10 Discussion and Conclusions

10.1 By Scenario

10.1.1 Scenario 1: Creek clearing

The benefit in terms of flooding for this option is very low for rare events such as the 100-year event. It may however provide a larger relative improvement in smaller events, where a higher proportion of flows are contained within the creek and hence affected by the improved flow conditions in the channel.

While this option is quite cheap in terms of overall cost, it does require an ongoing continued effort from Council to maintain, and if in future years funds are not allocated towards this maintenance then the benefits would be lost.

This option also faces some potential challenges in implementation as permission from landholders would be required to undertake the works as no easement for the creek currently exists. There may also be backlash from the community as removal of trees may be seen as having a negative impact on the natural and aesthetic character of Middleton. In addition, if not managed carefully, the removal of trees and bushes from the creek banks may increase the potential for erosion in the creek channel.

Overall, this option is not recommended as the costs (although small) and potential difficulty in implementation outweigh the small benefit it may have.

10.1.2 Scenario 2: Channel widening

The benefit in terms of flooding for this option is low, with only a minor reduction in flood depths (and hence damages) in private properties. It may however provide a larger relative improvement in smaller events.

This option is among the cheapest of the scenarios considered, however it faces significant implementation challenges. The widened channel would require more permissions from private landholders than the creek clearing scenario, including from the owners of the Middleton Caravan Park. It would also involve the removal of a larger number of trees and have a larger visual impact on the town. The channel would also be very susceptible to erosion until vegetation can become established.

Physical access to undertake the works and constructability may also prove difficult, as some sections of the creek are very close to private residences. The potential impacts of any involved earthworks on these buildings would need to be considered carefully and the risks managed. As with the creek clearing scenario, if not managed carefully the removal of trees and bushes from the creek banks may increase the potential for erosion in the creek channel.

Overall, this option is not recommended, as the costs and difficulty in implementation outweigh the small benefit it may have.

10.1.3 Scenario 3: Flood levees

This option provides protection to all private property up to a 100-year event. It should be noted however that the creation of levees may impact on natural flow paths from the local urban catchment, as runoff from within the town may be blocked from flowing directly into the creek. For this reason, additional works may be required to ensure that runoff from the town does not become trapped at the levees and locally increase flooding.

This option is among the cheapest of the scenarios considered, however it faces significant implementation challenges. The levees would need to be constructed within a number of separate private properties, and in some cases, would lie within the backyards of private residences. Sections of these levees would need to be constructed with vertical walls instead of sloped earthen embankments owing to the limited amount of space. These walls could however be constructed in a way to make them

more visually appealing e.g. by having murals or other artwork fitting with the character of Middleton on them.

If one or more landowners do not grant permission/access to allow the construction of the levees, then the levee system may be seriously compromised. In particular, if the two levee sections north of Goolwa Road (A and B) are not fully constructed, then flows breaking out of the creek would still occur and cause flooding. If the southern levees (C, D and E) were not fully constructed, this would allow flooding to occur, however it would not affect the performance of the northern levees to prevent flooding north of Goolwa Road.

The sections of earthen embankment that lie within private property would require some level of maintenance over time. For example, fallen trees may damage the levee and compromise its ability to retain water. In this case, the owner of the property would need to undertake the repair works or request assistance from Council.

Physical access to undertake the works and constructability may also prove difficult, as some sections of the creek are very close to private residences. The potential impacts of any involved earthworks on these buildings would need to be considered carefully and the risks managed.

Although this option does face some serious potential implementation/construction difficulties, the flooding improvement is major and the cost relatively low. **For these reasons it is recommended that the potential to implement this be investigated further.**

10.1.4 Scenario 4: Flood detention

This option provides the greatest benefit to flooding out of all of the options considered. Apart from local flooding from the immediate urban catchment, this option has the potential to completely prevent flooding up to a 100-year event, and would even provide major benefits in extreme events such as a 500-year flood event. It does however introduce the risk of dam failure, which if it occurred may result in dambreak flows causing major flooding within Middleton. This risk would have to be evaluated further and may have greater legal implications regarding how the dam would be operated and maintained. This risk may also cause resistance from the Middleton community.

Depending on how the dam was configured, this may provide the opportunity for a water harvesting scheme where water captured within the dam may be used for alternate purposes.

This option is by far the most expensive option and funding from the state or federal government would be required. The extent of works would also mean that it would take the longest to implement, likely taking a number of years to acquire the required land, gain the necessary regulatory approvals, complete the design, and finally construct. While detailed calculations have not been undertaken, from a cost benefit perspective it is unlikely that this option would be recommended as the costs are likely to greatly outweigh the reduction in flood damages.

Overall this option represents the extremes of the options considered, being the most effective in preventing flooding (even reducing flooding in extreme events) but also requiring the most investment and the most difficulty in implementation. **Due to the cost, it is not recommended that this option be pursued further.**

10.1.5 Scenario 5: Goolwa Road culvert upgrade

The benefit in terms of flooding of this option is fairly low for rare events (such as the 100-year event). In addition, the current culverts have adequate capacity for smaller events, with the current weak point of the 'system' being the flow capacity of the actual creek itself, and so upgrading the culverts will provide little to no benefit in these smaller events.

This option is quite expensive, although being a DIT asset, funding may be sought from DIT. However, based on their internal assessments identifying the culverts as having adequate capacity, the chances of

getting funding from DIT would be considered low. Regardless of funding, approval to undertake these works will be required from DIT and the road reconstructed to DIT standards.

