BARALABA SOUTH

Baralaba South Project

Environmental Impact Statement

CHAPTER 6

Flooding and Regulated Dams

arc ENVIRONMENTAL SOLUTIONS

Table of Contents

List of Figures

List of Tables

6 Flooding and Regulated Dams

This chapter assesses the potential impacts of the Project on existing environmental values in relation to flooding and regulated dams and evaluates the current flood risk to the Project area and surrounding communities. It also proposes mitigation, management and monitoring measures to address the identified flooding risks.

6.1 Environmental objectives and performance outcomes

This chapter has been prepared in order to assist the DES in carrying out the environmental objective assessment in respect of the following environmental objectives prescribed in Schedule 8, Part 3, Division 2 of the EP Regulation:

> *The design of the regulated structures and facilities permits the [Project] site to operate in accordance with best practice environmental management (the design objective).*

The detailed assessment presented in this chapter and in Appendix C, Flood Impact Assessment, demonstrates that the Project will achieve item 2 of the performance outcomes relating to the design objective, in satisfaction of section 2(4) of Schedule 8 of the EP Regulation, by ensuring that:

- regulated structures comply with the document 'Manual for assessing consequence categories and hydraulic performance of structures', (DES, 2016a); and
- containers are provided for the storage of hazardous contaminants that are secured to prevent the removal of the containers from the site by a flood event.

Importantly, the assessment presented in this chapter and in Appendix C, Flood Impact Assessment also demonstrates that the following objectives set out in the TOR will also be met:

- that the construction and operation of the Project is aimed at ensuring that the risk and potential adverse impacts from flooding are avoided, minimised or mitigated to protect people, property and the environment; and
- that, in order to protect human life and the environment, the standards for the design, construction, operation, modification and decommissioning of regulated structures ought to mitigate the consequences arising from potential failure or collapse of those structures.

6.2 Description of environmental values

In undertaking an assessment of the Project's flood risks, the following matters have been considered:

1) Nearby water resources—the Project is located:
   a) Adjacent to the eastern floodplain of the Dawson River, near the confluence of Banana Creek and the Dawson River (Figure 4.3 in Chapter 4, Surface Water). The Dawson River is subject to seasonal flooding and is characterised by:
      i) a lower floodplain extending 1.5-3 km on either side of the river channel;
      ii) several anabranch channels, both upstream and downstream of the Project, indicating that the river channel is laterally active.
   b) Near one minor unnamed tributary to the Dawson River, which traverses the MLA and confluences with the Dawson River approximately 1 km to the north-west of the MLA boundary (Figure 4.4 in Chapter 4, Surface Water); and
   c) Near an HES wetland, which is located within the MLA outside the mine footprint (Figure 4.9 in Chapter 4, Surface Water). The environmental values for water quality and water resources are described in Chapter 4, Surface Water.

2) Proximity to agricultural properties, including habitable and non-habitable infrastructure and land use associated with each property—prime agricultural land is located on the floodplain of the Dawson River and its tributaries, and the area to the west of Banana Creek and the Dawson River is mapped as a Priority Agricultural Area under the RPI Act. The floodplain areas are used for irrigated and rain-fed cropping and, on improved pastures, beef cattle grazing. Away from the floodplain, cattle are typically grazed on native or improved dryland pastures. Properties located in proximity of the Project contain habitable and/or non-habitable structures. Dwellings located within or proximal to the flood model boundary are shown in Figure 6.1.
3) Proximity to infrastructure—the Project is located near the following infrastructure (Figure 6.1):
    a) the Baralaba North Mine, which is located approximately 11 km downstream of the Project on the Dawson River western floodplain;
    b) Baralaba township, which is downstream of the Project on the eastern bank of the Dawson River;
    c) Neville Hewitt Weir, which is downstream of the Project on the Dawson River;
    d) Baralaba-Woorabinda Road Bridge, which is downstream of the Project spanning across the Dawson River channel;
    e) Moura-Baralaba Road Bridge, which is upstream of the Project spanning across the Banana Creek channel;
    f) Moura-Baralaba Road, which runs parallel to the Dawson River on the eastern floodplain downstream of the Project (though the development of the mine will require the relocation of an approximate 4.5 km section of the existing Moura-Baralaba Road from within to outside the MLA area);
    g) Alberta Road, which runs parallel to the Dawson River on the western floodplain; and
    h) Baralaba-Woorabinda Road, which crosses the Dawson River western floodplain approximately 9 km downstream of the Project.

6.2.1 Flood modelling

6.2.1.1 Regional hydrologic model

Engeny Water Management (2021b) developed a Unified River Basin Simulator (UBRS) hydrologic model of the Dawson River catchment to assess the current flood risk and the potential impacts of the Project on flooding. Details of the model development are provided in Appendix C, Flood Impact Assessment.

The Dawson River CatchmentSIM model was subdivided into 244 sub-catchments (total catchment area 40,800 km2) as follows:

- 114 sub-catchments representing the Upper Dawson River to the headwaters of the Nathan Gorge (23,660 km2).
- 62 sub-catchments representing the Mimosa Creek catchment to the confluence with the Dawson River (8,820 km2).
- 19 sub-catchments representing Banana Creek to the confluence with the Dawson River (1,170 km2).
- 44 sub-catchments representing the Lower Dawson River to the Beckers stream gauging station downstream of the Baralaba township (11,350 km2).
- 5 sub-catchments representing the area downstream of the Beckers gauging station within the hydraulic model extent (300 km2).

The sub-catchments were defined in the URBS model based on catchment area and catchment slope. Channel reaches were represented in the model using channel length and slope. The sub-catchment layout for the Dawson River URBS model is shown in Figure 6.2.

The Dawson River model was calibrated against rainfall and stream flow gauging data within the Dawson River catchment. The gauging stations used in the calibration process were (refer Figure 6.2):

- 130342A Hutton Creek at Fairview
- 130324A Dawson River at Utopia Downs
- 130376A Eurombah Creek at Brookfield
- 130344A Juandah Creek at Windamere
- 130302A Dawson River at Taroom
- 130313A Palm Tree Creek at La Palma
- 130325A Palm Tree Creek at Bloomfield
- 130341A Robinson Creek at Glenleigh
- 130375A Robinson Creek at Broadmere
- 130303B Dawson River at Glebe Recorder
- 130338A Dawson River at Glebe Weir Headwater
- 130320A Dawson River at Nathan Gorge
- 130354A Dawson River at Gyranda Weir Headwater
- 130318A Castle Creek at Old Walloon
- 130305A Dawson River at Theodore
- 130317A/B Dawson River at Woodleigh
- 130339A Conciliation Creek at Barranga
- 130316A Mimosa Creek at Redcliffe
- 130363A/B Roundstone Creek at Dawson Highway
- 130374A Dawson River at Bindaree
- 130322A Dawson River at Beckers

The Dawson River UBRS model has been calibrated to the following six historic flood events: February 1978, May 1983, March 1997, December 2010, January 2013 and November 2021. The model has been used to develop design hydrology hydrographs ranging from the 20% AEP flood event up to the Probable Maximum Flood (PMF) event for the Dawson River. The calibrated model was then used to assess design event hydrology with the modelled peak flows validated to Flood Frequency Analysis (FFA) of streamflow gauging data and the Regional Flood Frequency Estimation technique.

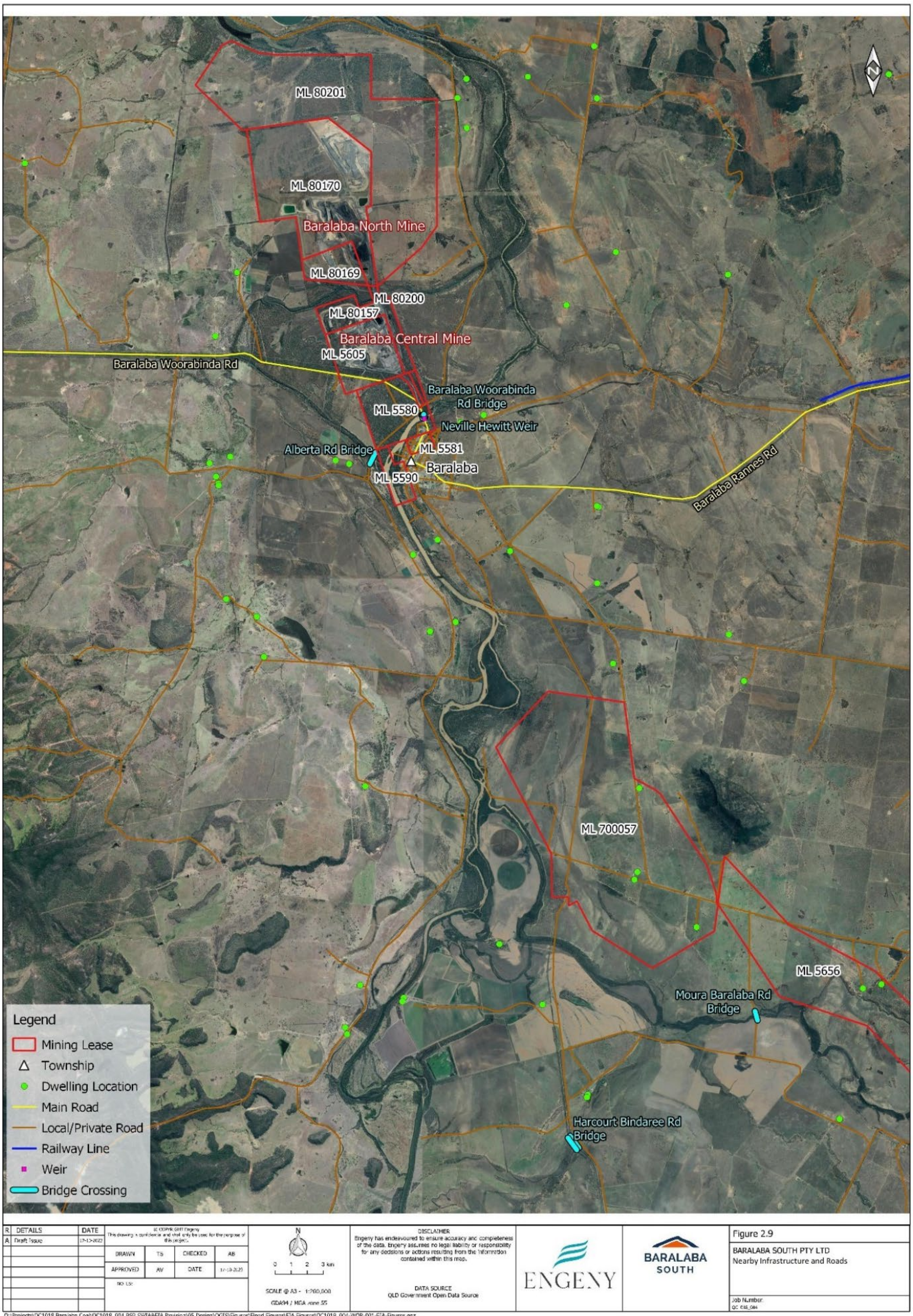


Figure 6.1: *Nearby infrastructure and roads*

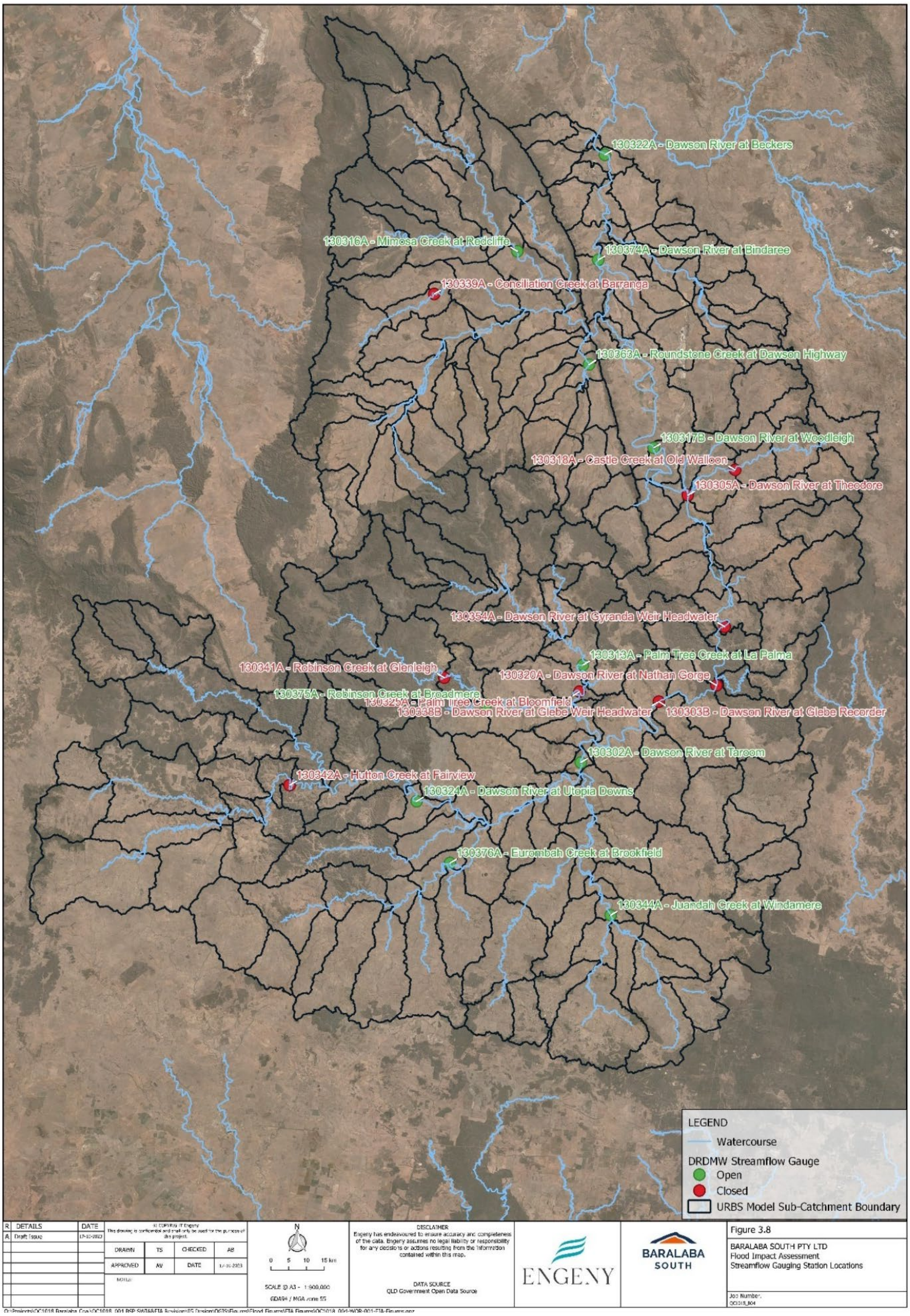


Figure 6.2: Gauging station locations and sub-catchments

Data from pluviographic and daily rainfall stations in the vicinity of the Dawson Basin catchment which were operational during the calibration flood events have been sourced from the Bureau of Meteorology and DRDMW. The recoded rainfall depth from the daily and pluviographic stations was used to determine the rainfall depth for each sub catchment during each calibration event. The pluviographic rainfall station data was then used to determine hourly rainfall temporal patterns for the event and applied to the nearest sub-catchment based on proximity of the sub-catchment centroid to the gauge location.

A hydrodynamic model has been developed using TUFLOW HPC software to assess Dawson River hydraulics and potential flood impacts resulting from the Project. The two-dimensional model extent covers a 44km length of the Dawson River and Banana Creek floodplain with an upstream extent approximately 15 km upstream of the Bindaree (130374A) gauging station and a downstream extent 18.5km downstream of the Beckers (130322A) gauging station. The upstream and downstream extents of the model were located to avoid influence of the adopted inflow and outflow boundary conditions on the model results at the Project location and the model calibration point locations.

