Table 11.1 Redbank Creek catchment residential damage disbenefits and costs summary for base case

Summary of residential damage												
Event	No. of properties flooded above ground	No. of properties flooded above floor	Total damage	Contribution to AAD Total	Damage / Cost components (Contribution to AAD)							
					Structural	Contents	External	Intangibles	Infrastructure uplift	Mental health	Clean-up	Social and wellbeing
PMF	2,145	1,310	$303,922,373	$55,018	$28,280	$14,308	$4,363	$8,068	$5,502	$1,443	$1,155	$0
1 in 5,000 AEP	2,069	1,232	$275,217,753	$47,719	$25,263	$12,331	$3,989	$6,136	$4,772	$1,225	$1,056	$0
1 in 2,000 AEP	515	240	$42,909,347	$54,209	$33,109	$13,205	$5,718	$2,178	$5,421	$1,190	$1,513	$0
1 in 500 AEP	397	182	$29,369,552	$70,623	$44,229	$16,135	$8,102	$2,158	$7,062	$1,414	$2,145	$0
1 in 200 AEP	283	117	$17,712,283	$79,187	$49,566	$17,649	$9,484	$2,487	$7,919	$1,547	$2,510	$0
1% AEP	242	93	$13,962,329	$123,076	$77,074	$27,467	$14,904	$3,631	$12,308	$2,414	$3,945	$1,227
2% AEP	202	72	$10,652,895	$267,261	$171,076	$57,045	$33,059	$6,082	$26,726	$4,843	$8,751	$10,403
5% AEP	164	50	$7,164,512	$276,311	$181,531	$52,768	$37,485	$4,526	$27,631	$4,154	$9,922	$11,417
10% AEP	116	33	$3,887,913	$286,330	$188,647	$53,691	$39,743	$4,249	$28,633	$4,249	$10,520	$15,289
20% AEP	54	11	$1,838,679	$275,802	$188,915	$52,831	$29,807	$4,249	$27,580	$4,249	$7,890	$7,668
Total AAD				**$1,535,535**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Table 11.2 Redbank Creek catchment commercial / industrial buildings damage disbenefits and costs summary for base case

Summary of commercial / industrial and public buildings damage						
Event	No. of properties flooded above ground	No. of properties flooded above floor	Total damage	Contribution to AAD Total	Damage / Cost components (Contribution to AAD)	
					Structural and Internal	Loss of trading + Clean-up
PMF	80	70	$22,842,042	$4,106	$4,106	$1,232
1 in 5,000 AEP	80	70	$20,381,547	$3,876	$3,876	$1,163
1 in 2,000 AEP	34	31	$5,458,890	$7,535	$7,535	$2,261
1 in 500 AEP	30	26	$4,588,130	$10,919	$10,919	$3,276
1 in 200 AEP	19	15	$2,690,878	$12,381	$12,381	$3,714
1% AEP	14	10	$2,261,542	$19,050	$19,050	$5,715
2% AEP	11	6	$1,548,549	$44,863	$44,863	$13,459
5% AEP	8	5	$1,442,322	$62,720	$62,720	$18,816
10% AEP	4	3	$1,066,459	$92,007	$92,007	$27,602
20% AEP	2	2	$773,686	$116,053	$116,053	$34,816
Total AAD				**$373,510**	**-**	**-**

Table 11.3 Redbank Creek catchment public buildings damage disbenefits and costs summary for base case

Summary of commercial / industrial and public buildings damage						
Event	No. of properties flooded above ground	No. of properties flooded above floor	Total damage	Contribution to AAD Total	Damage / Cost components (Contribution to AAD)	
					Structural and Internal	Loss of trading + Clean-up
PMF	27	25	4,605,847	$855	$855	$257
1 in 5000 AEP	27	25	4,397,625	$840	$840	$252
1 in 2000 AEP	11	11	1,205,135	$1,569	$1,569	$471
1 in 500 AEP	9	8	886,934	$2,556	$2,556	$767
1 in 200 AEP	7	7	817,082	$3,375	$3,375	$1,012
1% AEP	4	4	532,909	$5,258	$5,258	$1,577
2% AEP	4	4	518,695	$12,803	$12,803	$3,841
5% AEP	4	4	334,815	$8,458	$8,458	$2,537
10% AEP	1	1	3,504	$350	$350	$105
20% AEP	1	1	3,504	$526	$526	$158
Total AAD				**$36,590**	**-**	**-**

Table 11.4 Summary of sensitivity analysis of number of steps on AAD

Event	Plus One Step				Existing case				Minus One Step			
	Residential		Commercial / Industrial		Residential		Commercial / Industrial		Residential		Commercial / Industrial	
	Total damage	Contribution to AAD Total	Total damage	Contribution to AAD Total	Total damage	Contribution to AAD Total	Total damage	Contribution to AAD Total	Total damage	Contribution to AAD Total	Total damage	Contribution to AAD Total
PMF	$240,614,381	$42,996	$17,698,440	$3,091	$303,922,373	$55,018	$22,842,042	$4,106	$416,578,365	$76,331	$24,771,325	$4,479
1 in 5000	$211,977,528	$35,724	$14,837,328	$2,590	$275,217,753	$47,719	$20,381,547	$3,876	$386,906,827	$67,951	$22,375,420	$4,203
1 in 2000	$26,183,826	$29,980	$2,428,486	$3,197	$42,909,347	$54,209	$5,458,890	$7,535	$66,101,327	$85,594	$5,647,881	$7,847
1 in 500	$13,789,419	$33,283	$1,833,939	$4,818	$29,369,552	$70,623	$4,588,130	$10,919	$48,023,524	$118,503	$4,815,316	$11,604
1 in 200	$8,398,958	$37,126	$1,377,849	$6,703	$17,712,283	$79,187	$2,690,878	$12,381	$30,978,326	$140,914	$2,920,557	$13,270
1% AEP	$6,451,423	$57,216	$1,303,535	$11,580	$13,962,329	$123,076	$2,261,542	$19,050	$25,387,177	$225,171	$2,387,484	$19,962
2% AEP	$4,991,757	$110,422	$1,012,368	$27,237	$10,652,895	$267,261	$1,548,549	$44,863	$19,647,071	$513,791	$1,604,825	$46,066
5% AEP	$2,369,678	$91,085	$803,413	$29,047	$7,164,512	$276,311	$1,442,322	$62,720	$14,605,630	$566,460	$1,466,256	$63,318
10% AEP	$1,273,732	$91,902	$358,456	$26,884	$3,887,913	$286,330	$1,066,459	$92,007	$8,052,758	$607,252	$1,066,459	$92,007
20% AEP	$564,307	$84,646	$179,228	$26,884	$1,838,679	$275,802	$773,686	$116,053	$4,092,280	$613,842	$773,686	$116,053
Total AAD	**-**	**$614,380**	**-**	**$142,030**	**-**	**$1,535,535**	**-**	**$373,510**	**-**	**$3,015,808**	**-**	**$378,809**
% Difference	**-**	**-60%**	**-**	**-62%**	**-**	**-**	**-**	**-**	**-**	**96%**	**-**	**1%**

11.3 Key infrastructure assets

There are two main types of key infrastructure assets as presented below:

- The first type includes facilities that are occupied by emergency responders such as police stations, fire stations or SES centres.
- The second type includes facilities with particularly vulnerable residents such as schools, childcare centres, aged care facilities and hospitals.

The locations of these key assets have been sourced from publicly available information (e.g., Google Map). A list of these facilities is provided in **Table 11.5** along with a brief description of the flood affectation of each asset. A map showing the location of the main infrastructure assets is presented in **Figure 11.1**.

