APPENDIX

A

STUDY AREA & DATA REVIEW

Appendix A Study Area & Data Review

A.1 Community profiles

The proposed warning system is to be developed to assist flood affected occupants of urban areas of Bemboka, Wolumla, Candelo, Bega, Kalaru, Tathra and Mogareeka and their environs (Including the Bournda Parkway area) in the Bega Valley Shire LGA. An overview of the population characteristics of each community (based on 2016 Census Data) is provided in **Table A.1**. The location of each community is shown on Figure A.1**.**

Table A.1 Population characteristics of communities within the Study Area (ABS, 2016)

Community	Total Population	% Children (0-14 years)	% Over 65 years
Bemboka	577	18.37	22.2
Wolumla	174	19.1	16.3
Candelo	686	19.8	15.6
Bega	4668	19.6	21.4
Kalaru	708	24.6	20.9
Tathra	1,675	13.1	26.1
Mogareeka	56	NA	NA
NSW		**18.5**	**16.2**

A.2 Catchment Description

The study area is located within the Bega Valley Shire local government area (LGA) on the South Coast of NSW, approximately 80 km from the Victorian border. The total catchment area of the two river systems is 1,810 km^2 at the confluence at Bega, of which the Bega River contributes 1,030 km^2, and the Brogo River 780 km^2. The below catchment description is taken from the Bega and Brogo Rivers Floodplain Risk Management Study and Plan (FRMSP) (Cardno, 2018).

The two rivers meet at the Bega Township and eventually discharge into the Tasman Sea at Mogareeka, 24 km downstream from Bega. The region between the Bega Township and Mogareeka contributes another 125 km^2 of catchment area. The total catchment area for the Bega River at its outlet is approximately 1,935 km^2.

The upper catchment is significantly higher than the lower catchment, with elevations of up to 1,320 mAHD, compared with 15 mAHD at Bega. The terrain falls sharply from these heights to a large central plain that includes the townships of Bemboka, Kameruka, Candelo, Brogo and Bega. The upper regions of the catchment remain forested, while the central valley and downstream regions have been cleared for agriculture. This central valley has historically been known for dairy produce.

In the upper catchment is the township of Candelo, which is located on Candelo Creek, with a single crossing in the middle of town. While access over this bridge is lost due to overtopping in flood events above the 5% Annual Exceedance Probability (AEP) event, both sides of the community have flood free evacuation roads out of Candelo.

The township of Bega is the largest settlement in the catchment. The Bega Township is bordered by the Bega River on its western, northern and eastern sides. The confluence with the Brogo River is immediately north of the township.

The township is primarily residential, with a central commercial district. Small areas at the edge of the town are light industrial. Outside the township is open pasture for cattle grazing.

Due to historical flooding, much of the developed areas of Bega are outside the mainstream 1% AEP flood extent, although some low-lying areas at the edges of the township are affected by this event. The lower lying areas of the town are typically utilised for open space and recreational purposes.

Flooding of the Bega Township is largely driven by overbank flows from the Bega River. Flooding from the Bega River is compounded by flows from the Brogo River, as the systems are adjacent to each other and of a similar size, so peak flows arrive at Bega at similar times.

In addition to riverine flooding, the Bega Township is also affected by local catchment flooding and overland flow, which can result in local flooding issues and loss of access, independent of flooding in the Bega River. The local sub-catchments that have been identified at risk of local catchment flooding and overland flow include:

> Ravenswood Street – Charlotte St Bega Tributary, southwest of central Bega;

> Rawlinson St – East St Bega Tributary, south of central Bega; and,

> Boundary Road – Kerrisons Lane, southeast of central Bega.

Downstream of Bega, approximately half way to the river's outfall into the Tasman Sea, are two inter-related geographic features, Bottleneck Reach and Jellat Jellat.

Bottleneck Reach is a significant constriction, throttles the flow from over 1,000 m wide upstream in the 1% AEP and Probable Maximum Flood (PMF) events down to 300 m through the constriction. In the 1% AEP flood, flows reduce to 3,900 m^3/s through Bottleneck Reach, down from 10,400 m^3/s in the Bega River upstream of this feature; a reduction of over 60%.

Bottleneck Reach runs for approximately 7 km and fully contains all events up to and including the PMF. Bottleneck Reach also results in backwater effects extending upstream towards Bega. In the PMF event, this backwater effect extends as far as the Princes Highway.

Because of this constriction, a large storage area forms upstream of Bottleneck Reach. This region, Jellat Jellat, is a permanent water body bounded to the north by the Bega River, and large ranges on the east and west and a smaller range to the south. In flood events, the restriction at Bottleneck Reach causes the area to operate as a significant flood storage area. In the 1% AEP, the region stores approximately 9.7 million cubic metres of water. In the PMF, this storage volume increases to approximately 21.9 million cubic metres. In comparison to the total flow volumes, this represents storage of 2% of the total flood volume in the 1% AEP and 1% in the PMF.

As noted above, the terrain to the south also rises, but not as sharply as the ranges to the east and west. As a result, in the PMF event, this southern terrain overtops and floodwaters flow from Jellat Jellat into Wallagoot Lake. The outlet of the Bega River is located at Mogareeka. The tidal influences extend upstream approximately 15 km to Jellat Jellat, although in large flood events the influence of ocean levels extends as far upstream as Bega.

The study areas are shown in Figure A.1**.**

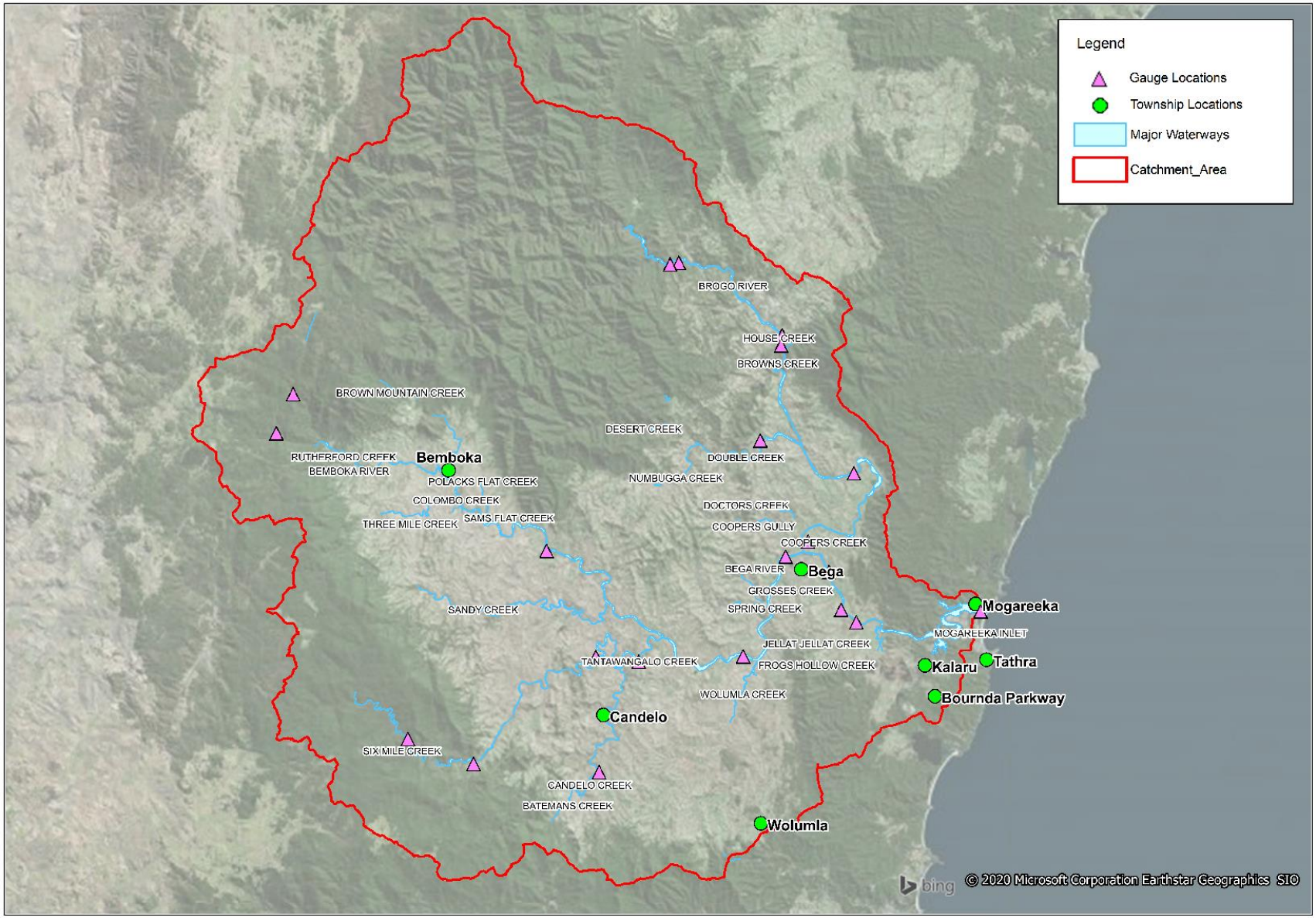

Figure A.1 Location of communities within the study area

A.3 Site Visit

Site visits were conducted on the 7th-9th December 2020, during the day ahead of each community consultation session. The visits were attended by staff from Cardno, accompanied by staff from Bega Valley Shire Council staff (7th Dec) and NSW SES (9th Dec).

The site visit involved driving throughout the catchment and visiting locations of interest. These included:

> Mogareeka;

> Tathra;

> Bega;

> Jellat Jellat;

> Candelo (via Kameruka and Kanoona);

> Bemboka;

> Brogo Dam;

> Wolumla (via Toothdale); and

> Bournda Dam.

The site visits provided Cardno staff with a good appreciation of catchment characteristics, existing gauge locations, key roads frequently overtopped and recent developments in the area. Key observations and key discussion points from the site visit are outlined below (not exhaustive):

> Tarraganda Bridge – noted to be overtopped by the Brogo River;

> Mogareeka – MHL gauge (219410) near the Hancocks Bridge over the Bega River;

> Jellat Jellat – 1974 flood event saw water stretch across the flats. Sometime after this event the power poles were raised, presumably to deal with the floodwater issue. The current power poles along this stretch of road are higher than the standard 11m poles;

> Jellat Jellat – identified that the straight crosses a number of smaller tributaries which can back up from the river (due to catchment rainfall and, to some degree, king tides) and cause inundation even if no local rainfall has occurred;

> Candelo – Flash flooding risk confirmed including disruption when key access routes are temporarily cut from Candelo Creek which bisects the township;

> Wolumla – confirmed that despite there being minimal flood risks to existing properties within the established village areas, access to and from Wolumla can be impacted by flooding in the area and the steep terrain in the surrounding catchment influences the nature of flooding;

> Council noted there are likely access impacts on the key regional roads and local drainage issues/flowpaths in the land surrounding the village of Wolumla. There are new growth areas outside of the established village area;

> Bega – low point on Carp Street that is frequently flooded was observed; and

> Bega – Council is currently building an emergency access upgrade to the adjacent hospital. The emergency access upgrade of Boundary Road provides access to the construction entry at the rear of the hospital.

A.4 Previous Studies and Reports

A.4.1 Bega and Brogo Rivers Flood Study at Bega, SMEC, 2014

This flood study describes the process undertaken to determine a range of design flood events for the Bega and Brogo River Catchments.

The study area included two primary catchments:

> Bega River Catchment
  - 5 km upstream of Bega
  - 1,030 km^2
> Brogo River Catchment
  - 8.5 km upstream of the Bega-Brogo Rivers junction along the Brogo River
  - 780 km^2

The model extended to the outlet at the sea in Mogareeka. Candelo Creek at Candelo was modelled in 1D in addition to the Bega and Brogo River models.

The study identifies hydraulic and preliminary hazard categorization for these design events, as well as providing preliminary Flood Planning Levels (FPLs) for the catchment, with consideration of catchment and ocean flooding. Estimated joint probability of occurrence of the peak flows from the Bega River and water level conditions from the ocean were adopted to establish downstream conditions. The adopted Catchment and Ocean Flooding Combinations are shown in Table 15.5 of the Flood Study report.

An XP-RAFTS hydrological model was set up to generate inflows for a XP-SWMM2D hydraulic model for design flood events including 10%, 5%, 2%, 1%, 0.2% AEP and PMF. Percentage imperviousness values were specified according to the land use zoning. Losses and roughness values were altered to calibrate the model to four historical events. Spatially variable rainfall maps were developed through daily rainfall gauges, these isohyetal maps were used to prescribe varying amounts of rainfall to each sub-catchment for a particular event. Pluviograph data was used to inform the temporal distribution of rainfall events. The events adopted for calibration and validation were February 1971, March 2011, March 1983 and February 2010.

The hydrological models were calibrated with Streamflow Gauging Stations and Water Level Recording Stations at various locations in the catchment. The adopted initial and continuing losses were 10 mm and 2.5 mm/hr, respectively.

The hydraulic model adopted a 25 m grid and 1-second time-step. The model included rivers and obstructions as 1D elements, informed by riverbed cross-sections from either the ground/bathymetric survey, DTM or interpolations.

The February 1971 and March 2011 events were used to calibrate the hydraulic model by means of flood marks throughout the catchment (23 and 46 respectively). Overall, the hydraulic and hydrologic models showed a reasonable representation of these historical events.

Within the studies list of recommendations it provided a list of recommended gauge locations which were described as:

> near Princes Highway (i.e. upstream of the river junction),

> downstream of the Bega/Brogo Rivers junction between Princes Highway and Tarraganda Lane; and

> in the lower reaches of the Bega River between Jellat Jellat Flats and Tathra Bridge.

Implications for this Study: *The SMEC Flood Study formed the basis of the FRMS&P (Cardno, 2018, described below), and contains an extensive data review of previous studies, reports, and historic flood events investigated as part of the calibration process. The Flood Study was used to provide background information to the catchment and its flood history and give consideration to the potential suitable gauge locations.*

A.4.2 Bega and Brogo Rivers Floodplain Risk Management Study and Plan, Cardno, 2018

Following on from the Bega and Brogo Rivers Flood Study at Bega (SMEC, 2014), the Bega and Brogo Rivers FRMSP used the flood modelling tools developed in the Flood Study to investigate and assess:

> Flood risk across the Study Area;

> Flood Damages;

> Flood Emergency Management; and

> Mitigation Options.

The Study undertook community consultation (described further in **Section A.11**) and culminated in the development of the Bega and Brogo Rivers Floodplain Risk Management Plan. Option **EM2 Flood warning system** was given a High Priority in the implementation plan, and has become the basis for this Flood Warning System Scoping and Feasibility Study. The description of the recommended option is reproduced below:

EM 2 – Flood Warning System (Bega and Brogo Rivers FRMSP, Cardno, 2018, Section 11.3.2)

Existing water level and flow gauges are installed throughout the Bega and Brogo Rivers catchment area. There are two water level gauges within the study area; the first at the Princes Highway Bridge adjacent to the township and the second at the ocean outlet in Tathra. There are also flow gauging stations on both the Bega River and Brogo River, each approximately 10 km upstream of the Bega Township.

*As discussed in **Section 10.4.2**, a flood warning system would utilise these gauges, as well as installing new gauges adjacent to Bega and Mogareeka.*

Warnings issued from the upstream flow gauges would provide a warning time of approximately 12 hours depending on the trigger levels adopted. Warnings issued from the water level in the township would be a better indicator of risk, but warning times would be reduced to 2 to 3 hours.

Given that local evacuation is possible within these timeframes, and that no regions are required to travel large distances to escape from floodwaters, the warning from nearby gauges would be suitable to allow the safe evacuation of residents to flood free areas, particularly if residents had been primed by an earlier warning from the upstream gauges. The warning may be issued by automated SMS, phone calls or a siren, triggered when either overfloor flooding of properties or loss of access to properties was imminent. Such a warning would only allow the immediate evacuation of residents to local flood refuges. It would not provide sufficient time to move or evacuate belongings.

Should a system be implemented, it will be important for the community to understand the operation of the system and its limitations. A key point to inform the community of will be the likely frequency of warnings issued from the gauge. In order for the warning to be effective, it will need to be issued before property flooding commences. The community will need to understand that there will be false positives reported from the system, and that for the system to be effective, they will need to continue to respond to the evacuation warning, even after a number of issued warnings that were not followed by subsequent flooding.

It should also be noted that the warnings would only be applicable to flooding occurring from the Bega and Brogo Rivers. The smaller, local tributaries experience shorter duration flooding are not well suited to flood warning systems. Severe weather warnings are likely to be the only assistance for these areas.

In summary, a flood warning system would allow effective and safe evacuation of flood affected areas, and this option provides for the necessary investigations to be undertaken to establish a flood warning system.

***Implications for this Study:** The FRMS&P was the foremost source of flood risk information in the study area, and greatly assisted in identifying at-risk properties, roads, areas that may be isolated, and appreciating rates-of-rise and flood travel time, which informed required flood warning lead times. The FRMS&P identified areas at risk of flash flooding and riverine flooding and identified the need for further actions that informed this study.*

A.4.3 Bega Valley Coastal Processes and Hazards Definition Study, BMT WBM, 2015

The Bega Valley Shire Coastal Processes and Hazards Definition Study report provides a regional assessment of the coastal hazards impacting on the Bega Valley Shire coastline. It outlines the key coastal processes and interactions operating on the coastline and presents the projected extent of the coastal hazards arising from these processes.

***Implications for this Study:** Information regarding the Coastal Hazards at Tathra in particular was considered in terms of both current risk and under climate change scenarios, and the potential changes in catchment flooding and coastal interaction that may occur. It is also noted that information regarding protective behaviours required during storm events in the Coastal region may impact the Council resources available to prepare for flooding elsewhere in the catchment.*

A.4.4 Draft Bega Valley Shire Floodplain Risk Assessment, URS, 2006

URS was engaged by Bega Valley Shire Council to review and assess current flood risk and floodplain risk management within the Bega Valley Shire LGA. The Study provided Council with:

> A detailed review of its floodplain risk management status and how that compares with best practice;

> A priority listing for floodplain risk management studies and plans;

> A recommendation on measures to be adopted within Council to efficiently and effectively introduce procedures for the dissemination of floodplain information to all stakeholders; and

> An estimate of the cost implications to achieve all the recommended measures.

The Study concluded that a Flood Study and Floodplain Risk Management Study for the Bega/Brogo River system for Bega, Kalaru and Mogareeka was identified as the highest ranking priority in the LGA, which as above (Cardno, 2018) has now been completed.

Implications for this Study: *The Floodplain Risk Assessment identified Flood Warning as a key issue in Bega, Kalaru and Mogareeka, and provides background information about flood risk in the LGA more broadly, which will be used to provide context for this assessment.*

A.4.5 Bega Valley Floodplain Management Appraisal Volumes 1 & 4, Willings and Partners, 1987

In the early 1980s the valley wide floodplain management studies funded by the Commonwealth and State Governments were finalised for 13 of the major coastal rivers of NSW. Subsequently it was resolved that a similar study should be undertaken for the Bega Valley and that this study should take account of the Government's revised flood policy adopted since the completion of the earlier valley wide studies.

The Appraisal, much like a Flood Study and Floodplain Risk Management Study, describes the data available, details the existing flood problem and uses flood frequency analysis to derive design flood levels, assesses existing management provisions and makes recommendations for improvement.

Flood profiles for the 1%, 2%, 5% and 10% floods were derived by the Department of Water Resources between Bega and Bottleneck Reach, and extended downstream to Mogareeka for this appraisal. However, upstream of Bega no information on the profiles of these floods has been determined as yet.

The appraisal made two key recommendations in regards to Flood Warning Systems, reproduced below:

(a) Bega Valley Shire Council should approach DWR to ensure that future reduction of DWR stream gauging installations in the valley is done in such a manner as to leave Bega SES with adequate installations for flood warning purposes.

(b) Installation of a flood forecasting system such as ALERT or AROS should be investigated. Such a system would enhance the reliability of the present flood warning system, improve flood warning times for the lower valley, and enable flood warnings to be provided for the upper part of the valley.

Implications for this Study: *The Appraisal provides information about historic flood events and background and context for previous flood investigations and management recommendations in the catchment.*

A.4.6 Floods of February 1971 on the South Coast, NSW Water Resources Commission, 1976

This report presents meteorological and hydrographic information concerning the floods which occurred on the South Coast of NSW in February 1971, which in some streams, was of record proportions. The report was prepared as a 'ready reference to persons and organisations interested in flood problems', however retained the use of imperial units previously used in the internal Water Resources Commission report on which it is based.

Implications for this Study: *Information and details regarding the 1971 event were particularly important to understand and have on hand when speaking to residents of Bega and surrounding towns during community consultation. Being such a large event, and possibly still within living memory of residents (and particularly farming families), the 1971 event provided a useful point of reference when discussing other design events, and may also be a useful reference point for flood warning messaging.*

A.4.7 Brogo Rivers Behaviour Studies Waras Model, Lyall & Macoun Consulting Engineers, 1989

Data Gap: *At the time of writing, Cardno had approached WaterNSW for information regarding the above study and model.*

A.4.8 History of Bega Floods 1851-1978, Bernice E. Smith, 1978

This brief report provides an insight into various flood events in Bega from 1851 to 1978. In particularly wet years, the author provides a high-level overview of the amount of rainfall received, along with anecdotes of the consequences of flooding across the valley in relation to cropping/farming, road closures, property damages and fatalities.

Implications for this Study: *As with information about the 1971 flood, context and anecdotal reports of damage from even earlier events provided important background information, particularly in areas where there may be limited understanding (or memory) of flood risk.*

A.4.9 Illawarra-Shoalhaven Smart Water Management Project

Over the past 50 years the Illawarra-Shoalhaven has experienced 33 floods classified as serious to extreme due to the challenging and unique local topography. Stormwater management is a key responsibility for local governments and a major challenge to consider in planning for urban growth. Annually, significant investment is required to manage our waterways and install, renew and upgrade stormwater infrastructure to safely convey stormwater to local waterways while minimising the impact on water quality and the risk and impact of flooding.

The Illawarra-Shoalhaven Smart Water Management project is using smart technology solutions and developing data analytics to respond to and improve storm-water management, water quality, flood mitigation and access to information to ensure community safety in flash flood events. This project is a regional collaboration between local government, tertiary and secondary education institutes and industry.

The Smart Water Management project uses environmental sensors and data analytics for improved stormwater management. The project applies smart solutions to detect culvert blockages; manage estuaries more effectively to reduce flooding; monitor water quality; and optimise the maintenance of Gross Pollutant Traps. The project will also develop a model that integrates sensor data to better predict flood risk with greater accuracy and timeliness for enhanced community safety.

Implications for this Study: *Cardno liaised with key people in the industry about the project which helped to develop a deeper understanding of the project and its infrastructure requirements, as well as its challenges, to help inform and identify opportunities for application in the Bega and Brogo River Valleys.*

A.5 Council Policies

A.5.1 Bega River Entrance Management Policy, Bega Valley Shire Council, Nov 2016

The Bega River Entrance Management Policy provides a framework which assists in the management of the entrance to the Bega River Estuary. The Policy aims to:

> Minimise interference with natural entrance opening processes and minimise associated impacts on ecological processes;

> Accommodate future climate change considerations and in particular, sea level rise;

> Minimise risks to public and private safety associated with excessive inundation of foreshores and associated infrastructure;

> Conserve or enhance the biological diversity and flora and fauna communities of the estuarine lakes systems;

> Clearly establish triggers (water level height for initiating artificial entrance openings);

> Determine procedures to be initiated for entrance operations including entrance breakouts;

> Determine key responsibilities for management of the entrance; and

> Detail the procedure for monitoring of lake entrances.

The Policy notes that the following conditions are required to initiate an opening of the entrance channel:

> Water levels in the estuary between 1.26 mAHD and 1.36 mAHD and at least 200 mm of rain forecast to fall within the catchment;

> Water levels in the estuary at or above 1.36 mAHD.

It is important to note that initiation of the opening of the entrance channel is part of a flood mitigation strategy only. Its understood that a full entrance bar breaching occurred during the 2011 flood event.

Implications for this Study: *The opening procedure relies on forecast rainfall data over the catchment, any improvements to recorded and forecast rainfall in the catchment may warrant consideration when the Policy is next reviewed. In addition, inclusion of channel opening operations (and the time and resources required) is important to include in consideration of the 'Protective Behaviours' required to be implemented by Council in the event of a flood.*

A.5.2 Bega Valley Community Engagement Procedure and Community Engagement Strategy (P6.16.1, v3, February 2018)

Bega Valley Shire Council Community Engagement Strategy and Community Engagement Procedure sets out Council's commitment to encourage open and transparent relationships between Council and the community, acknowledging that effective engagement leads to better outcomes for the broader community.

Council has adopted the IAP2 Public Participation framework as a methodology for determining the scope of engagement and how decisions are made. Depending on the scope or impact of the project, this guides Council to either inform, consult, collaborate or empower the community in decision making.

Implications for this Study: *The community engagement strategy developed for this project aligned with the IAP2 Public Participation framework and was consistent with Council's Community Engagement Strategy and Procedure P6.16.1, v3.*

A.6 Emergency Management Documentation

A.6.1 Bega Valley Local Disaster Plan DISPLAN, 2003

Flood Emergency Management for the Bega Valley Shire LGA is organised under the Bega Valley Local Disaster Plan (DISPLAN) (2003), which has effect under the authority of the *State Emergency and Rescue Management Act 1989* (as amended).

The DISPLAN details emergency preparedness, response and recovery arrangement for the region to ensure the coordinated response to emergencies by all agencies having responsibilities and functions in emergencies.

The plan is consistent with similar plans prepared for areas across NSW and covers roles and responsibilities in emergencies, preparedness measures, response operations and co-ordination of immediate recovery measures.

The DISPLAN outlines the key responsibilities of the different organisations involved in emergency management. It is generally the responsibility of the SES, as the "combat" agency, to respond to and coordinate the flood emergency response. It is the responsibility of Council and DPE (formerly OEH) to manage flood prevention / mitigation through development controls, the floodplain management process and mitigation schemes.

The Bega DISPLAN identifies flood hazard to be a high probability with high consequences. It should be noted that this categorisation is a general one for the whole LGA.

Implications for this Study: *The DISPLAN sets out the overarching legislated roles and responsibilities for emergency response. Along with the Sub-Plan (described below), this informed the development of the Draft Flood Warning System Owners' Manual.*

A.6.2 Bega Valley Shire Flood Emergency Sub-Plan, 2021

The SES, in conjunction with Council, has prepared a sub-plan to the local DISPLAN. The Bega Valley Shire Flood Emergency Sub-Plan (the Flood Plan) was recently updated in November 2021 with the previous version being developed in 2017. The Plan covers the preparation for, response to and recovery from flooding emergencies for the LGA.

The SES Flood Plan focuses exclusively on flooding emergencies, and more explicitly defines the roles and responsibilities of parties in a flood event. It also makes note of which key roads can be flood affected.

The Flood Plan identifies Bega, Candelo and Tathra as flood prone regions in the catchment and also identifies circumstances when roads are likely to be cut off in flood events, resulting in the disruption of movement throughout the catchment.