It is noted also that a number of piped services, including a water mains pipe for Middleton, are attached to the road structure. These services would need to be temporarily relocated during construction, which would involve liaison with a number of service authorities and the potential for significant additional costs.

The road construction would also likely have a significant impact on traffic as Goolwa Road is a main road connecting a number of coastal towns including Victor Harbor, Port Elliot and Goolwa. For this reason the construction staging and traffic management would have to be considered carefully.

Overall this option is not recommended as the high cost and moderate difficulty in implementation outweigh the small benefit that it would provide.

10.1.6 Scenario 6: Creek clearing and levees

As with Scenario 3, this scenario provides protection to all private property up to a 100-year event. However, due to the creek clearing there is a reduction of peak water levels of up to 200mm compared with Scenario 3. This reduction in peak water levels serves to reduce the required levee heights by a similar amount.

This scenario includes all of the same difficulties in implementation as with Scenario 1 and Scenario 3 combined. It is likely that the initial and ongoing access approval negotiations would be complicated.

This scenario is among the cheaper of the scenarios considered, however as with Scenario 1 it would also require ongoing funding from Council to maintain the benefit of vegetation clearing.

Although this option does provide a small improvement in peak water levels compared to only creating the levees without creek clearing, the additional cost and complexity associated with the creek clearing is not considered worthwhile. **It is therefore not recommended to pursue this option further.**

10.1.7 Scenario 7: Channel widening and levees

As with Scenario 3 and Scenario 6, this option provides protection to all private property up to a 100-year event. The channel widening has a significant benefit in reducing the peak water levels and thus reducing the required size of the levees, meaning that levees C and D may not be required at all. The channel widening would also continue to provide a small benefit to flooding in the event of levee failure.

This option, while not being highly expensive, does represent significant expenditure to implement as it involves the costs associated with both the channel widening and the levees.

It also faces significant implementation challenges, although there is likely to be overlap in terms of the approvals required to construct the levees and undertake the channel widening.

This scenario also faces the same potential community resistance to the removal of trees with the creek and the visual impacts as with the other creek clearing and channel widening scenarios.

Although this option is more expensive than Scenario 3, the improvement in peak water levels means that the required size of the levees is significantly reduced, with levees C and D potentially not requiring to be constructed. The levees being smaller also reduces the risk of levee failure. This option could be considered an advanced version of Scenario 3. **It is therefore recommended that this option be investigated further.**

10.1.8 Scenario 8: Creek clearing and culvert upgrade

This option provides a low to medium benefit in terms of flooding, with significant reductions in flood depth particularly downstream of Goolwa Road on either side of the creek. Due to the clearing of the creek, this option may also provide a small benefit in smaller events.

This option is quite expensive, although the culvert upgrade forms the majority of the cost, and Goolwa Road is a DIT asset meaning that funding may be sought from DIT. Regardless of funding, approval to undertake these works will be required from DIT and the road reconstructed to DIT standards. It also would require continued funding from Council to maintain the condition of the creek in terms of vegetation.

This option also faces the same potential challenges associated with creek clearing as with Scenario 1 as well as those for the culvert upgrade as with Scenario 5.

Although this option does provide some benefit in terms of flooding, the high cost and significant challenges in implementation outweigh this benefit. **For this reason it is not recommended to pursue this option further.**

10.1.9 Scenario 9: Channel widening and culvert upgrade

This option provides a large benefit in terms of flooding, particularly downstream of Goolwa Road on either side of the creek where flooding is almost entirely prevented on the eastern side and flooding within the caravan park is reduced to nuisance flooding only with little to no safety risk.

This option is quite expensive, although the culvert upgrade forms the majority of the cost, and Goolwa Road is a DIT asset meaning that funding may be sought from DIT.

This scenario presents significant challenges in terms of implementation, with extensive approvals required to achieve both the channel widening and the culvert upgrade. There is little overlap between the approvals required for both aspects of this scenario, so this process would be highly complex.

Although this option is quite expensive and involves significant implementation challenges, the flooding benefits are major with a number of private buildings being entirely protected from flooding. **For this reason it is recommended to investigate this option further.**

10.1.10 Scenario 10: Creek clearing, levees and culvert upgrade

As with the other scenarios including construction of levees, this option provides protection to all private property up to a 100-year event. As stated in the analysis for the other levee scenarios, the capacity of the existing Goolwa Road culverts is a limiting factor on the water levels upstream of the road. In this scenario, the culvert upgrade has a significant benefit in reducing the peak water levels upstream and thus reducing the required size of levees A and B. The creek clearing also has a minor additional benefit in reducing the peak water levels and thus reducing the required size of the levees.

This option is quite expensive, although the culvert upgrade forms the majority of the cost/

It also faces major implementation challenges associated with the creek clearing, levee construction and the culvert upgrade. As with Scenario 9, there is minimal overlap between the approvals required for the works associated with this scenario, and so the approvals process is likely to be highly complex.

Although this option does provide a significant improvement in peak water levels compared to only creating the levees without creek clearing or culvert upgrade, the large additional cost and complexity associated with these elements is not considered worthwhile. **It is therefore not recommended to pursue this option further.**

10.1.11 Scenario 11: Early warning system

This option provides no actual benefit to flooding. However, this may provide a significant reduction in damage to private property and may assist in evacuations during larger flooding events, thus reducing the safety risk. This benefit is also magnified if the population is prepared with a flood response plan and knowledge about the correct behaviour during a flood event.

