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BROADWATER PUBLIC SCHOOL

Flood and Civil Engineering Assessment

Prepared for: NSW Department of Education | School Infrastructure NSW

Document no: DESIGN_DOC - 220826 - Broadwater - Flood Assessment

Revision no: Revision 01

Broadwater Public School

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Revisions

Revision	Description	Date	Prepared by	Approved by	Signature
01	For information	26/08/2022	Karl Umlauff	Jarrod Novosel	

Review Panel

Division/ office	Name
Civil/Brisbane	Niall Davidson

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1 Introduction

Record breaking floods in late February and early March 2022 occurred in several major river systems in north-east New South Wales, including the Richmond River. Broadwater Public School was totally inundated with all but one school building experiencing above floor inundation, rendering the school unfit for use.

School Infrastructure New South Wales (a Department of New South Wales Government) is coordinating planning for the reconstruction of several schools, including Broadwater Public School, for the purposes of reopening.

This report provides flood and civil engineering information to assist the project team with planning and design.

2 Criteria

The following guidelines were reviewed for this flood assessment:

- Richmond River Flood Mapping Study Final Report (2010) and other documents
- Flood documentation from Richmond Valley Council
- Richmond Valley Local Environmental Plan (2012)
- Richmond Valley Development Control Plan (2021) Part H.

3 School site characteristics

3.1 Location

Broadwater Public School is located at 9 Byrnes Street, Broadwater NSW 2472 on Lots 4 & 5, DP1043232 and Lot 501, DP755624. The Richmond River is located to the west of the school.

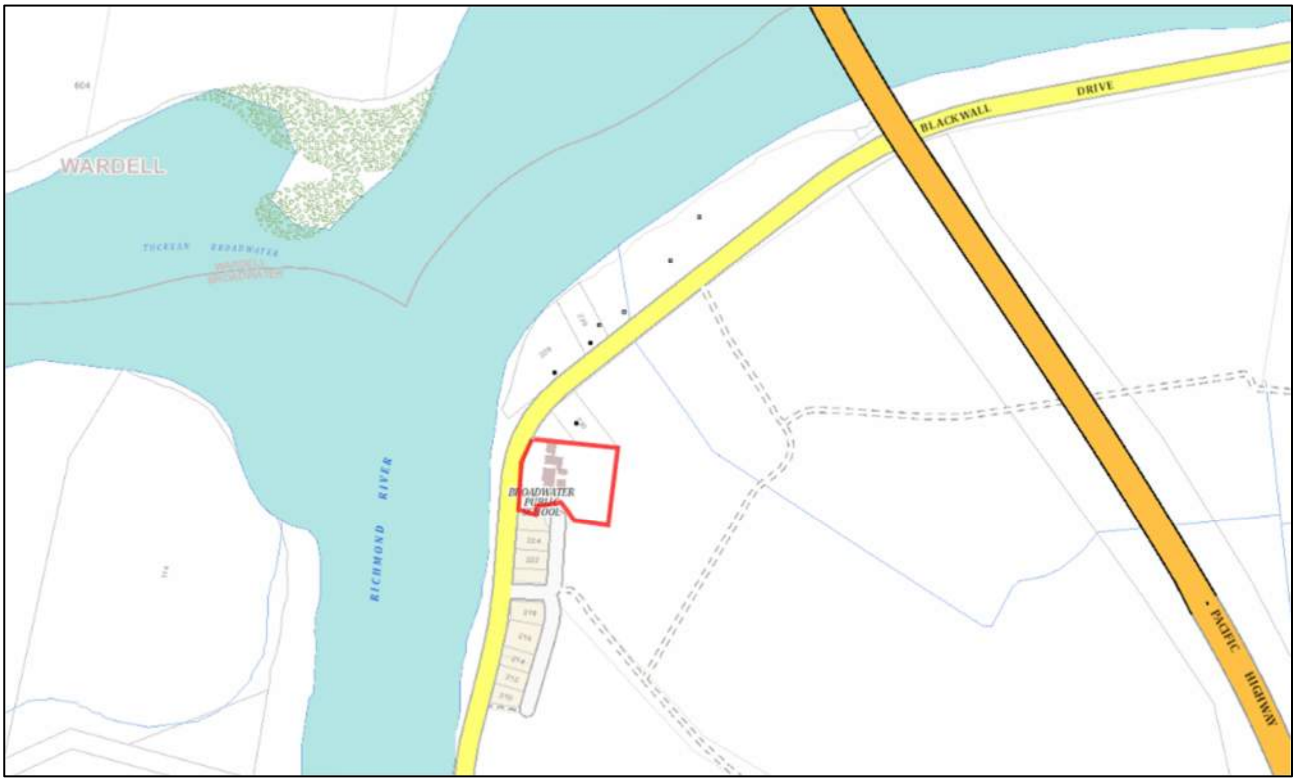

Figure 3-1 School location (NSW Government Spatial Map Viewer)

Document Set ID: 1908329
Version: 1, Version Date: 26/02/2024

3.2 Site layout

The Broadwater Public School layout and names of buildings are shown in the figure below. These labels match the building name labels in Section 0.