Implications for this Study: *The Sub-Plan provides more specific information about flood consequences in the communities in the Study Area, and informs Cardno's appreciation of current flood warning systems and emergency management. As key outcomes of this study are implemented, the Flood Plan will need to be updated.*

A.7 Service Level Specification, Bureau of Meteorology, Version 3.13

The Bureau of Meteorology (BoM) provides a flood warning service for the township of Bega, utilising information collected from the river gauge at Bega (gauge number 219900 at Princes Highway). Based on data from this gauge, coupled with data from rainfall gauges in the catchment, the BoM aims to provide three hours advance warning of minor flood events.

Details from the BOM Service Level Specification for Flood Forecasting and Warning Services for New South Wales and the Australian Capital Territory are provided in **Table A.2**.

Table A.2 BOM Service Level Specification – Bega River Valley

Bureau Number		219 – Bega River Valley
Gauge Number		69120
AWRC Number		219900
Forecast Location		Bega
Station Owner		WaterNSW
Gauge Type		Automatic
Gauge Datum		Local
Flood Classification (m)	Minor	4.6
	Moderate	7.0
	Major	8.0
Prediction Type		Quantitative
Target warning lead time	Time (hrs)	3 hrs
	Trigger height (m)	>4.6 m
70 % of peak forecasts within		+/- 0.3 m
Priority		High

Implications for this Study: *The Service Level Agreement provides information about the current flood warning system in Bega, and will be used as a basis for comparison when considering options to improve the current service level in Bega itself or establish new flood warning systems elsewhere. This Service Level Agreement provides information about the existing infrastructure, which will be likely to be leveraged in any new or augmented flood warning system.*

A.8 Industry Guidance

A.8.1 Australian Disaster Resilience Handbook Collection, Manual 21: Flood Warning, 2009

In 1995 the Australian Emergency Management Institute, following a national review of flood warning practices after disastrous flooding in the eastern states in 1990, published a best-practice manual entitled 'Flood Warning: an Australian Guide' (AEMI, 1995). In describing practices for the design, implementation and operation of flood warning systems in Australia, the manual introduced the concept of the TFWS. It also re-focused attention on flood warning as an effective and credible flood mitigation measure but made it clear that successful system implementation required the development of some elements that hitherto had been given little attention as well as the striking an appropriate balance between each of the elements. In particular, it was noted that more attention needed to be given to risk communication and the education of communities about the flood risk, the measures that could be taken to alleviate the problems that flooding causes and the place of warnings in triggering appropriate actions and behaviours. It also clearly enunciated the need for several agencies to play a part, with clearly-defined roles and with the various elements carefully integrated, and for the members of flood liable communities to be involved.

The philosophy that underlies the TFWS concept coupled with the need for a coherent set of linked operational responsibilities and overlapping functions are documented and discussed in the context of guiding principles for effective early warning in UN (1997). While the original manual has been updated and republished as Manual 21 of the Australian Emergency Manuals Series (EMA, 2009), the concepts, practices and key messages from the original manual endure.

Manual 21 focuses on defining 'best practice' in flood warning as this is presently understood in Australia. In doing so it promotes a consultative, community-incorporating approach to the definition of flood warning issues, problems and solutions. The Guide is designed for use by all those who have roles to play in developing and operating flood warning systems and providing flood warning services. Among these people are flood forecasters, emergency management practitioners (including staff and volunteers in the State/Territory Emergency Service organisations which in most jurisdictions in Australia have a lead role in the management of floods), personnel employed by local councils and by various government departments, and members of flood-prone communities.

The Total Flood Warning System (illustrated in **Figure A.2**) recognises that a fully effective flood warning service is multi-faceted in nature and its development and operation involves input from a number of agencies each with specialised roles to play. It is vital that the agencies involved work in close cooperation through all stages of developing and operating the system.

Implications for this Study: *This study will be undertaken in accordance with Manual 21. The development of the preferred flood warning system and relevant investigations will be underpinned by the Total Flood Warning System concept, which considers the flood warning system holistically.*

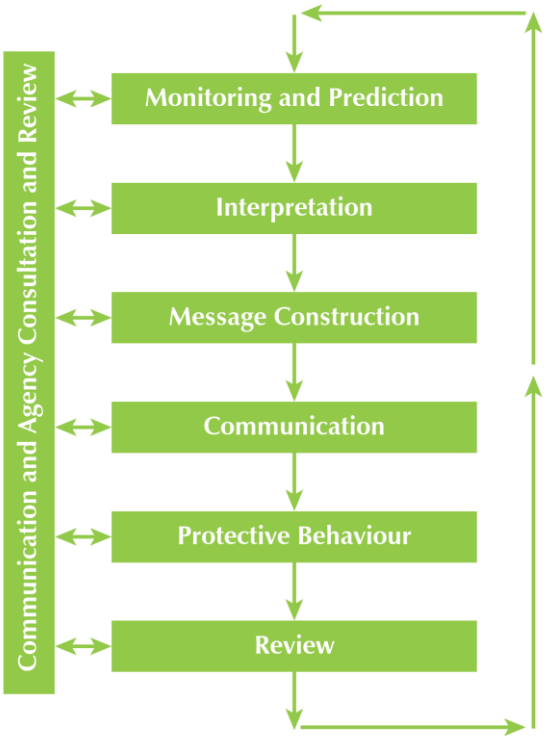

Figure A.2 ***The components of the Total Flood Warning System (Australian Emergency Manual Series, Manual 21 Flood Warning, Australian Government 2009).***

A.8.2 Flood Warning Infrastructure Standard, Bureau of Meteorology, 31 July 2019

The Flood Warning Infrastructure Standard identifies the specific performance requirement for infrastructure, sensing, collecting and communicating data for flood forecasting and warning purposes. It can be applied to both existing and new infrastructure.

Flood warning infrastructure involves field instruments and communications equipment, through to data ingest software for receiving, storing and displaying real-time flood data. Other infrastructure, such as satellite and radar, contribute data for flood forecasting and warning purposes. However, they are not within the scope of this Standard.

This Standard also includes the criteria and verification required to assess performance and ensure consistency across the solutions developed to meet the requirements (AS-003-Standards Australia 2016). This Standard is not intended for design specifications. Instead it can be used to assess design specifications and determine if these meet the standard for flood warning infrastructure.

The Flood Warning Infrastructure Standard (the standard) presents the performance requirements specific to flood forecasting and warning. The focus is on the 'what' and is independent of technology. The National Industry Guidelines for hydrometric monitoring (NIGL) present recommended Australian best practice for all aspects of hydrometric monitoring. Its focus is on the 'how' and is dependent on the technology. The NIGL prescribe actions in relation to measurement and provide specific guidelines for each technology solution. The NIGL is a useful reference for site set-up and sensor set-up, as well as site and sensor maintenance guidelines, to meet the requirements of the Standard.

The target audience for this Standard includes a range of disciplines including:

> Flood risk / flood hazard managers

> Flood forecasting and warning service providers

> Hydrometric data infrastructure providers

> Communication/network providers

> Civil engineering professionals

The application of the Standard involves five steps, which are separated into two parts. The first part (Chapter 3) involves determining site-specific performance levels. The second (Chapter 4) involves verifying that the performance of the infrastructure meets the site-specific performance levels, followed by examples of infrastructure that meet the performance requirement in Chapter 4. The workflow begins with gathering site/service input data, using that input data to characterise the site (Chapter 2), and then using the input data/site characterisation in conjunction with the performance requirement to evaluate the performance level.

To complete the assessment, infrastructure specifications are gathered. In conjunction with the verification methods these then verify that the infrastructure meets the performance level. The answers are then inserted into the form (Appendix 1). NB. The intention of the Standard is not to provide a design specification for a flood warning site, however, a design specification can be assessed against the Standard to determine if it complies.

Implications for this Study: *Advice from BOM indicated that the Standard is scalable, and is intended to be tailored to a level commensurate with the characteristics and needs of individual flood warning systems. The principles of the Standard should be applied as appropriate when developing the preferred TFWS option and preparing the draft Scope for implementation.*

A.8.3 BoM FLARE

The national Flash Flood Advisory Resource (FLARE) is an authoritative resource created to assist agencies with flash flood warning responsibilities, such as Councils and Emergency Services, to design, implement and manage fit-for-purpose flash flood warning systems. FLARE is not an operational service; rather it provides access to a wealth of information that supports local organisations to develop flash flood warning systems.

Co-ordinated by the BoM, FLARE includes a website and advisory service for registered users. The FLARE advisory service, available during business hours (Australian Eastern Standard Time), provides phone and email access to BoM staff with knowledge of resources available, and the standards and guidelines necessary for developing local flash flood warning systems. The advisory service is not an operational service and cannot provide guidance or access to operational data and information during a flash flood event.

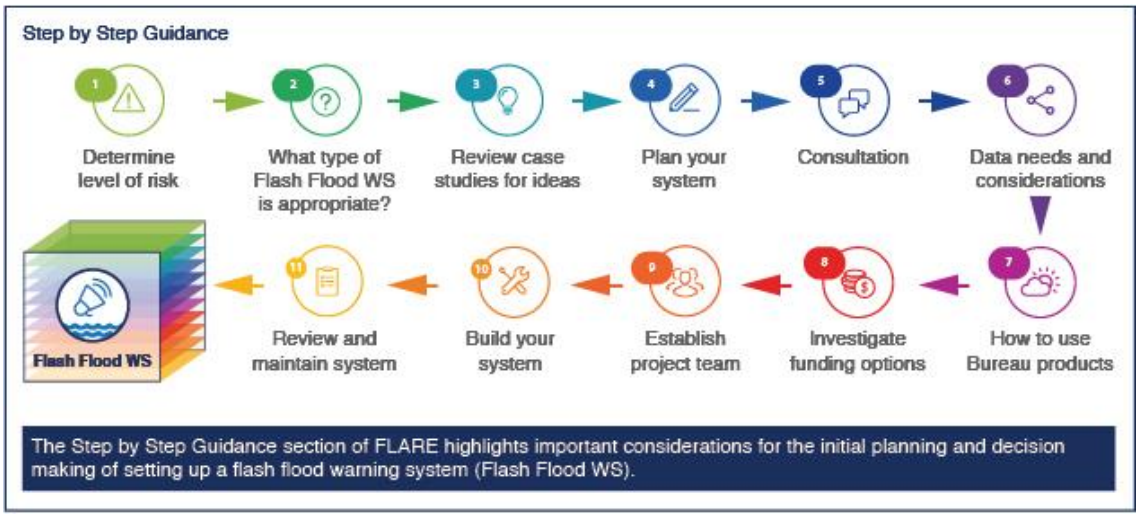

Figure A.3 BoM Flash Flood Advisory Resource (FLARE) Step by Step Guidance

Implications for this Study: *It is envisaged that the supporting information, standards and guidelines available through FLARE will be invaluable to guiding this project for the catchments with Flash Flooding, which effectively addresses steps 1 to 7 of the Step-by-Step Guidance for these catchments.*

A.8.4 Floodplain Development Manual, NSW Government, 2005

The NSW State Government's Flood Prone Land Policy provides a framework to ensure the sustainable use of floodplain environments. The primary objective of the NSW Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods. At the same time, the policy recognises the benefits flowing from the use, occupation and development of flood prone land (Reference 4).

Under the Policy, the management of flood liable land remains the responsibility of local government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

Implications for this Study: *This Study is being undertaken in accordance with the guidance provided in Appendix I of the Floodplain Development Manual, which sets out the way in which recommended floodplain risk management options are implemented.*

A.9 Rainfall and Stream Gauges

Information about existing and former gauging infrastructure will be a key component of this study. **Table A.3** below contains details of rainfall, stream level and reservoir water level gauges within the Bega River catchment.

Table A.3 Rainfall and Stream Gauges in the Bega River catchment

Gauge Number	Gauge Name	Owned/ Operated	Metric (Rainfall and Stream/ Water Level)	Operational Period (from YYYY – YYYY/Current)	Location
069003	Bemboka Post Office	BOM	Rainfall	1889-Current	(-36.6277,149.5706)
069002	Bega Newton Rd	BOM	Telegraphic Rain	1879-Current	(-36.6883, 149.8380)
069133	Bemboka (The Knob)	BOM	Rainfall	1985-Current	(-36.6631,149.5139)
069065	Brogo (Hawks Head Rd)	BOM	Rainfall	1962-Current	(-36.5675, 149.7509)
069140	Brogo Dam	BOM	Rainfall	1992-Current	(-36.4948, 149.7434)
069013	Candelo Post Office	BOM	Rainfall	1887-Current	(-36.7677, 149.6951)
069107	Kameruka (Kameruka estate)	BOM	Rainfall	1901-Current	(-36.7385, 149.7101)
069114	Brogo (Blanchards Rd)	BOM	Rainfall	1974-Current	(-36.5406, 149.8227)
219410	Bega River at Bega River	NSW DPE/MHL	Water Level	Current	(-36.7026,149.9779)
219410	Bega River at Bega River	Water NSW	Stream Water Level	2010-2019	(-36.7026,149.9779)
219003	Bemboka at Morans Crossing	Water NSW	Stream Water Level	1943-Current	(-36.6658, 149.6481)
			Discharge Rate	1943-Current	
219900	Bega River at Bega	Water NSW	Stream Water Level	1851-Current	(-36.6693, 149.8299)
			Discharge Rate	1851-2020	
			Rainfall	1879-2013	
219032	Bega River at Kanoona	Water NSW	Stream Water Level	1997-Current	(-36.7300, 149.7975)
			Discharge Rate	1997-Current	
			Rainfall	2005-Current	
219013	Brogo at North Brogo	Water NSW	Stream Water Level	1961-Current	(-36.53420, 149.8272)
			Discharge Rate	1961-Current	
219027	Brogo Dam	Water NSW	Reservoir Water Level	1976-Current	(-36.5405, 149.7420)
			Rainfall	1970-Current	
219034	Candelo at Greenmount	Water NSW	Stream Water Level	2002-Current	(-36.8005, 149.6880)
			Discharge Rate	2002-Current	
219025	Brogo River at Angledale	Water NSW	Stream Water Level	1976-Current	(-36.6185, 149.8817)
			Discharge Rate	1976-Current	
			Rainfall	1999-Current	
219033	Cochrane Dam Storage	Water NSW	Reservoir Water Level	1959-Current	(-36.5703, 149.4554)
			Rainfall	1959-Current	

Gauge Number	Gauge Name	Owned/ Operated	Metric (Rainfall and Stream/ Water Level)	Operational Period (from YYYY – YYYY/Current)	Location
219022	Candelo Damsite	Water NSW	Stream Water Level	1971- Current	(-36.7303, 149.6855)
			Discharge Rate	1971-Current	
219017	Double Creek near Brogo	Water NSW	Stream Water Level	1966-Current	(-36.5985, 149.8106)
			Discharge Rate	1966-Current	
219006	Tantawangalo Mountain	Water NSW	Stream Water Level	1924-Current	(-36.7803, 149.5427)
			Discharge Rate	1924-Current	
			Rainfall	1990-1994	
219001	Rutherford Brown Mountain	Water NSW	Stream Water Level	1924-Current	(-36.5940, 149.4427)
			Discharge Rate	1924-Current	
219019	Tantawangalo Kameruka	Water NSW	Stream Water Level	1966-1978	(-36.7332, 149.7181)
219012	Devils at Tantawangalo	Water NSW	Stream Water Level	1960-1978	(-36.7954, 149.5925)
219007	Brogo River at Brogo	Water NSW	Stream Water Level	1954-1960	(-36.5405, 149.8263)
219064	Brogo at Apps	Water NSW	Stream Water Level	1972-1979	(-36.6601,149.8468)
219024	Brogo D/S Brogo Dam	Water NSW	Stream Water Level	Not Operational	(-36.4900, 149.7486)
219063	Bega at Darceys	Water NSW	Stream Water Level	Not Operational	(-36.6786, 149.8628)
219065	Bega at Barrage	Water NSW	Stream Water Level	Not Operational	(-36.7093, 149.8836)
219026	Bega R Warraguburra	Water NSW	Spot levels only	1974-2014	(-36.7016, 149.872)

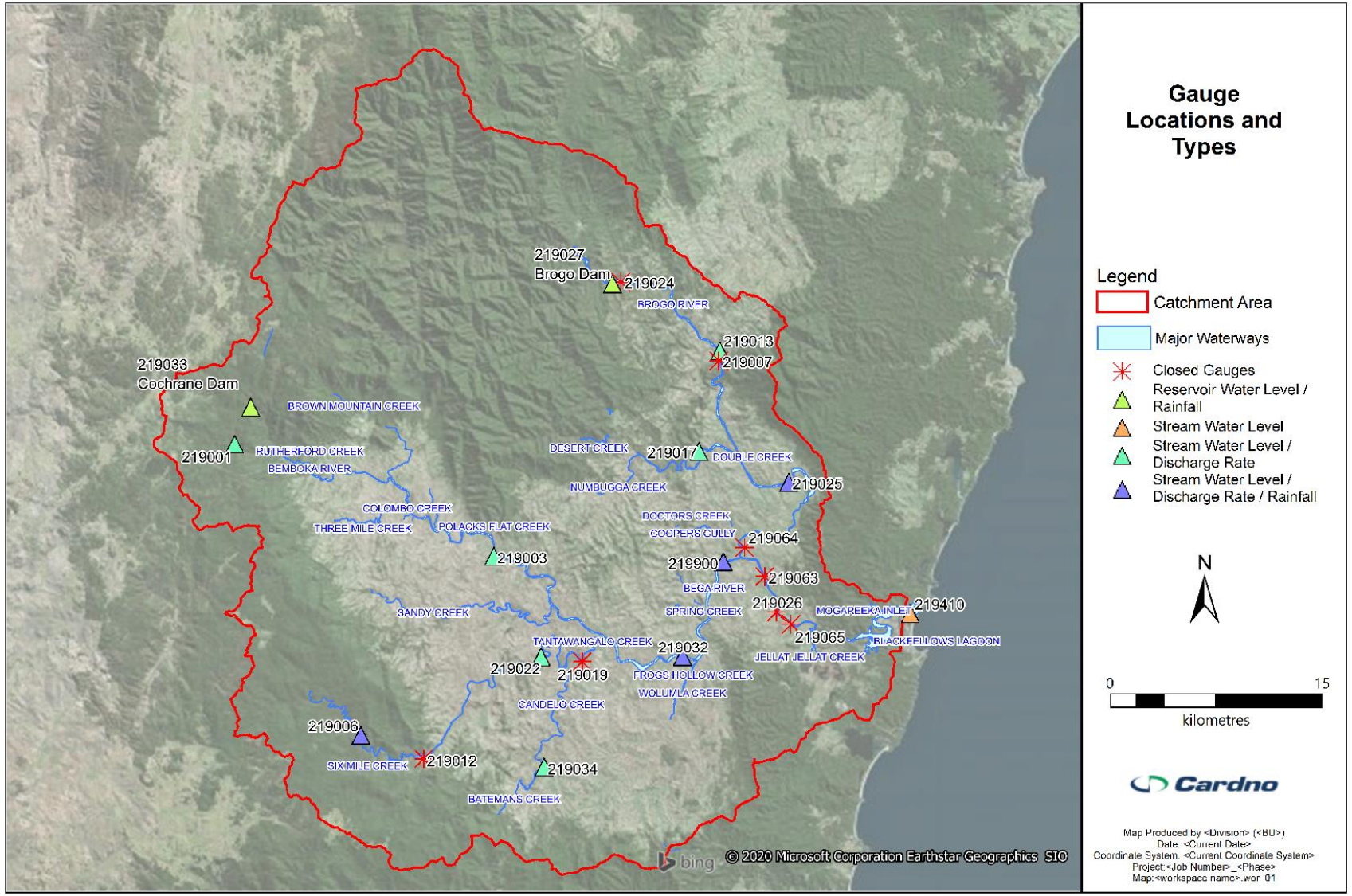

Figure A.4 *Rainfall and Stream Gauges in the Bega and Brogo River catchment*

A.10 **Dams in the Study Area**

There are three dams in this study area;

> Brogo Dam

> Cochrane Dam and

> Bournda Parkway Dam

It is important to understand the flood warning and emergency measures in place which may come into effect during dam releases, uncontrolled spilling or dam failures. These may provide an opportunity to leverage any existing gauges and water level sensing infrastructure in the future flood warning system.

The following sections outline the current available information about the dams listed above.

It is understood that Brogo and Cochrane Dam can be considered regulated structures however this is unknown for Bournda Parkway Dam.

A.10.1 Brogo Dam

Brogo Dam is owned and operated by WaterNSW, and is situated on the Brogo River upstream of Bega on the NSW South Coast and about 430 kilometres south of Sydney. The dam's 400 square kilometre catchment falls largely within Wadbilliga National Park with its rugged mountain terrain of steep ridges and deep gullies.

Table B.1 Brogo Dam was built to provide a reliable supply of water for the dairy industry, the main agricultural industry on the NSW South Coast. It provides water for improved pastures for stock feed as well as vegetables. The dam was completed in 1976 to provide water for irrigation, stock and domestic requirements on the NSW South Coast. Water released from Brogo Dam is taken from the river downstream for the townships of Quaama, Cobargo and Bermagui. Details of the dam are provided in **Table A.4**.

Table A.4 Brogo Dam Details

Dam wall height (m)	43
Dam wall length (m)	260
Full Supply Level	102.60 m AHD
Spillway Level	102.60 m AHD
Storage Capacity	8,980 ML
Dam Crest Level	118.1 m AHD
Stage Discharge Relationship	Available
Storage Discharge Relationship	Available
Historic event flow releases including any environmental flows or low flows	Available
Construction Period	1964-1976
Wall type	Concrete-faced rock embankment

Implications for this Study: *The Brogo Dam Flood Warning System and operational details were reviewed and considered as part of the subsequent phases of this study to ensure the existing flood warning system infrastructure is understood, and opportunities to complement the existing system are identified.*

A.10.2 Brown Mountain Power Station, Cochrane Dam, Dam Safety Emergency Plan, Aurecon 2020

Cochrane Dam (originally known as Georges Creek Dam) is located at Brown Mountain approximately 16 km upstream of Bemboka along the Bemboka River. It is owned and operated by Cochrane Dam Pty Ltd and functions as a water supply storage for the town of Bemboka and as a hydroelectric scheme for power generation (SMEC, 2014). The dam is located approximately 29 km east of Nimmitabel and 17 km west of Bemboka. It was constructed in and is an earth and rock fill dam with a storage capacity at full supply level (RL 910.13 m) of 4,750 ML.

The DSEP contains information regarding trigger levels, consequences and required actions for White, Orange and Red Alerts, and describes the operational details of the Cochrane Dam Flood Warning System.

Implications for this Study: *The Cochrane Dam Flood Warning System has been considered as part of this study. It is noted that the DSEP was reviewed and updated in 2020. The operational details of the Cochrane Dam Flood*

Warning System are described in the DSEP. It is considered there may be opportunities to ensure the operational details of the flood warning system are well understood and opportunities to complement the existing system are identified.

A.10.3 Bournda Dam

A small dam exists to the east of Sapphire Coast Drive near Bournda Parkway. Council understands that the dam was originally constructed as a gully erosion structure for the private land owner. During the subdivision of the surrounding land the dam was used for sediment control. The dam is now used for water supply for private use, road works and firefighting and provides visual amenity and recreational value.

Due to the temporary nature of its original intended purposes, it is Council's understanding that the dam was likely not constructed to comply with design guidelines and dam safety regulations that would provide some certainty of its structural stability and longevity.

In 2014, Council was notified that erosion had been identified at the dam wall. Remediation works were subsequently undertaken by Council in an attempt to stabilise the damage. To assist Council in planning for the future of the dam, a dam break assessment was undertaken as part of the Bega and Brogo Rivers FRSMP (Cardno, 2018). For the assessment, a local TUFOW model was constructed. The model adopted all the model parameters of the full TUFLOW model, but was able to utilise a finer, 2m grid cell. The results showed that there was no change in the 1% AEP peak flood extents as a result of the dam failing. This is due to the dam volume being significantly less than the volume in the Bega River, so that the additional volume applied did not result in any changes in peak water levels.

An information brochure and questionnaire was distributed to those properties surrounding the Bournda Parkway Dam area in December 2016 looking particularly at the risk associated with failure of the Bournda Parkway Dam. The purpose of this engagement was to identify how the community values the dam, what it is used for, concerns regarding dam failure and input to potential management strategies.

***Data Gap**: Further investigation is required to confirm if Bournda Dam is required to be declared under Dams Safety NSW.*

We have proceeded with this study without delay in the absence of receiving the outcomes of this investigation. Further consultation with Dams Safety NSW would be required to confirm if the dam is required to be declared which is outside the scope of this study.

A.11 Previous Community Consultation

A.11.1 Consultation undertaken in the Bega and Brogo Rivers Flood Study at Bega (SMEC, 2014)

A community consultation process was initiated to introduce the floodplain management program to the local area. The consultation process included introducing information about the flood study to residents and landowners within the project area by newspaper articles, interviews with Council on local radio and sending out a newsletter and flood questionnaires.

The flood questionnaire was primarily used to develop a database of floodmarks/ flood levels associated with various historic floods that could be used in calibrating and validating the flood models. To be beneficial for calibration, flood information needed to relate specifically to dates on which floods occurred, since the rainfall data needed to correspond to the flood data. Flood information obtained from the questionnaire included dates of flooding and floodmarks, estimates of flood depths, description of flooding and duration and qualitative estimate of flow velocities. In some cases photographs and videos were also provided. The responses from the flood questionnaire indicated the following historic flood events were the most remembered by residents:

> February 1971

> February 2011

> March 1983

> March 2011

> February 2010

> March 2012

Additional floodmarks were extracted from the questionnaires and surveyed by Caddey Searle & Jarman Consulting Surveyors for inclusion in the flood mark database from Council and previous reports.

A.11.2 Bega and Brogo Rivers Floodplain Risk Management Study & Plan (Cardno, 2018)

Community consultation was undertaken in three key phases over the course of the project:

> Community Information Brochure and Questionnaire;

> Community Workshops; and

> Public Exhibition of Draft FRMS&P.

The brochure and questionnaire were delivered to approximately 1,568 property owners in the catchment. The FRMS was also advertised in the local newspaper, informing residents of the study and advising that the survey was being undertaken. A total of 94 responses were received representing a return of approximately 5% of direct distribution. Of these, the vast majority were from Bega and surrounding suburbs, with only one respondent from Candelo. The survey was conducted outside of peak holiday times, and was mailed to property owners. It is therefore likely that the survey did not take into account the flooding knowledge and experiences of the visitors and tourists that visit the region during holiday periods.