The following hydraulic structures have been incorporated into the hydraulic model:

- Neville Hewitt Weir – located in the Dawson River channel at the Baralaba Township;
- The Baralaba-Woorabinda Road bridge – Crossing of the Dawson River downstream of the Neville Hewitt Weir; and
- Culvert crossing associated with the Baralaba North operations haul road – Crossing of the Dawson River anabranch between the Baralaba North and Central mining areas.

The Dawson River TUFLOW hydraulic model was calibrated to the December 2010 and January 2013 historic flood events used in the hydrologic model calibration. For both the historic flood events the model has been calibrated to stream height gauging data at Beckers (130322A) and Bindaree (130374A) gauging stations.

The model has also considered the results of a flood debris survey for the 2010 flood event undertaken by Water Solutions (2014) as part of the investigations for the Baralaba North Continued Operations Project. Landholder consultation was undertaken by Baralaba South Pty Ltd, with assistance from AARC for the preparation of the Project EIS from November 2020 to March 2021 and again in October 2023. The landholder consultation produced local insight and information for consideration with the model development and validation. The landholder consultation also produced anecdotal flooding information from local landholders present during the December 2010 flood event, which allowed further validation of the 2010 flood model calibration results.

The landholder anecdotal flooding information and comparison with the December 2010 flood model results are presented on Figure 6.3. Validation of the 2010 flood model calibration results against the anecdotal flood information shows:

- The flood model accurately reproduced the anecdotal flood extent on the Belvedere property located south of Banana Creek.
- Reports of the flood protection levees on the Harcourt property breaching from overtopping flows was replicated in the model results at the same locations.
- The flood model results showed flooding at the reported dwellings with the model results showing similar depths to the anecdotal information including:
    - Harcourt property reported a flood depth of 0.3 m in the western low set dwelling, and the flood model results show a flood depth of 0.3 m at the same location (no difference).
    - Harcourt property reported a flood depth of 0.85 m below the western high set dwelling (0.15 m below the 1 m high raised floor), and the flood model results show a flood depth of 0.4 m at the same location (0.35m lower).
    - Harcourt property reported a flood depth of 1 m below highset eastern dwelling, and the flood model results show a flood depth of 1.2 m at the same location (0.2 m higher).

- Riverland property reported a flood depth of 0.75 m at the raised dwelling, and the flood model results show a flood depth of 0.6 m at the same location (0.15 m lower).
- Alberta Vale property reported a flood depth of 0.9 m inside the lowset dwelling, and the flood model results show a flood depth of 1.2 m at the same location (0.3m higher).

Location	Landholder Flooding Information	Model Results
Belvedere - Approximate flood extent during December 2010 event	The 2010 flood waters came close to a shed located in the north-west of property as marked on a map during consultation in 2020	The flood model results show a similar flood extent to the marked flood extent.
Harcourt - Flood levees breached during December 2010 event	The flood levees within the property were breached during the 2010 flood	Food results show the levees breaching in multiple locations as reported during consultation in 2020.
Harcourt - Flooding at western lower dwelling	The Lower section of house and walkway reported as being under a foot of water (30 cm).	Modelled flood depth of 0.3m at the lower building
Harcourt - Flooding at eastern dwelling	Flood depth was approximately 1m deep beneath the high-set dwelling during the December 2010 event (located at the eastern side of the property)	Modelled flood depth of 1.2m which shows a good comparison to the reported 1m depth.
Riverland - Flooding at dwelling	The 2010 flood was waist deep (approximately 0.75m) at the dwelling location (raised dwelling)	Modelled flood depth of 0.6m at the dwelling location
Alberta Vale - Flooding at dwelling	Flood depth was approximately 0.9 m inside the low set dwelling.	Modelled flood depth of 1.2m at the Alberta Vale dwelling which would be a good match with the reported 0.9m flood depth inside the dwelling with an assumed of house slab thickness of 0.3m.
Harcourt - Flooding at western upper dwelling	Flood waters up to middle step of upper house and 6 inches (0.15 m) below the floor boards with an assumed floor height of 1m.	Modelled flood depth of 0.4m at the upper dwelling.

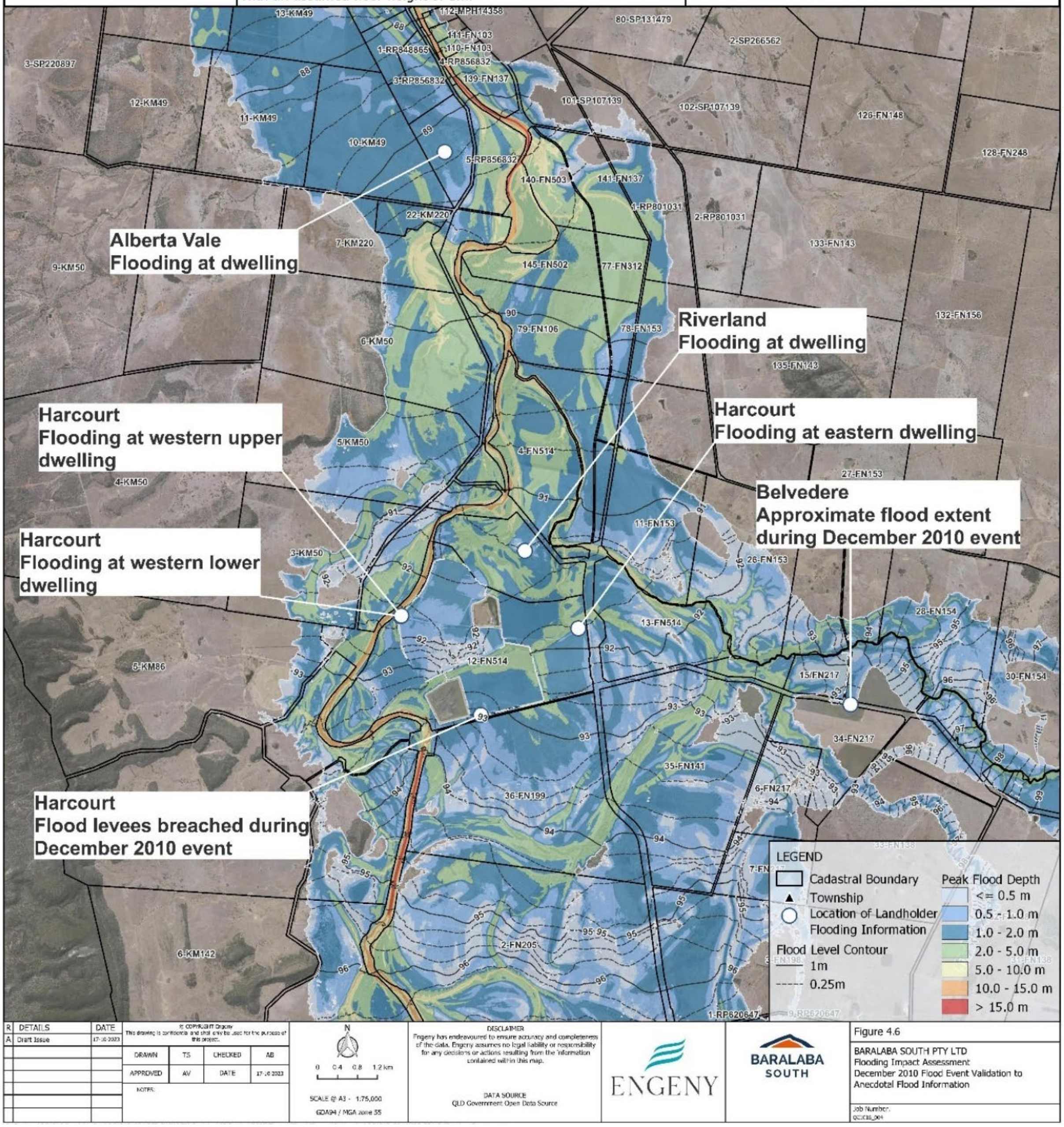


Figure 6.3: December 2010 validation of model against landholder flood observations

6.2.2 Current flood risk

The baseline model was simulated for the 10%, 2%, 1% AEP to determine baseline flood results for comparison against the mine developed case model. The model was also simulated for the extreme events including the 0.1% AEP and PMF to determine potential impacts and flood risks for the Project.

The baseline flood mapping (the existing case) for peak flood depth, velocity, and flood inundation duration are provided in Appendix C, Flood Impact Assessment.

In summary:

- Flood flows begin to break out of the Dawson River and Banana Creek channel in events greater than the 10% AEP and flow across the eastern floodplain at the Project site. The Project MLA area is partially inundated in the 2% AEP flood event but is not inundated in the 10% AEP flood event.
- The Dawson River floodplain has a flow width of approximately 5.5 km in flood events greater than 2% AEP adjacent to the Project.
- The flood extent in the 1% AEP event inundates approximately 50% of the Project MLA area however inundates less than 16% of the proposed Project disturbance area.
- Flooding of the Dawson River at the Baralaba township is largely confined to the main river channel although minor flooding of the local school and properties boarding the river channel results in the 1% AEP flood event.
- Peak flow velocities in the 1% AEP flood event within the Dawson River channel adjacent to the Project are generally between 1.0 m/s and 3.0 m/s and peak flood velocities on the floodplain areas are generally below 1.0 m/s.
- Properties located on the Dawson River floodplain near the Project site are inundated for >250 hours in the 1% AEP flood event. It is noted the duration of inundation is heavily dependent on the storm duration.
- Peak flood wave travel time between the Bindaree (130374A) and Beckers (130322A) gauging stations is approximately 22 hours in the 10% AEP flood event and 18 hours in the 1% flood event.

The Banana Creek dominated Flooding scenario has been simulated for a 1% AEP Banana Creek peak flow and a 10% AEP peak flow in the Dawson River. The 10% AEP flow is similar to the 2013 historical event, with the Dawson River flood flow is contained in the main channel. The 1% AEP flow in Banana Creek then results in widespread flooding of the lower reaches of Banana Creek before the Dawson River confluence adjacent the Project. The baseline Banana Creek flooding results show:

- The 10% AEP flood event is mostly contained within the Banana creek channel, however there is a small breakout flow path through the eastern side of the MLA before entering the Dawson River via an anabranch channel at the northern extent of the MLA.
- 1% and 0.1% AEP Banana Creek flood events engage the floodplain with floodwater breaking out of the Banana Creek channel upstream of the Project, flowing towards the Dawson River.
- The 1% and 0.1% AEP Banana Creek flood events also has a breakout flow path through the eastern side of the MLA, with flood waters spilling from the floodplain into the Dawson River channel at the eastern and northern extents of the MLA.
- Peak flood velocities for the Banana Creek dominated flooding are similar to the Dawson River scenario with peak flood velocities on the floodplain within the Project MLA between 0.6 m/s and 1.0 m/s.
- The extent of flooding for the 1% and 0.1% AEP Banana Creek flood events is similar to the Dawson River scenarios at the southern extent of the Project area however is smaller at the Dawson River and Banana Creek confluence as waters enter the Dawson River channel.

6.2.3 Geomorphology

A Geomorphic Impact Assessment was undertaken by WRM Water & Environment Pty Ltd (WRM 2023) to assess the potential impacts of the Project on the geomorphology of the Dawson River channel, floodplain and tributaries. The Geomorphic Impact Assessment is based on the results of the detailed hydraulic modelling undertaken by Engeny (2023) and provided in Appendix C, Flood Impact Assessment. The Geomorphic Impact Assessment is provided in Appendix D, Geomorphic Assessment.

6.2.3.1 Drainage characteristics

The main drainage feature relevant to the Project is the Dawson River, which drains the floodplain from south to north. There are also several anabranches and flood channels across the floodplain which become active as floodwaters rise. The Baralaba Weir pool (formed behind Neville Hewitt Weir) extends upstream past the Project site along both the Dawson River and Banana Creek.

The Geomorphic Impact Assessment (Appendix D) identified one particularly significant flood channel (referred to as Flood Channel A, shown on Figure 6.4) which starts approximately 10 km upstream of the Project and causes Dawson River floodwaters to interact with Kianga Creek and Banana Creek flows, for Dawson River 20% AEP flows and larger.

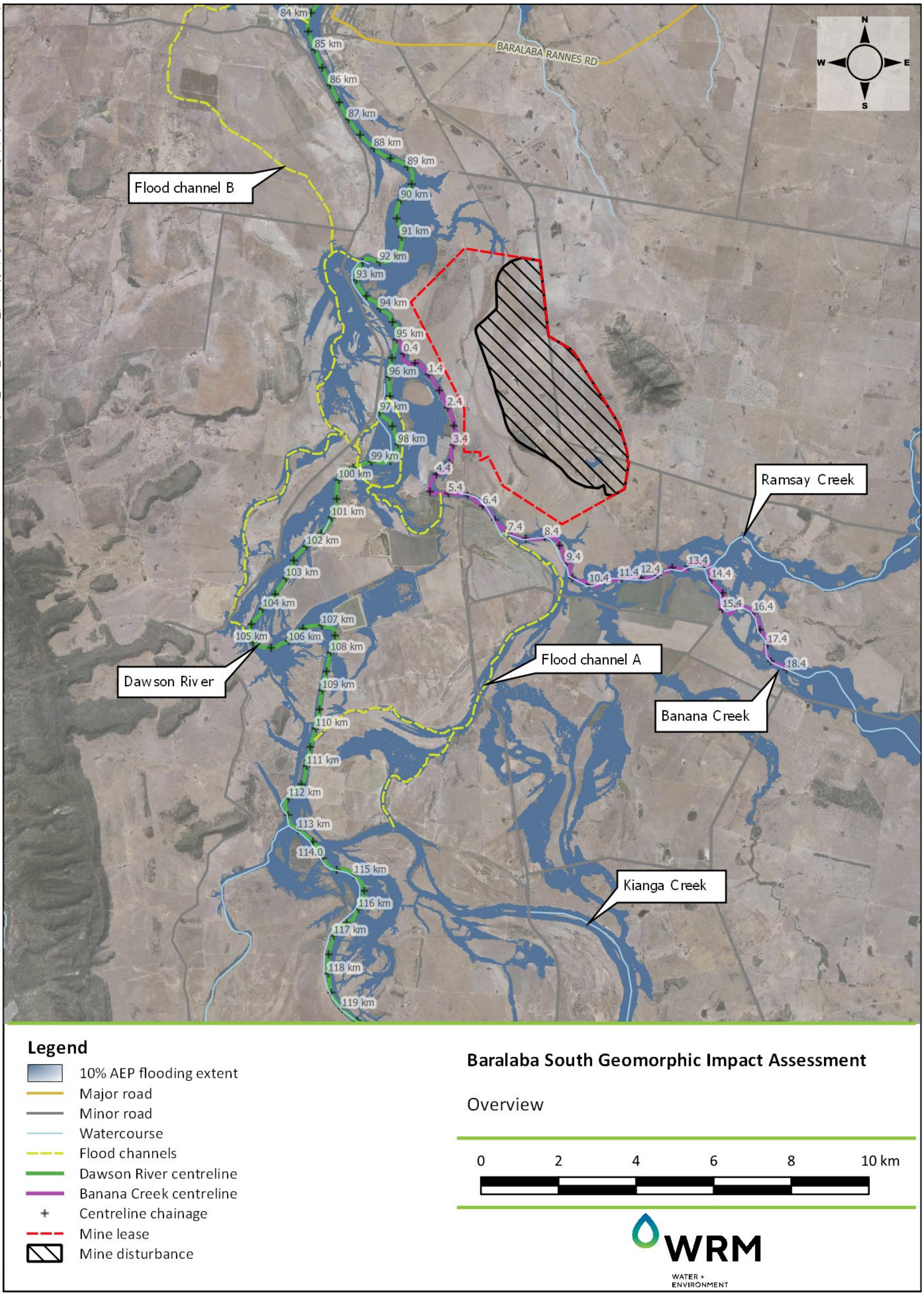
Figure 6.4 illustrates the connectivity of the various floodplain channels for the 10% AEP Dawson River flooding event. The characteristics of these floodplain channels, as well as the Dawson River floodplain are discussed below. Approximate Average Middle Thread Distances (AMTD) are estimated and shown on Figure 6.4 for the purpose of the following discussion.

