APPENDIX 10: AQ2 GROUNDWATER & SURFACE WATER ASSESSMENTS

A. AQ2 Groundwater Assessment
B. AQ2 Surface Water Assessment

C. AQ2 Groundwater Assessment

APPENDIX 10A: AQ2 GROUNDWATER

Keysbrook Mineral Sands Mine
Groundwater Assessment for Western Extension

Prepared for:

Doral Mineral Sands

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1. INTRODUCTION

1.1. Background

Doral operates the Keysbrook Mineral Sands Project (the Project), located 58 km south of Perth and 22 km east of Mandurah, in Western Australia. The Project is managed by Keysbrook Leucoxene Proprietary Limited (KLPL), which is a subsidiary of Doral.

The Project is located on privately owned land that is used for grazing and other rural land uses. It operates under Ministerial Statement No. 810 and No. 1089. The currently approved area of disturbance is 1,532 ha, within a 3,015 ha Environmental Protection Authority (EPA) Development Envelope. This has approval for 9 years of mining from October 2015 with the mine areas being progressively mined, backfilled to pre-disturbance contours, and rehabilitated within 2 years of mining (Doral, 2022).

Based upon the current mining schedule, the ore reserve within the approved mine area, as defined in MS810, is due to be exhausted in 2023. AQ2 has previously completed surface water and groundwater assessments (2022a, 2022b) on the active mining area within Part Lot 63 that Doral has submitted with an amendment to proposal under Section 45C of the Environmental Protection Act 1986 (EP Act). It should be noted that the Part Lot 63 amendment is still under assessment by the Department of Water and Environmental Regulation (DWER).

1.2. Purpose of this Document

To facilitate the continuation of the mine and workforce, Doral seeks to further amend the Project to include Part Lots 20, 62, 63, 64, 201, 507 and 508 under Section 40AA of the EP Act as shown on Figure 1. The amendment area, referred to as the Western Extension, is mostly located within the existing EPA Development Envelope and includes a disturbance (mine) area of 518 ha, consisting primarily of cleared pasture and up to 21.5ha of degraded native vegetation. Mining the amendment area will produce an additional heavy mineral concentrate and result in approximately 65 months (5.5 years) of additional mining for the Project.

To date, the approved mining operation has involved progressively clearing and mining about 30ha of active open pit at any one time, plus progressive backfilling and rehabilitation as the mine progresses. It is assumed that the area of active mining within the proposed amendment would be consistent with this approach (i.e. maximum 30ha of active open pit).

To facilitate the proposed amendment to the active mining area within the Western Extension (i.e. Lots 20, 62, 63, 64, 201, 507 and 508), Doral are required to submit refer the proposal under Section 40AA of the Environmental Protection Act 1986. The following information is required to support this, which is presented within this groundwater assessment:

4. *Provide details of any detrimental effects the proposed change/s might have on the environment, considering:*
   - *the values, sensitivity and quality of the environment which is likely to be impacted*
   - *the extent (intensity, duration, magnitude and geographic footprint) of the likely impacts*
   - *the resilience of the environment to cope with the impacts or change.*
5. *Describe whether the detrimental environmental effects of the change are additional to, or different from, any detrimental environmental effects of the original proposal.*

This report details the groundwater assessment of the active mining area within the Western Extension amendment. For the purpose of this report, the Western Extension is broken down into four sections, as shown on Figure 1, which cover an overall proposed mining period. It should be noted that a separate stand-alone report has been prepared to cover the surface water assessment for the proposed amendment (AQ2, 278E_020a).

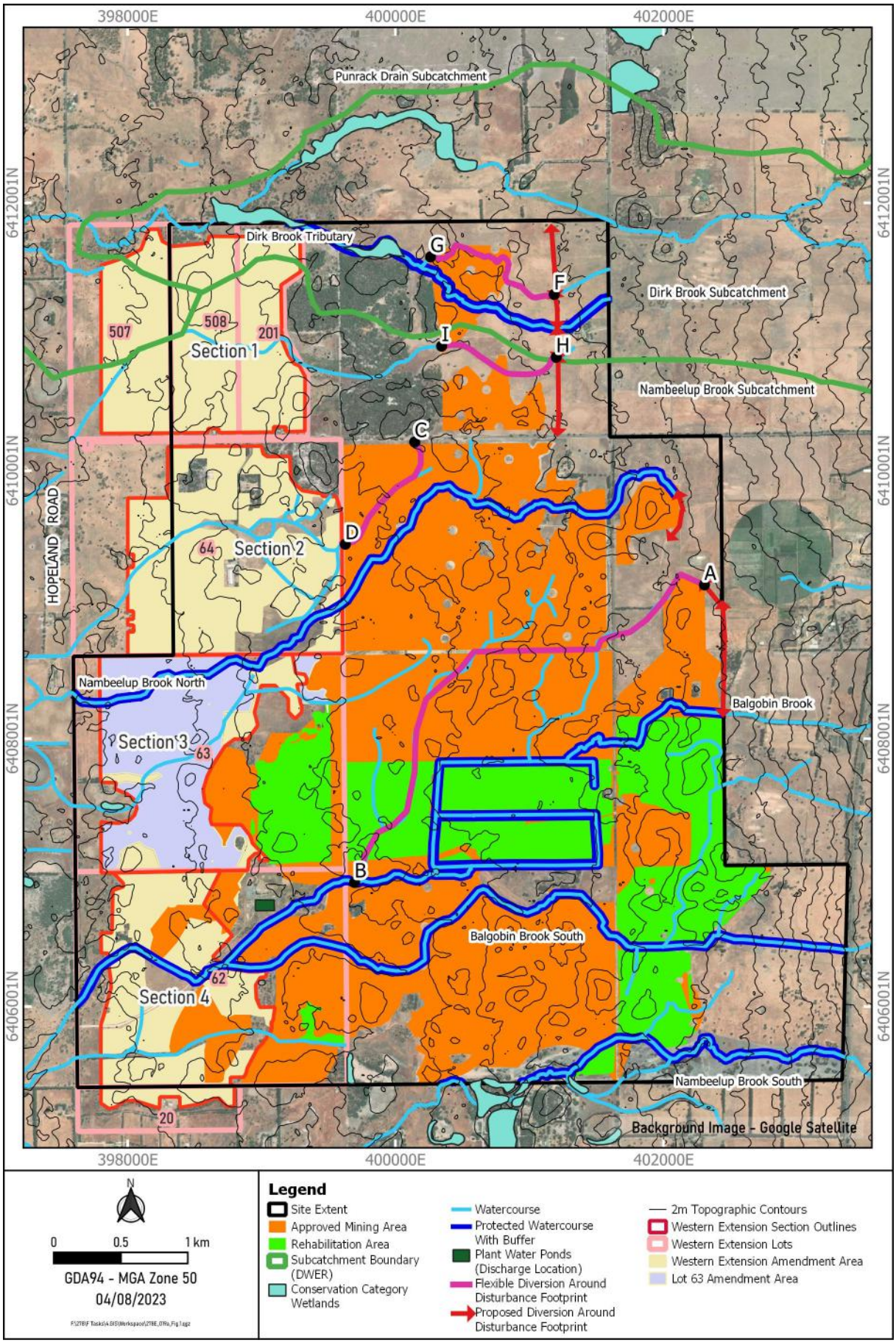

Figure 1 Proposed Western Extension

2. HYDROGEOLOGICAL SETTING

2.1. Local Geology

The Project is located in the Perth Basin and is underlain by about 10 to 15 m of superficial formations (Quaternary age), comprising the Bassendean Sand and the underlying Guildford Formation. These formations unconformably overlie about 50 to 130 m of the Leederville Formation – Wanneroo and Mariginiup Members – of Cretaceous age. The Mariginiup Member underlies most of the Project area whereas the Wanneroo Member, up to 25 m in thickness, is present only in the very western part. The Leederville Formation unconformably overlies the Cattamarra Coal Measures in the east and conformably overlies the South Perth Shale in the west. A schematic conceptual geological west-east cross section of the Perth Basin is shown in Figure 2.

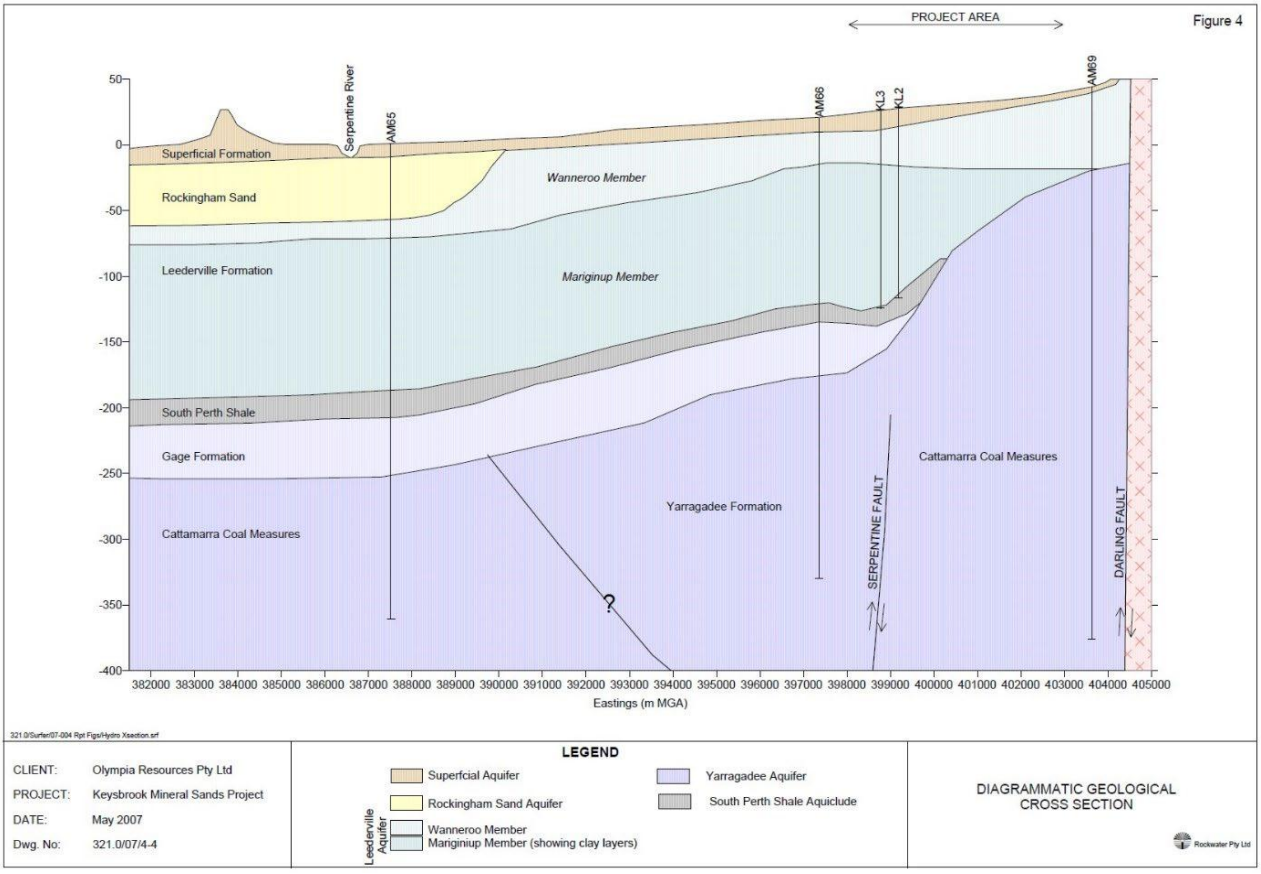

Figure 2 Schematic Conceptual Geological West-East Cross Section (Rockwater, 2007)

2.2. Local Hydrogeology

The Project lies on the Swan Coastal Plain, approximately 3 km west of the Darling Scarp, within the Serpentine and Murray groundwater management areas, west of the towns of Keysbrook and North Dandalup.

Two major aquifers, the Superficial and Leederville, have been identified within the Project. A detailed description of the aquifers of the Project area is given by Rockwater (2006, 2007), GRM (2021) and it is summarised below.

2.2.1. Superficial Aquifer

The Bassendean Sand and Guildford Formation form an unconfined Superficial aquifer. The permeability of the superficial aquifer is variable and depends on sediment type, with saturated sands having higher permeability than clays. At the Project, the Bassendean Formation forms the main portion of the aquifer, with the upper 4 to 8 m of this formation being moderately permeable, while the Guildford Formation is of lower permeability, owing to its more clayey nature. The high sand content in all the superficial units at the site mean they are in hydraulic connection and behave as a single aquifer unit.

The Bassendean Sand has a variable thickness (up to 5 m), thickening to the west. Owing to the shallow base of the Bassendean Sand, this sand is in places fully unsaturated in summer/autumn, and partly-saturated in winter/spring; water levels fluctuate about 1 m annually. In other areas, the formation extends below the summer water table and is partly to fully saturated year-round. The underlying Guildford Formation extends to 9 to 15 m below ground level (mbgl) and is mostly saturated, with the exception of the upper one metre or so where the Bassendean Sand is thinnest.

The groundwater level within the Superficial Aquifer varies from 0 (surface level) to 5 mbgl, with groundwater flow mainly to the west, under the prevailing hydraulic gradient. Groundwater salinity can be quite variable and is fresh to brackish, ranging from about 200 to 5,000 mg/L total dissolved solids (TDS).

The groundwater in the Superficial aquifer is derived from recharge resulting from direct rainfall and the local stream runoff from ephemeral drainage networks.

2.2.2. Leederville Aquifer

The Leederville aquifer is a confined groundwater system, separated from the overlying Superficial aquifer by the confining Guildford Formation. The Leederville aquifer comprises interbedded sandstones and siltstones, which extend to at least 130 mbgl and have a modest to high permeability in the vicinity of the Project. The piezometric level within the Leederville Formation is typically lower than that of the Superficial aquifer, although some local variability has been reported (Rockwater, 2013). The Leederville aquifer receives groundwater from the Superficial aquifer and transmits it mainly westwards.

The groundwater quality of the Leederville Formation is fresh to brackish, reporting a salinity of less than 1,500 mg/L TDS.

3. OTHER USERS AND GROUNDWATER ENVIRONMENT

3.1. Other Groundwater Users

A search of the Department of Water and Environmental Regulation (DWER) Water Information Reporting (WIR) database on other groundwater users, has identified 551 bores within a 10 km radius of the Project. The locations of the identified bores are shown in Figure 3, grouped by aquifer type (where the data is available). The data indicates:

- Two artesian Yarragadee monitoring bores (AM64 and AM66) are located north east and south west of the Project. The bores form part of the DWER Groundwater Assessment Network.
- A series of Superficial aquifer monitoring bores are located within and adjacent to the Project area. This series of bores (which includes T610, T620, T570 and T660) also forms part of the DWER Groundwater Assessment Network.
- There are numerous registered bores within and surrounding the Project area with little or no information in the WIR database.

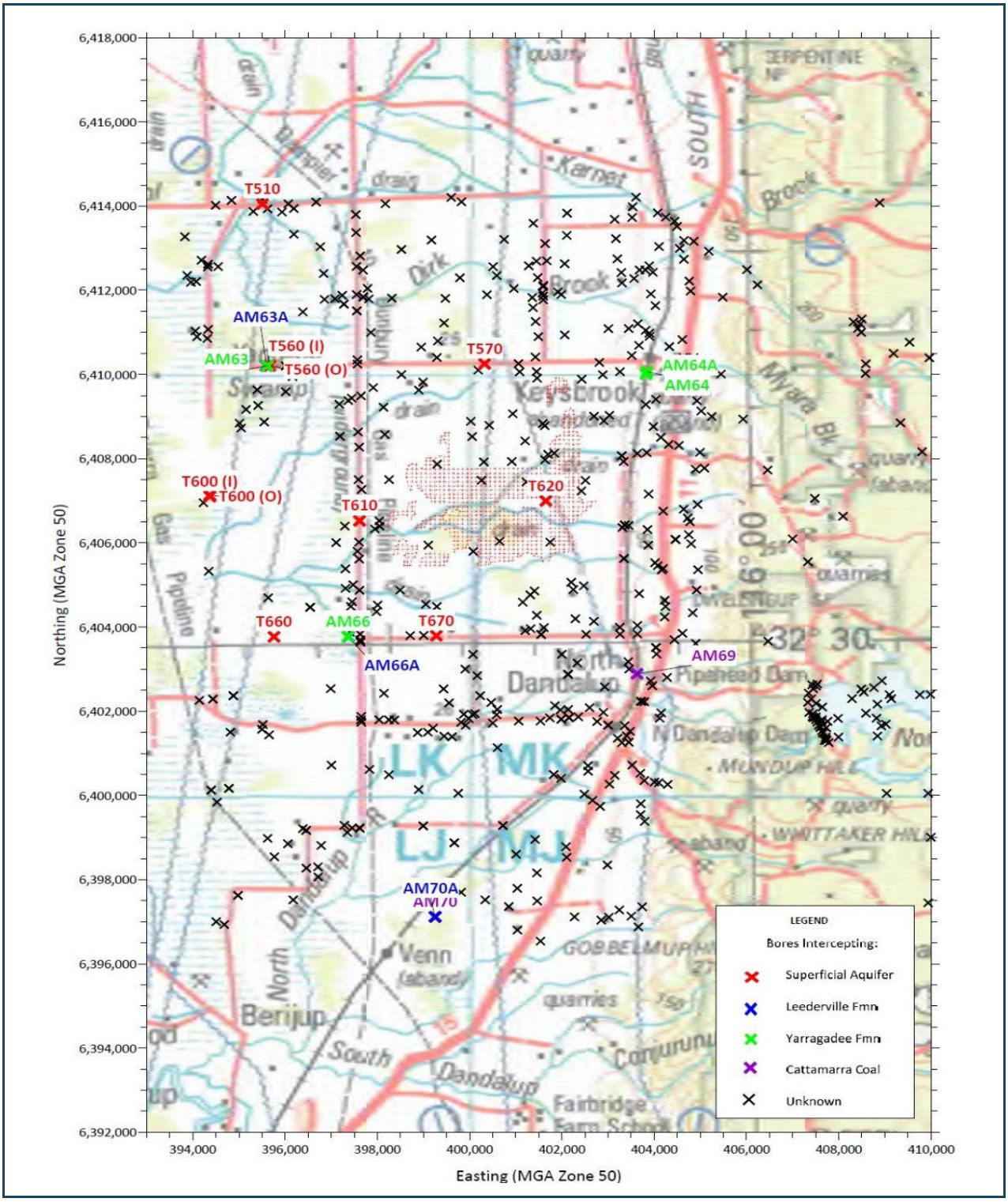

Figure 3 DWER other Groundwater Users (GRM, 2022)

3.2. Groundwater Dependent Ecosystem

3.2.1. Conservation Category Wetlands and Environmentally Sensitive Areas

A number of Conservation Category Wetlands (CCW) (DBCA, 2022) were identified to be located around the Project approved Mining Area, as shown in Figure 4.

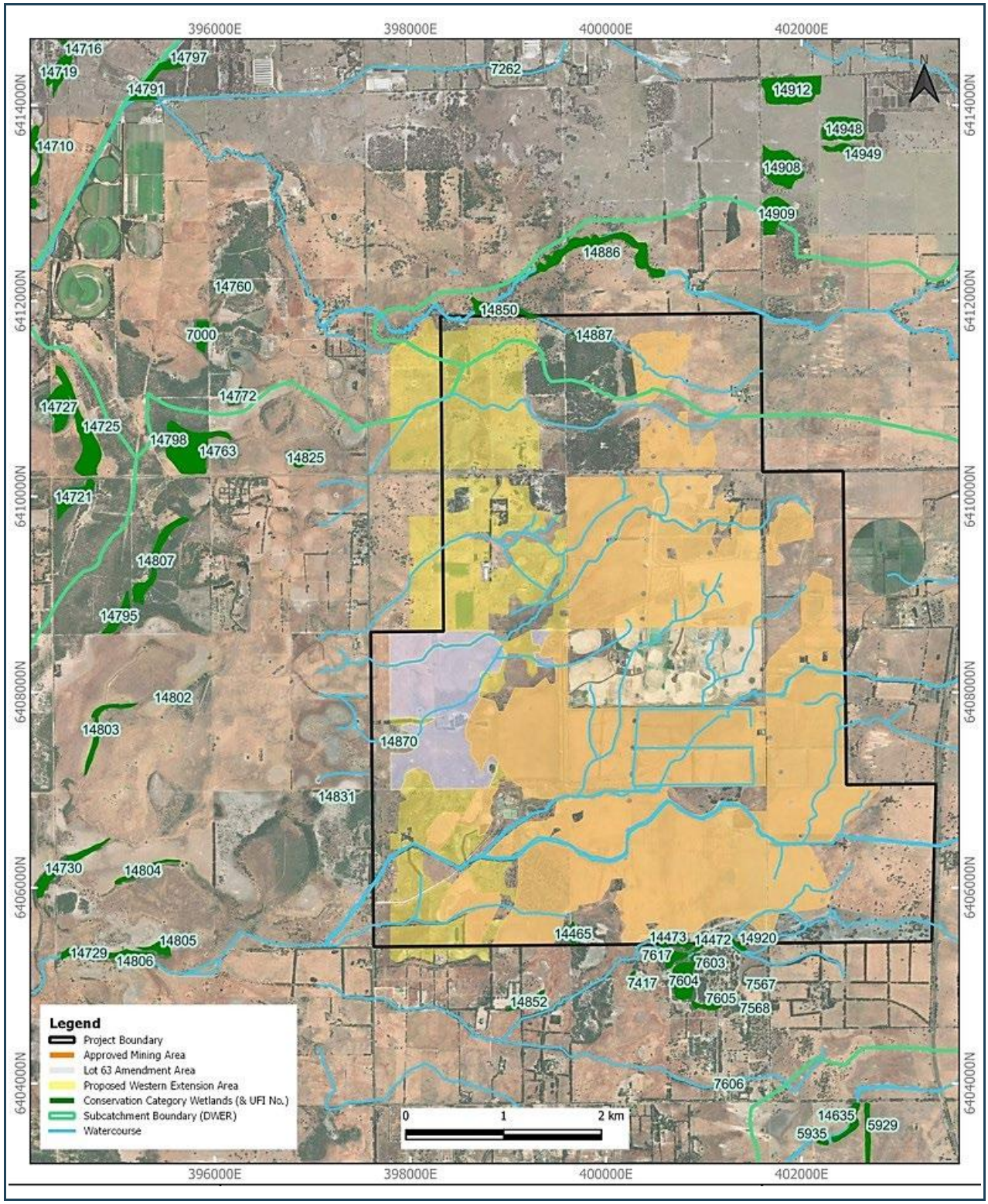

Figure 4 Conservation Category Wetlands

A summary of the CCWs located the closest to the proposed Western Extension is provided in Table 1. More details are to be found in Rockwater (2021) and Ecoedge (2021, 2022), all of which report that these monitored CCW areas were degraded due to clearing. It should be noted that the accuracy of this assessment of affected CCWs is based on limited topographical data for determining surface water flowpaths.

Table 1 Summary of CCW in the Proximity of the Western Expansion

Section	Subcatchment	CCW ID	Type	Management Category
1	Dirk Brook	14850 14887	Dampland	Seasonally waterlogged
	Punrack Drain	14760 7000 14472	Palusplain	Seasonally waterlogged
	Nambeelup Brook North	14825 14763	Palusplain	Seasonally waterlogged
		14798	Dampland	Seasonally waterlogged
2	Nambeelup Brook North	14807	Sumpland	Seasonally inundated
		14795	Palusplain	Seasonally waterlogged
3	Nambeelup Brook North	14870 14802 14803	Palusplain	Seasonally waterlogged
4	Nambeelup Brook North	14831 14804 14805 14806 14852 14465	Palusplain	Seasonally waterlogged

3.2.1.1. Section 1 (Lots 201, 507 & 508)

Two unnamed tributaries of Dirk Brook flow in a westerly direction as well-defined watercourses to the north of the proposed areas of disturbance within Lots 201, 507 & 508 (Section 1, Figure 4). A small unnamed stream flows through the southern half of these lots and continues to the west to converge with other tributaries of Nambeelup Brook.

Two CCWs (ID 14850 & 14887), shown on Figure 5, are located immediately upstream of Lot 201 along with an area of Resource Enhancement wetland (Ecoedge, 2022). These are all dampland wetlands (i.e. waterlogged), associated with the Dirk Brook Tributary.

Additionally, three CCWs (ID 14760, 14472 & 7000) lie approximately 1.6, 1.6 and 1.9 km to the west of Lot 507, respectively, associated with palusplain of the Punrack Drain.

There are also three CCWs (ID 14825,14763 & 14798) located 0.75, 1.9 and 2 km to the west of Lot 507, respectively, which are seasonally waterlogged wetlands associated with the Nambeelup Brook North.

There are several Environmentally sensitive areas (ESAs) within and nearby the proposed Section 1 area, all of which are associated with CCWs, which occur near the northern and western boundaries of the Section 1 area (Figure 5).