Based on the feedback provided in the returned questionnaires, the following key outcomes have been derived:

> A significant number of respondents (65%) were concerned with risk to property due to flooding, 39% were concerned with inconvenience related to flooding, and 27% were concerned with risk to life due to flooding;

> More than half (55%) of respondents were concerned with floods affecting specific roads in the area, 45% of respondents were concerned with flooding at their property, and 23% were concerned with flooding in public areas;

> Many respondents (60%) had heard of FPLs and felt that they were necessary for the protection of property and life, while only some (31%) of respondents understood what a freeboard is and why it is included in the FPLs;

> The most popular option chosen by respondents to minimise flood-related risk was the placing of restrictions on development on flood-prone land with 50% of respondents choosing this option. A total of 35% of respondents considered stopping all new developments on land with any potential to flood as needed to minimise flood-related risk;

> The implementation of planning and flood-related development controls was the most popular management option chosen by residents for the Bega River and Brogo River area with 51% of respondents choosing this option as most preferred. On the other hand, the voluntary purchase of highly affected properties by Council was the least popular management option with only 12% of respondents choosing it as their most-preferred option.

Implications for this Study: *Understanding the activities and findings of previous consultation allows Cardno now Stantec to:*

> Identify the preferred and most effective engagement techniques,

> Build upon previously received information and demonstrate to the community that their input is valued;

> Minimise the risk of over-consultation or consultation fatigue;

> Identify local leaders and key community 'champions' to assist directly with future engagement activities and, more broadly, floodplain risk management in their local community.

APPENDIX

B

COMMUNITY CONSULTATION METHODOLOGY & RESPONSES

Appendix B Community Consultation Methodology & Responses

B.1 Objectives

To ensure the relevance of flood warning systems and to encourage local ownership of them, Manual 21 states that:

"Community members should be involved in developing the warning systems which will generate the warnings. Agency personnel involved in system design must therefore listen to those at risk."

Flood warning systems and services are therefore best developed with the input of those who are affected by floods. Personnel in the agencies responsible for warning about flooding should meet with members of the community and establish their needs. These will relate to:

> the levels of flooding (usually at a specified gauge) for which warning will be needed;

> the consequences of flooding at different flood heights in areas around the gauge (i.e. in the gauge reference area);

> the amounts of warning time which will be required to take the required protective action;

> evacuation and other tasks which people may need to undertake for floods of specified severities;

> the ways in which warnings should be provided; and

> other matters related to the various components of the system.

(Australian Emergency Manual Series, Manual 21, Flood Warning, Australian Government 2009)

Figure B.1 ***The consultation goals at each of the project stages are guided by the IAP2 Spectrum of Participation. Table B.2 indicates the level of participation required at the key project stages.***

Table B.2 ***Level of engagement at each project stage (IAP2 Spectrum of Participation)***

Engagement activity	IAP2 Spectrum	Public Participation Goal	Promise to the Public
Press release and social media	Inform	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and solutions.	We will keep you informed.
Community Consultation Survey	Involve	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.
Community Information Sessions	Involve		
Public Exhibition	Consult	To obtain public feedback on analysis, alternatives and/or decisions	We will keep you informed, listen to and acknowledge your concerns and aspirations, and provide feedback on how public input influenced the decision. We will seek your feedback on drafts and proposals.

B.2 Methodology

B.2.1 Community Consultation Questionnaire

In consultation with Council and members of the Technical Working Group (Council, BoM, NSWSES, DPE) Cardno developed a community consultation survey to gather information from residents within the Study Area.

The questions included in the survey broadly fit into two key themes:

> Past experience of flooding, flood warnings and the protective behaviours required to be taken; and

> Preferences and suggestions for improvement and enhancement of the existing flood warning system.

The survey was available online from 30th November 2020 to 15th February 2021, advertised through Council's Have Your Say webpage, social media and a press release. Hardcopies of the survey were available at the drop-in sessions, at Council's offices in Zingel Place, and copies were left with community members of Bemboka and Candelo.

In total, nine (9) online responses were received, and no hardcopy surveys were returned to Council.

B.2.2 Community Information Sessions

Three (3) information sessions were held in early December 2020 for the purpose of providing residents with an opportunity to discuss the projects and their concerns with Council and Cardno Staff (in person).

Representatives from NSW SES also attended the Candelo and Tathra sessions in person and representatives from BOM and DPE attended all three sessions via video link. Sessions were held at the below venues. In total, 11 residents attended consultation sessions as follows

> Session 1: Monday 7th December, Club Bega, 3:30pm – 6:15pm (4 attendees: 2 from Bega, 2 from Tarraganda);

> Session 2: Tuesday 8th December, Candelo Town Hall, 3:30pm – 6:15pm (1 attendee from Toothdale);

> Session 3: Wednesday 9th December, Tathra Town Hall, 3:30pm – 5:30 pm (1 attendee from Tarraganda);

Two additional sessions were arranged in January 2021 to engage with members of the farming community:

> Session 4: Thursday 21st January, Zingel Place – Committee Room 2: 10:00 am- 11:00 am (4 attendees from farming community); and

> Session 5: Thursday 21st January, (Online): 5:00pm – 6:00pm (1 attendee).

Each session was held as an informal workshop, with the components of the Total Flood Warning System providing a structure for discussion with attendees. The low attendance at each session allowed for an in-depth discussion of a range of issues both related to flood warning systems and broader issues around community flood education and awareness. An example of the discussion points captured (at the Candelo Session) is shown in Figure B.2.

Figure B.2 ***Discussion points and ideas were recorded using the Total Flood Warning System components as a framework (Photo: Cardno, Candelo Information Session (9th Dec 2020)).***

B.2.3 Community Consultation Survey Questions and Responses

1. Have you experienced a flood event in the study area (e.g. June 2016, March 2011, February 1971)?

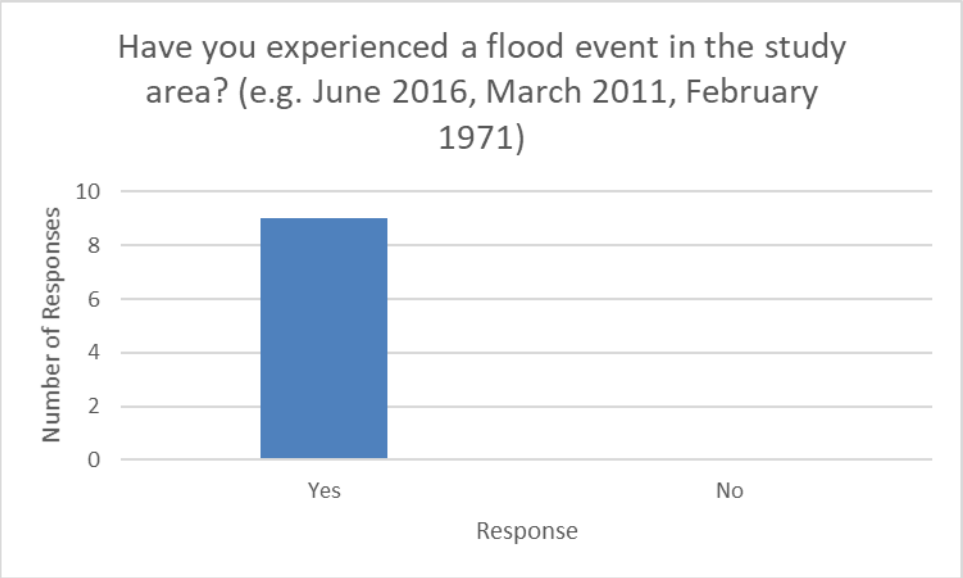

Figure B.3 Number of respondents who have experienced floods in the study area in the past

Note Responses to Questions 2-3 contain private information and have not been provided in this document.

2. Please enter the date of the flood(s) you've experienced (year and month if possible)

> Respondent 1: *[No Response]*

> Respondent 2: “Feb 2010?, Mar 2011, June 2016”

> Respondent 3: “March 2011, June 2016”

> Respondent 4: “17/02/2010, 1/06/2010, 23/03/2011, 8/12/2014, 6/01/2016 ,29/07/2020”

> Respondent 5: “Many occasions over the last 30 years! Probably averages nearly one a year!”

> Respondent 6: “2015, 2017, 2018”

> Respondent 7: *[No Response]*

> Respondent 8: “2011”

> Respondent 9: “All floods”

3. If you answered 'yes' to the above question, please describe how you were affected

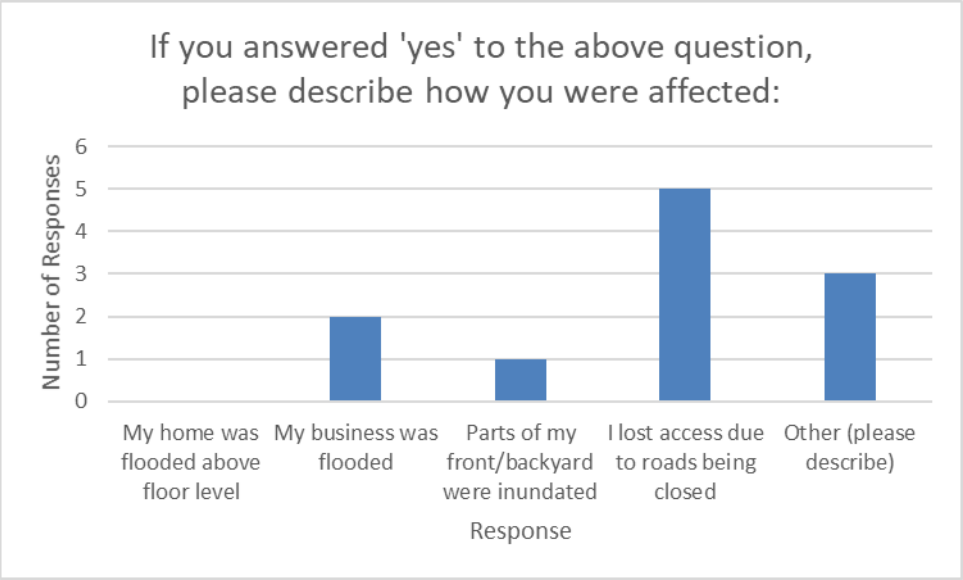

Figure B.4 Previously experienced flood impacts

3.1 Other (Please Describe):

> Respondent 4: “No Damage, only extra work to prepare”

> Respondent 8: “Dairy Farm”

> Respondent 9: “Parts of farm flooded”

4. In these flood events, how did you receive flood warnings? Please select all that apply

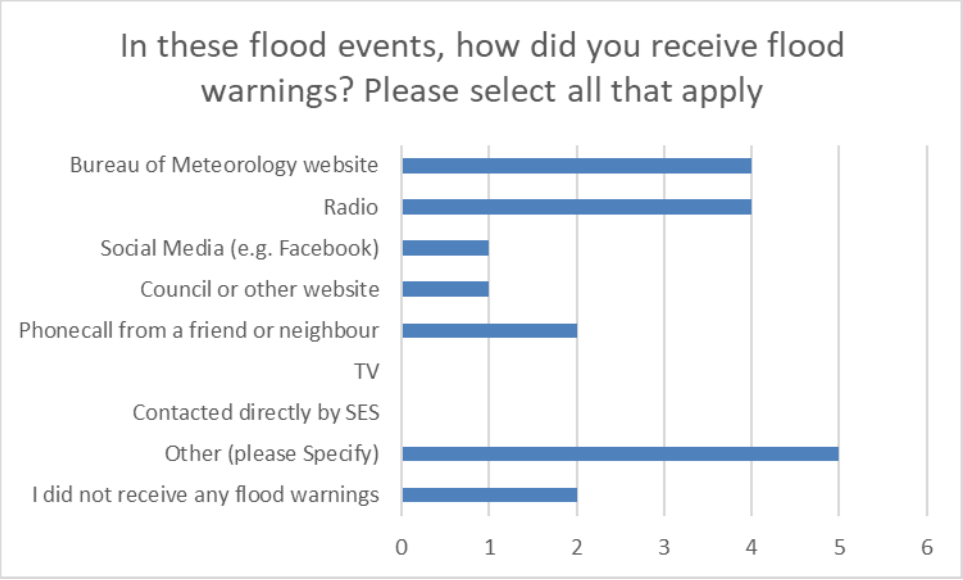

Figure B.5 Methods of receiving warning during previous floods

4.1 Other (Please Specify):

> Respondent 3: “Rumours of work colleagues about possible road closures”

> Respondent 4: “SMS”

> Respondent 5: “Road signs at Dr George intersection”

> Respondent 8: “WaterNSW”

> Respondent 9: “Did receive flood warnings from WaterNSW to recent events. Water users have to register with WaterNSW. Farmers usually have acted through experience before receiving the flood warnings”

5. How well did the flood warnings allow you to understand the predicted flood risk? (move the slider from left to right to show your response)

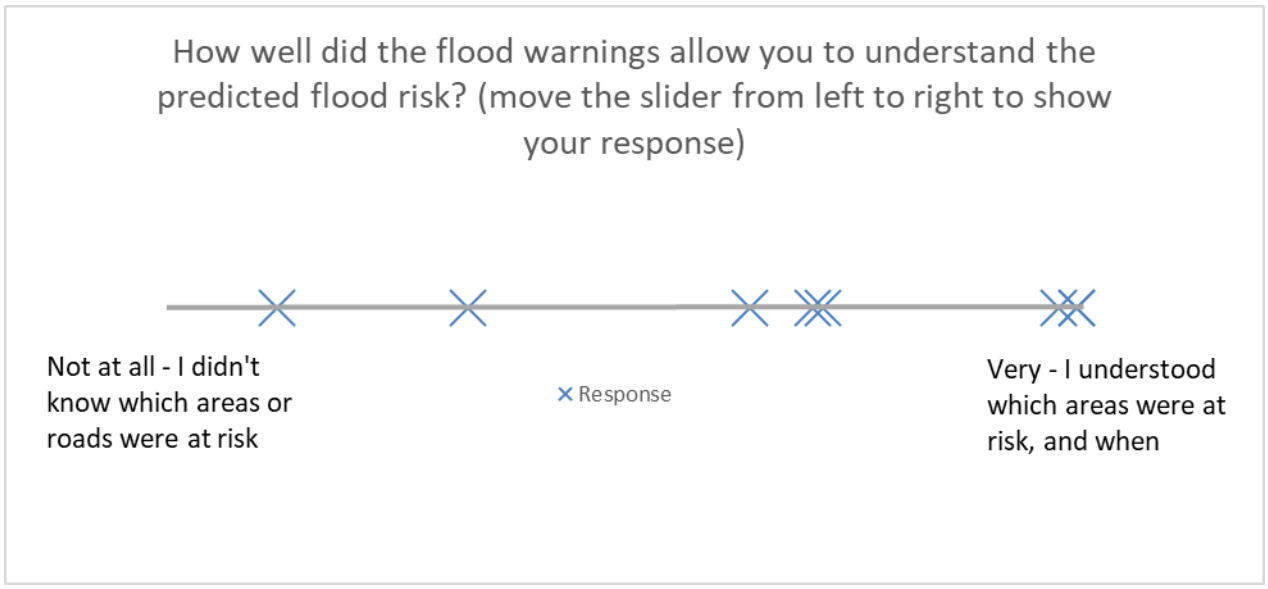

Figure B.6 Rating of flood warnings helping with understanding predicted flood risk

6. How well did the flood warnings help you understand what actions to take? (move the slider from left to right to show your response)

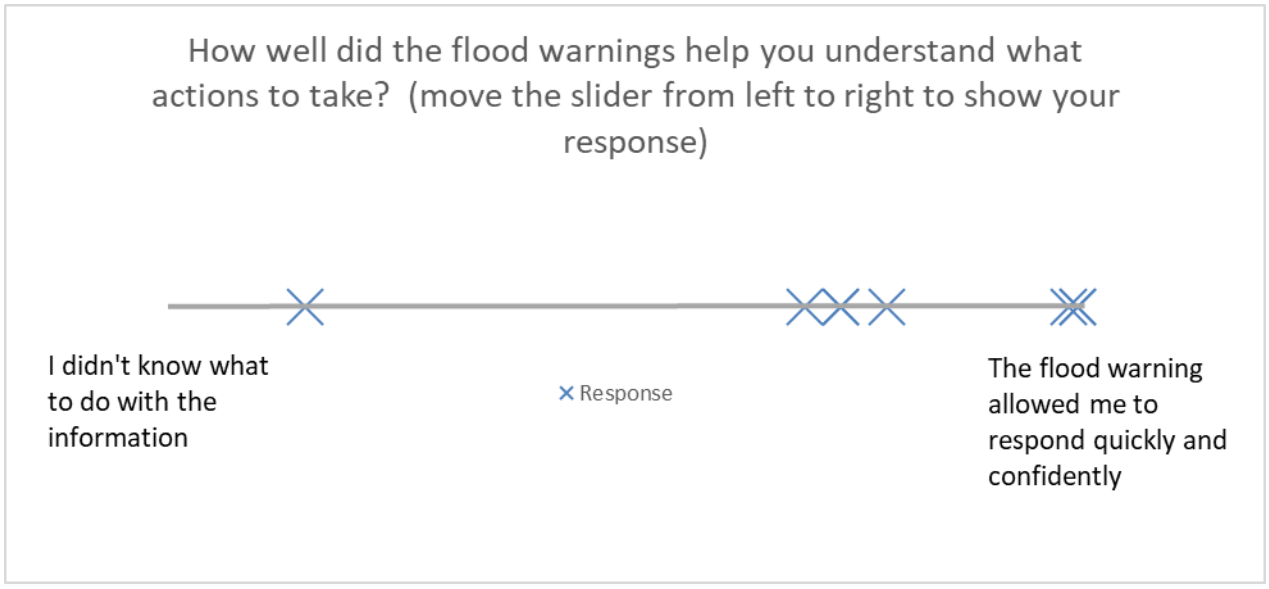

Figure B.7 Rating of flood warnings helping with understanding actions to take

7. In previous floods, what actions did you take to reduce losses, or to protect property or your personal safety? (Select all that apply)

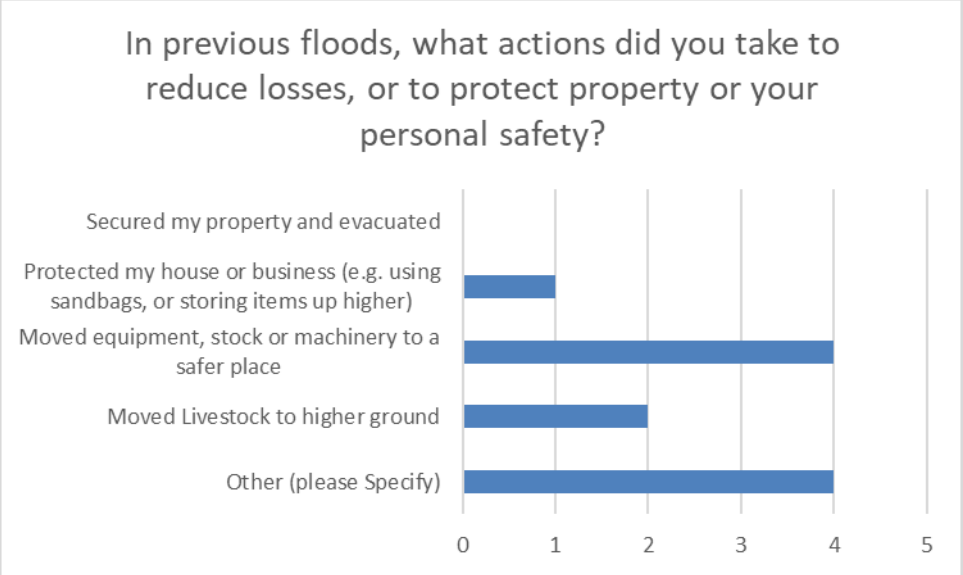

Figure B.8 Actions taken to reduce flood impacts

7.1 Other (Please Specify):

> Respondent 1: “Indirect impacts, detour to work”

> Respondent 2: “Detour to work”

> Respondent 3: “Stocked up food, prepared for isolation”

> Respondent 5: “Took alternative routes”

8. For your answers above, how long did these actions take (once you had received the warning)? (Move the slider from left to right to show your response)

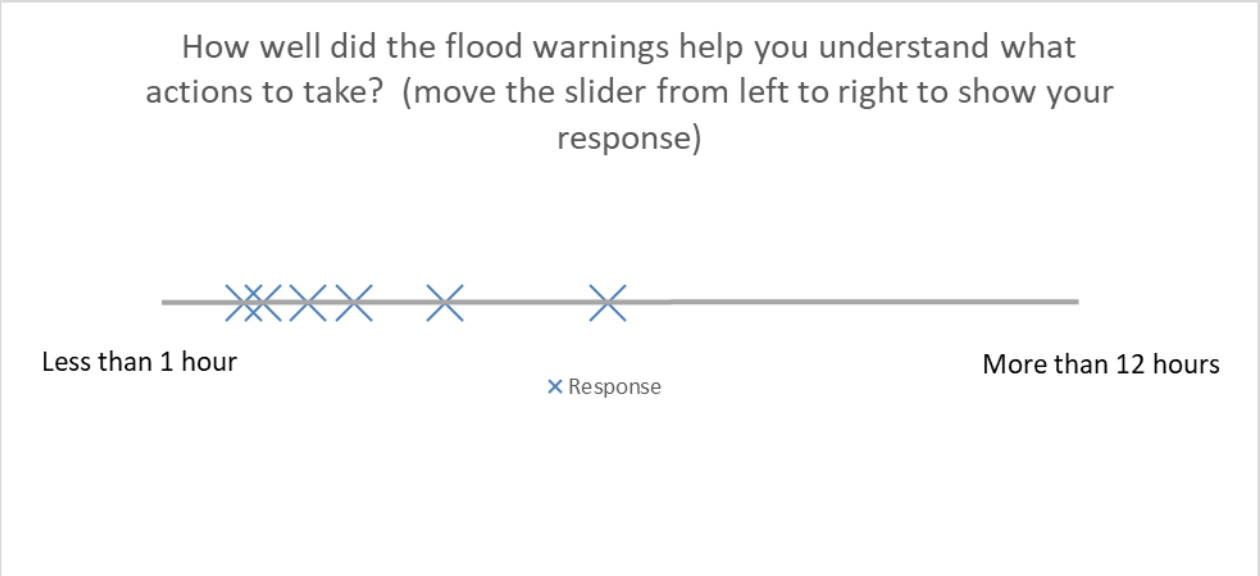

Figure B.9 Time taken during previous floods to take actions to reduce losses, or to protect property or personal safety

9. Flood warnings are currently provided for the Bega River at the Bega North gauge. Can you think of any other specific locations where it would be useful to monitor river levels and/or provide flood warnings?

> Respondent 1: “Candelo, Bemboka, Wolumla, Jaunceys Bridge over Brogo River- Angledale, Tantawangalo Lane causeway at Tantawangalo Lane, Wolumla Ck bridge - Candelo Bega Road, Tylers Ck bridge - Candelo-Bega - Road. Hancocks Bridge - Mogareeka, Bega River Anabranch Bridge - tarraganda Lane, Jellat Jellat straight - Tathra Road, Double Ck bridge over Double Ck - Upper Cobargo Road, Grosses Ck bridge Buckajo - Buckajo Road, Stony Ck bridge - Mogilla Road, Bemboka River crossing Bemboka - Yankees Gap Road, Polack’s Flat Ck bridge - Polack's flat, Colombo Ck bridge Bemboka - Sams Corner Road, bridges over Tantawangalo Ck and Candelo Ck Candelo - West Kameruka Road”

> Respondent 2: “Candelo, Bemboka, Kanoona, Mogareeka, Jellat Jellat, Jaucey's bridge Angledale, Double Creek”

> Respondent 3: “Tarraganda Bridge. Brogo and Bega river junction”

> Respondent 4: “Flood heights are monitored on most rivers in the Bega Valley now”

> Respondent 5: “Notification of when Mogareeka is likely to be cut/ opened”

> Respondent 6: “Tarraganda Bridge, this is a key access point from Tarraganda, and Tanja”

> Respondent 7: “At the intersection of Buckajo Rd and Grosses Creek Rd, as that goes under before it reaches the north Bega location”

> Respondent 8: “Brogo and Cochrane Dam, Junction”

> Respondent 9: “Bemboka river at Bemboka and at Moran's Crossing for the Bega/Bemboka Brogo Dam and North Brogo gauge”

The locations given where respondents believed it would be useful to monitor river levels and/or provide flood warnings are listed below and mapped on Figure B1 to B3.

Table B.3 Suggested Locations for Monitoring River Levels and/or Providing Flood Warnings

ID	Location	Number of Respondents who Recommended
01	Grosses Ck Bridge, Buckajo Rd / Buckajo Rd and Grosses Creek Rd Intersection	2
02	Brogo and Bega River Junction	1
03	Wolumla Ck Bridge, Candelo-Bega Rd	1
04	Tylers Ck Bridge, Candelo-Bega Rd	1
05	Bridges over Tantawangalo Ck and Candelo Ck Candelo, West Kameruka Rd	1
06	Double Creek Bridge over Double Creek, Upper Cobargo Rd	2
07	Colombo Ck Bridge Bemboka, Sams Corner Rd	1
08	Stony Ck Bridge, Mogilla Road	1
09	Polack’s Flat Ck Bridge, Polack’s Flat Rd	1
10	Bemboka River Crossing Bemboka, Yankees Gap Rd	2
11	Tarraganda Bridge / Bega River Anabranch Bridge, Tarraganda Lane	3
12	Handcock’s bridge, Mogareeka	1
13	Jauncey’s Bridge Angledale Rd	2

14	Jellat Jellat Straight, Tathra Rd	1
15	Tantawangalo Lane causeway	1
16	Mogareeka (non-specific)	2
17	Candelo (non-specific location)	2
18	Bemboka (non-specific location)	2
19	Kanoona (non-specific location)	1
20	Jellat Jellat (non-specific location)	1
21	Wolumla (non-specific location)	1
22	Brogo River Dam	2
23	Moran's Crossing (non-specific location)	1

10. How would you like to receive flood warnings in the future? (e.g. phone calls, smart phone apps, sirens). Please describe:

> Respondent 1: "Radio, text, Facebook, various websites"

> Respondent 2: "Radio, TV, text, website, Facebook"

> Respondent 3: "Smart phone app. Text messages"

> Respondent 4: "SMS and radio station updates are working now"

> Respondent 5: "Emergency app or Facebook or council website?"