It is noted however than the effectiveness of this option also depends on the nature of the storm event. If the rainfall is highly intense over a short period of time (as opposed to less heavy rainfall over a longer period), or the rainfall is particularly heavy directly over the town, then the warning time may be reduced or even eliminated. There may also be times where the warning system gives out an alert but flooding does not eventuate that could result in complacency.

This option is the cheapest of those considered, however the cost estimate is a very high-level estimate and may increase significantly depending on the details of the gauging station, the communications system from the gauge to the relevant authority, and how the monitoring of the system is managed by that authority. It could also be rolled out to cover other flood prone areas within the Council.

As stated previously, the key stakeholders involved in managing and maintaining this system would be the Department for Environment and Water (DEW) and the Bureau of Meteorology (BoM).

The potential benefits of this system may be significant and is not likely to be highly expensive. **For these reasons, it is recommended that this option be investigated further.**

10.2 Scenario Scores

To assist in quickly comparing each of the scenarios, scores out of five (where a higher score is better than a lower score) have been chosen for the following four categories:

- Flood benefit – this score relates to the benefit to the community in terms of the reduction of damages and reduction of safety risks. It also includes secondary benefits (e.g. water reuse) where applicable.
- Affordability – this score relates to the cost of each of the options, but also factors in whether external funding is likely to be available.
- Ease of implementation – this score relates to how easily each option may implemented from legal, social, political and cultural perspectives. In particular, options requiring approval from many stakeholders or that have the potential for community backlash (e.g. due to reduced aesthetic value of the creek) will score lower than those that do not.
- Constructability – this score relates to how easily the options can actually be physically constructed once they are approved by the relevant stakeholders and funded. Options that have a high potential for construction problems/complexity arising will score lower than those that do not.

It should be noted that these scores are qualitative only, and are only to aid in comparison between the options.

A weighted overall score for each of the scenarios has also been calculated with the following weightings:

- Flood benefit: 50%
- Affordability: 20%
- Ease of implementation: 20%
- Constructability: 10%

The scores are summarised in Table 10-1 below.

Table 10-1: Scenario scores (out of 5)

Scenario	Mitigation Options	Benefit (50%)	Affordability (20%)	Ease of implementation (20%)	Constructability (10%)	Weighted Overall Score
Scenario 0	Existing infrastructure (no mitigation)	0	5	4	5	**2.3**
Scenario 1	Creek clearing	1	4	2	5	**2.2**
Scenario 2	Channel widening	1	3	2	3	**1.8**
Scenario 3	Levees	4	3	1	2	**3.0**
Scenario 4	Flood detention	5	0	2	2	**3.1**
Scenario 5	Goolwa Road culvert upgrade	1	2	3	1	**1.6**
Scenario 6	Creek clearing, levees	4	2	1	2	**2.8**
Scenario 7	Channel widening, levees	4	3	1	2	**3.0**
Scenario 8	Creek clearing, Goolwa Road culvert upgrade	2	2	2	1	**1.9**
Scenario 9	Channel widening, Goolwa Road culvert upgrade	3	2	1	1	**2.2**

Scenario	Mitigation Options	Benefit (50%)	Affordability (20%)	Ease of implementation (20%)	Constructability (10%)	Weighted Overall Score
Scenario 10	Creek clearing, levees, Goolwa Road culvert upgrade	4	2	1	1	**2.4**
Scenario 11	Early warning system	2	4	3	4	**2.8**

10.3 Conclusion and Next Steps

Hydraulic modelling and cost estimation has been undertaken for the existing infrastructure scenarios as well as a wide range of potential flood mitigation scenarios.

Analysis of the current condition of the creek and Goolwa Road culverts suggests that the overall standard of the system, defined as the event magnitude at which flooding of private property outside of the creek corridor begins to occur, is a 20-year Average Recurrence Interval standard.

Overall, the degree of complexity for each of the options is fairly high, particularly due to the fact that no Council easement over the creek exists, and so any works undertaken on the creek require negotiation and approval from multiple external parties.

The options which are most within Council's ability to undertake (in terms of cost and ease of implementation) were shown to have only a minor impact on the flood standard of the system and hence flood impacts. The results demonstrate achieving significant improvement to the system is likely to require significant monetary investment and a fairly complex negotiation with multiple landowners and various authorities.

Overall, it appears that the options worth investigating further are as follows:

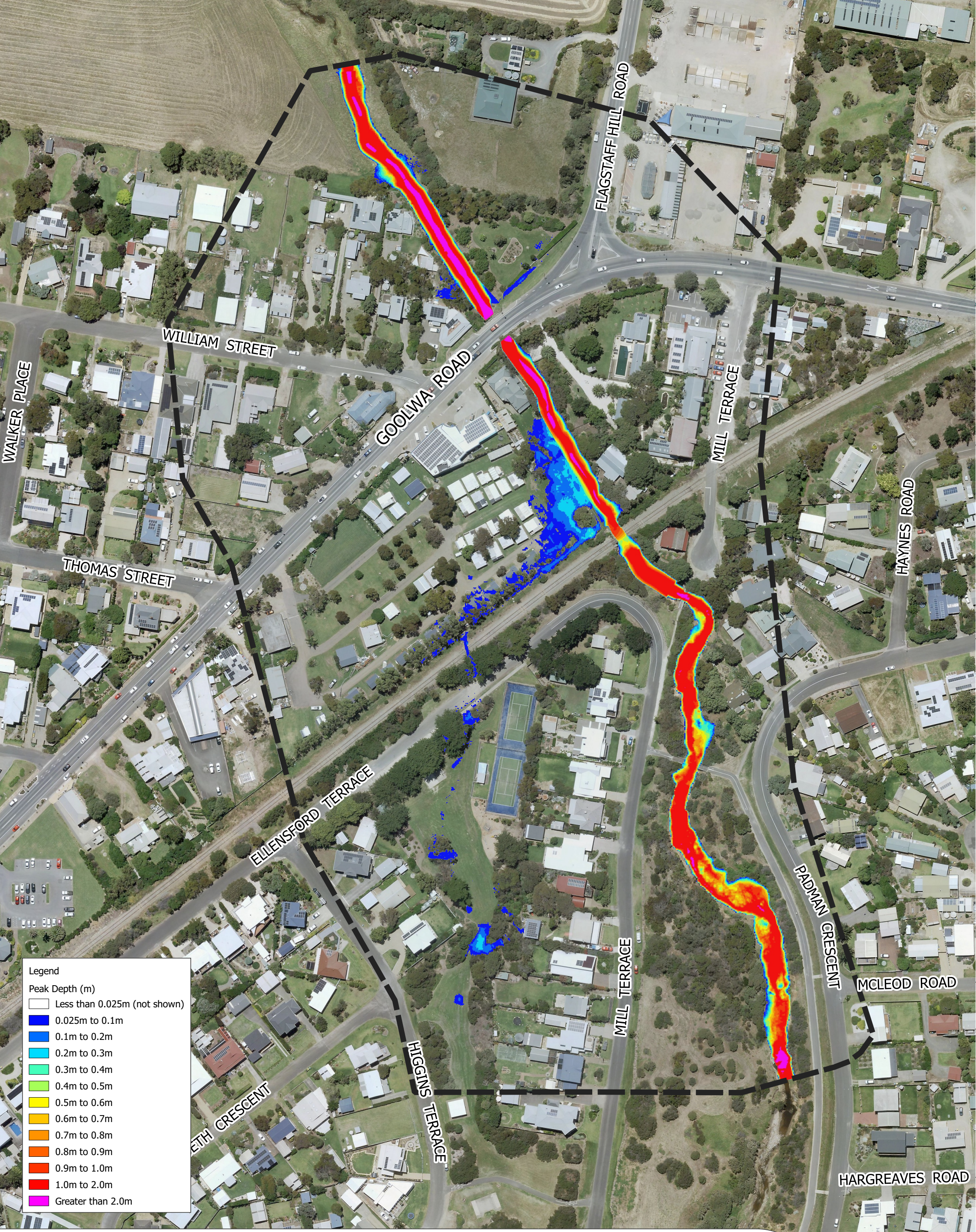
- Creating flood levees, with or without widening the creek channel (Scenario 7 and Scenario 3)
- Widening the creek channel and upgrading the Goolwa Road culverts (Scenario 9)
- Creating an emergency warning system upstream of Middleton (Scenario 11)

The next steps to investigate these further is to undertake a formal assessment of the annual average damages (AAD) to then calculate the cost/benefit ratio along with a further refinement of the options to reduce uncertainty in the cost estimates. Stakeholder and community consultation should also be undertaken to inform Council's decision on the way forward and in seeking funding.

If the economic assessment does not result in a favourable outcome, there could be grounds for the "do nothing" option to be considered as the investment in infrastructure would need to be made against other competing interests.

It also recommended that consultation with and education of the community is implemented to communicate the best flood response during an event and to encourage the community to create a flood response plan. This could be implemented in parallel with any of the other options, especially the emergency warning system. It also is likely to have a very low cost compared with the mitigation options considered and is also not likely to need many approvals to be implemented.