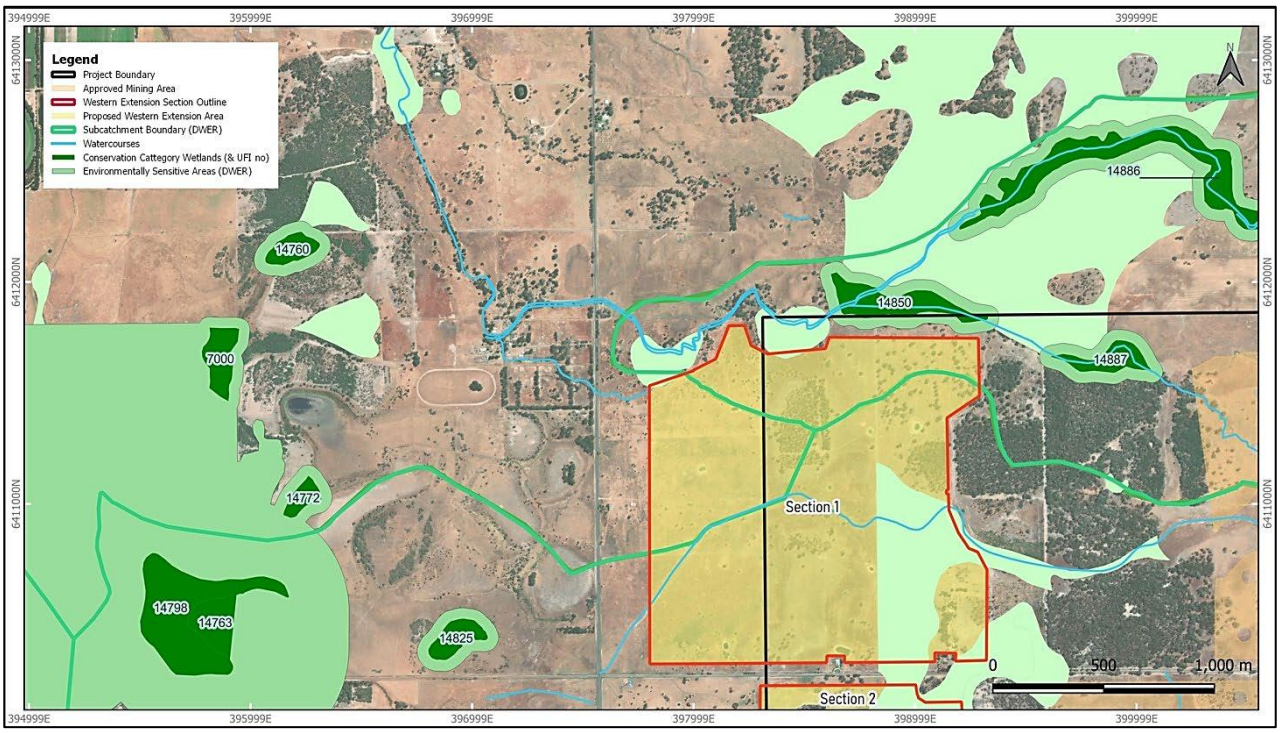

Figure 5 CCWs and ESAs in proximity to Section 1 (Lots 201, 507 & 508)

3.2.1.2. Section 2 (Lot 64)

Nambeelup Brook North Tributary flows through the southeastern corner of Lot 64 (Section 2) and continues to the west to converge with other tributaries and form Nambeelup Brook. A smaller unnamed tributary of Nambeelup Brook flows west through the centre of the Section 2 (Figure 6).

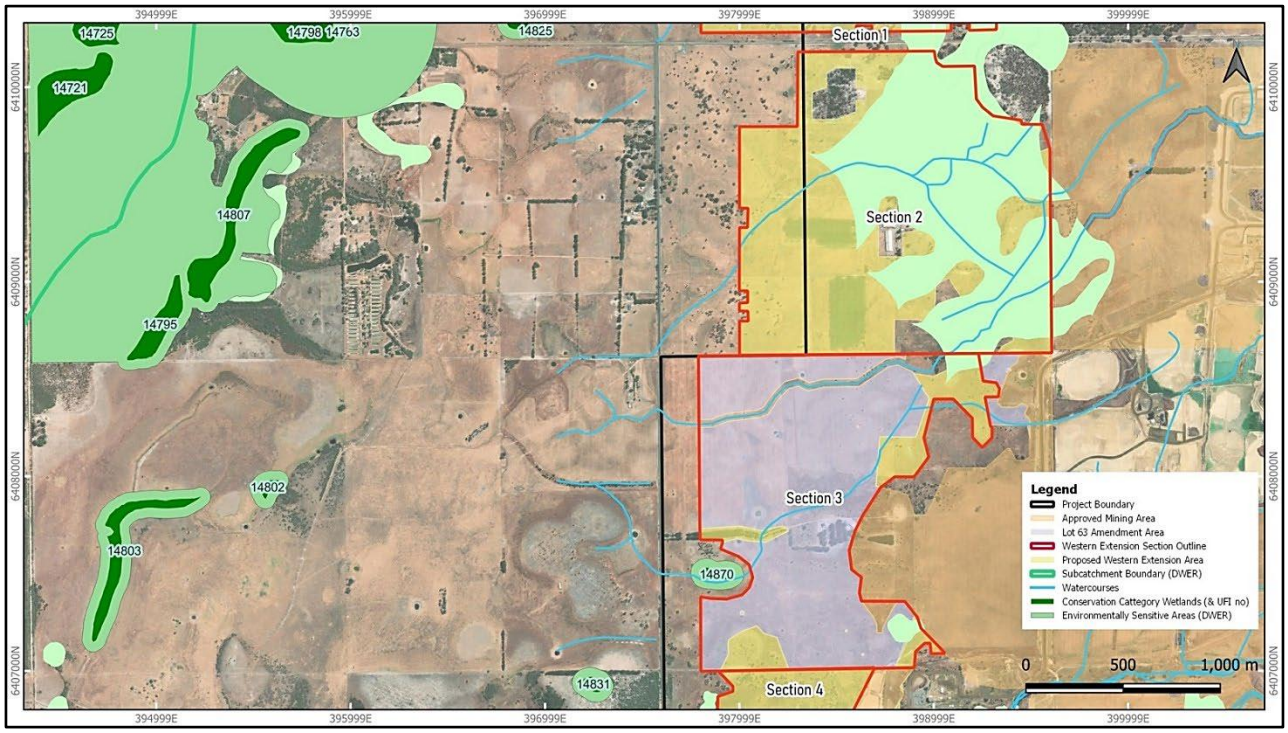

Figure 6 CCWs and ESAs in proximity to Section 2 (Lot 64) and Section 3 (Lot 63)

There are two CCWs (ID 14807 & 14795) 2.3 and 2.9 km to the west of Lot 64, respectively, which are associated with paulsplain and sumpland of the Nambeelup Brook North. There are also ESAs to the west of the proposed Section 2, which are associated with CCWs (Figure 6).

3.2.1.3. Section 3 (Lot 63)

Nambeelup Brook North Tributary flows from Section 2 and continues south-westerly through the northern part of Section 3. A smaller unnamed tributary of Nambeelup Brook flows south-westerly through the Section.

There is one CCW (ID 14870) located within the proposed Western Extension area, on the western boundary of Lot 63. This CCW is mapped as palusplain (seasonally waterlogged flat) wetland.

There are also two CCWs (ID 14802 & 14803), 2.2 and 2.6 km to the west of Lot 63, respectively, which are all associated with paulsplain flats of the Nambeelup Brook North. There are also ESAs to the west of the proposed Section 3, associated with CCWs (Figure 6).

3.2.1.4. Section 4 (Lots 20 and 62)

The largest tributary of Nambeelup Brook that crosses the Project, Balgobin Brook, flows westerly through Section 4, joining with Balgobin Brook South close to the centre of the Section which also flows westerly through the southern half of Section 4. A smaller unnamed tributary of Balgobin Brook flows westerly through the southern half of the Section (Figure 7).

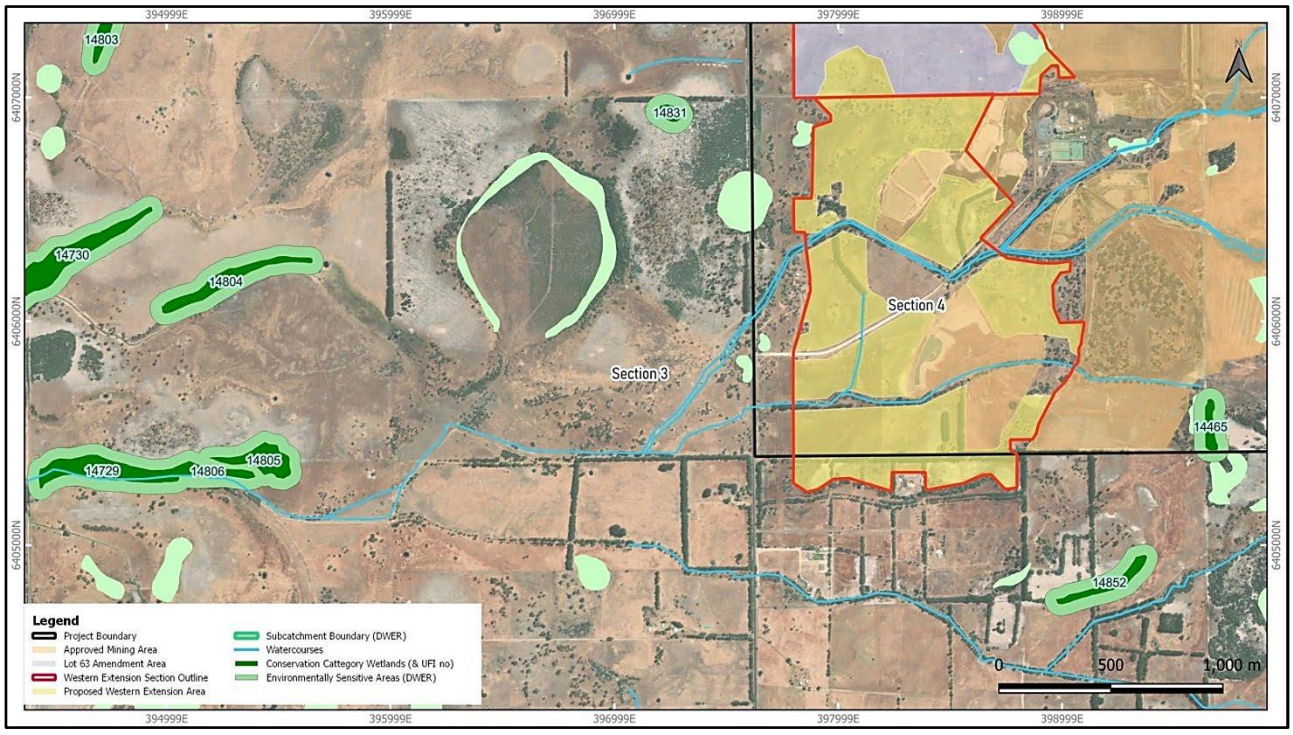

Figure 7 CCWs and ESAs in proximity to Section 4 (Lots 20 and 62)

There are two CCWs (ID 114852 &4465) located 0.5 and 0.7 km to the south east and east of Lots 20 and 62, respectively, which are seasonally waterlogged wetlands associated with the Nambeelup Brook North.

Additionally, there are five CCWs (ID 14831, 14804, 14805 & 14806) located between 0.5 and 2.4 km from the western boundary of Lot 62.

Similar to other Sections, there are several ESAs identified nearby the proposed Section 4, associated with CCWs (Figure 7).

3.3. Threatened and Priority Ecological Communities

As reported by Ecoedge (2022), ecological communities are defined as "*...naturally occurring biological assemblages that occur in a particular type of habitat. They are the sum of species within an ecosystem and, as a whole, they provide many of the processes which support specific ecosystems and provide ecological services*". Threatened Ecological Communities (TECs) may be listed under one of three conservation categories:

- Critically Endangered (CR),
- Endangered (EN) and
- Vulnerable (VU).

Priority flora is under consideration for future declaration as "Threatened flora", dependent on more information. Species classified as Priority One to Three (referred to as P1, P2 and P3) require further survey to determine their status. Priority Four (P4) species are adequately known rare or Threatened species that require regular monitoring.

A summary of Threatened and Priority Ecological Communities and Threatened and Priority flora located within and/or downstream of each Section of the Western Extension is provided in Table 2, based on Figures 8 and 9 from Ecoedge (2022). These figures show that there is one TEC (SCP15), which includes one P4 priority flora, located downstream of Section 1 to the west, within the Nambeelup Brook catchment. Although not shown on these figures, Figure 10 shows an occurrence of the TEC (SCP FCT 3c) in good condition, located to the east of the south-eastern corner of the same Section, but the topographical data available suggests that they are not connected in terms of surface water flows (up-gradient).

Table 2 TEC and Priority Flora Communities in the Vicinity of the Western Extension

Section	Community Classification	Description
1	TEC (SCP15)	Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain (SCP15)
	P4	None provided
2	P1, P2, P3	None provided
3	-	-
4	P2	None provided

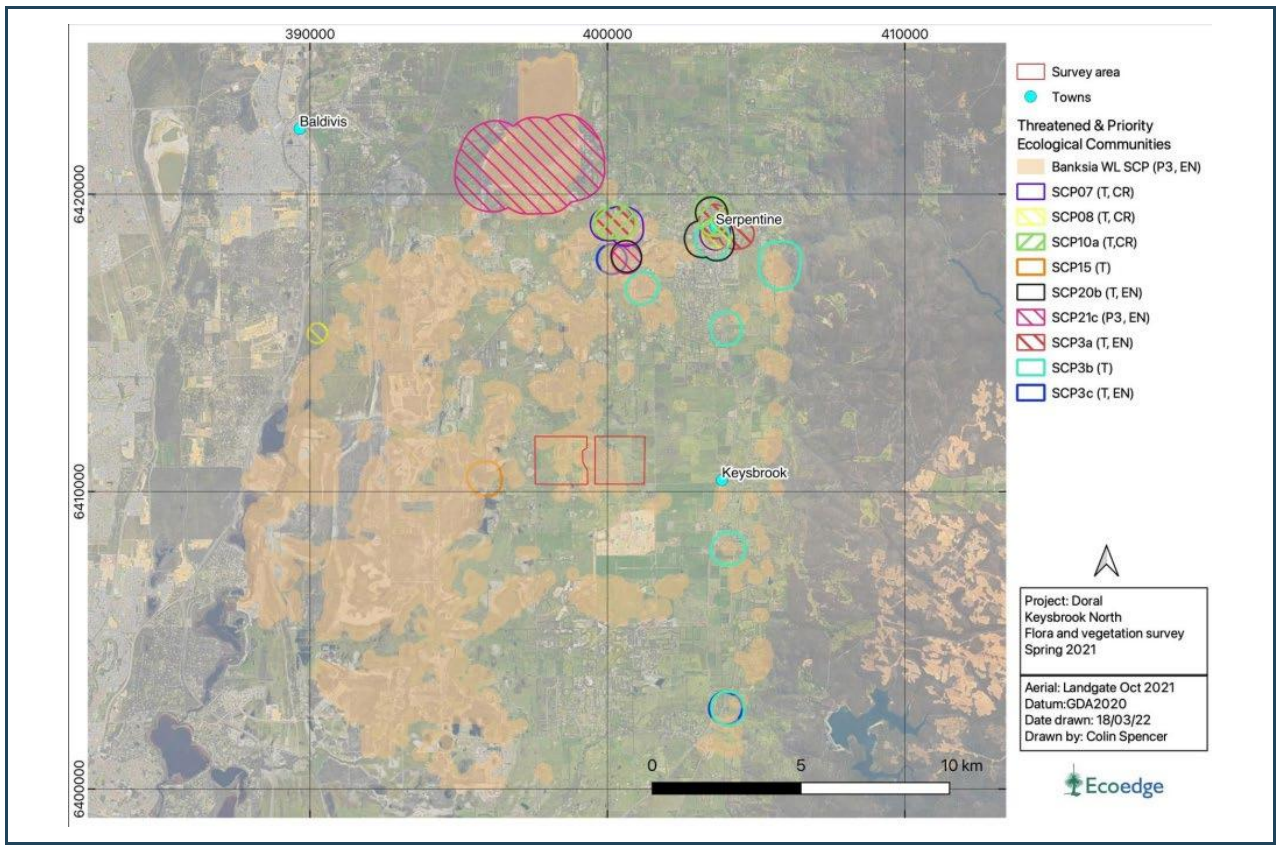

Figure 8 Desktop Search Results of TECs and PECs (Ecoedge, 2022)

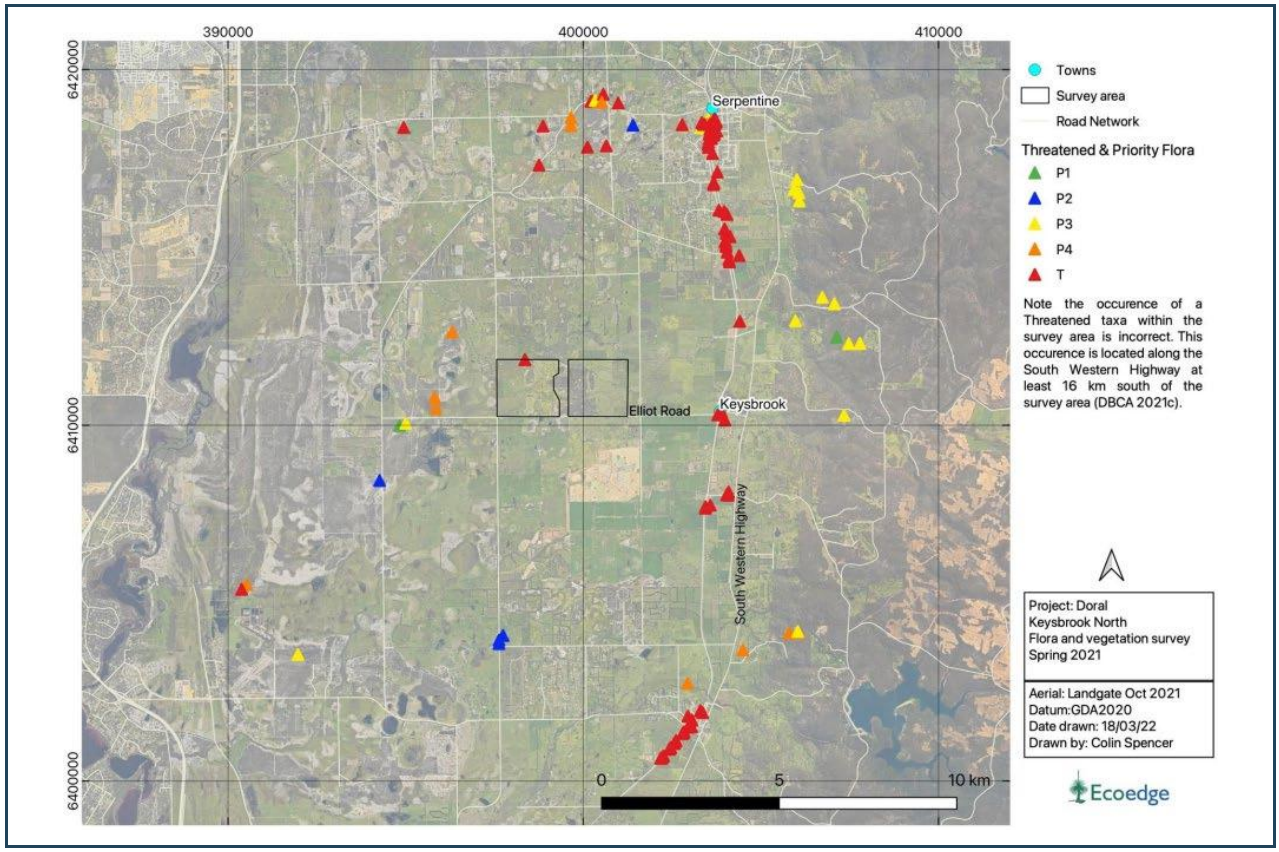

Figure 9 Desktop Search Results of Threatened and Priority Flora (Ecoedge, 2022)

4. SCHEME DESCRIPTION

4.1. Mine Dewatering

At Keysbrook, the mineral sand deposit, which occurs within the Bassendean Sand, contains on average 2.6% heavy minerals; principally leucoxene and zircon. KLPL mine the deposit using conventional dry surface mining methods (i.e. excavator and dump trucks).

Over the LoM the mine pit will extend to depths of between about 0.5 and 8 mbgl and will require dewatering where it extends below the water table, which was originally around 1 to 5 mbgl over the majority of the mining area, and typically exhibits a seasonal variation in the order of about 1 to 2 m. Dewatering the Superficial aquifer is necessary during the wetter months to maintain dry mining conditions. During summer months the dewatering required is minimal, if required at all. Dewatering in the mine pit, where necessary, is achieved via sumps located at low points on the pit floor. The groundwater is transferred to a settlement pond and process water dam prior to its use for dust suppression or within the processing plant. Surface water and any shallow groundwater is diverted around the mine pit with the use of shallow drains.

4.2. Groundwater Licences

KLPL has been granted 4 groundwater abstraction (5C) licences, allowing groundwater abstraction of up to 1.8 GL per annum from the Leederville Aquifer (water supply purposes) and up to 0.6 GL per annum from the Superficial Aquifer (dewatering purposes).

4.3. Monitoring Bore Network

Two production bores (KL2P and KL3P) and seven monitoring bores were constructed in the Mariginiup Member of the Leederville Formation. Two production bores have been installed to provide the make-up water to meet the project's process water demand, with each bore capable of producing 28 L/s. Additionally, 36 shallow monitoring bores were initially constructed into the Superficial formations to monitor potential water level change in the Superficial aquifer due to operation of the Leederville aquifer production bores and dewatering and tailings infiltration into the Superficial aquifer.

In early 2022, 5 shallow monitoring bores were additionally constructed in the Superficial aquifer across Lot 56. Some of the superficial aquifer monitoring bores are located close to the sensitive vegetation (CCW and TEC) to measure any drawdown that may occur in these sensitive areas.

Additionally, there are:

- 5 monitoring bores within Lots 201, 507 and 508 that were constructed in the Superficial formations to monitor historical groundwater abstraction from the Superficial aquifer within this area.
- 22 local farmers bores that are located close to the sensitive vegetation (CCW and TEC) to the west of the Project area and are occasionally monitored for any potential impacts.
- Five DWER monitoring bores (T570, T610, T620, T670 and T680B) which are part of the DWER regional monitoring programme to assess regional impacts from groundwater abstraction.

In May 2023, 6 monitoring bores across Lot 63 were additionally constructed in the Superficial formations to monitor potential water changes due to groundwater abstraction from the Superficial aquifer within this area and potential impacts that may occur in the nearby sensitive vegetation (CCWs).

Locations of the production and monitoring bores are shown in Figure 10.

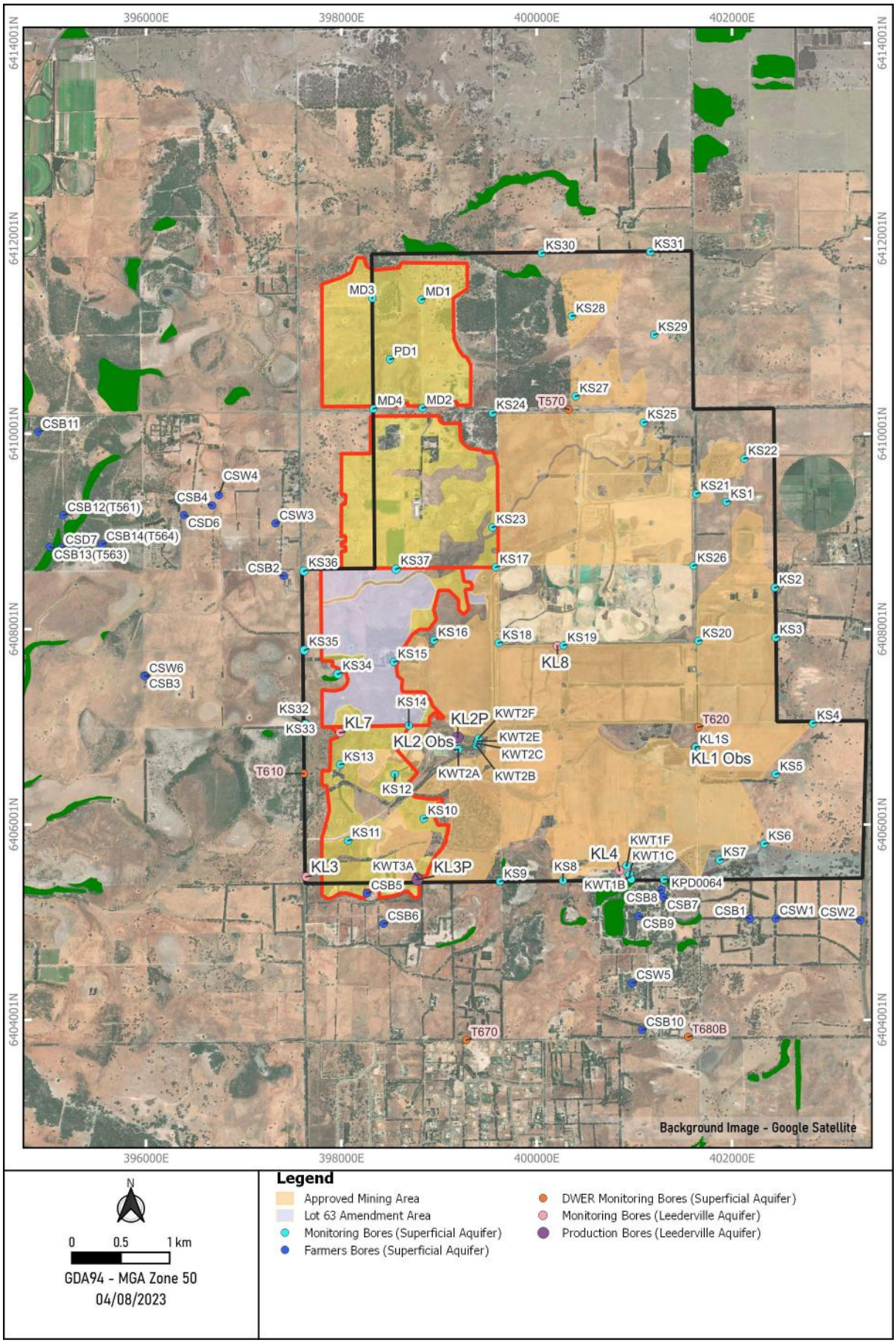

Figure 10 Current Bore Locations (July 2023)

4.4. Western Extension Proposed Disturbance Footprint

The proposed 'amendment area' within the Western Extension (i.e. Lots 20, 62, 63, 64, 201, 507 and 508; Figure 11) is mostly located within the existing EPA Development Envelope, except for a minor amendment to include part Lot 64 and Lot 507. The proposed significant amendment under Section40AA includes a disturbance (mine) area of 512 ha of cleared pasture (which is approximately 30% increase from the already-approved proposal).

To date, the approved mining operation has involved progressively clearing and mining about 30 ha of active open pit at any one time, plus progressive backfilling and rehabilitation as the mine progresses through that 30 ha. It is assumed that the area of active mining within the proposed Western extension will be consistent with the original approved mining approach (i.e., a maximum 30 ha of active open pit).