Dawson River

The Dawson River in the reach passing the Project site (91 km AMTD to about 100 km AMTD, refer Figure 6.4) has a well-defined channel, about 150 m to 200 m wide and approximately 10 m to 15 m deep, carved through a relatively flat floodplain. The river channel forms the weir pool of Neville Hewitt Weir and as such, the bedform is wholly drowned in this reach.

The Dawson River has a perched channel, where the riverbanks are raised higher than the adjacent floodplain. The floodplain is between about 5 km to 6 km wide in the vicinity of the Project.

The river channel comprises a continuous active channel carrying the regulated flows, with multiple anabranches and flood channels in the vicinity of the Project. The presence of multiple anabranches and flood channels indicates historical and ongoing lateral activity of the Dawson River channel in the vicinity of the Project.



J:\0876-17 Baralaba Sth Flood\GIS\QGIS\Report_Local_TUFLOW_(v28).qgz (Fig3-2 - Local drainage) (Exported: 31 October 2023)

Projection: EPSG:28355

Figure 6.4: Local drainage characteristic

Banana Creek

Banana Creek discharges to the Dawson River at approximately 95 km AMTD, about 0.7 km west of the proposed Project boundary. Banana Creek in the vicinity of the Project is an ephemeral stream, with the final 9 km of the lower reach crossing the Dawson River floodplain adjacent to the Project and consequently affected by Dawson River backwater and floodwater. It is likely that this section of the Banana Creek channel is a palaeo-channel of the Dawson River.

The Banana Creek channel on the Dawson River floodplain is about 150 m wide and is incised about 8 m to 10 m below the adjacent floodplain consistent with the Dawson River main channel. Like the Dawson River, the Banana Creek channel is slightly perched above the adjacent floodplain. The creek channel comprises of a 40 m wide low flow channel that has incised into the only Dawson River palaeo-channel surrounded by a lower bench about 8 m below the surrounding floodplain. The creek channel is heavily vegetated (including stands of mature trees), which indicates a reasonably stable channel.

The upper reach of Banana Creek that is not affected by Dawson River floodwaters is only 40 m wide and about 2 m to 4 m deep. The channel has low flood carrying capacity with significant flood flows draining along multiple flood channels.

Floodplain channels

There are several flood channels on the Dawson River floodplain in the vicinity of the Project. These channels only become active once Dawson River floodwaters reach a sufficiently high level, generally at about or even just below the 'bank full' level.

Two notable flood channels on the Dawson River floodplain in the vicinity of the Project (refer Figure 6.4) include:

- Flood Channel A: connecting the Dawson River (about 110 km AMTD) and Banana Creek (about 7.5 km AMTD). Flood channel A is likely to be a remnant or palaeo-channel of the Dawson River.
- Flood Channel B: connecting the Dawson River (about 84.5 km AMDT) to an anabranch which loops northwest to bypass Baralaba town and the Neville Hewitt Weir, before turning east to pass north of the Baralaba North Mine and re-join the Dawson River at about 76.5 km AMTD. There is no specific channel in this location.

The flood channel across the Project area becomes active for the 10% AEP event where it receives minor overflows from Banana Creek and shallow overflows directly from the Dawson River. The flood channel drains local catchment flows for more frequent events or backwater flooding directly from the Dawson River.

6.2.3.2 Existing flooding characteristics

The results of flood modelling by Engeny (2023) of the Dawson River floodplain for the existing case were used by the Geomorphic Impact Assessment to characterise hydraulic conditions of relevance to the floodplain geomorphology including velocity, bed shear stress and stream power.

Modelling has been undertaken for two storm event scenarios:

- Scenario 1 has the storm centred across the entire Dawson River (Dawson River flood). Design discharges for this scenario use Dawson River design rainfalls (factored for catchment area) and Dawson River storm durations.
- Scenario 2 has the storm centred across the Banana Creek catchment (Banana Creek flood). Design discharges for this scenario use Banana Creek design rainfalls (factored for catchment area) and Banana Creek storm durations, which are shorter than for the Dawson River flood. Scenario 2 assumes that a 10% AEP design event is occurring concurrently in the Dawson River

The geomorphic assessment of baseline conditions considered velocity, bed shear stress, and stream power under a range of flood scenarios.

The analysis shows that there is a minor but distinct change in the hydraulic behaviour of the Dawson River between the reaches upstream and downstream of the Project under existing conditions, particularly for the larger events. It would appear that the Neville Hewitt Weir does not have a significant impact on the channel behaviour for these events. Rather, the greatest impact occurs as a result of the main channel crossing from the western side of the floodplain to the eastern side between chainages 89 km and 93 km. The narrower floodplain downstream from 89 km may also cause higher channel velocities and stream power for the larger events. This section also forces engagement of the floodplain in events 2% AEP and greater.

Banana Creek adjacent to the Project would appear to be dominated by Dawson River flows.

6.3 Potential impacts

The flood modelling summarised in section 6.2 was used to assess the flood impacts associated with the operational and post-mining phases of the Project (the mine developed case).

6.3.1 Extreme flood depth and extent

A flood protection levee is not required as the mining void remains outside the 0.1% AEP flood extent. Over the duration of the Project the out-of-pit waste rock emplacement (WRE) will be developed at the northern extent of the mining pit and will remain as a post mining landform.

The out-of-pit WRE is not required to perform the function of pit flood protection immunity, however the northern section of it is located partially within the Dawson River 0.1% AEP flood extent and may result in flooding impacts.

Post-mining, a low earthen embankment landform will be incorporated into the final landform design as a permanent feature of the landscape. This landform provides PMF protection to the final void, above the required 0.1% AEP design event flood protection target. Extreme event flood maps (0.1% and PMF) demonstrate the pit maintains 0.1% AEP flood protection for the Project duration and that the final void will achieve PMF immunity. The modelled peak flood depth and extent for the mine developed case for the 0.1% AEP and PMF flood events is shown on Figure 6.5 and Figure 6.6, respectively.

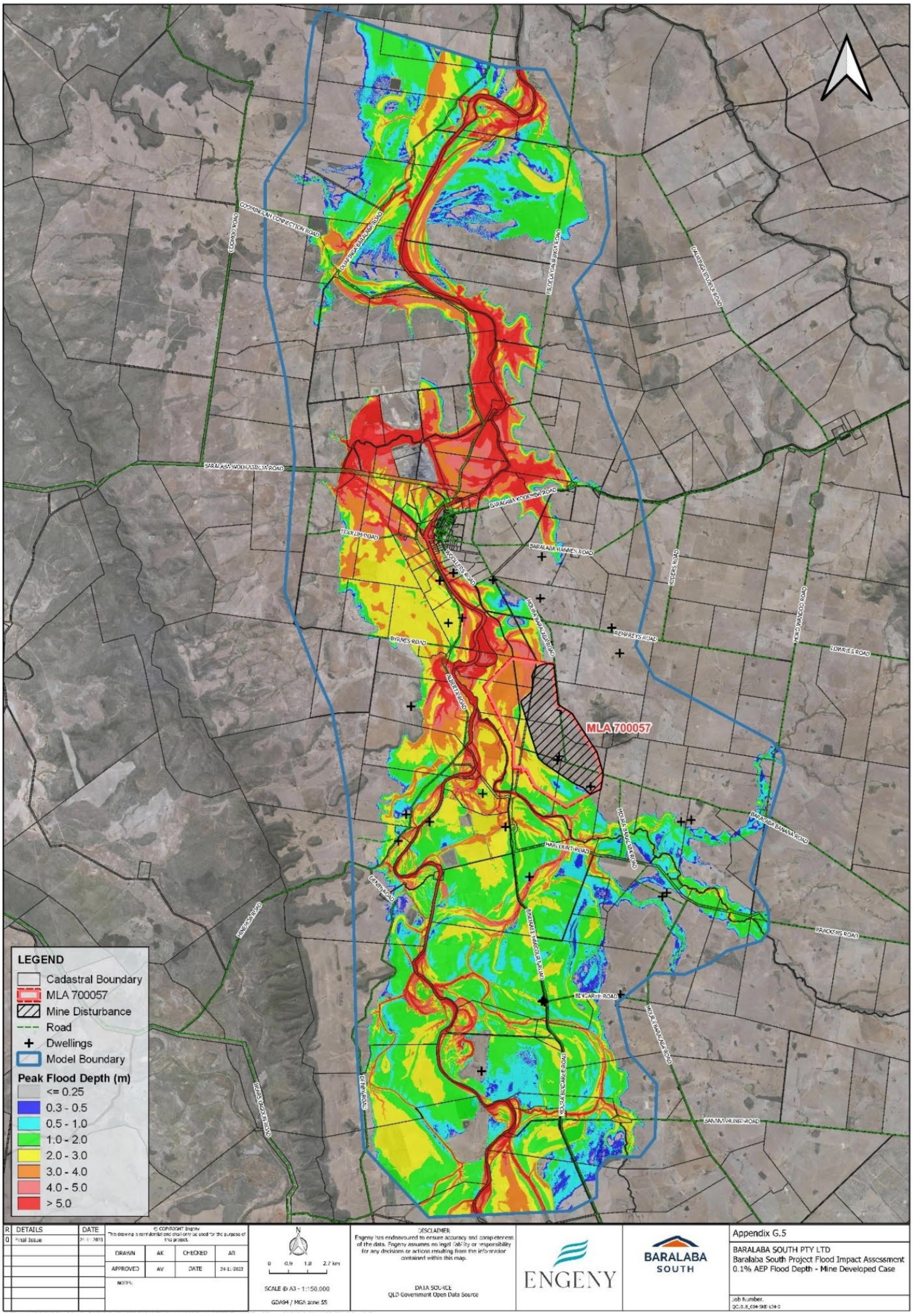


Figure 6.5: 0.1% AEP peak flood depth (mine developed case)

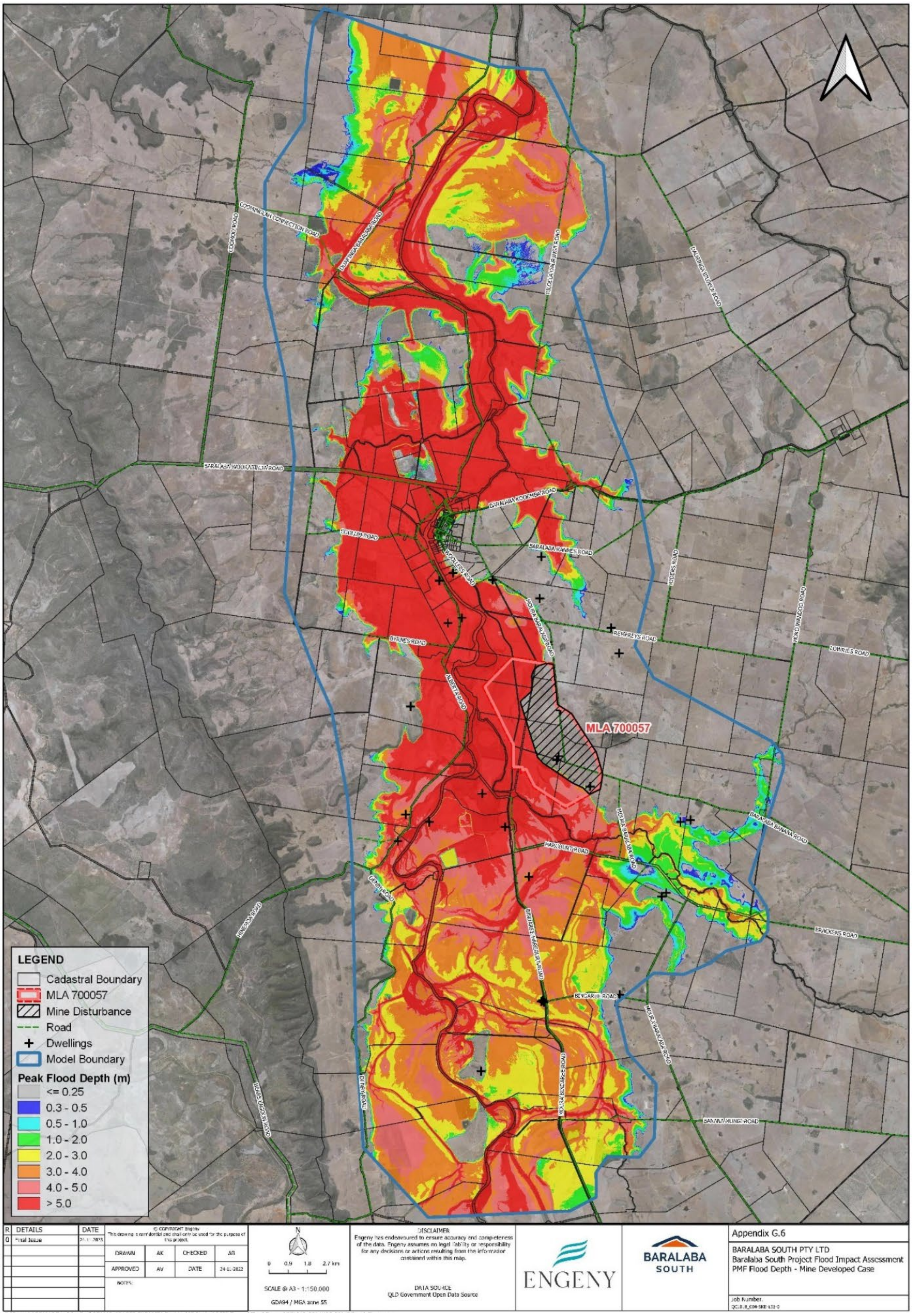


Figure 6.6: PMF peak flood depth (mine developed case)

6.3.2 Flood depth afflux

Flood depth mapping for the existing case and mine developed case is provided in Appendix C, Flood Impact Assessment for each AEP flood event up to 1% AEP. Flood depth afflux mapping showing the difference between the mine developed case and the existing case is also provided in Appendix C, Flood Impact Assessment for each AEP flood event. The modelled peak flood depths for the existing case and mine developed case for the 10% AEP flood event are shown on Figure 6.7 and Figure 6.8, respectively.

Figure 6.9 shows the change in peak flood depth – the afflux (mine developed case compared to existing case) for the 10% AEP flood event. Figure 6.10 and Figure 6.11 show the change in peak flood depth for the 2% and 1% AEP flood events, respectively.

The Flood Impact Assessment indicates that:

- There is no change in flood depth in flood events up to an including the 10% AEP since the Project footprint is located outside of the 10% AEP Existing Case flood extent.
- Flood afflux up to 200 mm is predicted for the 2% AEP and 1% AEP flood events in localised areas against the mine landform within the Project MLA.
- Flood afflux outside of the Project MLA will be less than 10mm for the 2% AEP flood event.
- Flood afflux of up to 40mm is predicted to occur outside of the Project MLA in a 1% AEP flood event between Banana Creek and the Project MLA, with up to 20 mm of flood afflux predicted on the Dawson River floodplain to the west of the Project MLA.
- Areas with flood afflux between 10mm and 20 mm in a 1% AEP are limited to the area immediately to the west of the Project MLA.
- The Project will cause a small (less than 10 mm) reduction in peak flood levels in the Dawson River channel and on the eastern floodplain downstream of the Project MLA in a 1% AEP flood event. This is due to the Project directing slightly more flood waters in larger flood events to the western floodplain and anabranch.
- The flood modelling of the Project shows no change in peak flood levels at the Baralaba township greater than 0.001 m for flood events up to the 1% AEP event.