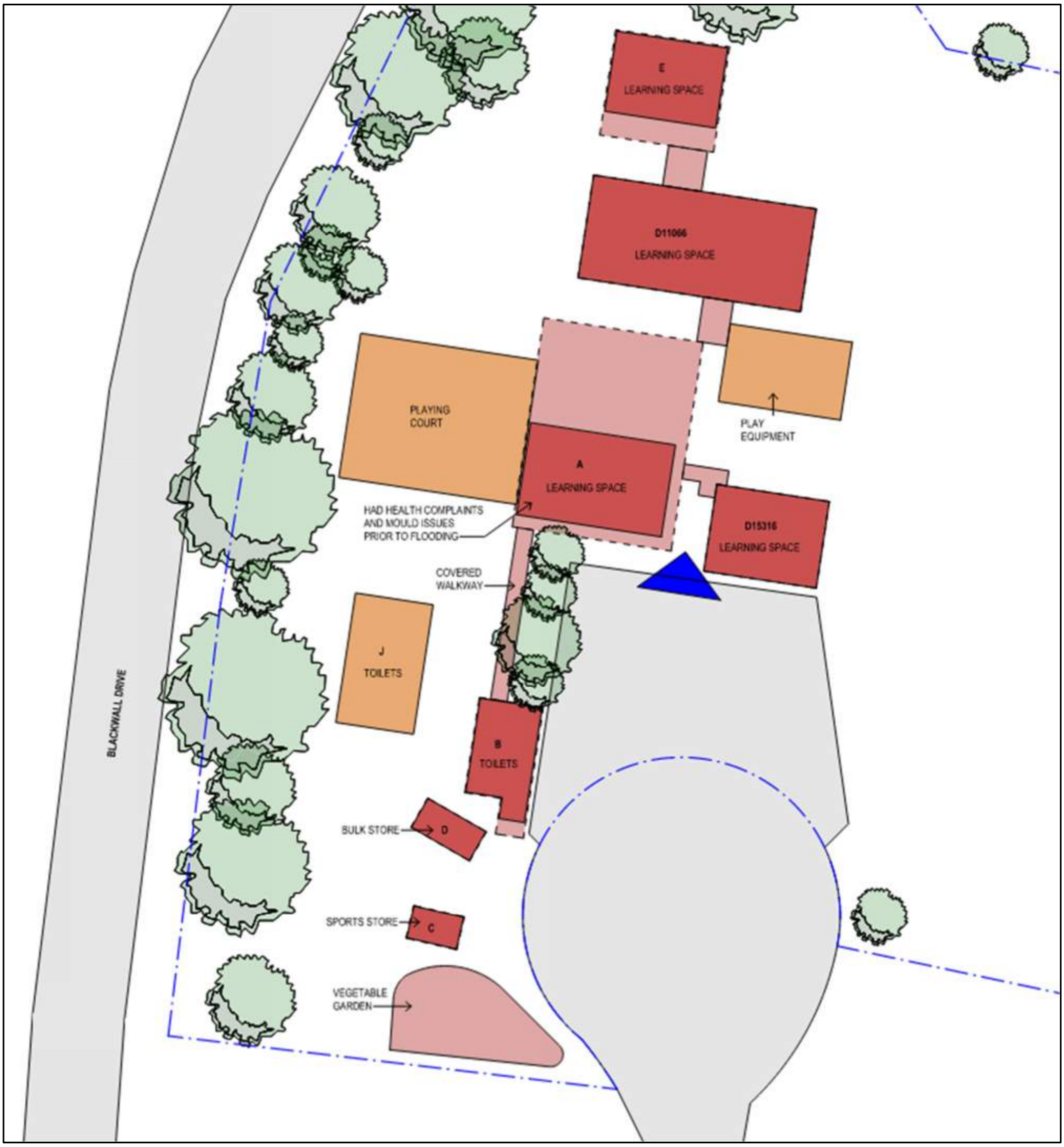

Figure 3-2 School site layout and building name labels

A recent Nearmap image of the school is shown in the figure below.

Figure 3-3 School site Nearmap image of developed building area (Date of capture 16 July 2022)

4 Flood assessment

4.1 Introduction

The flood assessment presented in this section presents the applicable flood sources and mechanism of flooding, flood likelihood and flood levels, historical flood levels, applicable flood planning levels, flood characteristics, site inspection findings, description of February/March 2022 flood and impacts, and depths of above floor flooding at the school.

4.2 Flood sources and mechanism of flooding

Flood inundation at a flood prone location can occur from one or more of the following flood sources:

- Overland flow
- Creek flooding
- Riverine flooding
- Tidal inundation
- Coastal hazard (storm surge) flooding.

The predominant source of flooding that impacts Broadwater Public School is riverine flooding of the Richmond River. The Richmond River catchment is prone to flooding and has experienced many flood events.

Overland flow emanating from Baraang Drive may also enter the school site at the northern boundary from Baraang Drive and the adjacent property to the north.

4.3 Available flood information

Flood information presented herein has been obtained from flood studies, brochures, online sources and site inspection, which are referenced throughout the report.

4.3.1 Flood likelihood and flood levels

The following flood likelihood and corresponding flood levels for the subject lot were sourced from Richmond Valley Council email correspondence and BMT WBM (2010). The flood levels provided in the table below are for climate change conditions. Flood levels for current climate conditions are not utilised by Council for flood planning purposes. Climate Change conditions incorporates 0.9 m sea level rise and 10% increase in rainfall intensity.