> Respondent 6: "Phone call, txt, email"

> Respondent 7: "Text message would be good"

> Respondent 8: "SMS"

> Respondent 9: "emails and messages"

Figure B.10 *provides a summary of the preferred flood warning methods as compared to the methods through which respondents previously received flood warnings (taken from the survey question shown in Appendix B, Section 1.3).*

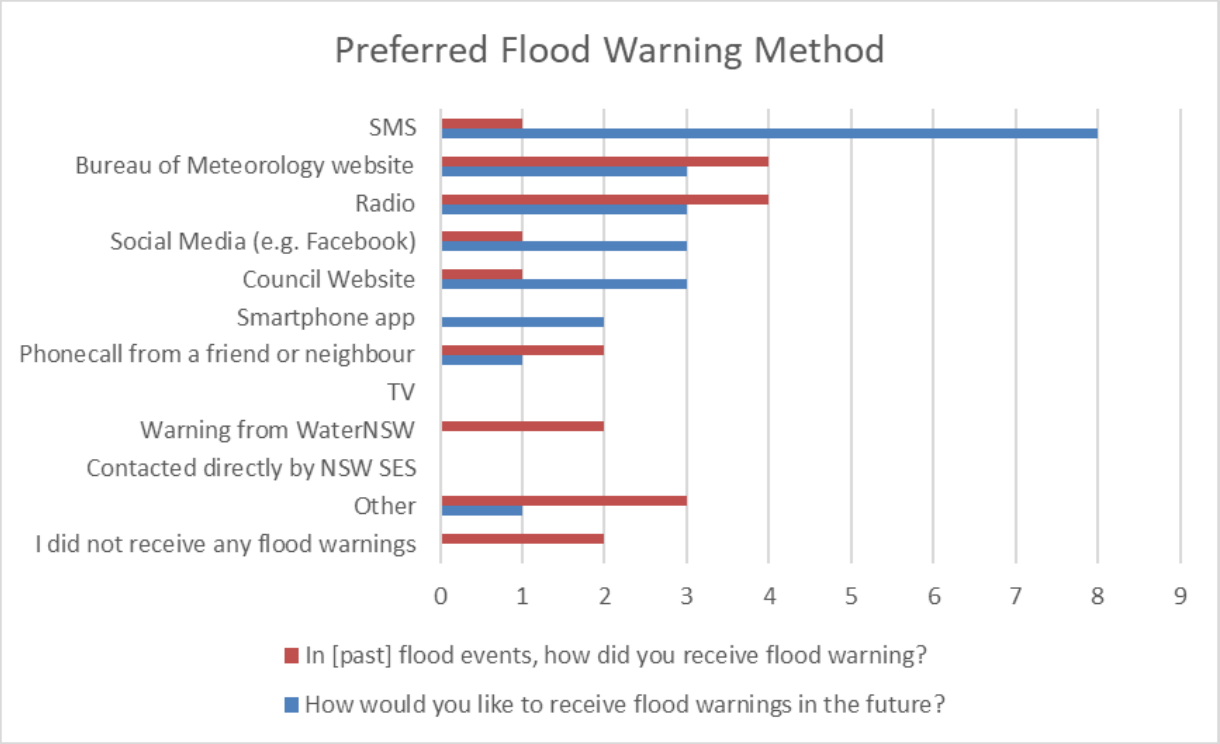

Figure B.10 Survey respondents past used and future preferred flood warning methods

11. Do you have any other suggestions for improving or expanding the flood warning system in the Bega and Brogo River valleys?

> Respondent 1: "Identifying key gauges at key locations for key communities with specific gauge height and messaging/actions"

> Respondent 2: "Expanding the warnings and message to specific communities outside of Bega township"

> Respondent 3: "Invest in infrastructure like raising roads, community safe places. Secured power infrastructure which is frequently lost in the major flood events"

> Respondent 4: "Use the existing BOM warnings. 1. Most FWS are on inland rivers with long river travel times, greater than one day, to allow people to move stock and equipment from the flood plain after the warning. The Bega Valley flood times are less than 12 hours during heavy rains. 2. It relies on automatic communications to operate and warn people. In a heavy storm event these communications could be unreliable. 3. Weather forecasting and warnings from the BOM are more accurate and people should react to the warnings and move stock and equipment from the flood plain prior to the flood. Council knows which roads are affected by flooding and should have signs and people ready to close roads when required. 4. WaterNSW already has an automated flood notification system on the Brogo River, the Early Warning Network (EWN), to improve notification of dam and supply activities to the public. This may be expanded to include other rivers using existing river monitoring stations in the valley. Anyone can register to receive a SMS warning. https://www.waternsw.com.au/supply/ewn for the Brogo River. 5. A Flood Inundation Map Bega and Brogo Rivers at Bega, 1979 edition, showing a 10 year and 100 year flood areas is available here, https://nla.gov.au/nla.obj-232777066/view showing areas in danger.[1] 6. The Bureau of Meteorology, BOM, is the government body responsible for monitoring and predicting a flood. And in this process, they can issue a Flood Watch or a Flood Warning to the relevant authority and Radio Stations. This proposed "Total Flood Warning System (TFWS)" and its "Our aim is to develop a fit-for-purpose flood warning system tailored to the different needs of each community in the study area." sounds like a expensive solution to a problem that is not a big concern to residents, but only to pumps not removed quick enough and road infrastructure damage which will happen anyway. The Flood Warnings are covered by local radio stations and social media now"

> Respondent 5: "After all these years, surely council can now predict when roads will be cut by floodwaters and therefore issue appropriate warnings according to the amount of rain?"

[1] This map has now been superseded by the flood mapping within the FRMS (Cardno, 2018)

> Respondent 6: “I was quite unaware there was an existing flood warning system. I've been living here since 2010”

> Respondent 7: “Maybe if the river was cleaned out of debris and excess sand, we wouldn’t have as many floods!!!”

> Respondent 8: “Integrate with WaterNSW data”

> Respondent 9: [*No Response]*

12. Can we contact you to discuss your responses further?

> Respondent 1: Yes

> Respondent 2: Yes

> Respondent 3: Yes

> Respondent 4: Yes

> Respondent 5: Yes

> Respondent 6: Yes

> Respondent 7: Yes

> Respondent 8: Yes

> Respondent 9: Yes

APPENDIX

C

FLOOD WARNING OPTION ANALYSIS

Appendix C Flood Warning Option Analysis

The 'Flood Warning Option Analysis' has been developed to provide a '1 page summary' of each of the ten (10) options and includes:

> option name;

> brief description and summary of what each option involves;

> alignment to the TFWS component (as per the components detailed below in figure C.1);

> source of identified option (e.g. community consultation);

> overview of comparative assessment undertaken including the rating against each of the criteria items of expected cost, technical feasibility and community benefit for all ten (10) options;

> potential benefits of each option;

> what would be require to implement each option;

> cost estimates for seven of the ten options (undertaken as at August 2022);

> cost assumptions and limitations; and

> an overall recommendation for each option.

Figure C.1 The components of the Total Flood Warning System (Australian Emergency Manual Series, Manual 21, Flood Warning, Australian Government 2009)

There are a range of opportunities to apply for grants to help fund or contribute to funding the options described below. Grant funding schemes are available to contribute to capital investment costs, however they will not cover ongoing costs associated with operational and maintenance expenditure which will need to be covered by other means.

Monitoring and Prediction

Option 1

Install Stream Gauge and provide a level of service (LOS) (i.e. information, alert, warning) at Tarraganda Bridge

TFWS Component	Monitoring & Prediction		
Source of Identified Option	Community consultation, Council		
Option Overview	Installation of gauge at Tarraganda Bridge and dissemination of flood information, alerts and/or warnings related to this location, based on levels in the Brogo River		
Expected Cost	**Technical Feasibility**	**Community Benefit**	**Total Score**
$$$	Average	Good	6

Detailed Description

What would this the option involve?

This option would involve the installation of a water level gauge at Tarraganda Bridge to allow for the provision of a level of service for the flood affected communities of Tarraganda and Tanja. The level of service will aim to provide information, alerts and warnings during a flood event.

What would be the potential benefits of the option?

> **Improve the knowledge base:** Improve the knowledge base for future flood events including travel times and rate of rise and fall.

> **Flood preparedness:** Enable trigger levels to be developed for key consequences to the community at different flood levels and contribute to the realisation of an aware and flood resilient community.

> **Targeted flood alerts and/or warnings: c**ontribute to achieving targeted flood alerts and/or warnings that link to localised impacts and consequences.

What would be required to implement this option?

> **Further investigation:** The Tarraganda bridge flood levels will be influenced by the Bega and Anabranch Rivers in addition to the upstream Brolga River. Modelling may be required to accurately capture the interaction of these systems and to set the triggers levels for flood levels;

> **Coordination:** This option will require coordination between BoM, WaterNSW and Council to implement the new gauge and to ensure an effective warning system is established as part of the implementation phase;

> **Costs:** Capital up-front cost in the range of $15,000 - $35,000 to install the gauge and approximately $15,000 p.a. to maintain the monitoring network;

> **Cost Assumptions:**

> The above cost estimates should only be used for the acquisition of funds or approvals;

> The above cost estimate is for the provision of a singular gauge;

> Upfront costs will vary significantly based on location of site, quality and resolution of the gauge and additional infrastructure required such as security fencing; and

> Maintenance costs will vary based on whether the station is isolated or can be incorporated into an existing maintenance/servicing schedule and external environmental factors.

> **Cost-benefit:** The cost-benefit of implementing this option should be considered; and

> **Cost sharing agreement:** A cost sharing agreement would be required to progress this option.

Discussion	This option has good community benefit and average technical feasibility, but with high expected cost. Overall, it ranked 6th in all options
Preliminary Recommendation	**Recommended for further investigation**
Final Working Group Decision	**Option recommended for implementation** **Initial scope developed for LoS (water level sensor) as part of this project**

Option 2

Install additional BoM rain gauges in upper catchment areas

Monitoring and Prediction

TFWS Component	Monitoring & Prediction		
Source of Identified Option	Council, Cardno		
Option Overview	Provides additional rainfall data in upper catchment areas, may improve lead time for some catchments.		
Expected Cost	**Technical Feasibility**	**Expected Cost**	**Technical Feasibility**
$$	Average	Limited	5

Detailed Description

What would this the option involve?

This option would involve the installation of rain gauges within the upper portion of the catchment areas.

What would be the potential benefits of the option?

> **Improvement to the monitoring network:** Assist in increasing the level of certainty for flood warnings in the catchment by enhancing the monitoring network and the predictions made by BoM.

> **Improve the knowledge base:** Provide benefit for future flood studies by allowing a relationship between rainfall totals in the catchment headwaters and corresponding rate of rise for rivers to be established; and

> **Increasing lead times for flood warnings:** Knowledge on the rainfall/flow behaviour of the catchment would likely increase confidence in river level predictions and allow technology such as SMS alert functionality to be trialled within the catchment, thus increasing lead time for flood warnings.

What would be required to implement this option?

> **Confirm locations and undertake feasibility of suitable locations for additional gauges:** The locations for potential gauge installations will need to meet defined criteria set by BoM in regards to accessibility, power and land tenure.

> **Coordination:** This option will require coordination between BoM, WaterNSW and Council.

> **Costs:** Capital up-front cost estimated in the range of $8,000 - $12,000 to install the gauge and approximately $3,000 - $5,000 to maintain the monitoring network.

> **Cost Assumptions:**

> The above cost estimates should only be used for the acquisition of funds or approvals;

> The above cost estimate is for the provision of a singular gauge;

> Upfront costs will vary significantly based on location of site, quality and resolution of gauge and additional infrastructure such as security fences;

> Maintenance costs will vary based on whether the station is isolated or can be incorporated into existing maintenance/servicing schedule and external environmental factors; and

> The above costs accounts for installing the BoMs Alert 2 radio telemetry system which is required to integrate into BoMs monitoring network.

> **Cost-benefit:** The cost-benefit of implementing this option should be considered; and

> **Cost sharing agreement:** A cost sharing agreement would be required to progress this option.

> **Hardware options:** The hardware options to be investigated further and confirmed. BoM's advisory service provided through it's FLARE resource may be of assistance.

Discussion	This option has been given an overall ranking of 8 due to the limited benefit to the total flood warning system.
Overall Recommendation	**Not recommended to be pursued at this stage**
Final Working Group Decision	**Won't be pursued at this time**

Option 3

Install additional stream level gauges in upper catchment areas

Monitoring and Prediction

TFWS Component	Monitoring & Prediction		
Source of Identified Option	Council, Cardno		
Option Overview	Provide stream gauges in upper catchment areas for Candelo township (Candelo Creek)		
Expected Cost	**Technical Feasibility**	**Community Benefit**	**Total Score**
$$	Average	Limited	5

Detailed Description

What would this the option involve?

Installation of additional stream level gauges in the headwaters of the catchment contributing to flooding of the Candelo Township.

What would be the potential benefits of the option?

> **Additional lead time and alerts:** Given the nature of flooding along the Candelo Creek has been characterised as a flash flooding environment, the installation of a stream level gauge in the upper portion of the catchment could provide additional lead time in providing alerts to the community as BoM does not currently warn to flash flood environments (less than 6hrs response time).

What would be required to implement this option?

> **Further investigation:** Due to the quick response times of the creek, further investigation into the validity of disseminating messages from this gauge would be required. Aspects to be considered include;
>
> > Trigger levels, rate of rise and consequences (may be obtained from FRMSP);
>
> > Possible limitation around the river rise and fall rate being faster than message distribution; and
>
> > Shortlist of preferred locations, balancing lead time (higher in the catchment) and accuracy (lower in the catchment).

> **Suitable location:** Suitable location(s) for the stream gauge would need to emerge from the investigation.

> **Costs:** Capital up-front cost in the range of $15,000 - $25,000 to install the gauge and approximately $10,000 p.a. to maintain the monitoring network.

> **Cost assumptions:**

> The above cost estimates should only be used for the acquisition of funds or approvals;

> The above cost estimate is for the provision of a singular gauge;

> Upfront costs will vary significantly based on location of site, quality and resolution of the gauge and additional infrastructure such as security fencing; and

> Maintenance costs will vary based on whether the station is isolated or can be incorporated into existing maintenance/servicing schedule and external environmental factors.

Discussion	This option has been given an overall ranking of 8 due to the uncertain nature in regards to community benefit.
Overall Recommendation	**Value to Council & Community to be confirmed**
Final Working Group Decision	**Won't be pursued at this time**

Option 4

Install level sensors at key roads

Monitoring and Prediction

TFWS Component	Monitoring & Prediction		
Source of Identified Option	Council, Cardno		
Option Overview	Install level sensors with alert functionality to notify Council when a specified threshold is reached, indicating need for road closure.		
Expected Cost	**Technical Feasibility**	**Community Benefit**	**Total Score**
$$	Average	Medium	6

Detailed Description

What would this the option involve?

Installation of water level sensors, equipped with alert functionality, upstream of key road crossings. It is envisaged that when certain water triggers levels are engaged, a notification would be issued to Council. This would allow increased lead time for Council to commence actions/communications involved within road closure activities.

What would be the potential benefits of the option?

> **Road safety:** data sourced from the proposed level sensors could provide a comprehensive warning system for road inundation that contributes to an enhance level of safety; and

> **Real time capability:** Utilise flood knowledge and intelligence to enable a proactive response to enact road closures during flooding.

What would be required to implement this option?

> **Resolving maintenance and liability issues:** Arrangements to maintain infrastructure would be a key challenge to overcome;

> **Determining roles and responsibilities:** Discussions will be required to determine which organisation/key personnel will be responsible for overall incident control during an event; and

> **Further Investigation:** Aspects of this option that need to be investigated further include:

- > Hardware and messaging platform options, including capital and ongoing costs;
- > Identify and shortlist preferred location(s) in consultation with Council;
- > Response required; and
- > Potential to add flashing lights / signage for motorist safety at key locations.

> **Costs:** Capital up-front cost in the range of $15,000 - $25,000 to install the gauge and approximately $10,000 p.a. to maintain the monitoring network.

> **Cost assumptions:**

- > The above cost estimates should only be used for the acquisition of funds or approvals;
- > The above cost estimate is for the provision of a singular gauge.
- > Upfront costs will vary significantly based on location of site, quality and resolution of the gauge and additional infrastructure such as security fencing.
- > Maintenance costs will vary based on whether the station is isolated or can be incorporated into existing maintenance/servicing schedule and external environmental factors.

Discussion	This option has been given an overall ranking of 6.
Overall Recommendation	**Value to Council to be confirmed**
Final Working Group Decision	Not being pursued at this time. Potential to be part of a future initiative.

Option 5

Realtime hydrologic modelling

Monitoring and Prediction

TFWS Component	Monitoring & Prediction		
Source of Identified Option	Council, Cardno		
Option Overview	Develop and run hydrologic model with observed and forecast rainfall inputs to give peak flow predictions. Relate flow to levels based on Flood Study/ rating curves.		
Expected Cost	**Technical Feasibility**	**Community Benefit**	**Total Score**
$$$	Difficult	Medium	4

Detailed Description

What would this the option involve?

The pre-development and running hydrologic models for the catchments using a range of observed and forecast rainfall inputs provide an opportunity to enhance flood predictions within this study area.

What would be the potential benefits of the option?

> **Increasing accuracy of flood predictions:** by comparing the peak flow rates to existing rating curves and flood studies the ability to predict peak river levels with greater confidence and greater levels of confidence will be able to be realised.

What would be required to implement this option?

> **Hydrologic model development and maintenance:** Development and maintenance of hydrological modelling and associated costs.

> **Potential reliance on external modelling software:** Likely that modelling outputs would be reliant on the use of external modelling software environments.

> **Partnership approach:** Integration of hydrological modelling outcomes provided externally into Council's emergency management arrangements.

> **Costs:** Capital up-front cost in the range of $30,000 - $50,000 to develop hydrologic models and approximately $10,000 p.a. to maintain the models.

> **Cost assumptions:**

> The above cost estimates should only be used for the acquisition of funds or approvals;

> The cost has accounted for the development of new hydrologic models by external consultants;

> Cost estimates will vary significantly based on the number of hydrologic models required, complexity of the catchments and the fee for any data acquisition; and

> The above cost has not made an allowance for hydraulic modelling.

Discussion	This option has been given an overall ranking of 10, being the least preferred option for this study.
Preliminary Recommendation	**Not recommended to be pursued at this stage**
Final Working Group Decision	**Won't be pursued at this time**

Interpretation

Option 6 Static inundation maps linked to trigger levels			
TFWS Component	Interpretation		
Source of Identified Option	Cardno		
Option Overview	Develop stage - inundation relationships from flood study at intervals at a gauge location. Maps could be for internal use or publicly available to improve flood awareness and education.		
Expected Cost	**Technical Feasibility**	**Community Benefit**	**Total Score**
$	Easy	Good	9

Detailed Description

What would this the option involve?

Development of flood maps that illustrate the extent of flood inundation at various river heights, at gauges throughout the catchment. This option aims to provide a visual aid in assisting the community to understand the impacts associated with minor, moderate and major flood classifications and/or other key trigger levels.

What would be the potential benefits of the option?

> **Links flood mapping to flood warnings and key flood triggers:** enables a link to be made between flood warning triggers and flood consequences through flood extent mapping.

> **Flood education:** has the potential to increase understanding of flooding risks and provide powerful tools for the SES and Council in flood education initiatives.

What would be required to implement this option?

> **Collation and review of all flood studies to:**

- > Ensure that flood modelling includes current catchment conditions;
- > Ensure that flood models adopt current industry practice are utilised for mapping;
- > Confirm if bathymetric information is required following deposition of silt in 2020 bushfires;
- > Determine the preferred gauge location and trigger levels and intervals to include in the maps; and
- > Extract result grids at each stage.

> **Confirm approach to use the flood maps:** Confirm preferred method of providing information to Council (e.g. online GIS portal) and the community including consideration of how this information could enhance Flood Response Planning and Flood Education

> **Costs:** Capital up-front cost of $20,000 - $40,000 for mapping and approximately $10,000 p.a. to maintain.

> **Cost assumptions:**

- > The above cost estimates should only be used for the acquisition of funds or approvals;
- > The cost has not accounted for the development of new hydraulic models or any remodelling;
- > Cost estimates will vary significantly based on the number of locations to be mapped, the scale of mapping and the number of events to be mapped;
- > The above maintenance costs accounts for minor updates only to flood maps; and
- > The above maintenance costs have not have not accounted for periodic updates to the flood maps resulting from updated hydraulic models undertaken in the future which may trigger the need for a more significant update to flood maps.

Discussion	This option has been assigned an overall ranking of 1, indicating that it is a preferred option to progress.
Preliminary Recommendation	**Recommended for further investigation**
Final Working Group Decision	**Funding to be sourced to deliver this option**

Message Construction/Communication

Option 7 Add alerting capability to selected rain gauges and stream level gauges			
TFWS Component	Message Construction/Communication		
Source of Identified Option	Community consultation, Council		
Option Overview	Add additional infrastructure to specific rainfall and stream level gauges to enable automatic SMS/email alerts to be sent to selected users. No interpretation of consequences provided (not intended for public)		
Expected Cost	**Technical Feasibility**	**Community Benefit**	**Total Score**
$$	Average	Good	7

Detailed Description

What would this the option involve?

This option involves improving the function of existing rainfall and stream gauges by adding infrastructure that enables automatic SMS/emails to be issued to selected users.

The gauges envisaged to be targeted for this technology include those in the upper parts of the catchment which currently do not have adequate warning systems in place. The alert system would be for internal use by Council or other service providers, who have the knowledge to correctly interpret the information.

The system would send alerts to the predefined users when certain rainfall/water level thresholds are triggered and would therefore provide a "heads up' message.

What would be the potential benefits of the option?

> **Flood response times:** enable initiation of early response procedures; and

> **Early warnings:** enable Council and emergency managers to alert or warn communities about a flood event earlier providing greater potential for protective actions to be undertaken in a timely manner.

What would be required to implement this option?

> **Potential integration with Council's existing systems and/or tools (i.e. SCADA, MHL Tool):** Consideration into the use of and integration with Council's existing SCADA system (water and sewer) and/or MHL tool.

> **Research into installation and maintenance:** Further investigation into the approach to sync current gauges with automatic messaging technology including list of recipients and content. Consideration would also be required into who is responsible for maintenance and trouble shooting.

> **Costs:** Capital up-front cost estimated in the range of $9,000 - $11,000 to install the infrastructure and approximately $1,000 - $3,000 to maintain the service.

> **Cost assumptions:**

> The above cost estimates should only be used for the acquisition of funds or approvals;

> Upfront costs will vary significantly based on a range of factors including the time and process required to integrate into Councils SCADA system;

> Upfront costs has have accounted for a Bom Alert 2 radio telemetry receiver, router and associated antennas required to receive existing BoM data feeds;

> SMS alerts would be controlled by the SCADA system however as BoM does not issue SMS alerts a third party would be required to manage this service and is not accounted for in the above cost.

> The inclusion of a 4G router has not been included in the above costs

Discussion	This option has been assigned a ranking of 3 and could provide benefit for improving internal flood warning processes.
Preliminary Recommendation	**Recommended for further investigation**
Final Working Group Decision	**Funding to be sourced to deliver this option.** **Option to be delivered as part of a future initiative.**

Communication

Option 8 Council Website Emergency Dashboard			
TFWS Component	Communication		
Source of Identified Option	Community consultation		
Option Overview	Front page of Council website utilised during a flood event to provide a central source of information.		
Expected Cost	**Technical Feasibility**	**Community Benefit**	**Total Score**
$$	Average	Good	7

Detailed Description

What would this the option involve?

This option involves the development of a Council website used specifically during a flood event to act as a central and consolidated source of information.

An example website of what is envisaged can be found at : https://disaster.burdekin.qld.gov.au

What would be the potential benefits of the option?

This option would aim to achieve the following objectives;

> **Consolidation of information**: consolidate information from BOM, NSW SES, WaterNSW, live road closures (as interactive map) and links to further information;

> **A source of truth:** Ability to reproduce information from other agencies without 're-interpreting' core message; and

> **Consistency of message:** Consistency across all of Council's communication platforms

What would be required to implement this option?

> **Further Investigation:** Further investigation is required into who would gain ownership of the site and be responsible for website support and functionality (i.e. Council or external managed). Additional consideration would include the content/timing of information presented on the website such as:

  > Frequency of website update during an event (2-3 time daily);

  > Linked publishing services (i.e. Facebook any community groups);

  > Migration of any maps to ESRI & ArcGIS - better capability for outward facing mapping; and

  > Map for road closures could be useful – similar to LiveTraffic NSW but for local closures.

> **Cost assumptions:** Based on the qualitative comparative cost estimate undertaken, the costs for this option are expected to be moderate, however further investigation would be required to quantify the estimated costs of this option.

Discussion	This option has been assigned a ranking 3 due to the accessibility and benefits to the community.
Preliminary Recommendation	**Recommended for further investigation**
Final Working Group Decision	**Option supported. Noted that an Emergency Dashboard was recently established for Council with support from Resilience NSW**

Communication

Option 9 Early warning alert or messaging service for irrigators and directly affected residents			
TFWS Component	Communication		
Source of Identified Option	Cardno, Community consultation		
Option Overview	Develop database of selected users to receive BOM Flood Watch alerts or Brogo Dam Releases, (WaterNSW), Cochrane Dam (privately owned)		
Expected Cost	**Technical Feasibility**	**Community Benefit**	**Total Score**
$	Average	Good	8

Detailed Description

What would this the option involve?

This option focuses on the development of a database of users who have been assigned to receive certain flood warning information. Clear documentation of responsibilities and ownership in a flood event is critical to the seamless delivery of operational response procedures.

As such a database assigning roles to certain alert/warning messages would provide a single point of reference for individuals involved in managing the response to flood events.

In addition to assigning responsibilities, the database would also include information/education on interpreting any messages to assist the individual with determining any future actions. This service would not only be for Council; stakeholders such as farmers and agricultural industries with potential flood impacted infrastructure are also envisaged to receive warnings.

What would be the potential benefits of the option?

> **Personal flood resilience:** Contribute to personal flood resilience and empowering communities with information to make informed decisions during a flood.

What would be required to implement this option?

> **Trial of system:** This system would likely be trialled at locations/systems where early warning will provide the most value to the total flood warning system.

> **Similar Technology:** NSW SES currently implements a *pump and livestock warning system* which is triggered by rainfall thresholds, dam release notifications and issuing of flood watches. The list of recipients and format of these notifications could be reviewed and adapted for use in this system.

> **Establishing arrangements for service:** Further investigation is required into determining whether this service would be facilitated by BoM or if a third party is needed (e.g. Council, local SES) and who would bear the costs for the service;

> **Cost assumptions:** Based on the qualitative comparative cost estimate undertaken, the costs for this option are expected to be low, however further investigation would be required to quantify the estimated costs of this option.

Discussion	This option has been assigned a total ranking of 2 due to the low implementation costs and high community benefit.
Preliminary Recommendation	**Recommended for further investigation and implementation.**
Final Working Group Decision	**Option to be delivered as part of a future initiative.**

Communication

Option 10 Live Road Closure Updates provided as map on Council's website			
TFWS Component	Communication		
Source of Identified Option	Cardno, Community consultation		
Option Overview	Provide mapped information of road closures (particularly smaller, local roads) to provide context to residents.		
Expected Cost	**Technical Feasibility**	**Community Benefit**	**Total Score**
$$	Easy	Medium	7

Detailed Description

What would this the option involve?

The development of maps that detail which roads within the region (targeted at local and smaller rural roads) become closed or inundated during a flood event.

This option would utilise any existing information, e.g. flood studies or community insight to determine which/when roads are susceptible and generally become non-trafficable during an event.

It is envisaged that the maps would be in a GIS environment on a Council website that can be readily accessed by the community. The maps would intend to be educational and accompanied by information to assist the viewer to interpret the maps. Key information would include which roads become inundated, triggers for when inundation occurs and duration of closure.

What would be the potential benefits of the option?

> **Evacuation planning:** Predefined road inundation maps would assist community members in planning for evacuation prior to an event; including determining alternative access/egress routes and knowing key timings involved for evacuation.

> **Enhanced Flood Intelligence:** Consolidated, reliable information in easy to access locations including within current flood intelligence materials and Flood Response Plans.

What would be required to implement this option?