Flood afflux impacts to neighbouring properties are discussed in section 6.3.6.

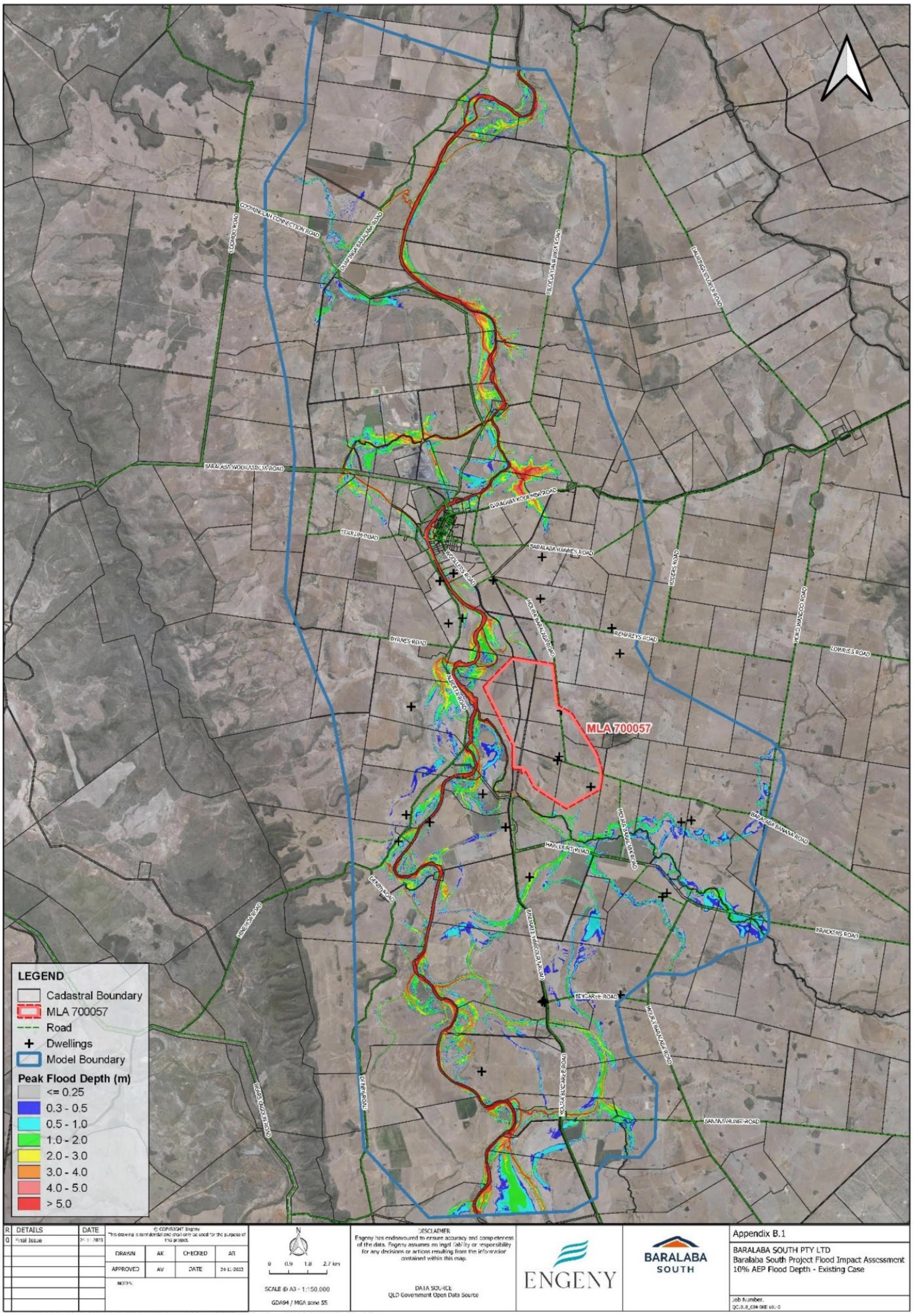


Figure 6.7: 10% AEP peak flood depth (existing case)

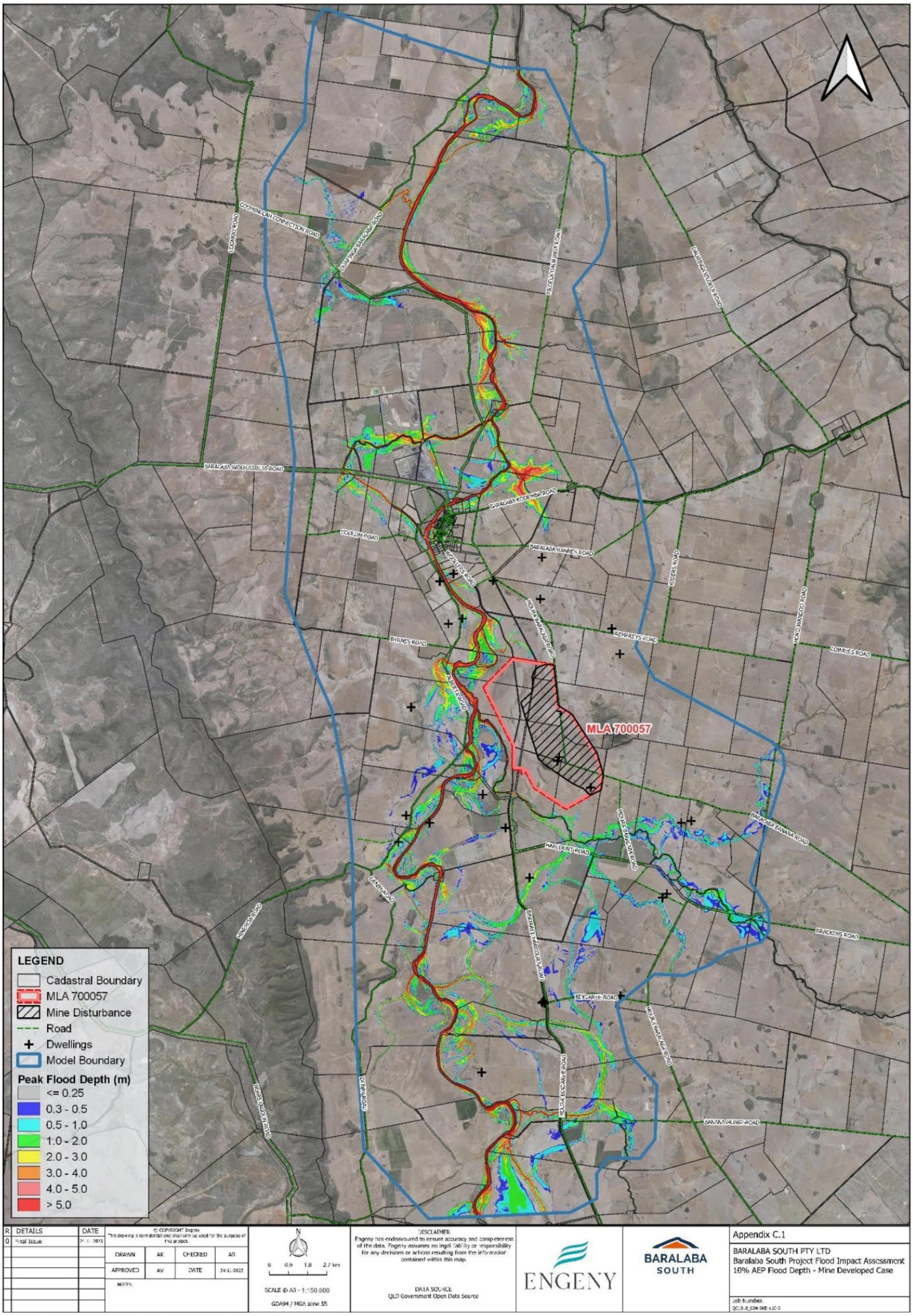


Figure 6.8: 10% AEP peak flood depth (mine developed case)

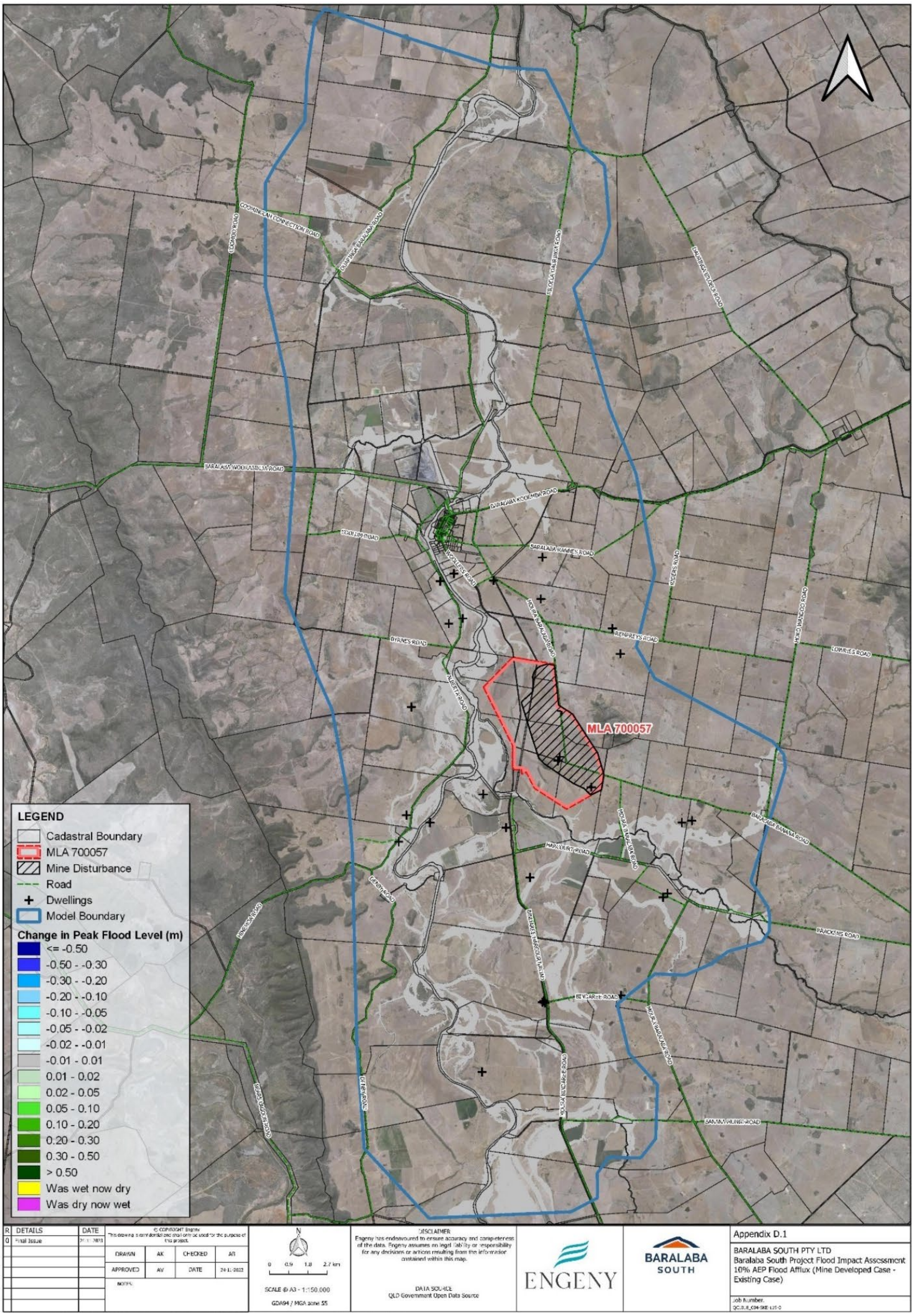


Figure 6.9: 10% AEP change in peak flood depth (mine developed case—existing case)

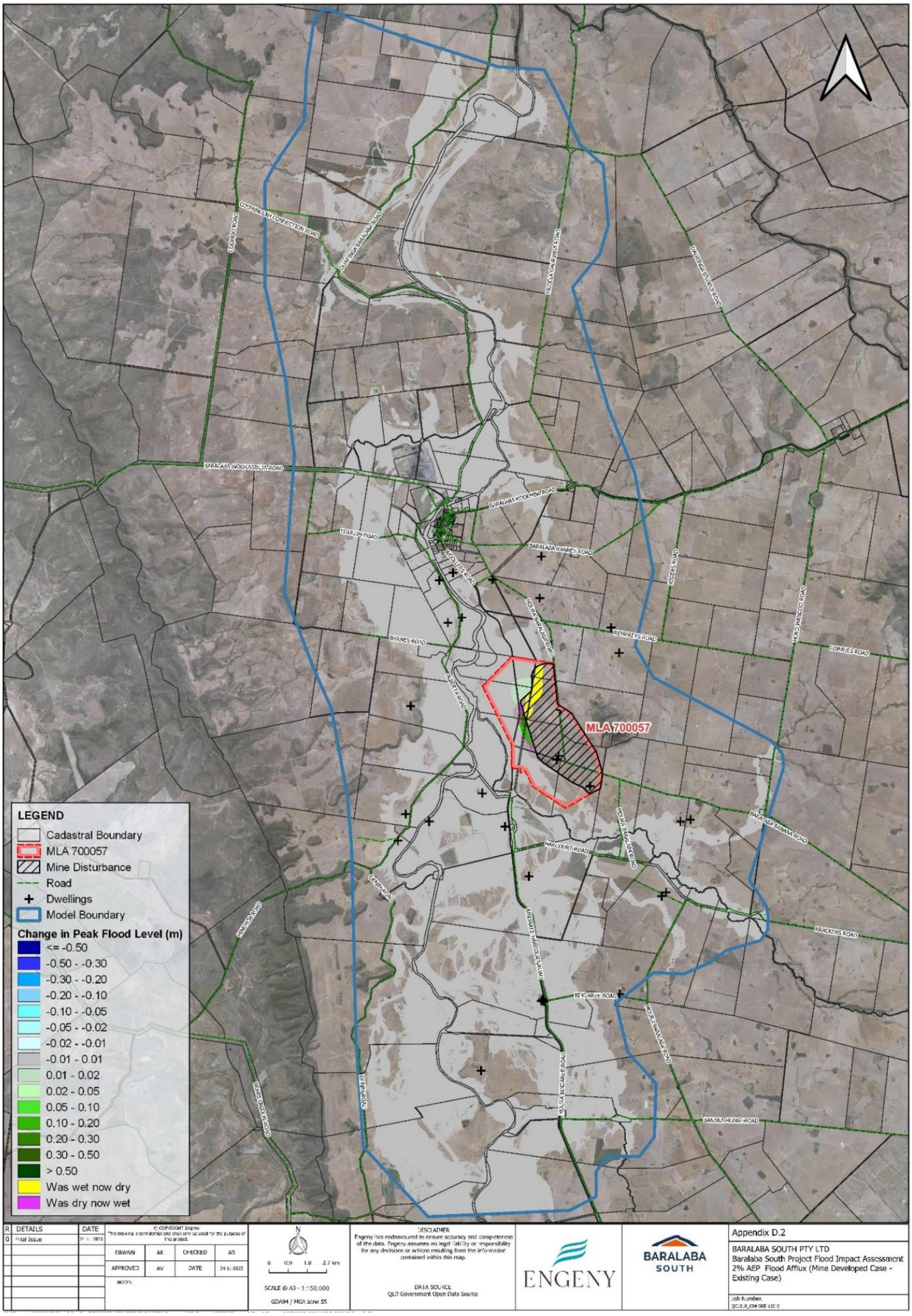


Figure 6.10: 2% AEP change in peak flood depth (mine developed case—existing case)