Table 4-1 Flood likelihood and flood levels for the subject lot

Flood likelihood (Annual Exceedance Probability)	Flood level (m AHD) - upstream flood contour level adopted
0.2% AEP (1 in 500 AEP) (Climate Change Year 2100)	5.6
1% AEP (Climate Change Year 2100)	4.4
2% AEP (Climate Change Year 2100)	3.9
5% AEP (Climate Change Year 2100)	3.2
PMF (Probable Maximum Flood)	8.41
0.2% AEP (1 in 500 AEP) (current climate)	5.18
1% AEP (current climate)	4.00
2% AEP (current climate)	3.47

4.3.2 Historical flood levels

The first flood of the Richmond River that was recorded by European settlers occurred in 1846. Historical flood levels at the Broadwater gauge are listed in the table below. The March 2022 flood is the flood of record at Broadwater and the school location.

Table 4-2 Historical flood levels (highest floods selected since 1954) in chronological order (BMT WBM (2008) and SES (2021) and SMH (2022))

Flood event	Peak flood level (m AHD) at Broadwater gauge
1954	3.72
1962	2.69
1974	3.25
1988	2.43
2017	2.08
2022	4.72

[1]Derived from 7.72 m quoted flood level (corrected to 4.72 m AHD due to perceived typographical error). Level in m AHD requires 0.86 m to be subtracted from the Broadwater gauge level.

4.3.3 Design Flood Event, Freeboard and Flood Planning Level

Richmond Valley Council has advised that the subject property is in an area where the 1% AEP year 2100 climate change scenario applies to set minimum habitable floor levels. The Design Flood Level for the subject site is 4.4 m AHD.

The minimum habitable floor level required by Council is 4.9 m AHD, inclusive of 0.5 m freeboard as per Part H of the Richmond Valley Council Development Control Plan 2021.

4.3.4 Flood characteristics for Design Flood Event

Flood characteristics for the site obtained from Richmond Valley Council documentation is as follows:

- 1% AEP flood velocity is up to 1.5 m/s. Refer to the Appendices for a figure showing Flood Velocity.
- 0.2% AEP (1 in 500 AEP) flood velocity is up to 1.5 m/s. Refer to the Appendices for a figure showing Flood Velocity.
- The school site is located in the vicinity of ‘Low Hazard’ (school lot), ‘High Floodway Hazard’ (Richmond River), and ‘High Depth Hazard’ (school lot and area to the east, south and north). Refer to the Appendices for a figure showing Flood Hazard Categories.

(5) The Risk Plans also reference Floodplain Hazard Categories. These are tools for assessing the suitability and minimum requirements for development based on a combination of depth (D) and velocity (V). These categories are:

(a) **High Floodway Hazard (HFH)** - based on a 100 year design flood – Flow paths that carry significant volumes of flood water during a 100 year flood. Danger to life and limb, evacuation difficult, potential for structural damage, high social disruption, and economic losses.
V>2m/s or VxD>1 [for D>1m] or D+(0.3xV)>1 [for V>1m/s]

(b) **High Depth Hazard (HDH)** - based on a 100 year design flood – Area where floodwaters are deep but are not flowing with high velocity.
V<1m/s and VxD<1 or D+(0.3xV)>1

(c) **High Isolation Hazard (HIH)** - based on a 100 year design flood – As per High Depth but with no easy access to safe refuge (ie more than 500m to high ground)

(d) **Possible High Depth Hazard (HFH) or Low Hazard (LH)** - based on a 100 year design flood – Insufficient ground level information. Final category dependent on the exact ground levels at the particular site.

(e) **Low Hazard (LH)** - based on a 100 year design flood – Flood depths and velocities are sufficiently low that people and their possessions can be evacuated.- based on a

(f) **Rare Low Hazard (RLH)** - based on PMF - Any land that is inundated in the PMF event and has not been assigned one of the other hazard categories. These areas are generally above the 100 year design flood.

(g) **Rare High Floodway Hazard (RHFH)** - based on 500 year design flood - Flow paths that carry significant volumes of flood water during a 500 year design flood.

These areas may or may not be affected by the 100 year design flood. Danger to life and limb, evacuation difficult, potential for structural damage, high social disruption, and economic losses. V > 2m/s or VxD>1 [for D >1m] or D+(0.3xV)>1 [for V>1m/s]

Figure 4-1 Definition of Flood Risk Precincts (Richmond Valley Council (2021))

4.3.5 Site inspection

A site inspection was undertaken by the report author on 3 August 2022. Heights of finished floor levels above the adjacent ground surface were measured and added to the ground surface elevation obtained from LiDAR sourced digital elevation model data (ANZLIC Committee on surveying and mapping, 2022) to obtain an approximate finished floor level in metres Australian Height Datum.

Table 4-3 Building finished floor levels (FFL)

Building (Block) name	Approx. ground level at building (m AHD)	FFL above ground (m)	Approx. finished floor level (m AHD)
Block A	2.2	3.15	5.35
Block B	2.2	0.45	2.65
Block C	2.4	0	2.4
Block D	2.4	0	2.4
Block E	2.2	0.6	2.8
Block J	2.2	0.15	2.35
D11066	2.2	0.6	2.8
D15316	2.2	0.75	2.95

4.3.6 March 2022 flood event

The peak flood level at the school was measured on site from the visible flood line adjacent to several buildings. The peak flood level calculated was approximately 4.7 m AHD.

