WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

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Dear Peter

Our ref: 24050074_L02V02_Flood_Evacuation_Modelling_Assessment

39-65 Old Castlereagh Rd – Flood Evacuation Modelling Assessment

A proposed mixed-use tourism development at 39 – 65 Old Castlereagh Road, Castlereagh is located within the Penrith Lakes Scheme and is subject to flooding from the Nepean River, which flows westwards 500 m south-west of the site (Figure 1). The site is also affected by local overland flooding which flows across the site from Old Castlereagh Road towards the Regatta Lake.

This letter sets out our review of existing flood evacuation models applicable to the site based on the following documents:

- *Hawkesbury-Nepean Valley Flood Emergency Plan* (NSW SES, June 2020)
- *Final Flood Emergency Management Plan* (WMAwater, April 2022). Prepared in support of the Penrith Lakes Scheme Early Flood Evacuation Guideline
- *Penrith Lakes Scheme Early Flood Evacuation Guideline* (NSW Department of Planning and Environment, May 2022)
- *Hawkesbury-Nepean Valley Flood Evacuation Modelling to Inform Flood Risk Management Planning* (Infrastructure NSW, May 2023)
- *Service Level Specification for Flood Forecasting and Warning Services for New South Wales and the Australian Capital Territory – Version 3.15* (BoM, 2024).
- *Hawkesbury-Nepean River Flood Study* (NSW Reconstruction Authority, 2024)

The letter then details our assessment of the capacity of existing evacuation routes and of the flood evacuation capability for the proposed development.

1 DESCRIPTION OF THE PROPOSED DEVELOPMENT

The proposed mixed-use tourism development at 39 – 65 Old Castlereagh Road, Castlereagh includes a club on the western portion of the site, an indoor recreation facility in the centre and a hotel with capacity for 147 hotel rooms on the eastern portion of the site. The hotel would include a restaurant, kitchen, swimming pool and gym.

The development would include 50 staff and could have up to 1,610 visitors (i.e., patrons and guests) at any given time (Figure 2).

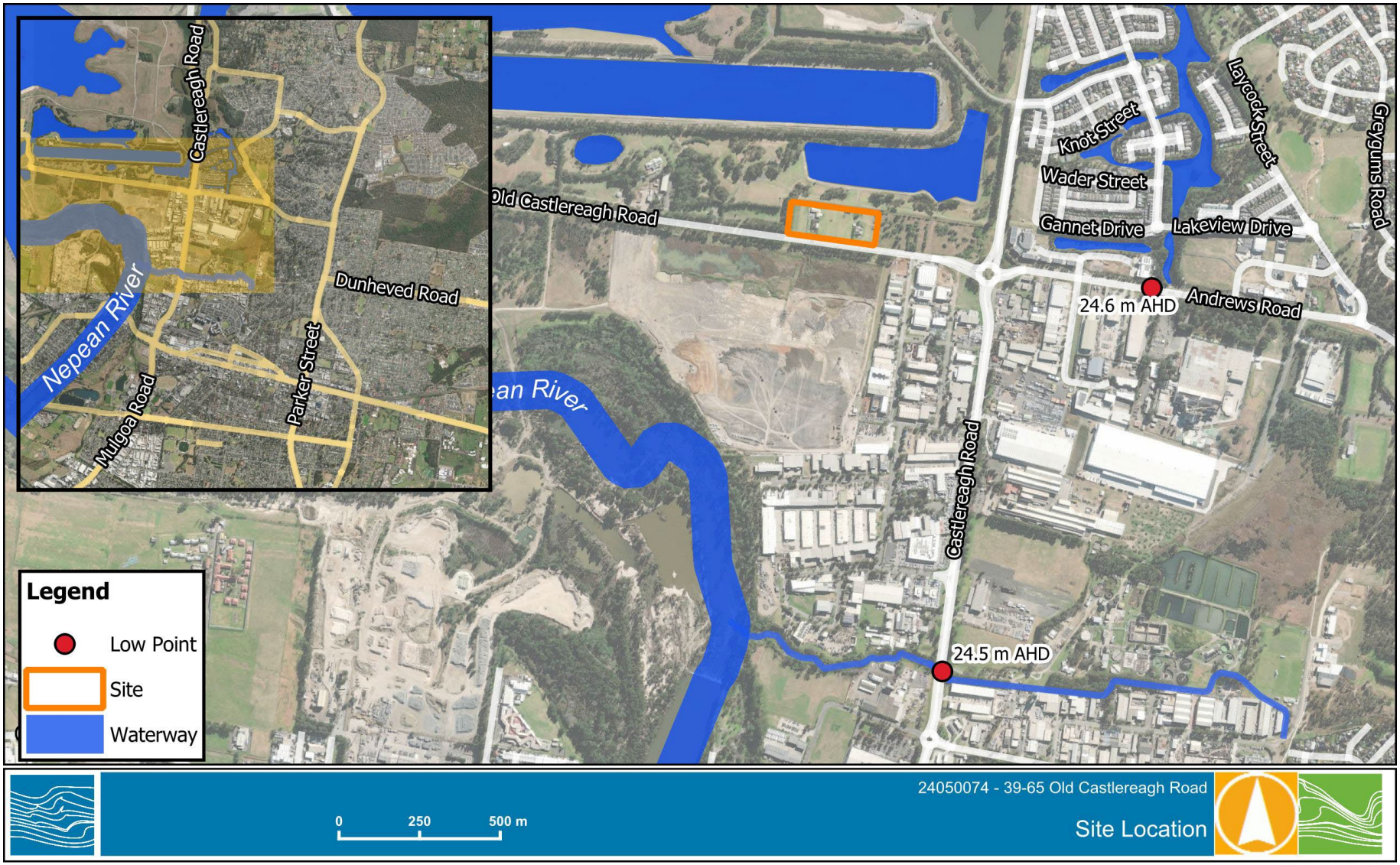

Figure 1 Site Location

LOT / USE	FLOOR AREA/Hotel	CAR SPACES	POPULATION (Staff)	POPULATION (Patrons/Guests)	WC's (including Urinals) Requirements
LOT 12					
HOTEL	147 hotel Rooms	178	10	290	160
LOT 14					
FAST FOOD	1298m²	30	10	50	10
INDOOR RECREATION	5713m²	159	15	635	25
LOT16					
CLUB	5177m²	169	15	635	25
TOTAL		**536**	**50**	**1610**	**220**

Figure 2 Floor areas and population numbers of the proposed development

2 EXISTING FLOOD EVACUATION MODELS

There are 2 main existing flood evacuation modelling assessments applicable to the site:

- Hawkesbury-Nepean Valley Flood Evacuation Model (FEM) (Infrastructure NSW, 2023)
- Penrith Lakes Scheme Early Flood Evacuation model (NSW DPE, 2022).

2.1 Hawkesbury-Nepean Valley Flood Evacuation Modelling

Infrastructure NSW, Transport for NSW, the NSW State Emergency Service (NSW SES) and the NSW Department of Planning and Environment (DPE) undertook regional-scale flood evacuation modelling (FEM) for the Hawkesbury-Nepean Valley (Infrastructure NSW, 2023). Penrith Lakes and 39-65 Old Castlereagh Road, Castlereagh, are located within the study area of the FEM.

2.1.1 Model Assumptions

The FEM was developed by National Information and Communication Technology Australia (NICTA). It is an agent-based simulation model based on transport modelling software MatSim (Infrastructure NSW, 2023). Given that vehicular evacuation is the preferred method of evacuation for the floodplain, in the model the agents are defined as vehicles which are able to dynamically react to one another's travel (Infrastructure NSW, 2023). The FEM identifies how many vehicles are able to evacuate and how many become trapped or isolated during specific flood scenarios.

The model simulates the NSW SES evacuation timeline and evacuation arrangements in a range of scenarios to understand the performance and capacity constraints on the road network in a range of flood events. The NSW SES evacuation timeline is set out in Annex C of the *Hawkesbury-Nepean Flood Emergency Plan* (NSW SES, 2020) and in Figure 3.

Based on this timeline, the time required for evacuation of the community is equal to 1 hour of Warning Acceptance Factor (WAF), which accounts for the community to accept the advice to evacuate, plus 1 hour of Warning Lag Factor (WLF), which accounts for the time taken for people to pack their essential items, plus Traffic Movement time plus Traffic Safety Factor, which accounts for vehicle breakdowns or road crashes. This is the standard NSW SES Timeline Evacuation Model that is detailed in *Timeline Modelling of Flood Evacuation Operations* (Opper et al., 2010). The Traffic Movement component of the model assumes a maximum traffic flow of 600 vehicles per lane per hour, although the Infrastructure NSW modelling assumes that 10% of this capacity would be background traffic (2023). Therefore, this evacuation modelling uses a rate of 540 vehicles per lane per hour for evacuating traffic.