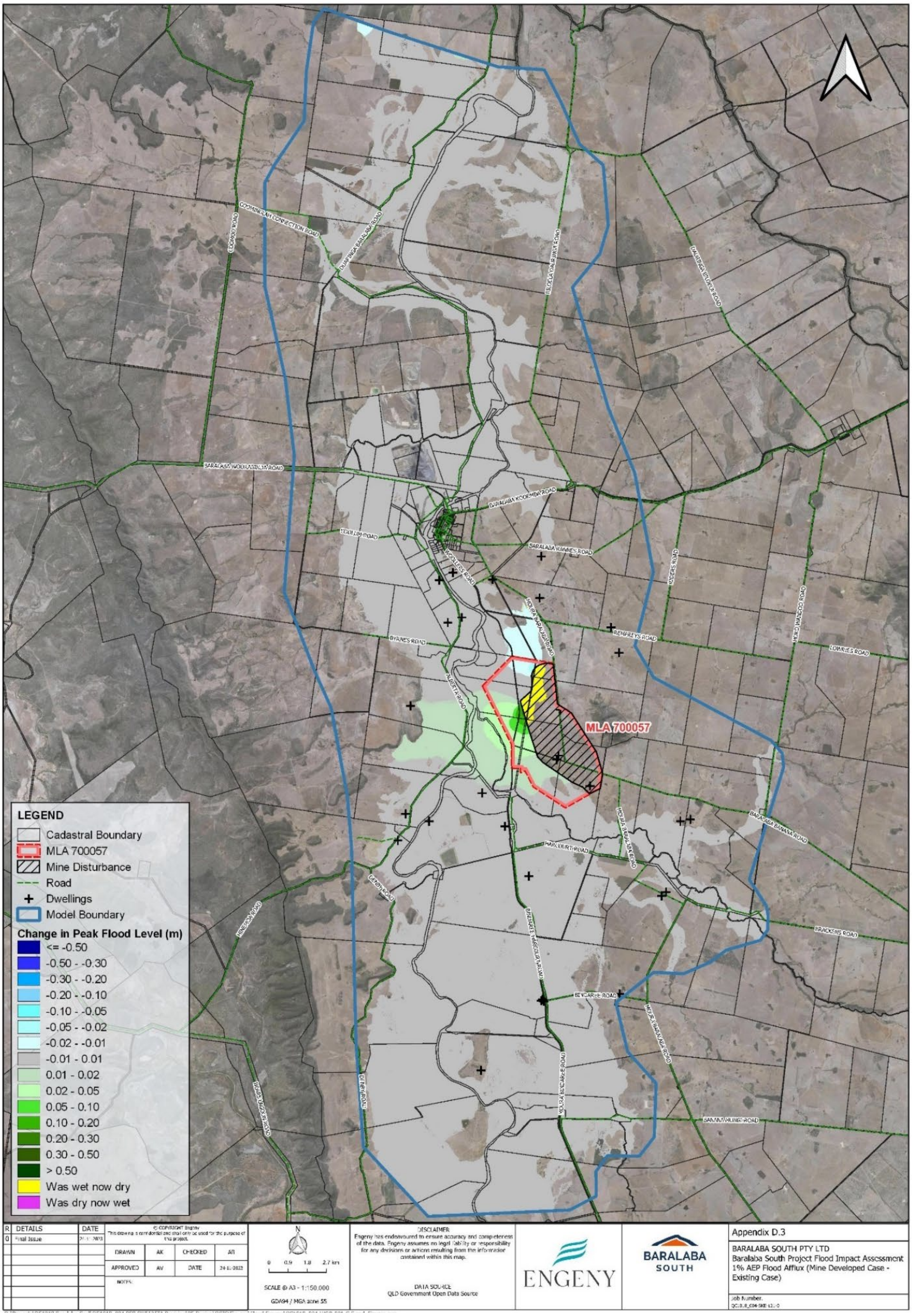


Figure 6.11: 1% AEP change in peak flood depth (mine developed case—existing case)

6.3.3 Flood velocity

Flood velocity mapping for the existing case and mine developed case is provided in Appendix C, Flood Impact Assessment for each AEP flood event up to 1% AEP, as well as afflux mapping illustrating the changes in flood velocities between the two respective cases.

The Flood Impact Assessment indicates that:

- The Project will not impact flood velocities for all events up to and including the 10% AEP flood event.
- Areas with changes in peak flood velocity greater than 0.1m/s are limited to very localised areas immediately adjacent to the Project within the Project MLA for the 2% AEP and 1% AEP flood events.
- For all AEP flood events assessed, flood velocity changes greater than 0.1 m/s are not expected to occur outside of the Project MLA boundary.

In summary, the changes in flow velocity up to and including the 1% AEP event are predicted to be within 0.1 m/s to 0.3 m/s adjacent to the northern out-of-pit WRE and will be contained within the MLA boundary. There are negligible changes to peak flood velocity outside of the Projects MLA boundary.

Figure 6.12 and Figure 6.13 show the change in peak flow velocity for the 2% and 1% AEP flood events, respectively.

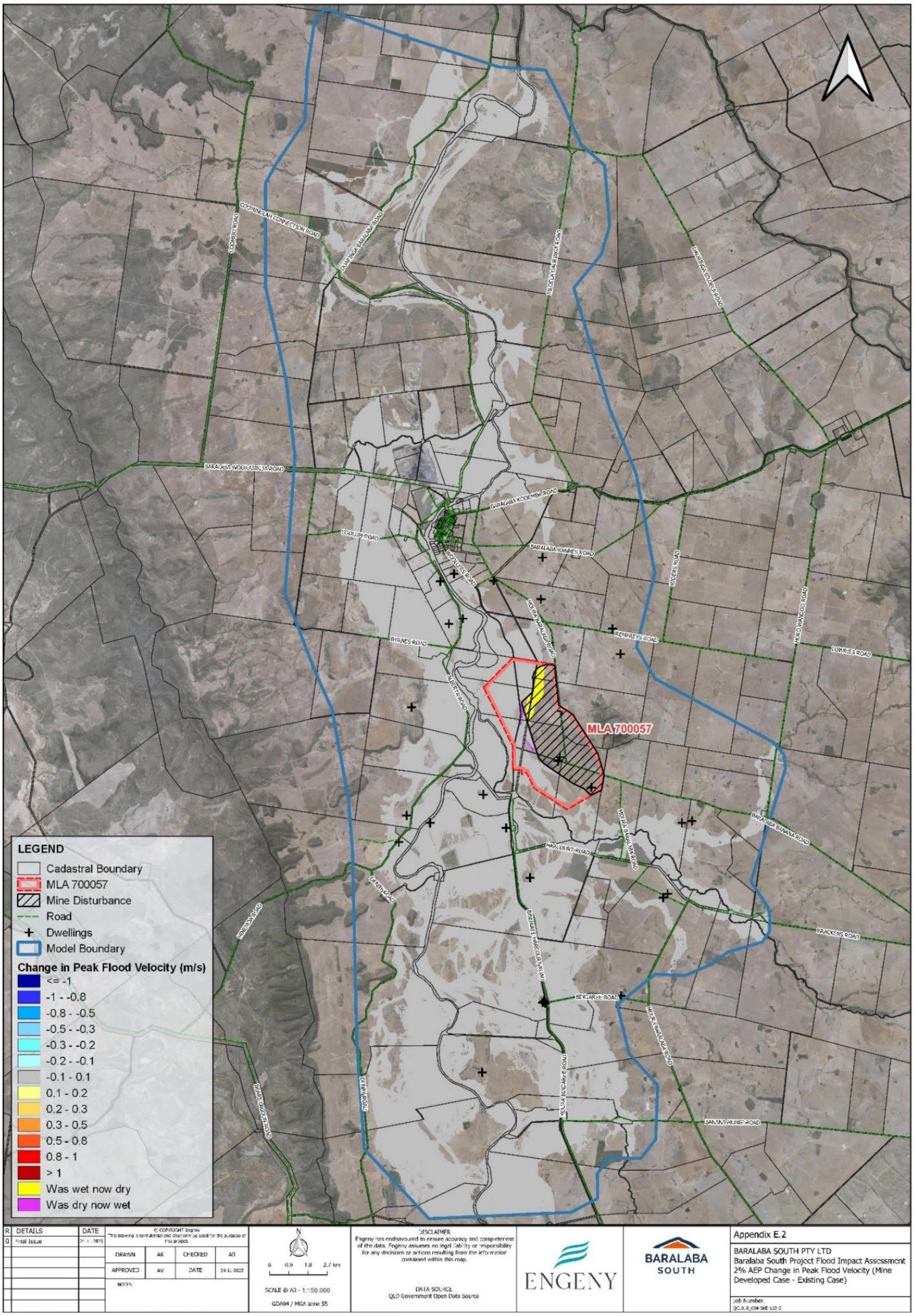


Figure 6.12: 2% AEP change in peak flood velocity (mine developed case—existing case)

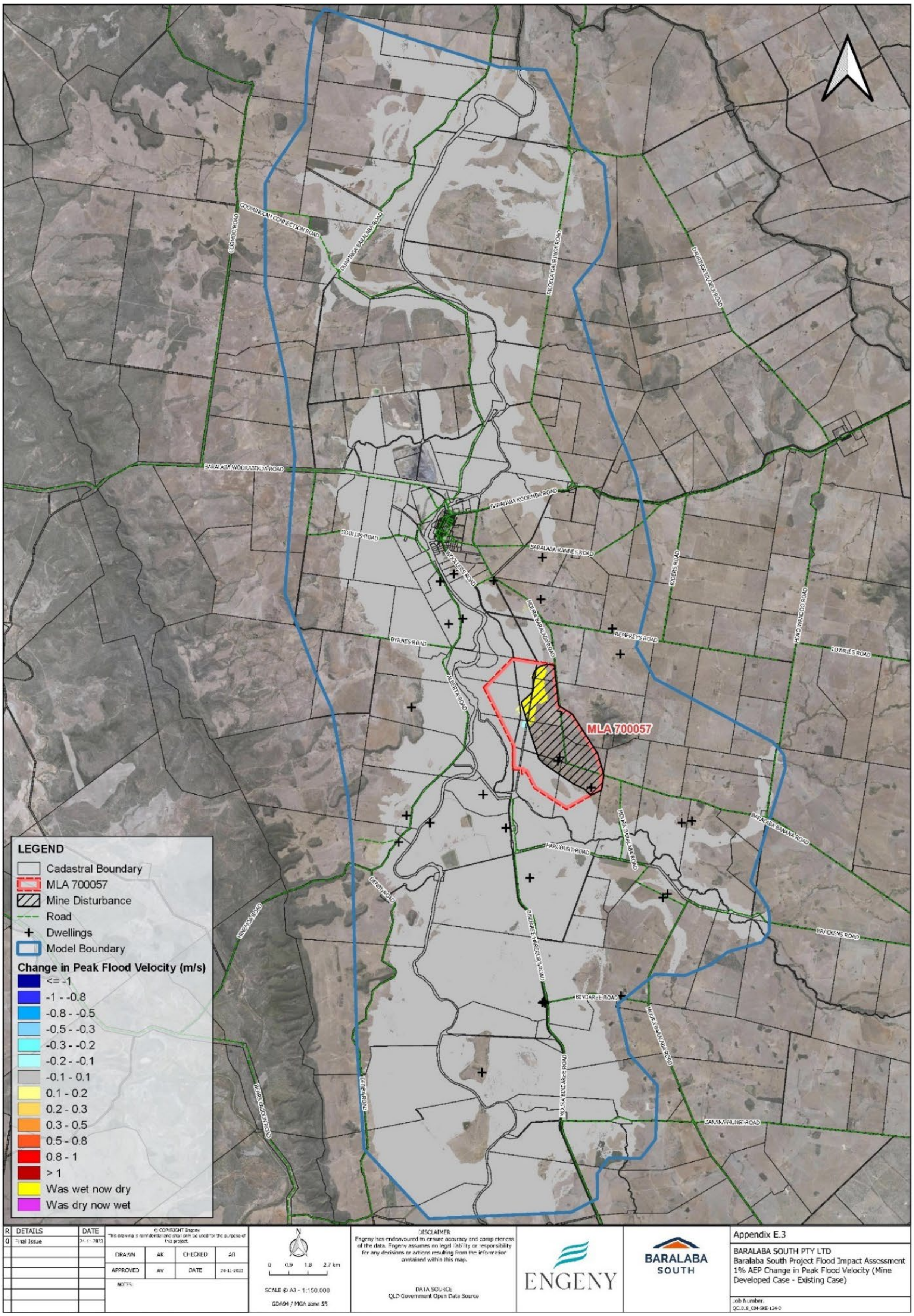


Figure 6.13: 1% AEP change in peak flood velocity (mine developed case—existing case)

6.3.4 Flood timing and travel times

Using the TUFLOW model, the impacts to flood timing and travel time along the Dawson River that may result from the Project have been assessed between the Bindaree gauging station (130374A) (upstream of the Project) and the Beckers gauging station (130322A) (downstream of the Project).

Table 6.1 summarises the changes in flood timing flood travel times and shows:

- There is negligible change to peak flow rates at the Beckers gauging station downstream of the Project for all flood events up to the 1% AEP event.
- There is no change in the flood peak travel time from the Bindaree (130374A) gauging station to the Beckers (130322A) gauging station for all flood events up to the 1% AEP event.

Table 6.1: Flood timing and travel times impact summary

Value	**Scenario**	**Flood event annual exceedance probability (AEP)**		
		10% AEP	**2% AEP**	**1% AEP**
Peak flow at Beckers (m3/s)	Existing case	1,844	3,610	6,149
	Mine developed case	1,844	3,611	6,152
	Change	0	1 (<0.03%)	3 (<0.05%)
Flood peak travel time from Bindaree to Beckers (hours)	Existing case	22.0	22.0	18.0
	Mine developed case	22.0	22.0	18.0
	Change	0.00	0.00	0.00

6.3.5 Flood inundation duration

The Flood Impact Assessment contained in Appendix C also mapped the Project's potential impacts on flood inundation duration. The results show that inundation duration is unchanged for flood events up to and including the 1% AEP.

Figure 6.14 and Figure 6.15 show the changes in inundation duration for the 2% AEP and 1% AEP flood events, respectively.