Plate 4-1 March 2022 approximate peak flood level at Block A (Learning Space) denoted by blue line

Plate 4-2 March 2022 approximate peak flood level at Block D11066 (Learning Space) denoted by blue line

4.3.7 Depths of flooding above floor level

The approximate depths of flooding above floor level for all buildings on site for the Climate Change 1% AEP (100 year ARI) flood and the March 2022 flood are provided in the table below.

Table 4-4 Depth of flooding above floor level

Building (Block) name	Approx. flood depth above floor level (m) for Climate Change 1% AEP (100 year ARI) flood[1]	Approx. flood depth above floor level (m) in March 2022 flood[2]
Block A	0.95 m below floor level	0.65 m below floor level
Block B	1.75	2.05
Block C	2	2.3
Block D	2	2.3
Block E	1.6	1.9
Block J	2.05	2.35
D11066	1.6	1.9
D15316	1.45	1.75

[1] Climate Change 1% AEP (100 year ARI) flood level adopted (4.4 m AHD)

[2] Approximate March 2022 flood level at the school = 4.7 m AHD

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4.4 Tidal inundation

The site is not affected by the tidal inundation during the highest astronomical tide (HAT) for current climate conditions. The HAT for 2022 at Yamba is 1.08 m AHD (HAT 2.0 m above datum; Mean Sea Level 0.92 m above datum), (Australian Hydrographic Office (2022)).

The site may also be impacted by tidal inundation under Climate Change conditions for the year 2100. The high scenario is in line with recent global emissions and observations of sea-level rise. This high scenario aligns to RCP 8.5, which has a median sea level rise of 0.84 metres by 2100 (Coastal Risk Australia, 2021).

Refer to Appendices for tidal inundation maps for these two scenarios.

4.5 Coastal hazard

No information has been found in regards to storm surge inundation that may impact the school site.

5 Civil engineering

5.1 Topography and site grading

The existing developed area where buildings are located has ground surface elevations generally between 2.2 m AHD to 2.6 m AHD. The ground surface is undulating within the school's developed building area. There are several areas that are poorly drained.

Refer to Appendices for plans showing arrows for ground surface fall direction.

5.2 Minor stormwater drainage

5.2.1 Internal drainage

The building roof areas typically discharge via downpipes to the ground or to grated inlet pits and 100 mm diameter PVC pipes. The discharge location of the school's piped drainage system was not obvious during the site inspection. The school carpark falls towards the east to the school playing field that generally falls to the south and a swale drain across the southern boundary. Site stormwater drainage is to be confirmed by survey.

Numerous poorly drained areas were noted at the site inspection. A significant amount of sand was deposited over the school grounds from the flood water, blocking most of the school's stormwater pits.

Refer to Appendices for locations of these features.

5.2.2 External drainage

A Council stormwater system in Byrnes Street or Baraang Drive is likely to collect runoff from the school stormwater system, which conveys it to an outlet at the Richmond River, however this may need to be confirmed.

A swale drain running parallel to the school's eastern and south-eastern boundary collects and conveys minor runoff from the lot to the east.

Baraang Drive on the western side of the school falls towards the school's western boundary. A small bund just inside the school's western boundary is aligned north-south, and was presumably installed to prevent runoff from Baraang Drive entering the school. A single grated sag inlet pit at the edge of Baraang Drive carriageway collects Baraang Drive runoff. The alignment of the stormwater pipe at this location was not observed during the site inspection.

A small cross drainage pipe under Byrnes Street conveys runoff from the eastern side of Byrnes Street to the western side, and presumably to the stormwater system in Baraang Drive.

Refer to Appendices for locations of stormwater pits and pipes noted at the site inspection.

5.2.3 Lawful point of discharge

The lawful point of discharge for stormwater is believed to be the stormwater pipe system in Byrnes Street, which should be confirmed from results of the site survey.

5.3 Sewer

It is understood that the school's sewerage is connected to the town reticulation system, which is within Baraang Drive.