> **Further investigation:** Further investigation will be required into exploring what product is most suitable to develop the maps and explore avenues for integration with Live Traffic (NSW Govt App) or Google Maps to provide way-finding functionality for detours.

> **Cost assumptions:** Based on the qualitative comparative cost estimate undertaken, the costs for this option are expected to be moderate, however further investigation would be required to quantify the estimated costs of this option.

Discussion	This option has been allocated a ranking of 3 and would provide good community benefit without high costs or onerous technical requirements to implement.
Preliminary Recommendation	**Value to Council & Community to be confirmed**
Final Working Group Decision	**Option is supported. Option not being pursued at this time. To be reconsidered at the half way point of the 10 year program.**

APPENDIX

D

COMMUNITY CONSULTATION – PREFERRED MITIGATION OPTIONS

Appendix D Public Exhibition – Preferred Mitigation Option

The preferred mitigation options report developed for the Bega and Brogo River TFWS Feasibility Study was placed on Public Exhibition for 21 days between the period of Monday 2nd September and Monday 23rd September 2021.

As part of the Public Exhibition, a number of consultation tools, mediums and strategies were used to obtain community input and feedback including:

> publishing a media release on the Bega Valley Shire Council website – refer to Figure B.1 below;

> putting information on the 'Have Your Say' page of Council's website and Council's social media pages (e.g. Facebook);

> obtaining input and feedback directly as part of three (3) Community Consultation sessions delivered; and

> collating information from the community online via the online survey.

B.2.4 Media release – Have your say on options for a flood warning system for Bega and Brogo floodplains

A media release was issued on 30 July 2021 to seek community input on options for a flood warning system for Bega and Brogo floodplains and included:

> details and background information for the project; and

> details of the three (3) community consultation sessions and how to register for one of the sessions.

Have your say on options for a flood warning system for Bega and Brogo floodplains

Community input is sought on options for a flood warning system for the Bega and Brogo Rivers Floodplain

30 July 2021

Bega Valley Shire Council is asking the community to review and give feedback on 10 options for improving the existing flood warning system as part of the Bega and Brogo Rivers Floodplain Risk Management Plan.

Council's Acting Works and Assets Manager, Gary Loure says the options are contained in a Preferred Mitigation Options report now on public exhibition until 22 August.

"Late last year we engaged with the communities of Bemboka, Wolumla, Candelo, Bega, Tarraganda, Kalaru, Tathra, Mogareeka and surrounding areas, asking for input on the design of a proposed flood warning system," Mr Loure said.

"Residents had the opportunity to review available and emerging flood warning technology and processes as part of this exercise.

"Local agencies, including SES and industry groups such as farmers, were included in the engagement process.

"It's all part of a scoping and feasibility study for a potential enhancement of the existing flood warning system that will help impacted communities beyond the Bega township prepare for and respond to future floods."

Mr Loure said the Preferred Mitigation Options report consolidates previous feedback and details 10 options that now need to be rated and short-listed for inclusion in the final options report.

"We're seeking community feedback to help us finalise the options and begin the design of the warning system," Mr Loure said.

"Each of the options we have narrowed down is presented using a traffic light system.

"The red options have been assessed by water engineers, Cardno, and classified as not recommended for further investigation.

"The green options are recommended, and the orange options are yet to be confirmed for further investigation or not.

"We need the community to give us their views on the orange options so we can determine a final list of the most feasible and useful options and whether it's feasible extending flood warning to other parts of the catchment.

"Total Flood Warning Systems can include a number of components that must be integrated for the system to operate effectively. These include stream and rain gauges, emergency dashboards and public communications.

"Our aim is to develop a fit-for-purpose, location-based and efficient flood warning system tailored to the different needs of each community in the study area."

The project follows on from the 2018 Bega and Brogo Rivers Floodplain Risk Management Study and Plan which recommended investigating a flood warning system for the Bega and Brogo River study area.

The community consultation for the preferred mitigations stage of the project includes an online survey open until 22 August through Council's Have Your Say web page, COVID-safe drop-in sessions and an online information session.

- Session 1: Monday 9 August, 4pm – 6pm, Biamanga Room, Civic Centre, Bega
- Session 2: Tuesday 10 August, 4pm – 6pm, Candelo Town Hall
- Session 3: Monday 16 August, 4pm – 5pm, online via Zoom. Please register by emailing mgillies@begavalley.nsw.gov.au

Registrations are required for the drop-in information sessions and can be managed by accessing the Have Your Say at https://bvl.ytelink/4717/B13F or emailing mgillies@begavalley.nsw.gov.au

Figure B.11 Media release: Have your say on options for a flood warning system for Bega and Brogo floodplains

B.2.5 'Have Your Say'– options for a flood warning system for Bega and Brogo floodplains (Bega Valley Shire Council)

The 'Have Your Say' page on Council's website was open from Monday 2nd August 2021 until Monday 22nd August 2021 and included:

> Links to the 'Preferred Options Report' and appendices;

> a link to a survey to provide feedback on the preferred options report;

> details of the three (3) community consultation sessions; and

> other pertinent information relating to the project.

B.2.6 Community Information Sessions

Three (3) information sessions were held throughout August for the purpose of providing residents with an opportunity to voice their opinion/preferences in regard to the proposed mitigation with Council and Cardno Staff (online).

Representatives from NSW SES, BoM and DPE attended the sessions both in person and via video link. Sessions were held at the below venues. In total, 11 residents attended consultation sessions as follows

> Session 1: Monday 9th August, Biamanga Room, Civic Centre, Bega 4:00pm – 6:00pm (in addition to members of the Technical Working Group and Council staff there were 4 attendees including the NSW SES Bega Unit Controller, the Deputy Mayor of Bega Valley Shire Council and 2 local residents);

> Session 2: Tuesday 10th August, Candelo Town Hall, 4:00pm – 6:00pm (in addition to members of the Technical Working Group and Council staff there was 1 attendee from the NSW SES in attendance);

> Session 3: Monday 16th August, online via Zoom, 4:00pm – 5:00 pm (in addition to members of the Technical Working Group and Council staff, 2 local residents attended).

Each session was held as an informal workshop, with the components of the Total Flood Warning System providing a structure for discussion with attendees. The low attendance at each session allowed for an in-depth discussion on the topics of interest to those in attendance which included but was not limited to:

> Feedback on options which were identified in the feasibility study as 'value to Council and community to be confirmed.'

> Discussion on some of the detail and specifics regarding some of the options identified in the 'Preferred Mitigation Options' report

An example of the discussion points captured (at the Candelo Session) is shown in Figure B.2.

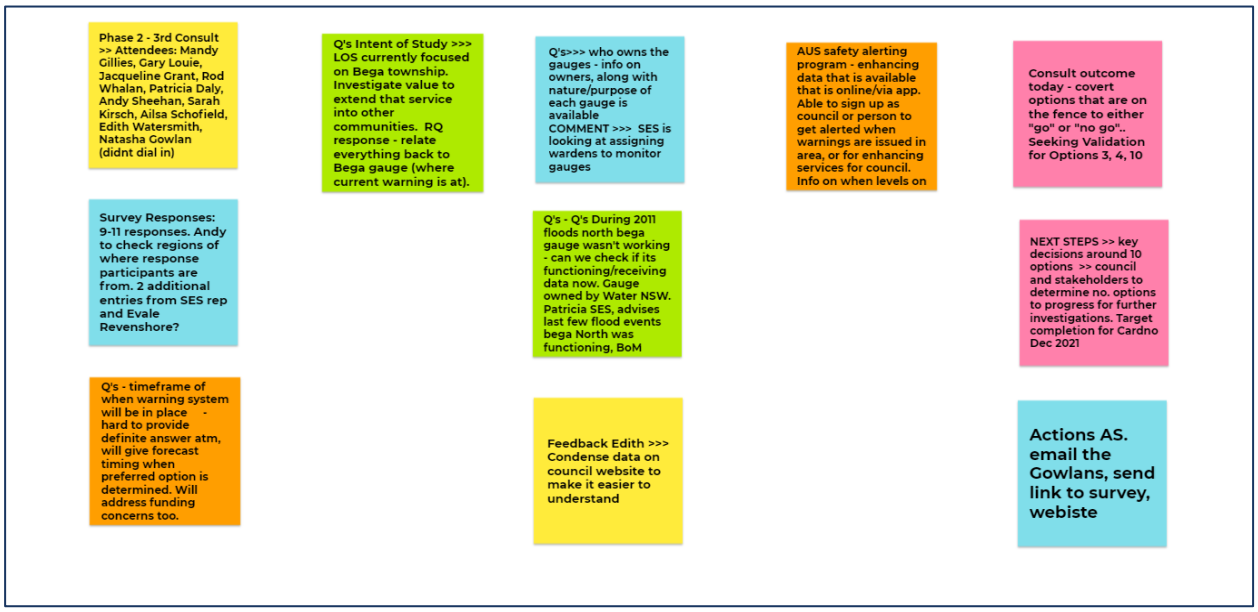

Figure B.12 Discussion points and ideas captured throughout the third session on Jamboard

B.2.7 Bega and Brogo River Catchment – Preferred Mitigation Options Survey

In partnership with Council and members of the Technical Working Group (Council, BoM, NSWSES, DPE) Cardno developed a community consultation survey to gauge which mitigation options were preferred within the communities. The questions included in the survey broadly fit into two key themes:

> Preferences of flood mitigation options ; and

> Suggestions to tailor mitigation options to provide the most benefit to the community.

The survey was available online from Monday 2nd September 2021 to Monday 22nd September 2021, advertised through Council's '*Have Your Say*' webpage, social media and a press release. Specific community members and groups were also targeted directly to promote the survey.

In total, twelve (12) online responses were received by Council with responses coming from residents within the following communities:

> Bega (3);

> Tathra (2);

> Reedy Swamp (1);

> Buckajo (1)

> Tanja (1)

There were three (3) respondents that did not provide their home location and one (1) respondent that did not live within the study area.

Responses to Questions 1 contain private information and have not been provided in this document and responses from Respondent 2 (the client) have not been considered in this document due to '*conflict of interest*' constraints.

13. **Please supply the address of your property located within the study area if different to your contact details**

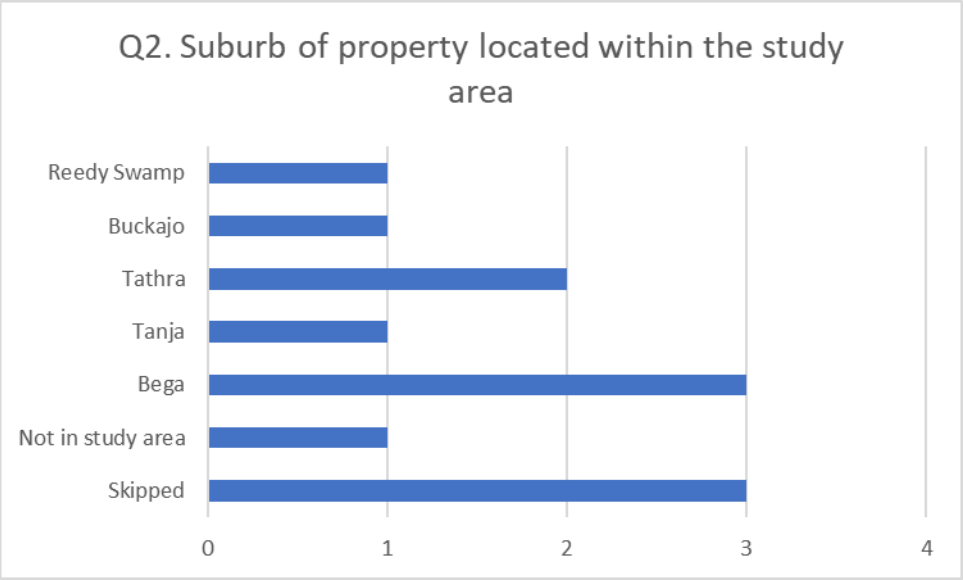

Figure B.13 Suburb of respondent's property within the study area

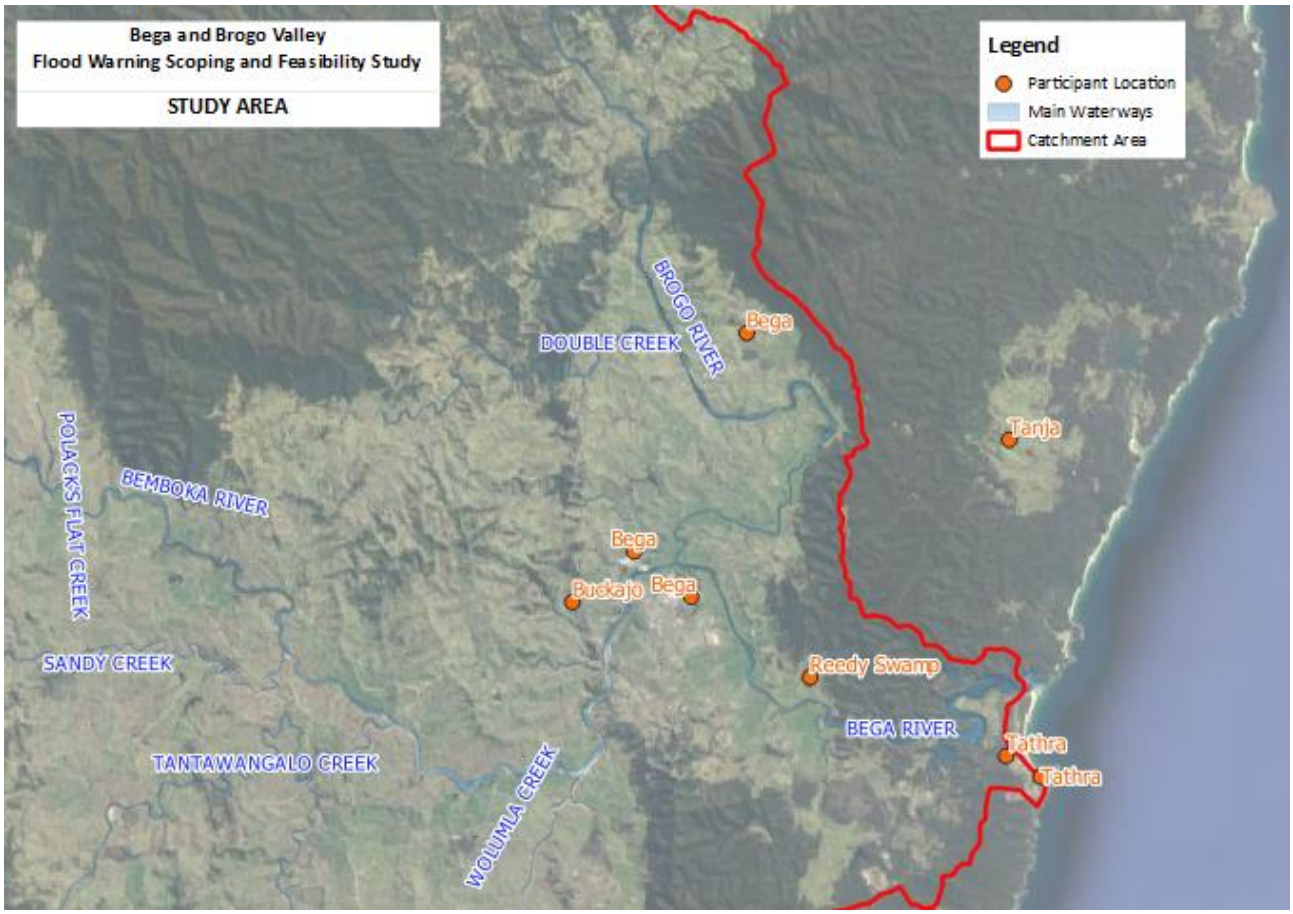

Figure B.14 Map of respondent's property location

14. From the 10 options below, rank in order the options you would like to see implemented from highest priority to lowest priority using the number scale. 1 being highest and 10 being lowest. Select and rank options from 1-10

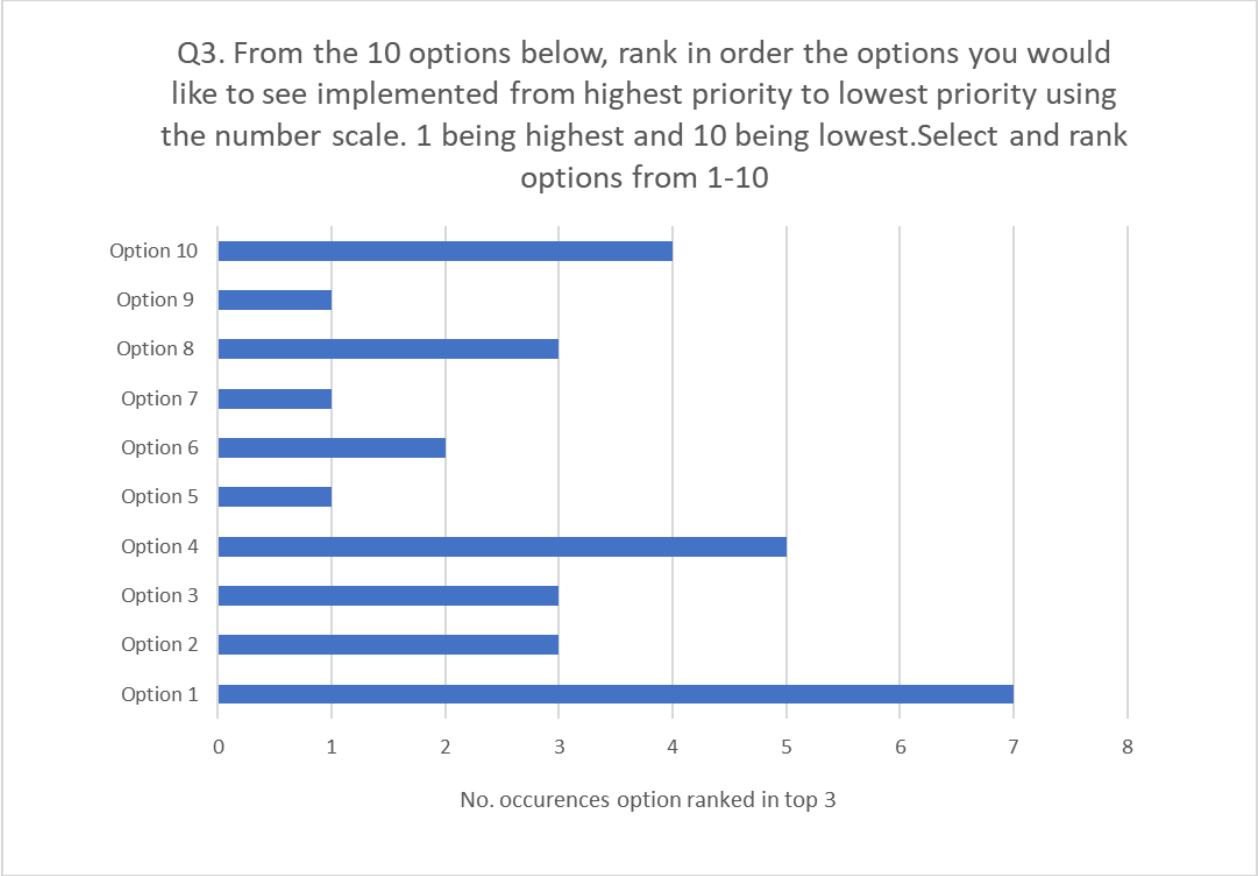

Figure B.15 Ranking of mitigation options by respondents

15. What are the factors that influence your prioritisation of the 10 options?

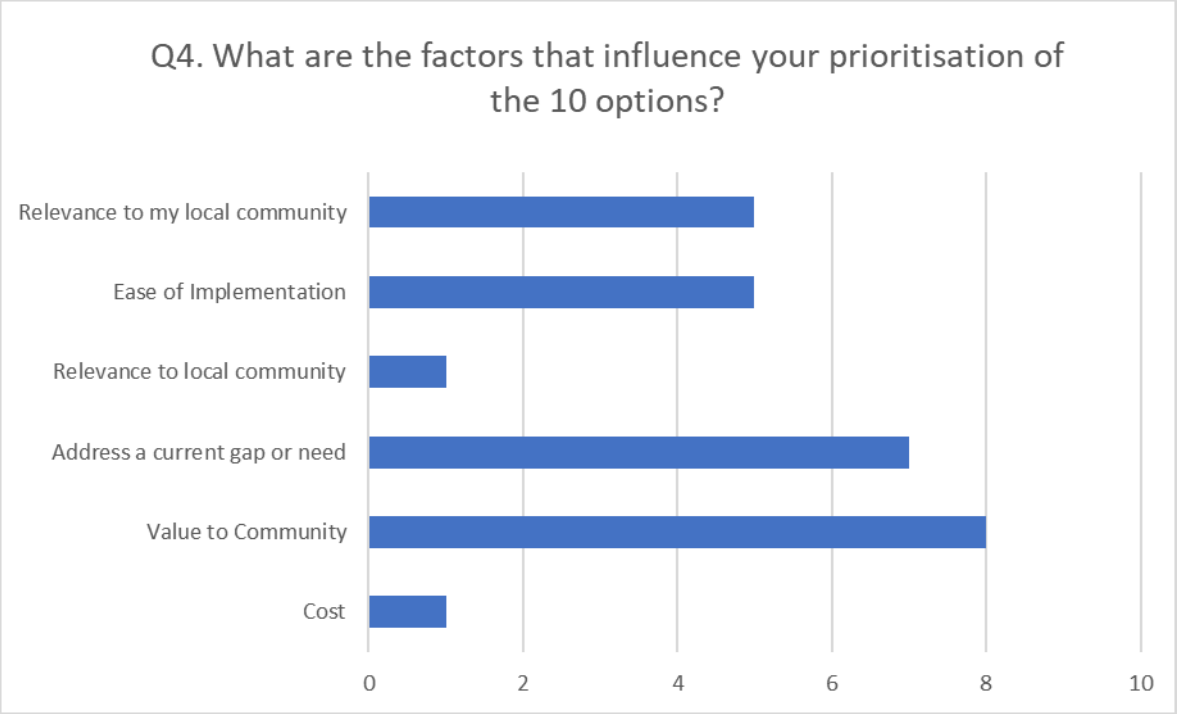

Figure B.16 Factors influencing prioritising of mitigation options

4.2 Comments (Please Describe):

Respondent 8: ***"All we want is to be able to look up a location (e.g. Jellat, Tarraganda, etc) on the council website and find out when that location will be inundated, closed, etc, after significant rainfalls. Surely there is enough expertise out there after all these years to say after 'x' amount of rain in the catchment, location. 'Y' will be inundated in ?.??hours. If it requires acquiring automated equipment, then surely it is absolutely worth it!!"***

16. What do you believe the level of benefit for option 3 is?

Option 3: Install additional stream level gauges in upper catchment areas (within Candelo Creek)

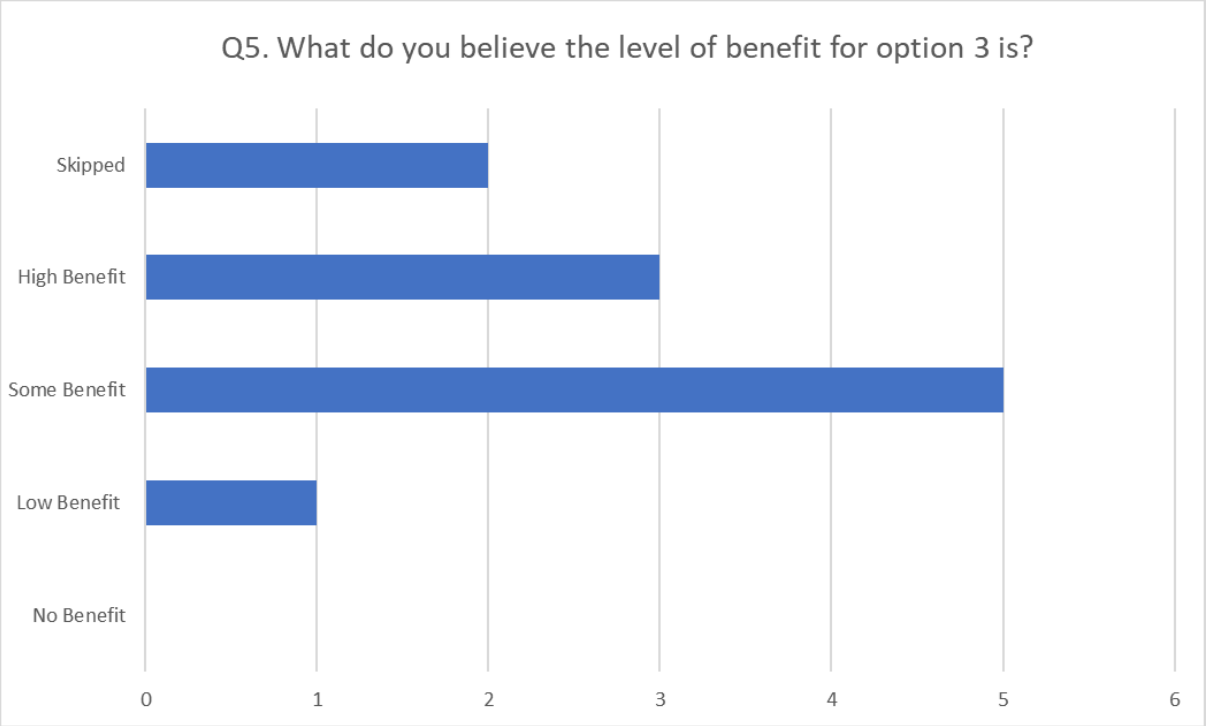

Figure B.17 Level of Benefit for Mitigation Option 3

5.1 Comments (Please Specify):

Respondent 1: ***"More validation with the wider village community is required as to the value of implementing this option "***

Respondent 3: ***"Acts as an early warning as the event is potentially developing."***

Respondent 9: ***"Real time and accurate road closure advice"***

Respondent 10: ***"This would provide details of what water could possibly be coming down the waterways downstream "***

Respondent 11: ***"The more indicators = more information = informed decision making and hopefully reducing risks"***

Respondent 12: ***"The Bureau of Meteorology are currently able to provide a forecast to Bega North Gauge 3hrs ahead of time, with an accuracy of +/-0.3m.***

Additional gauges in Candelo Creek might extend this lead time in some circumstances, however as this sub-catchment is roughly only 5% of the Bega River catchment, the advantages would be minimal. There are only a small number of properties in Candelo that would experience over floor flooding in a PMF event on Candelo Creek, so additional warning of these properties would be infrequently utilised."

