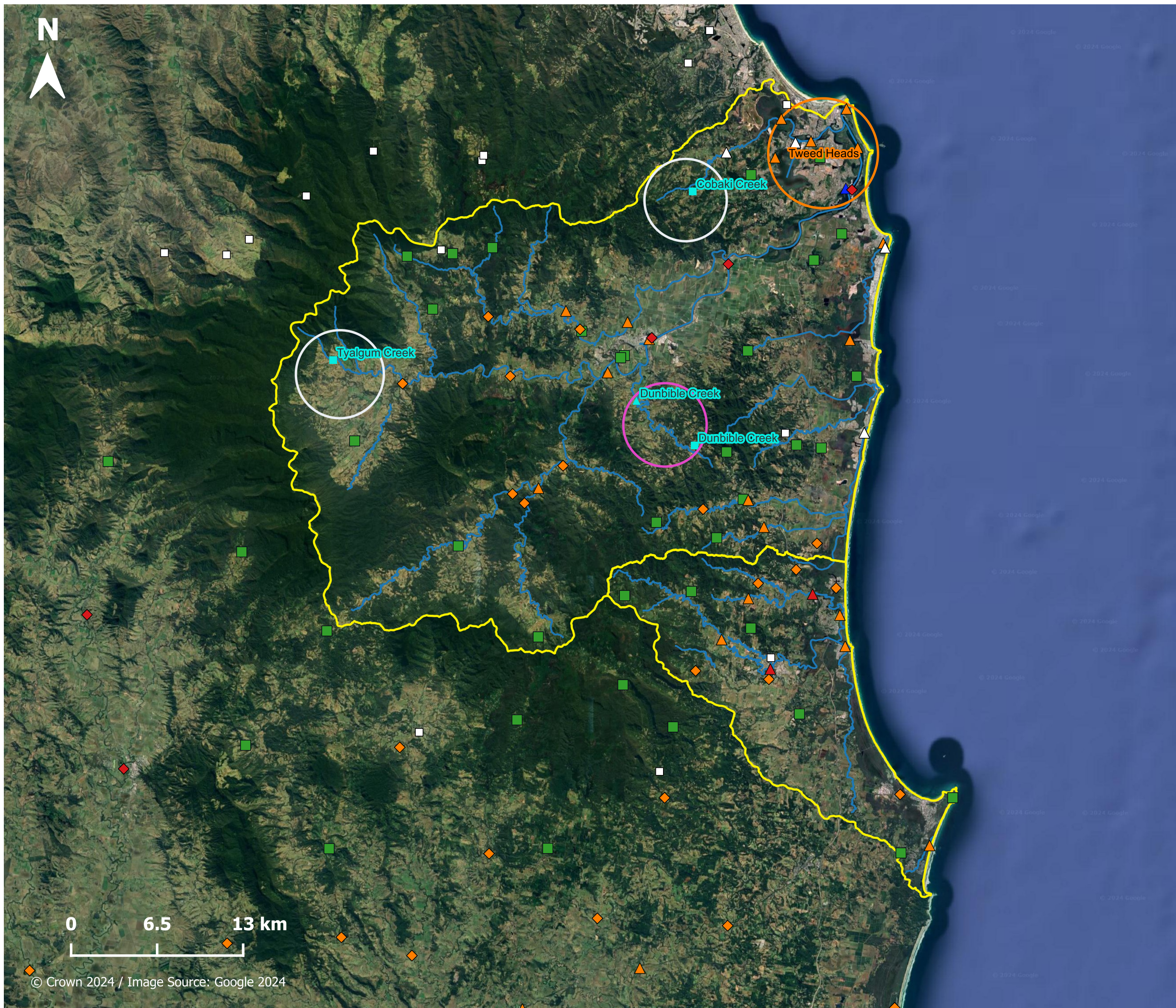
- 4- Adding dynamic scour modelling for ICOLL mouths into system post Belongil and Tallow Creek flood plan review and model improvements.

### 5.3 Potential non-SLS gauges upgrades

This section describes the most effective non-SLS gauges that can be used by the Bureau to possibly fill in the gap regions in the flood warning network. The Bureau uses information from various station types and classifications to monitor the potential for riverine flooding. This monitoring activity includes collection of rainfall and river level data, undertaking the routine catchment monitoring, and river height prediction activities necessary for flood warning system. In the updated Bureau Service Level Specification gauges 2024, several non-SLS gauges were incorporated into the Bureau’s SLS network. Given this information, **Table 5-2** presents 4 rainfall and 3 water level non-SLS gauges within the Tweed and Brunswick catchments that may be used by the Bureau to improve the accuracy of the flood forecast and prediction, and mitigate flood risk.

**Table 5-2 Potential non-SLS gauges upgrades within Tweed and Brunswick catchments**

Gauge	Bureau number	Data type	Owner
Mullumbimby (Fairview Farm)	58040	Rainfall	BoM
Mount Numinbah	58197	Rainfall	BoM
Coolangatta	40717	Rainfall	BoM
Cudgera	558046	Rainfall	DCCEEW BCD
Mooball Creek	-	Water level	DCCEEW BCD
Kingscliff Upstream	-	Water level	DCCEEW BCD
Cobaki Creek	-	Water level	WaterNSW



**Figure 5-1**

**Potential gaps identified for improving flood infrastructure in the study area**

**Legend**

Tweed and Brunswick Valley catchments

**Type of station**

Rainfall  
 River  
 River/ Rainfall

**Existing SLS gauges**

● Forecast locations  
● River data locations  
● Rainfall locations

**Existing stations outside the SLS network**

○ Non-SLS gauges

**Literature review priority list**

Flood warning improvement

**Broad data gap regions**

Rainfall  
 Water level / Rainfall

**Potential gap filling strategies**

● New gauge installation

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# Figure 5-2

## Stakeholder identified gaps




### Legend

 Tweed and Brunswick Valley catchments

### Type of station

-  Rainfall
-  River
-  River/ Rainfall

### Existing SLS gauges

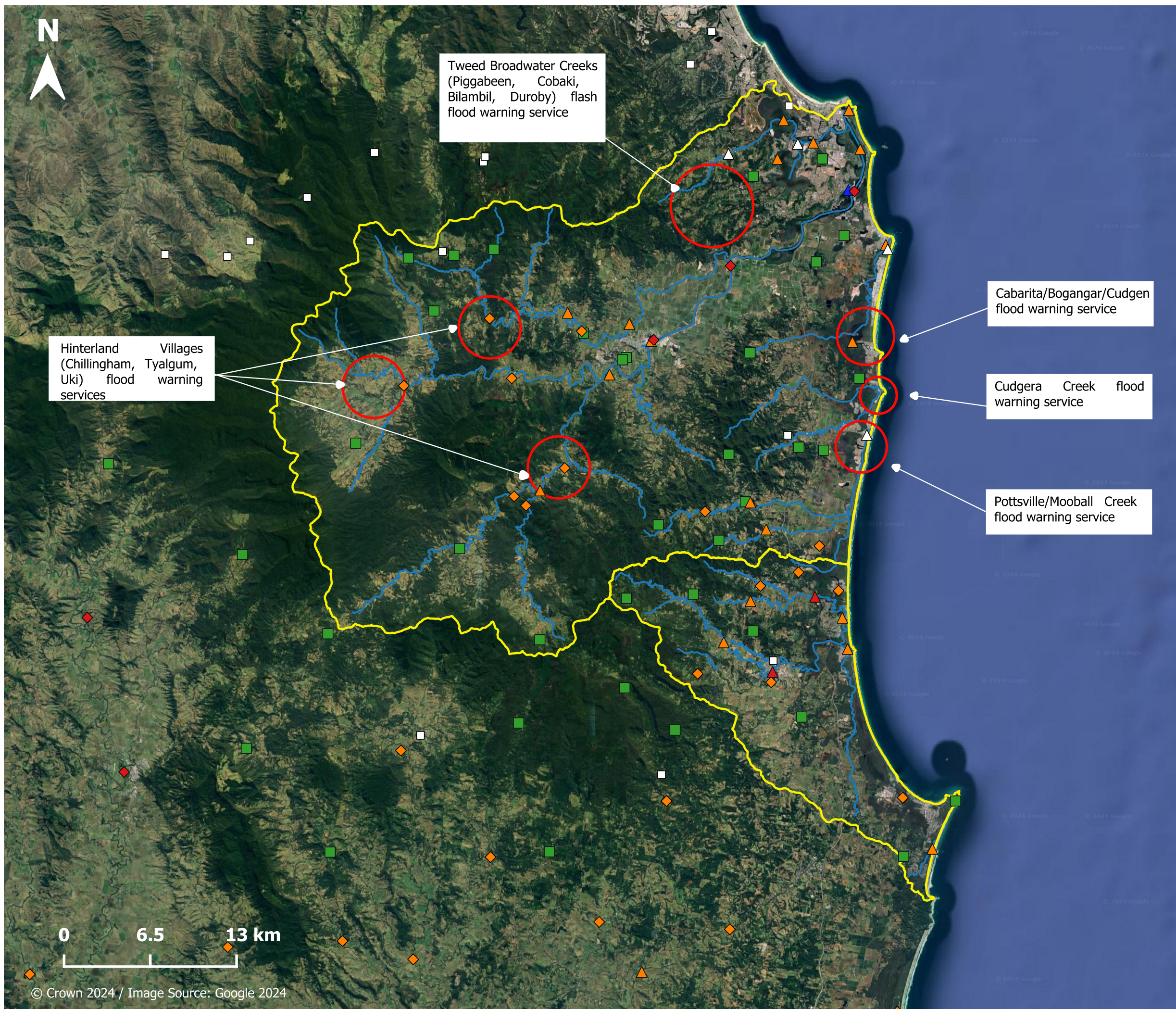
-  Forecast locations
-  River data locations
-  Rainfall locations

### Existing stations outside the SLS network

-  Non-SLS gauges

### Stakeholder identified gaps

-  Flood warning improvement



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## 6 Community feedback

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Consultation provides an opportunity for various stakeholders, including the community, to collaborate in developing and revising the identified recommendations for improving flood warning arrangements in the study area. Engaging the community throughout the process provides opportunities to both garner useful feedback and increase community acceptance of the proposed flood warning improvements.

The consultation program for the project included the development of a website and feedback form, which are discussed in more detail in [Section 6.1](#) and [Section 6.2](#).

### 6.1 Website

A project website was developed by MHL, which included the following webpages:

- **'Home'**: an outline of the broader project, objectives and expected outcomes.
- **'Frequently asked questions (FAQ)'**: general information on the total flood warning system, how the Bureau forecasts flooding, the type of warning products issued, how flood classifications (minor, moderate or major) are determined, the difference between flash and riverine flooding, how flood warning networks operate (data collection and communication), and key stakeholders for flood warning.
- **'Tweed and Brunswick Rivers Project'**: a project specific webpage was developed to provide updates as the project progresses.
- **'Additional Work Packages'**: provides an indication of additional work packages to be undertaken.
- **'Community Feedback'**: provides a link to the online feedback form developed as part of the project.