The mining within the Western Extension is proposed to operate for 65 months (i.e. 5.5 years), starting in the first quarter (Q1) of 2026 (i.e. January 2026) and finishing in Q2 of 2031 (i.e. May 2031). The total extent of mining Western Extension during this time, including the staged mining zones (quarters), are shown in Figures 12 and 13. A summary of proposed mining schedule in shown in Table 3. The monthly Mining Schedule within Western Extension is presented in Appendix A.

Table 3 Summary of Proposed Mining Schedule – Western Extension

Mining Section	Mining Lots	Mining Block Numbers	Mining Period
Section 1	201, 507 and 508	403-473	January 2026 to February 2028
Section 2	64	332-400	February 2028 to December 2029
Section 3	63	273, 277, 309, 319, 320, 321, 328, 329	December 2029 to May 2030, & May 2031
Section 4	62 and 20	211-269	May 2030 to April 2031

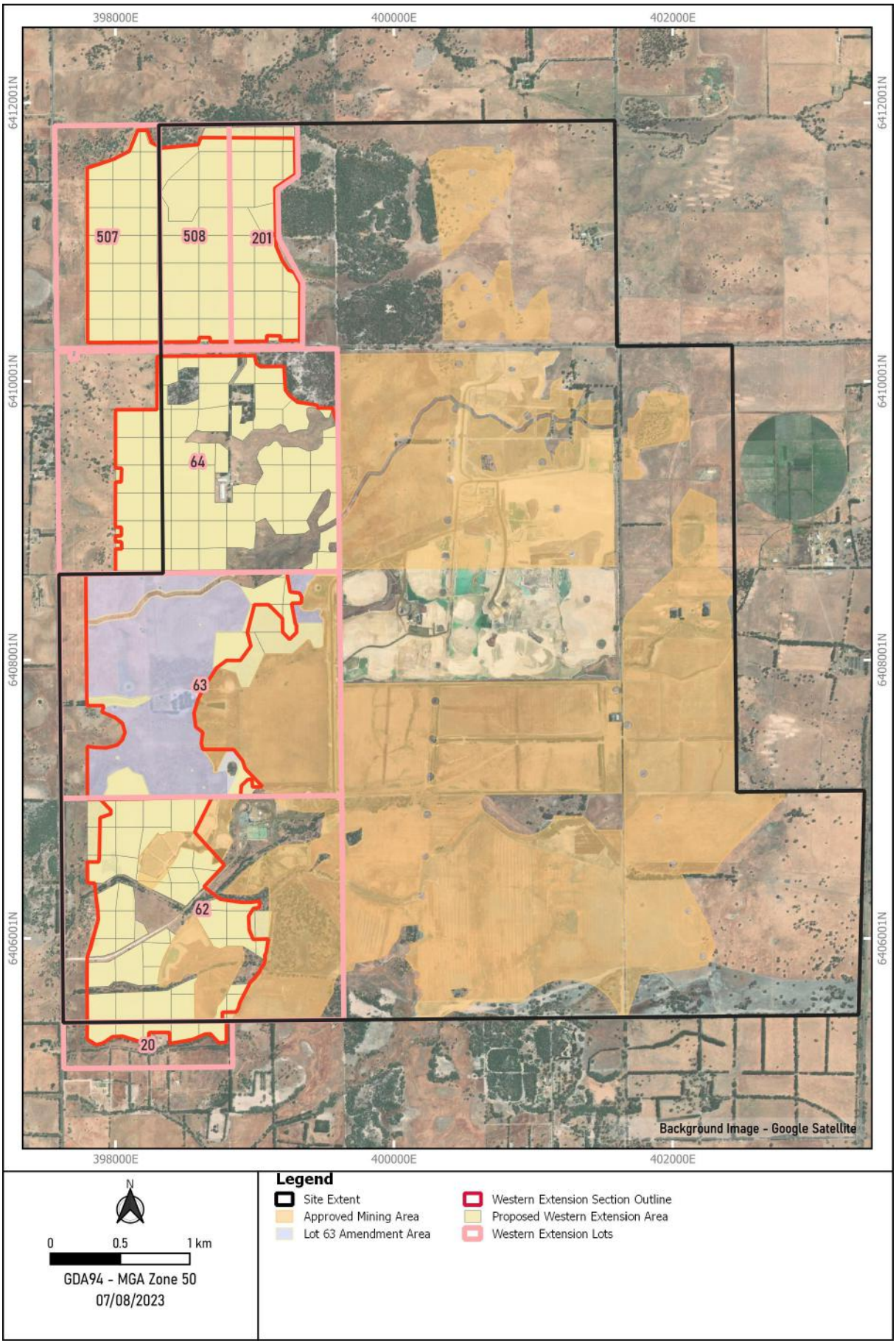

Figure 11 Proposed Western Extension Amendment Area Including Mining Blocks

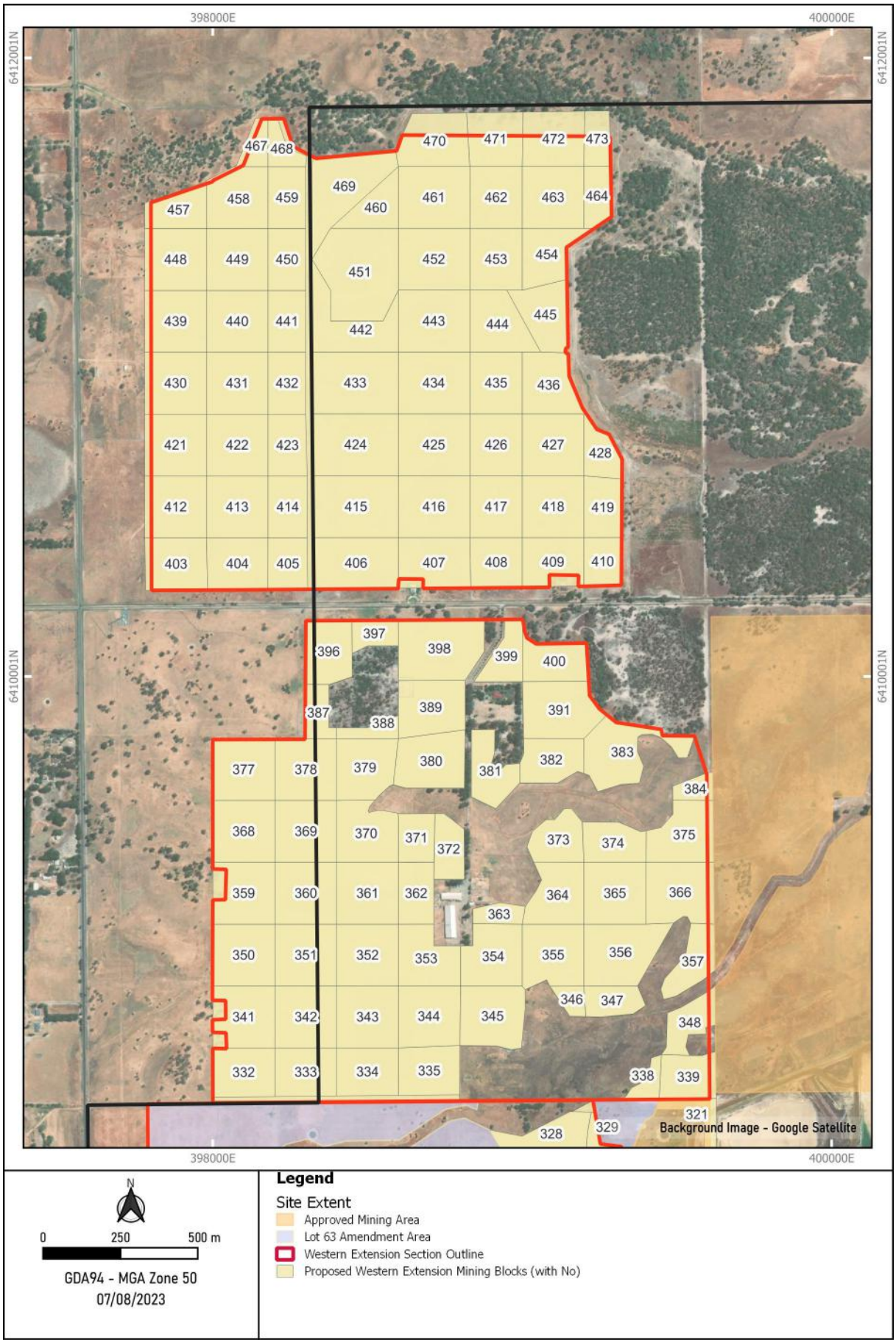

Figure 12 Proposed Total Extent of Mining, Including the Staged Mining Zones (Sections 1 and 2)

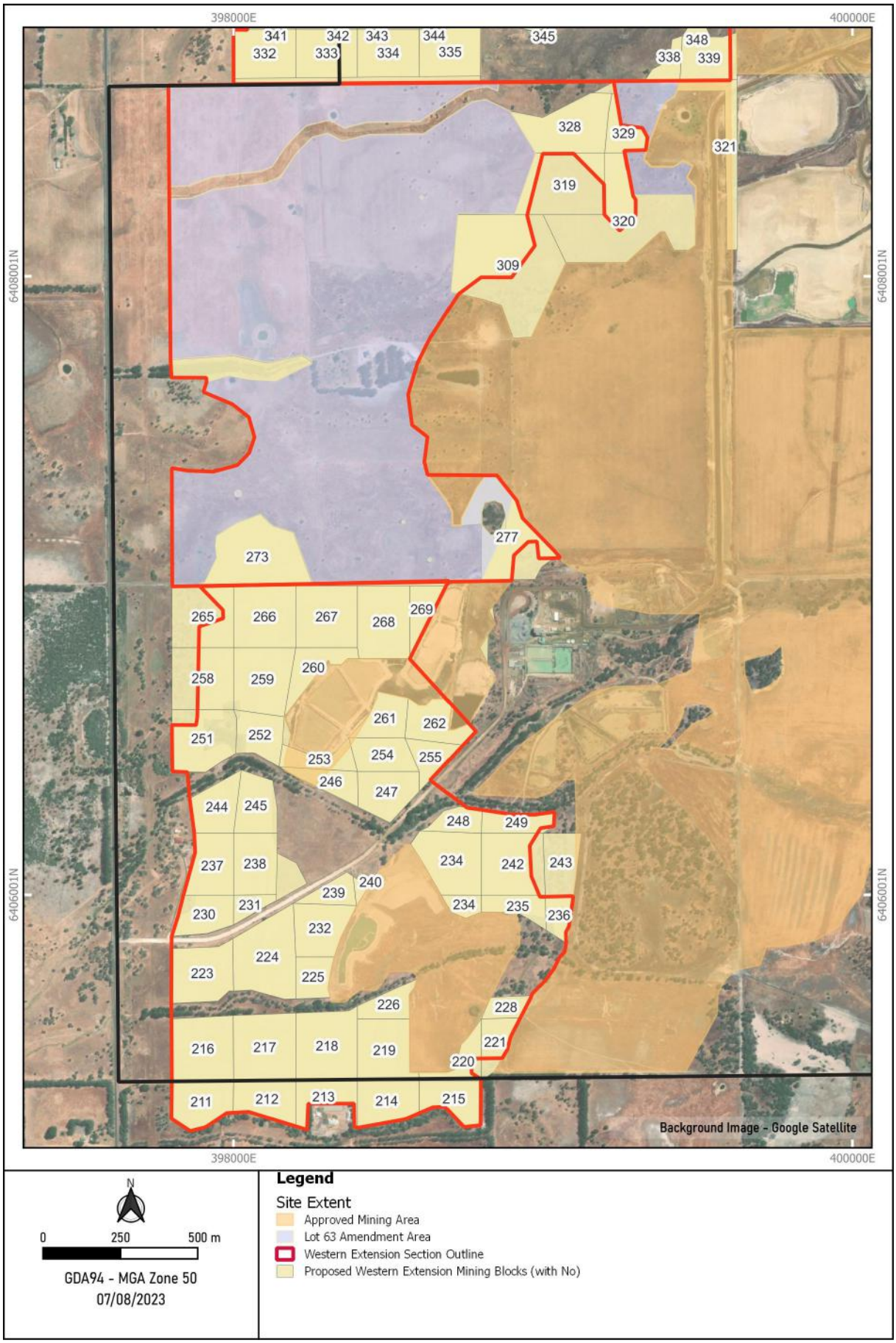

Figure 13 Proposed Total Extent of Mining, Including the Staged Mining Zones (Sections 3 and 4)

5. ENVIRONMENTAL IMPACTS DUE TO MINING

5.1. Original Predicted Drawdowns

A numerical groundwater flow model for the Project was originally developed by Rockwater (2006) to provide dewatering predictions of groundwater inflows to the proposed Keysbrook mine (based on the mine plan current in 2006) and also to predict the impact to the environment due to mining. The original groundwater model was complemented by additional field investigations and modelling by Rockwater in 2007. It should be noted that a revised mining schedule was used in Stage 2 modelling (2007), thus some of the original mining area were not modelled. Salient points from both reports (Rockwater 2006 & 2007) in regard to the impacts to the groundwater levels in the Superficial aquifer are as follows:

- Groundwater levels in the shallow Superficial aquifer will be locally and temporally lowered to the base of the mined depth (i.e. the base of the Bassendean Sand).
- The impact to groundwater levels is unlikely to be significant beyond the proximity of the proposed mining area, with modelling predicting drawdowns of less than 0.5 m at distances greater than 500 m from the mine boundaries (as shown on Figure 14).
- The modelling indicates that the impacts to the Superficial aquifer from dewatering and tailings deposition are short term (i.e. about a month or two), typically comprising a brief drawdown from dewatering, followed by slight mounding from tailings deposition (due to artificial recharge to the local Superficial aquifer).

A revised and recalibrated groundwater flow model was developed by GRM (2017) based upon the earlier Rockwater model (2007). This more recent modelling indicated that:

- Dewatering requirement for the pits (as per 2017) is small, up to 11 L/s.
- Seepage from the tailings to the Superficial aquifer is about 7.5 L/s.
- Confirmed the short-term impacts to the Superficial aquifer from dewatering and tailings deposition is consistent with the original Rockwater models (2006 & 2007).

5.2. Current (2021) Dewatering and Impacts to Superficial Aquifer

Dewatering volumes, groundwater levels and water quality monitoring in the Superficial aquifer at Keysbrook has been undertaken and reported by KLPL (Doral) as part of the conditions for groundwater licences (GWLs). The monitoring results from the 2021 Annual Groundwater Monitoring Summary (GMS) report (GMR, 2022) are as follows:

- Totals of around 350,000 kL (i.e. 11 L/s) was recorded as being abstracted from the Superficial aquifer due to mining of the Bassendean Sand in 2021.
- Dewatering was done via in-pit sumps only during a two-month period (i.e. January to February 2021), which included recycled water recovered from tailings backfill.
- It is understood that for most of the year mining was carried out above the water table, consequently groundwater seepage into the pits was minimal.
- The groundwater level in the Superficial Aquifer continues to demonstrate a cyclical seasonal variability (between 0.4 to 3.6 m, averaging 1.8 m), forming a peak around August and September each year following winter rainfall and a trough around March-April at the end of the dry season. The pattern of seasonal variability in the Superficial aquifer indicates active rainfall recharge.
- The groundwater level contours for the Superficial aquifer during December 2015 and December 2021 are shown in Figure 15. The monitoring data shows a groundwater flow direction towards the west (as in the pre-mining period) and the data does not indicate any impacts to the Superficial aquifer associated with pit dewatering and tailings discharge, apart from within the immediate mining areas.

- Groundwater quality monitoring indicates that the Superficial aquifer is fresh to brackish, with a neutral to slightly acidic pH and to be of sodium chloride type. The salinity varied between less than 100 to around 6,500 mg/L TDS in 2021, which is consistent with known regional variability and also generally consistent with previous monitoring years (apart from some seasonal trends in some bores).
- The water chemistry analyses do not indicate any adverse trends in pH, chloride, nitrogen or sulphate in the Superficial aquifer.

5.3. Current 2022 WLs

Groundwater levels data collected at the site during 2022 shows that groundwater levels in the Superficial aquifer are consistent with the previous years (refer to Section 5.2), which fluctuate seasonally, as a result of rainfall and streamflow regime and generally peaking around August to September (following winter rainfall) and then reaching their lows around March to April each year.

The groundwater level contours for the Superficial aquifer during October 2022 are shown in Figure 16 and confirm consistent groundwater flow direction towards the west (as in the pre-mining period and 2021, refer to Figure 15). Data does not indicate any impacts to the Superficial aquifer associated with pit dewatering and tailings discharge, apart from within the immediate mining areas, as per previous years.

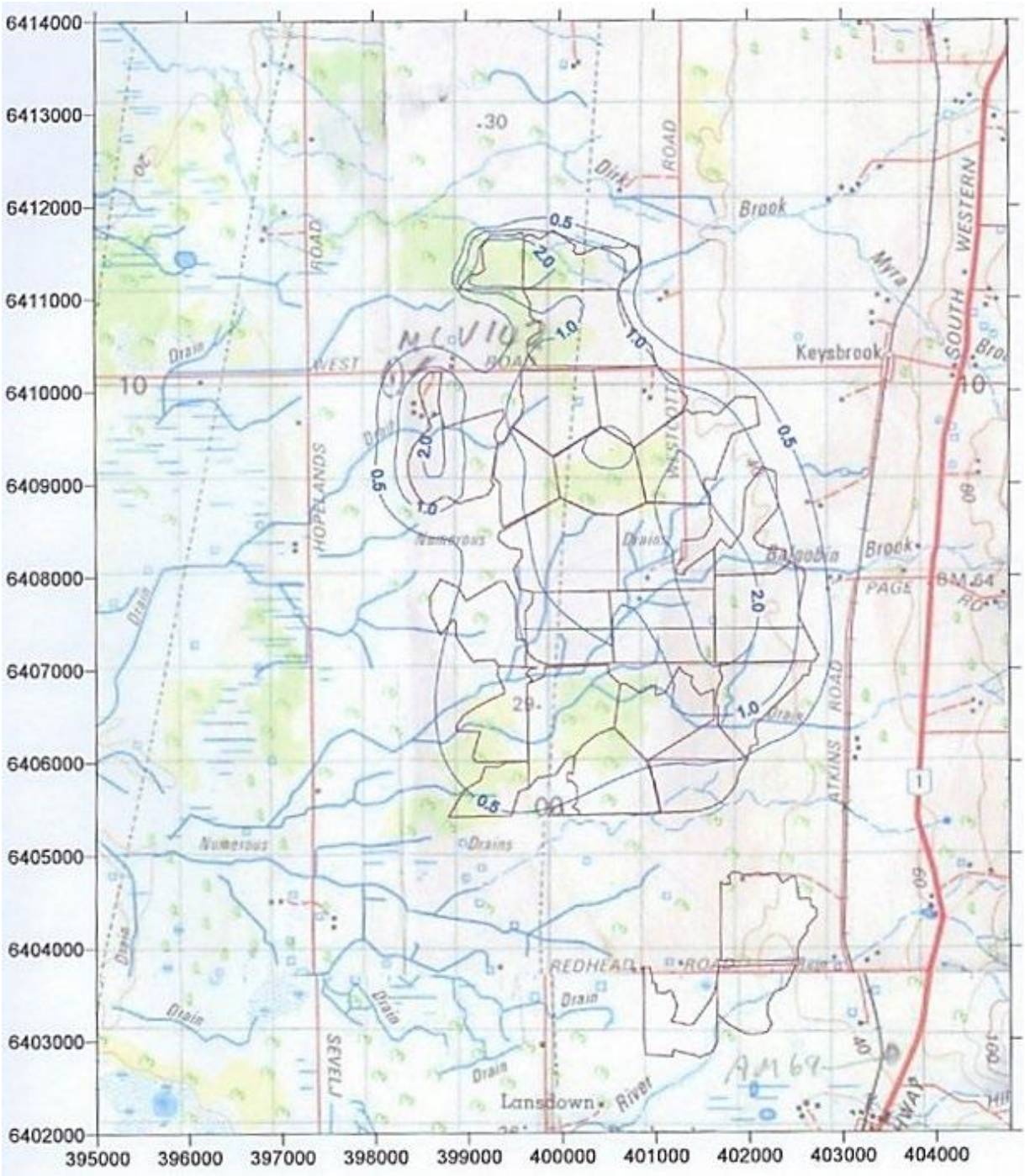

Figure 14 Original (2006) Predicted Drawdowns (m) in Bassendean Sand Aquifer after 7.7 years Operation (Rockwater, 2006)

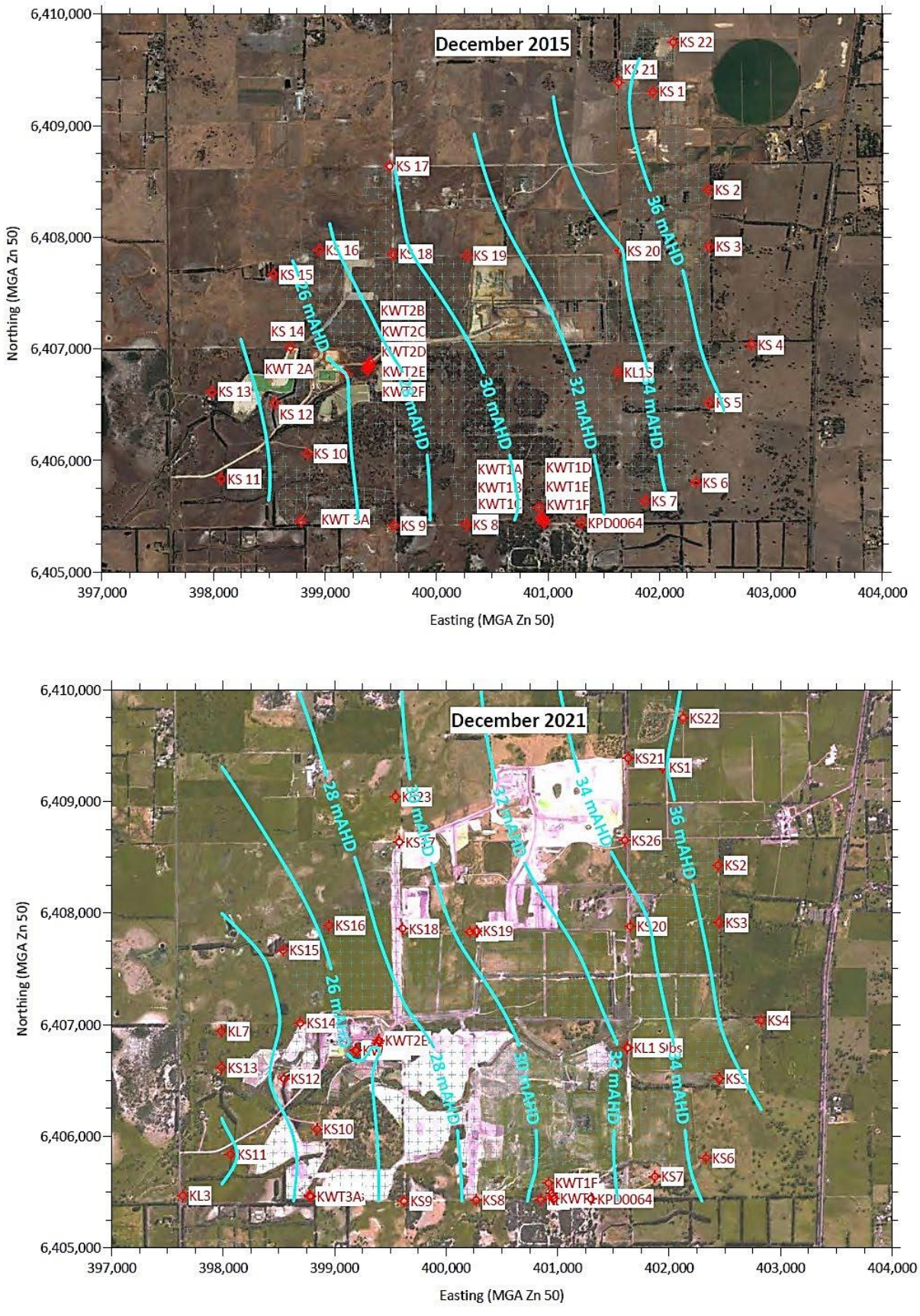

Figure 15 Superficial Aquifer Groundwater Level Contours in December 2015 6and December 2021 (GMR, 2022)

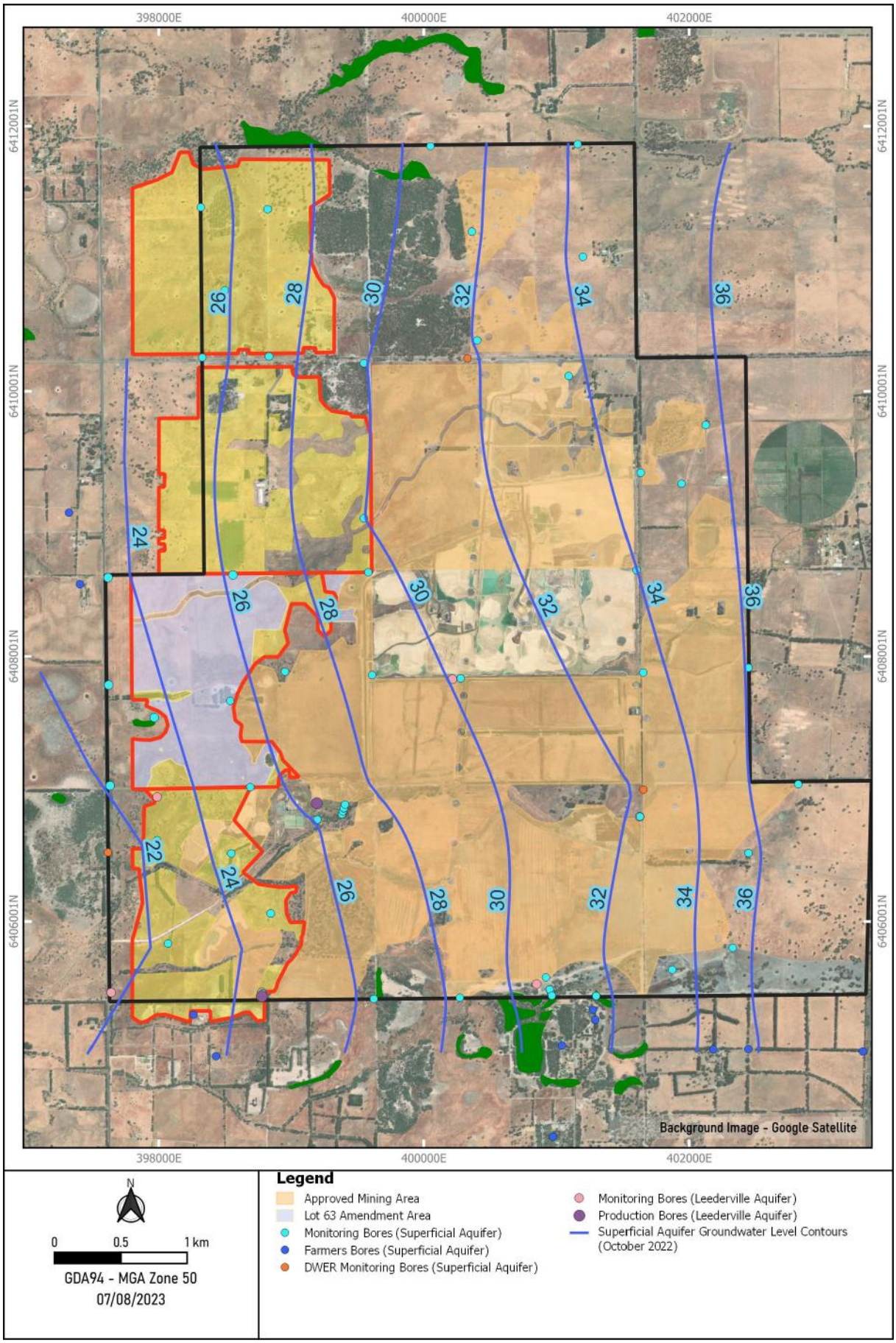

Figure 16 Superficial Aquifer Groundwater Level Contours in October 2022

5.4. Impacts on Vegetation

The identified Conservation Category Wetlands (CCW) around the immediate mining footprint (refer to Section 3.2) are not directly disturbed by mining, however there are processes associated with mining activities that may affect the health of these ecosystems.