17. What do you believe the level of benefit for option 4 is?

(Option 4: Install level sensors at key roads to notify Council when a specified threshold is reached, indicating need for road closure)

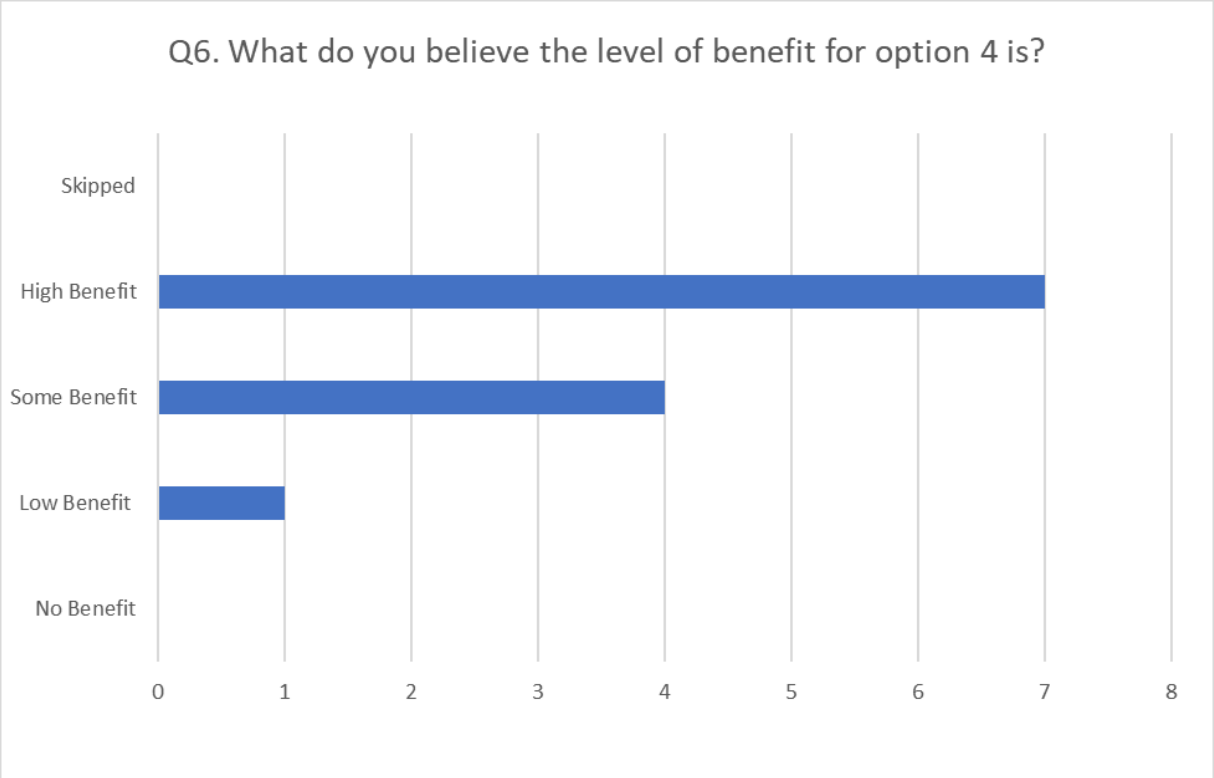

Figure B.18 Level of Benefit for Mitigation Option 4

Respondent 1: ***"Provides instantaneous feedback to response agencies to take relevant action. Could also feed directly into a road closure map/portal."***

Respondent 3: ***"Would allow a real time position with road closures rather than a lag. May also help when re-opening as know when to inspect."***

Respondent 8: ***"Surely you have enough data from the last 100 years or so to be able to predict with some certainty when road closures will occur at specific locations… not just find out after the fact."***

Respondent 9: ***"Real time and accurate road closure advice"***

Respondent 10: ***"Most know affected roads are monitored when flooding is expected"***

Respondent 11: ***"Reduces traffic in turn reducing risks"***

Respondent 12: ***"This work would go a long way to generating good situational awareness for all agencies with responsibilities for road/traffic management under the NSW State Flood Plan. NSW SES would incorporate these notifications into their tactical response arrangements."***

6.1 Comments (please specify)

18. What do you believe the level of benefit for option 10 is?

(Option 10: Provide live road closures as a map on Council's website during floods)

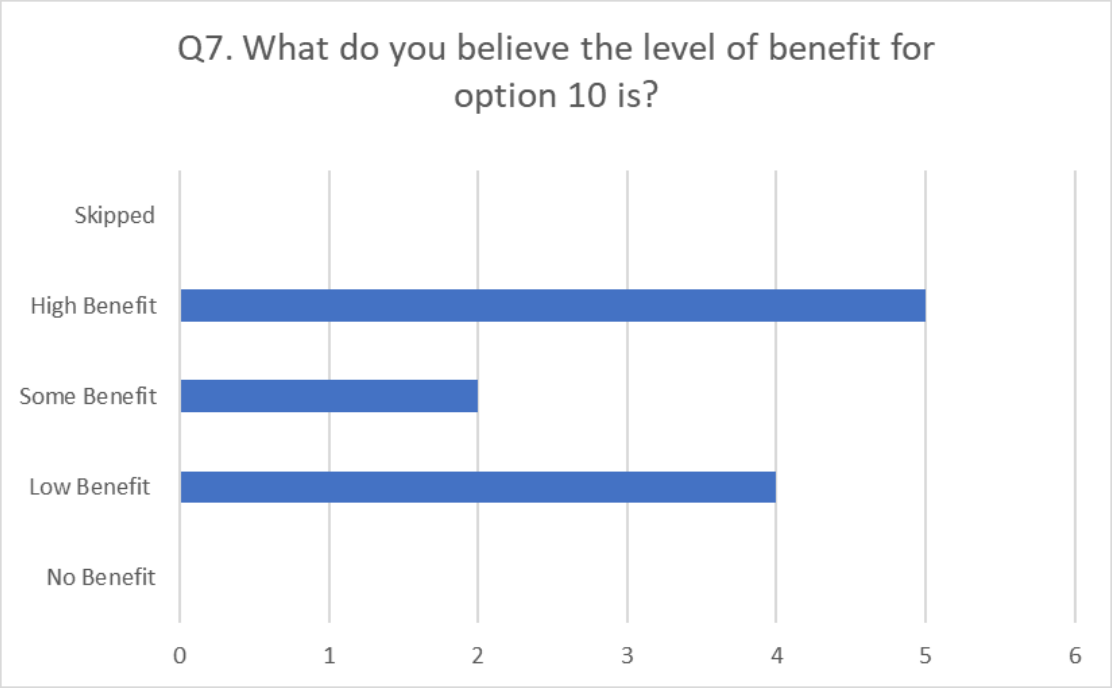

Figure B.19 Level of Benefit for Mitigation Option 10

7.2 Comments (please specify)

Respondent 1: ***"From past event experiences, the local community looks for information on road closures on Council's website. In the past, the impacted roads have been listed. A map provides more contextual information similar to the RMS live traffic app. A picture tells a 1000 words."***

Respondent 3: ***"Visual presentation is always better than words."***

Respondent 6: ***"It is never up to date. Everyone asks on line using Facebook!!!"***

Respondent 8: ***"Again, information after the closure is of limited benefit, quite apart from the fact that over the years, council road closure alerts are often hours if not days out of date… we need to be able to plan travel around predicted flood levels…i.e. leave early to save an extra hour or two of diversions."***

Respondent 9: ***"Provides current advice, but may not be able to be accessed by all community members."***

Respondent 10: ***"Would help members of the public know what roads are closed so they can plan their travels"***

Respondent 11: ***"Need to be able to access internet which not all people in all locations can"***

Respondent 12: ***"This would assist in informing the community, and allow for them to make smart decisions. PLEASE NOTE: Roads and Maritime Services are currently expanding the scope of Live Traffic to include local government roads. A council led initiative would like duplicate this service. Recommended contact - Jamie Caldwell, Manager Regional Operations - Southern -jamie.caldwell@rms.nsw.gov.au."***

19. What is your preference for the level of service to be provided at Tarraganda Bridge?

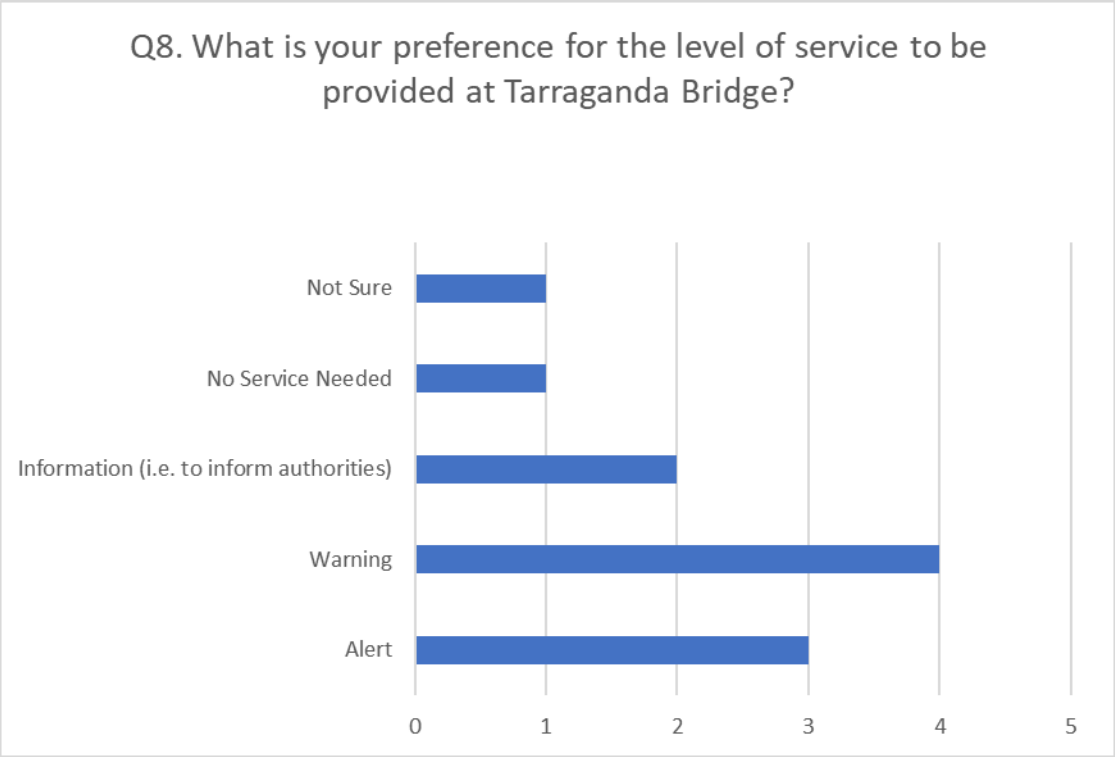

Figure B.20 Preference of level of service to be provided at Tarraganda Bridge

8.1 Comments (Please Specify):

Respondent 3: ***"Gauge at North Bega is helpful but the gauges on Brogo are limited and more suited to experts."***

Respondent 5: ***"This is a key community and aspect of infrastructure that is not well managed in floods. Any improvement would be welcomed including options to address road infrastructure."***

Respondent 6: ***"So people that need to cross this are alerted!!"***

Respondent 8: ***"Not clear what you meaning we need to know if Tarraganda is or will be, open at a certain time, rather than driving over Dr George to find out"***

Respondent 12: ***"Roll into Option 4. Use a consistent methodology across the area."***

20. What would you like to see regarding the flood maps in Option 6? (select all that apply)

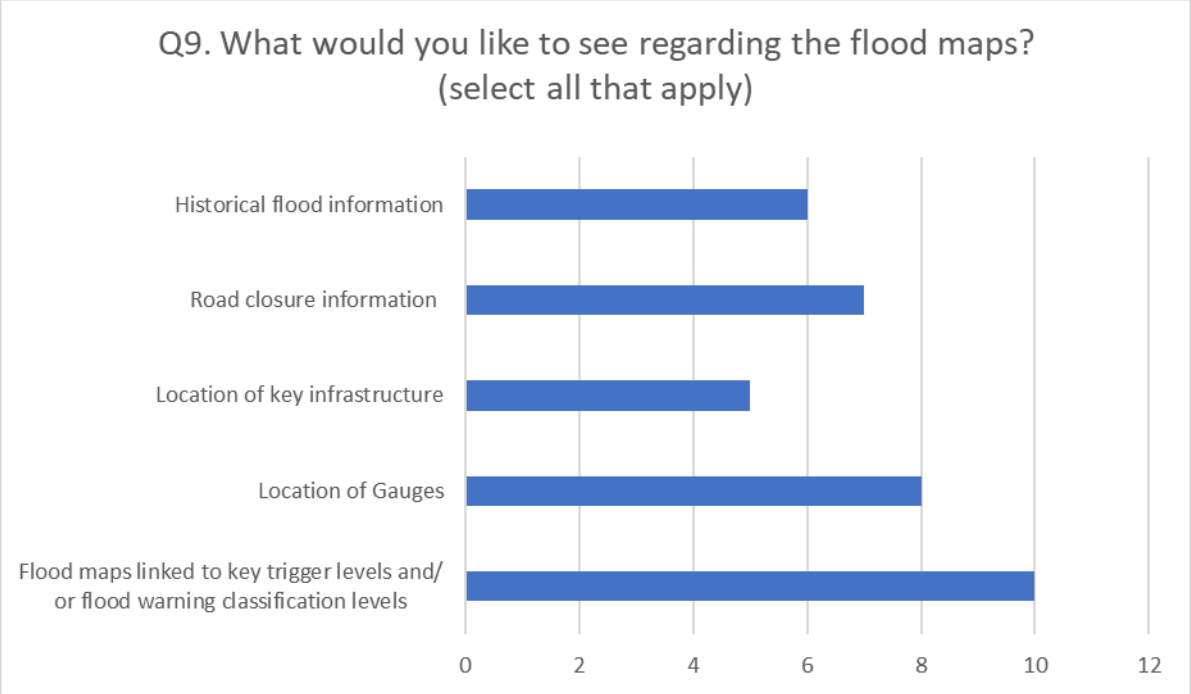

Figure B.21 Preference of information to be displayed on flood maps

9.1 Comments (Please Specify)

Respondent 5: ***"Anything is better than nothing."***

Respondent 8: ***"Anything to enable planning of travel."***

Respondent 11: ***"Once again is about collecting data to assist with informed decision making."***

Respondent 12: ***"Flooding occurs via a variety of mechanisms in Bega Township. Variation in flow from the Bega/Bemboka and Brogo Rivers, exacerbated by the variable intensity of local catchment rainfall mean that the modelled scenario is almost never the scenario that plays out in the environment. Current technological solutions such as WaterRIDE rely on a single scenario and interpolate results between the published flood layers. The result is useful as a consideration in community decision making, however without training or experience in flood analysis, most members of the public are unable to identify the limitations in this technology, or apply the information effectively. The provision and promotion of this data as an authoritative source of information in all circumstances can lead to misunderstanding and frustration at emergency services, who will have a fuller picture of the situation."***

21. Using the map below, identify any existing stream level or rainfall gauges you would like to see an alerting function provided?

- **Respondent 1:** "Brogo D/S Brogo Dam 2190243, Brogo River @ Angledale 2190256, Bega river @ Bega 2199008 , Bega river @ Entrance 21941011, Candelo @ Greenmount 21903412 and Devils @ Tantawangalo 21901213"
- **Respondent 3**: "Brogo River @ Brogo 2190045, Brogo River @ Angledale 2190256 and Bega River Warragaburra 21902610"
- **Respondent 4**: "Bega river @ Bega 2199008, Bega @ Darceys 2190639, Bega River Warragaburra 21902610 and Bega river @ Entrance 21941011"
- **Respondent 5:** "Brogo River @ Brogo 2190045, Brogo River @ Angledale 2190256, Brogo @ Apps 2190647, Bega river @ Bega 2199008 and Candelo @ Greenmount 21903412)
- **Respondent 11:** "Brogo Dam 2190232, Brogo D/S Brogo Dam 2190243, Brogo @ North Brogo 2190134, Brogo River @ Brogo 2190045 and Brogo @ Apps 2190647"

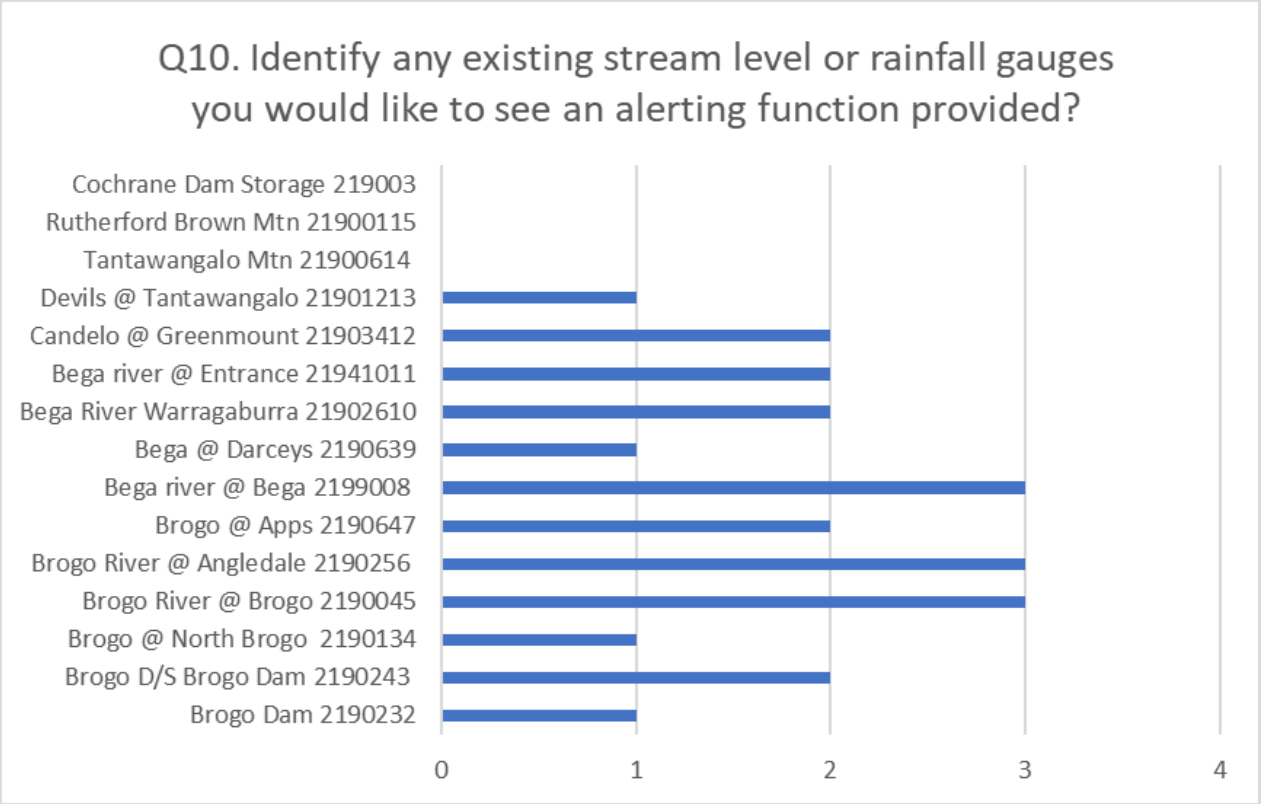

Figure B.1 Preference of existing gauges to add alerting function

Table B.4 Preference of existing gauges to add alerting function

ID	Location	Number of Respondents who Recommended
01	Brogo Dam 2190232	1
02	Brogo D/S Brogo Dam 2190243	2
03	Brogo @ North Brogo 2190134	1
04	Brogo River @ Brogo 2190045	3
05	Brogo River @ Angledale 2190256	3
06	Brogo @ Apps 2190647	2
07	Bega river @ Bega 2199008	3
08	Bega @ Darceys 2190639	1
09	Bega River Warragaburra 21902610	2
10	Bega river @ Entrance 21941011	2
11	Candelo @ Greenmount 21903412	2
12	Devils @ Tantawangalo 21901213	1
13	Tantawangalo Mtn 21900614	0
14	Rutherford Brown Mtn 21900115	0
15	Cochrane Dam Storage 219003	0

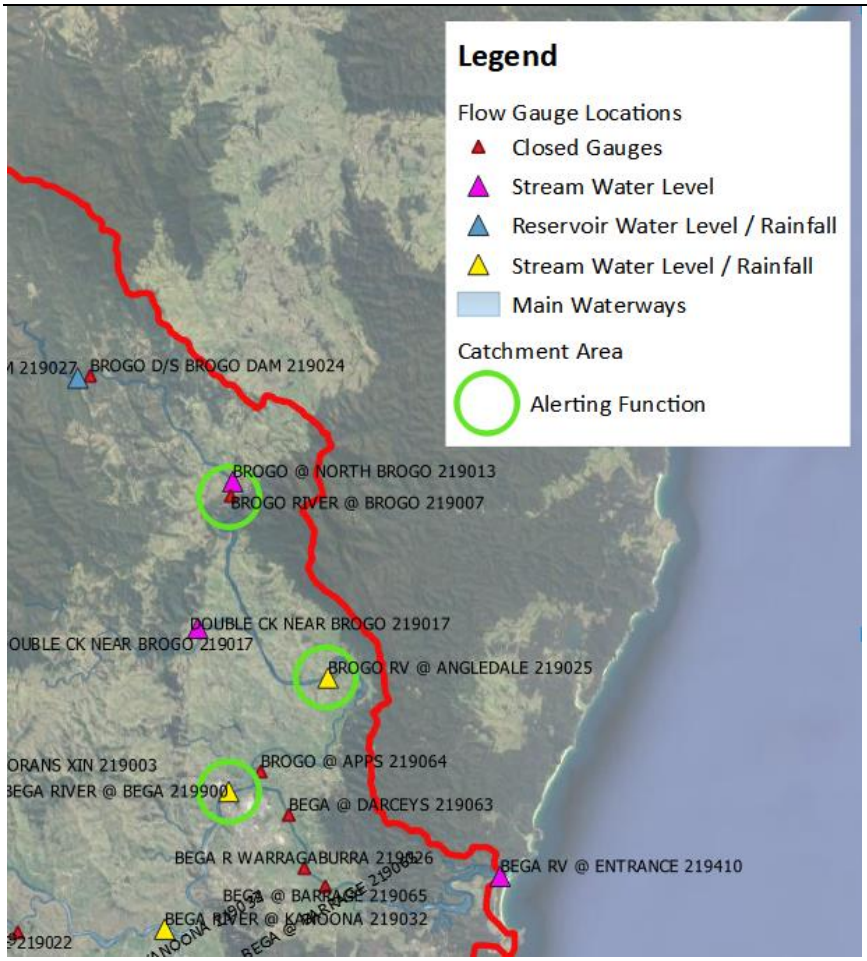

Figure B.1 Location of top three existing rain gauges identified by respondents to be provided with an alerting function

22. What information would you like to see displayed on the Council Website Emergency Dashboard in Option 8?

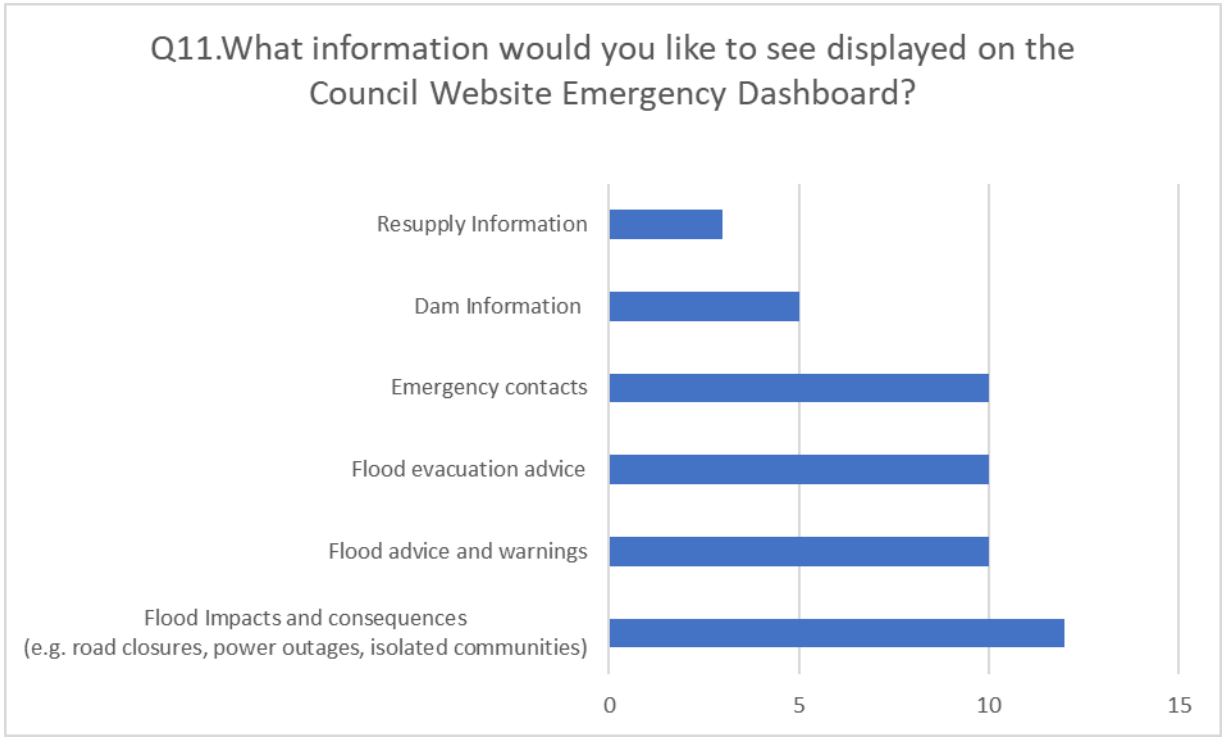

Figure B.2 Preference of information to be displayed on Emergency Dashboard

11.1 Comments (please specify)

Respondent 6: ***"Accurate up to date information live streamed!!"***

Respondent 11: ***"All of them"***

Respondent 12: ***"Emergency data of this nature should come from a single source across all government stakeholders."***

23. What is your level of interest in an early warning alert or messaging service?

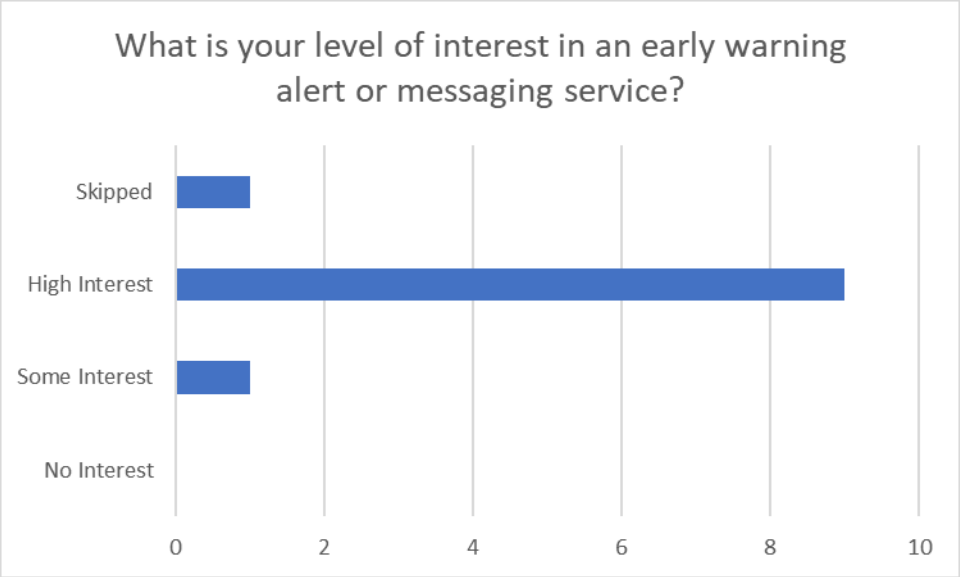

Figure B.3 Level of interest in receiving an early warning alerts or messaging services

12.1 Comments (please specify)

Respondent 3: ***"Better to know before the event."***

Respondent 5: ***"Isolation for at least 12 hours is a frequent event with longest isolation to date being 72 hours without power nor with any contact by authorities."***

24. Please provide comment if you believe option 5 should be further investigated or pursued?

(Option 5: Realtime hydrologic modelling. Develop and run hydrologic model with observed and forecast rainfall inputs to give peak flow predictions. Relate flow to levels based on Flood Study/ rating curves. Highly sophisticated computing system required (likely to be external to Council). Ongoing maintenance and support required.)

