Model of Flood Behaviour Report

Shepparton Area 3 - Kialla North Growth Corridor

Greater Shepparton City Council

1 September 2022

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GREATER SHEPPARTON

Front Cover Image: September 2010 Floods (Source: NearMap)

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EXECUTIVE SUMMARY

Water Technology was commissioned by Greater Shepparton City Council (GSCC) to investigate and create a better understanding of the flood impact that development may have on the Kialla North Growth Corridor (KNGC) (formerly Investigation Area No. 3) and the broader floodplain area along the Broken River with the inclusion of climate change.

An earlier investigation assessed the current flooding conditions (based on current day hydrology). Updated hydrology and changes to planning requirements now require an assessment to incorporate climate change conditions. The study provided an update to the mapping provided in the Shepparton Investigation Area No.3 Flood Modelling[1] project, undertaken in 2016 and supersedes the flood modelling undertaken for the 1% AEP flood event and incorporates climate change modelling.

Initial modelling of the proposed layout (based on previous work) was undertaken with LiDAR captured in early 2020 and the updated climate change flows. The modelling showed increases in flood levels outside the site in a 1% AEP event. This did not meet acceptable limits from the floodplain referral authority as part of a greenfield development.

These initial results were submitted to GSCC, following their submission, further information from GSCC and Goulburn Broken Catchment Management Authority (Goulburn Broken CMA) was provided. Several design iterations were undertaken until a result was achieved that meet appropriate afflux. Flood modelling has been undertaken providing mapping outputs and an area marked for development from a purely floodplain management perspective. Update to the climate change modelling suggests significantly more of the site is inundated when using climate change as the design scenario.

An additional sensitivity test was undertaken based on the proposed development to the north of the Broken River (known as the Shepparton South East Precinct/Channel Road development area). The assessment found the cumulative impact of the development on both precincts did not increase flood levels outside the 20mm tolerance assessed within this investigation.

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1 BACKGROUND

The development of a detailed flood model of the KNGC was required to provide information on developable land and the broader context of flooding and drainage along the growth corridor. This growth corridor is located on the northern side of Kialla, and comprises an area of approximately 474 ha. It is bounded by Archer Road to the west, River Road to the south, Doyles Road to the east and the Broken River to the north (Figure 1-1).

Since the completion of the Investigation Area 3: Model of Flood Behaviour project in 2016, the Shepparton Mooroopna Flood Mapping and Flood Intelligence project, with the inclusion of climate change (Water Technology, 2021) has been completed and adopted by Council. This superseded the 2018 study and is known as the Shepparton Mooroopna 1% AEP Flood Mapping Project (2021). The current study utilised updated LiDAR datasets (collected in early 2020) and a more defined model grid resolution to produce flood mapping and flood intelligence information. Therefore, an update to the 2016 Model of Flood Behaviour study was required to bring the information for the investigation area in line with the most recent flood modelling information.

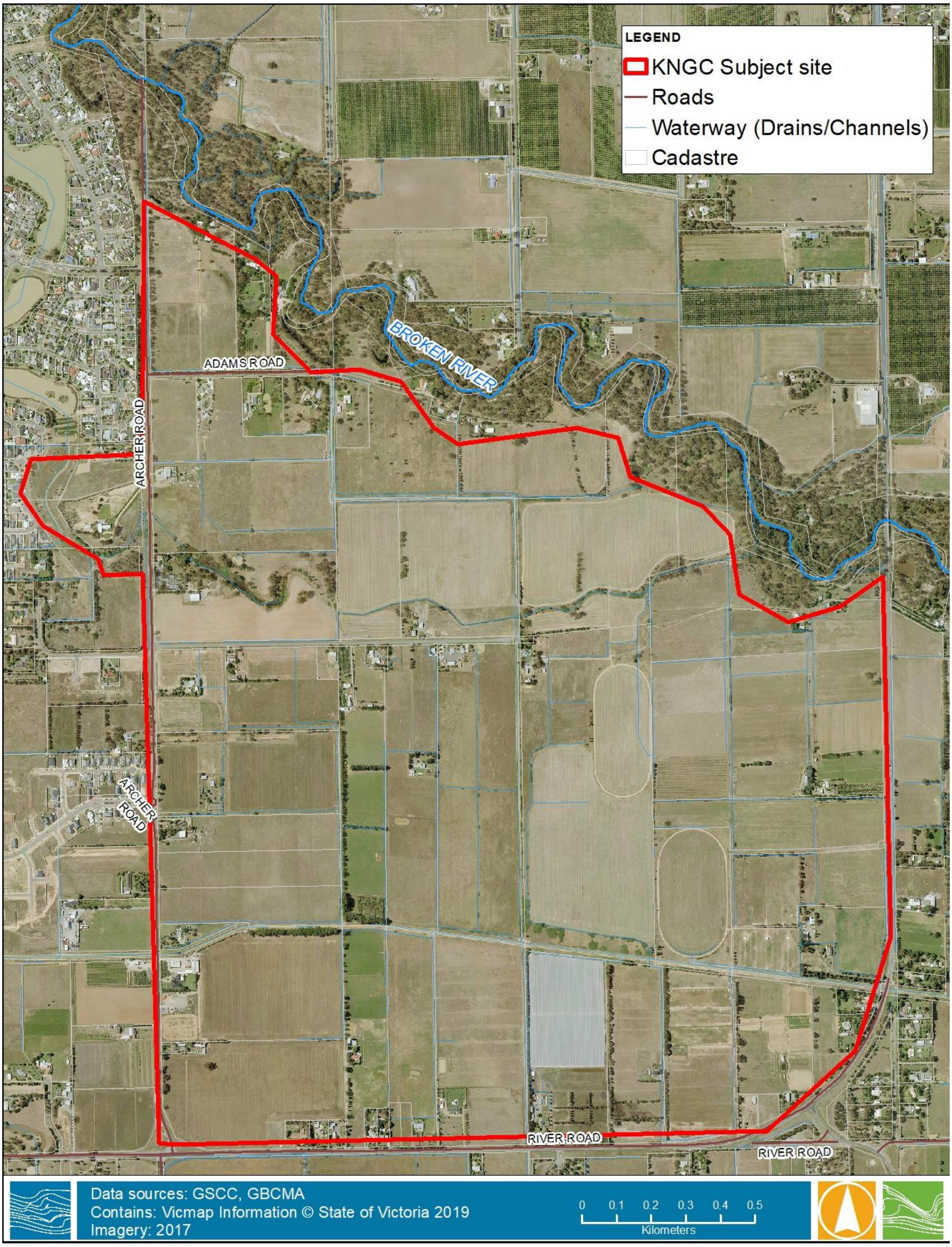

Figure 1-1 KNGC Site

1.1 Kialla North Growth Corridor

As part of the study undertaken in 2016, a series of model scenarios were carried out to assess the floodplain management suitability of development. The key criteria assessed included:

- No negative impact to flood levels outside of the study site.
- Any loss of floodplain storage be compensated with the replacement of floodplain storage volume.

Several iterative layouts were modelled as part of the project to develop a conceptual layout that allows for flood free development while not increasing the flood risk off site. The final developed scenario (Development Scenario 13) was chosen as the preferred development layout by GSCC (Figure 1-2). This layout was shown to meet GBCMA requirements for no increase in water levels of more than 20 mm outside of Investigation Area 3 when compared with existing conditions.

General Residential areas were filled above the floodplain, while Rural Living Zone lots of 2ha had a 50x50m fill pad raised above the flood level. Internal roads were raised to ensure flooding was maintained below 300mm. Safe egress throughout the site appears to be achievable with access to the roads to the south and east of the site during a 1% AEP flood event.