Links to the website were distributed to the community by local councils in their respective communication channels.

### 6.2 Feedback form

#### 6.2.1 Feedback form description

A simple, open-ended online feedback form was developed, which introduced the project and briefly summarised the work to date. The online feedback form was developed using the SurveyMonkey platform and was open for response from early August to mid-September 2024. The primary goal of the feedback form was to gain information from community regarding the potential gaps and areas for improvement within the existing flood warning network. The feedback form comprised the following questions:

- 'Can you identify any gaps or areas of improvement for the existing flood warning network within the Tweed and Brunswick Rivers catchments?'
- 'Do you have any other feedback or comments?'

### 6.2.2 Feedback results

Two (2) responses were received, and the following gap regions were identified based on the responses collected:

- **A water level gauge on Mooball Creek.** There is flooding problems in the Pottsville area near the Mooball Creek. It should be noted that this report identified that the existing water level gauge at Mooball Creek may be integrated into the Bureau's flood warning network. It was clear that some members of the community were not aware of the existing Mooball Creek water level gauge.
- **Making the gauge datum consistent for all the gauges within Tweed and Brunswick.** Standardising the gauge datum across all gauges in Tweed and Brunswick is recommended. Currently, some gauges, such as Letitia 201472, use the LGH (Local Gauge Height) Datum, while others, like Chinderah 558010 and Tumbulgum 558014, use the AHD (Australian Height Datum). Adopting a consistent datum, preferably AHD, would make it easier for the community to access and interpret the data. This has been discussed in **Section 10.7**.

## 7 Multi-criteria analysis for recommendations

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The following subsections outline the approach taken to prioritise the recommended improvements to flood warning identified from the literature review, gap analysis, and community feedback as discussed in **Section 4** and **Section 5**, and **Section 6**. Three separate MCAs were completed to evaluate the different work packages for filling both broad gaps and specific/stakeholder identified gaps, which included: (1) new rainfall or water level gauges; (2) the integration of existing non-SLS rainfall or water level gauges into the Bureau's flood warning network; and (3) the setup of potential new flood forecast locations.

### 7.1 Overview

Multi-Criteria Analysis (MCA), sometimes referred to as Multi-Criteria Decision Analysis, is a non-monetary decision-making framework often used in environmental decision making (Janssen, 2001). Its main advantage over a more traditional Cost-Benefit Analysis (CBA) is that it is able to account for a range of intangible values (or significance) as one does not need to quantify all values in terms of dollars. Additionally, it can accommodate differing or conflicting priorities more transparently than a CBA by integrating them into a rational decision-making framework. The MCA (Multi-Criteria Analysis) process is intended to have decision makers informed about the problem situation, their own and others' values and judgments, and to be guided by the organization, synthesis, and appropriate presentation of information in identifying, often through extensive discussion and a preferred course of action (Belton & Stewart, 2002).

MCA does this through a selection of criteria which aim to cover all the important factors, or dimensions, of the problem from the point-of-view of each stakeholder group or concerned party. Following this selection, the MCA process involves assessment and discussion of the options against the selected criteria and includes weighting of criteria and sensitivity analysis around the proposed decision. This process, then, can help to complement and challenge intuition, make use of relevant experience and lead to more considered and justifiable decision-making (Belton & Stewart, 2002).

MHL has opted to use an MCA framework in the options assessment primarily for its ability to act as a tool for initiating and directing discussion among the PWG and for the easy comparison of the relevant factors in developing a rational and justifiable outcome. The MCA framework will be used to assess each previously recommended gauge installation or potential new flood forecast location individually, and then create a shorter, prioritised list of recommendations to be considered for further investigation. In this way, stakeholders will be able to assess a manageable subset of options rather than needing to deal with all the permutations of the system.

### 7.2 Criteria Selection

This section describes the criteria used to assess the installation of (1) new rainfall or water level gauges; (2) the integration of existing non-SLS rainfall or water level gauges into the Bureau's flood warning network; and (3) the setup of potential new flood forecast locations. These criteria informed which options are suitable for different tiers of warning as well as their

overall viability. The criteria selected for this assessment were collected from prior MHL studies and discussions with the PWG. It should be noted that some criteria used for assessing the previously recommended gauge installations and integrations into Bureau SLS did not apply to the assessment of potential new forecast locations. Therefore, the MCA was completed separately with appropriate criteria for the potential new forecast locations and the recommended rainfall and water level gauge installations and integrations. Brief explanations of MCA criteria for three above-mentioned MCA types are outlined in **Section 7.2.1** to **Section 7.2.3**.

### **7.2.1 New gauge installations**

The criteria used for the MCA of recommended installations of new rainfall and water level gauges are explained in **Table 7-1**, and further information on how each criterion was weighted and scored is presented in **Table 7-2**.

### **7.2.2 Non-SLS gauge integrations**

The criteria and associated weightings used for the MCA of integration of non-SLS gauges into the Bureau's flood warning network based on the gap analysis are using the same criteria as the MCA of recommended new rainfall and water level gauges installations explained in **Table 7-1** and **Table 7-2** but included the following changes:

- The ownership of land and planning zone were not applicable.
- Maintenance cost was not included as the gauges are existing and the maintenance was therefore expected to already be covered.
- Ease of work and cost of works were assumed as 3 and environmental impact was set as 5 for all gauges as part of this preliminary assessment, pending further information on characteristics of the gauges and level of upgrade required to be incorporated into the Bureau's SLS network (i.e. gauge already setup appropriately or requiring technical or equipment updates).

### **7.2.3 Potential new forecast location criteria**

The criteria used for the MCA of potential new flood forecast locations are explained in **Table 7-3** while further information on how each criterion was weighted and scored is presented in **Table 7-4**. The criteria include relation to riverine or flash flooding, scale of benefit to the community, flood hazard the community is exposed to, and the benefits for emergency response.

**Table 7-1 New gauge installations MCA criteria explanations**

MCA Criteria	Explanation
Does this recommendation relate to flash or riverine flood processes?	Higher score was placed on the previously recommended rainfall or water level gauges proposed to be installed in a catchment characterised by riverine flooding, as opposed to flash flooding. While the setup of new, or improvement of existing flash flood warning arrangements is considered to be out of this project's scope of works, recommendations are documented for consideration in the future.
Benefit to flood forecasting lead time	Lead time refers to the length of time between rainfall or water level information being collected and the flood forecasting service provided based on that information. Target warning lead times for existing flood forecasting from 3 hours at Mullumbimby and Billinudgel to 6 hours at North Murwillumbah, Tumbulgum, and Chinderah. It should be noted that most key watercourses are gauged in the Tweed and Brunswick catchments and considering the fairly short target warning lead time in these catchments, any additional improvement in flood warning lead times would likely be relatively minor.
Benefit to flood forecasting accuracy	Accuracy may refer to the correctness of the flood forecast or the redundancy of the network. The coverage of rainfall and water level gauges within a network drives the accuracy of the flood forecast. If key watercourses upstream of the forecast location are not gauged, the flood forecast may have greater uncertainties. Alternatively, the redundancy of the network refers to the ability of flood forecasts to remain reliable when elements of the flood warning arrangements fail or not work as designed. By minimising the number of moving parts (or points of failure) there is less opportunity for these failures to occur and hence a more robust system. This is particularly important in flood warning system design when uncertainty may lead to catastrophic consequences.
Scale of benefit to community	Scale of benefit to the community refers to the size of the town and density of population. As part of this project, the improvement of flood warning arrangements for a spatially smaller urbanised community is preferred over extensive rural areas with a smaller population.
Flood hazard the community is exposed to	The flood hazards a community is exposed to were estimated using flood hazard mapping from previous flood studies. Communities exposed to more severe flooding at more frequent intervals, such as Tweed Heads, indicate the necessity of improved flood warning arrangements. A score of 3 was assumed for any location outside of the extent of available flood hazard mapping.
Benefits for emergency response (SES)	Benefit to emergency response, primarily the NSW SES, refers to the ability of the new rainfall or water level gauge to improve emergency planning and decision making. Factors such as existing flood warning arrangements, susceptibility to flooding, and population contribute to the improvement of emergency response.
Ease of works	Ease of works refer to the difficulty of installation or works associated with rainfall or water level gauges. It was assumed that the installation of a water level gauge would be more difficult than a rainfall gauge, which would be more difficult than the upgrade of an existing gauge.

MCA Criteria	Explanation
Ownership of land and planning zone	The ownership of land the previously recommended gauge was positioned on was considered through the use of cadastral spatial layers identifying which lots or road corridors were Crown land, council owned, or freehold. Crown and council owned land were scored higher due to the challenges associated with private land access and long-term tenure. Land planning zones were also considered due to their influence in determining whether a review of environmental factors (REF) was required to install the rainfall or water level gauge. Planning zones exempting the requirement of an REF were scored higher.
Environmental and ecological impact of the works	Environmental and ecological impacts refer to the amount of disturbed land as part of the installation of new gauges. The installation of a rainfall gauge was assumed to disturb less land area than the installation of a water level gauge while the upgrade of an existing rainfall or water level gauge may disturb even less ground than a new rainfall gauge installation.
Costs of equipment and/or installation	Costs have been assessed against estimated capital cost to install the gauge (\$), as well as the relative maintenance costs to continue operation. The number of routine inspections per year were used as a proxy for maintenance costs. For example, water level gauges typically require quarterly maintenance, as opposed to rainfall gauges, which require bi-annual maintenance.