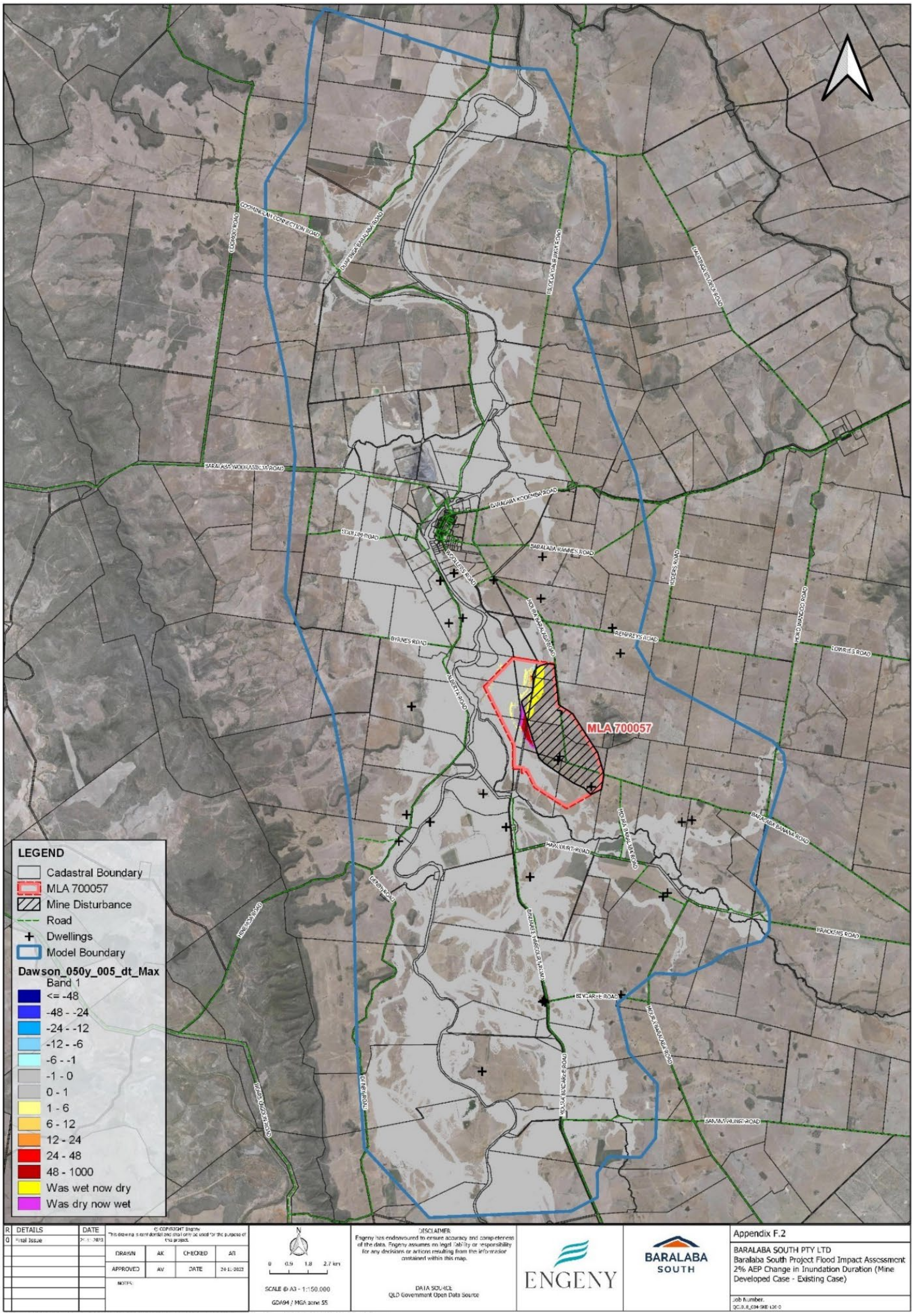


Figure 6.14: 2% AEP change in inundation duration (mine developed case—existing case)

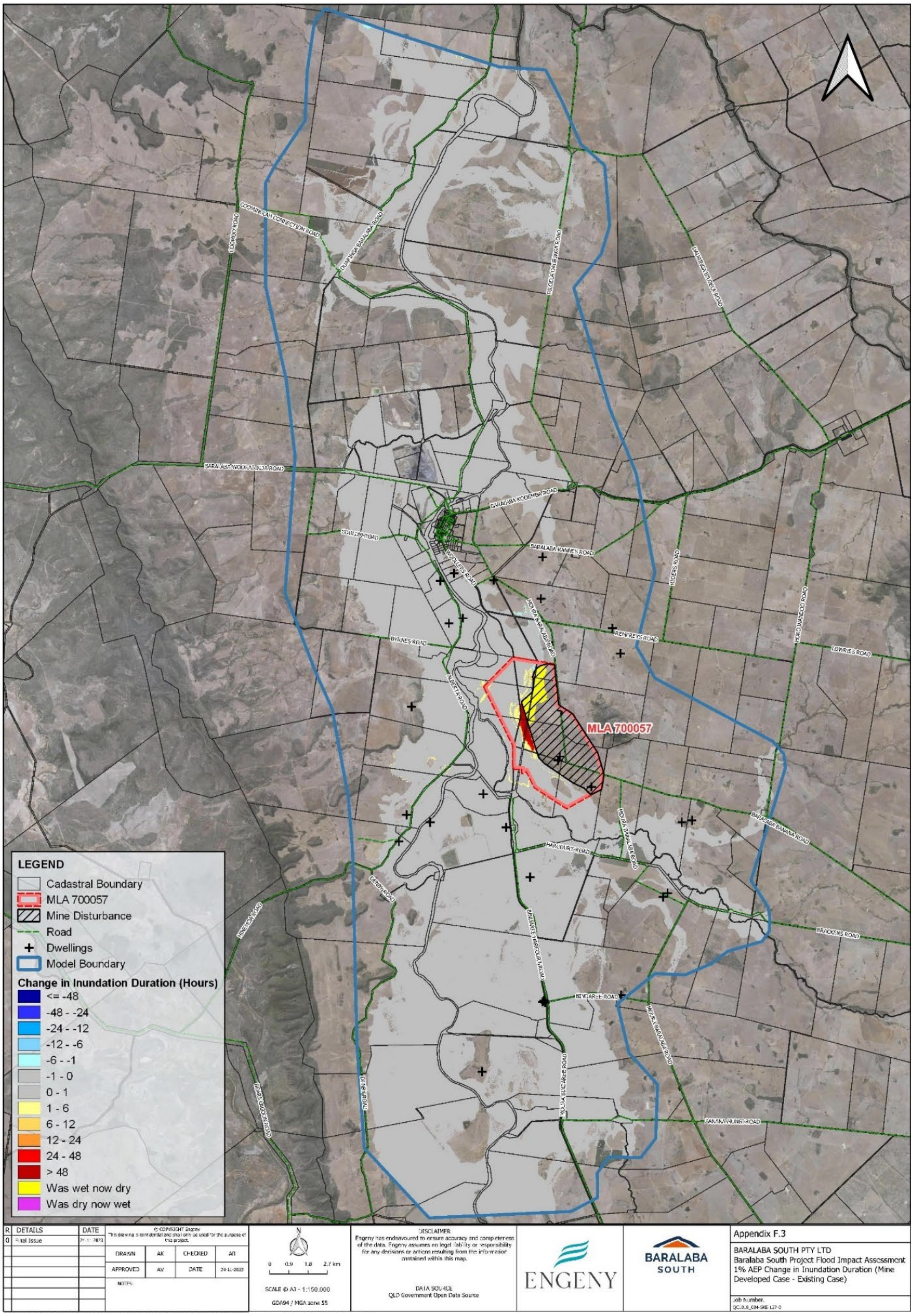


Figure 6.15: 1% AEP change in inundation duration (mine developed case—existing case)

6.3.6 Stream power and bed shear stress

The Flood Impact Assessment (Appendix C) evaluated the Project's impacts on stream power and bed shear stress in the Dawson River channel and floodplain areas, in the 10% and 1% AEP flood events. The stream power and bed shear stress assessment for the mine developed case shows:

- Stream power in the Existing Case is typically less than 10 W/m^2 on the Dawson River floodplain and less than 100 W/m^2 in the Dawson River channel for the 10% and 1% AEP flood events. Higher stream power is reported at channel meanders and locations with an increase in channel grade.
- Bed shear stress in the Existing Case is typically less than 10 N/m^2 on the Dawson River floodplain and less than 50 N/m^2 in the Dawson River channel for the 10% and 1% AEP flood events.
- The Mine Developed Case results show no change to stream power and bed shear stress in the 10% AEP flood event.
- Only minor changes in stream power and bed shear stress are predicted for the 1% AEP flood event and isolated to areas inside the MLA boundary, adjacent to the mine landforms.

6.3.7 Geomorphology

The Project will comprise open cut pits and related mining infrastructure constructed adjacent to the Dawson River floodplain. Only a small area of overburden will be placed on the floodplain. The mine disturbance boundary will be at least 1,300 m away from the top of bank (or edge of the channel) of Banana Creek and at least 2,000 m away from the Dawson River top of bank. No works are proposed within the Dawson River or Banana Creek channels, with the exception of proposed water release/extraction infrastructure on the bank of the Dawson River. The final mine landform has the potential to affect geomorphological behaviour of the Dawson River and Banana Creek channels and floodplain through:

- increased channel velocities, bed shear stress and stream power, which could increase the potential for channel erosion;
- reduced channel velocities, bed shear stress and stream power, which could increase the potential for channel sedimentation and reduced channel capacity; or
- changes in the distribution of flow, which could increase the erosion potential of the floodplain.

The geomorphic assessment concluded (Appendix D, Geomorphic Impact Assessment):

- The Project will have a negligible impact on the velocities, bed shear stress and stream powers along the Dawson River and Banana Creek channels for the 10% and 1% AEP events. Although peak flood levels increase along the channel for the larger events, the increase is negligible in comparison to the existing flood depths along each channel. Any changes are well within the range of velocities, bed shear stress and stream powers observed along the existing channel reaches. Consequently, the Project will not cause any material change in the morphology of the river channel. It will not change the sediment transport characteristics or erosion potential for any of the events investigated.
- There are no velocity impacts to the floodplain for the 10% AEP event, and only localised impacts adjacent to the final landform for the 1% AEP event. At this location, the peak velocities for the proposed conditions are no greater than at other locations on the floodplain. On this basis, the change in the erosion potential of the floodplain is expected to be negligible.
- A review of historical aerial photos suggests that the lateral migration of stream channels is relatively slow in this reach of the river system and that any change in the alignment of the river due to lateral erosion would occur over hundreds if not thousands of years.

Based on these findings, there would be no material geomorphological impacts on the Dawson River and Banana Creek channels and floodplains associated with the Project.

6.3.8 HES wetland

The modelled flood impacts of the Project at the HES wetland situated within and adjacent to the MLA are summarised in Table 6.2. The flood model results show the wetland becomes flooded at AEP's smaller than 10%, however no change in flooding conditions occur in a 2% AEP flood event. Peak flood depths are increased by 0.02 m for a 1% AEP flood event which is expected to have negligible impact to the wetland condition. Peak flood velocity remains unchanged for all flood events, which indicates no increased risk of erosion during flood events. Based on the assessment, the Project is not expected to result in flooding impacts to the MSES wetland.

Table 6.2: HES wetland flood impacts

Flood event AEP	Peak flood depth (m)			Peak flood velocity (m/s)		
	Existing case	Mine developed case	Change	Existing case	Mine developed case	Change
10% AEP	Wetland not inundated in 10% AEP flood event					
2% AEP	0.85	0.85	<0.01	0.15	0.15	<0.01
1% AEP	1.99	2.01	0.02	0.38	0.38	<0.01

6.3.9 Nearby properties (infrastructure and agricultural land use) and roads

Flood impact objectives have been adopted for the Project and are outlined in Table 6.3.

Table 6.3: Flood impact objectives

Land Use	Objective[1]
Existing habitable structures (e.g. dwellings)	• When flooding is predicted to occur above habitable floors in the existing case, flood level afflux of ≤ 1 cm; and • When flooding occurs below habitable floors in the existing case, flood level afflux does not cause above habitable floor flooding.
Existing non-habitable structures (e.g. agricultural sheds, carports, containers, meter boxes)	Flood level afflux of ≤5 cm
Property with agricultural (cropping) land use	Flood level afflux of ≤ 20 cm
Property with agricultural (grazing) land use	Flood level afflux of ≤ 40 cm
Roads	Less than 10% increase in un-trafficable road length

[1] Assessed for flood events up to and including 1% AEP flood event.

Assessment of modelled flood impacts against the flood impact objectives is provided in section 6.3.9.1 to section 6.3.9.3.

6.3.9.1 Habitable and non-habitable structures

Flood impacts at the location of habitable and non-habitable structures have been assessed against the Project flood impact assessment objectives provided in Table 6.3 (Appendix C, Flood Impact Assessment). The flood model shows there are no changes in flooding at existing habitable and non-habitable structures in all events up to the 2% AEP flood event.

Afflux between 1 cm and 2 cm is predicted at a number of non-habitable structures in the 1% AEP flood event including:

- Two unidentified structures on the Riverland property (4/FN514) adjacent the Banana Creek channel with predicted afflux up to 2.6cm (26mm).
- Two sheds on the Alberta property (5/KM50) with predicted afflux of up to 1.4cm (14mm).
- One silo on the Alberta property (6/KM50) with predicted afflux of up to 1.1cm (11mm).

Although flood afflux between 1 cm and 2 cm is predicted at 5 non-habitable structures, it impacts remain below the flood impact objective of 5 cm for non-habitable structures.

Afflux greater than 1 cm is not predicted to occur at any existing habitable dwelling for flood events up to the 1% AEP event.

6.3.9.2 Agricultural land use (cropping and grazing)

Flood impacts to agricultural land (cropping and grazing) have been assessed against the Project flood impact objectives (Table 6.3). All properties with cropping or grazing lands were assessed as meeting the flood impact objectives. Afflux to agricultural land outside of the Project MLA does not exceed 1cm for flood events up to the 2% AEP. Afflux of 1 cm to 3 cm in the 1% AEP flood event is predicted on the nearby properties ‘Riverland’, ‘Alberta’ and ’Mount Ramsay’, however remains well below the flood impact objective of 20 cm and 40 cm for cropping and grazing land uses respectively. The flood level afflux maps in Appendix C, Flood Impact Assessment illustrate the spatial variation in afflux across each of the properties.

6.3.9.3 Roads

Flood impacts to roads in the vicinity of the Project have been assessed against the Project flood impact objective for roads (Table 6.3). The flood impact objective for existing roads is less than a 10% increase in un-trafficable road length for the Mine Developed Case. Roads have been assessed as un-trafficable when flood depths over the road are greater than 0.3 m which is the depth limit for when small sized vehicles become unstable.

Negligible changes to road inundation lengths are predicted for all events up to the 1% AEP flood event, therefore road trafficability is not expected to be impacted.

6.3.9.4 Other nearby infrastructure and towns

Infrastructure near the Project with potential to be affected by flooding in the mine developed case is shown in Figure 6.1 in section 6.1.

Table 6.4 summarises the identified flood afflux impacts to nearby infrastructure for the mine developed case. The flood model shows there are negligible flood impacts to nearby infrastructure and the Baralaba township for flood events up to 0.1% AEP.

Table 6.4: Flood impacts to nearby infrastructure and towns

Infrastructure ID	Potential impact
Baralaba Township	< 0.01 m flood level increase in all events up to 0.1% AEP flood event
Neville Hewitt Weir	< 0.01 m flood level increase in all events up to 0.1% AEP flood event
Baralaba-Woorabinda Road Bridge	< 0.01 m flood level increase in all events up to 0.1% AEP flood event

Infrastructure ID	Potential impact
Moura-Baralaba Road Bridge	< 0.01 m flood level increase in all events up to 0.1% AEP flood event
Baralaba North Mine	< 0.01 m flood level increase in all events up to 0.1% AEP flood event

6.3.10 Banana Creek dominated flooding

Banana Creek dominated flooding was assessed for the Existing Case and Mine Developed Case scenarios for the 10%, 1% and 0.1% AEP event to determine the extent of flooding impacts compared to the Dawson River flood discussed above. The Banana Creek dominated 10%, 1% and 0.1% AEP flood results for the Existing Case and Mine Developed Case are presented in Appendix C, Flood Impact, as well as the change to flood depth (afflux) and peak velocity. The Banana Creek dominated flooding scenario shows:

- Similar to the Dawson River flooding scenarios there are no impacts for the Banana Creek 10% AEP flood event.
- The extent of flooding impacts for the Banana Creek 1% and 0.1% AEP events is less than the Dawson River scenarios, however, shows larger increases in flood afflux within the MLA.
- The Banana Creek dominated flood afflux shows the Project results in flood depth increases of up to 30mm outside of the MLA boundary in the 1% AEP event, however, is limited to the area between the MLA and Banana Creek. Afflux between 10mm and 20mm is also predicted on the western Dawson River floodplain adjacent to the Project in a small number of isolated locations.
- Although the extent of impacts is less, the magnitude of impacts is predicted to be slightly higher immediately adjacent to the mine landform within the Project MLA.
- Banana Creek 1% AEP flood impacts for both peak flood depth (afflux and velocity) is lower than the Dawson River 1% AEP flood impacts outside of the Project MLA.