Table 11.5 List of Key Infrastructure assets

Location	Comments on Flood Risk
Police and Fire Stations	
Police Station	There are no Police Stations located within the study area. The nearest Police Station is Windsor Police Station located at Mileham St, Windsor.
SES Centres	
SES	There are no SES facilities located within the study area.
Hospital and Ambulance Stations	
St John of God Richmond Hospital	St John of God Richmond Hospital is outside the PMF extent and access to the hospital may become limited during a PMF event.
Schools	
Kuyper Christian School	A few buildings of the school are impacted by local overland flooding from 1 in 5,000 AEP event. However, Redbank Road access approximately 2 km south of the school may be impacted from the 1% AEP event.
Richmond North Public School – Elementary School	The school is within the extent of the 1 in 5,000 AEP flood event and the access roads may also be impacted from the 1 in 5,000 AEP event.
Colo High School	A few buildings of the school are impacted by local overland flooding from the 1 in 5000 AEP event. However, Bells Line of Road bridge (road bridge) may be impacted from the 1 in 5,000 AEP event.
Childcare Facilities and Preschools	
Elizabeth Street Extended Hours Pre-School	The pre-school building is impacted by a 1 in 500 AEP flood event. Elizabeth Street access may become limited from the 1 in 500 AEP event.
Caring 4 Kids	The childcare centre is affected by the 1 in 5,000 AEP flood event and

Location	Comments on Flood Risk
	the access roads may be impacted from the 1 in 5,000 AEP event.
Aged Care Facilities and Retirement Villages	
RSL LifeCare	The RSL Lifecare building is outside of the extent of the PMF event; however, the access to the building may become limited during a 1 in 5,000 AEP flood event.
Designated Evacuation Centres	
North Richmond Community Centre	The North Richmond Community Centre is used as an evacuation centre for the township of North Richmond. The lot is impacted by an overland flow as frequent as a 20% AEP event to depths up to 0.25 m. This venue is impacted above the floor by an overland flow as frequent as a 20% AEP event to a depth of up to 0.03 m. Moreover, access to this venue by residents of various parts of the township may be restricted. It is therefore recommended that careful consideration be given to the design and management of the evacuation centre.
Turnbull Oval	The Turnbull Oval is used as an evacuation centre for the township of North Richmond. The majority of this oval is outside of the extent of a PMF event. However, access to the oval by residents of northern parts of the township may be restricted from the 1 in 200 AEP event and Terrace Road access will become limited for the majority of residents from the 1 in 5,000 AEP event.
Key plants	
North Richmond water filtration plant	The water filtration plant is outside of the extent of the PMF event; however, the Grose Vale Road access may get impacted from the 1 in 5,000 AEP event.
North Richmond wastewater treatment plant	The wastewater treatment plant is affected from the 1 in 5,000 AEP event; while Bell Lines of Road bridge (road bridge) access may become limited from the 1 in 5,000 AEP event.

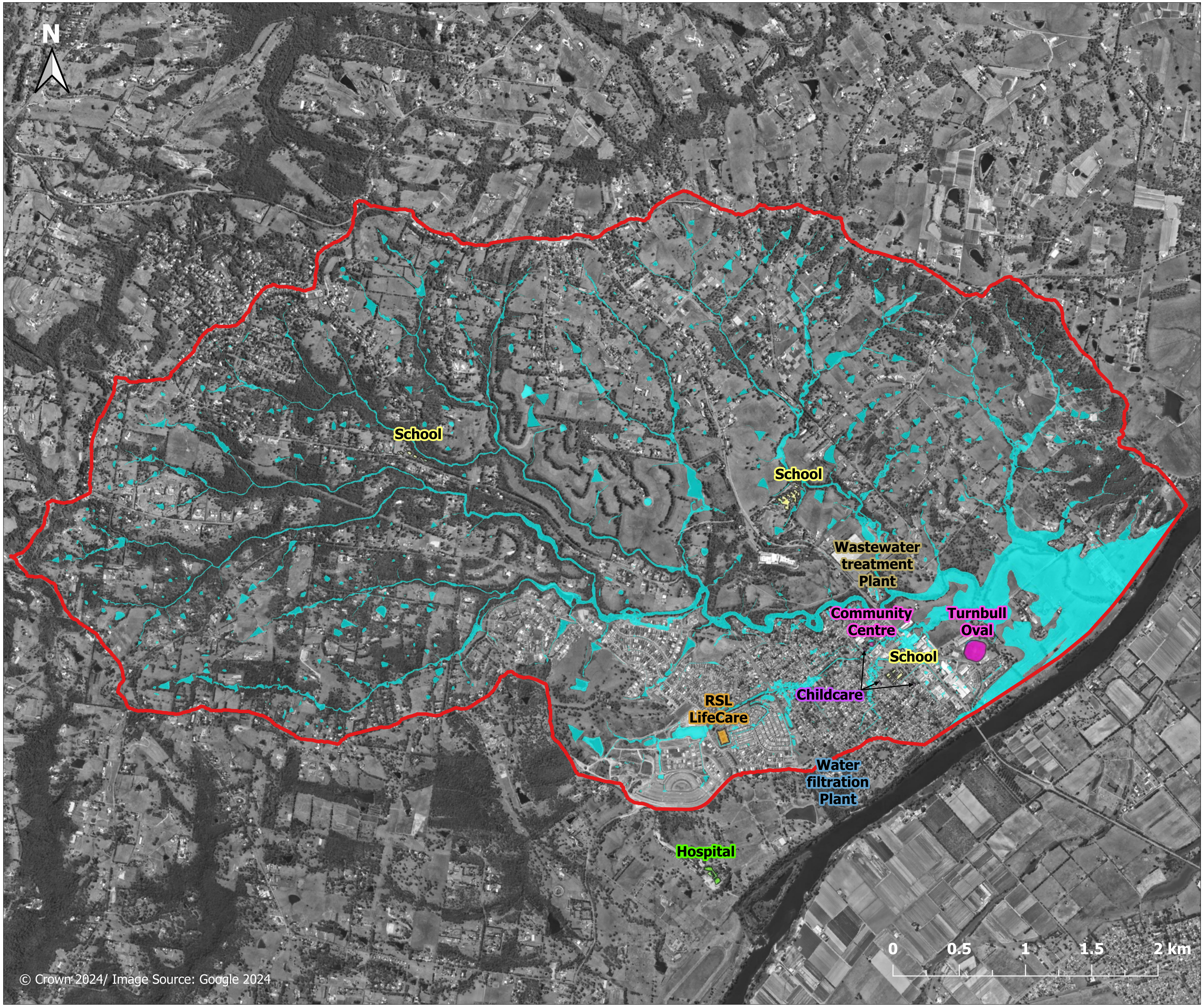

Figure 11.1

Key infrastructure locations

Report MHL3008

Redbank Creek Flood Study

NSW GOVERNMENT

Manly Hydraulics Laboratory

11.4 Road closure

An assessment of the frequency and hazard of road inundation is important to understand the risk of vehicles becoming unstable, posing a risk to life for their drivers and passengers. It is also important in order to understand evacuation risks and informing the classification of communities according to flood emergency response planning considerations. Measures to increase the flood immunity of critical roads could be considered as a result of this assessment. **Appendix G** depicts the flood events which result in road closures within the North Richmond township. Road closure was assumed as occurring when the depth of water over road reaches over 0.15 m, which is the depth that can start mobilising cars. This value was selected in liaison with the NSW SES. While the NSW SES recommends to never drive through floodwater due to the potential risk of driving through localised deeper areas or obstacles, not visible from the surface, this depth was considered to be a reasonable value for the purpose of flagging a road as closed in a flood study. **Table 11.6** summarises the peak depth, duration of flooding over 0.15 m and time to depth above 0.15 m for each location presented in **Appendix G** .