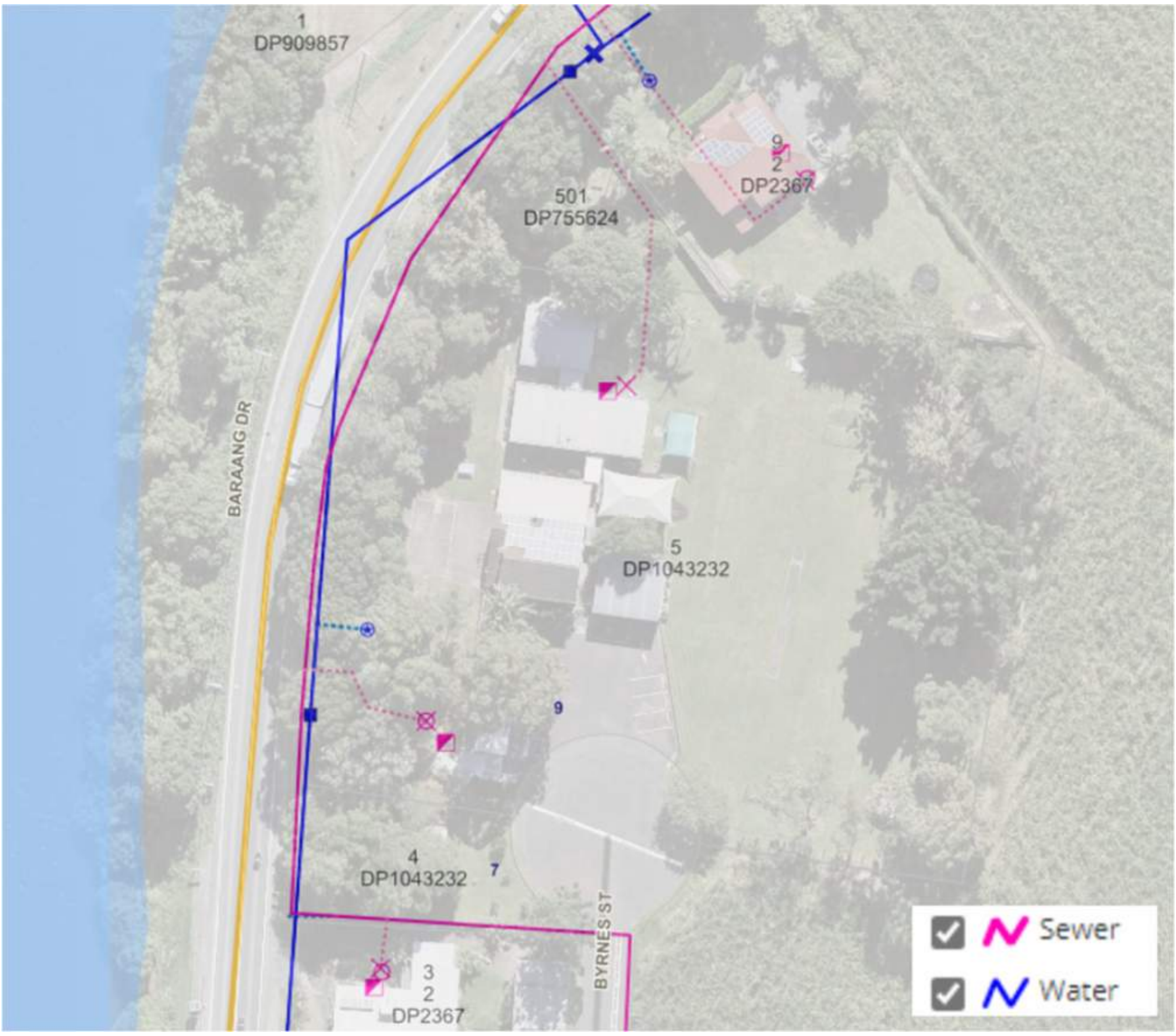

Figure 5-1 Local sewer assets (Richmond Valley Council intramaps)

6 Recommendations

6.1 Flood

The minimum habitable floor level required by Council is 4.9 m AHD, which is based on the 1% AEP (100 Year ARI) Climate Change event, inclusive of 0.5 m freeboard. This level provides approximately 0.2 m freeboard above the March 2022 peak flood level (4.7 m AHD). It is noted that the finished floor level of Block A is approximately 5.35 m AHD, which did not experience above floor inundation in the March 2022 flood. Consideration should be given to adopting a minimum habitable floor level similar to the existing floor level of Block A.

Replacement buildings should have undercroft areas without enclosed sides to allow flood water to pass beneath the enclosed building. Stairwells and ramps should be located on the northern (downstream side) of the buildings and of minimal footprint. Undercroft areas should not be used for storage of vulnerable equipment or assets in cages or otherwise. Floatable items such as tables and bench seating should be fixed securely (such that movement is not easily possible) to an undercroft ground slab. Essential electrical equipment such as switchboards and distribution boards should be located above the minimum habitable floor level.

If replacement buildings are located in the generally the same location and orientation as existing buildings, and are raised above the recommended flood level without enclosed sides to the undercroft, it is expected there will be negligible impacts on floodwater.

In the event of a pending flood, the school is expected to be evacuated prior to inundation of the school grounds, however raised buildings would allow shelter in place to occur, which should not be relied upon and is not recommended. Occupants sheltering in place would require evacuation by emergency services.

Further studies include a detailed Flood Emergency Management Plan for the school, incorporating information from the Broadwater Public School Emergency management plan, encompassing:

- Tracking of weather conditions and upstream Richmond River catchment rainfall and flood levels (available forecast and warning services)
- Educational resources for flood awareness for staff and parents
- Flood warning time
- Site access and evacuation
- Emergency procedures (trigger action response plan - TARP).

6.2 Civil engineering

The school Master Planning and detailed design should incorporate the following civil engineering aspects:

- Site grading design to rectify poorly drained areas
- Site stormwater management (quantity and quality management) and discharge to the lawful point of discharge
- Roof water discharge and drainage
- Remediation of existing drainage system (de-silting and repair of drainage infrastructure) where it is to be kept
- Sewage reticulation, treatment and disposal.

7 References

ANZLIC Committee on surveying and mapping (2022). LiDAR digital elevation model data. https://elevation.fsdf.org.au/.

Australian Hydrographic Office (2022). Australian National Tide Tables 2022. https://www.hydro.gov.au/prodserv/publications/AHP11_2022.pdf

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BMT WBM (2010). Richmond River Flood Mapping Study Final Report. R.B16784.002.03 Volume 1. April 2010. https://richmondvalley.nsw.gov.au/services/flood/.