Based on the Banana Creek dominated flooding assessment it was determined that the Project will result in larger flooding impacts for a Dawson River dominated flood and represents the overall flood impacts for the Project.

6.3.11 Project infrastructure

The water management infrastructure stage plans presented in Appendix C, Flood Impact show the proposed mine landform over the Project Life. The flood model results show all mine water storages and site infrastructure proposed for the Project are located outside of the 0.1% AEP flood extent besides the northern section of the out of pit WRE and number of small sediment dams.

Localised increases in peak flood velocity are identified in flood events greater than 10% AEP at the downstream toe of the out-of-pit WRE at the northwest corner of the site. Flood velocities are expected to increase locally by up to 0.35m/s, however, remain below 0.6 m/s in the Mine Developed Case for the 1% AEP flood event. Although the expected flood velocities are low, localised erosion protection works such as rock armouring and establishment of floodplain vegetation (trees) may be implemented to prevent scouring and degradation of this area.

There are a number of sediment dams and located at the downstream toe of the out-of-pit WRE. These dams have greater than 10% AEP flood immunity from the Dawson River. The sediment dams are used to contain sediment runoff from the out-of-pit WRE and do not contain hazardous materials and are designed and proposed to be operated in accordance with the Best Practice Erosion and Sediment Control Guidelines (IECA, 2018). The sediment and clean water dams located within the 0.1% AEP flood extent are to be of mostly excavated construction (embankment to provide spillway freeboard) to prevent risk of dam break during flooding of the Dawson River.

The proposed extent of open cut mining over the Project duration relative to the modelled existing 0.1% AEP flood extent is shown Figure 6.16. The flood results show the open cut pit is located outside of the pre-mining 0.1% AEP flood extent for the duration of the Project and artificial landforms are not required to provide flood immunity.

The mining pit maintains 0.1% AEP climate change flood immunity without flood protection levees. The closure mine landform includes a rehabilitated final landform bund located around the southern extent of the final void with a crest elevation above the predicted PMF level to provide the residual void PMF immunity post closure.

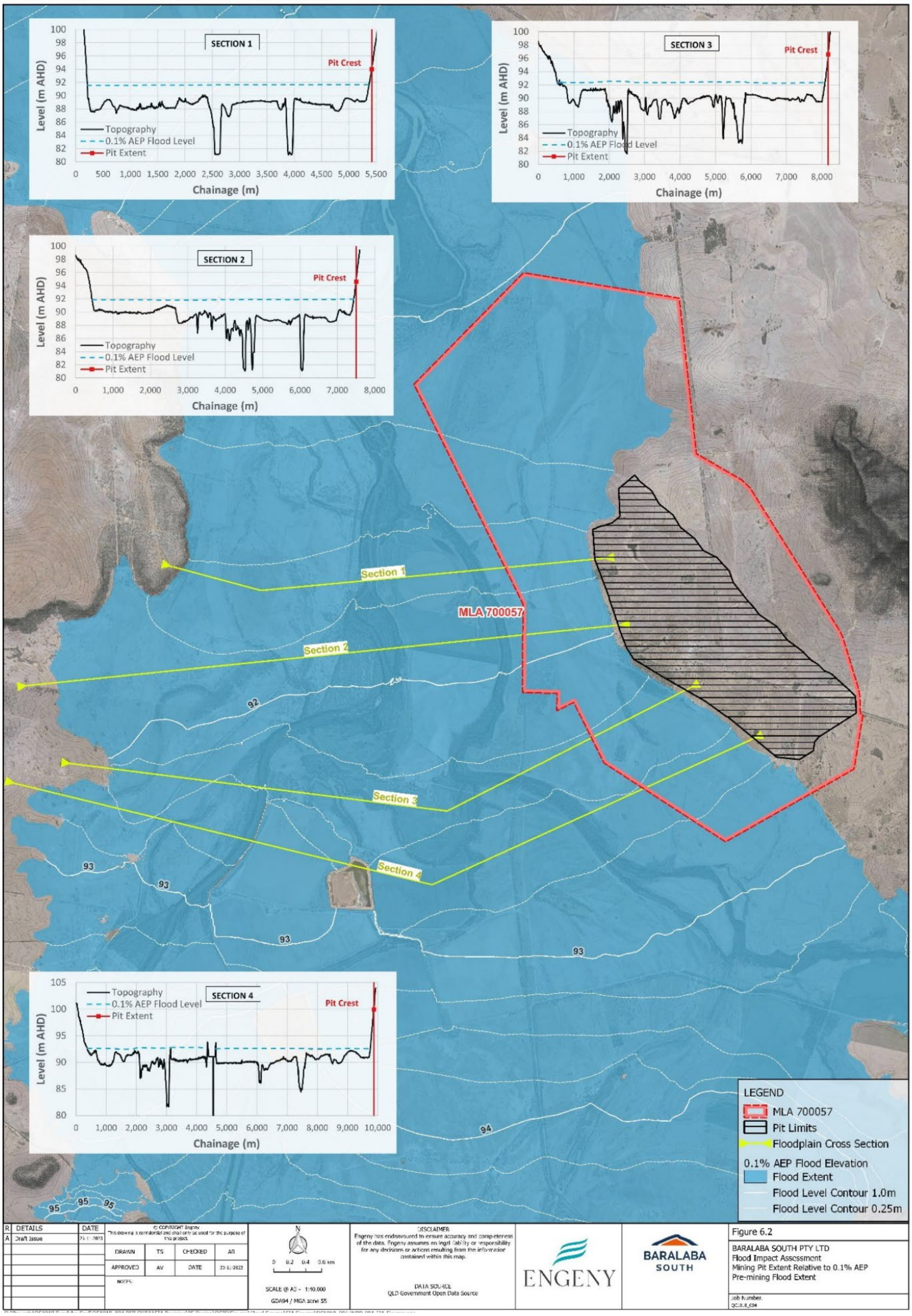


Figure 6.16: Mining pit extent relative to 0.1% AEP pre-mining flood extent

6.3.12 Cumulative impacts

The Flood Impact Assessment has considered existing structures that may affect flood behaviour, including structures that are proposed as part of the Project.

There are no known projects in the planning or development phase that may result in additional structures on the floodplain in the vicinity of the Project. Additionally, while the Project proposes the realignment of the Moura-Baralaba Road, this is beyond the influence of the effective flow area of the Dawson River floodplain and will not impact on the predicted flood impacts associated with the operational activities and final post-mining landform. For further information, see Appendix C, Flood Impact Assessment.

6.3.13 Sensitivity assessments

Using the Dawson River flood model, a number of sensitivity assessments were conducted in order to understand the sensitivity of the modelled Project impacts on flooding, including:

1) A climate change sensitivity assessment—the assessment used the methodology outlined in the ‘Australian Rainfall and Runoff Guideline’ (Ball *et al.*, 2019) to develop a climate change design hydrology for the 1% and 0.1% AEP flood events. This was done by increasing design rainfall intensities using climate change factors provided by the ‘Australian Rainfall and Runoff Guideline’ for the Dawson River catchment. Climate change projection year 2070 has been adopted for the purposes of the assessment. The results from the sensitivity analysis indicate that flood levels are likely to increase due to climate change impacts on Dawson River hydrology. For example, for the mine developed case, the peak flood levels in the Dawson River are projected to increase by 0.25 m for the 1% AEP flood event and by 0.3 m for the 0.1% AEP flood event adjacent to the Project as a result of climate change. The changes to flood levels under the climate change projections are negligible and as a result, there are no key risk areas for climate change vulnerability for the Project and no alternative adaptation strategies are considered to be required.
4) General sensitivity assessment— The December 2010 historical event sensitivity assessment was undertaken to assess flood impacts for a flood event with significantly more flood volume than a design flood event of a similar AEP. The assessments indicated peak flood level impacts associated with the Mine Developed Case are not highly sensitive to the volume of the hydrograph and are instead more dependent on the peak flow rate in the Dawson River.

6.4 Mitigation measures, management and monitoring

The mitigation management, and monitoring measures outlined below are expected to avoid, minimise or mitigate the Project's impacts on flooding, with respect to the safety of people, property, and the environment.

6.4.1 Flood protection and final landform design

The current mine plan has been optimised to minimise adverse flooding impacts in the Dawson River and Banana Creek, and the adjoining floodplain areas. The mine design ensures operational pit inundation protection against the 0.1% AEP peak flood event, climate change scenario.

Post-mining, the final landform design will include a low earthen bund on the south western corner of the final void that will act as a permanent feature of the landscape and will provide PMF design event protection to the final void. The height of the bund is proposed to be 98 m AHD (max 5 m above ground level), which is approximately 1 m to 1.5 m above the PMF level.

6.4.2 Nearby properties (infrastructure and agricultural land use)

6.4.2.1 Habitable and non-habitable structures

Mine planning has targeted minimal impact to the Dawson River floodplain to reduce flood impacts which has achieved the Project's flood impact objectives for habitable structures.

No further mitigation measures are considered necessary to prevent flood impacts on habitable structures.

Further consultation will be conducted with relevant landholders to assess whether the flood level afflux predicted to occur at non-habitable structures on their property will result in a material impact, and to identify whether any localised mitigation measures may be appropriate.

6.4.3 Mine site infrastructure

Erosion protection works, such as rock mulching, and monitoring of the areas identified as having localised increases in peak flood velocity near the north west extent of the out-of-pit WRE landform. Erosion protection works and floodplain vegetation establishment to prevent localised scouring and degradation of the area identified with increases in peak flood velocity. Monitoring is proposed to observe the performance of the erosion protection works following large flood events.

Site infrastructure, access road and haul roads are to be located above the Dawson River 0.1% AEP peak flood level. With all site infrastructure located above the Dawson River 0.1% AEP peak flood level there is no potential for additonal flood impacts associated with the Project.

Sediment Dams and clean water dams located within the 0.1% AEP flood extent are to be of mostly excavated construction to reduce risk of dam break during flooding of the Dawson River. The dams are proposed to be mostly excavated preventing the possibility of erosion and failure of a dam embankment in a large flood event.

Hazardous materials will be stored at the infrastructure areas at the eastern extent of the MLA boundary, which maintains Probable Maximum Flood (PMF) immunity. Any storage containers that hold hazardous materials will be secured in line with relevant Australian Standards to prevent the removal of the containers from the site by a flood event.

6.4.4 Monitoring

Mine water infrastructure will be inspected by a suitably qualified and experienced person in advance of the wet season each year. In addition, following major flood events, a visual inspection of any water infrastructure in flood areas will be conducted to identify any impact from flood waters to conduct required maintenance activities.

Monitoring will be conducted in the areas near the north-western extent of the northern WRE, that may have localised contact with flood water. Where erosion protection works are required, monitoring will be conducted to assess the effectiveness of such works following flood events.

Aerial imagery of the river channels will be obtained (possibly via drone or plane) prior to the commencement of construction and immediately following each flood that encroaches the final landform. The aerial imagery extend a distance of 5 km along the watercourse upstream and downstream of the Banana Creek confluence and about 5 km of Banana Creek. The purpose of collecting the imagery would be to define the geomorphic changes that occur (naturally or otherwise) along the reach for further assessment and evaluation by a suitably qualified person if required.

6.5 Regulated structures

6.5.1 Water management infrastructure

The proposed water management infrastructure for the Project includes:

- mine water dam;
- environmental water dam;

- sediment dam, eastern dams 1-5, western dams 1-6, year 1 dam; and
- clean water dams 1-2.

Information on the water management infrastructure is contained in Chapter 2, Project Description. In particular:

- the purpose of each structure and the maximum volume for each dam;
- the location of the water management infrastructure; and
- how the water management infrastructure is sited to avoid or minimise risks from flooding.

6.5.1.1 Mine water system

The Mine Water System for the Project has been designed to utilise a series of dams to achieve the separation of anticipated water types as follows:

- Mine water dams will be used to collect / store water which has interacted with mining activities consistent with the Mine Affected Water definition from the 'Model Mining Conditions' (DES, 2017a) including surface water runoff and groundwater collected within the mining pit, recycled water from the CHPP, runoff from the MIA area and excess water in the tailings drying cells.
- Sediment dams will be used to collect rainfall and runoff generated by disturbed landforms including waste rock, pre-cleared areas and rehabilitated areas that are not yet established. Sediment dams will be used to ensure runoff from overburden and disturbed areas, which contain elevated concentrations of solids, is contained prior to overflows being directed to the receiving environment during rainfall events. Sediment dams are designed in accordance with the requirements of the 'Best Practice Erosion and Sediment Control Guidelines' (IECA, 2018) and, therefore, sediment dam overflow should be of a quality to mitigate any environmental harm arising.
- Clean water dams will be utilised for the management of natural rainfall and runoff from undisturbed or established rehabilitation area and has not come into contact with disturbed land or active mining areas. Water collected in clean water dams exhibits water quality characteristics of the receiving environment.
- Diversion of clean catchment has been maximised to reduce the harvest of clean catchment into the mine water system. Where topography allows, clean catchment is diverted via drainage features which connect upstream clean catchment with the receiving waterways.

Preliminary design parameters of proposed mine water dams, sediment dams and clean water infrastructure are summarised in Table 6.5. The proposed dams will be constructed progressively, in alignment with the mining pit progression. The progressive development of the mine and corresponding location of dams are shown on Figure 4.21 to Figure 4.26 in Chapter 4, Surface Water.

6.5.1.2 Mining void

Assessment of the mining void as a regulated structure is not required. The mining void is not an intended water storage, will be actively dewatered following rainfall events and will be used temporarily to store mine water when the out-of-pit mine water storage inventory is exceeded (Appendix A, Surface Water Impact Assessment).