Figure 3 NSW SES Evacuation Timeline components (Infrastructure NSW, 2023)

The *Hawkesbury-Nepean Valley Flood Evacuation Modelling to Inform Flood Risk Management Planning* identifies the site as belonging to the Penrith Lakes evacuation sector (Figure 4) (Infrastructure NSW, 2023). The site is located in the southernmost subsector of the Penrith Lakes sector, although further details about this subsector are not available.

The Penrith Lakes sector uses The Northern Road regional evacuation route (Figure 5), which joins the Great Western Highway to the south. Annex C of the *Hawkesbury-Nepean Flood Emergency Plan* (NSW SES, 2020) identifies the southern area of Penrith Lakes as a low flood island, which means that it is an area of higher ground within the floodplain that is linked to areas outside of the floodplain by roads that can be cut by floodwater (DPE, 2023). The area can become isolated by floodwaters during a flood and if floodwaters continue to rise the island can be entirely inundated.

The FEM was run based on a number of flood forecast timeframes issued by the Bureau of Meteorology (BoM). These were based on a range of modelled floods selected from 19,500 Monte Carlo modelled events (Infrastructure NSW, 2023). Seven fast- to slow-rising events were considered for each flood probability considered, with flood probabilities ranging from 2% Annual Exceedance Probability (AEP) to 0.02% AEP. For each flood probability the FEM results for each of the 7 events were averaged. The FEM did not consider evacuation under the PMF as the modelled PMF hydrographs are based on limited temporal variation in rainfall and may not be as realistic as the variable rates of rise modelled for events of other magnitudes.

The FEM makes the following assumptions regarding vehicles evacuating from the floodplain:

- The number of residential vehicles was calculated by multiplying the number of dwellings in a subsector that could be isolated or flooded by the average number of vehicles per dwelling in that subsector based on the 2016 Census
- The number of employee vehicles was calculated based on Journey to Work data and 2016 Census data. The data was used to calculate the number of people who work in subsectors that could be flooded or isolated but do not live in the floodplain. Those who work in the floodplain but also live in the area were not included because they would be included in the number of residents
- Visitor vehicles were not included in the FEM. This includes visitors such as tourists, customers, students and patients. It should be noted that vehicles belonging to visitors to the Penrith Lakes (Employment) area were an exception to this and were included in the FEM. The Penrith Lakes (Employment) area is the land south of the subject site bounded by Old Castlereagh Road, the Nepean River and industrial buildings along Leland Street and Cassola Place.

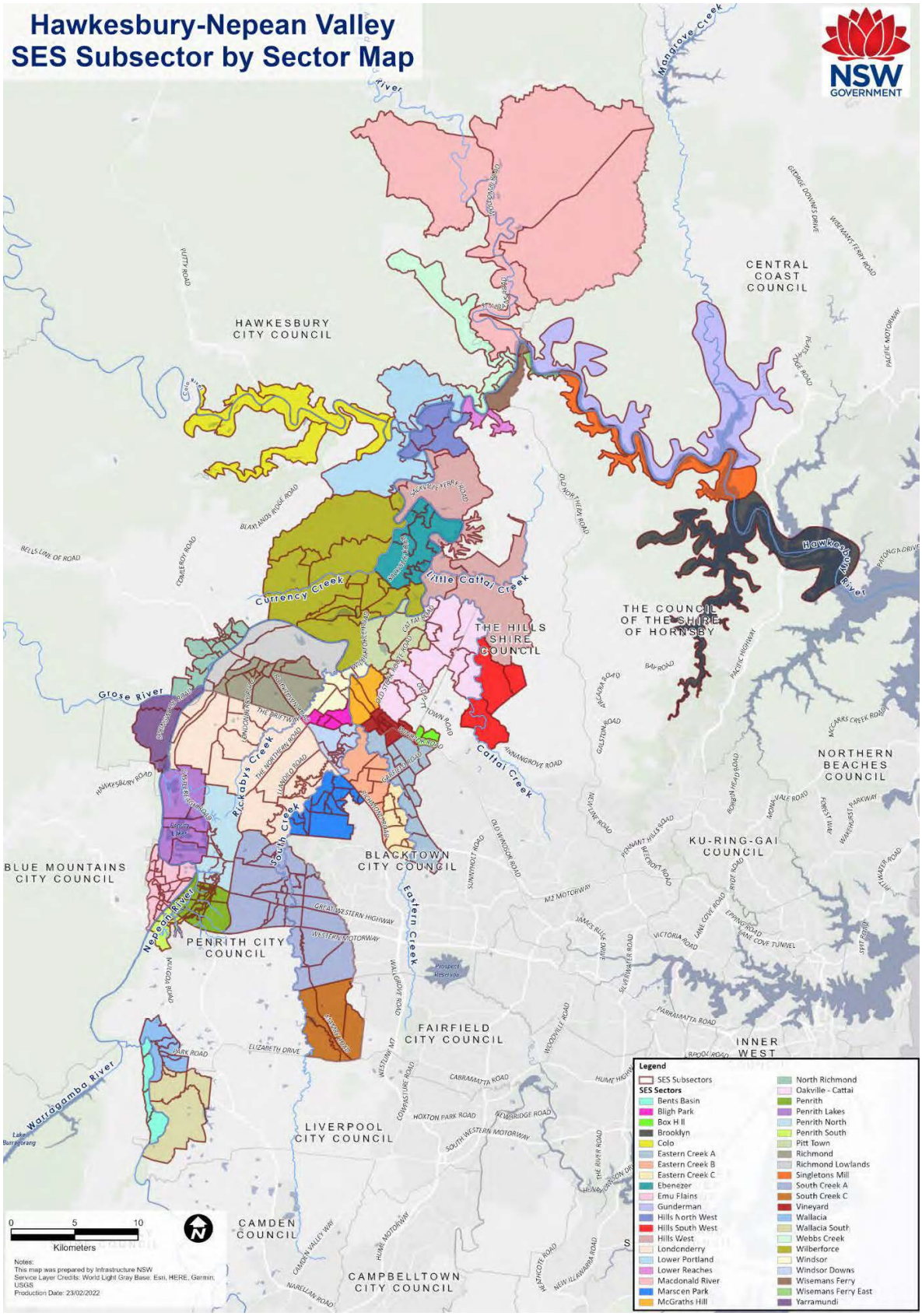

Figure 4 NSW SES sectors and subsectors in the Hawkesbury-Nepean floodplain (Infrastructure NSW, 2023)