**Table 7-2 MCA criteria for the installation of new rainfall and water level gauges**

Item	Weighting	Score				
		1	2	3	4	5
		Low				High
Does this recommendation relate to flash or riverine flood processes?	5	Related to local flash flood systems	n/a	Only related to potential new riverine forecast locations	n/a	Related to existing riverine forecast locations
Benefit to flood forecasting lead time	5	No impact	0 – 4-hour improvement	4 – 8-hour improvement	8 – 12-hour improvement	>12-hour improvement
Benefit to flood forecasting accuracy	5	No impact	Captures an ungauged length of watercourse with downstream gauging	Captures an ungauged length of watercourse with no downstream gauging	Captures multiple minor ungauged watercourses with no downstream gauging	Captures key ungauged watercourse
Scale of benefit to community	4	No impact	Few properties benefiting	Benefits localised areas	Benefits extensive rural or smaller urban areas	Benefits higher density urban areas or multiple communities
Flood hazard the community is exposed to	4	H3 or lower for a PMF or extreme event	H4 for a PMF or extreme event	H5 – H6 for a PMF or extreme event	H5 – H6 for a 1% AEP event	H5 – H6 in a 5% AEP event
Benefits for emergency response (SES)	5	No impact	n/a	Minor improvement for SES planning, response and decision making	n/a	Major improvement for SES planning, response and decision making
Ease of works	3	Very difficult (platform or long sensor run required)	Difficult (standard new water level gauge)	Neutral (standard new rainfall gauge)	Easy (upgrade or repair)	Very Easy (do nothing)
Ownership of land and planning zone	4	REF required and gauge on freehold land	n/a	Either an REF is required, or the gauge is on freehold land	n/a	No REF required and the gauge is on public land
Environmental and ecological impact of the works	1	High impact	Moderate	Minor impact	Negligible impact	No impact
Cost of equipment and/or installation	2	Very high (\$55,000 - \$70,000)	High (\$40,000 - \$55,000)	Moderate (\$25,000 - \$40,000)	Low (\$10,000 - \$25,000)	Very low (<\$10,000)
Cost of maintenance	2	Very high (monthly maintenance)	High (quarterly maintenance)	Moderate (bi-annual maintenance)	Low (annual maintenance)	Very low (no routine maintenance)

**Table 7-3 Potential new flood forecast location MCA criteria explanations**

MCA Criteria	Explanation
New forecast location where there is an identified need?	The establishment of a new flood forecasting service where there is a critical need in helping mitigate flood risk. It was assumed existing rainfall and water level gauges available supporting the potential new forecast location would allow for a streamlined development. If there were insufficient supporting gauges, additional rainfall or water level gauges would likely be installed, thus increasing costs, and delaying development.
Does this recommendation relate to flash or riverine flood processes?	Higher score was placed on the previously recommended rainfall or water level gauges proposed to be installed in a catchment characterised by riverine flooding, as opposed to flash flooding. While the setup of new, or improvement of existing flash flood warning arrangements is considered to be out of this project's scope of works, recommendations are documented for consideration in the future.
Scale of benefit to community	Scale of benefit to the community refers to the size of the town and density of population. As part of this project, the improvement of flood warning arrangements for a spatially smaller urbanised community is preferred over extensive rural areas with a smaller population.
Flood hazard the community is exposed to	The flood hazards a community is exposed to were estimated using flood hazard mapping from previous flood studies. Communities exposed to more severe flooding at more frequent intervals, such as Tweed Heads, indicate the necessity of improved flood warning arrangements. A score of 3 was assumed for any location outside of the extent of available flood hazard mapping.
Benefits for emergency response (SES)	Benefit to emergency response, primarily the NSW SES, refers to the ability of the new rainfall or water level gauge to improve emergency planning and decision making. Factors such as existing flood warning arrangements, susceptibility to flooding, and population contribute to the improvement of emergency response.
Hydrological forecast capability	Hydrological forecast capability relates to a capability assessment of the bureau to deliver. This would take into account the difficulty level in developing forecast techniques/modelling based on level of available historical data, availability of rating curves, suitability to hydrological modelling.

**Table 7-4 MCA criteria for the setup of potential new flood forecast location**

Item	Weighting	Score				
		1	2	3	4	5
		Low				High
New forecast location where there is an identified need?	5	Service already established	n/a	No existing forecast location but few existing surrounding gauges for setup	n/a	No existing forecast location but many existing surrounding gauges for setup
Does this recommendation relate to flash or riverine flood flooding?	5	Related to local flash flood systems (< 6 hrs)	n/a	Related to flash/ riverine flood systems (6 - 9 hrs)	n/a	Related to riverine flood systems (> 9 hrs)
Scale of benefit to community	4	No impact	Few properties benefiting (<10 properties)	Benefits localised areas (<5 streets of properties)	Benefits extensive rural or smaller urban areas	Benefits higher density urban areas or multiple communities
Flood hazard the community is exposed to	4	H3 or lower for a PMF or extreme event	H4 for a PMF or extreme event	H5 – H6 for a PMF or extreme event	H5 – H6 for a 1% AEP event	H5 – H6 in a 5% AEP event
Benefits for emergency response (SES)	5	No impact	n/a	Minor improvement for SES planning, response and decision making	n/a	Major improvement for SES planning, response and decision making
Hydrological forecast capability	4	Not viable (outside current Bureau capabilities )	Major changes needed (bespoke Bureau approach required)	Some changes needed	Minor changes needed	No significant changes needed (standard Bureau approach)

### 7.3 Component analysis

When completing the MCA, each recommended work package from literature review and gap analysis were assessed against the criteria outlined in **Section 7.2.1** to **Section 7.2.3**. A score from one (1) to five (5) was assigned to each criterion based on the degree to which it conformed to the assessment criteria outlined in **Table 7-2** and **Table 7-4**.

When the scores for all the options had been summed, a weighting was assigned to each criterion based on its relative importance to the outcome. The result was the total of the weighted sum for each criterion, presented as a score which allowed for direct comparison of options against one another to determine order of preference and relative desirability.

The component items with the highest scores have been used to generate a condensed and prioritised list of viable options for new rainfall or water level gauges, the setup of potential new flood forecast locations, and the integration of existing non-SLS rainfall or water level gauges into the Bureau's flood warning network for consideration by the PWG and LGRG.

### 7.4 Results summary

The results of the recommended literature review and gap analysis MCA indicate several viable options that offer differing levels of benefit to the improvement of flood warning within the study area. Top scoring items from each component analysis (refer to **Table 7-5**, **Table 7-6**, and **Table 7-7**) were added to the literature review and gap analysis recommendation list presented in **Table 7-8** if related to riverine flood warning system. In this report, there was no prioritised recommendations related to flash flooding warning system. It is important to note that the main objective of the current program is to improve the existing SLS flood warning network that focuses on riverine flooding and hence, the present report will further investigate recommendations from **Table 7-8**.

The MCA results for the installation of new rainfall and water level gauges are presented in **Table 7-5**. Three rainfall gauges and a water level gauge in the Tweed catchment were assessed. Installing a rainfall gauge and a water level gauge on Dunbible Creek and installing a rainfall gauge on Tyalgum Creek and Cobaki Creek proved to be useful in aiding community flood preparedness and response.

The MCA results for potential new flood forecast locations are presented in **Table 7-6**. Relative to the MCA scores presented in **Table 7-6**, the two options for the set-up of flood forecast locations at Tweed Heads and Uki scored higher than the Chillingham, Cudgera Creek, Tyalgum, Cabarita/Bogangar (Cudgen Creek), Pottsville (Mooball Creek), and Tweed Broadwater Creeks (Piggabeen, Cobaki, Bilambil, Duroby) forecast options. Flood forecasting at Tweed Heads ranked first as it is in an area with an identified need and large scale of benefit to community. It is noted that Tweed Heads area is hydraulically complex and can be impacted by storm surge flooding, riverine flooding, and flash flooding from local creeks. Riverine and storm surge risk comes from the ocean/river (east) side of Tweed Heads while the flash flood risk comes from the local creeks to the West. The potential new forecast location at Uki ranked second in the MCA (**Table 7-6**). Uki, with a potential warning lead time of over 12 hours was classified as a riverine warning system.

It is important to note that development of potential new flood forecast locations related to flash flooding or where there are complex flood characteristics including variable entrance

conditions is outside the scope of this project. The main objective of this report is to identify opportunities to improve the SLS flood warning network that focuses on riverine flooding and development of flash flooding warning locations is therefore outside the scope of this project. The responsibility for implementing these services, including the consideration of flash flood warning systems, lies with the Bureau of Meteorology, which may assess these options as part of future projects when alternative funding becomes available.

The MCA results for the integration of existing non-SLS water level gauges are presented in **Table 7-7**. All gauges scored relatively less than other basins and therefore were not added to the recommendation list. It is also noted that in the updated Bureau Service Level Specification gauges 2024, several non-SLS gauges in the vicinity of Mount Numinbah gauge were incorporated into the Bureau's SLS network and this recommendation can therefore be considered as implemented.

**Table 7-5 MCA results for the installation of new rainfall or water level gauges**

Applied Weighting			5	5	5	4	4	5	3	4	1	2	2		
Option	Gauge type	Origin of recommendation	flash or riverine flooding ?	Flood warning lead time	Flood forecasting accuracy	Scale of benefit to community	Flood behaviour community is exposed to	Benefits for emergency response (e.g., SES)	Ease of works	Ownership of land and planning zone	Environmental and ecological impact of the installation	Cost of works	Cost of maintenance	Weighted Sum	Rank
Dunbible Creek	RF	Gap analysis	5	2	2	5	4	3	3	3	4	3	3	133	1
Tyalgum Creek	RF	Gap analysis	5	1	2	5	4	3	3	3	4	3	3	128	2
Dunbible Creek	WL	Gap analysis	5	2	2	5	4	3	2	3	3	2	2	125	3
Cobaki Creek	RF	Gap analysis	5	1	2	5	3	3	3	3	4	3	3	124	4

**Table 7-6 MCA results for the potential new flood forecast locations**

Applied Weighting		5	5	4	4	5	3		
Option/ Criteria	Origin of recommendation	New forecast location where there is an identified need?	Flash or riverine flooding?	Scale of benefit to community	Flood behaviour community is exposed to	Benefits for emergency response	Hydrological forecast Capability	Weighted Sum	Rank
Tweed Heads	Literature review	5	5	5	3	5	2	113	1
Uki	Gap analysis	5	5	3	3	3	3	98	2
Cudgera Creek	Gap analysis	3	5	4	3	3	1	86	3
Tyalgum	Gap analysis	3	5	3	3	3	1	82	4
Cabarita/Bogan gar (Cudgen Creek)	Gap analysis	3	5	2	3	3	1	78	5
Pottsville (Mooball Creek)	Gap analysis	3	5	2	3	3	1	78	5
Chillingham	Literature review & Gap analysis	5	1	3	3	3	1	72	7
Tweed Broadwater Creeks (Piggabeen, Cobaki, Bilambil, Duroby)	Gap analysis	3	1	5	3	3	1	70	8

**Table 7-7 MCA results for the integration of relevant rainfall or water level gauges into the SLS**

Applied Weighting			5	5	5	4	4	5	3	1	2		
Option/Criteria	Gauge type	Origin of recommendation	flash or riverine flooding?	Flood warning lead time	Flood forecasting accuracy	Scale of benefit to community	Flood behaviour community is exposed to	Benefits for emergency response (e.g., SES)	Ease of works	Environmental and ecological impact of the installation	Cost of works	Weighted Sum	Total Rank
Mount Numinbah	RF	Gap analysis	5	1	1	2	3	3	3	5	3	90	1
Cudgera	RF	Gap analysis	5	1	1	2	3	3	3	5	3	90	1
Mooball Creek	WL	Gap analysis	5	1	1	2	3	3	3	5	3	90	1
Kingscliff Upstream	WL	Gap analysis	5	1	1	2	3	3	3	5	3	90	1
Mullumbimby (Fairview Farm)	RF	Gap analysis	5	1	1	2	3	3	3	5	3	90	1
Cobaki Creek	WL	Gap analysis	3	1	2	3	3	3	3	5	3	89	6

**Table 7-8 Recommendation list for work packages identified in the gap analysis related to riverine flood forecast location**

Item No.	Work package	Type	Work package	LGA	Related forecast location
1	Dunbible Creek rainfall gauge	RF	New installation	Tweed	North Murwillumbah
2	Cobaki Creek rainfall gauge	RF		Tweed	Potential new Tweed Heads proposed as part of this study
3	Tyalgum Creek rainfall gauge	RF		Tweed	North Murwillumbah
4	Dunbible Creek water level gauge	WL		Tweed	North Murwillumbah
6	Tweed Heads	WL	Forecast locations	Tweed	-
7	Uki	WL		Tweed	-

## 8 Proposed flood warning improvements

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### 8.1 Proposed new forecast location

Based on the results of the MCA for potential new flood forecast locations related to riverine flood warning system (refer to **Table 7-6**), Tweed Heads and Uki ranked first and second, respectively. Preliminary concept designs of the potential new Tweed Heads and Uki flood forecast locations are presented in **Section 8.1.1** and **Section 8.1.2**. Locations of the relevant rainfall and water level gauges proposed to support the potential new Tweed Heads and Uki flood forecast locations are presented in **Figure 8-1** and **Figure 8-2**. It should be noted that this study focusses on potential new flood forecast locations related to riverine warning system. Addressing flash flooding and establishing potential new flood forecast locations in areas such as the Tweed Broadwater Creeks (Piggabeen, Cobaki, Bilambil, Duroby) are considered out of scope for this project and would require alternative funding avenue to be further investigated.