Table 11.6 Peak depth, duration of flooding over 0.15 m and time to depth above 0.15 m at road closure locations

Road ID-	First AEP to flood-	Peak depth (m)											Duration of depth above 0.15 m (hr)											Time to depth above 0.15 m										
		20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	1 in 200 AEP	1 in 500 AEP	1 in 1,000 AEP	1 in 2,000 AEP	1 in 5,000 AEP	PMF	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	1 in 200 AEP	1 in 500 AEP	1 in 1,000 AEP	1 in 2,000 AEP	1 in 5,000 AEP	PMF	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	1 in 200 AEP	1 in 500 AEP	1 in 1,000 AEP	1 in 2,000 AEP	1 in 5,000 AEP	PMF
1	20%	0.27	0.30	0.31	0.33	0.34	0.34	0.36	0.36	0.37	0.50	0.50	3.12	5.08	6.21	6.89	8.00	8.72	18.59	18.60	18.69	19.65	19.87	7.30	7.31	6.70	4.42	4.27	4.00	3.84	3.72	3.58	0.40	0.24
2	20%	0.19	0.21	0.22	0.24	0.25	0.26	0.31	0.32	0.33	0.50	0.50	-	0.04	0.24	0.37	0.47	0.56	1.51	1.73	2.08	11.22	11.35	-	1.58	1.59	7.27	7.33	7.33	7.16	7.12	7.07	0.49	0.31
3	20%	0.18	0.21	0.23	0.24	0.25	0.26	0.29	0.30	0.31	0.39	0.40	0.25	0.51	0.59	1.18	1.54	1.73	7.62	8.60	9.10	12.05	12.14	1.64	1.58	7.25	7.09	6.06	4.40	4.26	4.20	4.06	0.34	0.21
4	20%	0.15	0.18	0.21	0.22	0.23	0.23	0.24	0.24	0.25	0.47	0.47	-	0.02	0.44	0.69	1.03	1.22	1.45	1.86	2.21	10.26	10.42	-	1.66	7.36	4.98	4.77	7.41	4.13	7.38	7.23	0.84	0.74
5	1%	-	0.10	0.14	0.15	0.15	0.16	0.17	0.17	0.18	0.38	0.38	-	-	-	-	-	-	0.31	0.45	0.51	8.92	9.04	-	-	-	-	-	-	1.16	1.08	1.09	1.14	1.12
6	20%	0.50	0.57	0.69	0.73	0.77	0.80	0.96	1.00	1.03	2.24	2.45	18.58	18.76	19.05	18.73	18.86	18.91	19.11	19.07	19.12	19.73	*20.08*	2.14	1.80	1.51	1.52	1.41	1.35	1.23	1.16	1.10	0.27	0.00
7	5%	0.11	0.15	0.17	0.18	0.21	0.23	0.30	0.31	0.33	1.37	1.72	-	-	0.15	0.31	0.48	0.58	1.91	2.25	2.58	11.20	11.48	-	-	1.86	7.41	7.46	7.40	7.43	7.34	7.31	0.82	0.58
8	1 in 5,000	-	-	-	-	-	0.05	0.08	0.08	0.09	0.40	0.57	-	-	-	-	-	-	-	-	-	1.42	1.56	-	-	-	-	-	-	-	-	-	0.79	0.79
9	20%	0.31	0.37	0.42	0.45	0.48	0.49	0.55	0.57	0.58	1.01	1.02	1.43	2.40	5.85	6.03	7.21	8.60	12.13	12.18	12.25	13.06	13.20	7.42	7.37	6.89	4.24	4.09	3.99	3.85	3.78	3.73	0.47	0.27
10	20%	0.19	0.25	0.29	0.30	0.32	0.33	0.37	0.39	0.41	0.66	0.66	0.05	0.20	0.36	0.63	0.88	1.01	1.88	2.10	2.31	10.46	10.76	1.70	1.62	7.29	7.11	7.03	6.21	4.75	4.89	4.84	0.58	0.35
11	20%	0.33	0.36	0.40	0.40	0.41	0.42	0.47	0.49	0.51	0.72	0.72	3.57	5.26	17.75	17.65	17.77	17.78	17.83	17.81	17.86	18.38	18.58	6.72	5.31	4.91	3.72	3.58	3.37	2.84	2.53	2.37	0.23	0.14
12	20%	0.25	0.26	0.27	0.27	0.27	0.28	0.30	0.30	0.31	0.38	0.38	17.68	17.92	18.08	18.07	18.18	18.23	18.30	18.27	18.32	18.95	19.12	1.49	1.25	1.09	1.15	1.04	1.00	0.92	0.87	0.83	0.20	0.13
13	5%	0.07	0.12	0.24	0.26	0.30	0.35	0.41	0.44	0.46	1.06	1.11	-	-	4.04	6.49	7.36	7.77	8.61	9.30	9.91	12.70	13.03	-	-	7.24	7.38	7.46	7.41	7.25	6.78	5.01	0.79	0.60
14	20%	0.19	0.24	0.38	0.41	0.50	0.62	0.76	0.81	0.85	2.10	2.19	1.31	3.35	8.97	10.86	11.22	11.43	19.03	19.04	19.10	19.75	19.90	7.46	7.51	7.52	7.14	6.53	4.39	4.21	4.11	3.98	0.59	0.26
15	20%	0.45	0.59	0.71	0.74	0.78	0.81	0.88	0.90	0.92	1.50	1.58	3.46	5.75	7.76	9.42	10.09	10.62	19.00	18.98	19.03	19.73	19.90	7.16	6.89	5.39	4.05	3.85	3.74	3.52	3.01	2.69	0.50	0.25
16	20%	0.20	0.34	0.45	0.49	0.66	0.79	0.91	0.94	0.96	1.74	1.80	-	1.81	3.15	6.63	7.19	7.48	18.49	18.48	18.54	19.29	19.46	-	7.59	7.13	6.50	6.38	4.51	4.15	4.04	3.86	0.61	0.33
17	1 in 5,000	-	-	-	-	-	-	-	-	-	0.30	0.31	-	-	-	-	-	-	-	-	-	0.79	0.89	-	-	-	-	-	-	-	-	-	1.42	0.93
18	5%	-	0.13	0.17	0.20	0.22	0.23	0.28	0.29	0.30	0.54	0.62	-	0.17	2.36	1.68	3.78	5.15	13.25	13.40	13.55	15.46	15.72	-	2.02	7.81	7.41	7.40	7.33	7.19	6.93	4.54	0.66	0.43
19	1 in 5000	-	-	-	-	-	-	-	-	-	0.54	0.73	-	-	-	-	-	-	-	-	-	0.55	0.57	-	-	-	-	-	-	-	-	-	1.74	1.73
20	20%	0.21	0.27	0.58	0.61	0.63	0.64	0.91	1.16	1.32	5.96	6.24	3.78	5.01	18.76	18.33	18.52	18.62	18.77	18.78	18.86	19.70	19.90	5.82	5.12	4.41	3.33	2.91	2.79	2.49	2.31	1.97	0.30	0.17
21	20%	0.27	0.28	0.30	0.30	0.31	0.31	0.53	0.77	0.95	5.71	5.97	18.70	18.89	19.04	18.75	18.87	18.93	19.01	18.98	19.03	19.71	19.90	1.68	1.39	1.22	1.29	1.17	1.11	1.02	0.96	0.92	0.24	0.16
22	20%	0.53	0.55	0.57	0.59	0.60	0.61	0.64	0.65	0.65	2.95	3.30	19.00	19.15	19.32	19.05	19.12	19.15	19.22	19.17	19.21	19.78	19.94	1.39	1.20	1.07	1.12	1.03	0.99	0.91	0.87	0.83	0.21	0.15
23	10%	0.13	0.30	0.38	0.40	0.41	0.42	0.43	0.44	0.45	4.95	5.28	-	0.73	18.88	18.55	18.69	18.75	18.87	18.85	18.91	19.66	19.87	-	7.60	7.42	7.41	7.26	7.21	7.13	7.07	4.43	0.63	0.29
24	5%	-	-	0.74	0.77	0.78	0.79	0.79	0.80	0.81	4.77	5.08	-	-	18.62	18.10	18.32	18.43	18.62	18.64	18.74	19.68	19.88	-	-	2.11	1.96	1.73	1.61	7.78	7.67	7.58	1.24	1.00
25	1 in 200	-	0.10	0.12	0.13	0.15	0.16	0.20	0.21	0.22	0.88	1.14	-	-	-	-	-	0.10	0.69	0.78	0.93	9.50	9.79	-	-	-	-	-	1.18	6.22	6.17	6.68	0.98	0.93
26	20%	0.32	0.33	0.33	0.34	0.35	0.35	0.36	0.37	0.37	0.43	0.43	16.37	16.66	16.96	17.02	17.11	17.15	19.17	19.12	19.16	19.68	19.83	1.54	1.38	0.97	1.01	0.90	0.86	0.79	0.75	0.72	0.17	0.13
27	20%	0.59	0.62	0.65	0.66	0.66	0.67	0.70	0.70	0.71	0.82	0.83	19.44	19.51	19.57	19.33	19.38	19.40	19.44	19.38	19.41	19.82	19.97	0.85	0.76	0.69	0.73	0.68	0.66	0.62	0.59	0.56	0.14	0.11
28	20%	0.51	0.58	0.62	0.74	0.78	0.82	0.86	0.89	0.92	2.58	2.82	4.04	5.34	8.91	11.14	11.39	11.52	18.25	18.23	18.28	18.99	19.16	8.67	7.76	7.25	5.77	5.10	4.85	3.92	3.86	3.79	0.32	0.22
29	20%	0.35	0.45	0.53	0.65	0.69	0.72	0.77	0.79	0.82	3.74	4.02	2.11	3.81	6.48	8.93	9.66	9.86	12.47	12.58	12.70	13.86	14.04	9.15	8.20	7.65	7.25	5.72	5.14	4.80	4.60	4.44	0.71	0.48
30	20%	0.44	0.52	0.59	0.68	0.72	0.74	0.76	0.78	0.80	3.58	3.86	19.03	19.18	19.29	19.03	19.10	19.13	19.19	19.14	19.18	19.76	19.94	1.26	1.10	0.99	1.04	0.96	0.92	0.86	0.82	0.79	0.20	0.14
31	20%	0.31	0.33	0.34	0.35	0.36	0.37	0.39	0.40	0.41	0.56	0.56	11.99	12.20	12.32	12.35	12.45	12.51	19.26	19.21	19.24	19.78	19.93	1.47	1.26	1.12	1.18	1.08	1.03	0.96	0.92	0.88	0.24	0.18