Appendix A – Flood Maps



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0 50 100 m

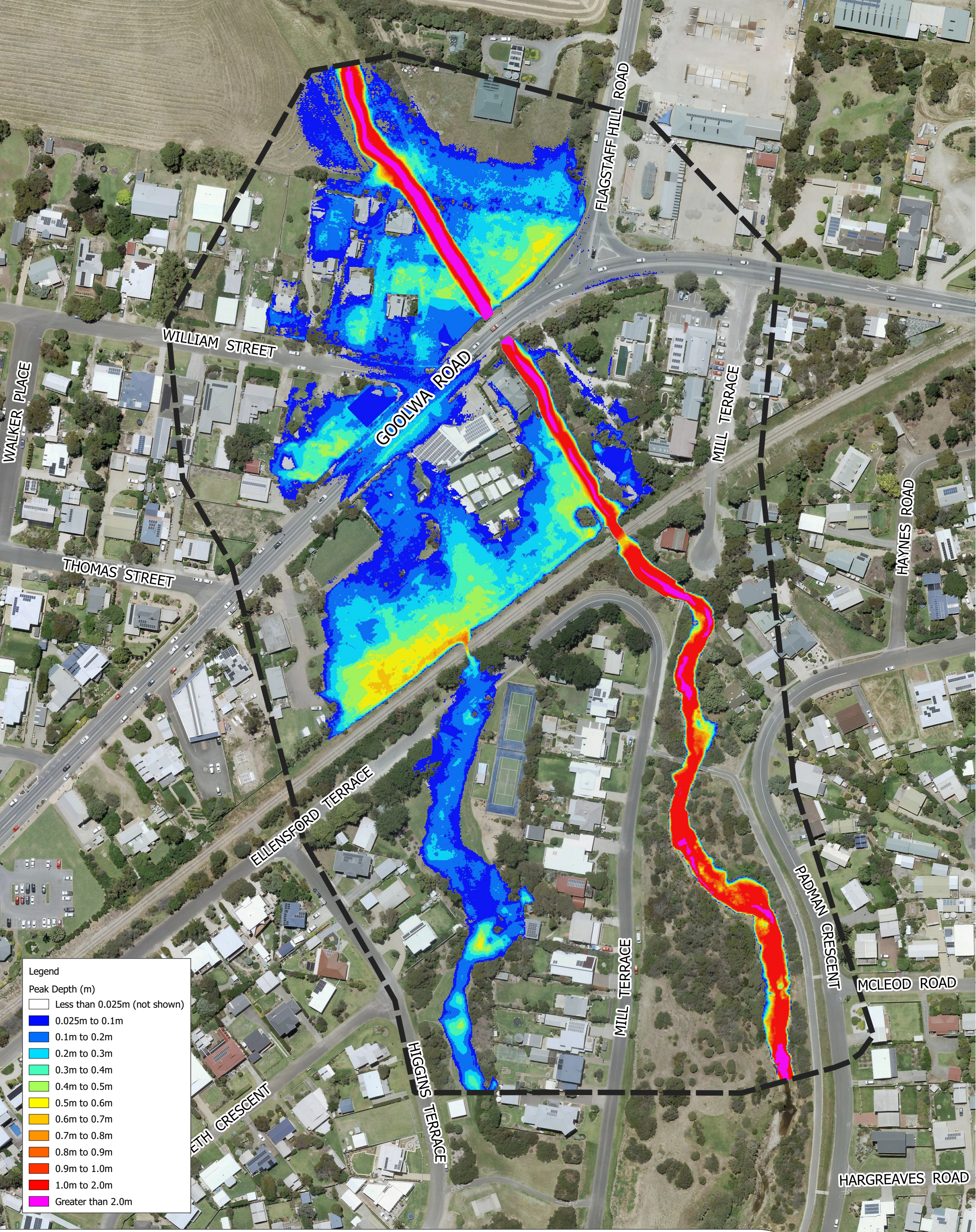
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Revision: Rev A
Date: 2024-01-23 12:17
Drawn: James Woolley

Data Acknowledgement:
Satellite Imagery from MetroMap (Aerometrex), 2022

Alexandrina Council

Middleton Flood Study
Scenario 0: Existing Infrastructure
Critical 20-year ARI event
Peak Depth



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0 50 100 m

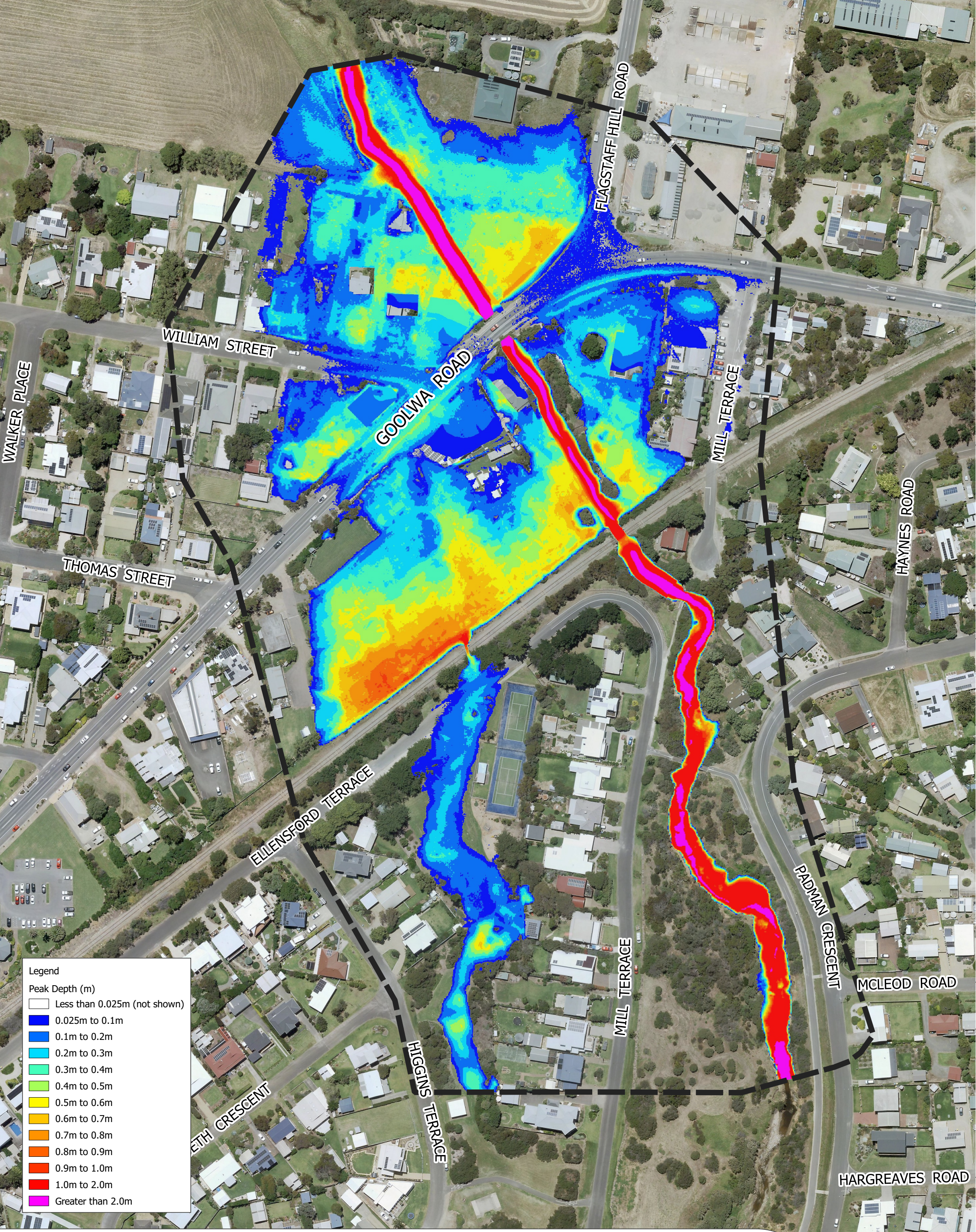
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Drawn: James Woolley