The potential impact to the wetlands from the original approved mining area has been assessed using groundwater flow modelling (Rockwater, 2007). A number of shallow bores were drilled at the Project area (Rockwater, 2007) to assist in gaining a better understanding of the hydrological processes present in the wetland areas. This assessment concluded that:

- The natural wetlands are not considered groundwater dependent, instead being surface water dependent.
- The wetlands are generally recharged during the wet season (winter) and sporadically during the rest of the year as a result of storm runoff and direct rainfall.
- The wetlands probably represent a source of recharge to the shallow groundwater system, rather than the reverse.

Additionally, hydrogeological and environmental monitoring data collected during 2020 and 2021 (Rockwater, 2021 & 2022a) suggests that mining activities at Keysbrook have not resulted in changes to the water regime that have the potential to impact the health of groundwater dependent vegetation at wetland monitoring sites.

Rockwater (2021) did however report that the vegetation condition within CCW (ID 14807 - Yangedi Swamp) improved from degraded to good in 2021. At this site, vegetation condition improves during wetter periods when surface water suppresses germination of many exotic terrestrial herbs, and declines in response to the presence of aggressive weed species in drier years and during drier stages in the wetland hydroperiod. This wetland is located within Bushland Forever Site 77, where vegetation on freehold land is managed for conservation purposes.

Moreover, a Detailed and Targeted Flora and Vegetation Survey within the proposed amendment of Lots 56, 201 507 and 508 (Section 1) undertaken in 2021 and 2022 (Ecoedge, 2022) concluded that:

- Most of the native vegetation was in Degraded or Completely Degraded condition, with only about 10% in Good condition (within Lot 56, outside and up gradient of the proposed amendment area.
- Degradation of the vegetation has been caused by ongoing grazing.
- Two CCWs (ID 14850 & 14887) identified close proximity to the Section 1 (Lots 201, 507 and 508), were in a Degraded to Completely Degraded Condition.
- Consideration may therefore, need to be given to revising the conservation status of the Cleared and Completely Degraded portions of the Resource Enhancement wetland and CCWs as these areas would be regarded as scoring poorly on both natural and human use attributes.
- Environmentally sensitive areas (ESAs) near to Section 1 are associated with CCWs in Degraded to Completely Degraded condition.

In November 2022 Rockwater undertook a site visit to inspect CCW 14870, located at the western boundary of proposed mining area (Section 3) on Lot 63 (Figure 6). This CCW is part of an extensive paulsplain (seasonally waterlogged flat) wetland of the Geomorphic Wetlands, Swan Coastal Plain (GWSCP). Rockwater report (2022b) is presented in Appendix A and concluded the following:

- The wetland does not appear to meet the criteria for this category.
- Vegetation of the site is parkland cleared with no understorey present.
- Mature Corymbia calophylla (marri) are the only trees present at the site.

- Several of these are in poor condition and many dead trees are evident. Using the Bush Forever vegetation condition scale, 100% of the vegetation within CCW 14870 is classified as 'completely degraded'.

Moreover, DWER (2008) defines CCW as wetlands of high conservation value for natural or human use, with a management objective to preserve the natural attributes and functions of the wetland. The management category of CCW 14870 is considered to be incorrect as there is no evidence of wetland vegetation at the site and the terrestrial vegetation is in a completely degraded condition. Therefore, Rockwater recommended Doral to submit a request to modify the management category of this CCW to the Department of Biodiversity, Conservation and Attractions (DBCA), who manage the GWSCP dataset (Rockwater, 2022b).

5.5. Assessment of Potential Impacts of Mining Western Extension

5.5.1. Groundwater Model

5.5.1.1. Background

As outlined in Section 5.1, a groundwater model for the Project was originally developed in 2007 to assess groundwater impacts (Rockwater, 2007). In 2017, the model was updated and recalibrated by GRM as part of the Project Groundwater Licence Operating Strategy (GRM, 2017).

GRM's 2017 model was provided to AQ2. Features of the 2017 groundwater model have been retained (boundary conditions, aquifer geometry and parameters) and no other changes to the model have been completed by AQ2. To allow for easier transfer of data and more efficient computation, the groundwater model has been converted to the Modflow USG groundwater modelling code (Panday et al, 2017), operating under the Groundwater Vistas graphical user interface (ESI, 1996 – 2021).

The model simulates groundwater conditions in the Project area and includes the Superficial aquifer (Layers 1 and 2) and the underlying Leederville Formation (Layer 3), seasonal rainfall recharge and groundwater outflow to the west (down gradient). The model simulates seasonal groundwater conditions assuming long term average rainfall (rainfall of 66 mm per month over the period June to September of each year and zero recharge over the period October to May each year). The model also simulates the observed pre-development groundwater conditions in the area of the proposed Keysbrook Lot 63 Extension (groundwater levels of around 23 to 29 mAHD).

The groundwater model was used to simulate the impact of the current proposed Western Extension development and the preceding mining of Lot 63 development. This included:

- Simulation of seasonal rainfall conditions (rainfall of 66 mm per month over the period June to September of each year and zero recharge over the period October to May each year).
- Initial conditions that simulate expected July 2025 groundwater levels (i.e., groundwater levels that will continue to rise during the recharge period (until the end of September), then decline until recharge is simulated in the following year.
- Dewatering of the Mining Blocks consistent with the mining schedule. Drain cells (Drain (DRN) package in MODFLOW USG) were used to lower groundwater levels to 1 m above the base of layer 1 (approximate base of the Bassendean Sand) within individual mining blocks. Once mining was complete, the drain cells were not active, and recovering groundwater levels were simulated.
- Mining blocks were assumed to be infilled with tailings after mining was complete (the following month). The replaced tailings were assumed to have the same aquifer properties as the original aquifer.
- Recharge associated with tailings deposition was applied to each mining block in the period after mining was complete, at rate of 300 mm per year (consistent with that estimated by GRM).

- The model was run over a period of several years, to include the following:
  - The Part Lot 63 mining schedule (a part of previous Doral Part Lot 63 amendment), that assumes that mining continues from July 2025 until March 2026 (with tailings deposition for an extra month until April 2026).
  - The current Western Extension mining schedule that includes mining commencing from January 2026 that continues until May 2031, for a period of just over five years. The mining schedule simulated is summarised in Table 3. Tailings deposition (post mining) is simulated for an extra month or until June 2031.
  - A period of groundwater recovery of 31 years following cessation of mining, was included in model predictions (from June 2031 to June 2062).
- No additional groundwater abstraction or development was simulated as part of model predictions.
- The prediction model was run with a monthly time increment (or stress period, i.e., the period over which all model stresses were held constant).
- A No Development model was also run that included the seasonal rainfall recharge to allow separation of groundwater level change associated with seasonality and the proposed development.

5.5.1.2. Modelling Results

Hydrographs of predicted water levels over the prediction and closure period for selected mining blocks (Blocks 212, 247, 320, 361, 433 and 454) are shown in Figures 17 and 18. Predicted water levels are shown for the case that includes the Western Extension and the No Development Case over the period January 2026 to mid-2062. The locations of the selected mining blocks are shown in Figure 19. Predicted water levels show the reduction in water levels (up to 3 m) at each mining block over a period of a month. This is immediately followed by recovery of groundwater levels over the subsequent months. The majority of the groundwater recovery (up to 2 m) predicted for each mining block occurs within 3 years of the completion of mining. The remainder of the groundwater recovery is predicted over subsequent years, over a period of between 20 and 30 years. The predicted groundwater level reduction and subsequent recovery is consistent with the mining schedule that includes mining of each block within a period of one to two months and the subsequent infilling of each block (tailing deposition) at the completion of mining.

Several key locations (modelled observation locations) in the vicinity of the Western Extension, where Conservation Category Wetlands (Figure 4) were identified, are shown in Figure 19 and summarised, by section location (Sections 1 to 4) in Table 4. Hydrographs of predicted water levels at modelled observation locations over the prediction period are shown in Figures 20 to 28. Also shown on Figures 20 to 28 are the predicted water levels from the No Development Case.

Table 4 Summary of Modelled Observation Locations

Mining Section	Observation Locations
Section 1 (Figures 20 to 23)	MB1, MB2, MB3, MB4, MB5, MB6, MB7, MB8, MB9, MB10, MB11 and MB12
Section 2 (Figure 24)	MB13, MB14 and MB15
Section 3 (Figure 25)	MB16, MB17 and MB18
Section 4 (Figures 26 to 28)	MB19, MB20, MB21, MB22, MB23, MB24, MB25 and MB26

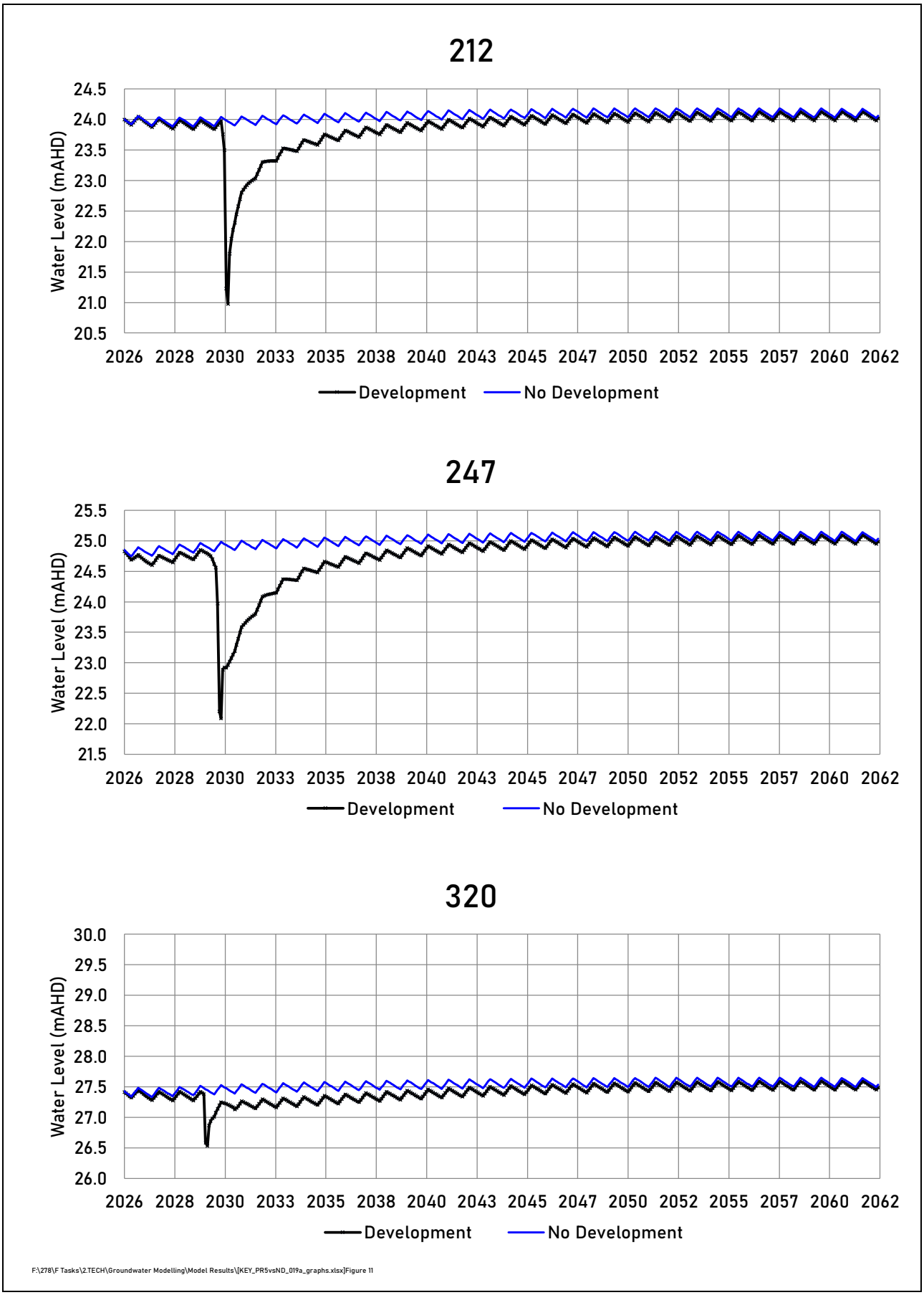

Figure 17 Predicted Groundwater Levels at Selected Mining Blocks (212, 247, 320)

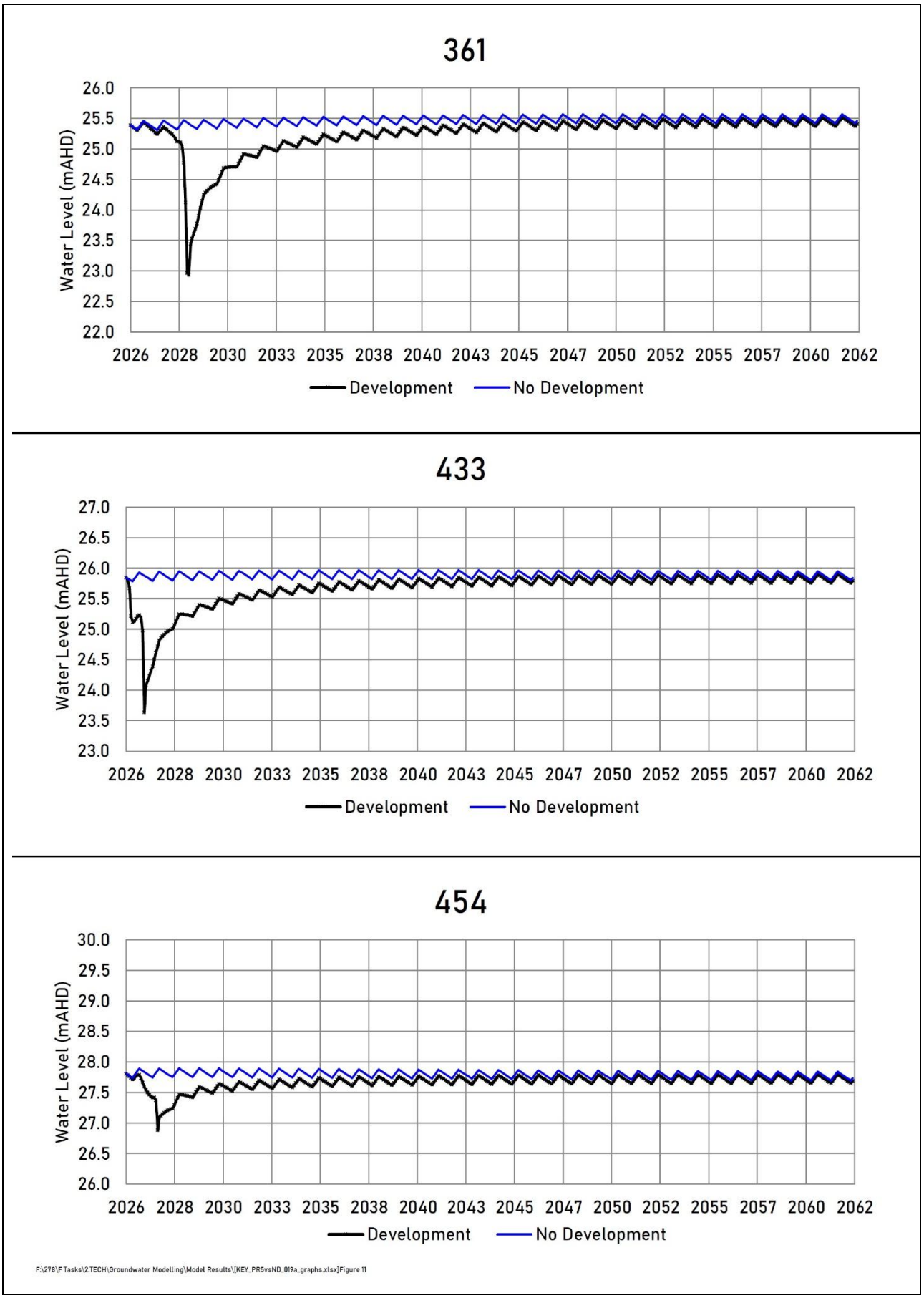

Figure 18 Predicted Groundwater Levels at Selected Mining Blocks (361, 433 and 454)