Road ID-	First AEP to flood-	Peak depth (m)											Duration of depth above 0.15 m (hr)											Time to depth above 0.15 m										
		20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	1 in 200 AEP	1 in 500 AEP	1 in 1,000 AEP	1 in 2,000 AEP	1 in 5,000 AEP	PMF	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	1 in 200 AEP	1 in 500 AEP	1 in 1,000 AEP	1 in 2,000 AEP	1 in 5,000 AEP	PMF	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	1 in 200 AEP	1 in 500 AEP	1 in 1,000 AEP	1 in 2,000 AEP	1 in 5,000 AEP	PMF
32	10%	0.15	0.17	0.19	0.20	0.21	0.22	0.23	0.25	0.26	0.41	0.42	-	0.33	0.44	0.77	0.97	1.10	2.10	2.38	2.58	11.23	11.42	-	1.61	1.56	7.00	6.91	6.20	5.96	4.51	4.14	0.44	0.26
33	1 in 5,000	-	-	-	-	0.05	0.06	0.07	0.07	0.07	0.33	0.34	-	-	-	-	-	0.04	0.10	0.11	0.13	2.74	2.82	-	-	-	-	-	1.26	1.14	1.10	7.39	1.27	1.26
34	1%	0.09	0.11	0.13	0.15	0.16	0.17	0.18	0.19	0.20	0.54	0.54	-	-	-	-	0.10	0.14	0.23	0.28	0.32	7.84	8.02	-	-	-	-	1.20	1.16	7.35	7.25	7.18	1.36	1.35
35	10%	0.14	0.16	0.18	0.18	0.19	0.19	0.20	0.20	0.21	0.33	0.33	-	0.20	0.32	0.52	0.64	0.75	1.26	1.46	1.62	10.97	11.30	-	1.65	1.58	7.05	6.95	6.89	4.52	4.31	4.13	0.53	0.26
36	10%	0.14	0.16	0.21	0.22	0.23	0.23	0.24	0.24	0.25	0.32	0.32	-	0.39	4.06	4.68	5.26	5.61	6.17	7.14	7.61	11.98	12.13	-	1.50	4.71	3.44	3.27	3.20	3.09	2.56	2.28	1.26	1.24
37	10%	-	0.15	0.19	0.20	0.21	0.22	0.29	0.30	0.31	0.39	0.39	-	-	0.12	0.21	0.27	0.34	5.12	5.66	6.26	11.60	11.86	-	-	1.61	1.16	1.18	1.14	7.16	7.09	6.38	0.83	0.78
38	1 in 5,000	-	-	-	-	-	-	0.11	0.12	0.13	0.25	0.26	-	-	-	-	-	-	-	-	-	1.29	1.32	-	-	-	-	-	-	-	-	-	1.01	1.00
39	1 in 500	-	0.11	0.13	0.14	0.14	0.15	0.16	0.17	0.18	0.37	0.37	-	-	-	-	-	-	-	-	0.07	4.84	4.96	-	-	-	-	-	-	-	-	0.31	1.34	1.29
40	10%	-	0.16	0.19	0.20	0.22	0.23	0.26	0.27	0.28	0.39	0.39	-	0.14	0.31	0.39	0.50	0.56	11.17	11.25	11.37	12.77	12.88	-	1.63	1.61	7.28	7.33	7.41	7.27	7.18	7.13	0.55	0.32
41	1 in 5,000	-	-	-	-	-	-	-	0.07	0.08	0.19	0.19	-	-	-	-	-	-	-	-	-	0.31	0.33	-	-	-	-	-	-	-	-	-	0.29	0.22
42	1 in 1,000	-	-	-	-	0.08	0.10	0.15	0.16	0.16	0.27	0.27	-	-	-	-	-	-	0.04	0.06	0.08	2.89	2.93	-	-	-	-	-	-	0.31	0.30	0.29	1.08	1.06
43	20%	0.17	0.21	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.59	0.60	0.52	1.18	5.29	6.22	6.90	7.42	8.26	8.87	9.29	11.98	12.24	7.18	6.78	4.92	7.06	7.25	7.23	7.16	7.11	7.02	0.63	0.28
44	5%	-	-	0.15	0.15	0.16	0.18	0.20	0.21	0.22	0.39	0.40	-	-	0.05	0.10	0.25	0.30	0.36	0.40	0.44	8.61	8.98	-	-	1.60	1.20	1.10	1.17	1.04	1.15	6.99	0.80	0.76
45	5%	-	0.09	0.16	0.17	0.19	0.19	0.21	0.22	0.23	0.57	0.60	-	-	0.09	0.18	0.28	0.32	0.43	0.48	0.57	9.45	9.96	-	-	1.61	1.20	1.13	1.10	7.19	7.20	7.11	0.91	0.90
46	5%	-	-	0.15	0.18	0.20	0.21	0.22	0.23	0.24	0.52	0.52	-	-	-	0.76	0.98	1.15	1.54	1.93	2.13	10.90	11.30	-	-	-	6.29	6.19	5.96	5.72	4.10	4.02	0.69	0.34
47	2%	-	-	0.15	0.17	0.21	0.22	0.25	0.26	0.27	0.56	0.57	-	-	-	-	0.92	1.15	1.36	1.52	1.66	10.03	10.39	-	-	-	-	6.68	6.60	6.12	6.10	6.02	0.87	0.76
48	5%	0.14	0.15	0.17	0.18	0.20	0.21	0.29	0.31	0.32	0.49	0.49	0.33	0.48	0.56	1.14	1.35	1.63	10.65	10.75	10.88	12.37	12.44	1.52	7.29	7.02	4.45	7.15	7.10	7.15	7.09	7.06	0.58	0.30
49	1 in 5,000	-	-	-	-	-	0.07	0.11	0.11	0.12	0.26	0.26	-	-	-	-	-	-	-	-	-	1.35	1.42	-	-	-	-	-	-	-	-	-	0.58	0.50
50	1 in 5,000	-	-	-	-	-	-	-	-	-	0.24	0.25	-	-	-	-	-	-	-	-	-	1.55	1.69	-	-	-	-	-	-	-	-	-	0.47	0.32
51	1 in 200	-	-	-	-	-	0.19	0.19	0.20	0.21	0.35	0.35	-	-	-	-	-	-	-	-	-	1.61	1.70	-	-	-	-	-	-	-	-	-	0.43	0.33
52	20%	0.99	1.14	1.21	1.51	1.64	1.73	1.88	1.99	2.20	7.18	7.37	11.42	11.97	12.39	14.73	14.94	15.04	15.16	15.15	15.34	18.23	18.72	7.11	6.80	6.60	4.15	3.95	3.85	3.75	3.69	2.86	0.64	0.25
53	5%	-	0.07	0.18	0.20	0.24	0.27	0.31	0.33	0.35	1.14	1.17	-	-	0.19	0.40	0.60	0.72	1.00	1.26	1.52	10.55	11.00	-	-	1.79	7.25	6.34	7.31	5.82	7.33	7.25	0.81	0.51
54	1 in 5,000	-	-	0.06	0.06	0.08	0.08	0.10	0.12	0.14	0.49	0.49	-	-	-	-	-	-	-	-	-	1.10	1.17	-	-	-	-	-	-	-	-	-	0.49	0.44
55	1 in 500	-	0.08	0.10	0.10	0.11	0.13	0.15	0.17	0.18	0.35	0.35	-	-	-	-	-	-	0.04	0.07	0.10	3.96	4.05	-	-	-	-	-	-	0.32	0.31	0.29	1.18	1.15
56	10%	0.12	0.19	0.24	0.24	0.25	0.26	0.28	0.30	0.31	0.44	0.44	0.20	0.38	8.10	8.22	8.80	9.32	9.63	9.81	10.00	12.97	13.18	1.73	7.30	6.85	7.21	7.17	7.13	6.53	5.73	5.65	0.59	0.22
57	1%	-	-	0.09	0.14	0.20	0.23	0.27	0.30	0.33	0.96	0.98	-	-	0.13	0.25	0.37	0.45	0.57	0.82	1.02	10.16	10.60	-	-	1.69	7.25	7.21	7.15	5.75	5.25	5.28	0.71	0.33
58	1%	-	-	0.09	0.12	0.16	0.19	0.22	0.24	0.26	0.66	0.66	1.45	2.04	2.78	2.72	3.35	3.84	4.48	5.13	6.53	11.34	11.79	6.95	6.84	5.45	4.62	4.46	4.33	4.14	3.84	3.34	0.68	0.30
59	2%	-	-	-	2.79	2.80	2.82	2.83	3.90	3.90	4.79	5.95	-	-	-	*20.07*	*20.06*	*20.06*	*20.05*	19.97	19.97	19.96	*20.08*	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	2%	-	-	-	3.65	3.65	3.65	3.65	4.68	4.68	4.74	6.62	-	-	-	*20.07*	*20.06*	*20.06*	*20.05*	19.97	19.97	19.96	*20.08*	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
61	1 in 5,000	-	0.05	0.06	0.07	0.09	0.09	0.10	0.11	0.11	0.29	0.29	-	-	-	-	-	-	-	-	-	1.51	1.64	-	-	-	-	-	-	-	-	-	0.38	0.26
62	1 in 5,000	-	-	-	-	-	-	-	-	0.09	3.06	3.27	-	-	-	-	-	-	-	-	-	9.04	10.90	-	-	-	-	-	-	-	-	-	1.53	1.11