#### 8.1.1 Tweed Heads

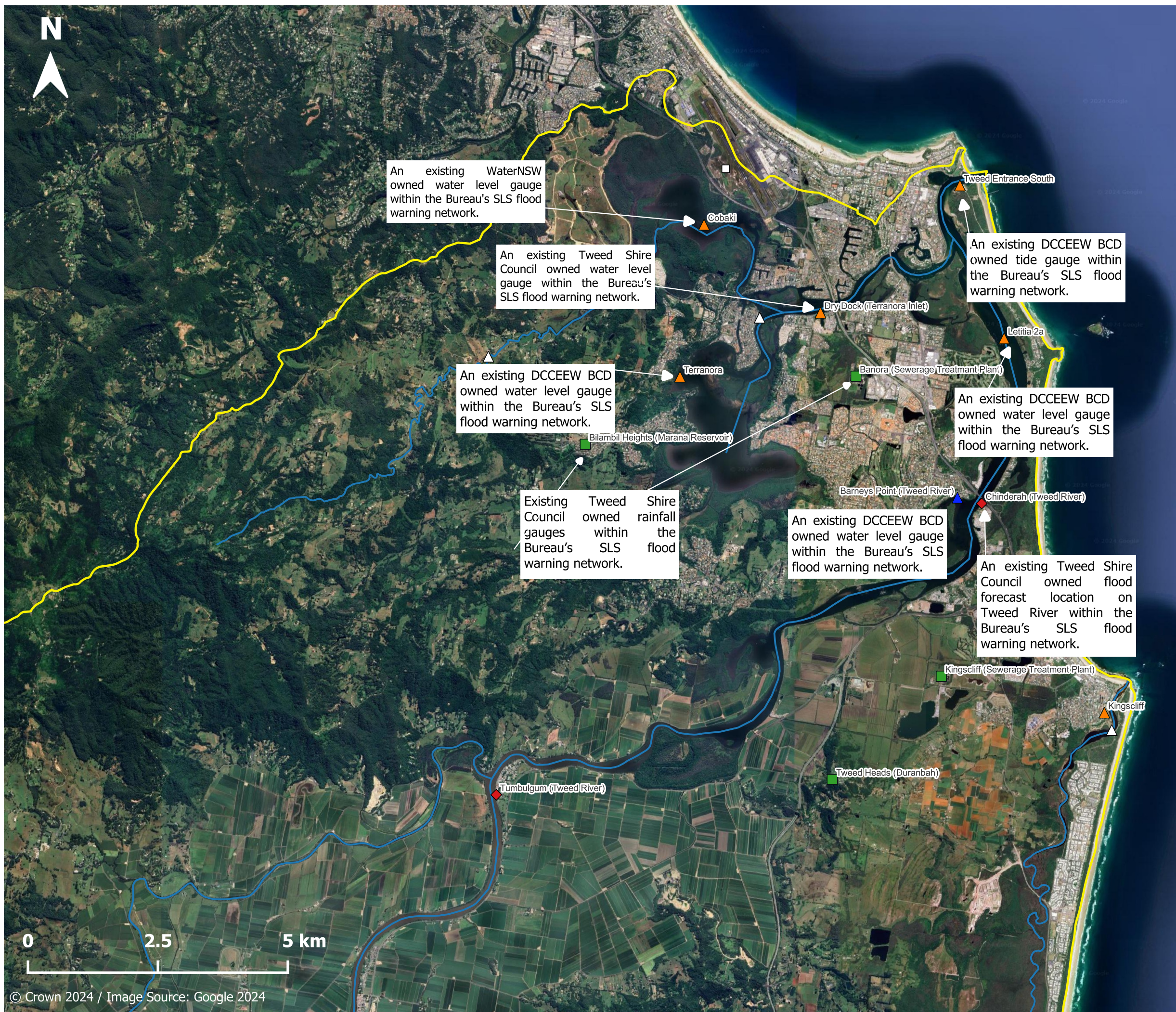
The potential new forecast location at Tweed Heads ranked first in the MCA, as shown in **Table 7-6**. The upper Tweed catchment to Tweed Heads area experienced significant impacts in the February/March 2022 flood event, resulting in extensive damage to both road infrastructure and communication infrastructure (NSW Parliament 2022). It is proposed that the potential new flood forecasting location at Tweed Heads covers the area from Tweed Heads South to downstream Tweed Heads to ensure residents in this area receive valuable flood warning information and communications.

An existing Bureau flood forecast location is located at Chinderah. Several minor creeks, Piggabeen, Cobaki, Bilambil, and Duroby flow into the Terranora Creek and eventually to Tweed River. Existing gauges within the Bureau's flood warning network may be utilised to support the potential new forecast location at Tweed Heads (**Table 8-1**). Locations of the relevant rainfall and water level gauges proposed to support the potential new Tweed Heads are presented in **Figure 8-1**. These gauges are Dry Dock gauge, Terranora gauge, Cobaki gauge, Letitia 2A gauge, Barneys Point, Chinderah, Tweed Entrance South (ocean gauge), Banora WWTP, and Bilambil Heights. Dry Dock is more central to where most of the flooding occurs which could be an appropriate location while Terranora and Cobaki may be able to potentially provide additional warning time. However, a preliminary assessment of the mapping and tabulated results from the Tweed Valley Flood Study Update (2009) highlights that the peak levels at the Dry Dock gauges, Terranora gauge, and Cobaki gauge are quite similar. Assessment of recorded levels at the gauges over the last few large events show some differences in levels between the various gauges and varying timing differences and order of response of the various gauges. On the other hand, Tweed Heads is exposed to riverine and storm surge risk which comes from the ocean/river (east) side where Letitia 2A gauge and Tweed Entrance South (ocean gauge) are located and can be considered for this forecast location. The existing ocean gauges can be considered to monitor ocean influence in storm events. The Dry Dock gauge, Terranora gauge, Cobaki gauge are on the west (broadwater side) where the local creek flood risk comes. The development of flood forecasting at this location is to be further investigated as part of this project alongside consideration of the

existing gauge networks, and land use exposures to determine the most effective/robust way to forecast flooding.

**Table 8-1 Existing gauges supporting the potential new Tweed Heads flood forecast location**

Gauge location and number	Type	Description
Dry Dock gauge (558029)	WL	Dry Dock gauge is an existing Tweed Shire Council owned water level gauge within the Bureau's SLS flood warning network, located in the Tweed Heads west.
Terranora (558056)	WL	Terranora gauge is an existing DCCEEW BCD owned water level gauge within the Bureau's SLS flood warning network that would provide inflow data upstream of the Terranora Creek.
Cobaki (558045)	WL	Cobaki gauge is an existing WaterNSW owned water level gauge within the Bureau's SLS flood warning network. This gauge is located on Cobaki Creek.
Letitia 2A (558041)	WL	Letitia 2A is an existing DCCEEW BCD owned water level gauge within the Bureau's SLS flood warning network. The gauge is located on Tweed River close to Tweed Heads South.
Barneys Point (558102)	WL	Barneys Point is an existing DCCEEW BCD owned water level gauge within the Bureau's SLS flood warning network. The gauge is located on Tweed River close to Chinderah flood forecast location upstream of the Tweed Heads.
Chinderah (558010)	WL/ RF	Chinderah is an existing Tweed Shire Council owned flood forecast location on Tweed River within the Bureau's SLS flood warning network.
Tweed Entrance South (201472)	Tide	Tweed ocean tide gauge is an existing DCCEEW BCD tidal gauge. This gauge is located at the entrance of the Tweed River to the ocean, which monitors tidal movements in the area.
Banora WWTP (558089)	RF	An existing Tweed Shire Council owned rainfall gauge within the Bureau's SLS flood warning network.
Bilambil Heights (558085)	RF	An existing Tweed Shire Council owned rainfall gauge within the Bureau's SLS flood warning network.