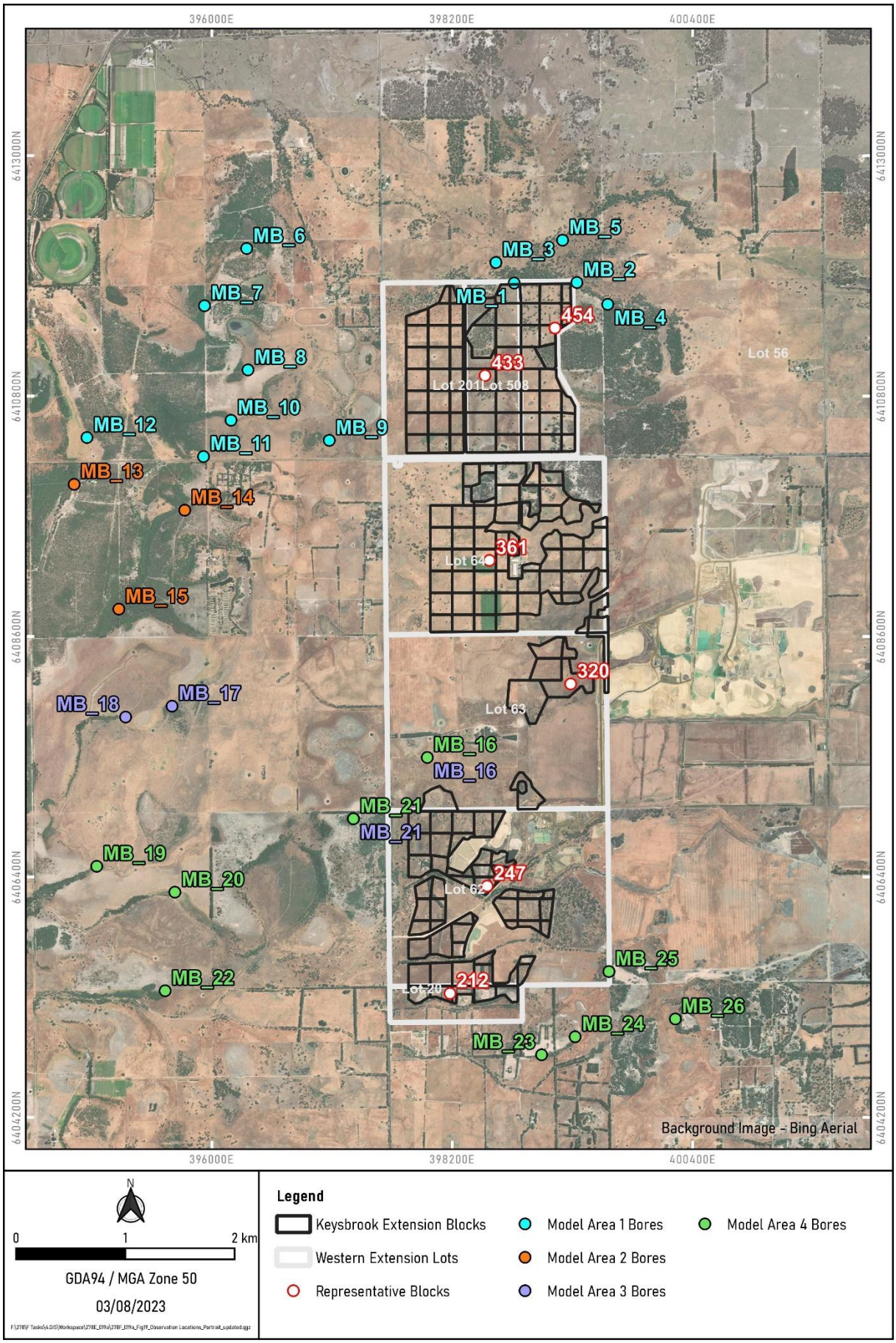

Figure 19 Locations of Predicted Hydrographs at Key Positions

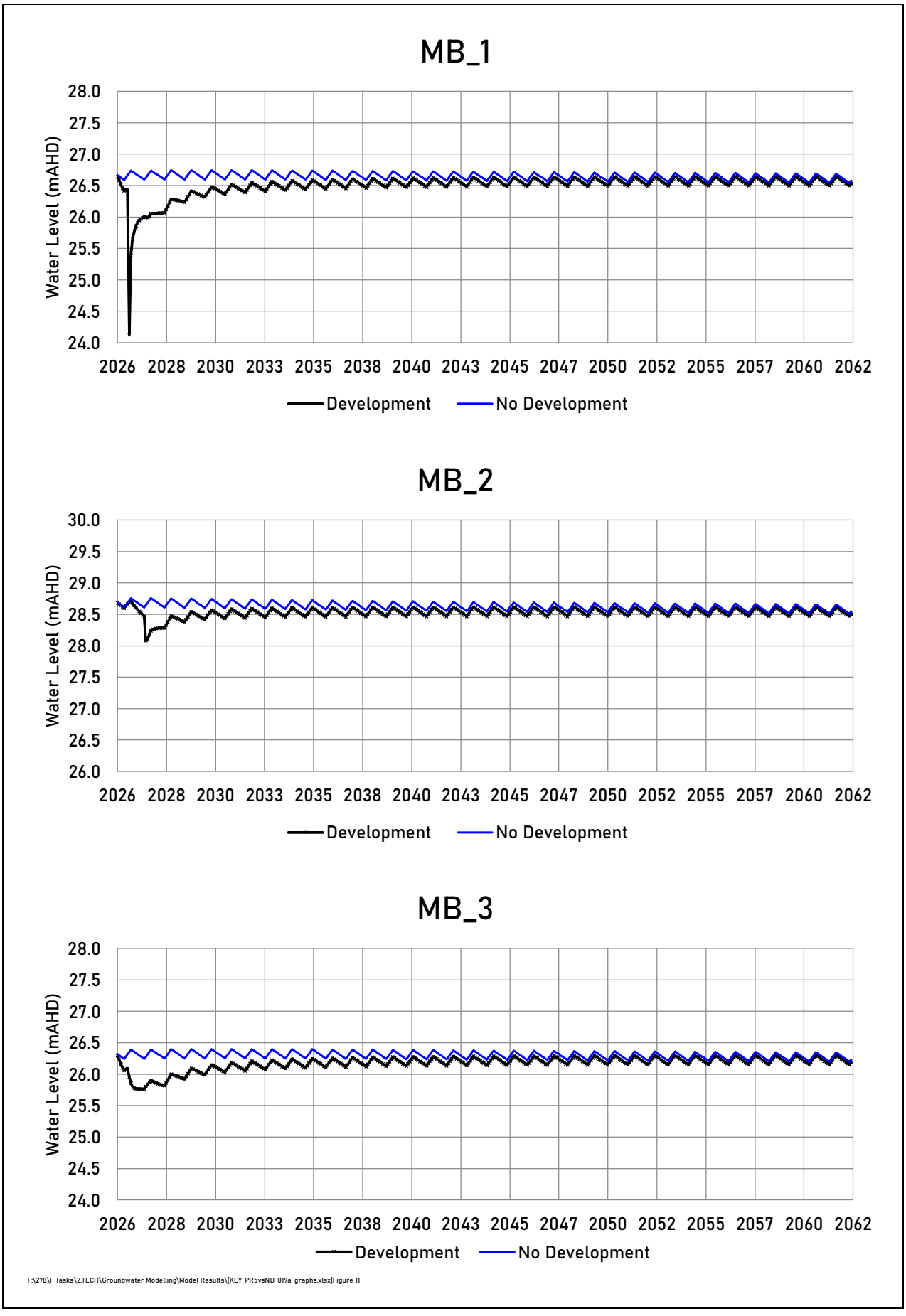

Figure 20 Predicted Groundwater Levels MB 1, MB 2 and MB 3

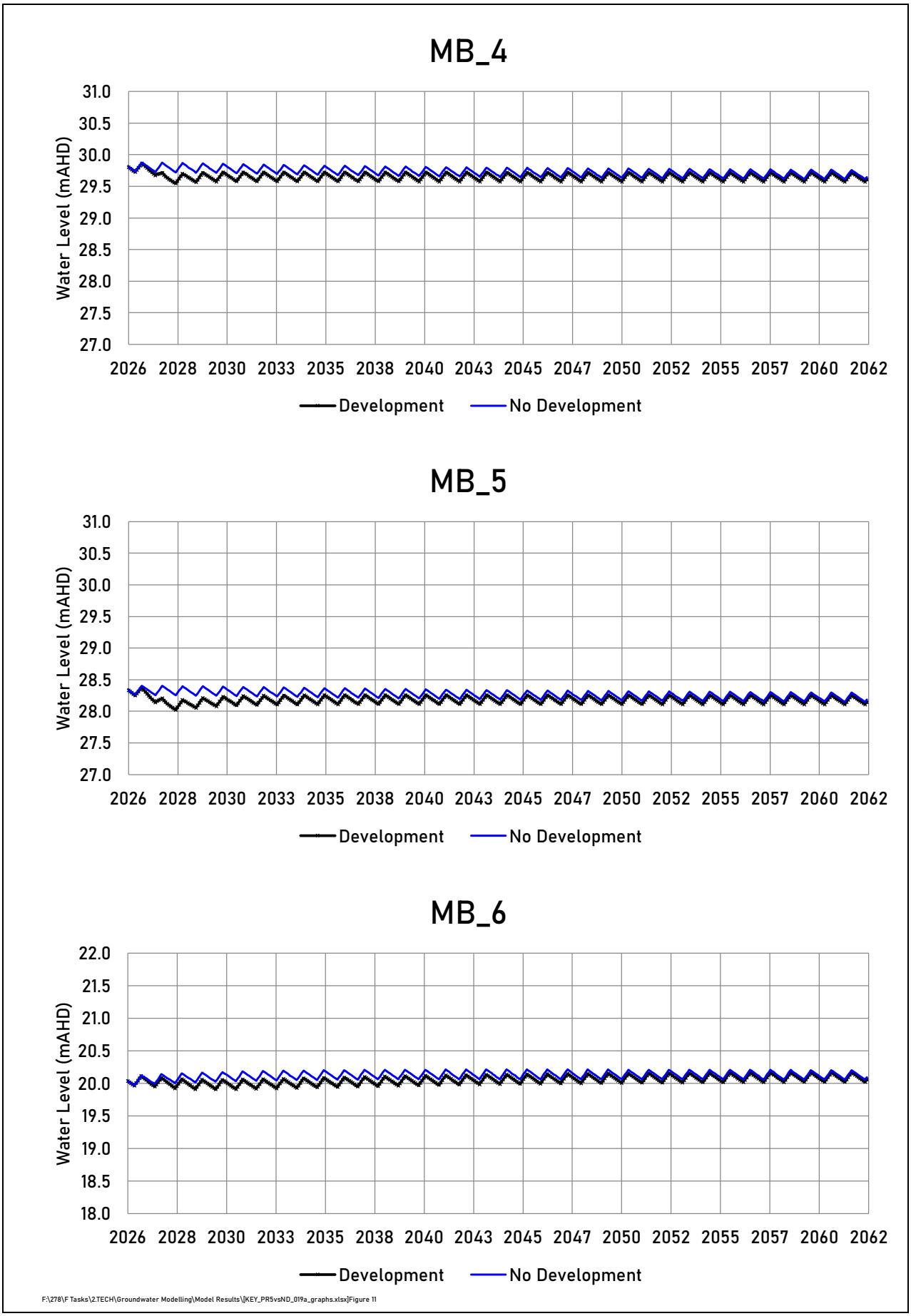

Figure 21 Predicted Groundwater Levels MB 4, MB 5 and MB 6

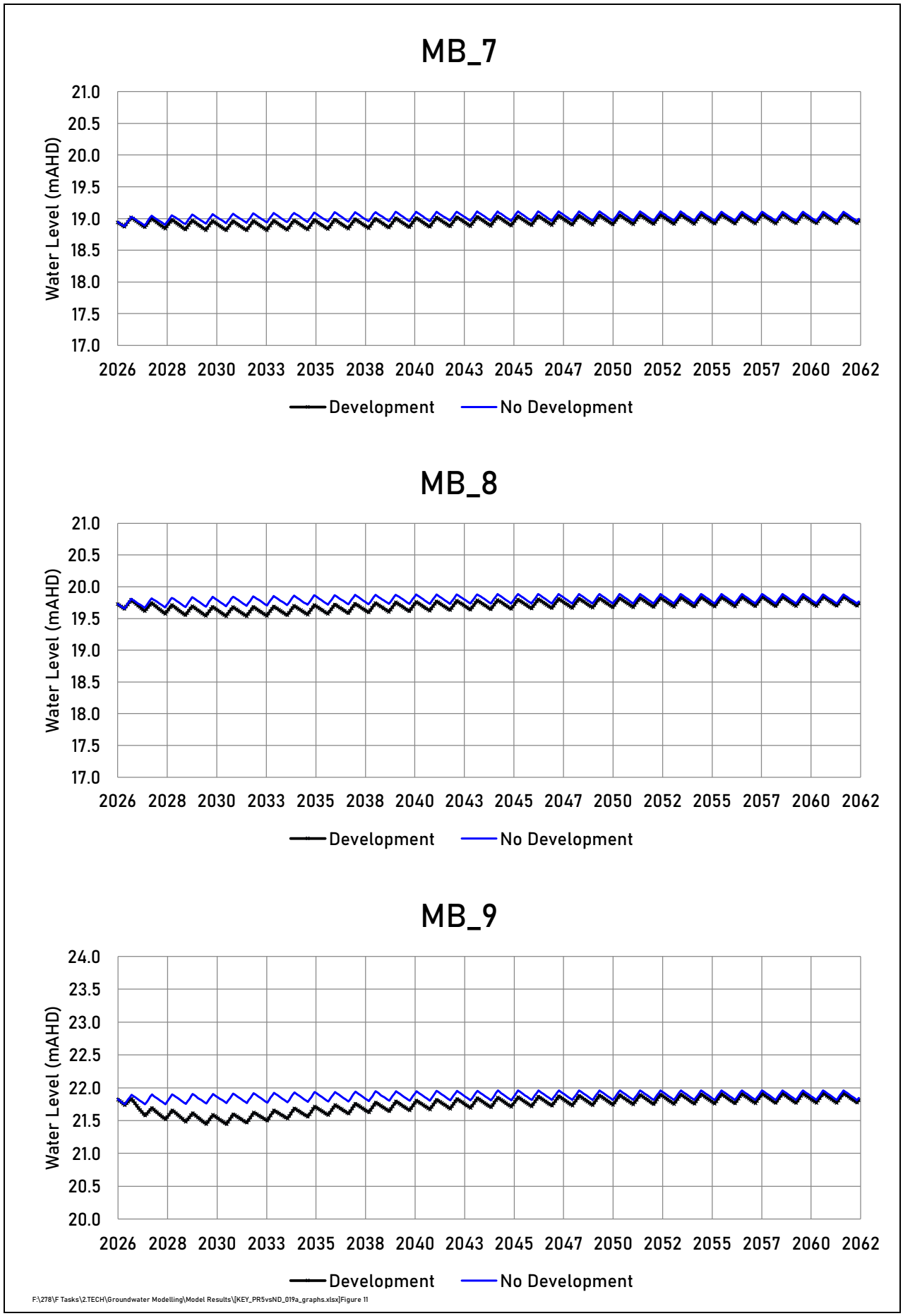

Figure 22 Predicted Groundwater Levels MB 7, MB 8 and MB 9

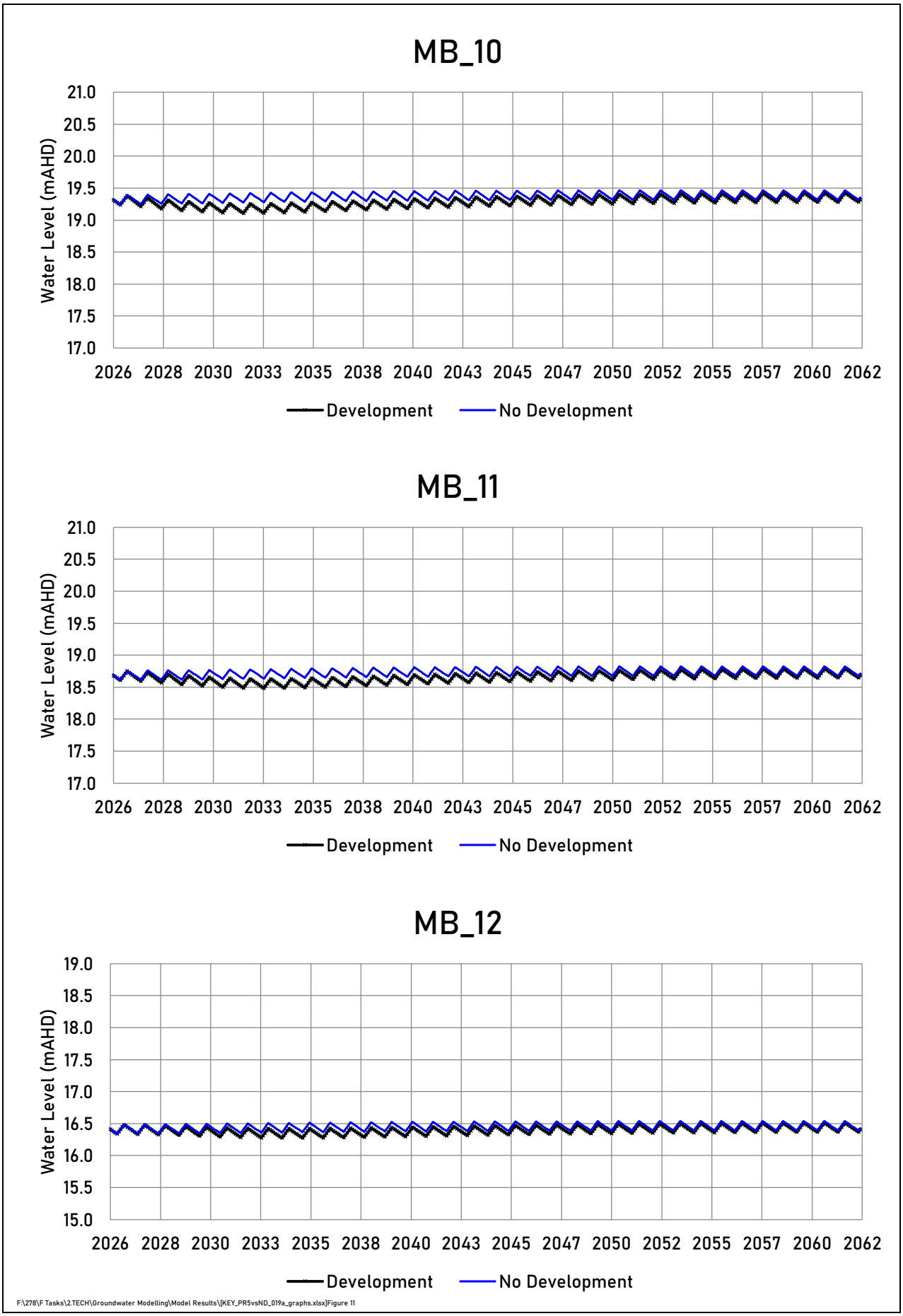

Figure 23 Predicted Groundwater Levels MB 10, MB 11 and MB 12

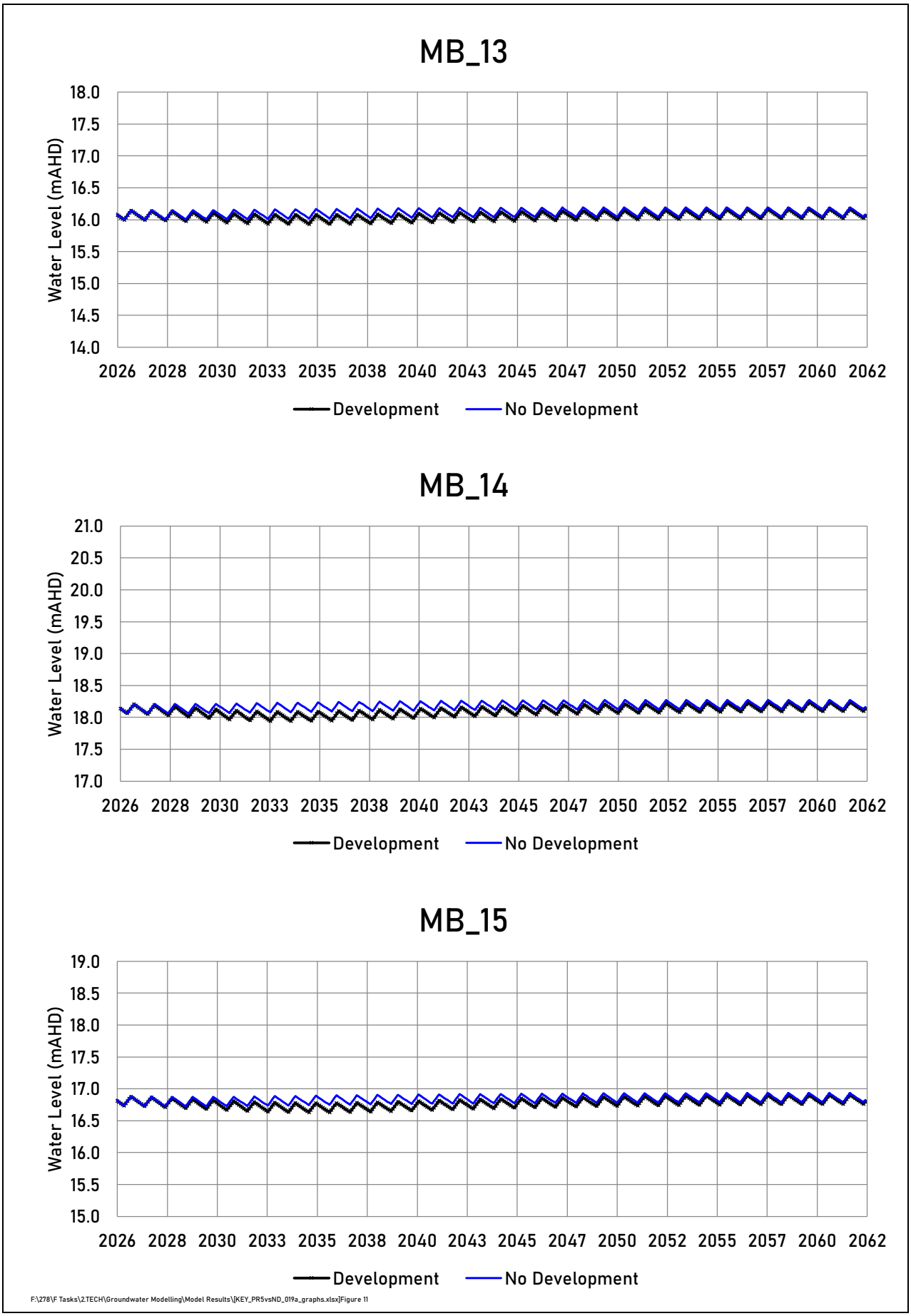

Figure 24 Predicted Groundwater Levels MB 13, MB 14 and MB 15

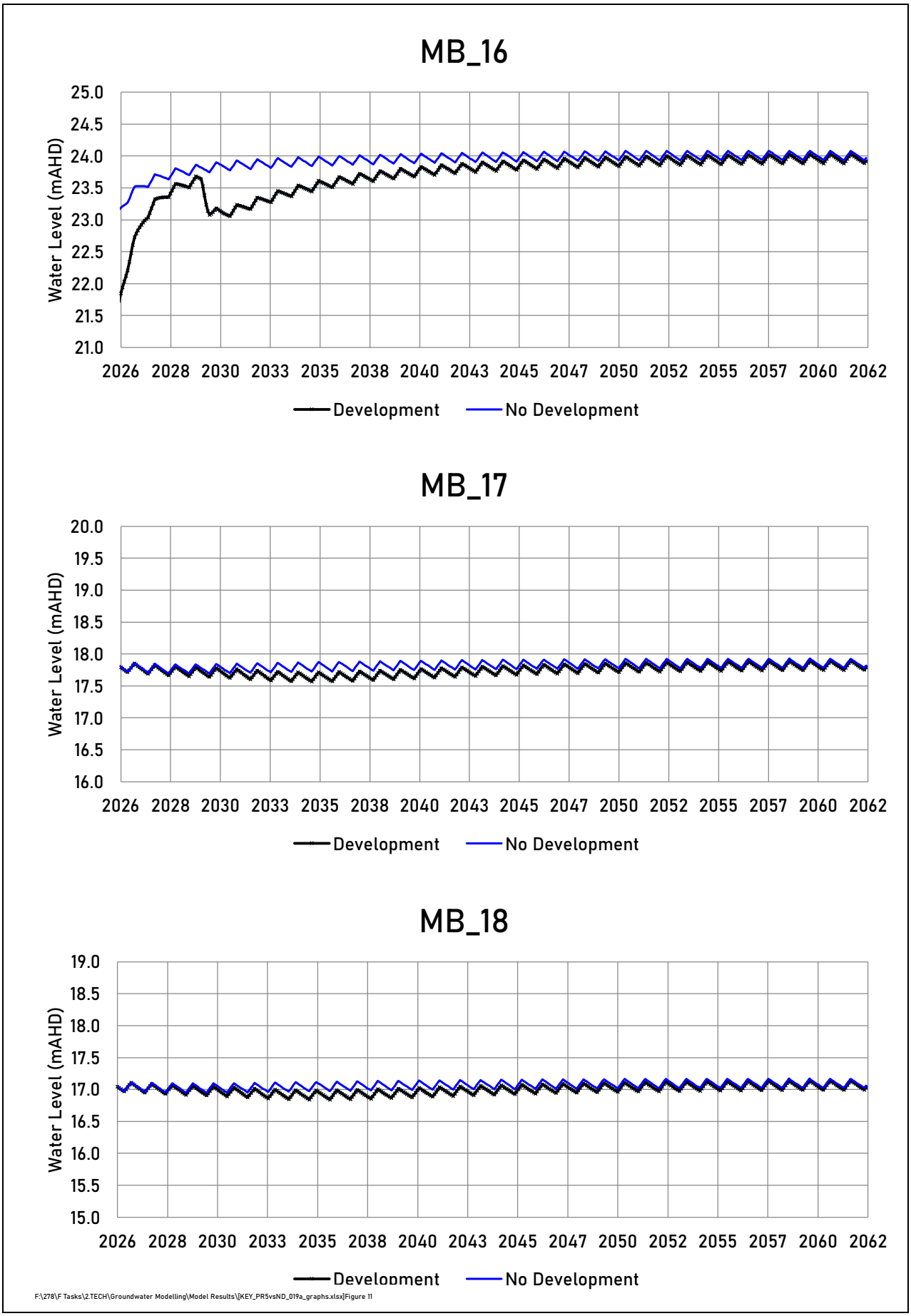

Figure 25 Predicted Groundwater Levels MB 16, MB 17 and MB 18

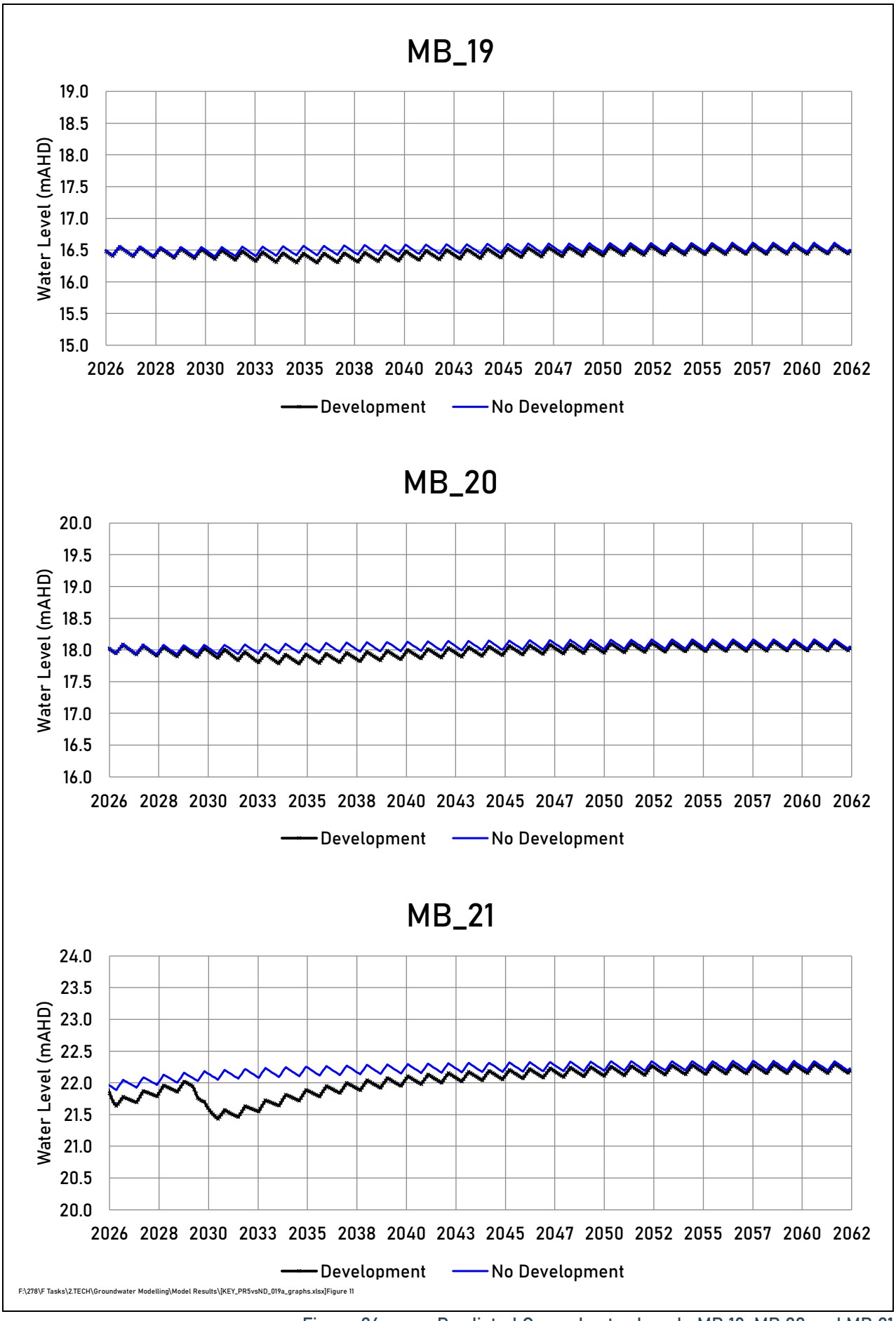

Figure 26 Predicted Groundwater Levels MB 19, MB 20 and MB 21

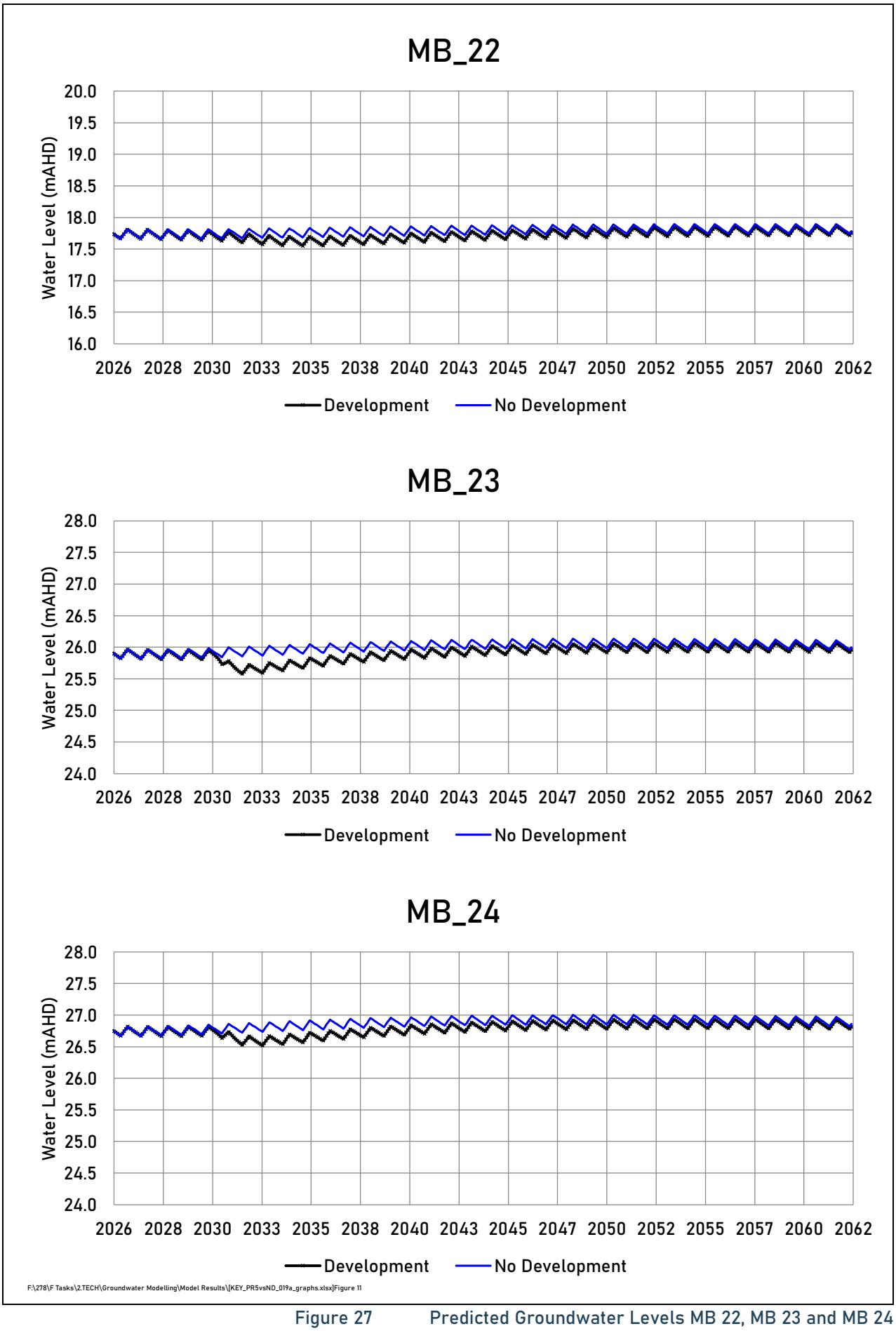

Figure 27 Predicted Groundwater Levels MB 22, MB 23 and MB 24

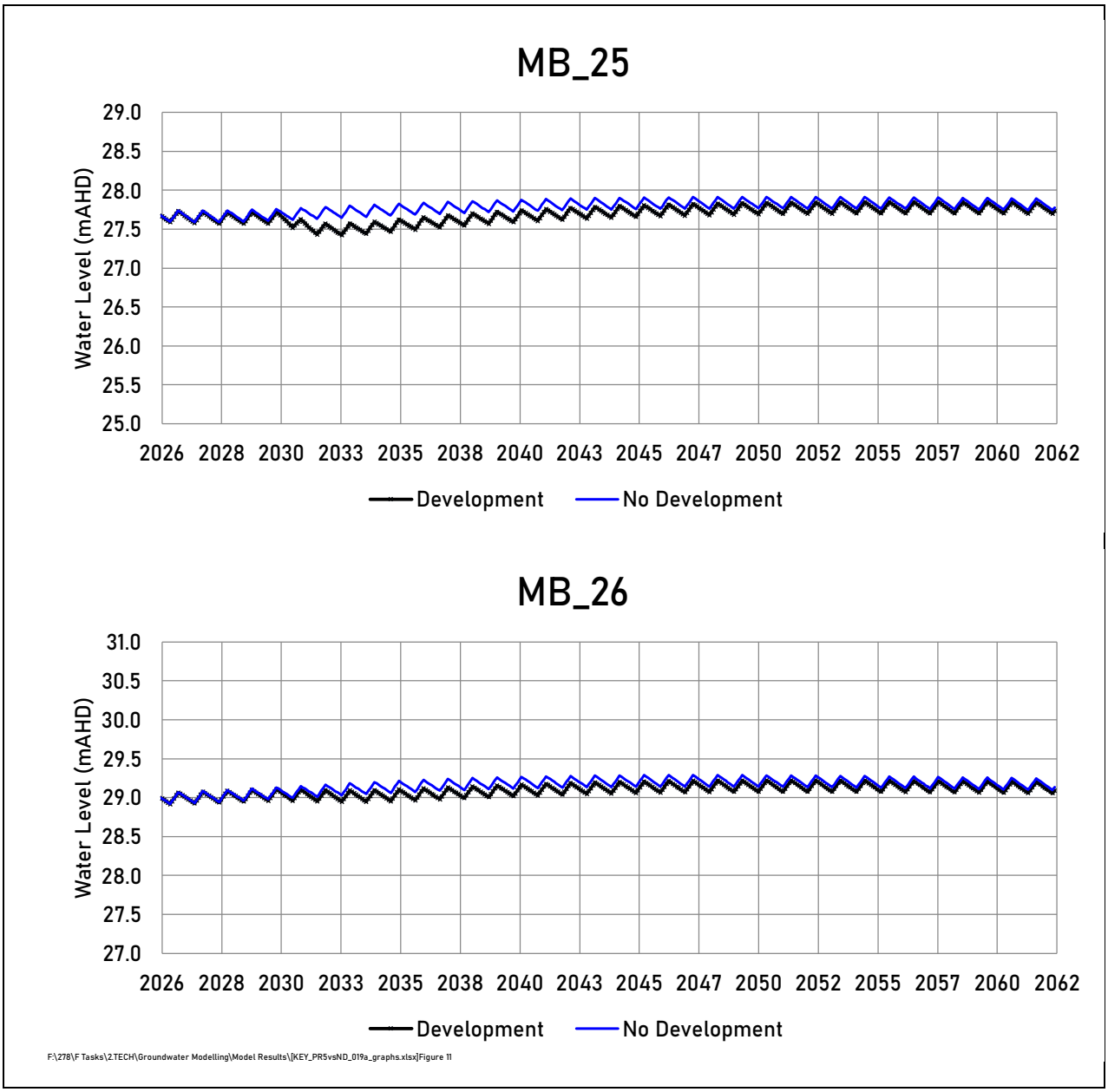

Figure 28 Predicted Groundwater Levels MB25 and MB 26

Predicted water levels at some modelled observation locations show similar trends in response to mining. At some locations, a reduction in water level of up to 2.5 m is predicted over a period of a month (e.g., MB_1 in Section 1, refer Figure 20, MB_16 in Section 3 and 4, refer Figure 25, and MB_21 in Section 4, refer Figure 26). At MB_16 (refer Figure 25) water levels over the period January 2026 to May 2029 are predicted to recover from dewatering simulated in 2025. These locations are generally within or very close to the proposed Western Extension mining areas.

At locations further away from the proposed mining area, the predicted reduction in water level, to the minimum predicted level, is predicted over a period of several years as modelled observation locations are impacted later and / or by mining from more than one area (e.g., MB_3 in Section 1, Figure 21). At some locations further away from the mining areas (up to 2 km from the proposed mining area), a total water level reduction of less than 0.5 m is predicted in response to mining (e.g., MB_12 in Section 1, refer Figure 23, MB_13, MB_14 and MB_15 in Section 2, refer Figure 24, MB_17 and MB_18 in Section 3, refer Figure 25, and MB_19, MB_20 and MB_22 in Section 4, refer Figure 26 and 27).

Modelled observation locations show predicted groundwater recovery similar to that predicted at selected mining blocks. Further away from the mine area, groundwater levels are predicted to have recovered to pre-development levels approximately 20 years after the completion of mining. The majority of the predicted groundwater recovery is complete after a period of approximately 10 years, with the remainder of the recovery predicted to occur over the following 10 years.

Contours of the maximum predicted extent of drawdown, for each stage of mining, are calculated as the difference between groundwater levels predicted for the Development Case and the No Development Case and are presented as summarised below. The maximum extent of drawdown is predicted one to two months before the end of each stage of mining:

- Figure 29, maximum extent of predicted drawdown Section 1 mining (October 2027).
- Figure 30, maximum extent of predicted drawdown Section 2 mining (November 2029).
- Figure 31, maximum extent of predicted drawdown Section 3 mining (December 2029).
- Figure 32, maximum extent of predicted drawdown Section 4 mining (April 2031).

At the end of Sections 1 to 4 of mining, the maximum drawdown is predicted in each mining area, as would be expected, with drawdown also predicted to extend radially away from the active mining area For the maximum extent of drawdown predicted during Section 4 mining, (the last Section of mining, refer Figure 32), drawdown of approximately 1 m is predicted in the last of the proposed mining blocks (located in the south of the proposed Western Extension mining area). Drawdown of approximately 0.1 m is predicted to extend a maximum distance of approximately 1.5 km north west, 1.6 km north and 0.8 km north east of the proposed mining area. As mining is only scheduled for the southern mining areas just prior to the end of mining in Section 4, drawdown of 0.1 m is predicted around 0.8 km to the south west and 0.4 km south east of the proposed mining areas.

Contours of predicted drawdown, when the maximum extent of drawdown is predicted, in June 2035, are shown in Figure 33. These contours are calculated similarly to those calculated for each Sections 1 to 4 of mining. The maximum predicted extent of the 0.1 m drawdown contour (refer Figure 33) is predicted to extend a maximum distance of 3.1 km to the west and 1.2 km to the east of the mining area. Drawdown of 0.1 m is predicted to extent a distance of 1.9 km south of the proposed mining area and a distance of up to 1.6 km north of the proposed mining area. At this time, a maximum drawdown of approximately 0.25 m is predicted over the central and southern mining area.

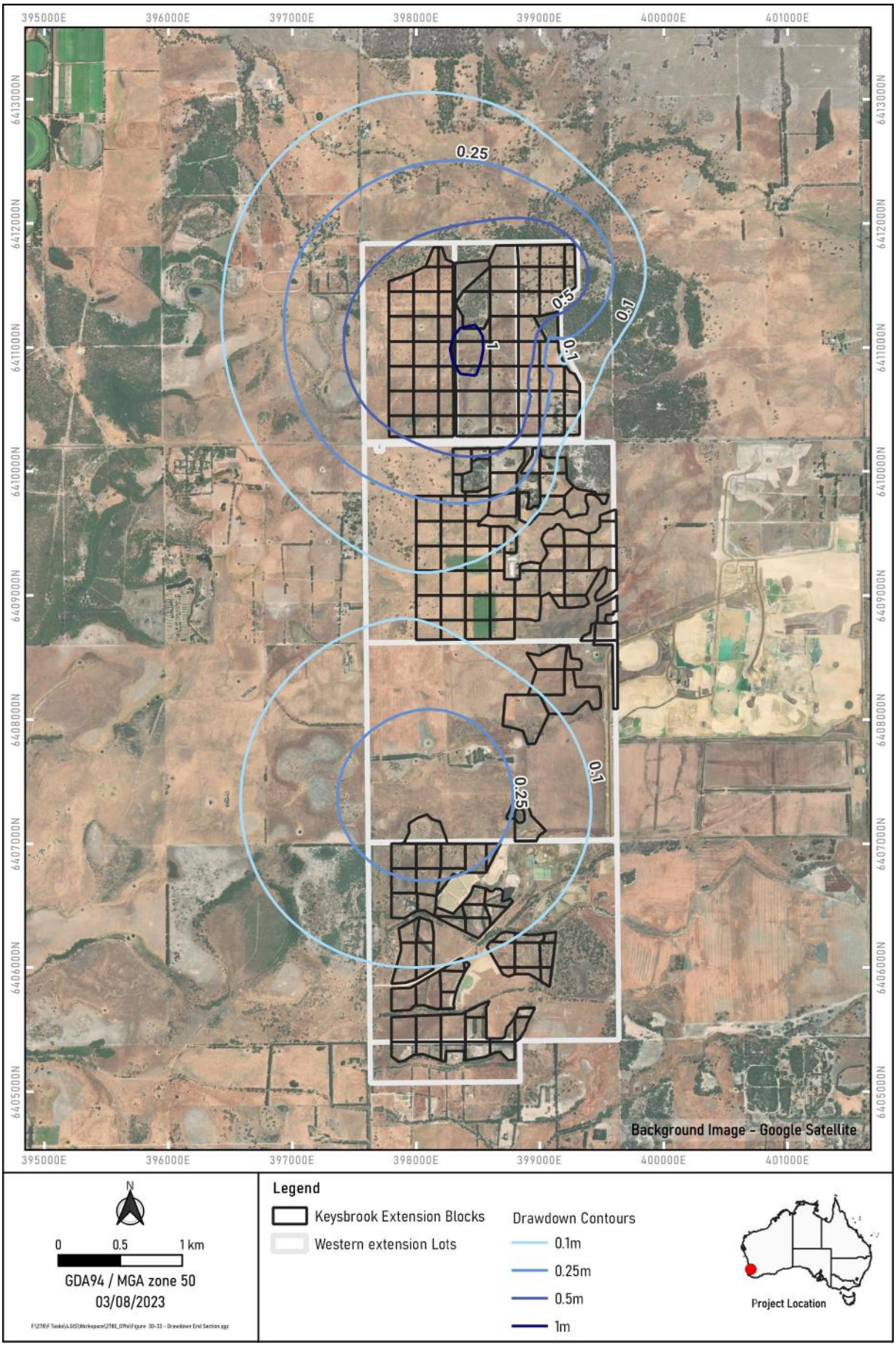

Figure 29 Contours of the Maximum Extent of Predicted Drawdown Section 1 (October 2027)

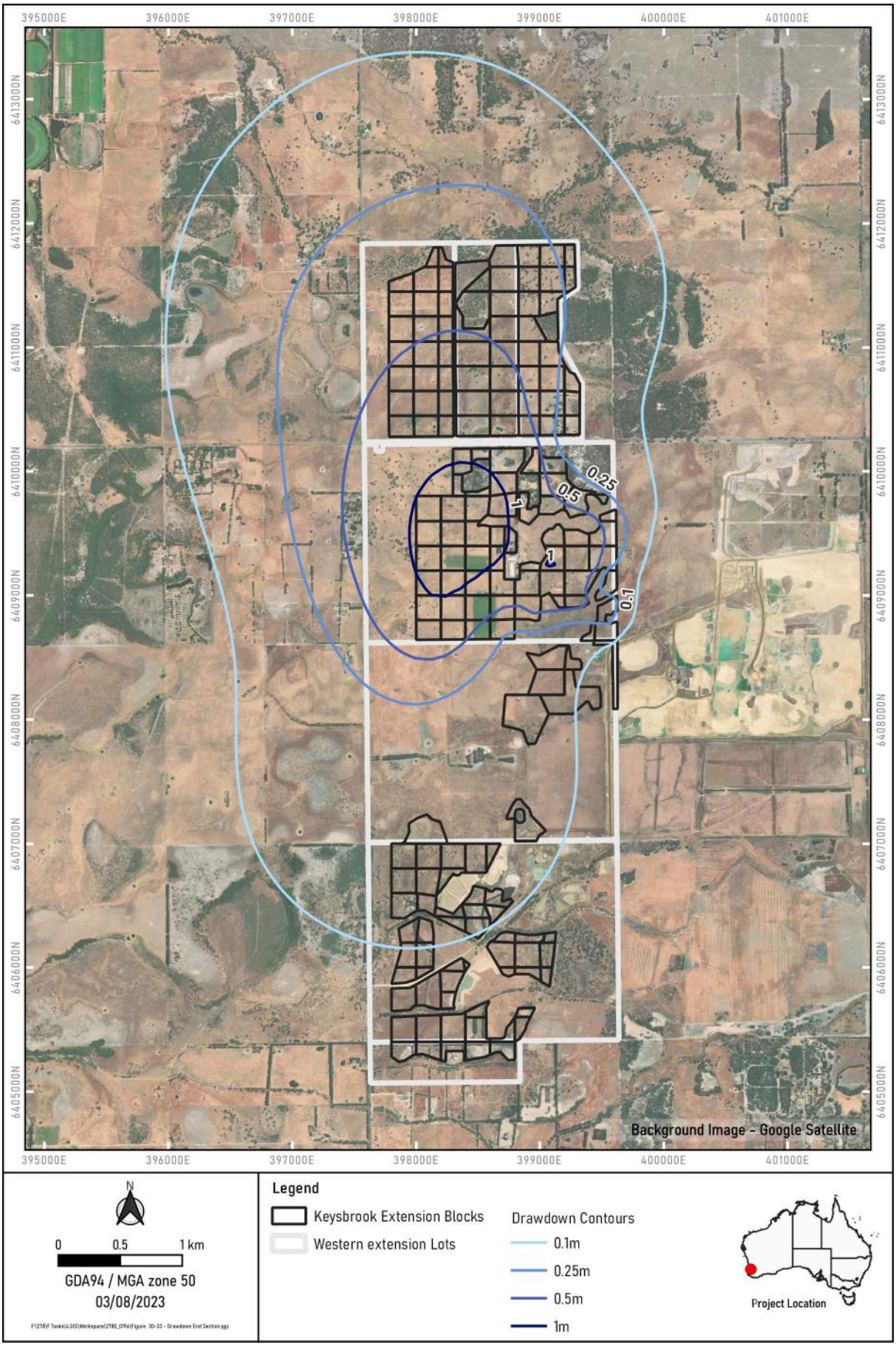

Figure 30 Contours of the Maximum Extent of Predicted Drawdown Section 2 (November 2029)

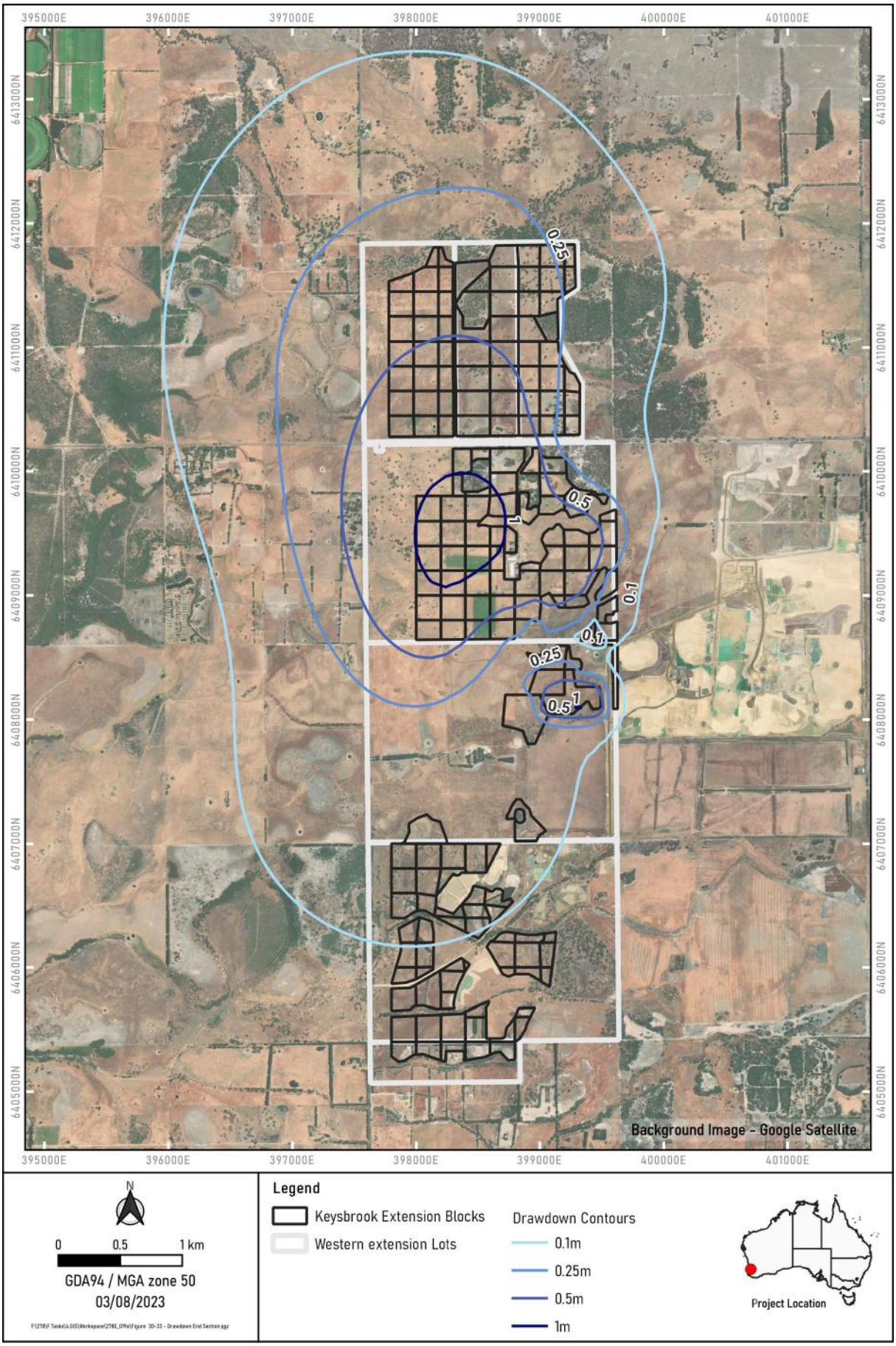

Figure 31 Contours of the Maximum Extent of Predicted Drawdown Section 3 (December 2029)

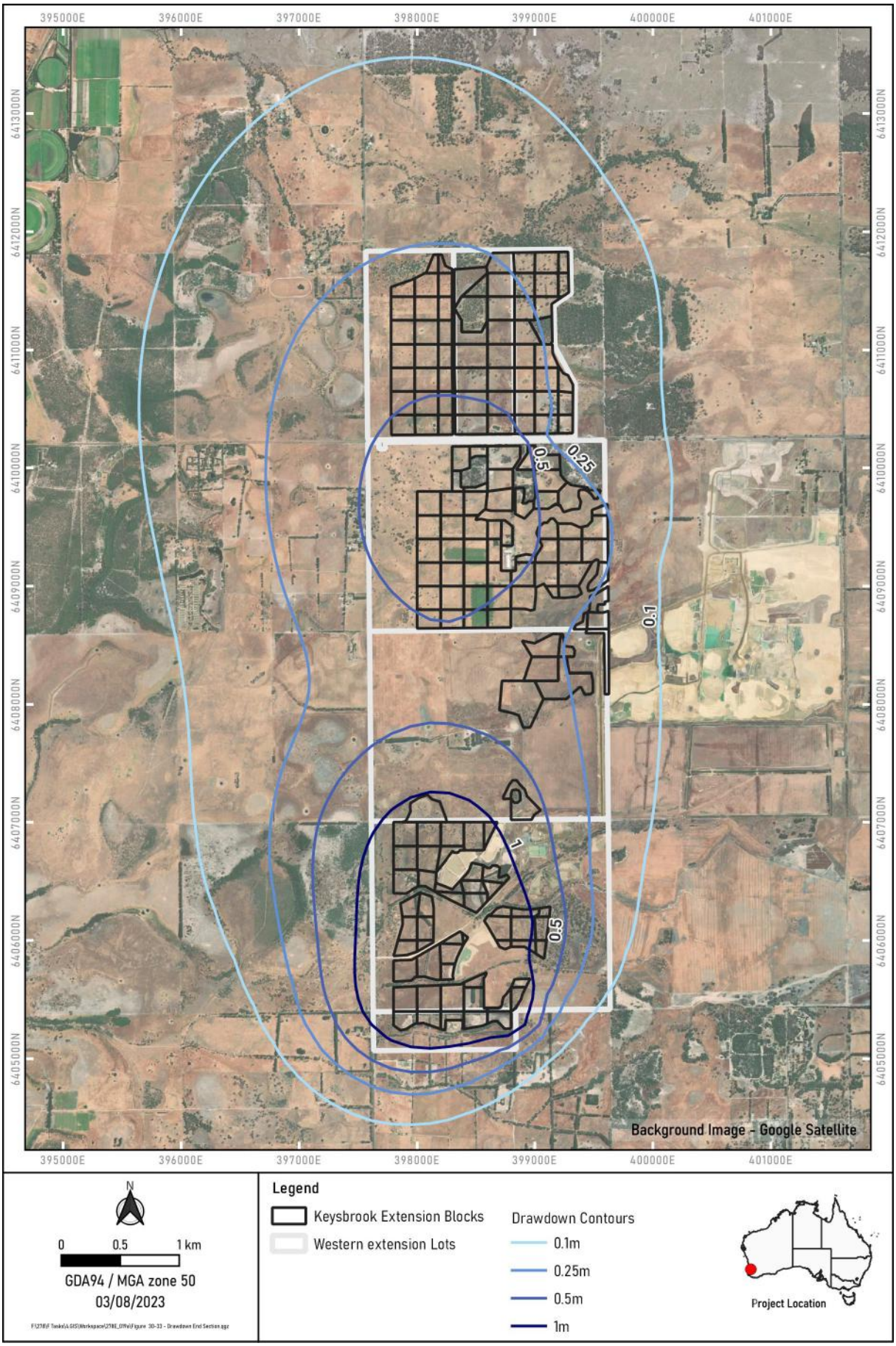

Figure 32 Contours of the Maximum Extent of Predicted Drawdown Section 4 (April 2031)

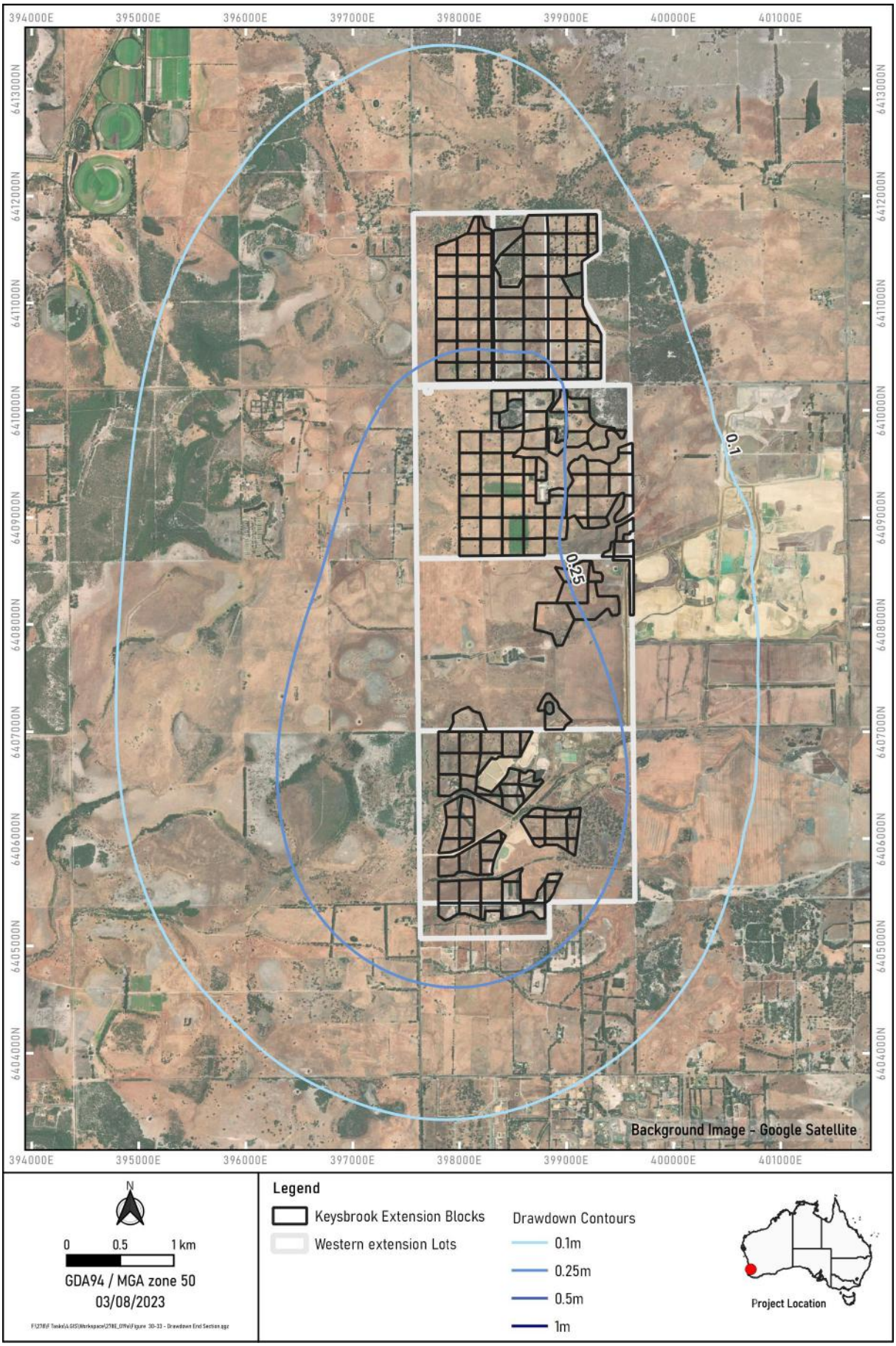

Figure 33 Contours of Maximum Extent of Predicted Drawdown (June 2035)

5.5.2. Impact to Environment Due to Mining Western Extension

Potential impacts from the proposed Western Extension amendment on the environment are related to short-term dewatering of mine pits and subsequent mined pit void backfilling, and associated changes to water level (i.e. drawdowns and water level recharge), which may:

- Affect superficial aquifer water flow regime.
- Area adjacent to Conservation Category Wetland (CCW) water levels.
- Reduce health and condition of native vegetation.