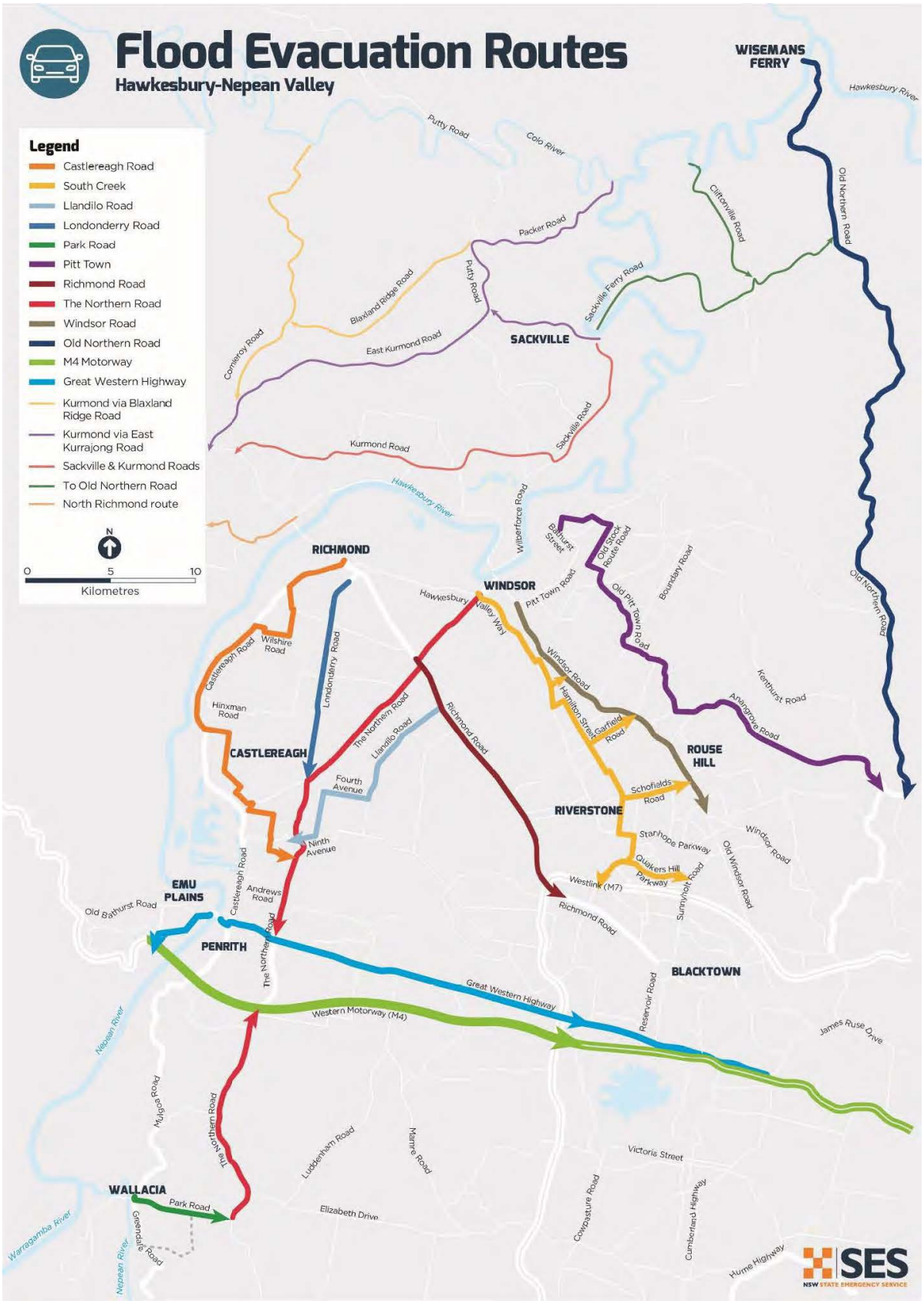

Figure 5 **Major and secondary evacuation routes out of the Hawkesbury-Nepean Valley (Infrastructure NSW, 2023)**

Two scenarios were considered for vehicles in the Penrith Lakes sector:

- 3,500 vehicles
- 10,400 vehicles.

Non-residential development in the Penrith Lakes area was considered as potential development. The report notes that residential development in Penrith Lakes was considered committed development. However, it is also indicated that no residential dwellings were modelled, with the number of evacuating people calculated solely based on vehicles from commercial and employment lands in this sector. Although not absolutely clear, it appears that the vehicles modelled from potential development in the Penrith lakes sector represent employee vehicles across the sector in addition to visitor vehicles from the Penrith Lakes (Employment) area.

Flood forecast warning times for Penrith in the FEM were based on the target lead warning time of 8 hours for gauge readings of 11.3 m or greater specified by the BoM for the Victoria Bridge gauge (gauge 567047) in the *Service Level Specification for Flood Forecasting and Warning Services for NSW and the ACT* (BoM, 2024). As the gauge datum for the Victoria Bridge gauge is 14.1 m AHD, this corresponds with flood levels of 25.4 m AHD or greater.

The FEM was based on the evacuation timeline set out in Figure 3, with evacuation triggered when the last evacuation route out of a subsector was predicted to be cut by flooding. The triggers for evacuation and road closures were based on flood levels at the gauges. Although not specified in the *Hawkesbury-Nepean Valley Flood Evacuation Modelling to Inform Flood Risk Management Planning* (Infrastructure NSW, 2023), it is most likely that the trigger for evacuation of the southern Penrith Lakes subsector was defined based on flood levels at the Victoria Bridge gauge.

2.1.2 Model Results

The FEM results suggest that by the year 2041 a cap of 3,500 vehicles in the Penrith Lakes area would increase the number of people unable to evacuate the floodplain in a 0.2% AEP event by 2,700 relative to 2018 (i.e., present) conditions. Given that the FEM assumes that there are 1.32 people on average in each vehicle, this can be interpreted as approximately 2,045 additional vehicles that were unable to evacuate. It also corresponds to an increase in the average annual people at risk across the floodplain from 42 to 89.

A cap of 10,400 vehicles in the Penrith Lakes area by the year 2041 would increase the number of people unable to evacuate in the 0.2% AEP event by 7,000 relative to present conditions (i.e., the year 2018). This corresponds to approximately 4,303 vehicles that were unable to evacuate and an increase in the average annual people at risk from 42 to 131 over the same timeframe.

Although not explicitly stated in the *Flood Evacuation Modelling to Inform Flood Risk Management Planning* report (Infrastructure NSW, 2023), it is most likely that the 10,400 cap on vehicles was used for the scenario in which all potential development options are included. This scenario incorporates all committed and potential development throughout the floodplain for the year 2041. In the 0.2% AEP event with this scenario approximately 23,700 people (18,000 vehicles) would be unable to evacuate the floodplain, with over 2,000 of these people originating from the subsector in which the subject site is located (Figure 6). The evacuation constraints would be exacerbated in the 0.1% AEP event, in which approximately 45,900 people (34,800 vehicles) would be unable to evacuate from the floodplain (Figure 7).

However, the *Flood Evacuation Modelling to Inform Flood Risk Management Planning* report indicates that DPE (now DPHI) is undertaking further investigation into potential early evacuation in the Penrith Lakes precinct (Infrastructure NSW, 2023). This refers to the *Penrith Lakes Scheme Early Flood Evacuation Guideline* (DPE, 2022).

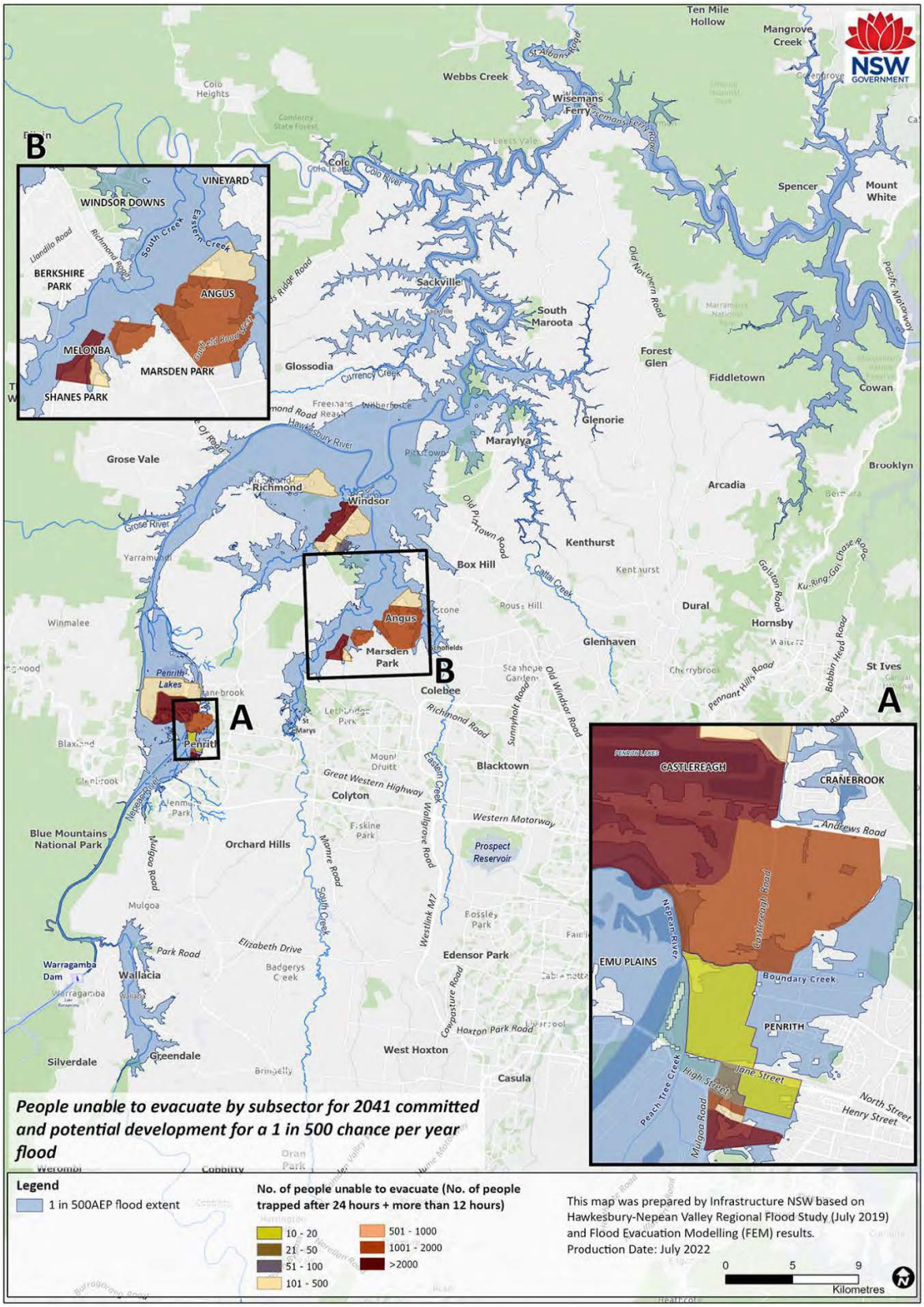

Figure 6 Number of people unable to evacuate for committed and potential development in the year 2041 for a 0.2% AEP event (Infrastructure NSW, 2023)