**Figure 8-1**

**Proposed new Tweed Heads flood forecast location concept design**

**Report MHL2978**

**Tweed and Brunswick Rivers flood warning improvement Recommendations Report**

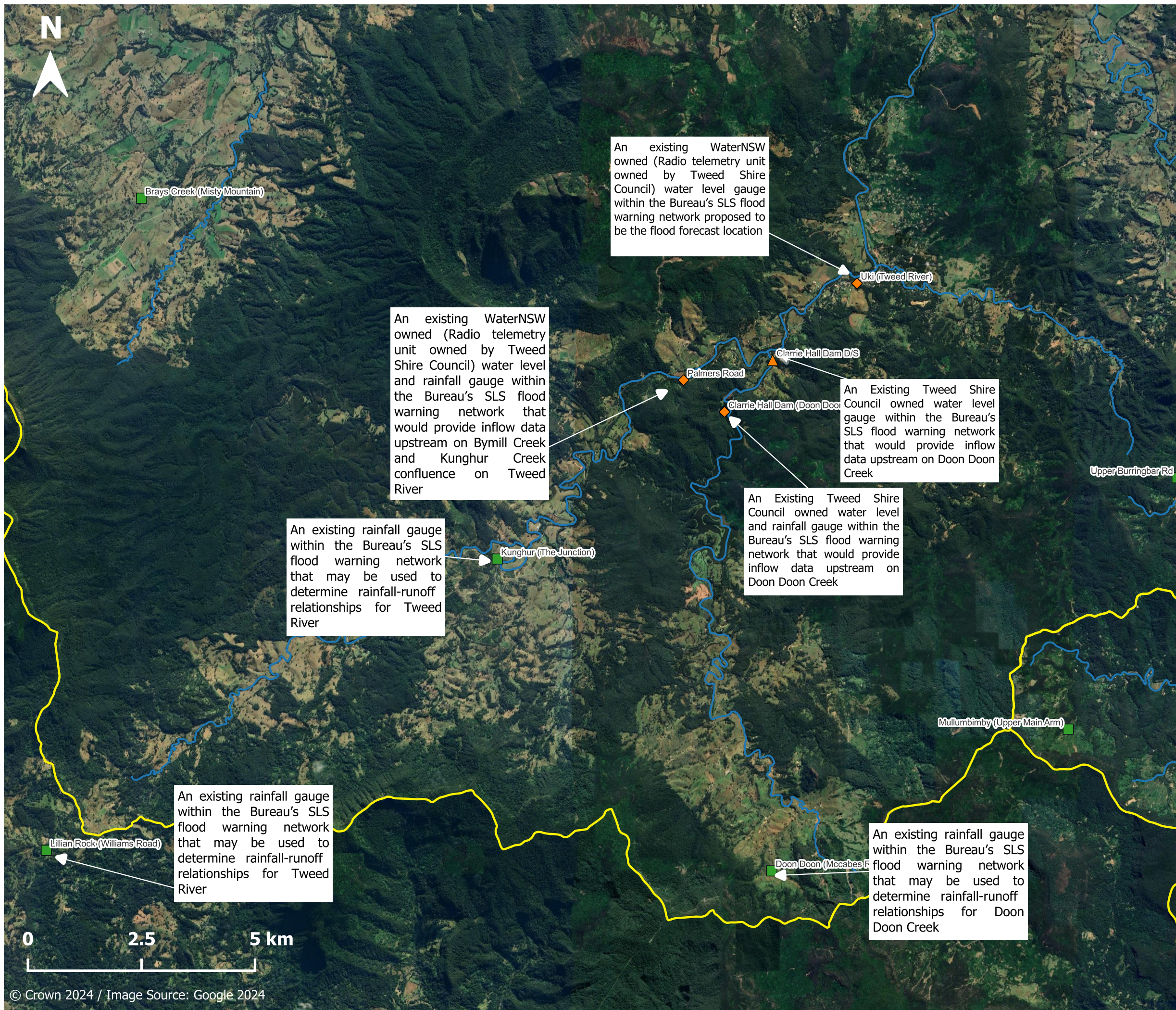
### 8.1.2 Uki

The potential new forecast location at Uki ranked second in the MCA (**Table 7-6**). Uki, with a potential warning lead time of over 12 hours from the start of event was classified as riverine warning system as noted by Bureau and Tweed Shire Council. February/March 2022 flood event remained extreme for Uki with AEP varying between 0.1% and 0.2% (CSIRO 2022) which caused severe erosion along the middle reaches of the Tweed River downstream of Uki, resulting in major damage to riverbanks, roads, bridges and riparian vegetation. Existing gauges within the Bureau’s flood warning network may be utilised to support the potential new forecast location at Uki. The following existing gauges outlined in **Table 8-2** may be utilised to support the potential new flood forecast location at Uki. Further discussion is required between key stakeholders such as the Bureau and the NSW SES to confirm Uki existing gauge as the potential new forecast location at Uki. Locations of the relevant rainfall and water level gauges proposed to support the potential new Tweed Heads are presented in **Figure 8-2**.

**Table 8-2 Existing gauges supporting the potential new Uki flood forecast location**

Gauge location and number	Type	Description
Uki (58167)	WL/ RF	An existing WaterNSW owned (Radio telemetry unit owned by Tweed Shire Council) water level and rainfall gauge within the Bureau’s SLS flood warning network proposed to be the flood forecast location. It should be noted that this water level gauge would be required to be integrated into the Bureau’s SLS flood warning arrangements as a forecast location and flood classifications be determined.
Clarrie Hall Dam (Downstream) (558009)	WL	An Existing Tweed Shire Council owned water level gauge within the Bureau’s SLS flood warning network that would provide inflow data upstream on Doon Doon Creek.
Clarrie Hall Dam (558028)	WL/ RF	An Existing Tweed Shire Council owned water level and rainfall gauge within the Bureau’s SLS flood warning network that would provide inflow data upstream on Doon Doon Creek.
Palmers Road (558018)	WL/ RF	An existing WaterNSW owned (Radio telemetry unit owned by Tweed Shire Council) water level and rainfall gauge within the Bureau’s SLS flood warning network that would provide inflow data upstream on Bymill Creek and Kunghur Creek confluence on Tweed River.
Kunghur (58129)	RF	An existing rainfall gauge within the Bureau’s SLS flood warning network that may be used to determine rainfall-runoff relationships for Tweed River.
Doon Doon (McCabes Road) (58019)	RF	An existing rainfall gauge within the Bureau’s SLS flood warning network that may be used to determine rainfall-runoff relationships for Doon Doon Creek.

Gauge location and number	Type	Description
Lillian Rock (Williams Road) (58148)	RF	An existing rainfall gauge within the Bureau's SLS flood warning network that may be used to determine rainfall-runoff relationships for Tweed River.



**Figure 8-2**

**Proposed Uki flood forecast location concept design**

**Report MHL2978**

**Tweed and Brunswick Rivers flood warning improvement**

**Recommendations Report**



**Manly Hydraulics Laboratory**

## 8.2 Proposed new gauges

Potential improvements to existing and new flood forecast locations within the study area based on the installation of the gauges identified in the recommendation list (**Table 7-8**), are presented in **Section 8.2.1** and **Section 8.2.2**. The location of the potential new gauge locations in relation to the existing gauge network are presented in **Figure 5-1**.

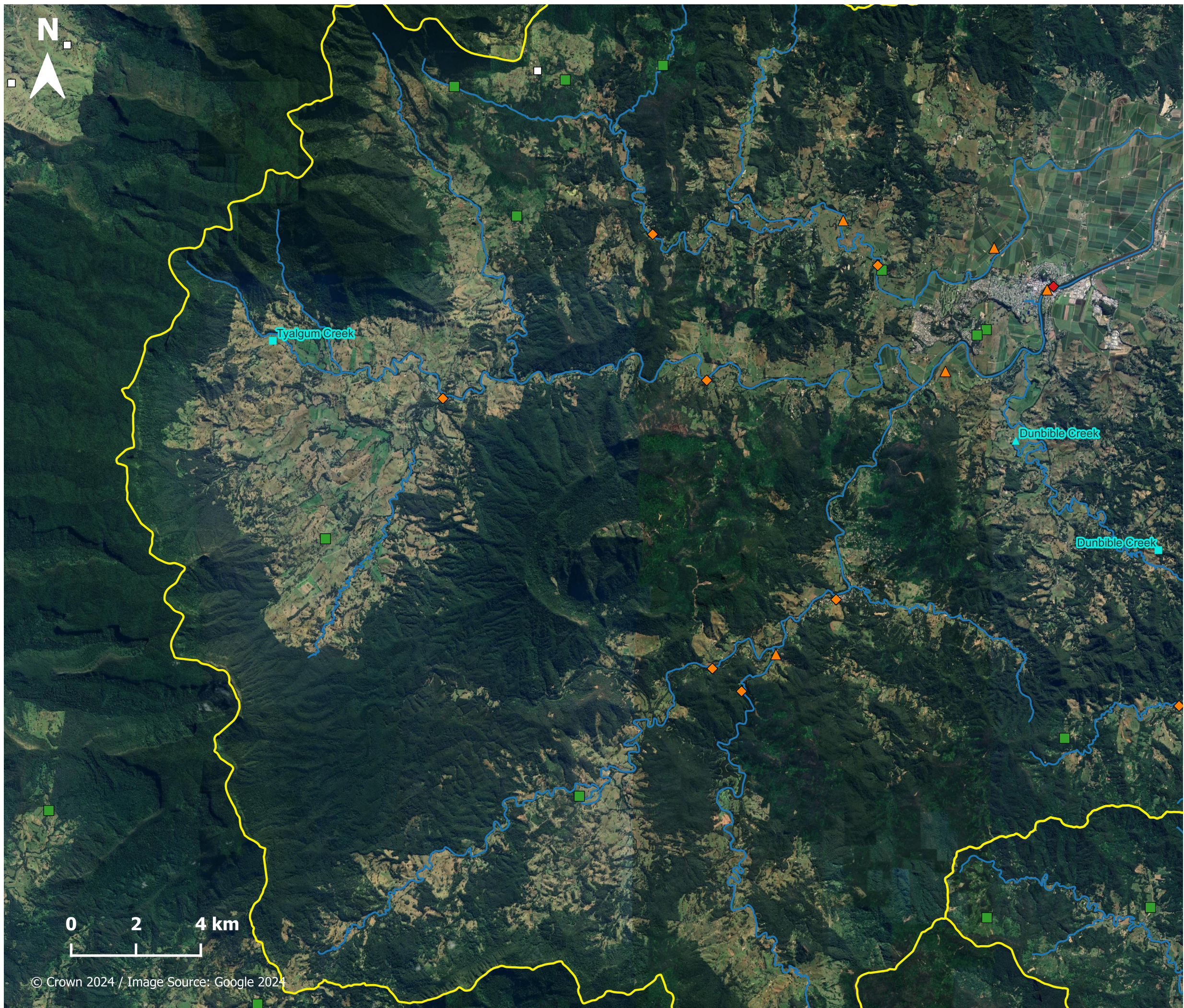
### 8.2.1 Improvement to existing forecast location (North Murwillumbah forecast location)

Potential improvements to the existing Bureau flood forecast location at North Murwillumbah as a result of installing the water level or rainfall gauges identified in **Table 7-8** are presented below in **Table 8-3**. The locations of the potential new rainfall and water level gauges related to the existing Bureau flood forecast at North Murwillumbah are shown in **Figure 8-3**.