		Peak depth (m)											Duration of depth above 0.15 m (hr)											Time to depth above 0.15 m										
Road ID-	**First AEP to flood-**	**20% AEP**	**10% AEP**	**5% AEP**	**2% AEP**	**1% AEP**	**1 in 200 AEP**	**1 in 500 AEP**	**1 in 1,000 AEP**	**1 in 2,000 AEP**	**1 in 5,000 AEP**	**PMF**	**20% AEP**	**10% AEP**	**5% AEP**	**2% AEP**	**1% AEP**	**1 in 200 AEP**	**1 in 500 AEP**	**1 in 1,000 AEP**	**1 in 2,000 AEP**	**1 in 5,000 AEP**	**PMF**	**20% AEP**	**10% AEP**	**5% AEP**	**2% AEP**	**1% AEP**	**1 in 200 AEP**	**1 in 500 AEP**	**1 in 1,000 AEP**	**1 in 2,000 AEP**	**1 in 5,000 AEP**	**PMF**
63	1 in 500	0.07	0.11	0.13	0.13	0.14	0.14	0.16	0.17	0.18	0.25	0.25	-	-	-	-	0.12	0.15	0.20	0.22	0.25	4.80	5.01	-	-	-	-	1.14	1.10	1.06	1.03	7.14	0.63	0.45
64	1 in 5,000	-	-	-	-	-	0.06	0.09	0.11	0.12	0.31	0.31	-	-	-	-	-	-	-	-	-	1.04	1.12	-	-	-	-	-	-	-	-	-	0.61	0.60
65	1 in 1,000	-	0.07	0.09	0.09	0.10	0.11	0.15	0.17	0.18	0.35	0.35	-	-	-	-	-	-	-	-	-	1.44	1.55	-	-	-	-	-	-	-	-	-	0.45	0.24
66	20%	0.17	0.22	0.24	0.27	0.31	0.37	0.55	0.60	0.64	1.78	2.05	0.80	1.65	2.36	2.97	4.11	4.75	11.93	12.04	12.16	13.53	13.74	7.53	7.57	7.50	7.15	4.42	4.31	4.17	4.06	3.95	0.66	0.42
67	20%	0.25	0.26	0.30	0.34	0.37	0.40	0.58	0.63	0.66	1.88	2.09	18.16	18.37	18.53	18.19	18.34	18.40	18.50	18.49	18.55	19.43	*20.08*	2.47	2.11	1.96	2.03	1.87	1.79	1.64	1.56	1.49	0.54	0.00

N.B.: Durations in italic are likely to be exceeded as the depth in the model was still higher than 0.15 m at the end of the simulation.

12 Post-processing of results

12.1 Preamble

Upon completion of the flood mapping for the main parameters (water level, depth, and velocity), it became possible to determine the flood function, flood hazard and flood emergency response classification resulting from these data. Development of such categorisations is described in this section.

12.2 Flood hazard

A starting point for the assessment of Flood Life Hazard categories is to better understand the flood hazard. Flood risk management guideline (FB03) (DPE, 2023c) present a set of hazard vulnerability curves shown in **Figure 12.1**. This shows how flood depths, velocities and depth-velocity product affect the stability of vehicles, pedestrians and buildings.