Coastal Risk Australia (2021). Predicted Coastal Flooding Resulting from Climate Change. IPCC Sixth Assessment Report Update 2021. https://coastalrisk.com.au/home.

SES (2021). FloodSafe Community FloodSafe. Woodburn and Broadwater. https://www.ses.nsw.gov.au/media/5151/floodsafe-woodburn-2021-september-2nd-draft.pdf

SMH (2022). Anatomy of the Lismore disaster. https://www.smh.com.au/interactive/2022/lismore-flooding/

Appendix A Site contour plan and Nearmap image

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0 5 10 m

Scale in metres (1:400 @ A3)
Map Projection: GDA94 Zone 56 (EPSG: 28356)
Horizontal Datum: Geocentric Datum of Australia 1994
Vertical Datum: Australian Height Datum

Contour elevations from LiDAR (WOODBURN, 2kmx2km 1 metre Resolution Digital Elevation Model)
Acquisition Start Date: 2010-06-30
Acquisition End Date: 2010-06-30
Spatial Accuracy Horizontal: 0.8m
Spatial Accuracy Vertical: 0.3m
Data extracted: 27 JUL 2022
Department of Finance, Services and Innovation.

School Infrastructure NSW Northern NSW Flood Recovery

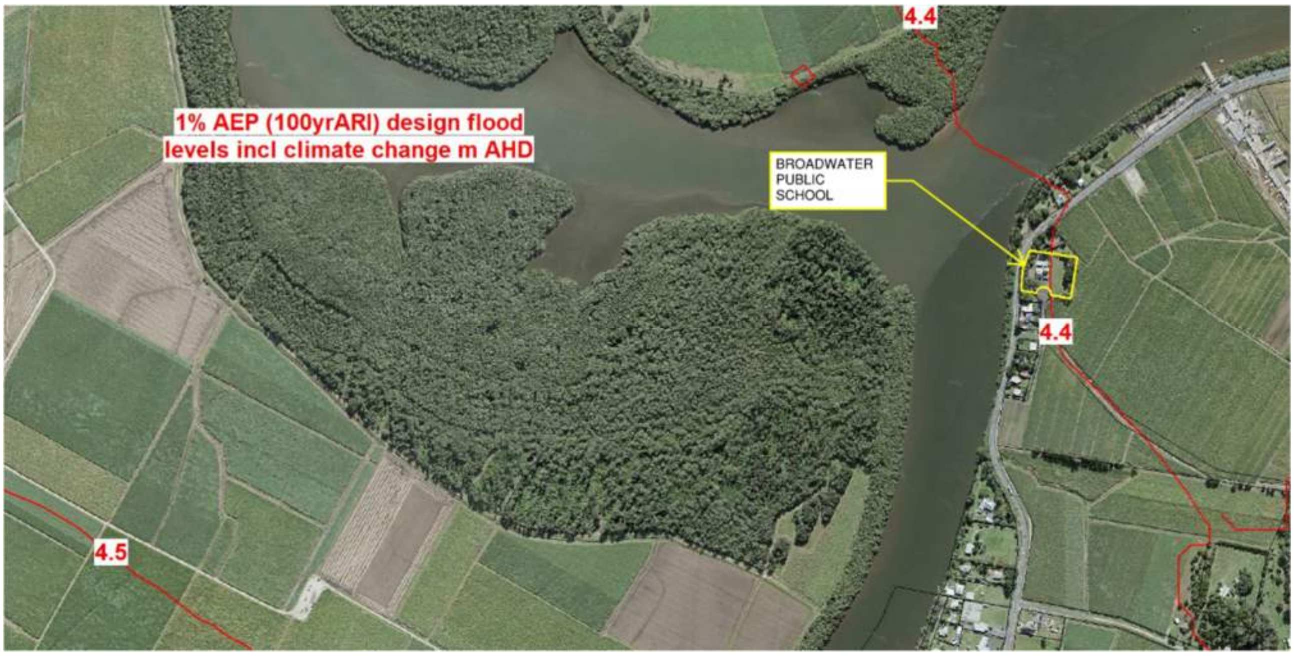
Plan 2 - Broadwater Public School contour elevations

Nearmap image date of capture 16 July 2022

Project Number: BR220288
Revision: 01
Drawn: KU
Date: 26/08/2022

Appendix B Flood maps

B.1 Flood contour levels for 1% AEP Design Flood Event (Climate Change Year 2100)



Richmond Valley Council (via email correspondence)