Data Acknowledgement:
Satellite Imagery from MetroMap (Aerometrex), 2022

Alexandrina Council

Middleton Flood Study
Scenario 0: Existing Infrastructure
Critcal 50-year ARI event
Peak Depth



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0 50 100 m

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Revision: Rev A
Date: 2024-01-23 12:18
Drawn: James Woolley

Data Acknowledgement:
Satellite Imagery from MetroMap (Aerometrex), 2022

Alexandrina Council

Middleton Flood Study
Scenario 0: Existing Infrastructure
Critical 100-year ARI event
Peak Depth

WILLIAM STREET
GOOLWA ROAD
FLAGSTAFF HILL ROAD
WALKER PLACE
MILL TERRACE
THOMAS STREET
ELLENSFORD TERRACE
HAYNES ROAD
PADMAN CRESCENT
MCLEOD ROAD
HIGGINS TERRACE
MILL TERRACE
ELIZABETH CRESCENT
HARGREAVES ROAD
ESPLANADE

Legend

Hazard Category

- No hazard
- H1
- H2
- H3
- H4
- H5
- H6

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0 50 100 m

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Alexandrina Council

Middleton Flood Study
Scenario 0: Existing Infrastructure
Critical 20-year ARI event
Flood Hazard Category

WILLIAM STREET
GOOLWA ROAD
FLAGSTAFF HILL ROAD
WALKER PLACE
MILL TERRACE
THOMAS STREET
ELLENSFORD TERRACE
HAYNES ROAD
PADMAN CRESCENT
MCLEOD ROAD
MILL TERRACE
HIGGINS TERRACE
ELIZABETH CRESCENT
HARGREAVES ROAD
ESPLANADE

Legend

Hazard Category

- No hazard
- H1
- H2
- H3
- H4
- H5
- H6

0 50 100 m

N

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Alexandrina Council

Middleton Flood Study
Scenario 0: Existing Infrastructure
Critcal 50-year ARI event
Flood Hazard Category

WILLIAM STREET
WALKER PLACE
GOOLWA ROAD
FLAGSTAFF HILL ROAD
MILL TERRACE
THOMAS STREET
ELLENSFORD TERRACE
HIGGINS TERRACE
MILL TERRACE
PADMAN CRESCENT
HAYNES ROAD
MCLEOD ROAD
ELIZABETH CRESCENT
HARGREAVES ROAD
ESPLANADE

Legend

Hazard Category

- No hazard
- H1
- H2
- H3
- H4
- H5
- H6

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0 50 100 m

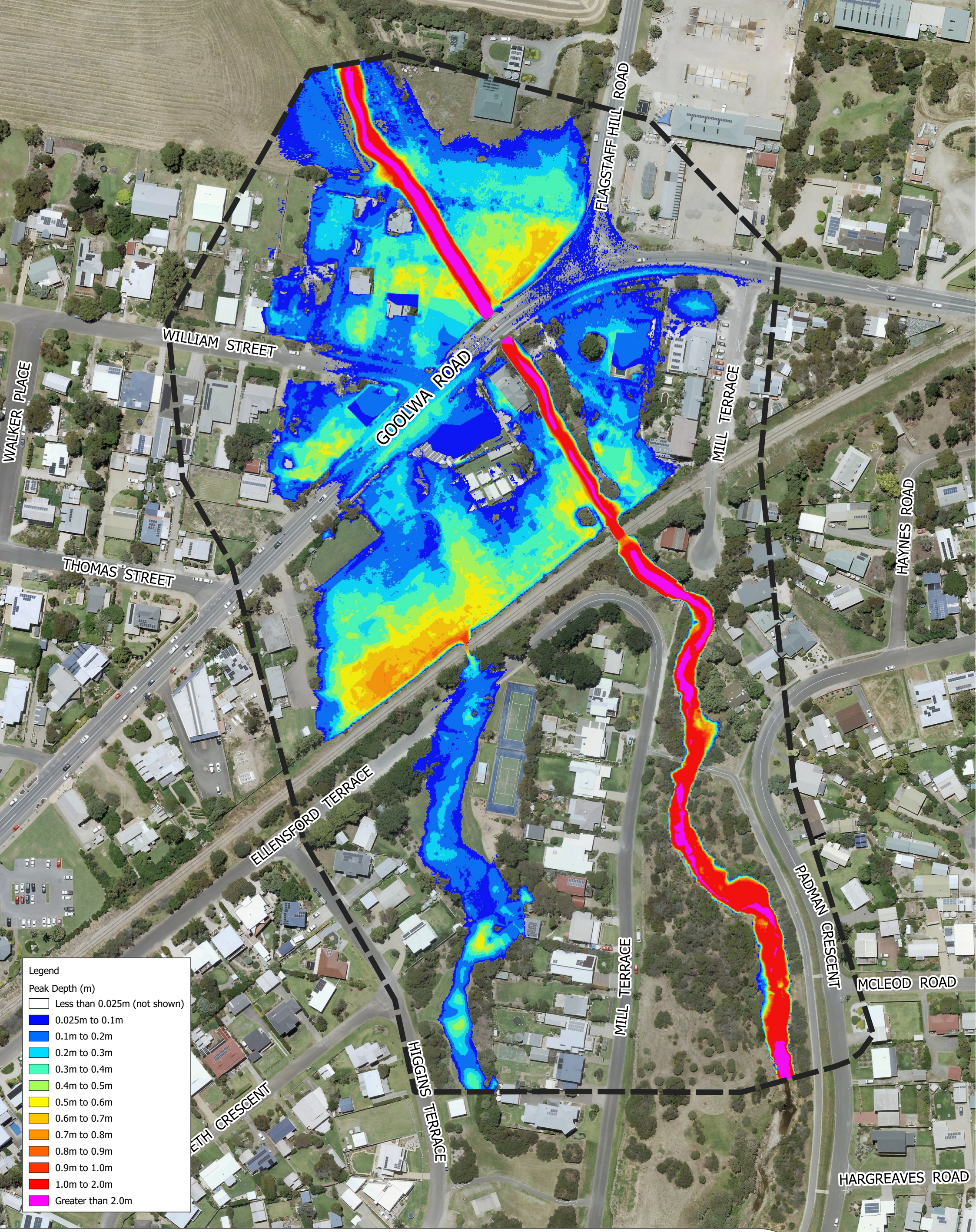
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Middleton Flood Study
Scenario 0: Existing Infrastructure
Critical 100-year ARI event
Flood Hazard Category