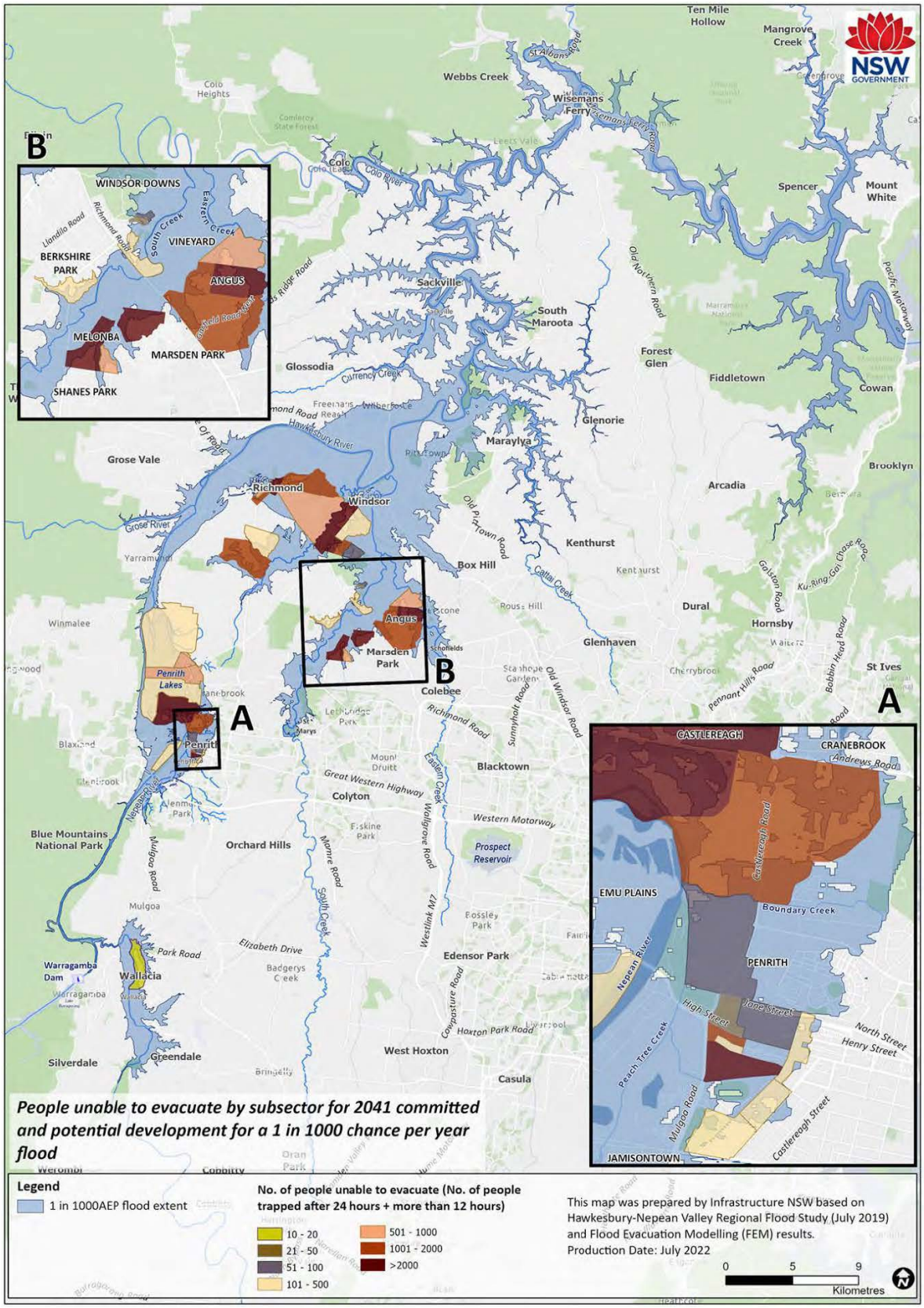

Figure 7 **Number of people unable to evacuate for committed and potential development in the year 2041 for a 0.1% AEP event (Infrastructure NSW, 2023)**

2.2 Penrith Lakes Scheme Early Flood Evacuation System

The flood evacuation road network in the Hawkesbury-Nepean Valley is already constrained in existing conditions, particularly in the vicinity of Penrith and Windsor. Therefore, in 2022 NSW DPE and WMAwater developed an early flood evacuation system for the Penrith Lakes precinct (NSW DPE 2022; WMAwater, 2022). The system is intended to evacuate the non-residential (i.e., employment and tourism) developments in the precinct prior to evacuation being triggered for surrounding areas. That is, the system is designed to fully evacuate the employment and tourism developments prior to the NSW SES ordering the evacuation of surrounding areas (NSW DPE, 2022), thereby avoiding evacuating traffic from the employment and tourism areas from exacerbating existing constraints in the flood evacuation network.

The system is detailed in the *Penrith Lakes Scheme Early Flood Evacuation Guideline* (Guideline) (NSW DPE, 2022) and supported by a *Flood Emergency Management Plan* (FEMP) (WMAwater, 2022). However, the Guideline has not been adopted by the State Government.

2.2.1 Model Assumptions

There are few details available regarding the flood evacuation model used to prepare the early flood evacuation system. It is understood to model self-evacuation of occupants of the area by vehicle.

The early flood evacuation system is designed to cover the non-residential developments in the Penrith Lakes Scheme (Figure 8). This includes the subject site, which is zoned for Tourism, and the Penrith Lakes (Employment) lands to the south (zoned as EP).

The early flood evacuation system consists of 3 stages:

1. Site Preparedness

   The site preparedness stage is intended to provide at least 2 hours' of warning in which occupants of Penrith Lakes can prepare for possible evacuation (NSW DPE, 2022). It therefore corresponds with the Mobilisation, Warning Acceptance Factor and Warning Lag Factor stages of the NSW SES TEM (Figure 3), although in the early flood evacuation system the mobilisation actions are undertaken by the site occupants rather than the NSW SES. The Guideline recommends that, if possible, business operations should be moved off site during the site preparedness stage.

   Site preparedness would be triggered when one of the following occurs (NSW DPE, 2022):

   - The flood level at the Victoria Bridge gauge reaches 16 m AHD and is rising
   - A Minor, Moderate or Major Flood Warning is issued by the BoM for the Hawkesbury-Nepean River

2. Site Closure and Early Evacuation

   Stage 2 covers early flood evacuation and closure of sites and is intended to provide at least 6 hours for evacuation of Penrith Lakes before the NSW SES orders the broader evacuation of the Penrith area (NSW PDE, 2022). This stage corresponds with the Traffic Movement and Traffic Safety Factor stages of the NSW SES TEM (Figure 3).