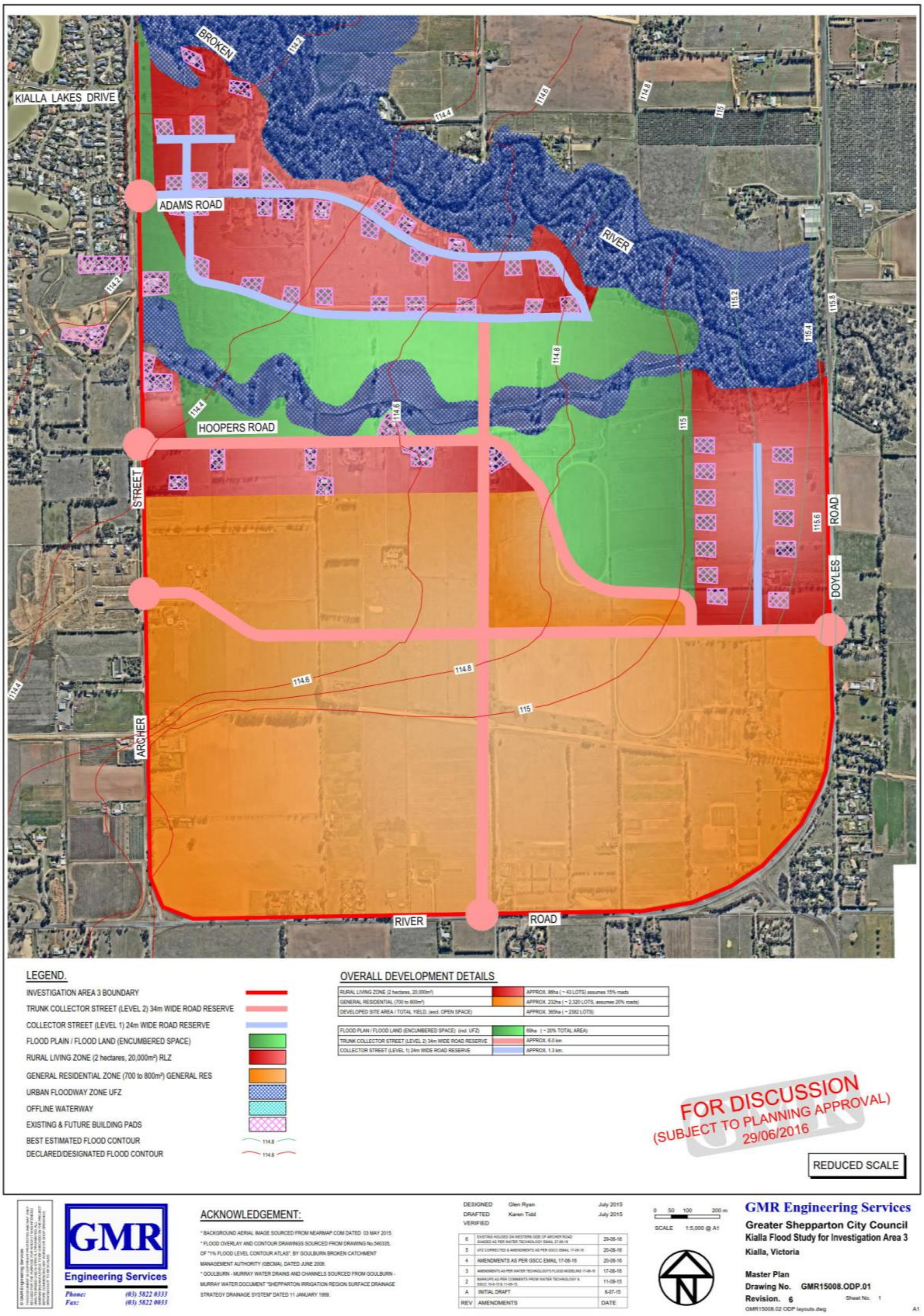

Figure 1-2 KNGC – 2016 Concept Plan

2 1% AEP FLOOD CONDITIONS

The 1% AEP flood modelling results from the Shepparton Mooroopna supplementary mapping project were used as the primary assessment tool for the Kialla North Growth Corridor. This was based on a 1% AEP event on the Broken River which produces a flood level of 12.1m at the Shepparton streamflow gauge. The 1% AEP flood depths are shown in Figure 2-1.

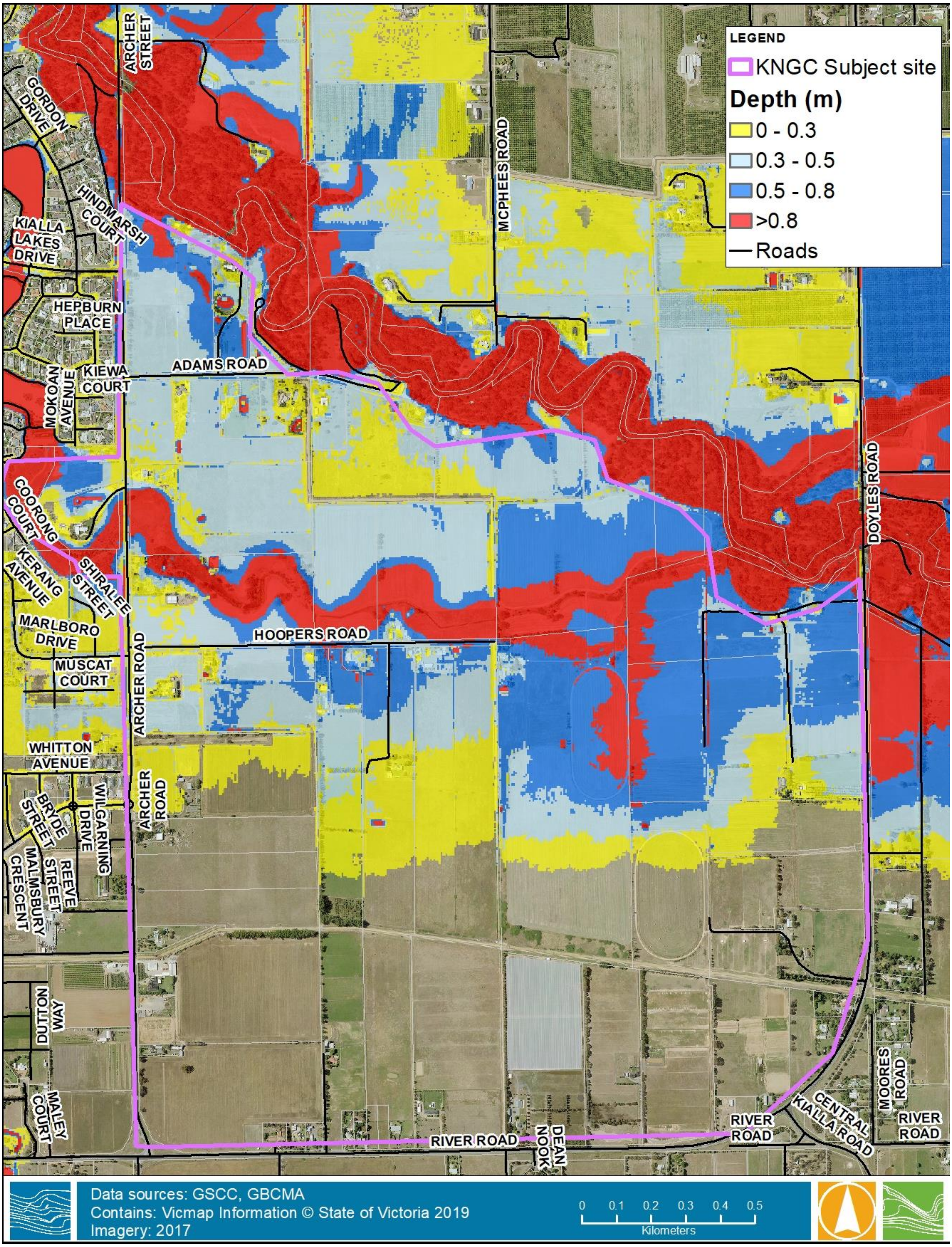

Figure 2-1 1% AEP – Existing Conditions Depth Plot

3 1% AEP CLIMATE CHANGE CONDITIONS

The 1% AEP climate change flood modelling results from the Shepparton Mooroopna supplementary mapping project were used as a primary assessment tool for the Kialla North Growth Corridor. This was based on a Broken River dominant event which produces a flood level of 12.3m at the Shepparton streamflow gauge. On average there are increases in the flood depth through the study area of around 150-200mm. This has the potential to reduce the 'Net Developable Area' by increasing a significant portion of the study area into depths greater than 300mm, and above 500mm in some cases, while also increasing the overall quantum of earthworks (related to increased fill levels) as well as potential access/egress issues.