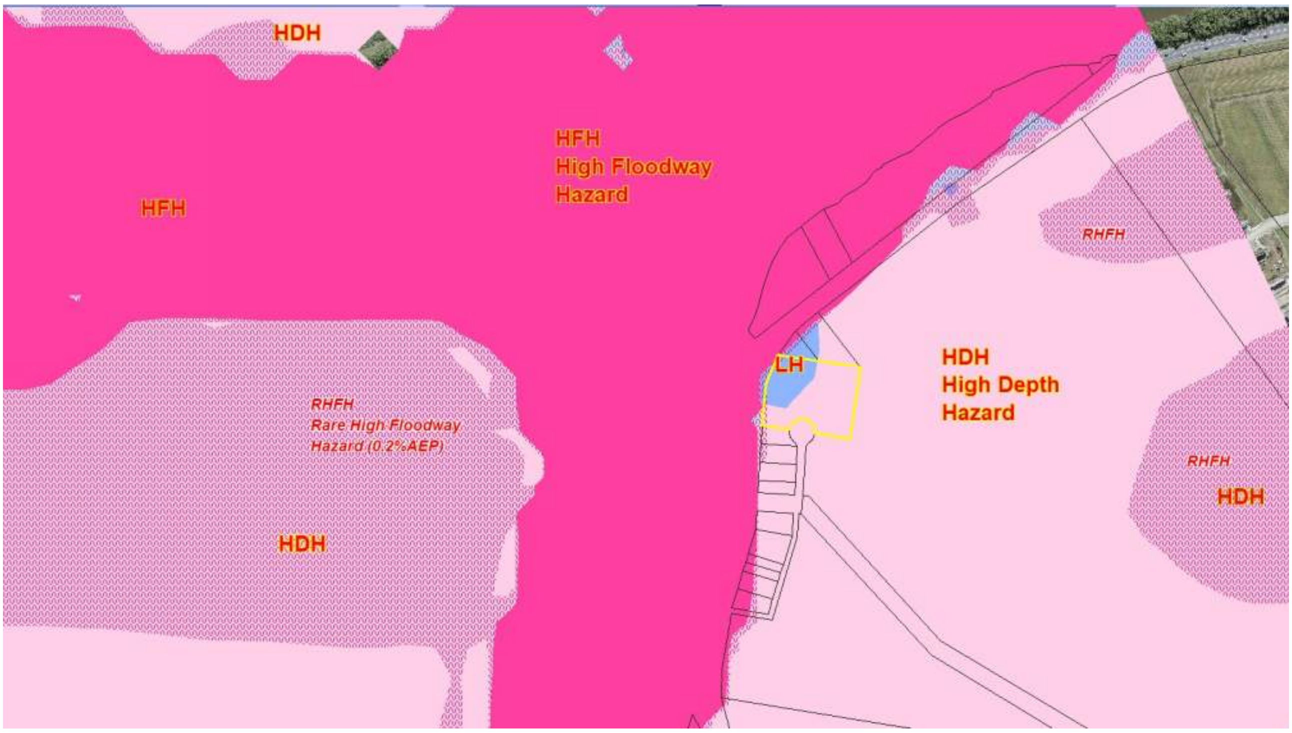
B.2 Other flood maps

B.2.1 Flood velocity

Richmond Valley Council (via email correspondence)

Richmond Valley Council (via email correspondence)

B.2.2 Flood hazard categories



Richmond Valley Council (via email correspondence)

B.2.3 Tidal inundation

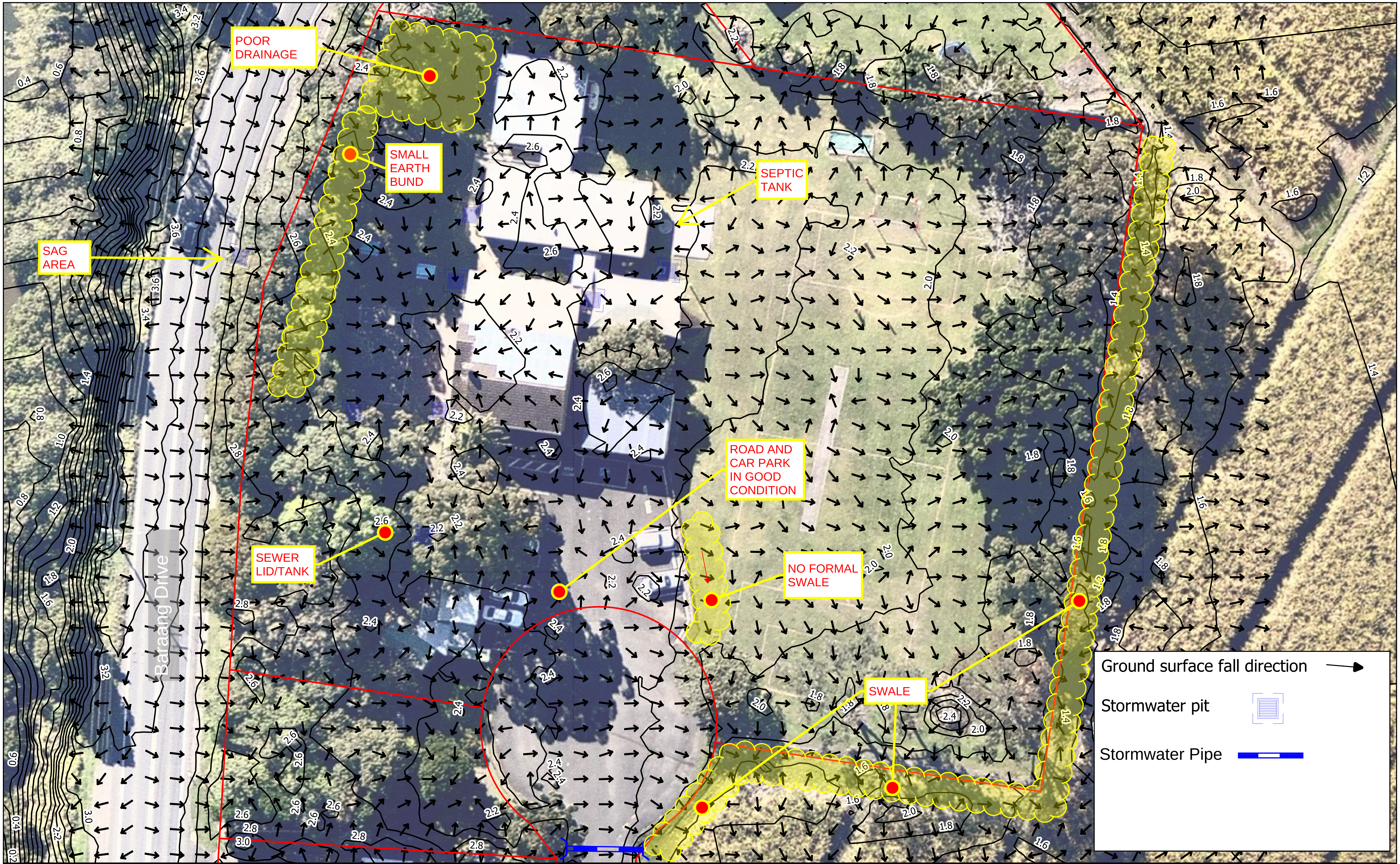
B.2.3.1 Current Day - Highest Astronomical Tide [High (medium confidence) predicted inundation scenario]