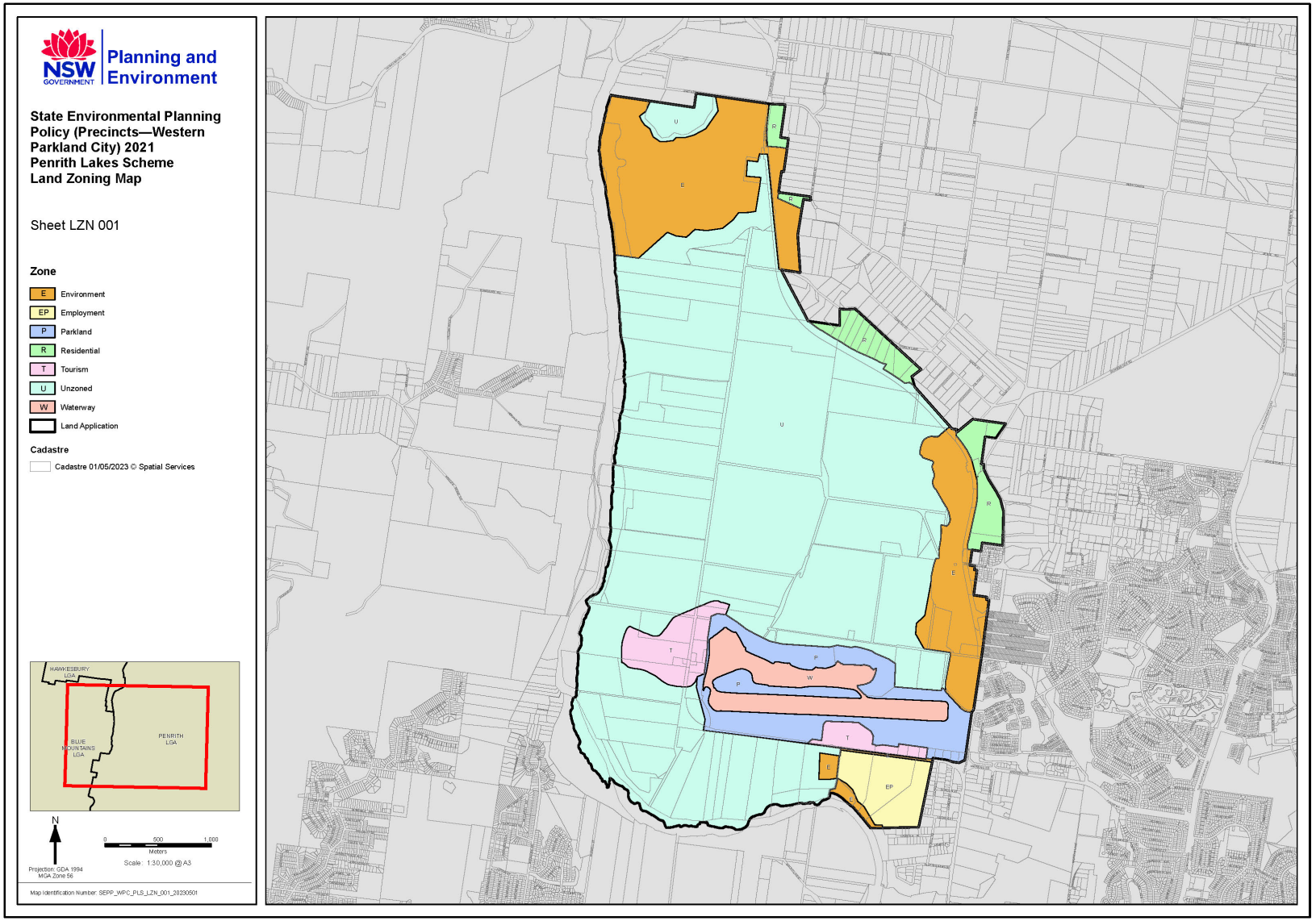

Figure 8 Land zoning for the Penrith Lakes Scheme

Site closure and early evacuation would be triggered when the Nepean Junction gauge exceeds 21.95 m AHD, the Warragamba Dam level exceeds 104.85 m AHD and the Victoria gauge exceeds 17.78 m AHD in addition to one of the following occurring (NSW DPE, 2022):

- Warragamba Dam was at full supply level when flooding started AND:
  - There are no water flows at Wallacia Weir AND outflow of Warragamba Dam is greater than 3,709 m^3/s

    OR
  - Water flows at Wallacia Weir exceed 0 m^3/s AND the combined outflow from Warragamba Dam and Wallacia Weir is greater than 4,063 m^3/s
- The water level at Warragamba Dam when flooding started was between 104.85 m AHD and the full supply level AND:
  - There are no water flows at Wallacia Weir AND outflow of Warragamba Dam is greater than 5,527 m^3/s

    OR
  - Water flows at Wallacia Weir exceed 0 m^3/s AND the water level at Wallacia Weir exceeds 31.81 m AHD.

The early flood evacuation system assumes that Penrith Lakes would be evacuated in zones. The modelling undertaken to support the system assumed that all zones evacuate simultaneously. However, the FEMP and Guideline advise that in practice priority should be given to zones based on occupant vulnerability, distance from the roundabout at the intersection of Castlereagh Road and Old Castlereagh Road and the number of occupants in the zone (NSW DPE, 2022). Should the early flood evacuation system be used, it is likely that the Tourism West sector would be given priority for evacuation over the Tourism South and Employment Precincts (WMAwater, 2022).

3. Safe to Return

   This stage covers checking that the site is safe to reopen and then reopening the site. Safety checks are triggered by flood levels at the Victoria Bridge gauge falling to 18.04 m AHD and still falling. The reopening of non-residential sites can then be triggered by flood levels at the Victoria Bridge gauge falling to 16.0 m AHD and continuing to fall.

The triggers outlined above were developed based on flood modelling undertaken for Penrith City Council as part of the *Nepean River Flood Study* (Advisian, 2018). However, the NSW Reconstruction Authority has since released the *Hawkesbury-Nepean River Flood Study* (2024). Therefore, any triggers used for early evacuation will need to be updated based on the newly available flood data. The Guideline specifies that an early warning service provider must be engaged to monitor for the triggers outlined above and issue the relevant evacuation alerts (NSW DPE, 2022). At the time of the Guideline's preparation a single service provider was intended to monitor conditions and trigger actions for the entire Penrith Lakes Scheme, with individual developments having the option to subscribe to alternative providers to monitor the same conditions and issue the same alerts (NSW DPE, 2022). At present a single service provider has not been engaged for the Penrith Lakes Scheme.

The FEMP prepared by WMAwater (2022) refers to the tourism area to which the subject site belongs as Tourism South (Figure 9). The FEMP indicates that the roundabout at the intersection of Castlereagh Road and Old Castlereagh Road would flood in the riverine 0.5% AEP event based on 2018 modelling (Advisian, 2018) and identifies this as a constraint on evacuation.