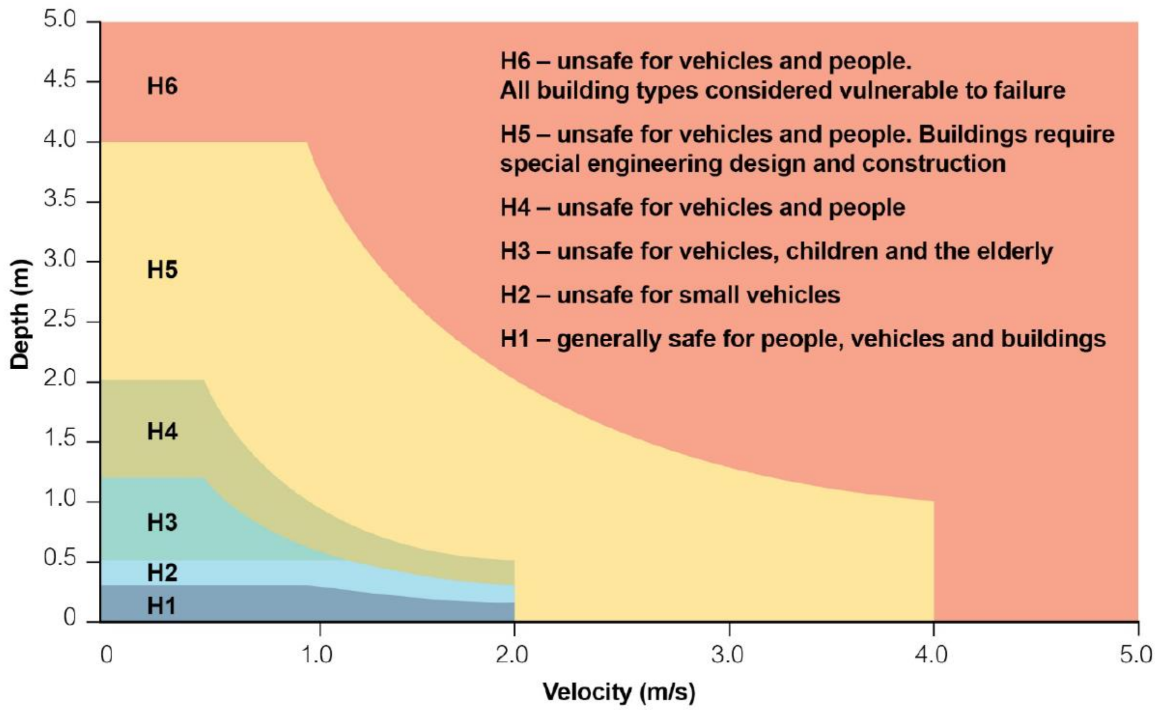

Figure 12.1 General flood hazard vulnerability curves; Source: (DPE, 2023c)

Appendix H presents the hazard vulnerability categories based on the H1 to H6 delineations for the 5%, 1%, 1 in 200, 1 in 500 AEP events and the PMF.

During the 5%, 1%, 1 in 200 and 1 in 500 AEP flood events, the extent of hazard conditions between H3 and H6 remain typically concentrated along Redbank Creek and drainage channels, while the majority of the township flooding is classified as H1 or H2 hazard category. However, some larger areas of hazard classification H3 can be observed at:

- The northern end of Elizabeth Street,
- The northern end of Micheal Street north-west of Gregory Street,
- Tyne Crescent north-west of Stephen Street,
- Susella crescent,
- Areas between Stephen Street and Pecks Road north of Arnorld Street,
- A lot between William Street and Bells Line of Road,
- Bells Line of Road between Grose Vale Road and Cherles Street.

The northern end of Willian Street would be subject to hazard of category H3 during the 1 in 500 AEP event.

During a PMF event, the majority of the township is either not impacted or subject to lower flooding categories (H1 and H2). However, most properties located along both sides of Bells Line of Road, William Street, Elizabeth Street between Redbank Creek and Grose Vale Road would be subject to hazard category H3 or above. Most properties located along Pecks Road, Stephen Street and Michael Street between Gregory Street and Tyne Crescent would also be subject to H3 to H5 hazard.

12.3 Flood function (Hydraulic categorisation)

Hydraulic categorisation is a useful tool in assessing the suitability of land use and development in flood-prone areas. Flood function - Flood risk management guideline FB02 (DPE, 2023b) describes the following three hydraulic categories of flood-prone land:

- **Floodway / Flow Conveyance:** Flow conveyance areas are defined as those areas where a significant flow of water occurs. They typically flow continuously from the upper reaches of waterways and flow paths within the catchment to the outlet during a flood. These flows often align with naturally defined channels. They are areas that, even if only partially blocked by changes in topography or development, cause a significant redistribution of flood flow or a significant increase in flood levels. They are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. In the DFE, they generally extend beyond the waterway banks.
- **Flood Storage:** During a flood event, significant amounts of floodwater can also extend into, and be temporarily stored in, areas of the floodplain. This water flows downstream as the flood recedes. Where storage is important in attenuating downstream flood flows and levels, areas storing this water are classified as flood storage areas. Filling of flood storage areas reduces their ability to attenuate downstream flood flows and, as a result, flood flows and flood levels may increase.
- **Flood Fringe:** Flood-fringe areas make up the remainder of the flood extent for the particular event. It is the area where the effects on flood function are not a constraint. Developing in flood-fringe areas is unlikely to significantly alter flood behaviour, beyond the broader impact of changes to run-off because of urbanisation within the catchment. However, other flood-related constraints may exist in flood-fringe areas.

These qualitative descriptions do not prescribe specific thresholds for determining the hydraulic categories in terms of model outputs, and such definitions may vary between floodplains depending on flood behaviour and associated impacts. The guideline outlines various techniques for defining floodways and flood storage areas including indicator techniques, encroachment techniques and conveyance methods. For the purposes of the Redbank Creek Flood Study, hydraulic categories have been defined as per the criteria outlined in **Table 12.1.** This method is an 'indicator' technique as recommended for overland flooding due to the complexity of flow paths behaviour in overland flow making the encroachment and conveyance techniques impractical to apply. The floodway criterion has been selected as it provides improved continuity of flow along the various flow paths and considers areas of deeper flows. The flood storage criteria were selected as they have been commonly applied on various recent overland studies around NSW and consider areas with deep flood depth allowing storage of flood water.

Hydraulic category mapping for the 5%, 1%, 1 in 200, 1 in 500 AEPs and the PMF events are presented in **Appendix H**

Table 12.1 Hydraulic category criteria

Hydraulic Category	Criteria	Description
Floodway	Velocity x Depth > 0.25 m^2/s	Flow paths and channels where a significant proportion of flood flows are conveyed
Flood Storage	Depth ≥ 0.3 m, Not Floodway	Areas that temporarily store floodwaters and attenuate flood flows
Flood Fringe	Depth < 0.3 m, Not Floodway or Flood Storage	Generally shallow, low velocity areas within the floodplain that have little influence on flood behaviour

During a 5% AEP flood event, it was observed that:

- The floodways typically remain within the main watercourses and drainage channels.
- A large anabranch off Redbank Creek cuts through the northern end of Flannery Avenue and Pansy Crescent.
- Several properties are located within the flood storage areas, including:
  - A few properties located between Stephen Street and Pecks Road north of Arnold Street.
  - A piece of land located on William Street as well as a commercial building on Bells Line of Road between Charles Street and Grose Vale Road.
  - The northern end of William Street, Elizabeth Street, Susella Crescent, Merrick Place, O'Dea Place, the corner of Bradley Road and Morton Street, the corner of Tyne Crescent as well as a section of Arthur Phillip Drive south of Peel Park.

During the 1%, 1 in 200 and 1 in 500 AEP flood events it was observed that:

- The floodways generally remain confined to the main watercourses and drainage channels, similar to the 5% AEP event.
- A significant anabranch off Redbank Creek continues to traverse the northern end of Flannery Avenue and Pansy Crescent, and a small anabranch shortcut the bend of Redbank Creek near the northern end of Elizabeth Street.
- During 1% AEP event it was observed that:
  - A few properties remain within the flood storage area between Stephen Street and Pecks Road north of Arnold Street, additional areas have been identified.
  - Specifically, the flood storage areas are slightly larger, encompassing the same properties on William Street and Bells Line of Road, as well as extending to include the corner of Tyne Crescent. The northern ends of William Street, Elizabeth Street, Susella Crescent, Merrick Place, O'Dea Place, the corner of Bradley Road and Morton Street, and a section of Arthur Phillip Drive south of Peel Park are also located within these expanded flood storage areas.
- During the 1 in 200 and 1 in 500 AEP events several properties are located within the flood storage areas, including:
  - A few properties located between Michael Street and Pecks Road south of Tyne Crescent and at the corner of Tyne Crescent.
  - A piece of land located on William Street as well as a commercial building on Bells Line of Road between Charles Street and Grose Vale Road.
  - The northern end of William Street, Elizabeth Street, Susella Crescent, Merrick Place, O'Dea Place, the corner of Bradley Road and Morton Street as well as a section of the Arthur Phillip Drive south of Peel Park.
  - Properties either side of Elizabeth Street and Bell Line of Road between Campbell Street and Grose Vale Road.