**Table 8-3 Potential improvements to the existing North Murwillumbah flood forecast location**

Gauge location	Type	Related forecast location type	Description
Dunbible Creek	WL	Riverine	<p>There is currently no water level installed in the Dunbible Creek catchment, which was inundated during the Feb/March 2022 flood event. Tweed Valley Flood Study Update (2009) indicated that a significant flood inundation can happen along the Dunbible Creek towards Murwillumbah.</p> <p>A water level gauge on Dunbible Creek would allow for improved redundancy and accuracy of the existing Bureau flood forecast at Murwillumbah. It should be noted that target warning lead time for North Murwillumbah gauges is reported as 6 -12 hrs.</p>
Dunbible Creek	RF	Riverine	<p>In 20% AEP, much of South Murwillumbah, located adjacent to the river and in the Dunbible Creek are inundated. These are subject to very high hydraulic hazard.</p> <p>There is no rainfall gauges in the Dunbible Creek. A rainfall gauge on Dunbible Creek may improve the accuracy of the existing Bureau flood forecast at Murwillumbah. It should be noted that target warning lead time for North Murwillumbah gauges is reported as 6 -12 hrs.</p>

Gauge location	Type	Related forecast location type	Description
Tyalgum Creek	RF	Riverine	<p>There is currently no rainfall gauge installed on Tyalgum Creek. The addition of a rainfall gauge in Tyalgum Creek enhances redundancy and accuracy in the existing flood forecasting system operated by the Bureau at Murwillumbah. With increased rainfall gauge density, particularly in hinterland areas like Tyalgum, forecasts and response to potential flood events can be better anticipated. While improving redundancy and accuracy, the addition of a rainfall gauge in Tyalgum Creek is not expected to change the lead time for flood forecasting. Instead, it ensures that forecasts remain reliable and consistent.</p>



**Figure 8-3**

**Improvement to existing North Murwillumbah forecast location**

**Legend**

Tweed and Brunswick Valley catchments

**Type of station**

- Rainfall
- River
- River/ Rainfall

**Existing SLS gauges**

- Forecast locations
- River data locations
- Rainfall locations

**Existing stations outside the SLS network**

- Non-SLS gauges

**Tweed Heads flood forecast location layout**

Flood warning improvement

**Potential gap filling strategies**

- New gauge installation

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### 8.2.2 Improvement to potential new forecast location (Tweed Heads forecast location)

Proposing a potential new Tweed Heads flood forecast location has been identified as a priority from the literature review. Any additional gauges that have been identified following the gap analysis may improve this forecast location, are presented in **Table 8-4**. The updated layout of the potential Tweed Heads forecast location and associated gauges is shown in **Figure 8-4**.

**Table 8-4 Potential improvements to the new Tweed Heads flood forecast location**

Gauge location	Type	Related forecast location type	Description
Cobaki Creek	RF	Riverine	<p>Many locations in the lower Tweed including Cobaki Creek are flooded in the relatively frequent 5% AEP, which is a serious evacuation concern. Early route closure for residents of Cobaki Broadwater Village may restrict the evacuation. Although there is adequate coverage of SLS river data locations in the north-eastern portion of the Tweed catchment, this part of catchment has inadequate rainfall gauges. There is currently one rainfall gauge close to Bilambil Creek.</p> <p>It should be noted that potential new flood forecast locations in the Tweed Heads would benefit from these rainfall gauges. If this new forecast location is established in the Tweed Heads, the addition of rainfall gauges will enhance redundancy and improve the accuracy of the Bureau flood forecast in the downstream area from Cobaki Creek to Tweed Heads.</p>



0 1.5 3 km

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# Figure 8-4

Improvement to potential new Tweed Heads forecast location

- Legend**
- Tweed and Brunswick Valley catchments
  - Type of station**
    - Rainfall
    - ▲ River
    - ◆ River/ Rainfall
  - Existing SLS gauges**
    - Forecast locations
    - River data locations
    - Rainfall locations
  - Existing stations outside the SLS network**
    - Non-SLS gauges
  - Tweed Heads flood forecast location layout**
    - Flood warning improvement
  - Potential gap filling strategies**
    - New gauge installation

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## 9 Preliminary desktop assessment of new gauge installations

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Prior to finalising recommendations of any new gauges, a preliminary desktop assessment was undertaken. It was then followed by a detailed site inspection to understand the feasibility of the installation. Both items are described in the following sections.

### 9.1 Preliminary desktop assessment

A preliminary desktop assessment of each of the proposed new gauge locations was undertaken to assess the suitability of each site. This desktop assessment consisted of assessing land ownership, land zoning, available flood information, preliminary communications availability and assessment of visible constraints. Desktop radio path assessment was undertaken by the Bureau prior to finalising the recommendation to confirm the site suitability before the implementation stage of the project. The summary of the preliminary desktop assessment is presented in **Table 9-1**.

**Table 9-1 Preliminary desktop assessment for new flood infrastructure**

<b>New infrastructure</b>	<b>Land ownership</b>	<b>Land Zoning</b>	<b>Available flood information</b>	<b>Visible constraints from existing aerial photography</b>	<b>Availability of communications</b>	<b>ALERT communication</b>	<b>Available survey point control</b>
A rainfall gauge in Dunbible Creek	Located in Crown land	RU2	Not required as the elevation was significantly above the river levels	Not observed	4G	Yes	Yes
A rainfall gauge in Cobaki Creek	Located in road corridors	RU2	Not required as the elevation was significantly above the river levels	Not observed	4G	Yes	Yes
A rainfall gauge in Tyalgum Creek	Located in road corridors	RU2	Not required as the elevation was significantly above the river levels	Not observed	4G	Yes, contingent on upgrading the Tweed Shire council station (Tweed Bridge) to a repeater	Yes
A water level gauge in Dunbible Creek	Located in road corridors	RU2	Preliminary TUFLOW Modelling was conducted	The suggested site is situated on Stockers Siding Rail Bridge)	4G	Yes	Not a suitable mark nearby, MHL to determine a new survey point by RTK

N.B.: While a desktop study for new gauge installations captures a large portion of the required data for implementation, factors such as rural areas with rugged topography may be a key limitation in inhibiting effective 4G/radio path communications. This discrepancy underscores the importance of site inspections.

## 9.2 Site inspections

Site suitability inspections has been completed as the first part of the implementation stage and included the following:

- survey of potential new gauge locations;
- on-site testing of communication networks with the Bureau;
- confirmation of accessibility; and
- identification of potential hazards, installation ease, and required infrastructure.

A detailed site assessment and feasibility report will be developed separately to this report. Brief outcomes of the site inspections are presented in the following section.

### 9.2.1 Outcomes

Site inspections were carried out for all four (4) 'new installation' work packages identified in the recommendation list (refer **Table 7-8**) as part of determining the hydrographic suitability of the potential new gauges. The results of the field inspection are presented in **Table 9-2**. This included brief comments and assessments on categories such as elevation, survey control, potential physical structure, potential instrumentation, and communications methods, as well as the final determination of suitability.

The following should be considered when reviewing **Table 9-2**:

- The site inspections considered site elevation, nearby survey controls, potential physical structures, potential communications methods, and overall site suitability.
- On one (1) occasion (Dunbible Creek rainfall gauge), the original proposed location was deemed to be unsuitable due to restricted access to Tweed Valley Way, however an alternative location was assessed to be more appropriate. In this case, the assessments outlined in **Table 9-2** reflect the updated location.
- If a proposed location was not located within the extent of an existing hydraulic model, preliminary modelling was completed to estimate an indicative 1% AEP flood level and ground level inundation within the vicinity of the site (refer to **Section 10.5**)
- Potential instrumentation and communications were assessed as marginal if the location had satellite phone as the only form of communication or if the installation of any tested repeaters were required. Potential instrumentation and communications were assessed as suitable if a location had suitable radio signal to an existing repeater or was within the Telstra NextG coverage.
- It is proposed that all stations will primarily be telemetered via ALERT1/2 radio where the network is available. Where ALERT1/2 radio telemetry is not available, stations will use an alternative communication method such as NextG IP or satellite technology and the station will be installed in a configuration to support later inclusion of communications equipment for ALERT1/2 radio telemetry at a later stage, when the Bureau managed system is available. It should be noted that the data transferred using satellite telemetry would be ingested by the Bureau in a very similar manner to data transferred using NextG IP technologies.

- Locations that have a final assessment of 'suitable' in **Table 9-2** were recommended to progress to the implementation phase of the Tweed and Brunswick Rivers flood warning improvement project.
- The field investigation determined that no additional repeaters is required for the installation of the recommended gauges.
- Based on the site inspections, all proposed equipment for the new rainfall and water level gauges (refer **Table 9-2**) is in-line with the Flood Warning Infrastructure Standard (Bureau, 2019).

The following summarises the site investigation results and recommendations for the installation of new rainfall and water level gauges within the study area, as presented in **Table 9-2**:

- The four (4) locations were deemed to be **suitable** based on the site inspection and are recommended for installation, these include:
  - Dunbible Creek, Stockers Road rainfall gauge;
  - Cobaki Creek, Carool Public School rainfall gauge;
  - Tyalgum Creek rainfall gauge; and
  - Dunbible Creek, Stockers Siding Rail Bridge water level gauge.

**Table 9-2 Field investigations results and potential infrastructure summary**

ID	Site	Type	Elevation		Survey control		Potential physical structure		Potential Instrumentation and communications			Additional comments	Final Assessment following further desktop assessment
			Comment	Rating	Comment	Rating	Comment	Rating	Instrumentation Comment	Communications Comment	Rating		
1	Dunbible Creek (displaced to Stockers Road due to restricted access to the original location on Tweed Valley way)	RF	Above the 1% AEP flood level	Suitable	Not assessed	N/A	Accessible, vented weatherproof and lockable cabinet	Suitable	Rainfall tipping bucket powered by a 12V 50AH battery with solar recharging	Primary: ERTS ALERT1/2 Secondary: Suitable NextG IP with booster antenna	Suitable	No traffic control required for installation. Landowner agreement is required.	Suitable
2	Cobaki Creek (Carool Public School)	RF	Above the 1% AEP flood level	Suitable	Not assessed	N/A	Accessible, vented weatherproof and lockable cabinet	Suitable	Rainfall tipping bucket powered by a 12V 50AH battery with solar recharging	Primary: ERTS ALERT1/2 Secondary: NextG IP with booster antenna	Suitable	No traffic control required for installation. Landowner agreement is required. It should be noted that nearby property owners' notification is required for surrounding properties.	Suitable
3	Tyalgum Creek	RF	Above the 1% AEP flood level	Suitable	Not assessed	N/A	Accessible, vented weatherproof and lockable cabinet	Suitable	Rainfall tipping bucket powered by a 12V 50AH battery with solar recharging	Primary: ERTS ALERT1/2 Secondary: NextG IP with booster antenna	Suitable	No traffic control required for installation. Landowner agreement is required.	Suitable
4	Dunbible Creek (on rail bridge handrail, Stockers Siding Rail Bridge)	WL	At 1% AEP flood level	Marginal	RTK, there was no permanent survey marks available	Suitable	Accessible, vented weatherproof and lockable cabinet to be mounted on a pole Radar attached to bridge railing	Suitable	Radar powered by a 12V 50AH battery with solar recharging	Primary: ERTS ALERT1/2 Secondary: NextG IP with booster antenna	Suitable	No traffic control required for installation. Landowner agreement is required.	Suitable

# 10 Discussion

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The following subsections discuss several items of importance to flood warning arrangements within the study area that may not have been outlined earlier in the report or may be considered outside the scope of works for the project.

## 10.1 Local flash flood warning arrangements

The improvement of existing, or development of new flash flood warning arrangements within the study area were considered outside of the scope of works for this project due to this study's main objective being to improve the Bureau's existing flood forecasting services that are generally focusing on riverine flooding.

However, the literature review, gap analysis and recommendations provided by the local councils throughout the consultation process highlighted a number of areas subjects to flash flooding including the various creek leading to the Tweed Broadwater, whereby future flash flood warning projects may be undertaken.