Table 6.5: Proposed water management dam design

ID	Description	Catchment area	Full supply volume	Estimated embankment height	Associated mine stages	Anticipated water quality
Mine water dams						
Mine Water Dam (MWD)	Embankment dam sized to maximum capacity allowing storage of dewatered inventory from Pit and sediment dams. Dam used as intermediary storage for CHPP process water. Allowing to capture recycled water from coal wash plant and mechanical dewatering.	29 ha	1,220 ML	~14 m	Year 1–19	Mine water dams receive mine water from the pit, recycled water from the CHPP, runoff from the MIA area and excess water in the tailings drying cells which is considered to have greater potential for contamination
Environmental Water Dam (Enviro Dam)	Storage to capture runoff from MIA area, ROM and rejects stockpile.	79 ha	410 ML	~ 8 m	Year 1–19	
Sediment dams						
Western Sedimentation Dam 1 (SDW01)	Manages sediment runoff generated from north-western section of the northern WRE.	92.4 ha	26.3 ML	~1m	Year 1-23	Sediment dams to collect and allow the moderated discharge of runoff from overburden and disturbed areas, which contain elevated concentrations of solids, however, are considered to have less potential for contamination.
Western Sedimentation Dam 2 (SDW02)	Manages sediment runoff generated from western section of the northern WRE	32.8 ha	9.3 ML	~1 m	Year 3 – 23	
Western Sedimentation Dam 3 (SDW03)	Manages sediment runoff generated from western section of the WRE	100.4 ha	28.6 ML	~1 m	Year 3 – 23	
Western Sedimentation Dam 4 (SDW04)	Manages sediment runoff generated from south-western section of the WRE	51.6 ha	14.7 ML	~1 m	Year 6 – 23	
Western Sedimentation Dam 5 (SDW05)	Manages sediment runoff generated from south-western section of the WRE	98.2 ha	27.9 ML	~1 m	Year 11 – 23	

ID	Description	Catchment area	Full supply volume	Estimated embankment height	Associated mine stages	Anticipated water quality
Western Sedimentation Dam 6 (SDW06)	Manages sediment runoff generated from southern section of the northern WRE.	72.6 ha	20.7 ML	~1 m	Year 23	
Eastern Sedimentation Dam 1 (SDE01)	Manages sediment runoff generated from northern section of the northern WRE.	10.0 ha	2.8 ML	~1 m	Year 1 – 23	
Eastern Sedimentation Dam 2 (SDE02)	Manages sediment runoff generated from north-eastern section of the northern WRE.	33.7 ha	9.6 ML	~1 m	Year 1 – 23	
Eastern Sedimentation Dam 3A (SDE03A)	Manages sediment runoff generated from north-eastern section of the WRE.	29.8 ha	8.5 ML	~1 m	Year 3 – 23	
Eastern Sedimentation Dam 3B (SDE03B)	Manages sediment runoff generated from north-eastern section of the WRE.	34.0 ha	9.7 ML	~1 m	Year 6 – 23	
Eastern Sedimentation Dam 3C (SDE03C)	Manages sediment runoff generated from eastern section of the WRE.	34.4 ha	9.8 ML	~1 m	Year 6 – 23	
Eastern Sedimentation Dam 4A (SDE04A)	Manages sediment runoff generated from eastern section of the WRE.	33.1 ha	9.4 ML	~1 m	Year 6 – 23	
Eastern Sedimentation Dam 4B (SDE04B)	Manages sediment runoff generated from eastern section of the WRE.	32.9 ha	9.4 ML	~1 m	Year 6 – 23	
Eastern Sedimentation Dam 4C (SDE04C)	Manages sediment runoff generated from eastern section of the WRE.	34.3 ha	9.8 ML	~1 m	Year 11 – 23	

ID	Description	Catchment area	Full supply volume	Estimated embankment height	Associated mine stages	Anticipated water quality
Eastern Sedimentation Dam 5 (SDE05)	Manages sediment runoff generated from southern section of the WRE.	55.8 ha	15.9 ML	~1 m	Year 11 – 23	
Year 1 Sedimentation Dam 1 (SDY01_01)	Manages sediment runoff generated from eastern section of the initial northern WRE.	17.1 ha	4.9 ML	~1 m	Year 1 – 3	
Clean water structures						
Northern clean water drain	Diverts clean catchment runoff east of MLA from mining activities, diverting it south into the Dawson River	470 ha	4.3 km drainage channel		Year 1-23	Water collected in clean water dams exhibits water quality characteristics of the receiving environment and acceptable for direct release to the Dawson River.
Southern clean water drain	Diverts clean catchment runoff east of MLA from mining activities, diverting it south into Banana Creek.	586 ha	3.7 km drainage channel		Year 1-23	
Tributary 8 Diversion drain	Minor diversion of Tributary 8 around the WRE toe and sediment collection drain at the northern extent of the MLA	3,180ha	0.39 km drainage channel		Year 1-23	
Clean Water Dam 1 (CWD1)	Captures clean catchment runoff from south-of the northern WRE.	181 ha	88 ML		Year 1-3	
Clean Water Dam 2 (CWD2)	Captures clean catchment runoff from south of mining pit.	66 ha	32 ML		Year 1-3	

6.5.2 Potential impacts

Infrastructure proposed to manage mine affected water and sediment runoff has been assessed in accordance with the 'Manual for Assessing Consequence Categories and Hydraulic Performance of Structures' – version 5.01 (the Manual) (DES, 2016a) and the TOR. The Manual specifies the procedure for consequence category assessment of regulated structures, constructed as part of environmental relevant activities under the EP Act.

Water retaining structures were assessed using the Manual to determine if their consequence category is low, significant or high. Structures deemed to be of significant or high consequence category are referred to as regulated structures.

The Manual requires the assessment of the consequences of the following failure event scenarios:

- 'Failure to contain – seepage' – spills or releases to ground and/or groundwater via seepage from the floor and/or sides of the structure.
- 'Failure to contain – overtopping' – spills or releases from the structure that result from loss of containment due to overtopping of the structure.
- 'Dam break' – collapse of the structure due to any possible cause.

For each failure event scenario, the Manual requires the consequences to be assessed for each of the following categories of harm.

- harm to humans;
- general environmental harm; and
- general economic loss or property damage.

6.5.2.1 Preliminary dam break assessment

The potential consequences associated with failure from mine water dams (MWD and Envrio Dam) were assessed in a preliminary dam break assessment undertaken by Engeny (Appendix A, Surface Water Impact Assessment). Dam break refers to the collapse of the structure due to any possible cause (DES, 2016a). Breach outflow hydrographs were generated, and Froehlich's equations were utilised to calculate breach dimension and development time. The results of the breach assessment are summarised in Table 6.6.

Table 6.6: Dam breach assessment results

Parameter	MWD	Enviro Dam
Volume of water released (ML)	1,186 Remaining storage is below natural ground level.	265 Remaining storage is below natural ground level.
Depth of breach (m)	8.4	4.3
Breach development time (min.)	44	37
Peak breach outflow (m3/s)	638	166

A localised two-dimensional flood model (HEC-RAS 2D) was developed for downstream dam extents to simulate the breach hydrographs and determine the failure impact extent. The model extent included the area downstream of MWD and Enviro Dam to the Dawson River where the dam breach outflows are contained within the Dawson River channel. The dam failure modelling was undertaken using the year 1 landform as it represents full impact of the potential failure of the Enviro Dam to the Dawson River. The pit progresses towards the failure pathway the Enviro Dam in the later stages of mine operations.

Figure 6.17 and Figure 6.18 show the dam failure extent for MWD and Enviro Dam respectively. The dam failure results show that once the break flows enter Banana Creek and the Dawson River the flows are contained within the main channel.

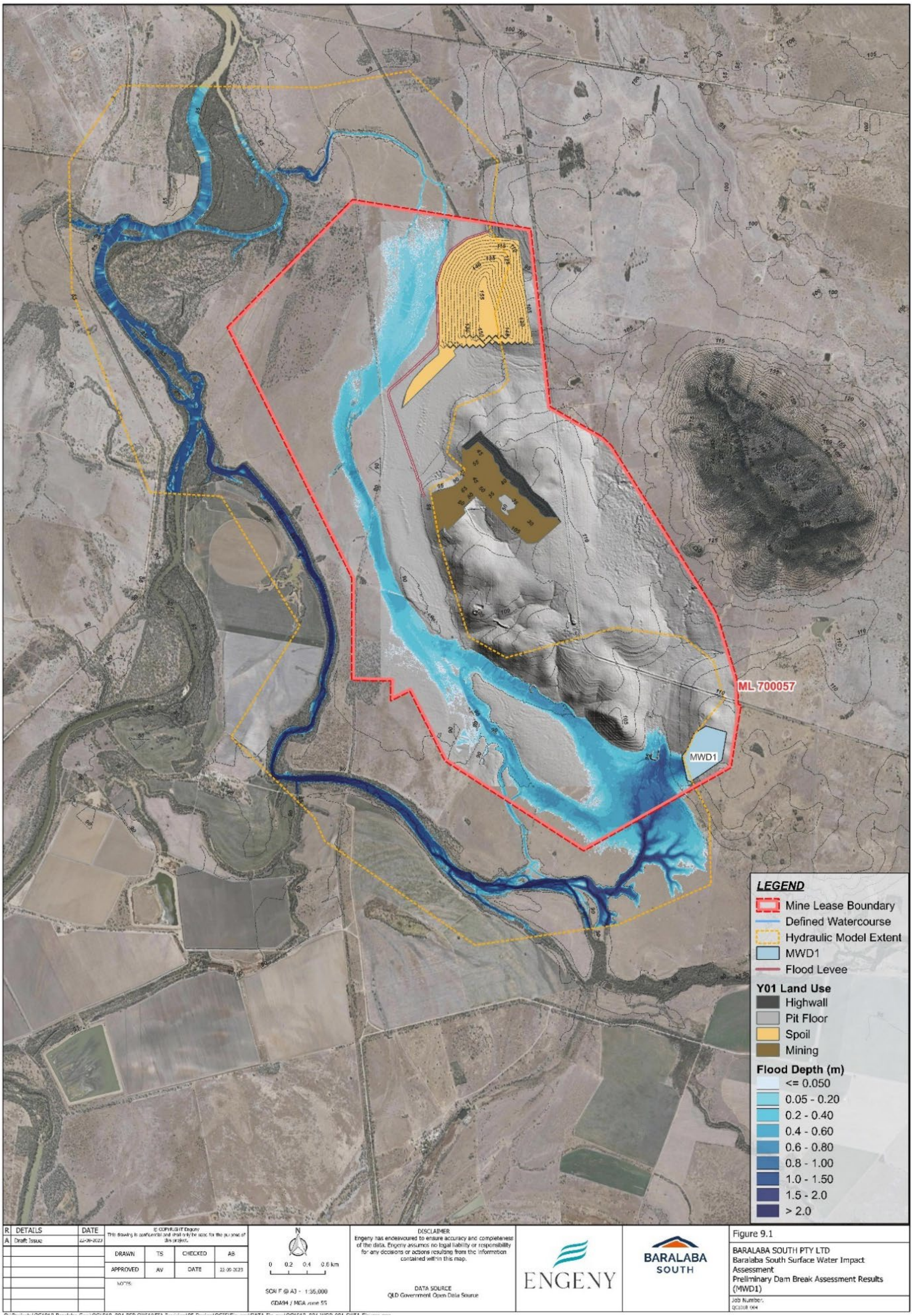


Figure 6.17: Preliminary mine water dam break assessment results— MWD

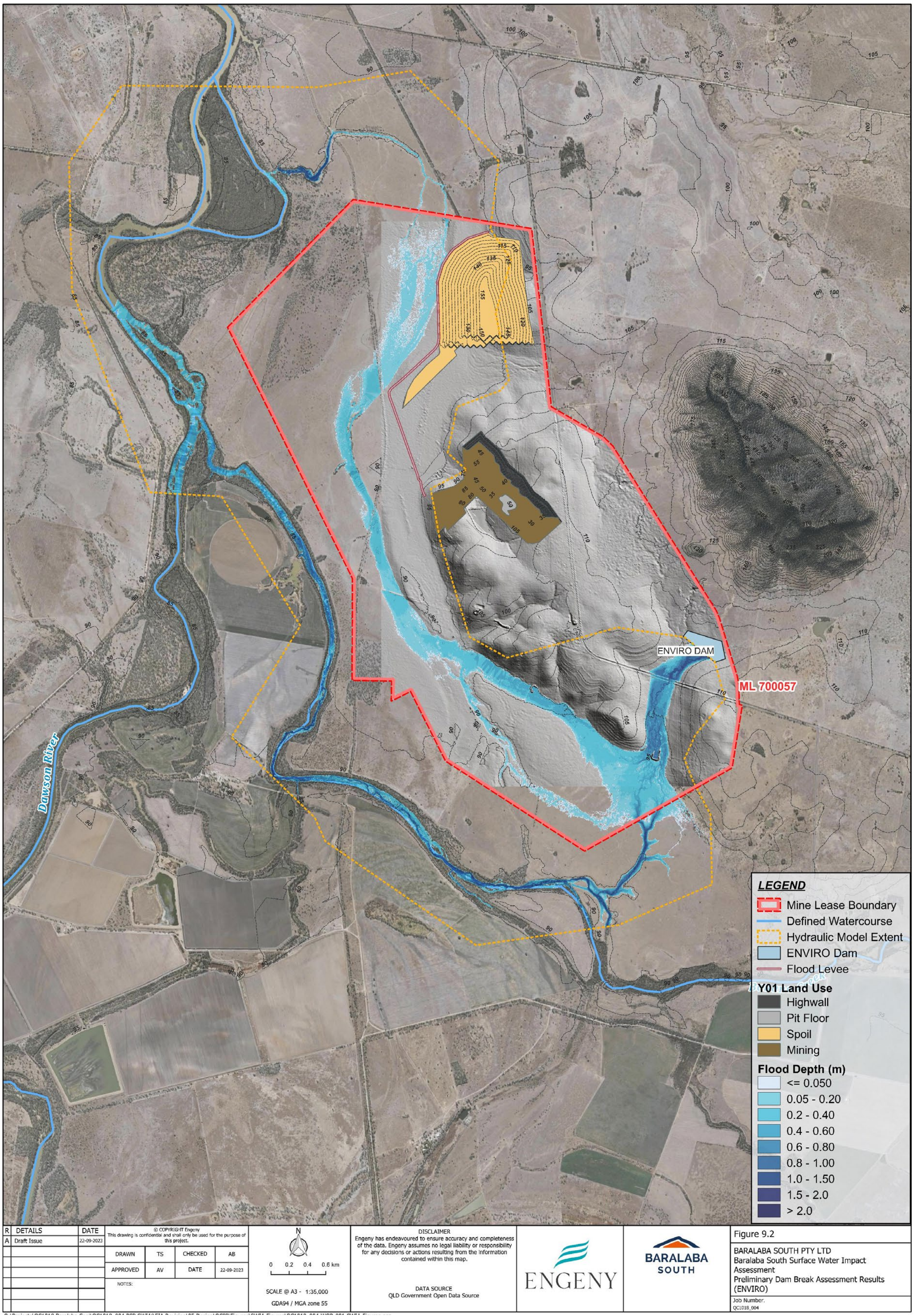


Figure 6.18: Preliminary mine water dam break assessment results— Enviro Dam

6.5.2.2 Preliminary consequence category assessment

A preliminary assessment of the water management infrastructure was conducted in accordance with the Manual. The preliminary assessment is detailed in Appendix A, Surface Water Impact Assessment.

Overall results of the preliminary consequence category assessment are shown in Table 6.7.

Table 6.7: Preliminary consequence category assessment summary

Structure	Failure to contain - seepage	Failure to contain overtopping	Dam break	Regulated
Mine Water Dam	Low	Low	Significant	Yes
Environmental Water Dam	Low	Low	Significant	Yes
Sediment Dams - Eastern Dams 1-5 - Western Dams 1-6 - Year 1 Dam	Low	Low	Low	No
Clean Water Dams 1-2	Low	Low	Low	No

Certification is provided in Appendix A of the Surface Water Impact Assessment (Appendix A).

The consequence category assessment will require review and revision once the engineering and design of the water infrastructure is finalised. In that case, further certifications for regulated structures will be provided.

6.5.3 Mitigation measures, management and monitoring

Any structures determined to be regulated for 'failure to contain overtopping' following detailed design will be designed and constructed with wet season containment, in accordance with the Manual's design criteria requirements detailed in Table 6.8.

Structures to be regulated for 'dam break' will be designed and constructed with spillway capacity, in accordance with the Manual's design criteria requirements (Table 6.8).

Table 6.8: Regulated structure design criteria requirements (DES, 2016a)

Consequence category	Design criteria		
	Wet season containment (design storage allowance)	**Extreme storm storage (ESS) allowance**	**Spillway design capacity**
Significant	5% AEP	10% AEP 72 hour	1%–0.1% AEP
High	1%AEP	1% AEP 72 hour	Minimum 0.1% AEP

Other mitigation measures relating to regulated structures include:

- operating the water storages as an integrated water management system (that is, water is transferred between each water storage as required to reduce the risk of failure);
- preparing a design plan for the regulated structures, to outline how all identified consequence scenarios are addressed in the design and operation of the regulated structures, which will include:
  - a description of the physical dimensions of the regulated structure;
  - the materials and standards to be used for construction of the regulated structure;
  - the criteria to be used for operating the regulated structure;
  - investigation and design reports, plans and specifications; and
  - planned decommissioning and rehabilitation outcomes;
- having the regulated structures certified by suitably qualified and experienced persons, in accordance the requirements prescribed in the Manual, and providing a statement of reasons that outline how the design plan supports the finding that the regulated structure is capable of its specific performance; and
- having inspections carried out for each regulated dam, by a suitably qualified and experienced person, to assess the condition and adequacy of the dams, and preparing an inspection report that contains details of the assessment and any recommended actions.