Groundwater drawdown (i.e. decrease in water levels) and the groundwater recharge (i.e. increase in water levels) in the Superficial aquifer due to open pit dewatering and tailings backfilling at the proposed Western Extension have been predicted by the numerical model and the results are discussed in Section 5.5.1 and the potential impacts on environment are summarised below:

- Superficial aquifer:
    - Dewatering due to mining at the Western Extension is likely to result in negligible regional scale groundwater drawdown in the Superficial aquifer.
    - Drawdown in the Superficial aquifer is predicted to be localised in the immediate area of the active mining (pits), be temporary in duration and relatively small (up to 3 m, but generally up to 1 m within the mining area).
    - Long-term post mining effects on water levels are expected to be minimal. The recovery of water levels will commence immediately mining of each active mine pit is completed, owing to the backfilling of mined-out pits.
    - Once all mining areas are completed, dewatering will cease and water levels will continue to rise until a steady state or equilibrium water level is resumed. The numerical model shows that the majority of water levels are predicted to return to pre-mining levels after approximately 10 years of mine closure. The remainder of the recovery predicted to occur over the next 10 years.
    - Therefore, the Superficial aquifer is resilient and will cope with the proposed changes due to mining of the Western Extension.
- CCW and Vegetation:
    - The magnitude of drawdowns along the CCW adjacent to the Western Extension vary depending upon the proximity of the active mining pits (Figures 20 to 28).
    - Groundwater modelling suggests that there will be drawdowns of generally less than 0.5 m around the CCWs. However, there are two CCWs (ID 14850 – Section 1 and ID 14870 – Section 3), where maximum drawdowns of up to 2.5 m are predicted, due to their close proximity to the proposed Western Extension mining areas. However, all drawdowns will be localised and temporary. It should be noted that at CCW ID 14870 water levels are predicted to recover from dewatering already simulated for Part Lot 63 in 2025.
    - As stated in Section 5.4, the identified CCWs are not considered to be groundwater dependent, but rather surface water dependent.
    - The CCWs and associated vegetation are likely to be resilient and cope with the proposed changes due to mining of the Western Extension. As stated in Section 5.4, the long-term monitoring of the health of vegetation near to Keysbrook mine indicates no changes in water regime that have the potential to impact the health of groundwater dependent vegetation. Additionally, the CCWs close to the mine site are in a Degraded to Completely Degraded Condition.

The potential environmental impacts due to mining of proposed Western Extension have been compared to the predicted impacts from the original modelling (2006). A comparison of the contours of predicted

drawdown at the end of each mining section area of the proposed Western Extension is shown in Figures 34 to 37.

The comparison of contours shows that the current predicted drawdowns due to mining Western Extension are slightly higher (up to 3 m) than the original predicted drawdowns (up to 2 m). This is due to the proposed Western Extension amendment having a larger area to the north and west compared to the original proposal. These changes are likely to be local and mainly contained within the development area.

It should be noted that the original mining schedule used in the 2006 modelling was revised in 2007. However, results (i.e. predicted drawdowns) of the 2007 modelling were not presented in the Rockwater report, thus it was not possible to compare the recently predicted impacts to the predicted impacts of the originally approved mining area. It is believed that the already approved parts of the Western Extension (i.e on Lots 62 and 63) had predicted drawdowns similar to the currently modelled (as the modelled area has not changed), with smaller original predicted drawdowns on the eastern and southern-eastern boundaries.

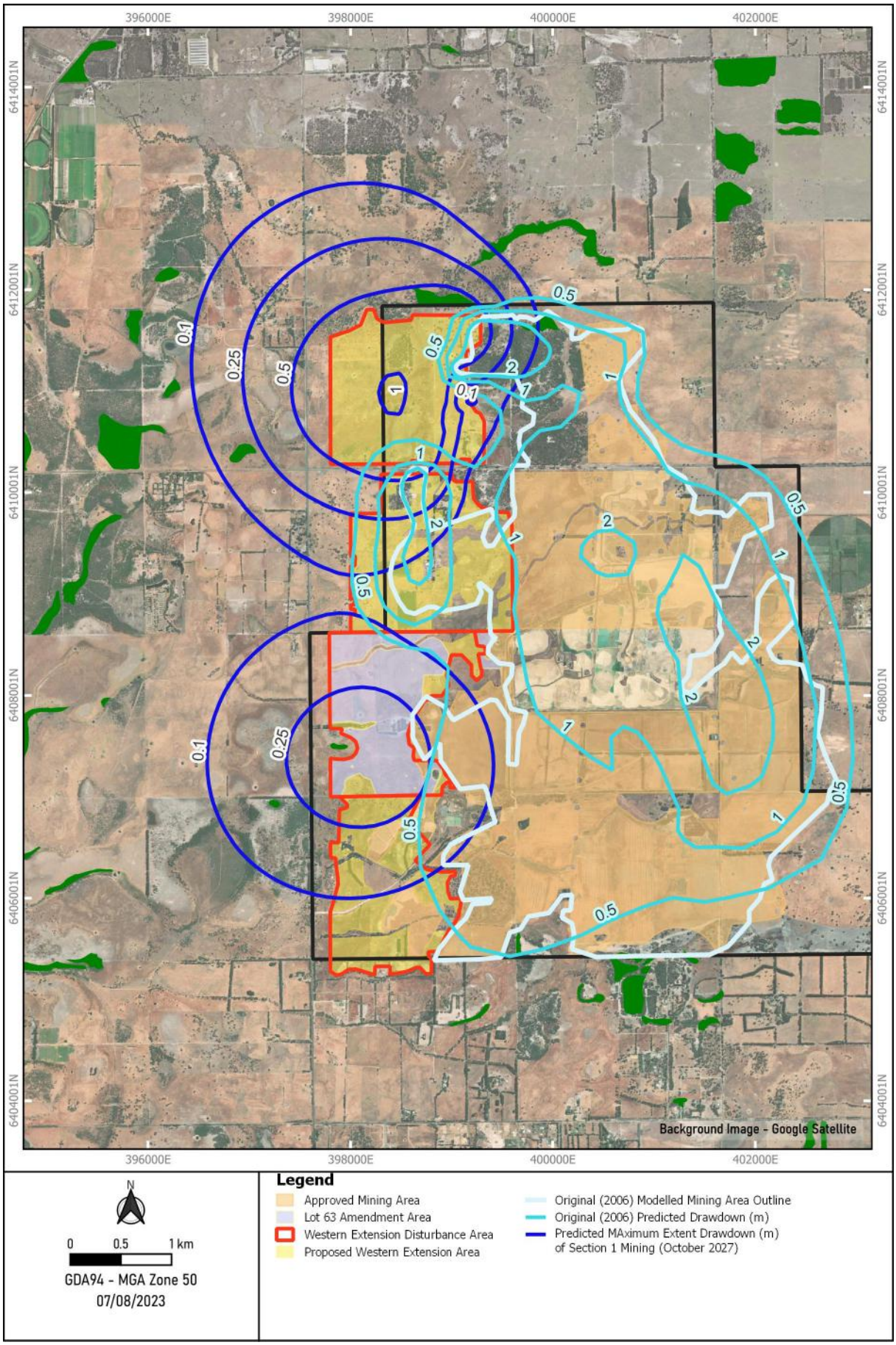

Figure 34 Comparison of Contours of Predicted Drawdown Between Original Modelling (2006) and the Current Proposed Amendment (October 2027, Maximum Extent of Section 1 Mining)

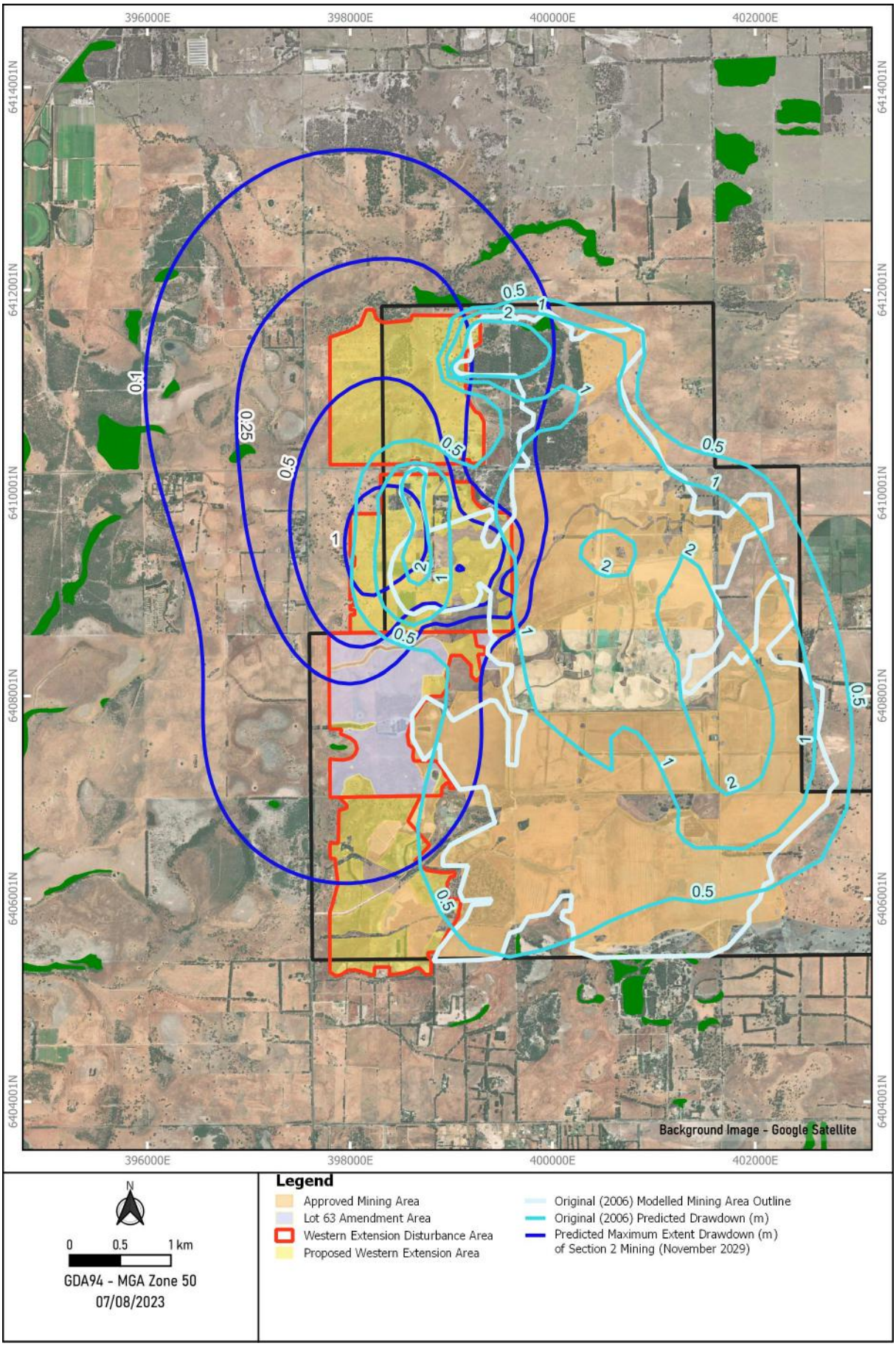

Figure 35 Comparison of Contours of Predicted Drawdown Between Original Modelling (2006) and the Current Proposed Amendment (November 2029, Maximum Extent of Section 2 Mining)

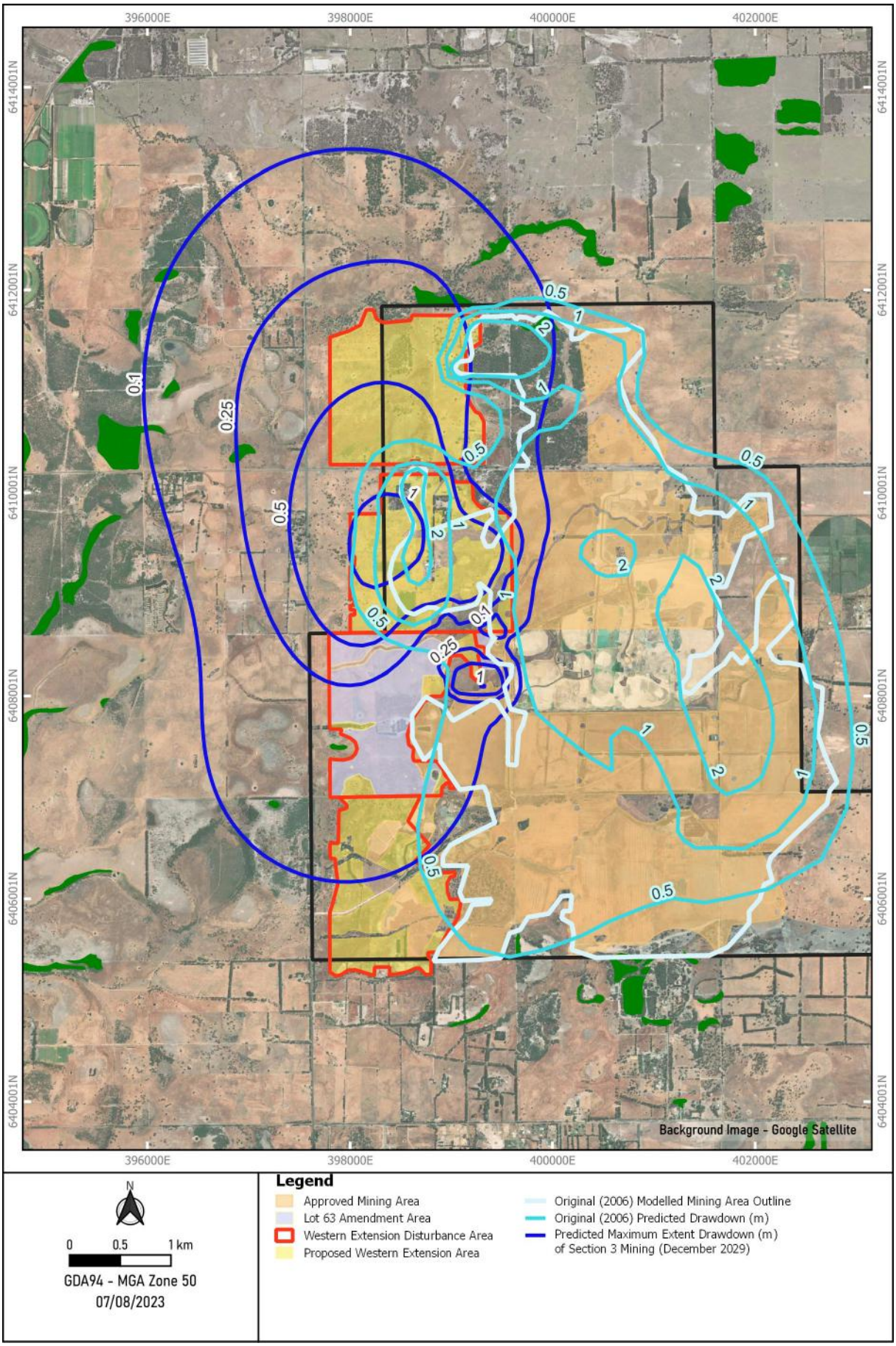

Figure 36 Comparison of Contours of Predicted Drawdown Between Original Modelling (2006) and the Current Proposed Amendment (December 2029, Maximum Extent of Section 3 Mining)

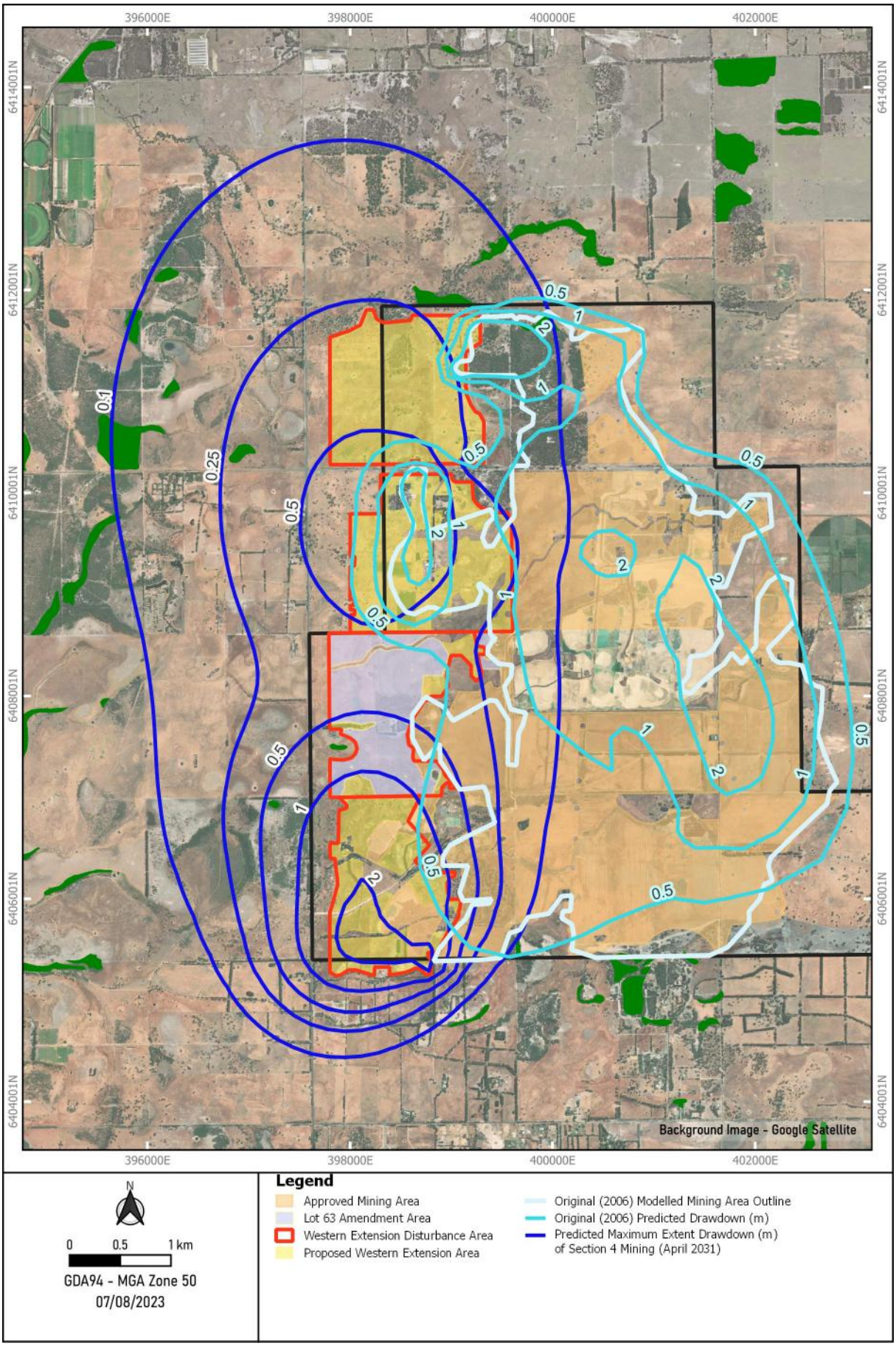

Figure 37 Comparison of Contours of Predicted Drawdown Between Original Modelling (2006) and the Current Proposed Amendment (April 2031, Maximum Extent of Section 4 Mining)

6. GROUNDWATER MANAGEMENT AND MONITORING

The current WMP (MBS, 2015) defines the approach to be adopted for management of groundwater. Additionally, the current Groundwater Operating Strategy (Doral, 2020) defines details of the groundwater monitoring programme (i.e. abstraction quantities, water levels and water quality), trigger levels and contingency actions to mitigate potential impacts caused by the Keysbrook mining operations and also to ensure the actual impacts are not greater than predicted. The groundwater monitoring as set out in the current GWOS and WMP will continue to be applied within the Western Extension. An amendment to the current GWOS to include any new groundwater monitoring sites will be required.

7. CONCLUSIONS

This assessment considers the changes in effects on the groundwater environment as a result of the proposed Western Expansion of the Project within Lots 20, 62, 63, 64, 201, 507 and 508, which has been broken down into four progressively mined Sections. The groundwater modelling, which simulated the mining within the Western Extension over a period of 65 months (i.e. 5.5 years), indicated minimal localised changes in the immediate area of the active mining (pits) and that these would be temporary and relatively small. There will be a negligible regional scale groundwater impact to the Superficial aquifer.

Mining at the proposed Western Extension is likely to have negligible effects on local CCWs. Potential short-term drawdowns are generally 0.5 m or less, with only two CCWs having potential drawdowns of up to 2.5 m, which are only slightly higher than the drawdowns originally predicted in 2006. Additionally, it is likely that the vegetation within the CCWs will be resilient and cope with the proposed changes due to mining of the Western Extension, as they are not considered to be groundwater dependent, but rather surface water dependent. Also, the long-term monitoring of the health of vegetation near to Keysbrook mine indicates no changes in water regime that have the potential to impact the health of groundwater dependent vegetation. Notwithstanding, regular monitoring of groundwater levels within and around the Western Extension mining area would provide any indication of detrimental changes to the environment and also would be used to compare the observed drawdowns (if any) with the modelled drawdowns.