During a PMF event it was observed that:

- The northwestern half of the township would be located within the floodway of Redbank Creek.
- Properties located along drainage channels flowing through the township would also be within the floodway.
- A few more properties around the township would be located within the flood storage area.
- During a PMF event, the larger part of the floodplain and a section of Crooked Lane between Bells Line of Road and Douglas Street would be classified as floodway.

12.4 Flood emergency response classification of communities

In order to assist in the planning and implementation of response strategies, DCCEEW developed the support for emergency management planning guideline (EM01) to classify communities according to the ease of evacuation (DPE, 2023d). The guidelines classify communities as presented in **Figure 12.2**.

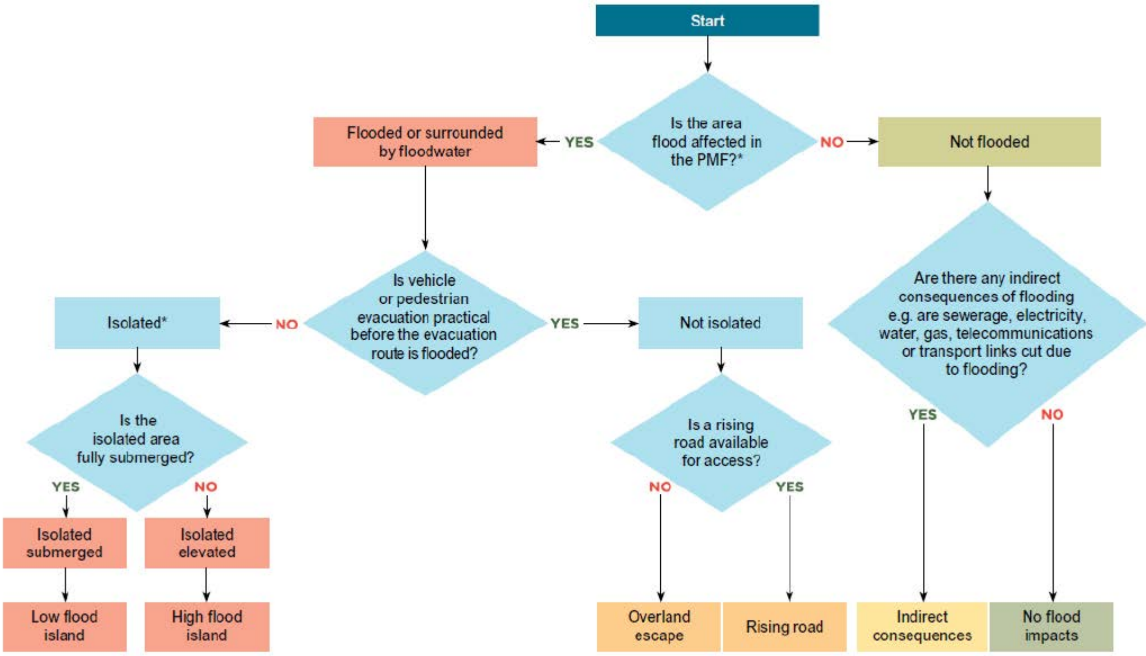

Figure 12.2 Flow chart for determining flood emergency response classifications (DPE, 2023d)

Flood Emergency Response Classifications (ERC) are based upon the probable maximum flood (PMF) or a similar extreme flood, if the PMF is not available. Where classifications are being retrofitted to areas covered by existing studies and the PMF or a similar extreme flood is not available, and a decision is made to not estimate or approximate an extreme event, classifications should be clearly indicated as 'Preliminary based upon the largest flood available'. Some consideration has been given to building locations on a block affected by flooding, but no consideration has been given to building styles.

Isolated areas may also be known as flood islands, where areas are isolated solely by flood waters. Where flood islands are completely submerged in the PMF, these may be called low-flood islands. Where flood islands have elevated areas above the PMF, they may be called high-flood islands. Properties classified as high-flood islands (Isolated elevated) indicate that the buildings remain dry (No flood above the floor level); however, access to the properties is cut off by flood water.

Trapped perimeter areas are areas isolated by a combination of floodwaters and impassable terrain. Where trapped perimeter areas are completely submerged in the PMF, these may be called low-trapped perimeter areas. Where trapped perimeter areas have elevated areas above the PMF, they may be called high-trapped perimeter areas.

Mapping Flood Emergency Response Planning classifications is to a degree a subjective exercise. Nevertheless, it serves to highlight areas most at risk in the event of severe flooding where people fail to evacuate early or shelter in houses is unsuitable for that purpose.

This exercise was completed for the 5%, 1%, 1 in 200, 1 in 500 AEP events and the PMF, using overland and Redbank Creek flooding extent. The summary of the Flood Emergency Response Classification is presented in **Appendix I** . It is noted that this mapping of Emergency Response Classifications focuses on the Redbank Creek and overland flooding and does not include flooding from the Hawkesbury Nepean River Flood Study.

During a 5%, 1%, 1 in 200 and 1 in 500 AEP flood events, the majority of the flood affected properties located at the north end of William Street, Elizabeth Street, Susella Crescent, Merrick Place, O'Dea Place of Jackson Street and north of Flannery Avenue are classified as isolated elevated and properties along the drainage channel through the township classified as flooded with overland escape or rising road route classification. It was observed that two properties at the corner of the Pansy Crescent are classified as flooded, isolated and submerged.

During PMF event, the majority of properties were classified as either flooded, isolated and submerged along Redbank Creek and the main drainage channel through the township as well as flood-affected, isolated and elevated within the township as the PMF would cut access on the main roads. It is however noted that this road closure on the main roads will be over a relatively long period of time, e.g., over 12 hours, refer to **Table 11.6**.

13 Implications of climate change

13.1 Climate change impacts on flood risk

The Sixth Synthesis Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC, 2023) underscores the clear and growing influence of human activities on the climate system, with observable impacts across all continents and oceans. Notably, projected changes in climate are anticipated to significantly affect flood risk, primarily through sea level rise and alterations in the hydrologic cycle, particularly the increase in frequency and intensity of heavy rainfall events.

The impacts of climate change on flood-producing rainfall events should be analysed both separately and in conjunction with changes to sea level rise, as discussed below (DPE, 2023a).

13.1.1 Sea level rise

According to Understanding and managing flood risk - Flood risk management guideline FB01 (DPE, 2023a) flood risk management should examine the likelihood and consequences of sea level rise based on the latest locally relevant and broadly recognised projection. Flood risk management guideline FB01 provides advice on projected changes to the New South Wales mean sea level (MSL) from the International Panel on Climate Change's (IPCC) Sixth Assessment Report (AR6) (Garner et al. 2021) for medium confidence modelling. The medium confidence modelling includes ocean / atmosphere interaction but excludes ice sheet processes. The very likely range of the highest projection (SSP5–8.5 or RCP8.5) is from 0.5 to 1.3 m by 2100 for the 95% confidence interval.

However, the more recent publication Synthesis Report, Contribution of Working Groups I, II, and III to the Sixth Assessment Report (IPCC, 2023) indicates likely global mean sea level rise projection under the SSP-8.5 GHG emission scenario (medium confidence) of:

- 0.20 - 0.29 m by 2050,
- 0.63 – 1.01 m by 2100, and
- 0.98 – 1.88 m under 2150.