Coastal Risk Australia (https://coastalrisk.com.au/home)

B.2.3.2 Year 2100 (+ 0.84 m) - Highest Astronomical Tide [High (medium confidence) predicted inundation scenario]

Coastal Risk Australia (https://coastalrisk.com.au/home)

Appendix C Civil engineering notes plan



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0 5 10 m

Scale in metres (1:400 @ A3)
Map Projection: GDA94 Zone 56 (EPSG: 28356)
Horizontal Datum: Geocentric Datum of Australia 1994
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Department of Finance, Services and Innovation.

School Infrastructure NSW Northern NSW Flood Recovery

Plan 2 - Broadwater Public School civil engineering notes

Nearmap image date of capture 16 July 2022

Project Number: BR220288
Revision: 01
Drawn: KU
Date: 26/08/2022

Appendix D Glossary

AEP Annual Exceedance Probability	The chance of a flood of a given or larger size occurring in any one year, expressed as a percentage.
AHD Australian Height Datum	A common national surface level datum approximately corresponding to mean sea level. Australian Height Datum (AHD) is the value adopted by the National Mapping Council of Australia as the datum to which all vertical control for mapping in Australia is to be referred. AHD approximates mean sea level and could be considered as a still water level if there were no tides or meteorological events affecting water levels.
ARI Average recurrence interval	The long-term average number of years between the occurrence of a flood as big as or larger than the selected event.
Catchment	The land area draining through the mainstream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Design flood event	A flood event to be considered in the design process.
Design flood level (DFL)	A flood event where flood water rises to the Design flood level (DFL) for the area.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
Flood emergency management plan	A step-by-step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations. The objective is to ensure a coordinated response by all agencies having responsibilities and functions in emergencies.
Flood hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this study the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Floodplain Development Manual (2005).
Flood risk	The potential risk of flooding to people, their social setting, and their built and natural environment. The degree of risk varies with circumstances across the full range of floods.

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Floodplain, flood-prone land	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. the maximum extent of flood liable land. Flat or nearly flat land adjacent to a stream or river that experiences occasional or periodic flooding.
Freeboard	A vertical height above the predicted flood level used to set floor levels, levee crest levels, etc. to provide a higher level of certainty (for the chosen design flood event) that the floor level or crest level will not be overtopped. It is a factor of safety to decrease the uncertainty in the predicted flood level. Freeboard is a height above the DFL that takes account of matters that may cause flood waters to rise above the DFL.
Gauge height	The height of a flood level at a particular gauge site related to a specified datum. The datum may or may not be the AHD (see also Australian Height Datum).
GIS Geographical information systems	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydraulic category	A classification of floodwater hydraulic behaviour. The categories are: Floodway: those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways' are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels. Flood storage: those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. Loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Flood fringe: remaining area of flood-prone land after floodway and flood storage areas have been defined.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Overland flow	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
Peak discharge	The maximum discharge occurring during a flood event.

Probability	A statistical measure of the expected frequency or occurrence of flooding.
Probable Maximum Flood (PMF)	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from PMP and, where applicable, snow melt, coupled with the worst flood-producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood-prone land – that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event, should be addressed in a floodplain risk management study.
Probable Maximum Precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given-size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (WMO 1986). It is the primary input to probable maximum flood estimation.
Representative Concentration Pathways (RCP)	RCPs make predictions of how concentrations of greenhouse gases in the atmosphere will change in future as a result of human activities. The four RCPs range from very high (RCP8.5) through to very low (RCP2.6) future concentrations. The numerical values of the RCPs (2.6, 4.5, 6.0 and 8.5) refer to the concentrations in 2100.
Risk	Refer to 'Flood risk' above.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Vulnerability	The degree of susceptibility and resilience of a business, and the natural and built environments to flood hazards. Vulnerability is assessed in terms of ability of the business and environment to anticipate, cope and recover from flood events.