Discussions with GBCMA have suggested that greenfield development should not be located where flood depths exceed 300mm in existing climatic conditions and 500mm under the climate change scenario. It is suggested that fill levels of developable lots within the study area be filled to the 1% AEP climate change flood level and the Finished Floor Level (FFL) be located 300mm above this level.

Access and egress levels may also be required to adopt a more lenient level when assessing climate change modelling results as opposed to existing conditions results. The 1% AEP climate change depths are shown in Figure 3-1.

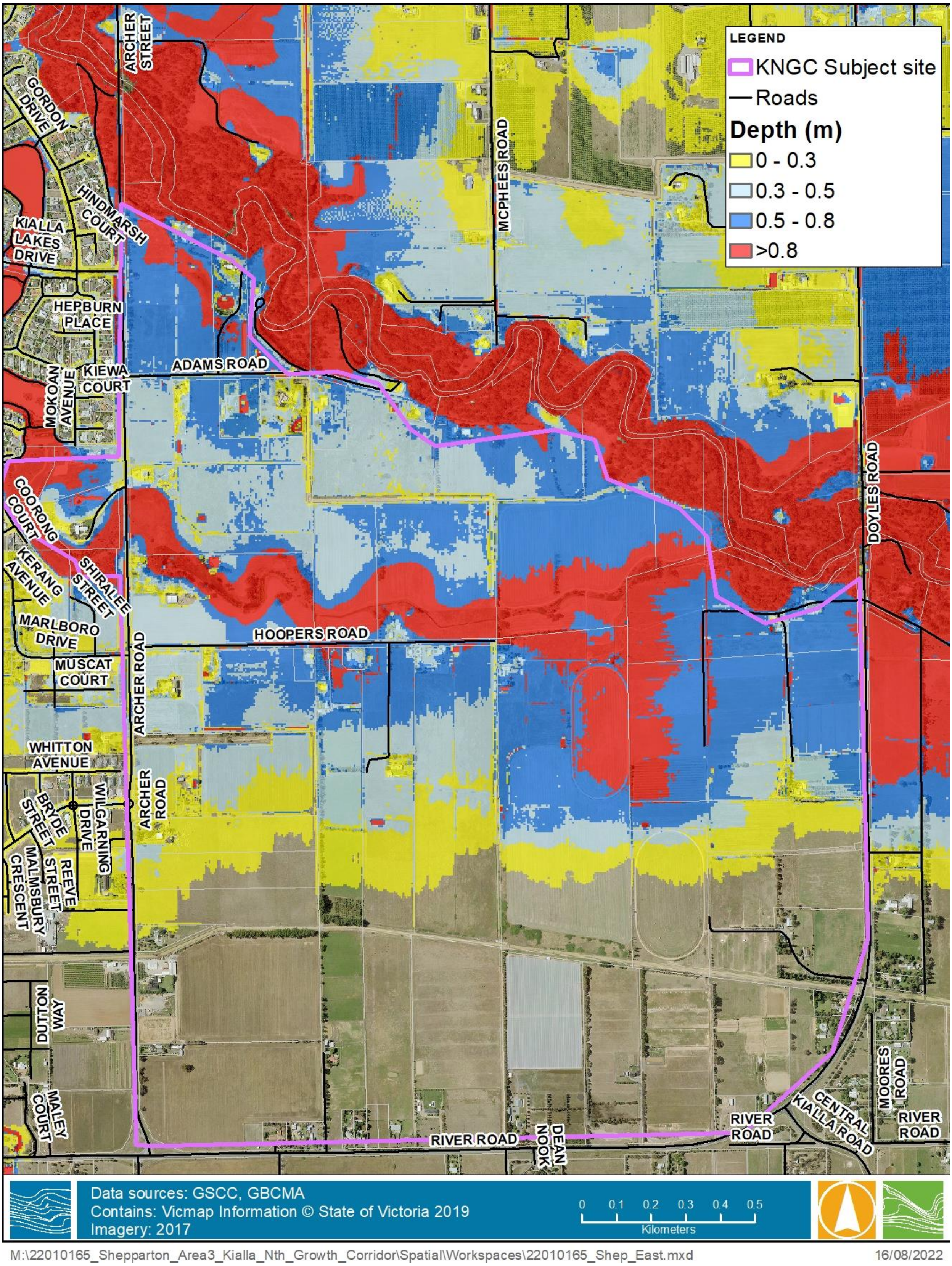

Figure 3-1 1% AEP – Climate Change Depth Plot

4 PROPOSED DEVELOPMENT

To understand the impact the development would have on flood levels, depths and extents a direct comparison was drawn between the Water Surface Elevation (WSE) predictions from the 'Base Case' and 'Developed' models. This comparison is calculated as follows:

Developed WSE – Base Case WSE = Difference in predicted WSE

This comparison shows the impact of the development in terms of a change in WSE. A positive change indicates an increase in WSE after development for the 1% AEP flood event. A negative change indicates a decrease in WSE after development during the 1% AEP flood event. The comparison also shows areas which were previous inundated and are now dry after the development and areas which were dry and are now inundated.

The adopted development plan from the previous 2016 study was initially tested under the updated flood model which included the climate change predictions. The flood level difference plot shown in Figure 4-1 shows the flood level increase is relatively confined to within the study area, with the exception of an increase in flood levels and extent to the north of the Broken River at Channel Road.