Furthermore, global mean sea level is forecasted to rise by 2-3 m with a 1.5°C warming limit and 2 - 6 m with a 2°C limit over the next 2000 years (low confidence) (IPCC, 2023). These projections underscore the urgency of addressing rising sea levels to mitigate flood risks.

The NASA satellite measurements since January 1993 indicate a steady rise in mean sea level, with the latest observation from March 2024 showing a level 103.8 mm above the January 1993 benchmark. Regional variations in sea level rise, such as those observed in the Western Pacific, can be notably larger or smaller than the global mean, underscoring the need for localised assessments (IPCC, 2014).

NASA developed Sea Level Rise projections associated with climate change for Fort Denison available at https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool and documented in **Table 13.1**. This assessment adopted the latest nomenclature of Shared Socioeconomic Pathways (SSP) as opposed to RCP. These projections extend to the year 2150.

Table 13.1 NASA Sea Level Rise projections for Fort Denison

Year	Percentile	SSP 2-4.5 (m)	SSP 5-8.5 (m)
2040	50^{th}	0.138	0.158
	95^{th}	0.242	0.267
2050	50^{th}	0.197	0.233
	95^{th}	0.377	0.377
2090	50^{th}	0.454	0.646
	95^{th}	0.794	1.072
2100	50^{th}	0.530	0.778
	95^{th}	0.939	1.300
2150	50^{th}	0.891	1.354
	95^{th}	1.640	2.414

13.1.2 Flood-producing rainfall events

Climate change projections also indicate potential shifts in the intensity and volume of flood-producing rainfall events (DPE, 2023a). Research continues into the scale of these impacts, therefore advice on how flood engineers and flood risk managers consider changes to flood-producing rainfall events will need to be updated over time.

The Australian Rainfall and Runoff (ARR) Data Hub provides valuable interim climate change factors, including temperature increases and percent rainfall increases. Using representative concentration pathway (RCP) or shared socioeconomic pathway (SSP) values, such as 4.5 and 8.5, allows for the estimation of future changes in rainfall intensity. Studies under the Floodplain Management Program consider various flood events, including rare events, to understand their impacts on communities (DPE, 2023a).

According to (DPE, 2023a), the general changes to the intensity and volume of flood-producing rainfall events are based on a 7% change in the intensity and volume for every 1°C change in mean temperature for the recommended scenarios of RCP 4.5 and 8.5 from the CSIRO work. Using this multiplier with temperature changes identified on the ARR Data Hub indicates that by 2090, values nearing 9.5% for RCP 4.5, and 19.7% for RCP 8.5 are expected in Redbank Creek study area. ARR 2019 follows Representation Concentration Pathway (RCP) scenarios up to the year 2090. For the Redbank Creek catchment these factors are tabulated in **Table 13.2**.

Table 13.2 Increase in temperature (degree C) and associated increase in rainfall intensity with climate change (ARR 2019 Data Hub)

Year	RCP 4.5	RCP 6.0	RCP 8.5
2030	**0.869 (4.3%)**	0.783 (3.9%)	**0.983 (4.9%)**

Year	RCP 4.5	RCP 6.0	RCP 8.5
2040	**1.057 (5.3%)**	1.014 (5.1%)	**1.349 (6.8%)**
2050	**1.272 (6.4%)**	1.236 (6.2%)	**1.773 (9.0%)**
2060	**1.488 (7.5%)**	1.458 (7.4%)	**2.237 (11.5%)**
2070	**1.676 (8.5%)**	1.691 (8.6%)	**2.722 (14.2%)**
2080	**1.810 (9.2%)**	1.944 (9.9%)	**3.209 (16.9%)**
2090	**1.862 (9.5%)**	2.227 (11.5%)	**3.679 (19.7%)**

Note: Brackets indicate the percentage increase in rainfall intensity.

ARR introduced an updated approach on climate change including climate change factor for IFD, initial and continuing losses published in Climate Change Considerations (Book 1: Chapter 6) in ARR (Version 4.2) in 2024.

13.1.3 Hawkesbury City Council approach for this study

Climate change sensitivity analyses undertaken in floodplain risk management studies under the DCCEEW Floodplain Management Program typically adopt sea level rise (SLR) values of between 0.4 m and 0.9 m and increases in rainfall intensity of between 10% and 30% as per the Floodplain Risk Management Guidelines Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments (DECCW 2010) and Practical Consideration of Climate Change (DECC 2007). The ranges of values recommended in these documents were based upon studies from the IPCC and CSIRO for the period to 2100.

In 2012 the NSW Government announced its Stage One Coastal Management Reforms, a result of which is that the NSW Government no longer recommends state-wide sea level rise benchmarks for use by local councils. The NSW Chief Scientist and Engineer's report titled Assessment of the Science behind the NSW Government's Sea Level Rise Planning Benchmarks (2012) however identified that the science behind sea level rise benchmarks from the 2009 NSW Sea Level Rise Policy Statement was adequate.

Following discussion with Hawkesbury City Council, a similar approach to that adopted for the Hawkesbury-Nepean River Flood Study (Rhelm and Catchment Simulation Solutions, 2024) was adopted for the purpose of the sensitivity analysis on Climate Change based on a 2040 and 2090 scenarios. The 2040 scenario projects a 0.40 m rise in Hawkesbury River water levels, along with a 9.5% increase in 1% AEP rainfall intensity. The 2090 scenario anticipates a 0.90 m rise in Hawkesbury River water levels, coupled with a 19.7% increase in 1% AEP rainfall intensity. Additionally, following consultations with Council and DCCEEW, the climate change sensitivity analysis was extended to the 2100 conditions, which forecasts a 1.30 m rise in Hawkesbury River water levels, along with a 30% increase in 1% AEP rainfall intensity.

13.2 Impact of climate change on local flood behaviour

For the purpose of the sensitivity analysis for this study, three scenarios have been run to understand the potential impact of climate change on the 1% AEP event in the Redbank Creek catchment study area including:

- **2040 Conditions:** Increase in 1% AEP rainfall intensity by 9.5% and increase in Hawkesbury River water level by 0.40 m;
- **2090 Conditions:** Increase in 1% AEP rainfall intensity by 19.7% and increase in Hawkesbury River water level by 0.90 m; and
- **2100 Conditions:** Increase in 1% AEP rainfall intensity by 30% and increase in Hawkesbury River water level by 1.30 m.

Changes in comparison to the 1% AEP peak flood levels associated with the simulated climate change scenarios for 2040, 2090 and 2100 conditions are presented in **Appendix J** .

In comparison with current design conditions, simulation of the 2040, 2090 and 2100 conditions highlighted the following impacts on the 1% AEP design flood conditions:

- **2040 Conditions:**
  - Areas affected by riverine flooding along the Hawkesbury River may increase by 0.40 m.
  - Flood levels on Flannery Avenue and Pansy Crescent may increase by up to 0.05 m.
  - Overland flooding originating from the western side of North Richmond impacting Pecks Road, Stephen Street, Michael Street and Tyne Crescent may increase by up to 0.20 m.
  - Flood levels between Elizabeth Street and Bells Line of Road may increase by up to 0.20 m.
  - Overland flooding between Elizabeth Street and Monti Place may increase by up to 0.05 m.
- **2090 Conditions:**
  - Areas affected by riverine flooding along the Hawkesbury River may increase by 0.90 m.
  - Flood levels on Flannery Avenue and Pansy Crescent may increase by up to 0.05 m.
  - Overland flooding originating from the western side of North Richmond impacting Pecks Road, Stephen Street, Michael Street and Tyne Crescent may increase by up to 0.30 m.
  - Flood levels between Elizabeth Street and Bells Line of Road may increase by up to 0.40 m.
  - Overland flooding between Elizabeth Street and Monti Place may increase by up to 0.10 m.
  - Flood levels at the northern end of Elizabeth and William Streets may increase by up to 0.20 m.