## 10.2 Flood warning arrangements related to ICOLLs and coastal lakes

The improvement of existing, or development of new flood warning arrangements related to ICOLLs and coastal lakes frequently resemble flash flood catchments but can exhibit extended critical durations. The relevance of coastal lake and ICOLL systems to the Bureau's warning service requires further consultation with the Bureau. Further investigation is required alongside the Bureau's ICOLLs and coastal lake forecast capabilities and the community risk assessment, especially if flooding poses significant threats to determine the feasibility of this recommendation within scope of this project. It is understood that the Bureau's responsibilities lie with riverine forecasting. Hence regardless of the body of water the forecast location is in, if the dominant flooding mechanism is riverine, it would come under that responsibility as outlined in the IGA.

## 10.3 Work package classifications

Based on the literature review, gap analysis and subsequent prioritisation, three types of work packages for improving flood warning arrangements within the study area were identified. These three types of works packages may be classified as; (1) new rainfall or water level gauges; (2) the integration of existing non-SLS rainfall or water level gauges into the Bureau's flood warning network; and (3) the setup of potential new flood forecast locations. Work packages comprising:

- The installation of new rainfall or water level gauges to fill the gap regions may demand significant resourcing and capital requirements during implementation (e.g., detailed site inspections alongside the Bureau, detailed design, equipment procurement, and installation works);
- The integration of existing non-SLS rainfall and water level gauges into the SLS may

demand the least amount of resourcing and capital requirements, whereby desktop reviews of gauge specifications are required; and

- The setup of new forecast locations may demand significant resourcing and capital requirements due to the development, calibration, and validation of the predictive modelling service.

## **10.4 Radio path testing**

### **10.4.1 Desktop assessment**

Prior to finalising recommendations in this study, a desktop radio path assessment was completed by the Bureau to assess the radio signal strength from existing repeater locations within the study area to the potential new rainfall or water level gauge installations outlined in the gap analysis recommendation list related to riverine warning system (refer **Table 7-8**). Sufficient radio signal strength indicates that ERTS (ALERT1/2) may be used as the primary or secondary method of communication for a new rainfall gauge in the Cobaki Creek and new rainfall and new water level gauges in the Dunbible Creek.

It was identified within the desktop radio path assessment that radio signal strength to existing repeaters was unsuitable for the potential new rainfall gauge on Tyalgum Creek. However, a potential new repeater location underwent a desktop assessment by the Bureau to test whether there may be improvements in the radio signal within the study area. Using Tweed Shire Council's Tyalgum Bridge monitoring station as the potential new repeater location was deemed to be effective.

### **10.4.2 In-field assessment**

In-field radio path testing was completed concurrently with the hydrographic site inspections for the suitability of the potential new rainfall and water level gauges. In particular, the field inspection highlighted that the upgrade of the Tyalgum Bridge monitoring station to include a repeater was not required as no additional repeater is required for the recommended gauges that were assessed.

## **10.5 Requirements for additional modelling**

As noted by the council, two studies are currently being undertaken within the Tweed Heads area that could assist in defining flood classifications for potential new forecast locations at Tweed Heads. Sufficient flood level information should be available for Tweed Heads and Tweed Heads South in the upcoming Tweed Valley and Tweed Heads South Flood Studies.

### **10.5.1 Preliminary modelling at potential new gauge locations**

A coarse hydraulic model was developed for potential water level gauge in Dunbible Creek to obtain a preliminary 1% Annual Exceedance Probability (AEP) flood level based on the Regional Flood Frequency Estimation (RFFE) approach to inform the site inspection and understand if the proposed gauge may be flood-affected or not. The rainfall gauges were proposed to be located at a suitable location considering land ownership and land zoning, and their elevations is expected to be elevated enough to ensure that they are not affected by floods.

### 10.5.2 Software

The hydraulic modelling was completed using the latest version of TUFLOW at the time of reporting (2023-03-AC). TUFLOW is a robust and widely accepted unsteady-state flood simulation software, offering combined 1D and 2D capabilities. The Heavily Parallelised Compute (HPC) version of TUFLOW significantly reduces run time (by an order of 10 to 15 times) through utilising the memory of graphics cards.

### 10.5.3 Inflows

Catchment areas upstream of the recommended gauges were estimated and catchment centroids were plotted to assist in the determination of design inflows. Model inflows were applied using the expected quantile of the 1% Annual Exceedance Probability (AEP) event estimated by the Australian Rainfall and Runoff (ARR) regional flood frequency estimation (RFFE) tool (Rahman at al., 2015). It is noted that the RFFE tool provides high level estimates of flows for AEPs up to 1% and provides generally conservative values.

### 10.5.4 Model setup

Based on the local topography, a model domain was delineated for a potential water level gauge in Dunbible Creek. The model domain was much smaller than the upstream catchment area (less than 1 km<sup>2</sup>). Grid cell size was set uniformly at 10 m x 10 m, therefore the total number of active grid cells within the model domain was approximately 10,000 which allowed efficient run times. Sub-grid sampling (SGS) was also utilised and targeted at 1 m intervals, to improve the representation of floodplain topography whilst retaining a relatively coarse grid size for the small model domains.

The model extent was defined to be far enough upstream and downstream of the area of interest to minimise any boundary effect on the local results at the proposed gauge location.

Model roughness zones were also delineated into three categories – low vegetation, high vegetation, and watercourses with Manning's n values of 0.040, 0.100 and 0.035, respectively.

It is noted that the model was not calibrated, and no detailed hydrology was completed for the catchment and outputs of the model should therefore be considered as indicative 1% AEP levels only.

### 10.5.5 Results

Ground level at the potential water level gauge in Dunbible Creek was determined to be inundated by approximately 3.5 m based on the preliminary 1% AEP flood event results. Two potential new locations were proposed which were assessed during the site inspection to confirm the feasibility of the locations.

## 10.6 Gauge data accessibility

Gauge data accessibility may relate to data sharing between government agencies/different levels of government, or it may be defined as data sharing between members of the public and government agencies (gauge owners).

### 10.6.1 Intergovernmental accessibility

A review of water modelling and monitoring information in 2019 by the NSW Modelling and Monitoring Hub (MaMH) showed there is a lot of water information available beyond the key public facing information portals but can be hard to find (MaMH, 2019). A key recommendation

from the MaMH (2019) study was to setup a NSW Government water information group through the Spatial Collaboration Portal with restricted access capability to facilitate metadata discovery and information sharing within government.

The use of federated data collaboration systems and metadata enables discovery of data, and facilitates the opportunity for data sharing, reducing future costs of repeat monitoring, improving outcomes from modelling activities and increasing the value of the collected information (MaMH, 2019).

### **10.6.2 Public accessibility**

It is noted the Bureau's 'Water Data Online', WaterNSW's 'Realtime Water Data', and MHL's website platforms individually convey the information of gauge data and location well, however the creation of a centralised platform combining all known data would benefit the public. Alternatively, all known data could be merged to the most popular platform used (e.g., WaterNSW Realtime Data, the Bureau's Rainfall and River Conditions, and the MHL website).

## **10.7 Gauge datum**

It is understood that multiple gauge datums exist in the study area (e.g., Australian Height Datum (AHD) and Local Gauge Height datum (LGH)). This subsequently creates confusion around flood level during an event. It is noted that standardisation of the datum across the study area should be completed. One solution may be to display the flood data in both mAHD and mLGH.

# 11 Conclusions and recommendations

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A literature review and gap analysis were completed to identify and recommend work packages to improve the riverine flood warning arrangements within the study area in consultation with local Councils and the PWG. An MCA was used to prioritise several work packages identified during the literature review and gap analysis components. A preliminary desktop assessment for new flood infrastructures has been undertaken (refer to [Section 9.1](#)) and a site suitability investigation of each of the proposed locations was completed to:

- Confirm radio path testing to support information relay to the Bureau.
- Identify available infrastructure (e.g., requirement for additional repeaters to be constructed).
- Confirm survey control point identified in this report are suitable.

Based on the currently available information, the following can be concluded:

- **Recommendation 1:** The setup of potential new forecast location at Tweed Heads and Uki ranked first and second as highlighted by the flood forecast MCA results (refer [Table 7-6](#)). Further investigation is required alongside the Bureau to determine suitability of gauges to be used for these forecast locations (refer [Table 8-1](#) and [Table 8-2](#)). It is noted that flood forecast location recommendations from this report will be considered for implementation in the Bureau's national prioritisation process to ensure ongoing sustainability and quality of the National Flood Warning Service. The national demand for flood service enhancements is currently significant and therefore specialist capacity of resources to deliver these enhancements also remains a limitation, requiring requests to be prioritised and sequenced as capacity allows. Hence, more complex flood warning systems requiring bespoke arrangements rather than more standard systems may be considered as lower priority in the national prioritisation process.
- **Recommendation 2:** Considering the existing water level and rainfall stations within the study area, some potential gaps in the flood warning infrastructure within the study area were identified in the gap analysis which are presented in [Table 5-1](#). Installing a water level and a rainfall gauge on Dunbible Creek and a rainfall gauge on Tyalgum Creek have been assessed and proposed to improve the existing Bureau flood forecast location at North Murwillumbah (refer [Table 8-3](#)). Installing a rainfall gauge on Cobaki Creek would improve a potential new flood forecast location at Tweed Heads, should this flood forecast location be setup (refer [Table 8-4](#)). Site inspection confirmed suitability of all four gauges.

MCA results for the installation of new gauges, setup of potential new forecast location, and integration of non-SLS gauges related to riverine warning system indicated several viable options that offered differing levels of benefit to the improvement of flood warning within the study area. The outcome of the literature review and gap analysis is summarised as a recommendation list presented in [Table 11-1](#).

Since the main objective of this project is to identify improvements to the NSW SLS flood warning system that focuses on riverine flooding, addressing flash flooding is a lower priority

under this project. Within the Tweed and Brunswick catchments no recommendations related to flash flooding scored sufficiently to be added to the recommendation list.