Respondent 4: ***"It could be very valuable for people to be able to forecast and plan ahead for their properties"***

Respondent 5: ***"Seems a logical and modern solution to what may become an increasing threat due to climate change."***

Respondent 6: ***"Don't bother."***

Respondent 8: ***"Surely this is essential! How can council predict road / etc interruptions without this modelling? Advanced warning surely relies on this data! Is council just going to keep being reactionary to these increasingly prevalent weather events, or is it going to be proactive in its responsibilities?"***

Respondent 12: ***"Only as a government resource. Not public facing."***

25. Please provide comment if you believe option 2 should be further investigated or pursued?

(Option 2: Install additional BoM rain gauges in upper catchment areas. Provides additional rainfall data in upper catchment areas, may improve lead time for some catchments.)

Respondent 3: ***"There would be benefit it getting early advice of rain falling in catchment area."***

Respondent 4: ***"More gauges will only benefit us with more information"***

Respondent 5: ***"Not clear what processes BoM already has in place to ensure their monitoring systems are adequate. The attachments provided by Cardno indicate the existing system was likely established in 70's yet climate change and severe flood frequency is increasing. Shouldn't BoM be constantly reviewing and updating its monitoring systems anyway?"***

Respondent 6: ***"Sometimes you could get 10 inches, and it may soak in. But sometimes you could get 10 inches and it may run off. So a road level may make more sense."***

Respondent 7: ***"Good value"***

Respondent 8: ***"If they are needed to give us more time to prepare, yes."***

Respondent 10: ***"It would be good to know what rainfall has occurred in upper catchments, then we could prepare for possibly flooding of lower waterways"***

Respondent 11: ***"Following from the devastating bushfires run off is far greater and more dramatic than in previous years so this needs to be monitored and assessed"***

Respondent 12: ***"Only on advice from the Bureau. Council would need to agree to fund ongoing maintenance."***

26. Provide any other final comments on the options presented in the preferred mitigation options report

Respondent 5: ***"The key issue is ensuring adequate monitoring, alert and warning systems are in place both to ensure the community can be better prepared and to ensure safety."***

Respondent 6: "CLEAN OUT THE BEGA RIVER ALONG BUCKAJO ROAD!!."

27. Can we contact you to discuss your responses further?

Respondent 3: ***"Yes"***

Respondent 4: ***"No"***

Respondent 5: ***"Yes"***

Respondent 6: ***"No"***

Respondent 7: ***"Yes"***

Respondent 8: ***"Yes"***

Respondent 10: ***"No"***

Respondent 11: ***"Yes"***

Respondent 12: ***"Yes"***

APPENDIX

E

DRAFT FLOOD WARNING SYSTEM OWNERS MANUAL

1. Introduction:

Flooding presents a risk to life and property across the areas affected by riverine flooding from the Bega and Brogo River systems. The Owner's Manual is based on the key features of the current Flood Warning System (as at September 2022) and is considered a 'live document' that would be updated as changes to the flood warning system are implemented.

It is intended that the Flood Warning System Owners Manual would utilised as a resource for the Local Emergency Management Committee in its role to prepare, respond and recover from flood events and other stakeholders with flood warning responsibilities within the Bega and Brogo River catchments.

2. Catchment and flooding characteristics

a. Catchment overview

The Bega and Brogo River catchments are located within the Bega Valley Shire local government area on the South Coast of NSW, approximately 80 km from the Victorian border.

The total catchment area of the Bega and Brogo Rivers is estimated to be 1,810km^2 at the confluence at Bega of which the Bega River contributes 1,030 km^2 and the Brogo River 780 km^2. The total catchment area for the Bega River at its outlet at Mogareeka which is 24km downstream of Bega is approximately 1,935 km^2.

The upper catchment is significantly higher than the lower catchment, with elevations of up to 1,320 mAHD, compared with 15 mAHD at Bega. The terrain falls sharply from these heights to a large central plain that includes the townships of Bemboka, Kameruka, Candelo, Brogo and Bega. The upper regions of the catchment remain forested, while the central valley and downstream regions have been cleared for agriculture. This central valley has historically been known for dairy produce.

In the upper catchment is the township of Candelo, which is located on Candelo Creek, with a single crossing in the middle of town. While access over this bridge is lost due to overtopping in flood events above the 5% Annual Exceedance Probability (AEP) event, both sides of the community have flood free evacuation roads out of Candelo.

The township of Bega is the largest settlement in the catchment. The Bega Township is bordered by the Bega River on its western, northern and eastern sides. The confluence with the Brogo River is immediately north of the township.

Much of the developed areas of Bega are outside the mainstream 1% AEP flood extent, although some low-lying areas at the edges of the township are affected by this event. The lower lying areas of the town are typically utilised for open space and recreational purposes.

Flooding of the Bega Township is largely driven by overbank flows from the Bega River. Flooding from the Bega River is compounded by flows from the Brogo River, as the systems are adjacent to each other and of a similar size, so peak flows arrive at Bega at similar times.

In addition to riverine flooding, the Bega Township is also affected by local catchment flooding and overland flow, which can result in local flooding issues and loss of access, independent of flooding in the Bega River. The local sub-catchments that have been identified at risk of local catchment flooding and overland flow include:

> Ravenswood Street – Charlotte St Bega Tributary, southwest of central Bega;

> Rawlinson St – East St Bega Tributary, south of central Bega; and,

> Boundary Road – Kerrisons Lane, southeast of central Bega.

Downstream of Bega, approximately half way to the river's outfall into the Tasman Sea, are two inter-related geographic features, Bottleneck Reach and Jellat Jellat.

Bottleneck Reach is a significant constriction, throttles the flow from over 1,000 m wide upstream in the 1% AEP and Probable Maximum Flood (PMF) events down to 300 m through the constriction. In the 1% AEP flood, flows reduce to 3,900 m3/s through Bottleneck Reach, down from 10,400 m3/s in the Bega River upstream of this feature; a reduction of over 60%.

Bottleneck Reach runs for approximately 7 km and fully contains all events up to and including the PMF. Bottleneck Reach also results in backwater effects extending upstream towards Bega. In the PMF event, this backwater effect extends as far as the Princes Highway. As a result this constriction, a large storage area forms upstream of Bottleneck Reach. This region, Jellat Jellat, is a permanent water body bounded to the north by the Bega River, and large ranges on the east and west and a smaller range to the south. In flood events, the restriction at Bottleneck Reach causes the area to operate as a significant flood storage area. In the 1% AEP, the region stores approximately 9.7 million cubic metres of water. In the PMF, this storage

volume increases to approximately 21.9 million cubic metres. In comparison to the total flow volumes, this represents storage of 2% of the total flood volume in the 1% AEP and 1% in the PMF.

As noted above, the terrain to the south also rises, but not as sharply as the ranges to the east and west. As a result, in the PMF event, this southern terrain overtops and floodwaters flow from Jellat Jellat into Wallagoot Lake. The outlet of the Bega River is located at Mogareeka. The tidal influences extend upstream approximately 15 km to Jellat Jellat, although in large flood events the influence of ocean levels extends as far upstream as Bega.

Flood mapping for some of the locations at risk are available within the Bega Valley Shire Local Flood Emergency Sub Plan. For the Bega and Brogo River catchment this includes the following flood maps:

> Bega River Basin map – *refer figure E1 below*

> Bega Town Map – (1% AEP and Probable Maximum Flood Extent Map)

> Tarraganda Town Map – (1% AEP and Probable Maximum Flood Extent Map)

> Angledale Town Map - (1% AEP and Probable Maximum Flood Extent Map)

> Candelo Town Map

> Tathra and Mogareeka Town Map (1% AEP and Probable Maximum Flood Extent Map)

> Buckajo Town Map (1% AEP and Probable Maximum Flood Extent Map)

> Springvale Town Map (1% AEP and Probable Maximum Flood Extent Map)

> Jellat Jellat Town Map (1% AEP and Probable Maximum Flood Extent Map)

> Kalaru Town Map (1% AEP and Probable Maximum Flood Extent Map)

> Wallagoot Town Map (1% AEP and Probable Maximum Flood Extent Map)

> Bemboka Town Map (1% AEP Flood Extent Map)

MAP 1 - BEGA RIVER BASIN

Fig E1 – Bega River Basin (Source: Draft Bega Valley Shire Local Flood Emergency Sub Plan, Vol. 2, November 2021)

b. Flood Travel Times

Indicative flow travel times between key water level gauges are provided below. Whilst knowledge from past events is useful to help inform the estimated indicative flow travel times they are used to provide a general guide only and can vary based on many different variables.

The travel times provided below are consistent with the information presented within the *Draft Bega Valley Shire Local Flood Emergency Sub Plan, Vol. 2, November 2021* and are as follows:

Table E1: Indicative Travel Times – Bega and Brogo River catchment

River reach description	Indicative travel time
Bemboka and Bega River: Morans Crossing Gauge (219003) to Bega North Gauge (219900)	6-9 hours
Brogo River (upper catchment) Brogo Dam Site Gauge (219024) to North Brogo Gauge (219013)	2 hours
Brogo River (lower catchment) North Brogo Gauge (219900) to Angledale Gauge (219025)	3-4 hours
Tantawangalo Creek Candelo Dam Site Gauge (219022) to Bega River Junction	4 hours

**Refer to the Bega Valley Shire Local Flood Emergency Plan for further information*

A schematic representing key river systems, significant gauges, communities of interest, key gauges and flow times between gauges represented in estimated hours is shown in Figure E2 below. The schematic titled '*219 Bega River Basin Schematic'* was developed by the Bureau of Meteorology's NSW Flood Warning Centre with the last audit and update being undertaken in September 2021.

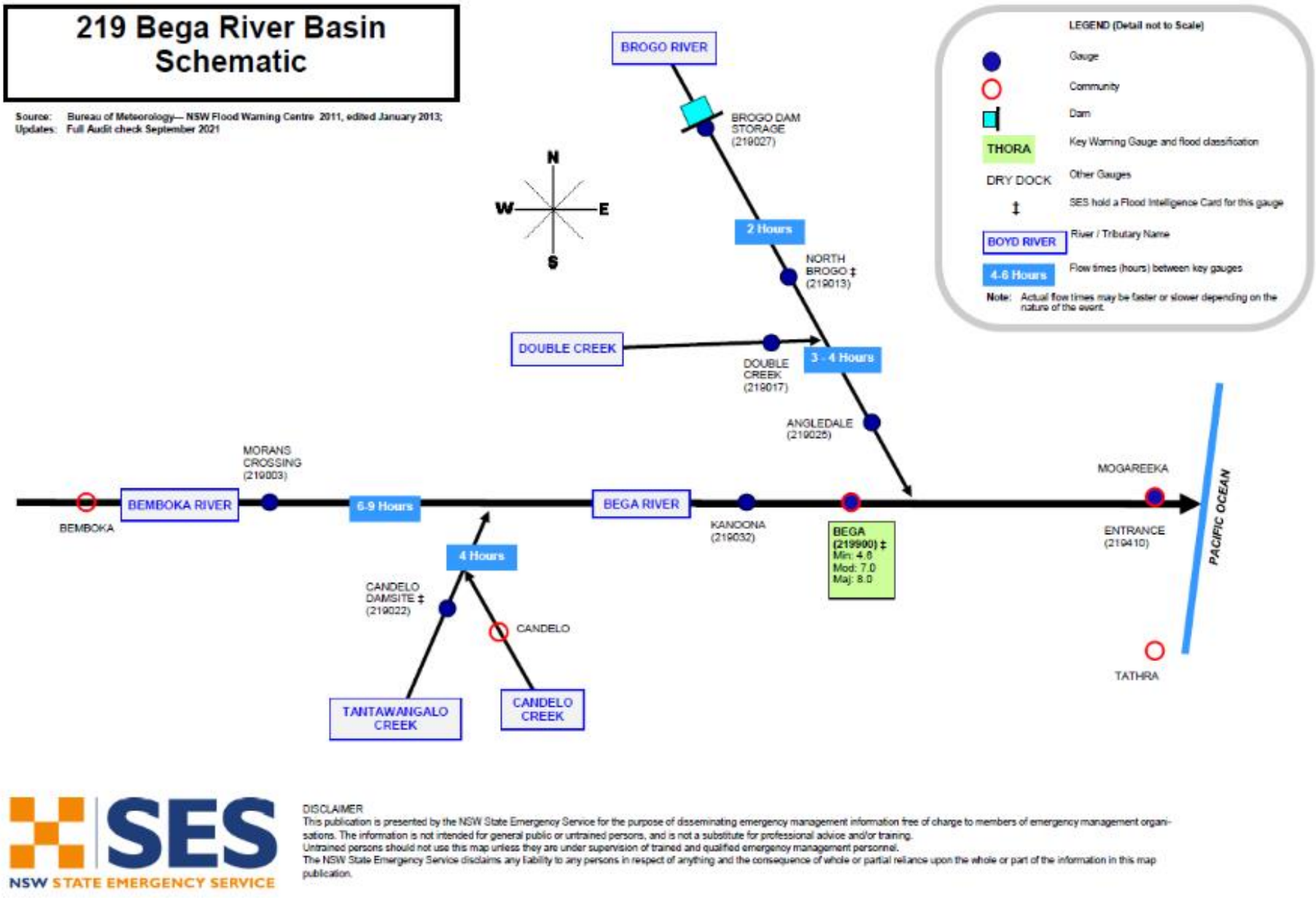

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Fig E2: Bega River Basin Schematic (Source: Draft NSW SES Bega Valley Shire Flood Emergency Sub Plan, Vol. 2, November 2021.)

3. Flood Warning System Overview:

a. Flood Warning Services roles

Bureau of Meteorology:

The Bureau of Meteorology (BoM) provides flood forecasting and warning services for the Bega and Brogo River catchments. The service levels provided by the BoM are set out in the *Service Level Specification for Flood Forecasting and Warning Services for New South Wales and the Australian Capital Territory* and are limited to riverine flooding warnings. The BoM provides flood warnings for riverine flooding where typical rain-to-flood times are six (6) hours or more.

The BoM work in partnership with Bega Shire Council, NSW SES, DPE, water authorities and other organisations as part of delivering flood forecasting and warning services.

NSW SES:

The SES Act 1989 stipulates that NSW SES has the function for the establishment of flood warning systems. NSW SES issues flood warnings to add local contextual information and translate flood level predictions at specified gauges into warnings about the consequences of flooding.

Bega Valley Shire Council:

Bega Valley Shire Council monitors risk associated with its assets and provide local flood response information including local road closure information via various communication mediums including on its website and social media.

Historically Council's in NSW have taken the lead in developing Flash Flood Warning Systems. Flash flood and small catchment warning services are defined as flooding of a short duration with a relatively high peak discharge, with a time interval between the observable causative event and the flood less than six (6) hours. As identified above in Fig E2 and Table E1, there are many catchments within the Bega and Brogo River catchments that meet this criteria.

Asset owners:

Asset owners including Water NSW monitor risks associated with storages and large dams and provide information about storage capacities, flow releases and other pertinent information.

b. Existing rainfall and stream gauges

The rainfall and stream gauge locations, owners, types and operational periods from when data is available are listed below in Table E1. The rainfall and stream gauge locations are also shown in the ***Figure E.3*** below.

Table E2: Rainfall and Stream Gauges in the Bega & Brogo River catchment

Gauge Number	Gauge Name	Owned/ Operated	Metric (Rainfall and Stream/ Water Level)	Operational Period (from YYYY – YYYY/Current)	Location
069003	Bemboka Post Office	BOM	Rainfall	1889-Current	(-36.6277,149.5706)
069002	Bega Newton Rd	BOM	Telegraphic Rain	1879-Current	(-36.6883, 149.8380)
069133	Bemboka (The Knob)	BOM	Rainfall	1985-Current	(-36.6631,149.5139)
069065	Brogo (Hawks Head Rd)	BOM	Rainfall	1962-Current	(-36.5675, 149.7509)
069140	Brogo Dam	BOM	Rainfall	1992-Current	(-36.4948, 149.7434)
069013	Candelo Post Office	BOM	Rainfall	1887-Current	(-36.7677, 149.6951)
069107	Kameruka (Kameruka estate)	BOM	Rainfall	1901-Current	(-36.7385, 149.7101)
069114	Brogo (Blanchards Rd)	BOM	Rainfall	1974-Current	(-36.5406, 149.8227)
219410	Bega River at Bega River	NSW DPE/MHL	Water Level	Current	(-36.7026,149.9779)
219410	Bega River at Bega River	Water NSW	Stream Water Level	2010-2019	(-36.7026,149.9779)
219003	Bemboka at Morans Crossing	Water NSW	Stream Water Level	1943-Current	(-36.6658, 149.6481)
			Discharge Rate	1943-Current	
219900	Bega River at Bega	Water NSW	Stream Water Level	1851-Current	(-36.6693, 149.8299)

Gauge Number	Gauge Name	Owned/ Operated	Metric (Rainfall and Stream/ Water Level)	Operational Period (from YYYY – YYYY/Current)	Location
			Discharge Rate	1851-2020	
			Rainfall	1879-2013	
219032	Bega River at Kanoona	Water NSW	Stream Water Level	1997-Current	(-36.7300, 149.7975)
			Discharge Rate	1997-Current	
			Rainfall	2005-Current	
219013	Brogo at North Brogo	Water NSW	Stream Water Level	1961-Current	(-36.53420, 149.8272)
			Discharge Rate	1961-Current	
219027	Brogo Dam	Water NSW	Reservoir Water Level	1976-Current	(-36.5405, 149.7420)
			Rainfall	1970-Current	
219034	Candelo at Greenmount	Water NSW	Stream Water Level	2002-Current	(-36.8005, 149.6880)
			Discharge Rate	2002-Current	
219025	Brogo River at Angledale	Water NSW	Stream Water Level	1976-Current	(-36.6185, 149.8817)
			Discharge Rate	1976-Current	
			Rainfall	1999-Current	
219033	Cochrane Dam Storage	Water NSW	Reservoir Water Level	1959-Current	(-36.5703, 149.4554)
			Rainfall	1959-Current	
219022	Candelo Damsite	Water NSW	Stream Water Level	1971- Current	(-36.7303, 149.6855)
			Discharge Rate	1971-Current	
219017	Double Creek near Brogo	Water NSW	Stream Water Level	1966-Current	(-36.5985, 149.8106)
			Discharge Rate	1966-Current	
219006	Tantawangalo Mountain	Water NSW	Stream Water Level	1924-Current	(-36.7803, 149.5427)
			Discharge Rate	1924-Current	
			Rainfall	1990-1994	
219001	Rutherford Brown Mountain	Water NSW	Stream Water Level	1924-Current	(-36.5940, 149.4427)
			Discharge Rate	1924-Current	
219019	Tantawangalo Kameruka	Water NSW	Stream Water Level	1966-1978	(-36.7332, 149.7181)
219012	Devils at Tantawangalo	Water NSW	Stream Water Level	1960-1978	(-36.7954, 149.5925)
219007	Brogo River at Brogo	Water NSW	Stream Water Level	1954-1960	(-36.5405, 149.8263)
219064	Brogo at Apps	Water NSW	Stream Water Level	1972-1979	(-36.6601,149.8468)
219024	Brogo D/S Brogo Dam	Water NSW	Stream Water Level	Not Operational	(-36.4900, 149.7486)
219063	Bega at Darceys	Water NSW	Stream Water Level	Not Operational	(-36.6786, 149.8628)
219065	Bega at Barrage	Water NSW	Stream Water Level	Not Operational	(-36.7093, 149.8836)
219026	Bega R Warraguburra	Water NSW	Spot levels only	1974-2014	(-36.7016, 149.872)

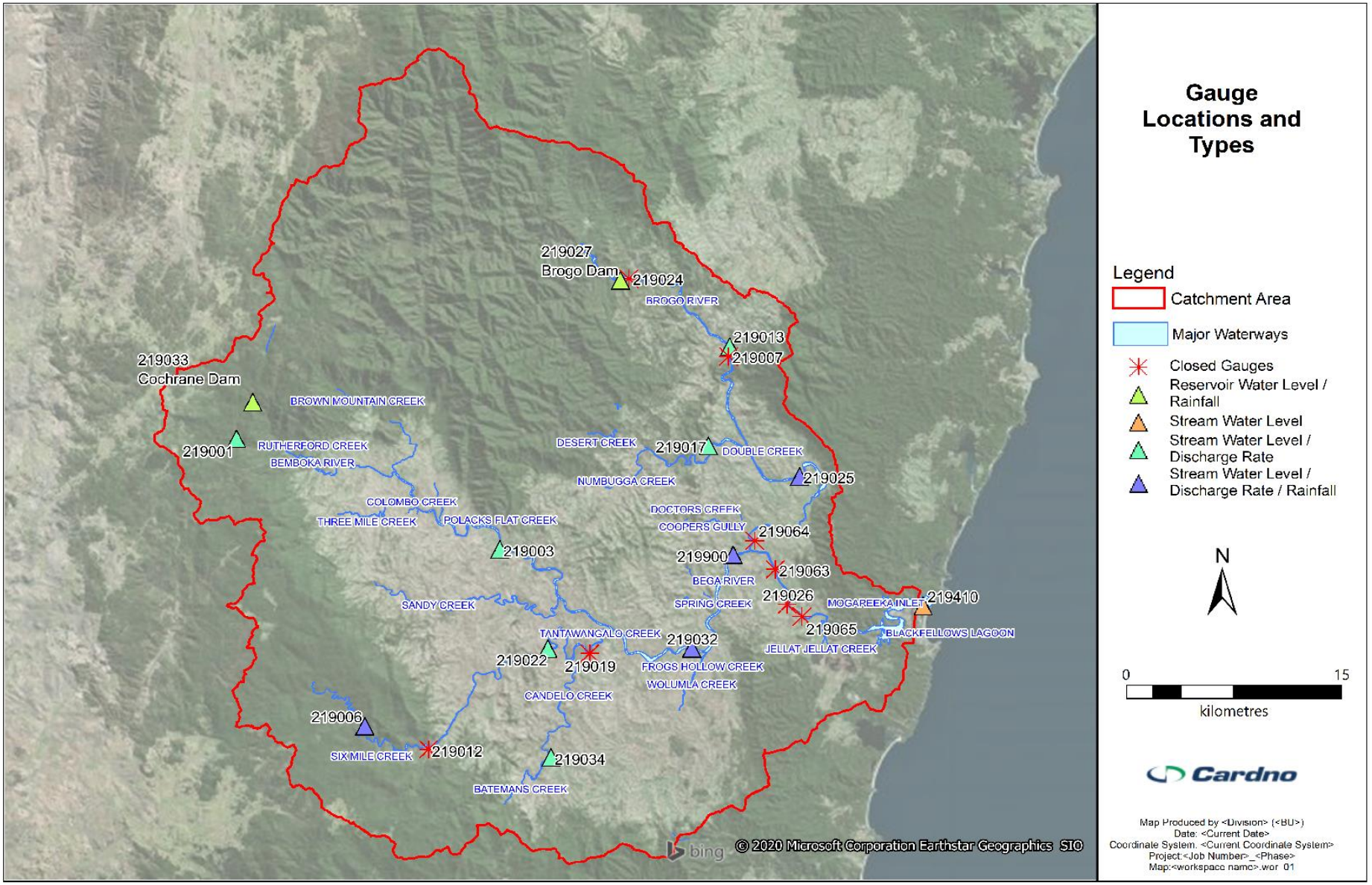


Fig E3: Rainfall and Stream Gauges in the Bega and Brogo catchment

c. Existing storages

There are three (3) existing storages of interest in the study area. Summary details of the dam are provided below any with any known flood warning system arrangements.

Table E3: Existing storages and flood warning system arrangements

Dams	Details of the dam	Flood Warning System details
Brogo Dam	• Owned and operated by WaterNSW • Located on Brogo River approximately 15km upstream of Bega • Storage capacity: 8,980 ML • Construction completed 1976 • Provides water for irrigation, stock and domestic requirements • Not designed to provide flood mitigation benefit	Communities of interest downstream of Brogo Dam include Brogo and Bega townships and farmers along the Brogo River. **No formal flood warning system is established.** **Water NSW Early Warning Network (EWN):** The Water NSW EWN provides information about controlled and uncontrolled releases online. This is an opt-in service established for downstream landowners and other interested parties. Notifications are issued when dam releases have the potential to impact downstream landowners For 'sunny day' failure the DSEP provides approximate travel times from Brogo Dam to downstream locations including to the Brogo and Bega township and the Double Creek and Bega River confluence. Further information on the EWN is provided on the Water NSW website and within the DSEP.
Cochrane Dam	• Owned and operated by Cochrane Dam Pty Ltd • Located on Georges Creek approximately 17km west of Bemboka and 29km east of Nimmitabel • Storage capacity: 4,750 ML • Construction completed 1958 • Provides water for irrigation and hydro-power station downstream • Not designed to provide flood mitigation benefit	Communities and infrastructure of interest downstream of Cochrane Dam include low lying areas along Bemboka and Bega Rivers, the Bemboka Sports Ground, Bega Racecourse and Sewerage Treatment Plant **The DSEP contains detailed information about the telemetry flood warning system which has been established to provide advance warning of flooding at the dam to staff at the Brown Mountain Power Station for operational reasons and to the NSW SES to facilitate emergency evacuation.** Operational details of the Cochrane Dam Flood Warning System including trigger levels, consequences and required actions for White, Orange and Red Alerts are detailed in the DSEP. As detailed in Appendix E of the DSEP, testing of the DSEP is scheduled to be undertaken on a five (5) yearly basis and it is understood that the DSEP was last tested and updated in 2020.

Dams	Details of the dam	Flood Warning System details
		Emergency contact details are listed in Appendix A of the DSEP.
Bournda Parkway Dam	• Owned and operated by Bega Valley Shire Council • Located to the east of Sapphire Coast Drive near Bournda Parkway • Provides water supply for private use, road works and firefighting and provides amenity and recreational value • Previous work has been undertaken to investigate dam safety risks – further work would be required to determine if the Bournda Dam is required to be declared under Dams Safety NSW	**No known warning system.**

d. Flood Prediction & Warning Services – Bureau of Meteorology, Council & NSW SES

Prediction and warning services provided by the BoM, Council and NSW SES are detailed in the table below.