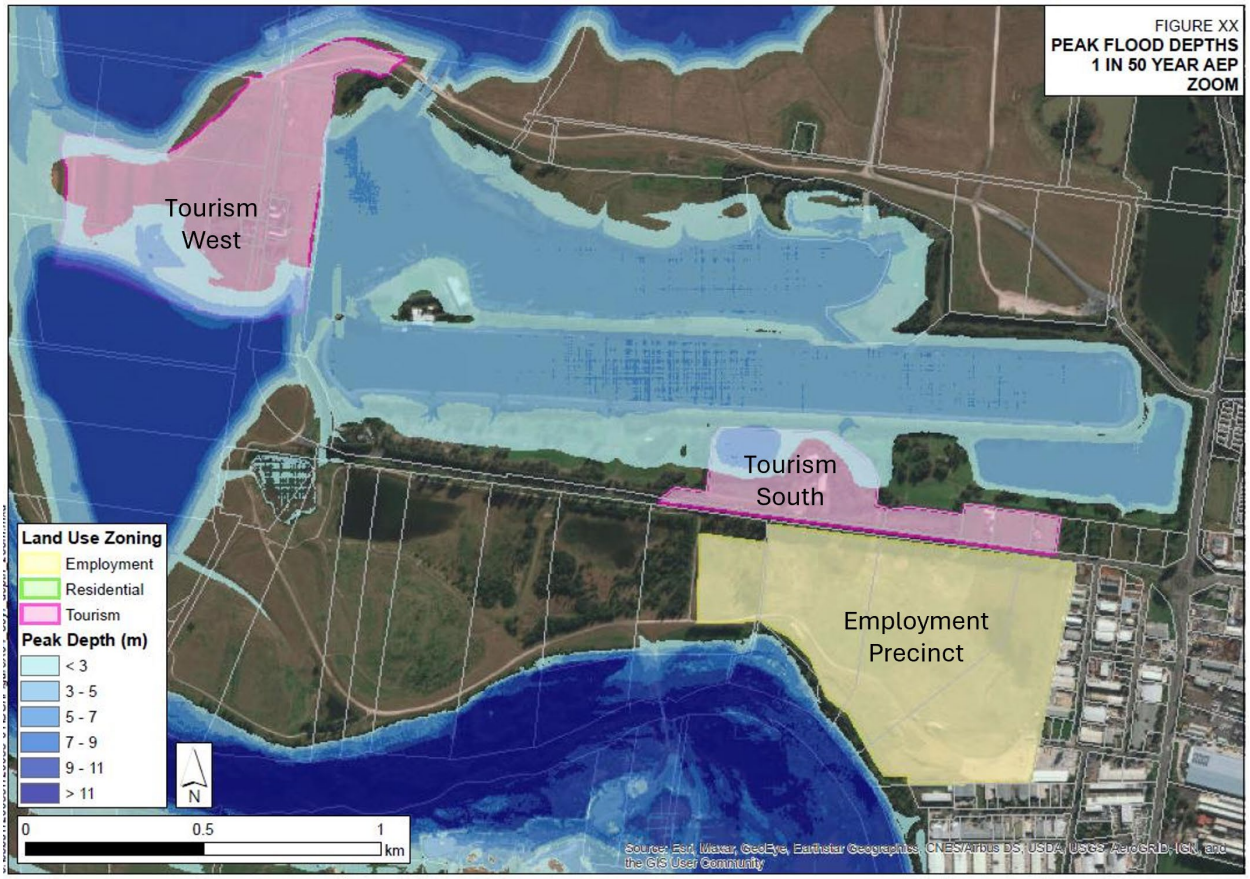

Figure 9 **2% AEP riverine flood depths from Advisian (2018) with Tourism South precinct shown**

The Guideline identifies the single lane entry from The Northern Road to the M4 Motorway as a bottleneck for evacuating traffic. Although the NSW SES indicated this lane would have a maximum capacity of 600 vehicles per hour, the modelling for the flood evacuation system reduced this by 10% to account for background traffic (NSW DPE, 2022). Therefore, the capacity of this lane was modelled as 540 vehicles per hour.

2.2.2 Model Results

The Guideline and supporting documentation suggest caps on vehicle numbers based on model results. The vehicle capacity for the southern end of the Penrith Lakes Scheme area is calculated as 3,500 vehicles (NSW DPE, 2022). Of these, 2,000 vehicles would need to evacuate via Old Castlereagh Road and head east on Andrews Road or south on Castlereagh Road (WMAwater, 2022). The caps assume that 1,000 of these vehicles originate from the Employment Precinct to the south.

The FEMP suggests a combined cap of 2,500 vehicles can be accommodated across the Tourism West and Tourism South precincts (WMAwater). Of these, 1,500 would need to evacuate Penrith Lakes via McCarthys Lane to the north and 1,000 would need to evacuate via Andrews Road. Given the location of the subject site, evacuating traffic from the proposed development would need to evacuate via Andrews Road and be included in the 1,000 vehicle cap for vehicles evacuating along this route from the Tourism South and Tourism West precincts.

2.2.3 Relationship to Planning Instruments

At the time of its preparation, the Guideline was intended to provide a standard against which consent authorities could assess development applications with regard to Clause 5.38(2)(c) of the *State Environmental Planning Policy (Precincts – Western Parkland City) 2021* (SEPP):

> *(2) Development consent must not be granted to development on land the consent authority considers to be below the level of a probable maximum flood unless the consent authority is satisfied the development—*
>
> > *(c) will not significantly adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of evacuation routes for the Hawkesbury-Nepean Valley floodplain in the event of a flood, and*

The Guideline is referenced in the *Penrith Lakes Development Control Plan – Stage 1* (DCP) in Section 3.1.1 control 1:

> *1) Development that will increase the number of people on the land below the probable maximum flood (PMF) level at Penrith Lakes covered by this DCP must be consistent with the Early Flood Evacuation Guideline (if available), or the objective to achieve early site evacuation and/or non-attendance in the event of a flood or probable flood.*

This would require proposed non-residential development in Penrith Lakes to be consistent with the Guideline. However, the Guideline has not been made available and therefore proposed developments do not necessarily need to be consistent with the Guideline. On the other hand, control 1 still refers to the objective of early evacuation and early site closure. In addition, control 3(d) also refers to evacuation in the event of early flood warning:

> *3) The flood emergency management plan must address the following matters:*
>
> > *d) measures to be undertaken by occupants of the site to ensure the efficient evacuation of people in the event of an early flood warning;*

Therefore, proposed non-residential development in the Penrith Lakes Scheme area proposing to increase the number of people below the PMF level (e.g., the proposed mixed use tourism development on the subject site) must make provision for early flood evacuation.

Recent correspondence has been sighted which indicates that the NSW SES does not support the proposed flood early evacuation system developed by the NSW DPE and WMAwater and therefore DPHI has advised that further development at Penrith Lakes is not possible. However, it must be noted that this position is contradictory to the Penrith Lakes DCP which, as discussed above, envisages development on land zoned Employment and Tourism in the Penrith Lakes precinct being reliant upon early flood warning and early site evacuation. It is by adopting early flood evacuation that proposed development is intended to achieve the safe occupation and efficient evacuation of people without exceeding the capacity of existing evacuation routes, as required by Clause 5.38(2)(c) of the SEPP.

A further important consideration is that the NSW Land and Environment Court has already approved development in the Penrith Lakes precinct on the basis of adoption of early flood warning and evacuation. The Nepean Business Park (i.e., the Penrith Lakes Employment area, or the Employment Precinct in Figure 9) is located within the Penrith Lakes precinct and was granted approval in 2023 based on the adoption of early flood warning. Therefore, the Land and Environment Court has provided precedent for approval of development in the Penrith Lakes precinct based on provision for early flood evacuation.

3 EVACUATION TRIGGERS

The results of the *Hawkesbury-Nepean Valley Flood Evacuation Modelling to Inform Flood Risk Management Planning* (Infrastructure NSW, May 2023) suggest that there is no capacity in the existing flood evacuation network for further development in the Penrith Lakes sector that relies on evacuation orders issued by the NSW SES.

However, the analysis undertaken by WMAwater for the Penrith Lakes Scheme Early Flood Evacuation System suggests that if the early flood evacuation system were adopted for the Penrith Lakes Scheme there would be capacity for approximately 1,000 vehicles from the Tourism South precinct and other developments within the Penrith Lakes Scheme along Old Castlereagh Road south of the Tourism West precinct and west of Castlereagh Road. It should be noted, though, that the WMAwater analysis was based on rates of rise from previous flood modelling and the triggers for early evacuation would need to be revised based on the flood model outputs from the *Hawkesbury-Nepean River Flood Study* (NSW Reconstruction Authority, 2024).

Table 1 sets out the timelines for the 72-hour duration PMF, 24-hour duration PMF and 72-hour duration 0.02% AEP design flood events from the new flood model outputs (NSW Reconstruction Authority, 2024) and demonstrates the timesteps at which specific flood levels would be reached at the Victoria Bridge gauge for each of these events. For example, the BoM provides 6 hours of lead warning time ahead of the flood level at the gauge reaching 23.0 m AHD. This flood level would be reached 18.0 hours after the start of rainfall in the 72-hour PMF and 21.0 hours after the start of rainfall in the 72-hour 0.02% AEP flood. Table 1 also shows that the 2% AEP flood level (26.1 m AHD) would be reached at the gauge 25.0 hours after the start of rainfall in the 72-hour PMF and 28.5 hours after the start of rainfall in the 72-hour 0.02% AEP event.

Table 1 **Timing of flood levels. (Red: no flood warning available, yellow: 6 hours of lead warning time available, green: 8 hours of lead warning time available)**

Flood Level (m AHD) at Victoria Bridge	Event	Time (hr) in 72-hr PMF	Time (hr) in 24-hr PMF	Time in 72-hr 0.02% AEP Event
17.3	50% AEP	11.5	6.33	15.83
20.9	20% AEP	15.5	8.83	19.0
23.036	6 hr warning available (BoM)	18.0	10.33	21.0
23.3	10% AEP	18.5	10.5	21.2
24.35	-	-	-	22.5
25.1	5% AEP	21.5	12	24.5
25.436	8 hr warning available (BoM)	22.25	12.33	25.67
26.1	2% AEP	25.0	13.67	28.5
26.8	1% AEP	28.0	15.67	31.4

The largest event used in the Hawkesbury-Nepean Valley flood evacuation modelling is the 0.02% AEP flood (Infrastructure NSW, 2023). Therefore, this assessment bases the flood evacuation timeline on the 72-hour 0.02% AEP flood.