**Table 11-1 Combined literature review and gap analysis option lists related to riverine warning system**

Item No.	Work package	Type	Work package	LGA	Related forecast location	Benefit and potential impacts	Limiting factors
1	Tweed Heads	WL	<b>Forecast locations</b>	Tweed	-	This flood forecast location would significantly improve the Tweed Heads community's preparedness for flood events. Tweed Heads was heavily impacted by the February/March 2022 flood event. This ensures that residents from Tweed Heads South to downstream Tweed Heads receive valuable flood warning information and communications.	Bureau will confirm resourcing available for development, calibration, validation and operation of this option from literature review
2	Uki	WL		Tweed	-	This flood forecast location would significantly improves the Uki community's preparedness for flood events. Uki was significantly impacted by the February/March 2022 flood event. This forecast location may also improve information provided to the North Murwillumbah forecast location.	Bureau will confirm resourcing available for development, calibration, validation and operation of this option from gap analysis
3	Dunbible Creek rainfall gauge	RF	<b>New installation</b>	Tweed	North Murwillumbah	A rainfall gauge on Dunbible Creek improves the accuracy and redundancy of the existing Bureau flood forecast at North Murwillumbah through increasing the density of the rainfall gauge network.	-

Item No.	Work package	Type	Work package	LGA	Related forecast location	Benefit and potential impacts	Limiting factors
			<b>New installation</b>			Installation of this gauge was deemed to be suitable option based on the site inspection and is therefore recommended for implementation.	
4	Cobaki Creek rainfall gauge	RF		Tweed	Potential new Tweed Heads	<p>A rainfall gauge on Cobaki Creek would improve the accuracy of the potential new Tweed Heads flood forecast location through increasing the density of the rainfall gauge network.</p> <p>Installation of this gauge was deemed to be suitable option based on the site inspection and is therefore recommended for implementation.</p>	This recommendation is dependent on the setup of the proposed new Tweed Heads forecast location
5	Tyalgum Creek rainfall gauge	RF		Tweed	North Murwillumbah	<p>A rainfall gauge on Tyalgum Creek improves the accuracy of the existing Bureau flood forecast at North Murwillumbah through increasing the density of the rainfall gauge network.</p> <p>Installation of this gauge was deemed to be suitable option based on the site inspection and is therefore recommended for implementation.</p>	-

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Classification: Public

Item No.	Work package	Type	Work package	LGA	Related forecast location	Benefit and potential impacts	Limiting factors
6	Dunbible Creek water level gauge	WL	<b>New installation</b>	Tweed	North Murwillumbah	<p>A water level gauge at Dunbible Creek would improve the existing North Murwillumbah forecast location through capturing water level data along an ungauged watercourse in the Dunbible Creek catchment.</p> <p>Installation of this gauge was overall deemed to be suitable option based on the site inspection and is therefore recommended for implementation.</p>	<p>Alternative location was assessed during the field investigation, and location was estimated to be 0.4 m above the 1% AEP flood level.</p> <p>It is important to note that should the gauge be installed on the handrail, it would be positioned well above the 1% AEP flood level (by 1.4 m) and this would provide additional freeboard.</p>

## 12 References

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# Appendix A Existing rainfall and water level stations

**Table A-1 Rainfall and water level stations within the study area**

Bureau number	AWRC	Station name	Owner	Gauge type	Data type	Priority
<b>SLS schedule 7: BoM owned and maintained</b>						
58005	-	Brays Creek (Misty Mountain)	BoM	Automatic	Rainfall	Medium
58019	-	Doon Doon (McCabes Road)	BoM	Automatic	Rainfall	Medium
58129	-	Kunghur	BoM	Automatic	Rainfall	Medium
558032	-	Limpinwood (Bald Mountain)	BoM	Automatic	Rainfall	Medium
58216	-	Cape Byron Aws	BoM	Automatic	Rainfall	Medium
558025	-	Mullumbimby (Chincogan)	BoM	Automatic	Rainfall	Medium
558034	-	Mullumbimby (Upper Main Arm)	BoM	Automatic	Rainfall	Medium
558036	-	Myocum	DCCEEW BCD	Automatic	Rainfall	Medium
558053	-	Main Arm	DCCEEW BCD	Automatic	Rainfall	N/A
558083	-	Burringbar Reservoir	Tweed Shire Council	Automatic	Rainfall	N/A
558107	-	Upper Burringbar Rd	Tweed Shire Council	Automatic	Rainfall	N/A
558094	-	Upper Crabbes Creek (Crabbes Creek Rd)	North Byron Parklands	Automatic	Rainfall	N/A
558084	-	Cudgera Creek (Pottsville Reservoir)	Tweed Shire Council	Automatic	Rainfall	N/A
558091	-	Hastings WWTP	Tweed Shire Council	Automatic	Rainfall	N/A

Bureau number	AWRC	Station name	Owner	Gauge type	Data type	Priority
558082	-	Clothiers Creek	Tweed Shire Council	Automatic	Rainfall	N/A
558092	-	Bray Park WTP	Tweed Shire Council	Automatic	Rainfall	N/A
558011	-	Tweed Heads (Duranbah)	Tweed Shire Council	Automatic	Rainfall	N/A
558090	-	Kingscliff WWTP	Tweed Shire Council	Automatic	Rainfall	N/A
558089	-	Banora WWTP	Tweed Shire Council	Automatic	Rainfall	N/A
558079	-	Couchy Creek	Tweed Shire Council	Automatic	Rainfall	N/A
558081	-	Numinbah	Tweed Shire Council	Automatic	Rainfall	N/A
558080	-	Upper Rous River (Hopkins Creek)	Tweed Shire Council	Automatic	Rainfall	N/A
558109	-	Coopers Shoot Repeater	Byron Shire Council	Automatic	Rainfall	N/A
558046	-	Cudgera Lake	DCCEEW BCD	Automatic	Rainfall	N/A
558104	-	Burringbar North Arm (Harwood Rd)	Tweed Shire Council	Automatic	Rainfall	N/A
058158	-	Murwillumbah (Bray Park)	BoM	Automatic	Rainfall	N/A
558093	-	Murwillumbah (WWTP)	Tweed Shire Council	Automatic	Rainfall	N/A
558085	-	Bilambil Heights (Marana Reservoir)	Tweed Shire Council	Automatic	Rainfall	N/A
58148	-	Lillian Rock (Williams Road)	BoM	Automatic	Rainfall	Medium
<b>SLS schedule 4: Water level data location</b>						
58204	201906	Boat Harbour	BoM	Automatic	Water level/rainfall	High
558077	201005	Boat Harbour (Nobbys Creek)	WaterNSW	Automatic	Water level	Low

Bureau number	AWRC	Station name	Owner	Gauge type	Data type	Priority
558065	201455	Bray Park Weir	DCCEEW BCD (Radio telemetry unit owned by Tweed Shire Council)	Automatic	Water level	Medium
58011	201008	Chillingham Bridge	Tweed Shire Council	Automatic	Water level/rainfall	High
558028	201905	Clarrie Hall Dam	Tweed Shire Council	Automatic	Water level/rainfall	Low
558009	-	Clarrie Hall Dam (Downstream)	Tweed Shire Council	Automatic	Water level	Low
558045	201448	Cobaki	DCCEEW BCD	Automatic	Water level	Medium
558029		Dry Dock	Tweed Shire Council	Automatic	Water level	Low
-	201428	Dry Dock	DCCEEW BCD	Automatic	Water level	Low
58193	201001	Eungella	WaterNSW (Radio telemetry unit owned by Tweed Shire Council)	Automatic	Water level/rainfall	Medium
558051	201422	Kynnumboon	DCCEEW BCD (Radio telemetry unit owned by Tweed Shire Council)	Automatic	Water level	Low
558041	201429	Letitia 2A	DCCEEW BCD	Automatic	Water level	Low
558067	201465	Murwillumbah Bridge	DCCEEW BCD (Radio telemetry unit owned by Tweed Shire Council)	Automatic	Water level	High
558018	201015	Palmers Road	WaterNSW (Radio telemetry unit owned by Tweed Shire Council)	Automatic	Water level/rainfall	Low
558056	201447	Terranora	DCCEEW BCD	Automatic	Water level	Low
558088	-	Tyalgum Bridge	Tweed Shire Council	Automatic	Water level/rainfall	Medium
58167	201900	Uki	WaterNSW (Radio telemetry)	Automatic	Water level/rainfall	High

Bureau number	AWRC	Station name	Owner	Gauge type	Data type	Priority
			unit owned by Tweed Shire Council)			
558059	201472	Tweed Entrance South (Tide gauge)	DCCEEW BCD	Automatic	Water level	Low
558043	202416	Bogangar	DCCEEW BCD	Automatic	Water level	Low
558063	202403	Brunswick Heads	DCCEEW BCD	Automatic	Water level	Low
558050	202418	Kingscliff	DCCEEW BCD	Automatic	Water level	Low
558005	202991	Middle Pocket	Byron Shire Council	Automatic	Water level	High
558004	202993	The Pocket	Byron Shire Council	Automatic	Water level	High
558008	202994	Mullumbimby Creek	Byron Shire Council	Automatic	Water level	High
558007	202001	Durrumbul	WaterNSW (Radio telemetry unit owned by Byron Shire Council)	Automatic	Water level	High
558095	-	Wooyung Road	North Byron Parklands	Automatic	Water level	Medium
558096	-	Yelgun	North Byron Parklands	Automatic	Water level	Medium
558099	-	Byron Bay (Belongil Creek Bridge)	Byron Shire Council	Automatic	Water level	Medium
558098	-	Byron Bay (Tallow Creek Bridge)	Byron Shire Council	Automatic	Water level/rainfall	-
558112	-	Yelgun Creek (Helen St Bridge)	Byron Shire Council	-	Water level/rainfall	-
558111	-	Mullumbimby Ck (Azalea St Bridge)	Byron Shire Council	-	Water level/rainfall	-
558105	-	Crabbes Creek	Tweed Shire Council	-	Water level	N/A
558108	202475	Orana Bridge	DCCEEW BCD	Automatic	Water level	N/A

Bureau number	AWRC	Station name	Owner	Gauge type	Data type	Priority
558106	-	Burringbar Rd (Burringbar Creek)	Tweed Shire Council	-	Water level/rainfall	N/A
558103	-	Burringbar (Burringbar Creek)	WaterNSW (Radio telemetry unit owned by Tweed Shire Council)	Automatic	Water level	N/A
558102	201426	Barneys Point (Tweed River)	DCCEEW BCD	Automatic	Water level	N/A
<b>SLS schedule 2: Forecast locations</b>						
58186	201420	North Murwillumbah	DCCEEW BCD (Radio telemetry unit owned by Tweed Shire Council)	Automatic	Water level/rainfall	High
558014	201432	Tumbulgum	DCCEEW BCD (Radio telemetry unit and rain gauge owned by Tweed Shire Council)	Automatic	Water level/rainfall	High
558010		Chinderah	Tweed Shire Council	Automatic	Water level/rainfall	High
558020	202400	Billinudgel	DCCEEW BCD (Radio telemetry unit owned by Byron Shire Council)	Automatic	Water level	High
558006	202402	Mullumbimby	DCCEEW BCD (Radio telemetry unit owned by Byron Shire Council)	Automatic	Water level	High
<b>Stations outside the Bureau SLS arrangement</b>						
-	202434	Kingscliff Upstream	DCCEEW BCD	Automatic	Water level	N/A
558046		Cudgera	DCCEEW BCD	Automatic	Rainfall	N/A
-	202435	Mooball Creek	DCCEEW BCD	Automatic	Water level	N/A

Bureau number	AWRC	Station name	Owner	Gauge type	Data type	Priority
58040	-	Mullumbimby (Fairview Farm)	BoM	-	Rainfall	N/A
-	201012	Cobaki Creek	WaterNSW	Automatic	Water level	N/A
40717	-	Coolangatta	BoM	Automatic	Rainfall	Medium
58197	-	Mount Numinbah	BoM	-	Rainfall	N/A



110B King Street

Manly Vale NSW 2093