- **Severe Thunderstorm Warnings:** issued by the BoM which may provide a 'heads up' for Council, emergency management personnel and the community for a defined area at risk of weather conditions that may include any combination of hail, damaging or destructive winds, tornadoes and intense rainfall leading to flash flooding
- **Severe Weather Warnings:** issued by the BoM for the for the *South Coast* region which may provide a 'heads up' for Council, emergency management personnel and the community for a severe weather event which may or not be associated with flooding;
- **Flood Watch:** issued by the BoM for the *Bega River* catchment may provide a 'heads up' for Council, emergency management personnel and the community for an impending flood event;
- **Flood Warnings (Minor, Moderate and Major Flood Warnings):** issued by the BoM for the Bega gauge (219900) for the township of Bega – refer below for further details;
- **NSW SES Flood Bulletins:** issued for the NSW SES South Coast region, Flood Bulletins will be issued to various media outlets and organisations to disseminate emergency information and warnings relating to flooding; and
- **Local Flood Advice:** issued by NSW SES to provide local flood advice for communities. It is understood Local Flood Advices have not been a feature of previous flood events within the Bega and Brogo River catchments. Local Flood Advice's are often used where there is stream level rises below minor flood level that may cause impacts to landowners and farmers but where a Flood Warning is not triggered.
- **NSW SES Livestock and Equipment Warnings:** issued by NSW SES where this is a known risk to landowners and farmers from flooding that may not be triggered by a Flood Warning. These warnings are often used for location where the BoM does not issue Flood Warnings.
- **Evacuation Warnings:** issued by NSW SES advising the community to prepare for a likely evacuation.
- **Evacuation Orders:** issued by NSW SES advising the community to communicate the need for evacuation.

The gauge locations where river height predictions are provided are categorised as either forecast locations, information locations and data locations and identified within the *Service Level Specification for Flood Forecasting and Warning Services for New South Wales and the Australian Capital Territory*. There is one (1) forecast location identified with the Bega Valley basin which is identified in Table E2 below. Additionally

nine (9) gauges are identified as data locations which are identified in order of their priority (High-Low) in Table E3 below.

Table E4: Forecast location – Bega Valley basin - Flood Warning Services (Source: Bureau of Meteorology)

Gauge Number	Gauge Name	Owned / Operated	Gauge type	BoM categorisation	Prediction Type	Target warning lead time (time & trigger height	Update time during developing stages of a flood
219900	Bega	WaterNSW	Automatic	Data location	Quantitative	3 hrs >4.6m	3 hrs

Table E5: Data locations – Bega Valley basin - Flood Warning Services (Source: Bureau of Meteorology)

Gauge Number	Gauge Name	Owned / Operated	Gauge type	Gauge datum	Priority
219025	Angledale	WaterNSW	Automatic	Local	High
219022	Candelo Damsite	WaterNSW	Automatic	Local	High
219003	Morans Crossing	WaterNSW	Automatic	Local	High
219013	North Brogo	WaterNSW	Automatic	Local	High
219017	Double Creek near Brogo	WaterNSW	Automatic	Local	Medium
219032	Kanoona	WaterNSW	Automatic	Local	Medium
219027	Brogo Dam	WaterNSW	Automatic	AHD	Low
219405	Regatta Point	DPE	Automatic	AHD	Low
219470	Bermagui (Tide gauge)	DPE	Automatic	Local	Low

4. Flood Warning operational arrangements

a. Bega Valley Shire Local Flood Emergency Sub Plan

The Bega Valley Shire Local Flood Emergency Sub Plan provides detailed information and references other sources that contain more information regarding operational arrangements for flood warning systems. This includes flood warning systems in place with DSEPs.

b. Existing systems, tools & dashboards

MHL FIT Tool:

Bega Valley Shire Council have a number of defined 'Intermittent Closed and Open Lakes and Lagoons (ICOLLs)' including at the outlet of the Bega and Brogo catchment.

Manly Hydraulics Laboratory (MHL) provide a service to Bega Valley Shire Council which includes ICOLL entrance management and real-time modelling services to assist Council in being able to manage and have access to data and information relating to its coastal environment.

The existing MHL FIT tool does not provide a flood warning service to Council and is currently limited to provided Council with data and information relating to its role in managing ICOLLs within Bega Valley Shire Council.

It is considered that if the existing services provided by the MHL FIT Tool were expanded to provide information and/or alerts to selected users this would have the potential to contribute to enhancing the *Monitoring and Prediction* element of the TFWS and assist Council's Asset Managers, Planners and Operations teams to be more informed about rainfall and river conditions in real time.

Bega Valley Shire Council Disaster Dashboard:

Bega Valley Shire Council have a Disaster Dashboard that was established by Resilience NSW to provide critical emergency information to the public during emergencies including flooding events. One of the sources of information the site provides is gauge level data which appears to be updated on 15 minute intervals. As of May, 2022 the site provided gauge level information for 22 gauges which includes:

> Wallagaraugh Princes Highway
> Towamba R @ Towamba
> Pambula R @ Lochiel
> Candelo @ Greenmount
> Bega River @ Bega
> Double Creek near Brogo
> Bemboka R @ Morans Crossing
> Tantawangalo Mtn
> Rutherford Brown Mtn
> Bega R @ Kanoona
> Brogo @ North Brogo
> Wadbiliga Wadbilliga
> Regatt Point (Live)
> Narira Rv @ Cobargo
> Murrah Rv @ Quaama
> Brogo R @ Angledale
> Bega (Live)
> Back Lagoon
> Merimbula Wharf (Live)
> Merimbula Lake (Live)
> Pambula Lake (Live)
> Lake Curalo (Live)

It is considered that the Disaster Dashboard aligns to the *Communication* and *Message Construction* elements of the TFWS. As the Disaster Dashboard is still in its infancy, there are limitations to what information is currently made available on the Dashboard during a flood, however there are opportunities to add to the information that is disseminated on this platform over time.

5. Potential future flood warning operational arrangements

As detailed in the final recommendations of the *Preferred Mitigation Options – Bega and Brogo Rivers Flood Warning Scoping and Feasibility Study* (2022) there are a number of initiatives that may be undertaken to enhance the existing flood warning system. Upon changes to the Flood Warning System being implemented, this would trigger a requirement to update the Flood Warning System Owner's Manual.

Upon adoption of the Flood Warning System Owner's Manual it is recommended that this would become a controlled document owned by Bega Valley Shire Council and would be reviewed periodically every three (3) years or following the implementation of a change to the Flood Warning System or a flood event that exceeded the Major Flood level at the Bega gauge.

> New level of service at Tarraganda Bridge:
  - **Monitoring and Prediction element of the TFWS:** Potential to provide flood information and alerts to Council and NSW SES operational staff in the event of a flood

> Alerting capability to selected rain gauges and stream level gauges:
  - **Monitoring and Prediction element of the TFWS:**
    - Potential to provide additional flood alerts to Council and NSW SES operational staff in the event of a flood
    - Potential to enhance the capability of the existing data monitoring through establishing an updated servicing agreement with a suitable service provider to ingest real time rainfall and stream level at key gauge locations
    - Potential to establish enhanced alert function for key gauges identified in this study to enhance the overall flood warning service levels across the Bega and Brogo River catchment

> Static inundation maps linked to trigger levels:
  - **Interpretation element of the TFWS:** Potential to provide key linkages between flood trigger heights and flood consequences through flood extent mapping and lead to enhancing the capacity to implement flood education and increase understanding of flood risks within communities.

> Council website Emergency Dashboard:
  - **Communication element of the TFWS:** An Emergency Dashboard was developed by Resilience NSW for Bega Valley Shire Council recently and provides an opportunity for Council to provide outward facing emergency information for the public including during flood events.

> Early warning alert or messaging service for irrigators and directly affected residents
  - **Communication element of the TFWS:** Potential to develop a database of selected users to receive BOM Flood Watch alerts or Brogo Dam Releases (via Water NSW *Water Insights* platform) and Cochrane Dam (via private dam owner)

In addition to the above, it is noted that Bega Shire Council have current arrangements in place with MHL including an existing 'Services Agreement' defining the services MHL delivers for Council under the terms of this agreement.

The existing 'Services Agreement' was established was set up to support Council in its management of the estuarine environment. Following completion of the second consultation period for the project, a meeting was held between Council officers, MHL, DPE, Cardno and the BoM. At this meeting it was agreed that the current services being provided under the current 'Services Agreement' could be reviewed with the potential to seek an expanded service offering from a suitable service provided to specifically include flood warning services.

APPENDIX

F

DRAFT SCOPE OF WORK FOR SYSTEM IMPLEMENTATION

1. Introduction & Purpose

The purpose of this document is to develop guidance and direction to Council to enable and facilitate the implementation of key actions to improve and enhance the flood warning system for the Bega and Brogo Rivers.

Specifically the document is developed to help Council to scope the key implementation items for the Bega and Brogo River System flood warning system improvements and undertake the necessary actions including seeking funding for system improvement projects and implementing procurement processes to deliver the necessary implementation items.

2. Procurement of water level sensor(s)

a. Identified need

The project has identified the option for a water level sensor at Tarraganda Bridge within option 1 of the Bega and Brogo Rivers Total Flood Warning System Feasibility project. As detailed within the report, this option is described as follows:

"This option would involve the installation of a water level gauge at Tarraganda Bridge to allow for the provision of a level of service for the flood affected communities of Tarraganda and Tanja. The level of service will aim to provide information, alerts and warnings during a flood event."

It is understood that Bega Valley Shire Council will be the owner and operator of the new flood warning service.

b. Case studies – water level sensor(s)

i. Darebin Yarra Link Flood Warning System using Level Sensors

The Darebin Yarra Link (DYL) is a 2.7km shared user trail that connected multiple other trails and networks totalling over 600km of off-road trails (Landscape Architecture in Australia, 2018). Despite the short distance, the link crosses the Darebin Creek thrice and the Yarra River once. It was therefore essential that the trail was fitted with a Flood Warning System (FWS) that would both limit access to the link during flood events, and enable safe emergency exit to those trapped in the link by raising water levels.

VicRoads worked in conjunction with relevant service providers to provide an FWS that consisted of multiple Water Levels Sensors and associated Flood Alert Systems to measure Darebin Creek and the Yarra River's water levels. Once the water has reached a configured trigger point level, the Level Sensors will activate flashing lights, close pathway access gates and open emergency exits. The system will also send automated messages to other systems such as boom gates, and to emergency personal and event management staff.

The individual level sensor nodes are self-powered, cost effective, and compatible with other remote data systems. In this case, VicRoads connected the Level Sensors to *STREAMS* software to help manage traffic related events and remote plant status information. Alerts sent from the Level Sensors to STREAMS could be passed onto system operation staff so that they could respond to system issues. Further information on the use of level sensors along the Darebin Trail and Main Yarra Trail is provided on the Tuftec website (https://tuftec.com.au/flood-warning-systems/).

ii. Oura community – Flood Warning System improvements project – a partnership approach between the Oura community, Wagga Wagga City Council, NSW SES, WaterNSW, BoM and Cardno (now Stantec)

The Oura community is located within the Murrumbidgee River catchment upstream of the township of Wagga Wagga, NSW. A number of flood warning system improvements were considered for the community of Oura as part of this study. Following a recommendation from a previous study the project explored the installation of a '*DipStik*' water level recorder. As part of the project a low cost radar based water level recorder was procured with capability to provide 'level alerts' and communicating these alerts via a custom built dashboard. The device was not intended to be deployed as a means of providing a flood warning service to the community of Oura, however was configured to Council and emergency services with key information from which to inform the issuing of localised flood warning information to compliment and provide localised value add to what the catchment level Flood Warning Services provided by the Bureau of Meteorology.

3. Draft scope

The following suggested scope items in dot point summary for are issued for the purpose of informing and assisting Bega Valley Shire Council to draft and issue a scope of work for the procurement, set up, establishment including installation of a water level sensor at Tarraganda Bridge.

The service provider delivering the scope of work should be required to:

Investigation phase:

> Visit the site at Tarraganda Bridge with Council staff to assist in understanding the sites constraints and opportunities;

> Confirm local datum requirements and system and dashboard integration requirements with Council's operational staff;

> Confirm local supporting infrastructure issues and requirements for installation, operation and maintenance;

> Obtain and review any survey and/or level data as required;

> Confirm key design criteria with Council;

> In consultation with Council and NSW SES confirm key triggers which should include:

- an initial 'heads up' advice notice that would notify operators to monitor the situation;
- a secondary 'act' alert that would notify operators to prepare for the Tarraganda Bridge to be closed;
- an 'alert' notification that would align with timing where it is too late for residents to cross the Tarraganda Bridge;
- an 'alert' notification that would align to the Tarraganda Bridge being closed;
- an 'alert' aligned to a receding water level which may prompt an assessment to confirm if it is safe to return.

> Present and confirm preferred option to Council on the recommended solution incorporating:

- Water sensor and associated technology proposed with consideration for:
  - System and dashboard integration requirements (Council and/or BoM systems);
  - Use of flood camera and associated smart analytics;
  - Redundancy and functionality during all conditions including night times, power outages, inclement weather conditions; and
  - Road closure arrangements including consideration for the use of lighting, boom gates, sirens and signage.
- Concept plan showing locational context and sufficient level of system detail;
- Estimate capex, opex and lifecycle cost estimates to install the preferred option and/or other options presented;
- Estimate a schedule with a timeframe for the works to be undertaken; and
- *Provisional:* as a provisional cost item include system that would activate an automated systems and/or device (i.e. flashing lights, gates) to provide options to close and open the road upon a trigger level being reached.

Establishment, Design, Construction & Installation phase:

> Design specifications to be submitted to Council for approval for a Preferred Option to guide the construction and installation of the infrastructure;

> Development of an Operational and Maintenance Manual to cover the testing, implementation phase;

> Construct and install flood warning infrastructure;

Testing, implementation and documentation phase:

> Carry out initial testing of the system with key operational staff at Council and other stakeholders if required;

> Identify and/or update key documents to be updated including emergency plans, flood warning owner's manual etc.

4. Capex and opex considerations

a. Capex costs

Capex costs for the installation of the flood warning infrastructure will be estimated as part of the above scope of work.

Indicative estimated capex costs to implement this option are:

$15,000 - $30,000 (excl. GST)

Grant funding to cover capex costs may be obtainable from the DPE *Floodplain Management Program*

b. Opex costs

It's assumed that opex costs to implement and maintain this system would need to be covered by Bega Valley Shire Council and/or other stakeholders due to restrictions of DEP FMP grants being able to fund opex costs. An estimate of opex costs would be provided as part of the scope of work to be delivered for the identified option to be implemented.

Indicative estimated opex costs to implement this option are:

$15,000 p.a. (excl. GST)

5. Potential additional scope items

The following suggested scope items in dot point summary are issued for the purpose of informing and assisting Bega Valley Shire Council to draft and issue a scope of work for the procurement, set up, establishment including augmentation of existing gauges to establish a flood alerting service.

The service provider delivering the scope of work should be required to:

Investigation phase:

> Visit the site(s) with Council staff to assist in understanding the sites constraints and opportunities;

> Confirm local datum requirements and system and dashboard integration requirements with Council's operational staff;

> Obtain and review any survey and/or level data as required;

> Confirm key design criteria with Council;

> Identify any potential to achieve enhanced levels of service to other warning services (e.g. lead time associated with the Bega gauge).

> In consultation with Council and NSW SES confirm key triggers which should include:

- an initial 'heads up' advice notice that would notify operators to monitor the situation;
- 'act' alerts to notify operators of:
  - pending impact (i.e. road closure);
  - a trigger to issue an alert or warning message (i.e. for road closure); and
  - a trigger aligned to a receding water level which may prompt an assessment to confirm if it is safe to return.

> Present and confirm preferred option to Council on the recommended solution incorporating:

- Flood alerting technology proposed with consideration for:
  - Augmentation of existing gauge infrastructure;
  - System and dashboard integration requirements (Council and/or BoM systems);
  - Use of flood camera and associated smart analytics;
  - Redundancy and functionality during all conditions including night times, power outages, inclement weather conditions; and
  - Road closure arrangements including consideration for the use of lighting, boom gates, sirens and signage.
- Concept plan showing locational context and sufficient level of system detail;
- Estimate capex, opex and lifecycle cost estimates to implement the preferred option and/or other options presented;
- Estimate a schedule with a timeframe for the works to be undertaken; and
- *Provisional:* as a provisional cost item include system that would activate an automated systems and/or device (i.e. flashing lights, gates) to provide options to close and open the road upon a trigger level being reached.

Set up and establishment phase:

> Design specifications to be submitted to Council for approval for a Preferred Option(s) to guide the implementation of the option;

> Confirm interoperability between systems;

> Development of an Operational and Maintenance Manual to cover the testing, implementation phase;

> If required contribute to community awareness material; and

> If required construct and install flood warning infrastructure.

Testing, implementation and documentation phase:

> Carry out initial testing of the system with key operational staff at Council and other stakeholders if required;

> Identify and/or update key documents to be updated including emergency plans, flood warning owner's manual etc.

*Capex and opex cost estimates to be confirmed but should be in the range provided within Appendix C.

APPENDIX

G

DRAFT FLOOD EDUCATION MATERIAL AND INITIAL COMMUNICATION PLAN

1. Introduction & Purpose

The purpose of this document is to develop guidance for the development of draft flood education and awareness material for the Bega and Brogo River catchment and the development of initial communication, consultation and education plan for the flood warning system.

It is suggested that this could may include the development of the following:

> A Targeted FloodSafe Guide

> A communication, consultation and education plan for the TFWS within the Bega and Brogo River catchment

2. Targeted FloodSafe Guide

The material presented is not intended to be comprehensive and is intended to act as a starting point to the potential development of targeted flood education material for the communities within the Bega and Brogo River catchment.

In developing draft content, a similar format to what has been used in other targeted FloodSafe materials has been adopted here. The sections for which draft content has been developed for below includes:

> What happens when Bega and Brogo Rivers are in flood?

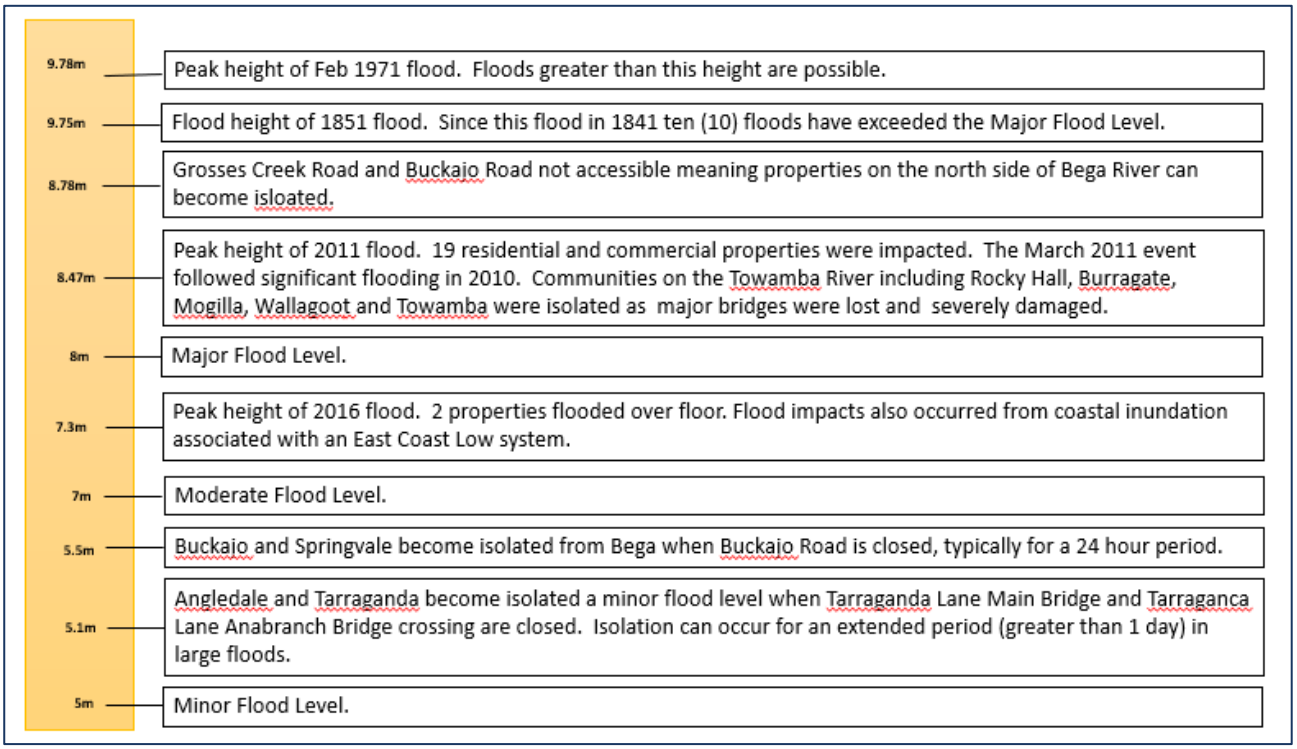
> Are you at risk from floods?

> Stay informed

> How will you stay up to date with warnings and information?

a. What happens when Bega and Brogo Rivers are in flood?

The below figure relates to key local flood consequences relating to the existing Bega River @ Bega gauge.



[2]

Additional note may be added as follows:

The Bureau of Meteorology provides predictions of flood heights in metres at the Bega River @ Bega gauge based on received and forecast rainfall.

[2] The above figure could be provided within a todem pole and/or visible and accessible location to help build awareness of potential flood consequences relating to locations within the Bega and Brogo River catchment

SES Flood Bulletins provide information on what may happen at the predicted height and what actions are required to protect yourself and your property. It is important to know the height at which your property may be affected and when evacuation routes may be cut.

b. Are you at risk from floods?

The Bega and Brogo River catchment area is located within the Bega Valley Shire local government area. Some of the communities within the catchment include Bega, Bemboka, Wolumla, Candelo, Kalaru, Tathra, Mogareeka, Tarraganda, Springvale, Buckajo, Wallagoot and Towamba.

These communities have a history of being impacted by flooding including direct impacts occurring to inundate properties, damage essential infrastructure and in some cases loss of life has occurred. Indirect impacts including isolation are a significant risk in events ranging from Minor to Major flood classification.

The largest recorded flood occurred in February 1971 however floods of a larger magnitude will occur in the future and should be planned for.

Recent flood events have occurred in 2010, 2011, 2012, 2016, 2021 and 2022. The March 2011 flood caused widespread damage to infrastructure and properties with the damage estimated at $10 million. Properties within Bega affected directly by inundation included those in Dowling Street, Kirkland Avenue, Bega Street, Nelson Street and Swan Street.

The influences of flooding include flash flooding, riverine flooding and coastal flooding.

In flash flooding, flood water can rise very quickly with high velocities risks to life in many locations across the catchment. This includes flooding associated with Candelo Creek that can affect parts of Mogilla Road, William Street, Sharpe Street, Eden Street, Candelo Street and Candelo Bega Road.

Coastal flooding can pose a risk to coastal communities within the catchment. This includes communities such as Mogareeka that may be impacted by storm surges particularly if these events coincide within riverine flooding.

You can be indirectly affected by flooding even if your property is not actually inundated. It is important to prepare yourself for floods by making sure you have adequate supplies of non-perishable food and essential medications. Many locations across the catchment can become isolated when access roads are cut to and from destinations. Some of the key access roads that may be closed during flooding include:

> **Bega River catchment:**

- **Below Minor Flood Level**: Carp Street Bega, Moore Wren Road Tarraganda and Reedy Swamp Road Tarraganda.
- **Minor Flooding:** Tarraganda Lane Bega, Buckajo Road Bega, Tathra Road Bega (north east end of East Street), Bega Street Bega, East Street Bega, Nelson Street Bega, Upper Street Bega, Swan Street Bega, Auckland Street Bega, Poplar Avenue Bega, Parrabel Street Bega, Angledale Road Angledale, Murrays Flat Road Tarraganda, Old Wallagoot Road Kalaru, Wallagoot Lake Road Wallagoot, Bournda Road Wallagoot, Clarks Road Greendale, Little Green Oaks Road Greendale, Tathra Bermagui Road Tathra and Frog Hollows Lane Frog Hollow.
- **Other (undefined):** Sullivans Gap Road Bemboka, Greens Lane Bemboka, Church Lane Candelo, Tarlingtons Lane Tantawangalo, Tantawangalo Mountain Road Tantawangalo, Dorrigo Road Brogo and Upper Brogo Road Brogo.[3]
- **PMF:** Princes Highway Bridge Bega.

Being ready to evacuate when a significant flood is approaching can prevent becoming isolated in a flood. Deciding to remain in your home or business when it is surrounded by floodwaters or has water over floor level can be dangerous. Your home or business may become a refuge for vermin, snakes and spiders. Services such as power, water, telephone, sewerage and gas may be unavailable for some time. You may be unable to call or receive help in an emergency that occurs if you are isolated.

c. Stay informed and how will you be advised of a coming flood?

It is considered that this and other sections are best completed by NSW SES in collaboration with Bega Valley Shire Council.

[3] Not all defined events are included in this list including locations where the onset of impacts may occur at other defined events including Moderate and Major Flood events

3. Preliminary communication, consultation and education plan

Bega Valley Shire Council Community Engagement Strategy and Community Engagement Procedure sets out Council's commitment to encourage open and transparent relationships between Council and the community, acknowledging that effective engagement leads to better outcomes for the broader community.

The following table forms the basis of the Communication, Consultation and Education Plan associated with the Bega and Brogo River catchment. Bega Valley Shire Council would work with key partner organisations to implement the communication, consultation and education plan.

Engagement activity	IAP2 Spectrum	Public Participation Goal
Release of *Preferred Mitigation Options – Bega and Brogo Rivers Flood Warning Scoping and Feasibility Study* (2022)	Inform	To provide the public with the outcomes of the Scoping and Feasibility Study
Targeted FloodSafe Guide	Involve	To work directly with the public throughout the process of developing a Targeted FloodSafe Guide to contribute to an enhanced level of flood preparedness.
Flood Warning System Operations Manual	Inform	To provide the public with a copy of the Flood Warning System Operations Manual.
Implementation of Option 1 – Install Stream Gauge (Water Level Sensor) and provide a level of service (i.e. information, alert, warning) at Tarraganda Bridge	Consult	To obtain targeted feedback from on the new level of service proposed, the limitations of the technology, any redundancy arrangements and input to how they may get informed or alerted of impending isolation from inundation of Tarraganda Bridge.
Implementation of Option 7: Add alerting to selected rain gauges and stream level gauges	Consult	To obtain targeted feedback from on the new level of service proposed, the limitations of the technology, any redundancy arrangements and input to how they may get informed or alerted of flood impacts and/or consequences.
Implementation of Option 6: Static inundation maps linked to trigger levels	Involve	To work directly with the public throughout the process of developing static inundation maps linked to trigger levels to contribute to an enhanced level of flood preparedness. It's advised that this option could be undertaken in concert with Option 7 or as a follow up action.
Implementation of Option 8: Council Website Emergency Dashboard	Inform	To work with and inform the public of any changes to the Council Website Emergency Dashboard.
Implementation of Option 9: Early warning alert or messaging service for irrigators and directly affected residents	Consult	To obtain targeted feedback from on any new warning alert or messaging service for irrigators or directly affected residents.