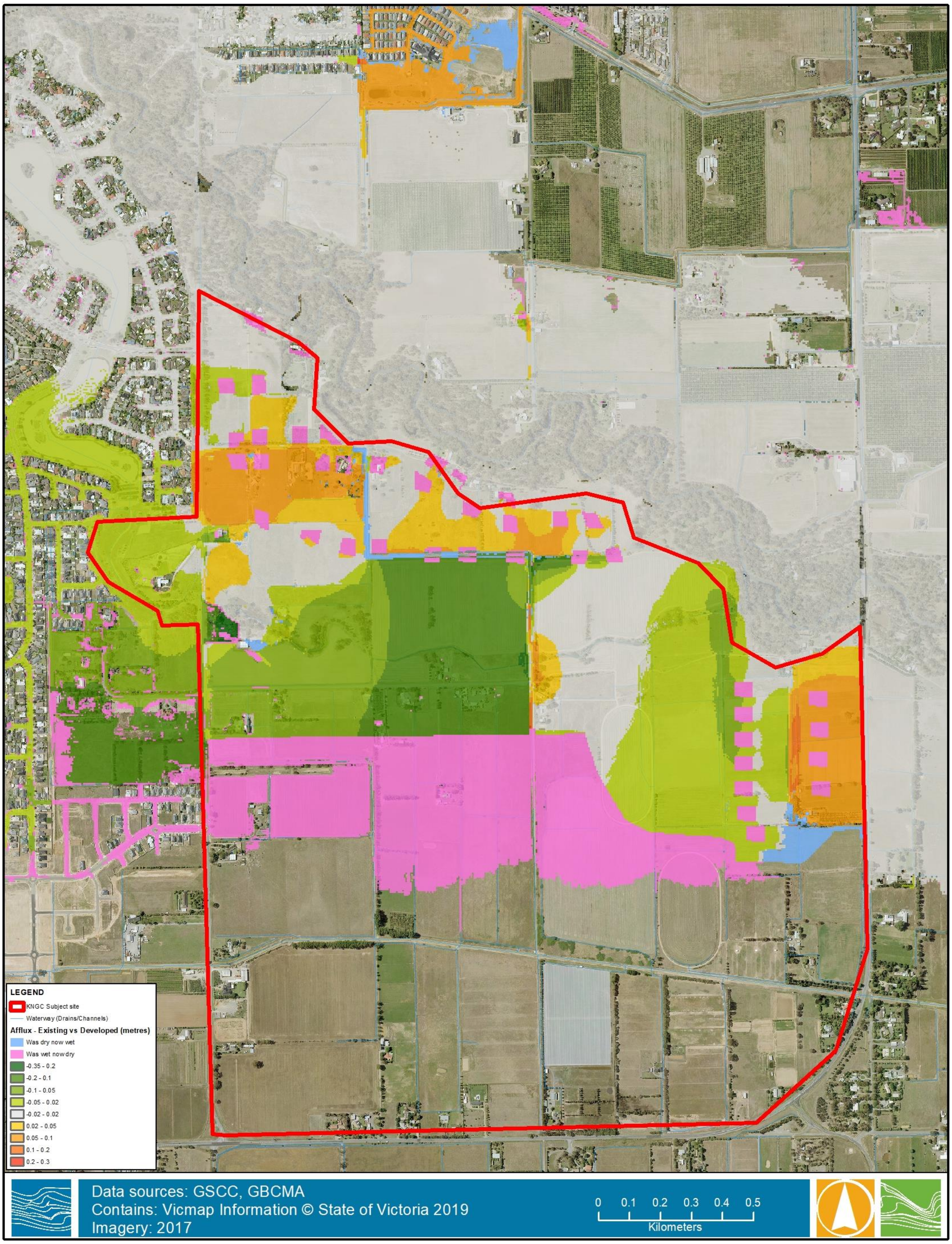

Figure 4-1 1% AEP Flood Level Difference Plot – 2016 Development Plan

4.1 Revised Development Footprint

Areas categorised for General Residential development were based on ensuring no development where the existing 1% AEP flood depths exceeded 500 mm. These areas would require fill up to the existing 1% AEP flood level to allow for the finished floor level of any new houses to be constructed at least 300 mm above the fill level. This aims to prevent new parcels being inundated in events up to the 1% AEP flood event. Further design work (including lot and road layouts) would be required to provide a more detailed earthworks estimate; however, roadways within the area would be likely to be filled to 250-300 mm below the 1% AEP flood level to ensure access and egress requirements are met.

Based on the existing conditions initial findings and the inception meeting held between Water Technology and GSCC on the 30th November 2021, several key features of the growth area were identified along with constraints associated with the plan developed in 2016. The first iteration which involved the following:

- Removal of the Rural Living Zone (RLZ) north of Hoopers Road.
- Removal of major earthworks for reshaping of existing anabranch through the site.
- Removal of the bridge across the anabranch waterway.
- Increase in fill level of development area at the eastern edge of the study area (adjacent to Doyles Road).

4.2 Final Development Footprint

From the above design changes, several iterations were undertaken to adjust the development layout until a final development scenario with 229 hectares of area marked for general residential development was modelled. The main criteria being able to maximise the development footprint without significant impacts of floodplain behaviour. Flood depth results for the 1% AEP with climate change scenario are provided in (Figure 4-2). This scenario was shown to meet the afflux requirements (Figure 4-3).