Traffic evacuating from the Penrith North and Penrith Lakes evacuation sectors would need to evacuate past a low point of 24.6 m AHD on Andrews Road to the east of the intersection of Andrews Road and Castlereagh Road prior to this low point becoming inundated by riverine flooding. Flood extents from the NSW Reconstruction Authority modelling indicate that this low point would be cut by flooding in the 2% AEP flood (Figure 10). In an event rising as fast as the 72-hour 0.02% AEP flood, the 2% AEP flood level (26.1 m AHD) would be reached at the Victoria Bridge gauge 28.5 hours after the start of rainfall (Table 1).

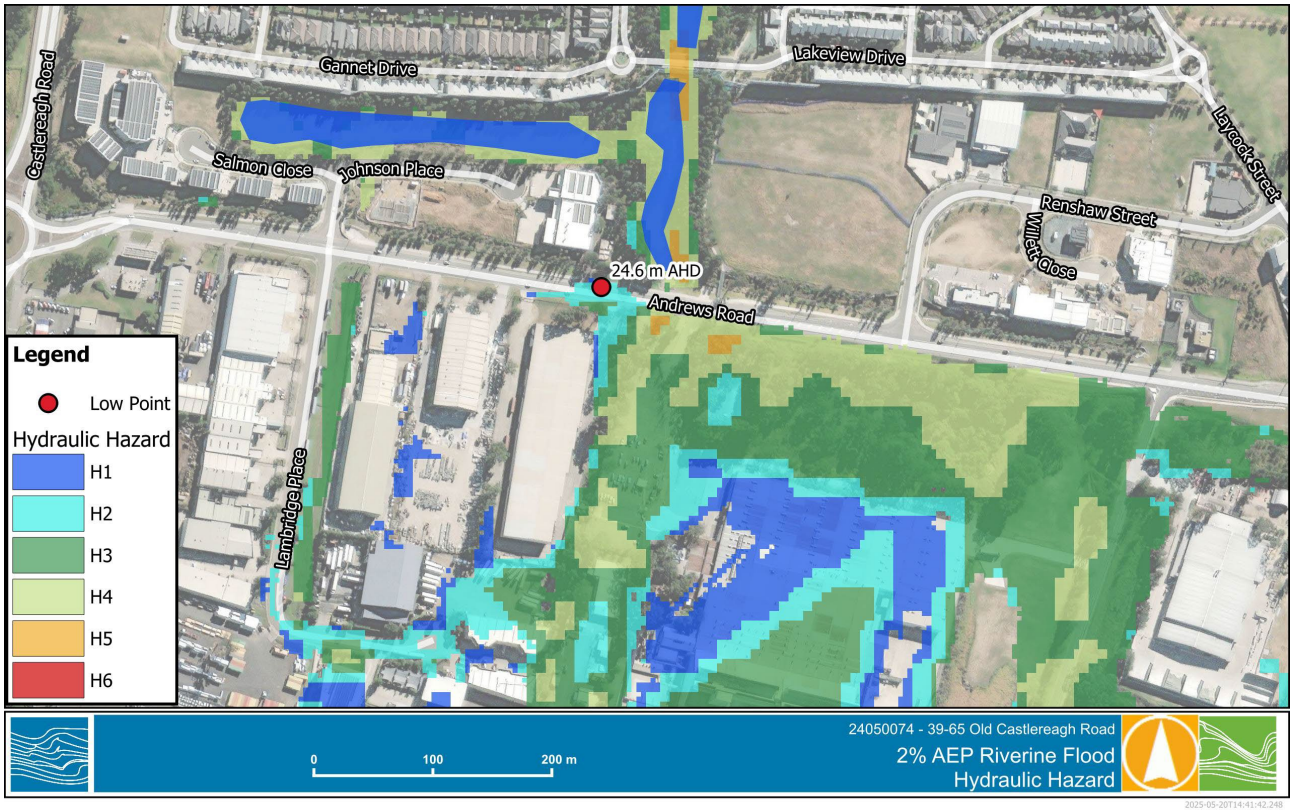

Figure 10 Hydraulic hazard in the 2% AEP riverine flood

The BoM provides 8 hours of lead warning time for flood levels at the Victoria Bridge gauge of 25.436 m AHD or greater. As the 2% AEP flood level is greater than this, there would be 8 hours of lead warning time ahead of the 2% AEP flood level being reached at the gauge and likely some additional time for flooding to travel further downstream to Andrews Road. This analysis conservatively assumes that the NSW SES would trigger evacuation for Penrith North and any residential development in the Penrith Lakes sector based on a quantitative flood warning for a flood level of 26.1 m AHD or greater at the gauge. This would provide at least 8 hours of lead warning time for occupants of these sectors to evacuate past the low point on Andrews Road. To provide 8 hours of lead warning time the BoM would issue this quantitative flood warning 8 hours prior to the 2% AEP flood level being reached at the gauge (at timestep 28.5 hours in the 0.02% AEP 72-hour event). Therefore, the flood warning would need to be issues approximately 20.5 hours after the start of rainfall (Figure 11) on the design flood hydrograph.

The Infrastructure NSW evacuation modelling is based on the NSW Timeline Evacuation Model, which includes 1 hour of Warning Acceptance Factor (WAF) and 1 hour of Warning Lag Factor (WLF) before evacuating vehicles join the road network (Figure 3). Therefore, evacuating vehicles from the Penrith North sector and the residential areas of the Penrith Lakes sector would not begin travelling until 2 hours after evacuation had been triggered (i.e., they would not leave their homes/businesses until timestep 22.5 hours) (Figure 11).

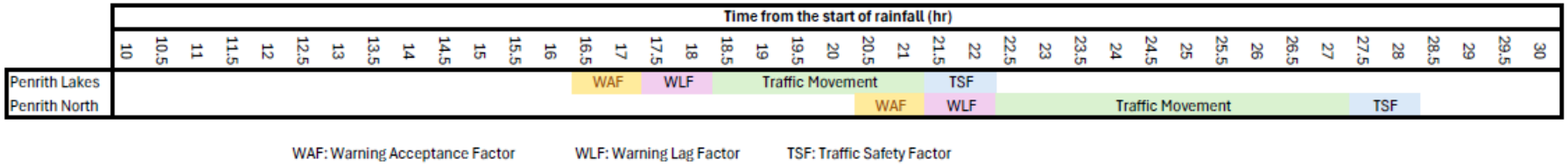

Figure 11 Evacuation timeline for Penrith Lakes and Penrith North evacuation subsectors

The early flood evacuation system set out by WMAwater and NSW DPE relies on evacuation of the non-residential development in the Penrith Lakes sector, including the Penrith Lakes (Employment) area, prior to vehicles from the Penrith North sector starting to evacuate on the road network (2022). That is, in an event rising as fast as the 0.02% AEP 72-hour duration design flood the Penrith Lakes sector must have evacuated before the 22.5 hours timestep (which is when vehicles from the Penrith North sector would start to travel). At time 22.5 hours after the start of rainfall in the design flood, the flood level at the gauge would be 24.35 m AHD (Table 1). This flood level is between 23.036 m AHD and 25.436 m AHD and therefore the BoM would provide quantitative flood warnings for this flood level with a lead warning time of at least 6 hours. In the 72-hour duration 0.02% AEP flood a quantitative flood warning for a flood level of 24.35 m AHD at the gauge would therefore be issued approximately 16.5 hours after the start of rainfall. If early evacuation of the non-residential portions of the Penrith Lakes sector is triggered based on this flood warning there would be 6 hours available in the 0.02% AEP event to evacuate these areas before evacuating vehicles from the Penrith North sector would start using the road network. A flood warning for a flood level of 24.35 m AHD or greater would have a probability of between 10% and 5% of being issued in any given year.

The peak flood levels at the Victoria Bridge gauge for historical events are shown in Table 2. This table includes historical floods since 1960, which is when the Warragamba Dam was built upstream of Penrith (pre-1995 flood levels are taken from Appendix G Table G4 of the Warragamba Flood Mitigation Dam EIS 1995). In most events over the past 65 years flood levels did not reach a level for which a Flood Warning for 24.35 m AHD or greater at the gauge would be triggered based on gauge service level specifications currently adopted by the BoM. The exception to this is during the March 2021 flood, where the flood level at the Victoria Bridge gauge reached 24.13 m AHD. A Flood Warning for 24.35 m AHD or greater may have been issued for this event, although flood levels at the gauge peaked 0.22 m short of 24.35 m AHD. Therefore, over the past 65 years the identified trigger for early evacuation of the Penrith Lakes sector may have been reached once. It should be noted, though, that flood probability is based on long term averages and that the frequency of flooding since 1960 may not reflect the probability of early evacuation being triggered.