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0 50 100 m

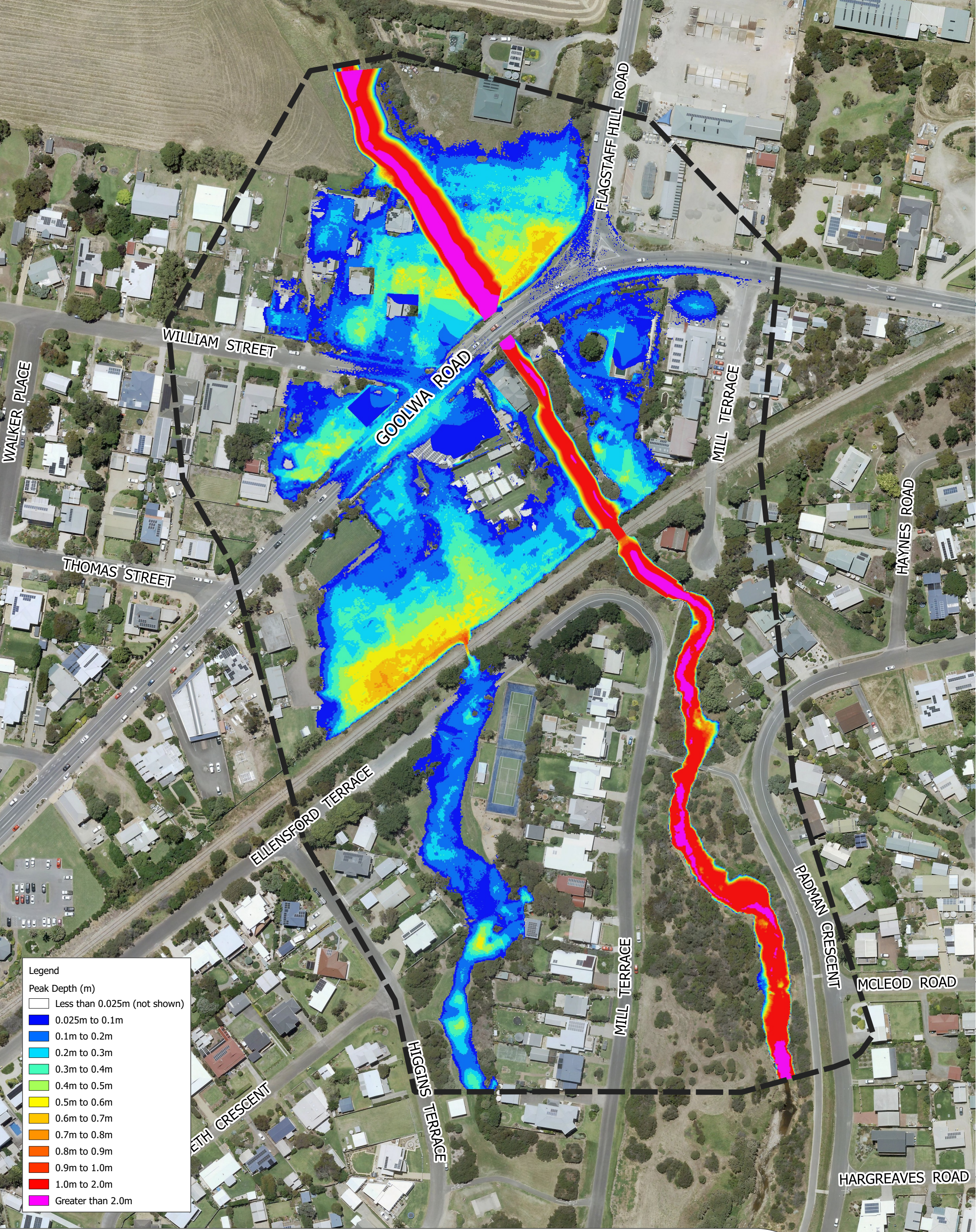
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Middleton Flood Study
Scenario 1: Creek Clearing
Critical 100-year ARI event
Peak Depth