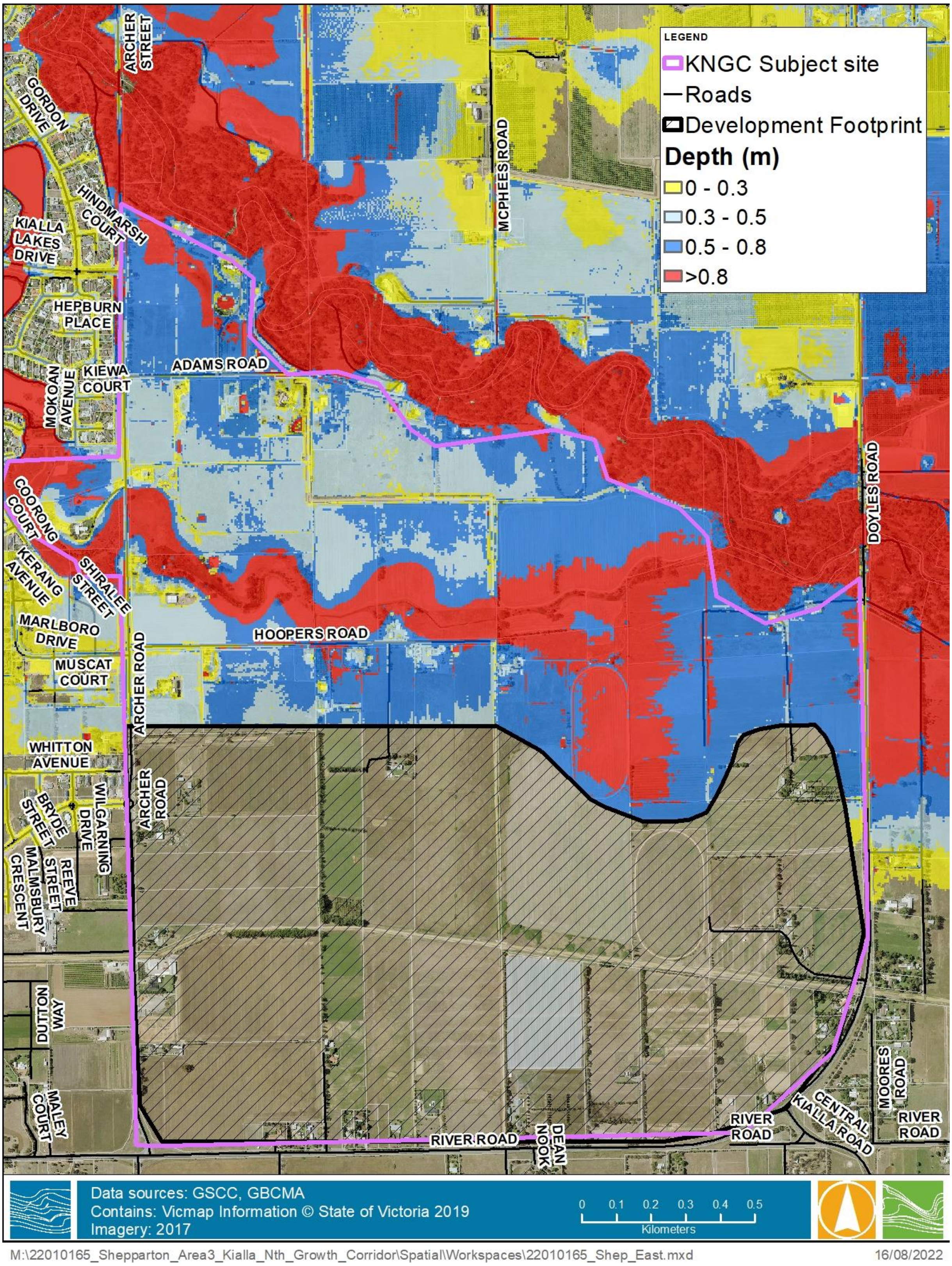

Figure 4-2 1% AEP Flood Depth Plot

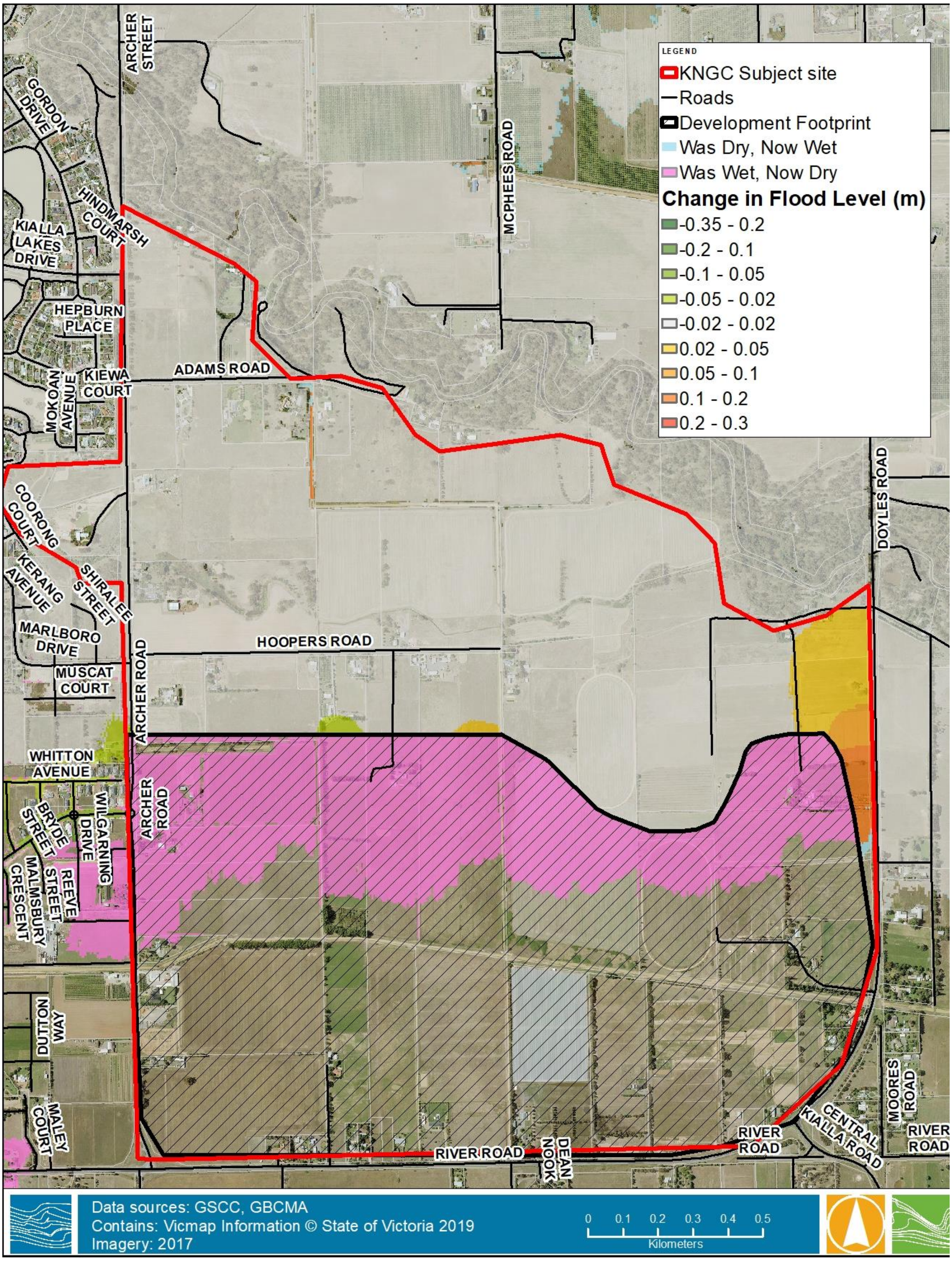

Figure 4-3 1% AEP Flood Level Difference Plot

5 EARTHWORKS AND FLOODPLAIN STORAGE

5.1 Earthworks

The proposed development scenario relies on filling the site to above the 1% AEP (with climate change) flood level in locations where existing flood depths are less than 0.5 m. This requires significant volumes of fill to be imported into the development precinct, which can be somewhat offset by 'cut' taken from within the site.

The finished levels used for the flooding modelling are not final design levels and are based on a grid resolution of 5m x 5m. These volumes are an estimate and are to only be used as an estimate of total earthworks required. The cut and fill volumes quoted are likely to change slightly at a further detailed design stage; the addition of road levels into the design will see further changes to the quoted volumes.

The total cut and fill calculated from the development layout is shown in Table 5-1 below and shows that a total of approximately 486,000 m^3 of fill will need to be imported (based on the assumptions adopted in the model). These calculations do not incorporate changes to floodplain storage, which are discussed further below.

Table 5-1 Cut/Fill Earthworks Summary

	Fill Required (m^3)	Cut Required (m^3)	Net Balance (m^3)
Investigation Area 3	506,000	20,000	486,000

5.2 Floodplain Storage

Typically, the GBCMA would require than any loss of floodplain storage be compensated in a 1:1.3 ratio for a single private development. Given the size of the development been undertaken, it is understood the GBCMA will assess floodplain storage requirements on a 1:1 ratio given flood modelling has been carried out to assess the impact. It is also assumed that provided flood mapping shows no significant afflux outside of the subject site. A summary of the loss of floodplain storage (based on a 1:1 ratio) is shown in Table 5-2. This shows that the proposed fill extents will result in a floodplain storage loss of approximately 203,000 m^3, which equates to around 13% of the total volume stored within the subject site under existing conditions.

Table 5-2 Floodplain Storage Summary

Storm Event	Floodplain Storage		Net Balance (m^3)
	Existing Conditions (m^3)	Developed Conditions (m^3)	
1% AEP + Climate change	1,600,700	1,397,400	-203,300

6 FLOOOD HAZARD

6.1 Potential Flood Risk with Development

Modelling of flood behaviour developed by Water Technology has shown that areas within the Investigation Area may be suitable for residential development from a floodplain management perspective; however, there is still a need to assess the broader flood hazard risk. The updated design has not considered drainage requirements from stormwater generated within the site. Mapping of the 1% AEP (with climate change) velocity and water surface elevation are provided in Figure 6-2 and Figure 6-3 respectively.

The combined impact of depth and velocity is often provided as a representation of flood hazard. The ARR2019 recommendations provide a further assessment of flood hazard through the Flood Hazard categories as outlined by Australian Emergency Management Institute (2014). The categories in Table 6-1 provide recommendations for suitable design criteria based on a value from 1 to 6. TUFLOW provides ZAEM1 output values are 0 (zero) for no hazard and 1 to 6 for H1 to H6 respectively. The results of the developed flood hazard conditions are shown in Figure 6-4. The plot shows the residential areas filled above the flood level and the remaining areas mostly classified as H1 and H2 with a small area of H3 category located in the drainage reserve and floodway.