Table 2 Peak flood levels at the Victoria Bridge gauge for historical events

Historical Event	Flood Level (m AHD)
November 1961	23.89
June 1964	23.74
June 1975	21.49
March 1978	23.35
August 1986	19.95
October 1987	17.6
May 1988	22.62
April 1989	18.50
August 1990	23.44
February 2020	20.1
March 2021	24.13
March 2022	22.44
July 2022	23.65

Based on the NSW SES Timeline Evacuation Model (Figure 3) the time required for evacuation includes 1 hour of WAF, 1 hour of WLF and 1 hour of Traffic Safety Factor (TSF). During the 6 hours that would be available for the early evacuation of Penrith Lakes these 3 factors would require a total of 3 hours, leaving 3

hours available (Figure 11) for vehicles to travel along the evacuation route past the low point on Andrews Road (i.e., the Traffic Movement component), which has a single lane eastbound. This analysis conservatively assumes a vehicular evacuation rate of 540 vehicles per lane per hour to be consistent with the evacuation modelling undertaken by Infrastructure NSW (2023) and WMAwater (2022). Based on this evacuation rate, 1,620 vehicles would be able to evacuate from the Penrith Lakes sector in the 3 hours of Traffic Movement available based on a flood warning for a flood level of 24.35 m AHD or greater at the Victoria Bridge gauge.

It should be noted that a quantitative flood warning for a flood level of 24.35 m AHD or greater at Victoria Bridge may not provide sufficient time for a full evacuation of the non-residential areas of the Penrith Lakes sector in the 24-hour or 72-hour duration design PMF events. However, assessing evacuation capability based on the rate of rise in the PMF would be inconsistent with the evacuation modelling undertaken by Infrastructure NSW, which considers events up to and including the 0.02% AEP riverine flood. Therefore, the 0.02% AEP flood is a more appropriate event to assess flood evacuation capability against.

4 VEHICULAR CAPACITY OF PENRITH LAKES

As discussed in Section 3, the NSW SES Timeline Evacuation Model suggests that there is capacity for 1,620 vehicles to evacuate from the Penrith Lakes sector, excluding the residential areas. The evacuation modelling undertaken by Infrastructure NSW excluded visitor vehicles, including the vehicles of tourists, customers, students and patients, except in the Penrith Lakes (Employment) area where these vehicles were included. Therefore, to be consistent with the Infrastructure NSW modelling the following analysis similarly excludes visitor vehicles. Residential vehicles are also excluded from the calculation of vehicle caps as the evacuation modelling undertaken by Infrastructure NSW would have incorporated these vehicles into its assessment for residential areas. Therefore, vehicles that need to be considered in assessment of evacuation capability as part of an early evacuation process for the Penrith Lakes sector are largely employee/commuter vehicles.

The Penrith Lakes (Employment) area was granted development consent on the assumption that a maximum of 1,000 vehicles can be on site when an early evacuation would be triggered. However, a proportion of the drivers would live within the floodplain and therefore would be included by the Infrastructure NSW modelling as traffic from the residential areas in the floodplain. These vehicles do not need to be considered in the vehicle limit for the Penrith Lakes evacuation sector.

The site and the Penrith Lakes (Employment) area are located within the Sydney International Regatta Centre travel zone in the Journey to Work Data and maps released by Transport Performance and Analytics. However, the most recent Journey to Work data is available for the year 2011. Given that in 2011 there were very few commercial or industrial developments within the Sydney International Regatta Centre zone, the nearby Penrith Industrial Northwest and Penrith Crane Enfield Metals travel zones likely better reflect the commuter vehicle trends for the Penrith area. According to the Journey to Work data about 74% of those who drove their cars to work in the Penrith Industrial Northwest and Crane Enfield Metals travel zones in 2011 lived outside of the floodplain. If this proportion is applied to the Penrith Lakes (Employment) area, 74% of the vehicles that could be in the area (conservatively assuming all vehicles in the Employment area are commuter vehicles and not visitor vehicles) should be considered in the calculation of traffic evacuating from the Penrith Lakes subsector, while the remaining 26% of vehicles are included in the evacuation modelling undertaken by Infrastructure NSW for residential areas in the floodplain. Therefore, approximately 740 vehicles would need to evacuate from the Penrith Lakes (Employment) area as part of an early evacuation process.

Given that there is capacity for 1,620 vehicles to evacuate from the Penrith Lakes sector, the vehicular capacity of the sector excluding the Penrith Lakes (Employment) area is 880 vehicles for employees who live outside of the floodplain. Existing developments in this area include Castlereagh Conference Centre the Sydney International Regatta Centre, the Penrith Lakes Environmental Education Centre, a Venue Operations Centre, Penrith District Nitro Racing and Stay Upright Penrith, Sydney Helicopters and Long's House restaurant. Most

of these would not have significant staffing requirements and this analysis conservatively assumes that in total 100 staff could be in the Penrith Lakes sector at any given time for these developments.

Calculation of the number of commuter vehicles associated with these developments needs to consider the proportion of staff that would travel to work as the driver of a vehicle. According to Journey to Work data, in 2011 there were 2,229 people who travelled to work in the Penrith Industrial Northwest destination travel zone and 1,821 who did so as the driver of a vehicle. In the Penrith Crane Enfield Metals travel zone 1,024 of the total 1,229 workforce travelled to work as the driver of a vehicle. Across these two travel zones therefore an average of 82% of workers drove to work. If this proportion is applied to the staff for the existing developments, there would only be 82 staff vehicles associated with these developments. Further, only 74% of these vehicles (61 vehicles) would be driven by staff who live outside of the floodplain. The remaining 26% of vehicles would be driven by staff who live in the floodplain and would therefore be included as residential vehicles in the modelling undertaken by Infrastructure NSW (2023).

Based on the above, the maximum number of employees who would drive to work at these locations at any one time from outside of the floodplain would be 61. Therefore, there is a remaining capacity of 819 vehicles in the Penrith Lakes sector.

The proposed development is likely to have a maximum of 50 staff on site at any one time. Based on the proportions calculated above, 82% of staff would drive to work (i.e., 41 employees) and only 74% of these staff (i.e., 30 employees) would be travelling from locations outside of the floodplain. Therefore, only 30 of the staff vehicles need to be considered in the vehicle cap for the Penrith Lakes sector. This is consistent with the evacuation modelling undertaken by Infrastructure NSW, which does not include visitor vehicles (2023).

The 30 vehicles belonging to staff who live outside of the floodplain are significantly fewer than the 819 commuter vehicles for which there is capacity in the area (excluding the 801 commuter vehicles from the Employment area and other existing non-residential developments). Therefore, in a flood rising as fast as the 72-hour duration design 0.02% AEP riverine event there would be sufficient time to evacuate the proposed development as part of an early flood evacuation triggered by a quantitative flood warning for a flood level of approximately 24.35 m AHD or greater at the Victoria Bridge gauge. Even should the number of staff required for the proposed development double to 100 staff on site at any given time, only 60 of these staff would need to be considered in the vehicle cap. These 60 vehicles would still be significantly fewer than the 819 commuter vehicles for which there is capacity in the area.

5 SUMMARY

The evacuation modelling undertaken by WMAwater and NSW DPE for the Penrith Lakes Scheme Early Flood Evacuation system found that there would be capacity to undertake early evacuation of the non-residential areas of the Penrith Lakes evacuation sector (2022) if the area was fully evacuated prior to evacuating traffic from the surrounding areas and residential areas entering the evacuation network.

This letter has analysed the timeline for flood evacuation taking into account flood modelling undertaken by the NSW Reconstruction Authority (2024) which was not available when the evacuation modelling was undertaken by WMAwater. This analysis shows that in a riverine event rising as fast as the 72-hour duration design 0.02% AEP flood there would be sufficient time to evacuate the non-residential areas of the Penrith Lakes sector provided that the number of employee vehicles in the sector belonging to employees who live outside of the floodplain does not exceed 1,620 vehicles. Taking into consideration the number of vehicles associated with existing and approved developments in the sector, there is a remaining capacity for 819 commuter vehicles in the area.

The proposed development would only generate 30 employee vehicles that would count towards this cap. Therefore, there is capacity in the existing road network to evacuate the proposed development as part of an early flood evacuation process.

Yours sincerely

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WATER TECHNOLOGY PTY LTD

Water Technology pays respect to all First Nations peoples, their cultures and to their Elders, past and present.

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