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Middleton Flood Study
Scenario 2: Channel Widening
Critical 100-year ARI event
Peak Depth

FLAGSTAFF HILL ROAD
WILLIAM STREET
GOOLWA ROAD
WALKER PLACE
MILL TERRACE
HAYNES ROAD
THOMAS STREET
ELLENSFORD TERRACE
PADMAN CRESCENT
MCLEOD ROAD
HIGGINS TERRACE
MILL TERRACE
ETH CRESCENT
HARGREAVES ROAD
ESPLANADE

Legend

Peak Depth (m)

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 2.0m
- Greater than 2.0m

tonkin

0 50 100 m

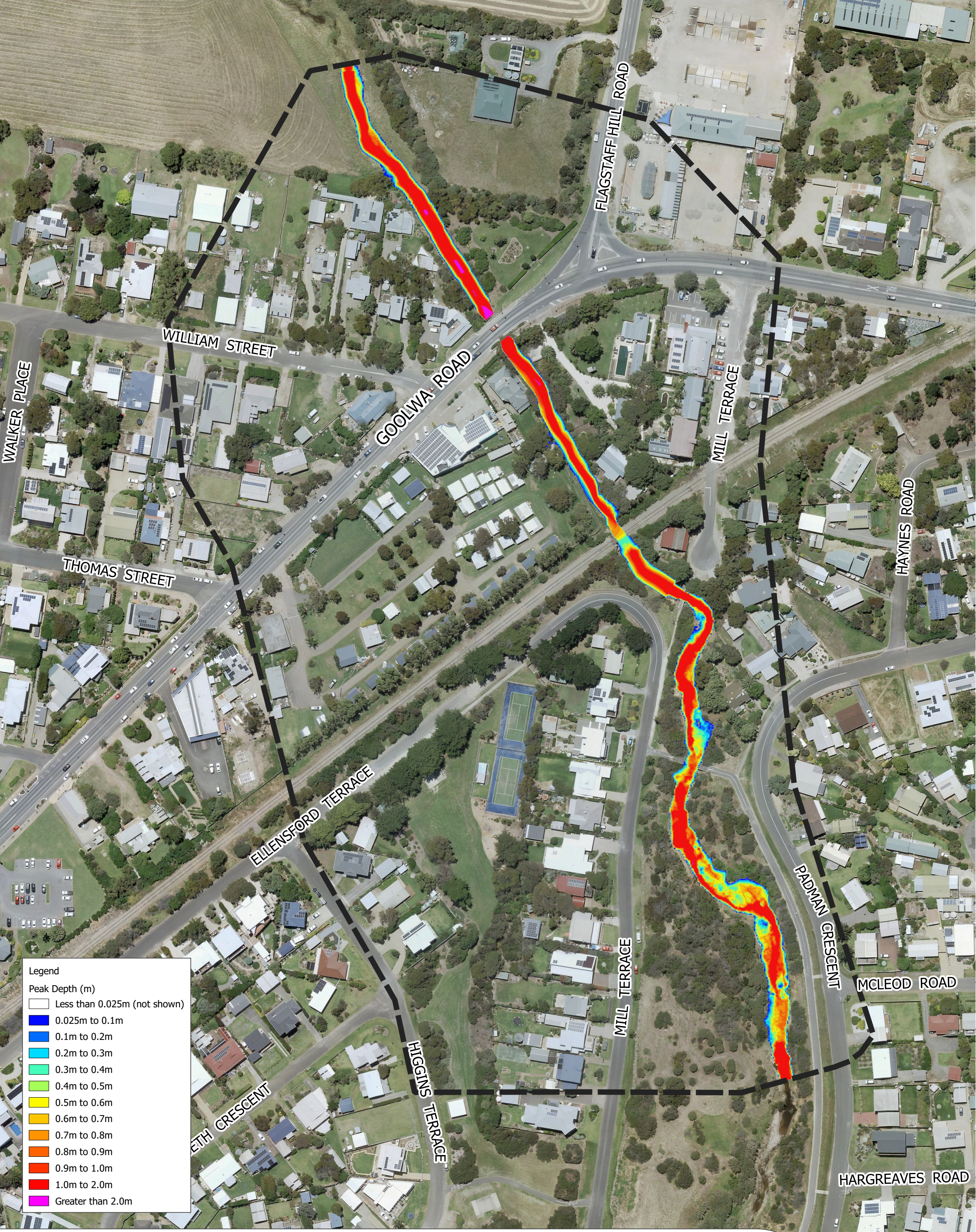
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Middleton Flood Study
Scenario 3: Flood Levees
Critical 100-year ARI event
Peak Depth



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0 50 100 m

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Middleton Flood Study
Scenario 4: Flood Detention
Critical 100-year ARI event
Peak Depth

WILLIAM STREET
GOOLWA ROAD
FLAGSTAFF HILL ROAD
WALKER PLACE
MILL TERRACE
THOMAS STREET
ELLENSFORD TERRACE
HAYNES ROAD
PADMAN CRESCENT
MCLEOD ROAD
HIGGINS TERRACE
MILL TERRACE
HARGREAVES ROAD
ESPLANADE

Legend

Peak Depth (m)

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 2.0m
- Greater than 2.0m

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0 50 100 m

N

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Middleton Flood Study
Scenario 5: Goolwa Road Culvert Upgrade
Critical 100-year ARI event
Peak Depth