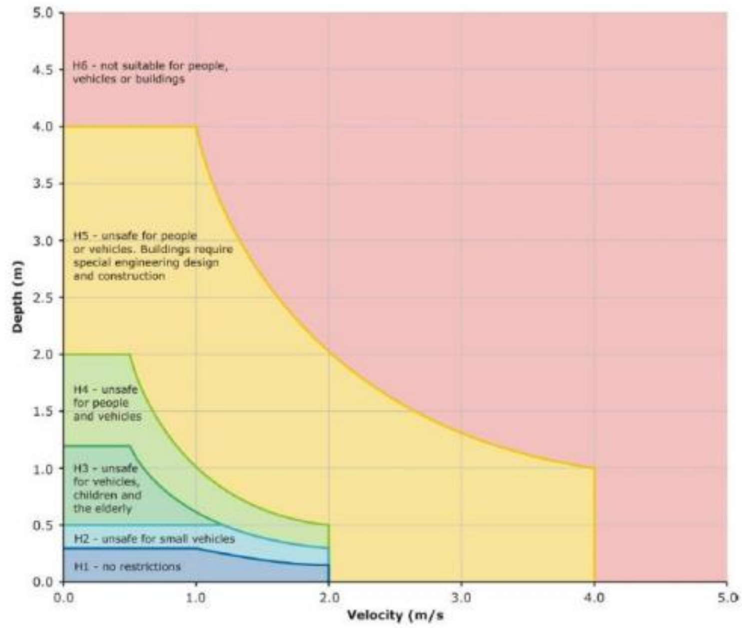

Figure 6-1 Flood Hazard Classification (ARR2019)

Table 6-1 Flood Hazard Classification Summary

Hazard Classification	Description
H1	Relatively benign flow conditions. No vulnerability constraints.
H2	Unsafe for small vehicles.
H3	Unsafe for all vehicles, children and the elderly
H4	Unsafe for all people and all vehicles
H5	Unsafe for all people and vehicles. Buildings require special engineering design and construction.
H6	Unconditionally dangerous. Not suitable for any type of development or evacuation access. All building types considered vulnerable to failure.

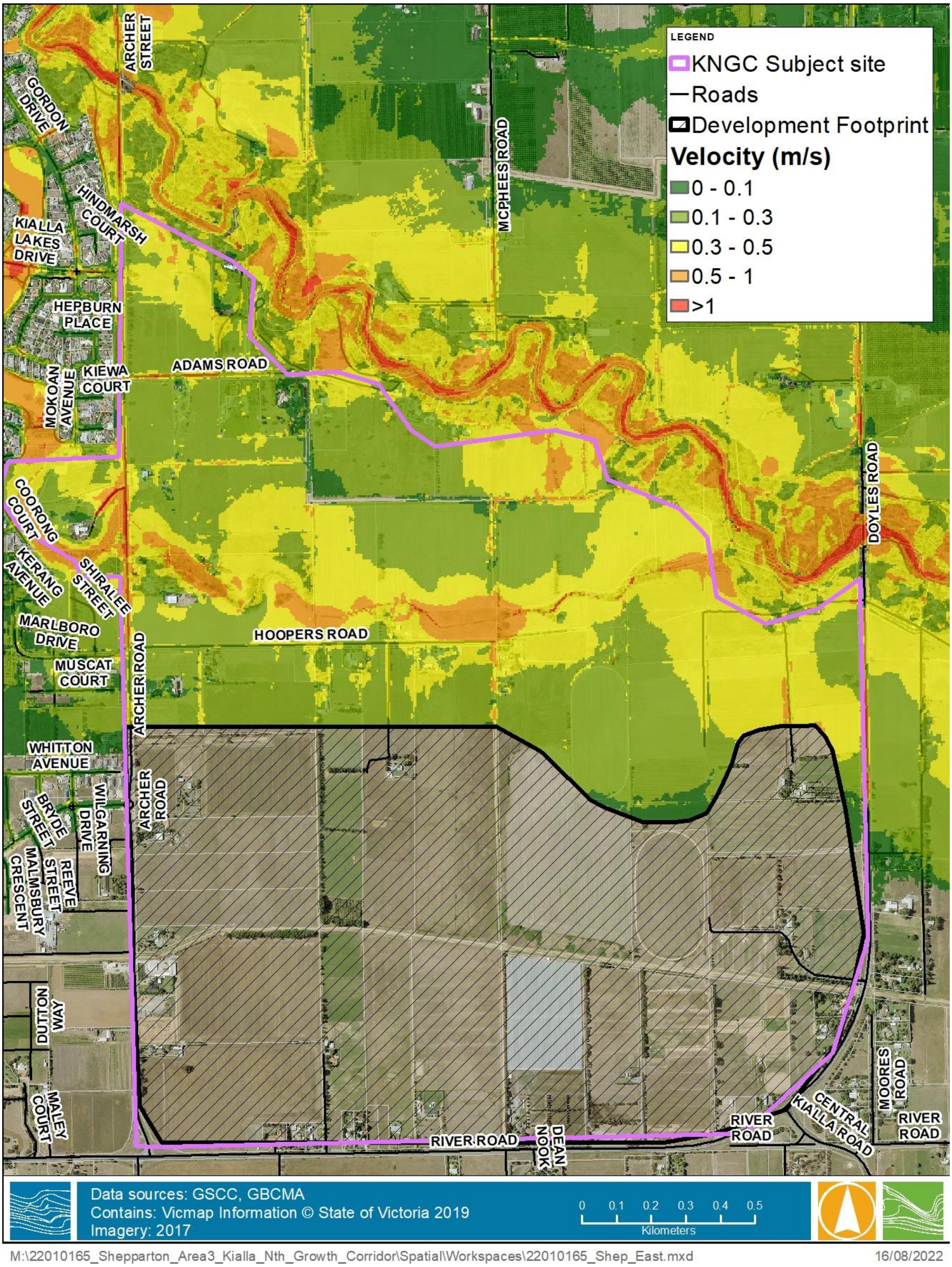

Figure 6-2 Development Scenario – 1% AEP Velocity Plot

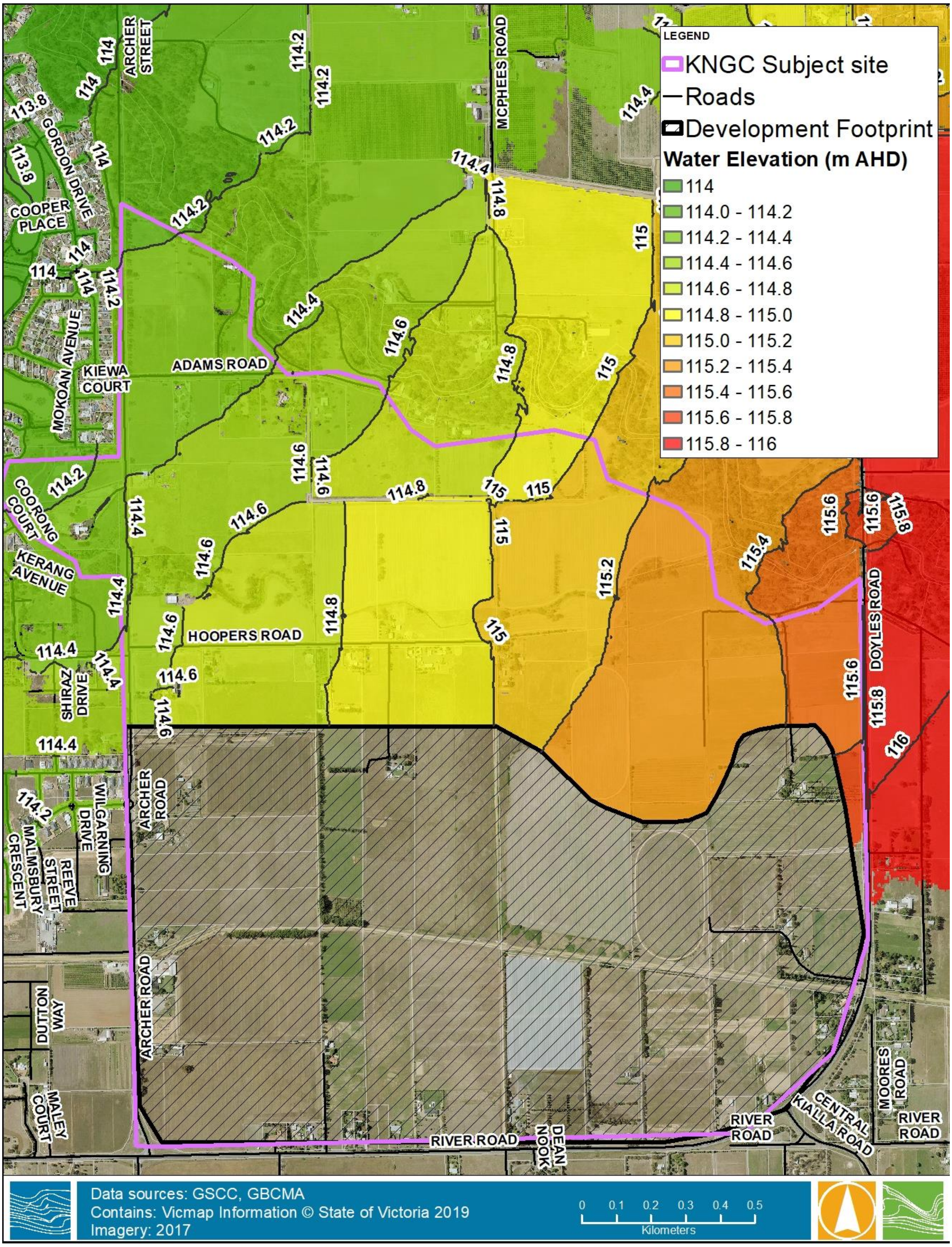

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Figure 6-3 Development Scenario – 1% AEP Water Surface Elevation Plot

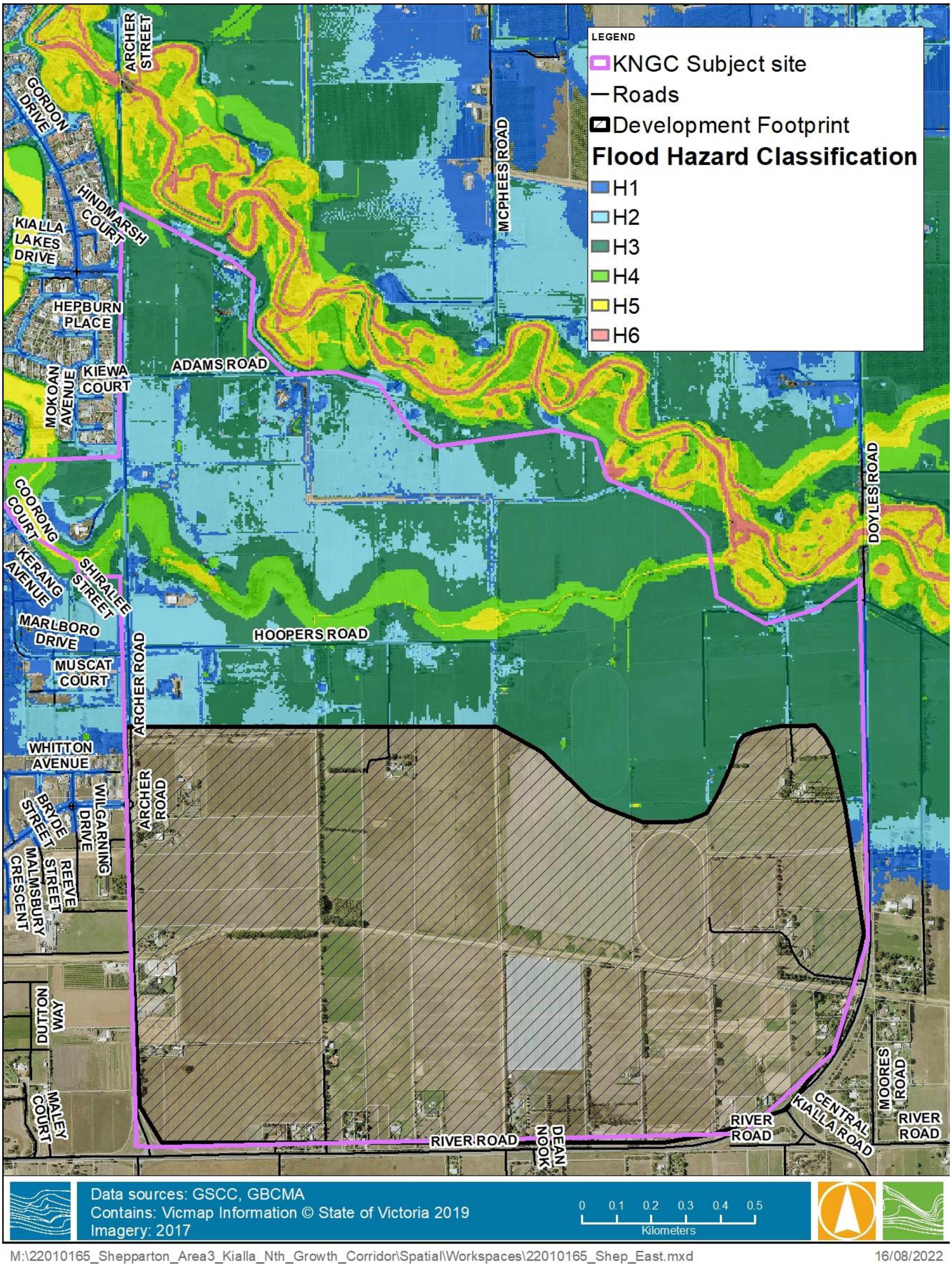

Figure 6-4 Development Scenario – 1% AEP Flood Hazard Plot

6.1.1 Flood Warning Time

The site has considerable flood warning time for a Broken River dominated flood. There are currently streamflow gauges on the Broken River at Lake Nillahcootie, Benalla, Casey's Weir, Gowangardie and Orrvale. These gauges provide a good indication of expected peak flooding as well as estimated flood levels at Orrvale. The Broken River at Orrvale gauge (located just upstream of site) is part of the of Bureau of Meteorology Flood Warning Network and predicted flood levels and flood class levels are provided for this gauge.

Flood peak travel times from the Gowangardie gauge downstream of Benalla to Kialla is estimated at 12 hours for a small flood (similar to 2003) up to 24 hours based on larger floods in 1993, and 2010.

6.1.2 Site Egress

Any vehicular and/or pedestrian access must be designed and constructed to comply with the following safety criteria as indicated by the Goulburn Broken CMA:

- Depth of flow does not exceed 0.50m; and
- Velocity of flow does not exceed 3.0m/s; and
- The Flood Hazard classification does not exceed H2.

Assessment of the developed conditions flood results along Archer Road shows the roadway is overtopped to a depth around 300-400mm in the climate change scenario. This is a known area of flooding and it is recommended flood evacuation routes utilise Doyles Road to the east of the site to reach Channel Road to the north of the Broken River. This indicates that safe access can be maintained to each of the respective lots during a 1% AEP flood event (current conditions). Climate change egress was also considered as a comparison between and 'existing' and 'developed' conditions scenario.

In the 1% AEP current (2020) conditions, flood depths along the egress routes from Doyles Road to the Channel Road are shown to generally be below 0.3 metres in depth with the exception of two short stretches north of the Broken River where the road profile lowers slightly. Flow velocities are less than 0.5 m/s along the route with the exception of 160 m where shallow water overtops Doyles Road, and velocities increase to 1m/s. The Flood Hazard classification is also shown to be at H2 or lower along this egress route.

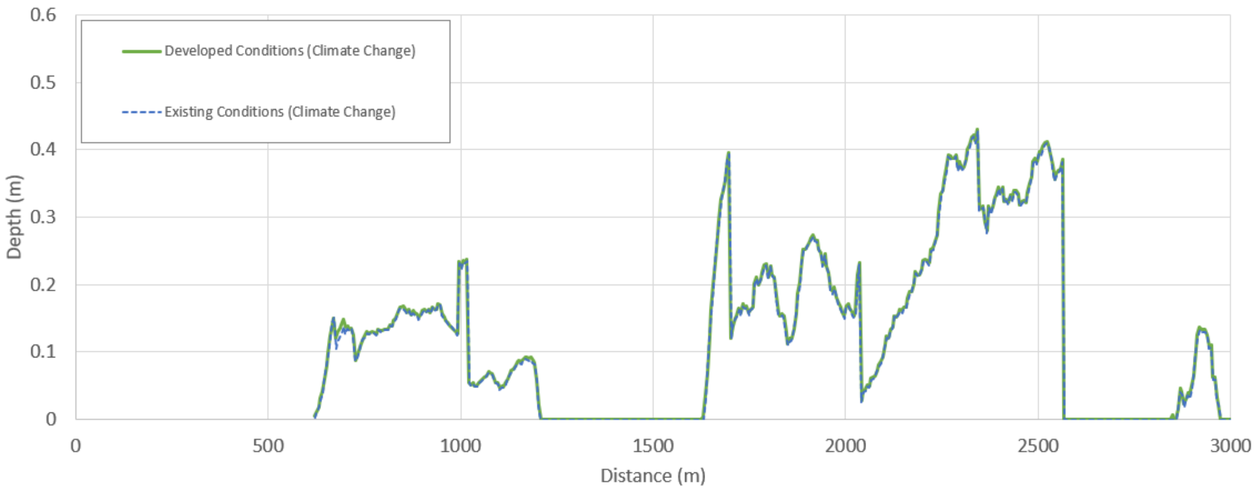

Figure 6-5 Flood Depths along egress route (Doyles Road to Channel Road)

6.2 Cumulative Impact Assessment

An additional sensitivity test was undertaken based on the proposed development to the north of the Broken River, known as the Shepparton South East Precinct (SSEP). In a similar manner to the KNGC flood investigation, several iterations of a development footprint provided by VPA through Alluvium, two development layouts were established that show negligible afflux outside of the site in a 1% AEP event (with climate change).

The cumulative impact assessment found the impact of the development on both the KNGC and SSEP precincts did not increase flood levels outside the 20mm tolerance assessed within this investigation. A flood level difference plot with one of the development layouts for SSEP along with the KNGC is shown in Figure 6-6.

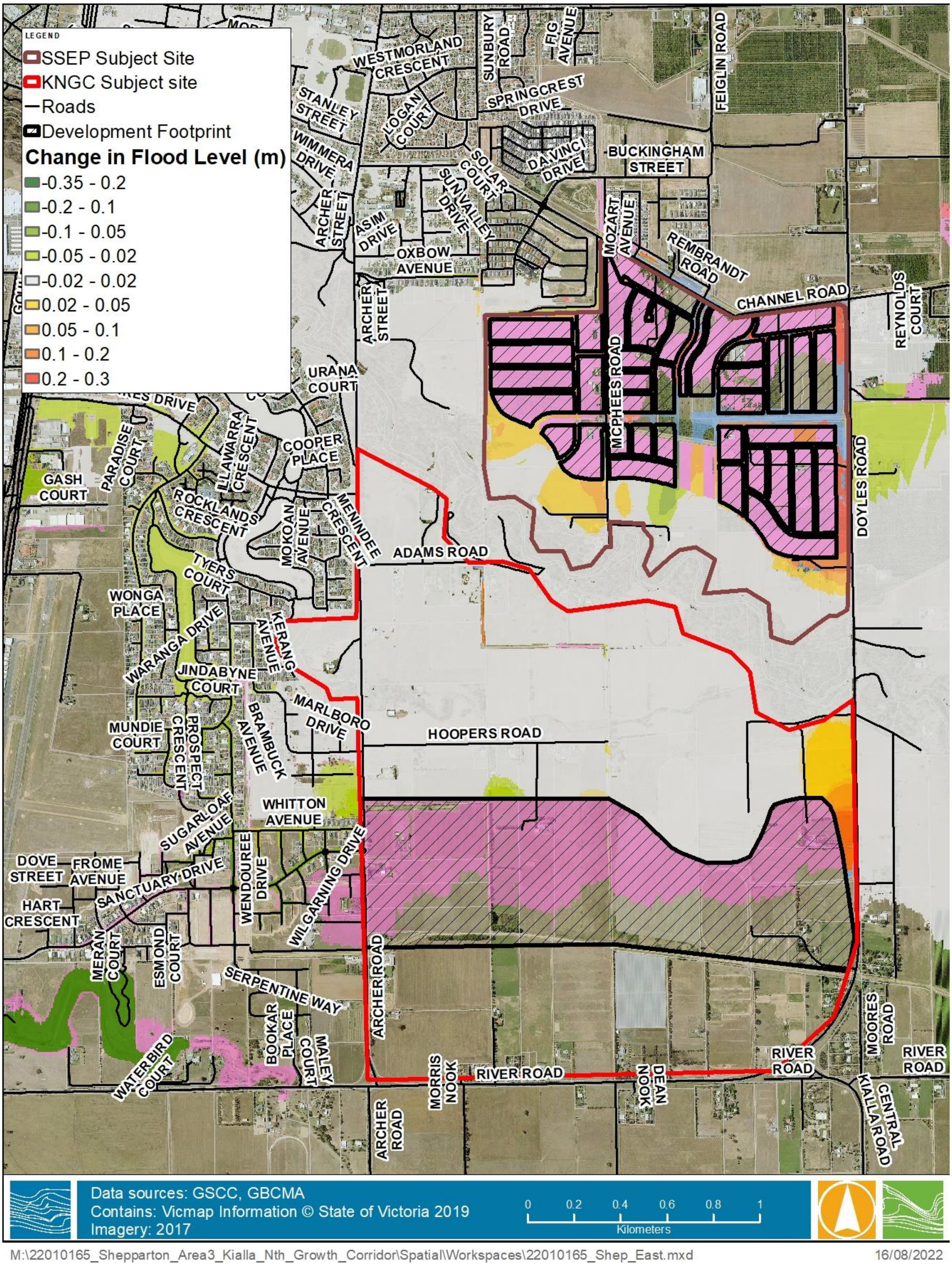

Figure 6-6 1% AEP Flood Level Difference Plot – Cumulative Impact (SSEP and KNGC)

7 SUMMARY

The initial proposed development plan provided in 2020 was modified based on feedback provided by GSCC and the GBCMA due to the 1% AEP flood level increases caused by floodplain fill. To mitigate the impact on flood levels, the design layout was modified to reduce the proposed fill areas, removal of Rural Living Zone fill pads and minimise earthworks along the existing anabranch.

Flood modelling was undertaken to provide mapping outputs and highlight an area marked for development from a purely floodplain management perspective. Update to the climate change modelling suggests there is significantly more of the site inundated when using climate change modelling as the design scenario. The revised modelling shows there is a significant increase in flood levels using the development footprint from the 2020 assessment. Refinement to the development footprint has resulted in an outcome which appears to meet suitable afflux requirements and provides around 229 hectares of land for residential development (from a floodplain management perspective).

Earthworks estimates indicate significant volumes of fill are required to be imported and there is a net loss of floodplain storage within the precinct. Further refinement and detailed flood modelling are expected to be completed at later stages of the design process, that includes incorporation of stormwater drainage assets, an internal road network (which can be inundated to depths up to 300mm) and a detailed design surface.

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