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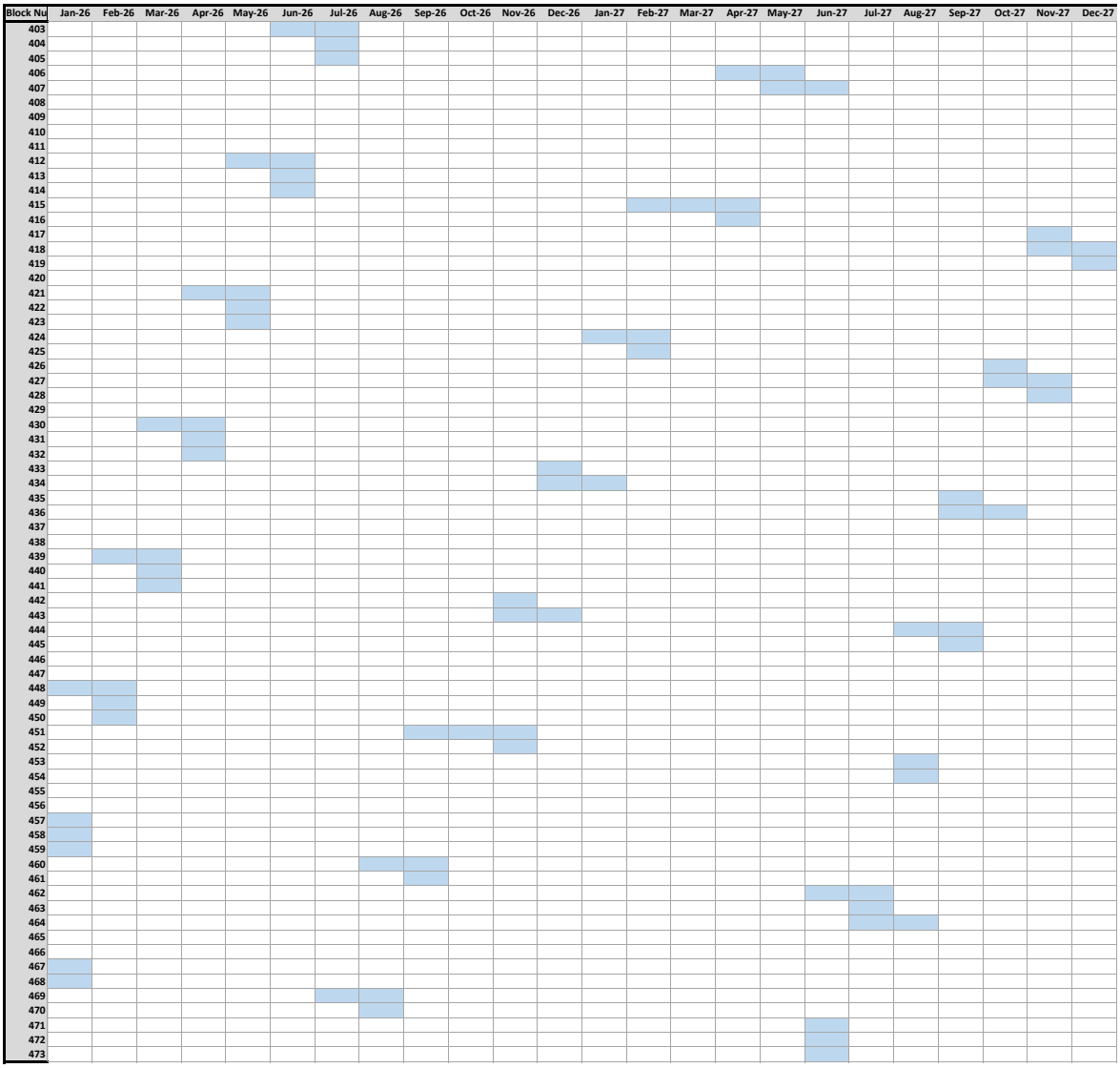
APPENDIX A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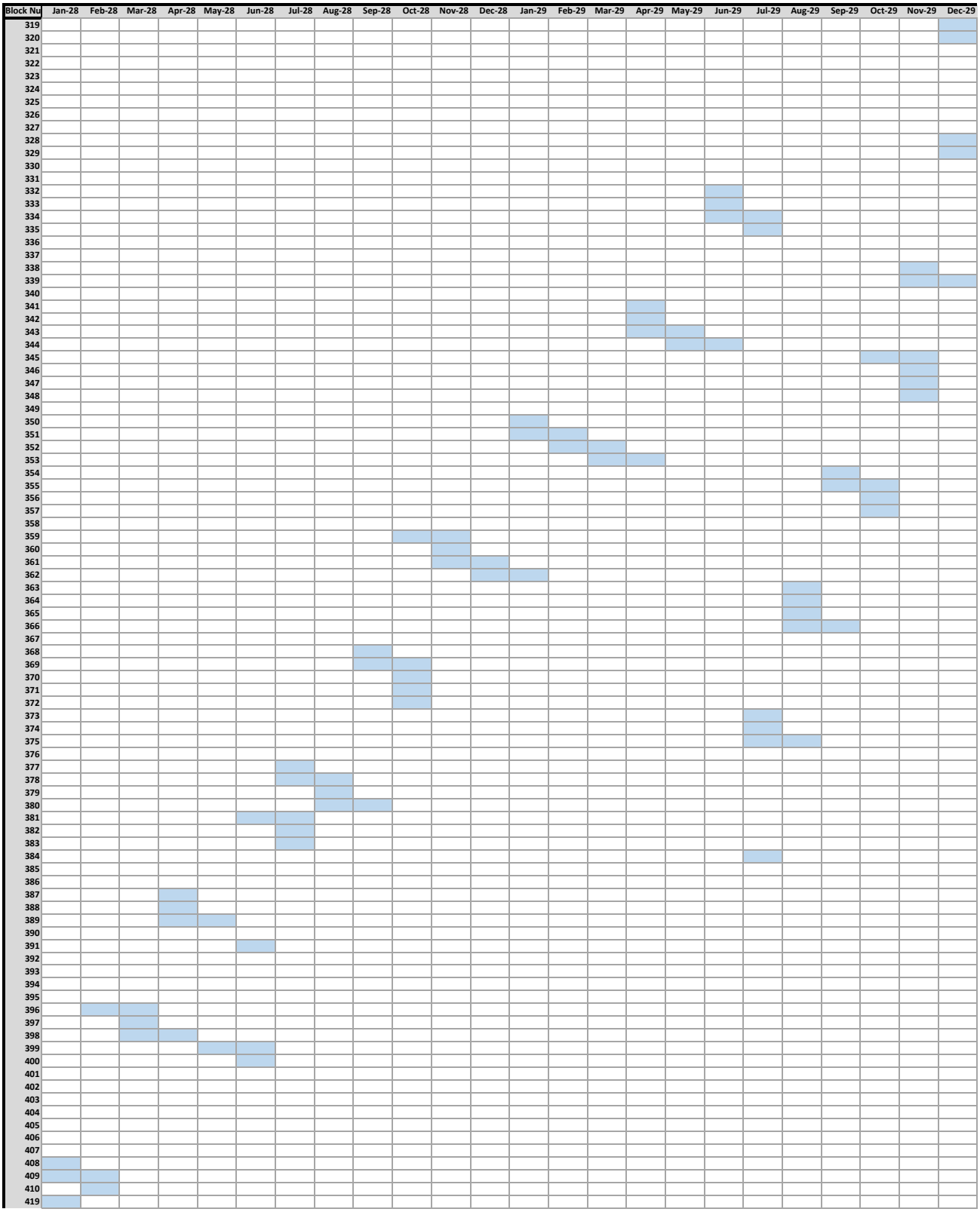
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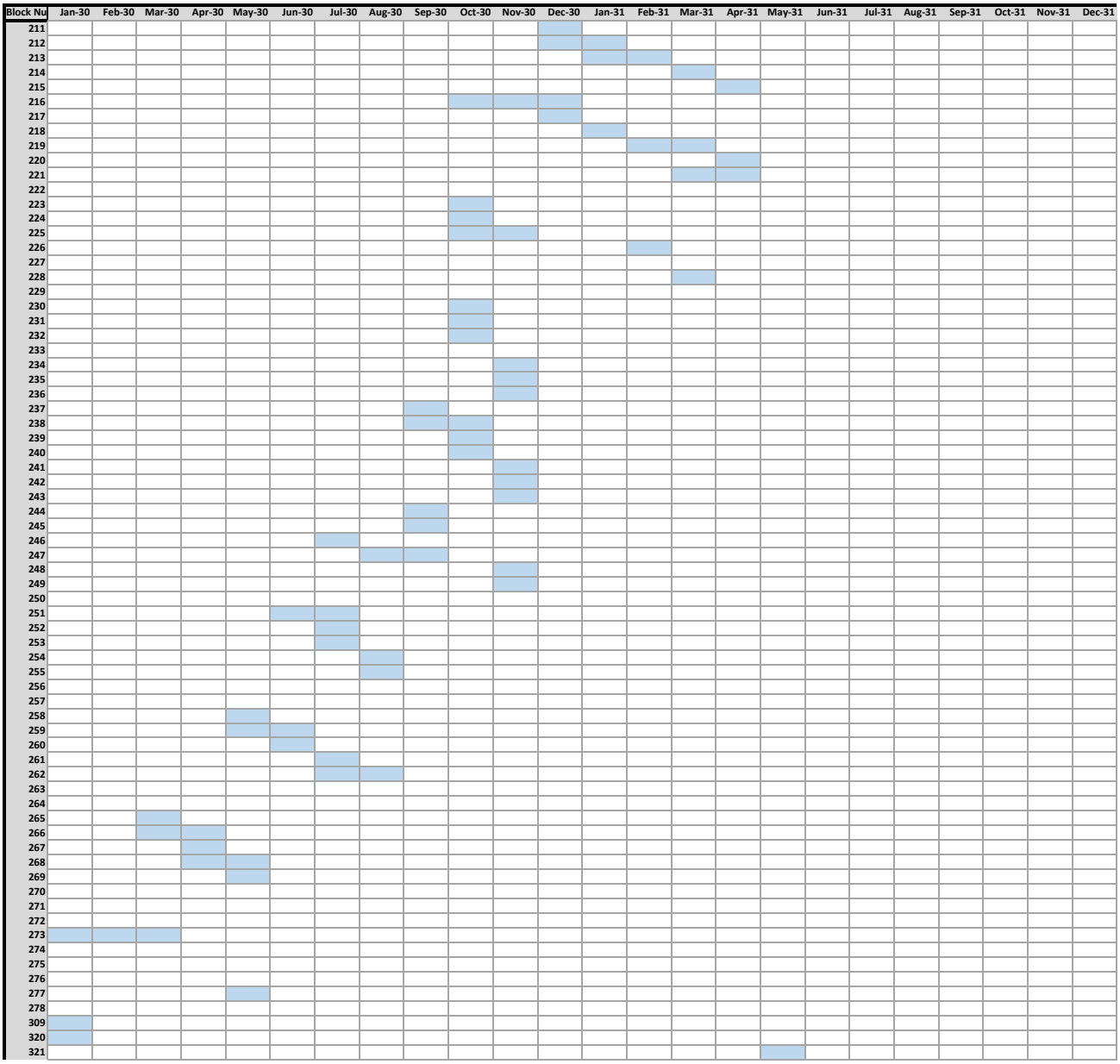
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APPENDIX B

Rockwater
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PROJECT:	**WETLAND ASSESSMENT, LOT 63 ELLIOT RD, KEYSBROOK**		
FROM:	Nick Evelegh	TO:	Craig Bovell
DATE:	16 December 2022	COMPANY:	Doral Mineral Sands Pty Ltd
JOB:	321-0	REFERENCE:	321-0/22-03

1 INTRODUCTION

The Keysbrook Leucoxene Project (the Project) is operated by Doral Mineral Sands Pty Ltd (Doral). The Project is located approximately 55 km south of Perth in the Shire of Serpentine-Jarrahdale, near the small townships of Keysbrook and North Dandalup.

The Project is situated on the Swan Coastal Plain, which contains numerous wetlands that support a range of ecological and cultural values. As part of the formal environmental impact assessment process to consider extension of the Project into adjacent farmland areas, Doral commissioned Rockwater to undertake a brief site visit to inspect Conservation Category wetland 14870, located at Lot 63 on Hopelands Road Keysbrook (Figure 1). The work was undertaken during the annual spring 2022 surveys of wetlands of the project area, in accordance with Doral's environmental commitments under Ministerial Statement 810. This memorandum presents the results of the spring 2022 site assessment

2 CONSERVATION CATEGORY WETLANDS

The geomorphic classification system (Semeniuk 1987; Semeniuk and Semeniuk 1995), which allocates wetlands into types based on the fundamental characteristics of the shape of the host landform and the wetland's hydrological regime, has been adopted as the primary classification system for mapping wetlands in Western Australia (DPaW 2013). The wetlands are grouped into consanguineous (inter-related) suites, which share a similar geomorphic/geologic and hydrologic setting, or have been formed by the same underlying processes.

The wetlands of the Project area are listed under the Keysbrook consanguineous suite. The wetland of focus to this assessment on Lot 63 (UFI 14870) is listed under the Geomorphic Wetlands, Swan Coastal Plain dataset (GWSCP, DBCA-019) as a Palusplain type wetland (see Table 1), and has been assigned under a conservation management category.

Table 1: Geomorphic Classification System for Mapping Wetlands

	Basin	Flat	Channel	Slope	Highland
Permanently inundated	Lake	-	River	-	-
Seasonally inundated	Sumpland	Floodplain	Creek	-	-
Intermittent inundation	Playa	Barlkarra	Wadi	-	-
Seasonally waterlogged	Dampland	Palusplain	Trough	Paluslope	Palusmont

3 SITE ASSESSMENT

A site visit by two botanists to Lot 63 Keysbrook was undertaken on 16 November 2022, accompanied by Craig Bovell (Doral OHSE Superintendent). UFI 14870 is mapped as a 0.78 Ha Conservation Category Wetland (CCW), and is part of an extensive palusplain (seasonally waterlogged flat) wetland of the Geomorphic Wetlands, Swan Coastal Plain (GWSCP). However, the wetland does not appear to meet the criteria for this category. Vegetation of the site is parkland cleared with no understorey present (Plate 1). Mature *Corymbia calophylla* (marri) are the only trees present at the site. Several of these are in poor condition and many dead trees are evident (see Plate 1). Using the Bush Forever vegetation condition scale, 100% of the vegetation within UFI 14870 is classified as 'completely degraded'.

The site is upslope of a completely cleared minor drainage line, which runs through a small remnant of *Melaleuca preissiana* on the western boundary of Lot 63, adjacent to Hopeland Rd (Figure 2, Plate 2). Remnant vegetation at that site is more indicative of a wetland community than the surrounding cleared pasture, or remnant marri trees within UFI 14870. The *M. preissiana* Low Woodland vegetation on the western boundary of Lot 63 is less than 0.1 hectares in size, and is mapped under the Multiple Use category. Most of Lot 63 is cleared for pasture; however, there are some small remnants of parkland-cleared vegetation. Two of these small areas, totalling less than five hectares, are listed under the Resource Enhancement category, with the remainder of the cleared areas on Lot 63 either classified as Multiple Use or not listed in the GWSCP dataset.

The Environmental Protection Authority (2008) defines CCW as wetlands of high conservation value for natural or human use, with a management objective to preserve the natural attributes and functions of the wetland. The management category of UFI 14870 is considered to be incorrect as there is no evidence of wetland vegetation at the site (Figure 2) and the terrestrial vegetation is in a completely degraded condition.

The GWSCP dataset is managed by Department of Biodiversity, Conservation and Attractions (DBCA) and a methodology for evaluation of wetlands of the Swan Coastal Plain has been prepared (DBCA 2017). Evaluation under that methodology is beyond the scope of this initial site visit, but will be required to request any changes to wetland management categories or boundaries.








Plate 1: Site photos at UFI 14870

Plate 2: *Melaleuca preissiana* swamp on western boundary of Lot 63 Keysbrook

4 RECOMMENDATION

A request to modify the management category of UFI 14870 should be submitted to DBCA. This will need to be accompanied by a preliminary desktop and site assessment form (refer Appendix C of DBCA, 2017). Under the DBCA (2017) wetland evaluation methodology, wetland attributes, functions and values are assessed against three broad evaluation criteria: representativeness, scarcity and naturalness. Based on a brief site inspection in spring 2022, it is our opinion that the wetland UFI 14870 has limited conservation value under these criteria.

Dated: **16 December 2022**

Rockwater Pty Ltd

Nick Evelegh
Principal Environmental Scientist

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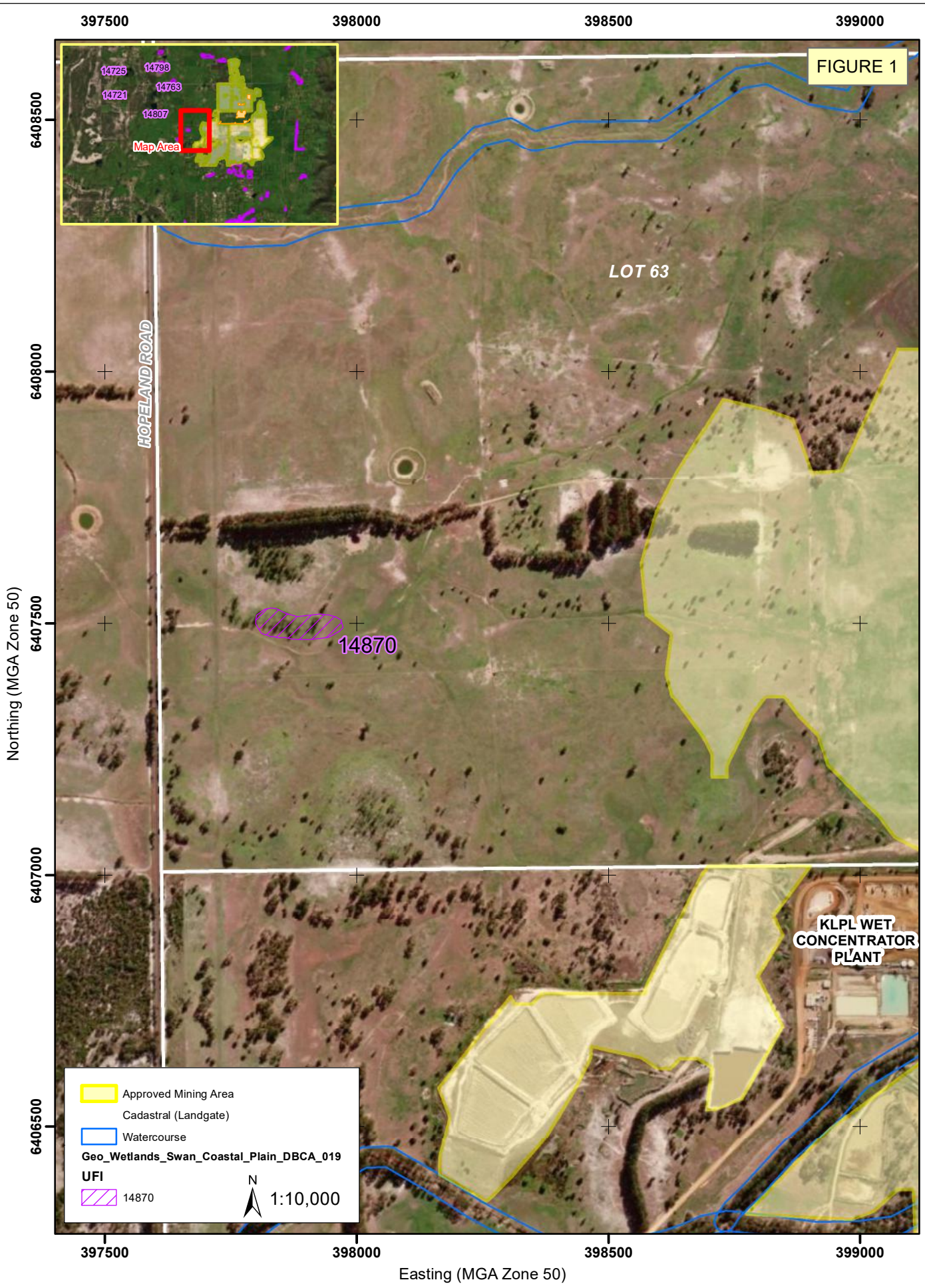
FIGURES



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PROJECT:	Keysbrook Minerals Sands Project
DATE:	December 2022
DWG NO:	321-0/22/03-1

LOT 63

LOCALITY

Rockwater PROPRIETARY LIMITED

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CLIENT:	Doral Pty Ltd
PROJECT:	Keysbrook Minerals Sands Project
DATE:	December 2022
DWG NO:	321-0/22/03-2

LOT 63
CONSERVATION CATEGORY
WETLAND 14870

Rockwater PROPRIETARY LIMITED

APPENDIX 10B: AQ2 SURFACE WATER

Keysbrook Mineral Sands Mine
Surface Water Assessment for Western Extension

Prepared for:

Doral Mineral Sands

August 2023

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1.1. INTRODUCTION

1.1. Background

Doral operates the Keysbrook Mineral Sands Project (the Project), located 58 km south of Perth and 22 km east of Mandurah, in Western Australia. The Project is managed by Keysbrook Leucoxene Proprietary Limited (KLPL), which is a subsidiary of Doral.

The Project is located on privately owned land that is used for grazing and other rural land uses. It operates under Ministerial Statement No. 810 and No. 1089. The currently approved area of disturbance is 1,532 ha, within a 3,015 ha Environmental Protection Authority (EPA) Development Envelope. This has approval for 9 years of mining from October 2015 with the mine areas being progressively mined, backfilled to pre-disturbance contours, and rehabilitated within 2 years of mining (Doral, 2022).

Based upon the current mining schedule, the ore reserve within the approved mine area, as defined in MS810, is due to be exhausted in 2023. AQ2 has previously completed surface water and groundwater assessments (2022a, 2022b) on the active mining area within Part Lot 63 that Doral has submitted with an amendment to proposal under Section 45C of the Environmental Protection Act 1986 (EP Act). It should be noted that the Part Lot 63 amendment is still under assessment by the Department of Water and Environmental Regulation (DWER).

1.2. Purpose of this Document

To facilitate the continuation of the mine and workforce, Doral seeks to further amend the Project to include Part Lots 20, 62, 63, 64, 201, 507 and 508 under Section 40AA of the EP Act as shown on Figure 1.1. The amendment area, referred to as the Western Extension, is mostly located within the existing EPA Development Envelope and includes a disturbance (mine) area of 518 ha, consisting primarily of cleared pasture and up to 21.5 ha of degraded native vegetation. Mining the amendment area will produce an additional heavy mineral concentrate and result in approximately 65 months (5.5 years) of additional mining for the Project.

Under current approvals for the operations (MS810), any surface water runoff which flows across a disturbed (non-rehabilitated) area of the Project must be collected, added to the Site Water Management System and added to the process water circuit. Areas that do not require capture of runoff include diverted upstream flows and stream corridors, and runoff from completely rehabilitated areas.

Doral are required to submit a request for a change to proposal under Section 40AA of the Environmental Protection Act 1986. The following information is required to support this, which is presented within this SW assessment:

4. *Provide details of any detrimental effects the proposed change/s might have on the environment, considering:*
   - *the values, sensitivity and quality of the environment which is likely to be impacted*
   - *the extent (intensity, duration, magnitude and geographic footprint) of the likely impacts*
   - *the resilience of the environment to cope with the impacts or change.*
5. *Describe whether the detrimental environmental effects of the change are additional to, or different from, any detrimental environmental effects of the original proposal.*

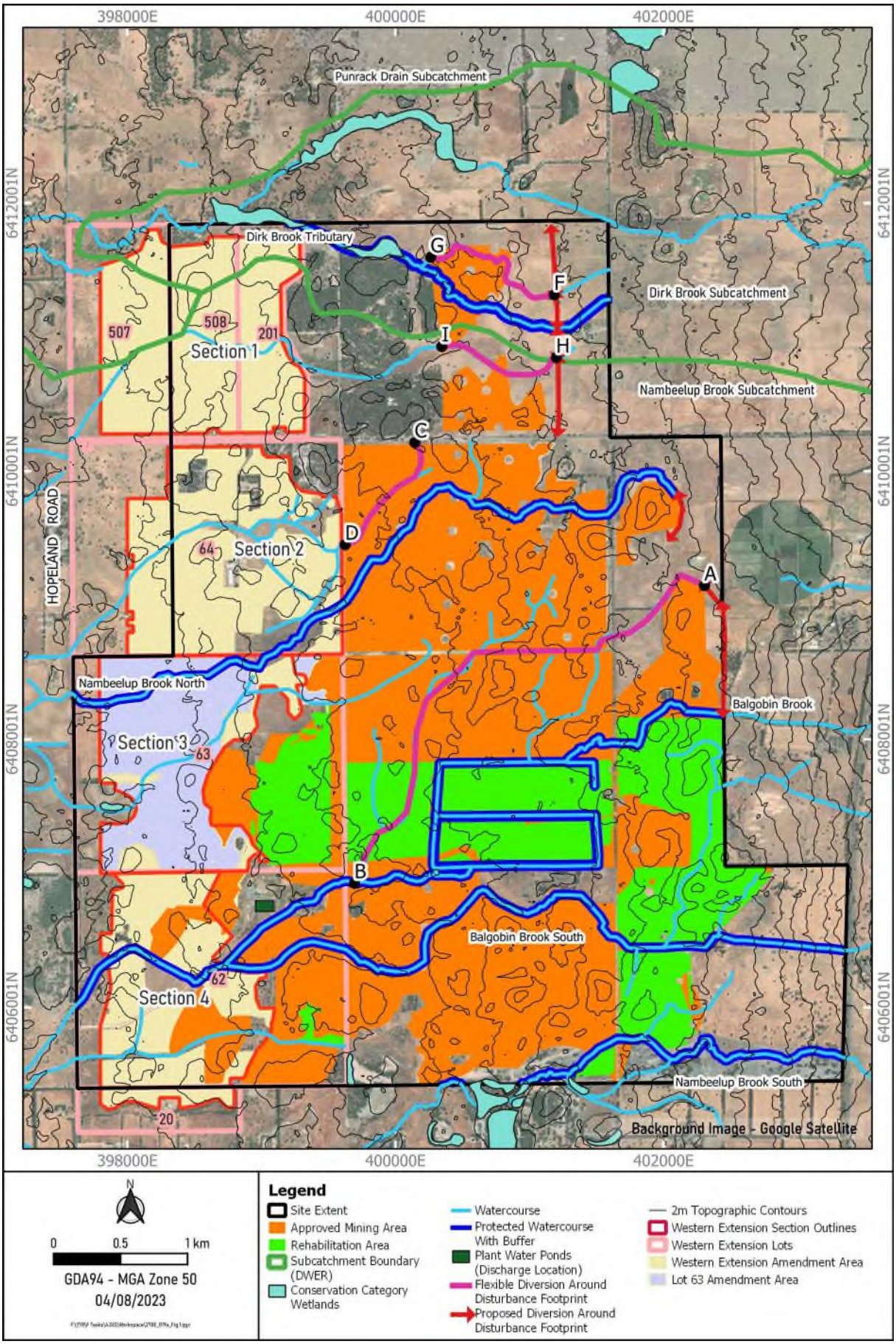

Figure 1.1 Proposed Western Extension

2. PROPOSED DISTURBANCE FOOTPRINTS

The proposed Western Extension, as shown on Figure 1.1, is mostly located within the existing EPA Development Envelope and, for the purposes of this report, will be broken down into the following sections, which cover an overall proposed mining period.

Table 2.1 Proposed Western Extension Components

Section	Part Lots	Proposed Mining Period	Approximate Proposed Disturbance (Mine) Area (ha)
1	201, 507, 508	January 2026 to February 2028	203
2	64	February 2028 to December 2029	177
3	63	December 2029 to May 2030, & May 2031	25
4	62, 20	May 2030 to April 2031	113

To date, the approved mining operation has involved progressively clearing and mining about 30 ha of active open pit at any one time, plus progressive backfilling and rehabilitation as the mine progresses. It is assumed that the area of active mining within the proposed expansion would be consistent with this approach (i.e., maximum 30 ha of active open pit).

3. HYDROLOGY

3.1. Regional Hydrology

At a regional level, all surface drainage from the Project area ultimately flows to the Peel Inlet (Peel-Harvey Estuary). Streams from the Darling Scarp and foothills flow from east to west through the mine area (MBS, 2006). MBS (2006, 2015) provide details of regional streamflow monitoring stations.

3.2. Local Hydrology

The mine area and surrounds are characterised by low relief topography that results in a landscape that becomes flatter and increasingly poorly draining westward from the scarp. In the pastured areas, most of the low-lying areas, creeks and wetlands have been cleared and drained. Downstream of the Project, west of Hopelands Road, the low relief is even more pronounced, resulting in a wetland chain all the way to Peel Inlet (MBS, 2006).

The watercourses flowing through, and adjacent to, the Project are discussed in MBS (2006) and shown on Figure 1.1. The northern part of the Project is located within the Dirk Brook Subcatchment, which flows to the Serpentine River and into Goegrup Lake and the Peel Inlet. The majority of the Project is located within the Nambeelup Brook Subcatchment, which discharges to several lakes in the Serpentine River Catchment System and then into the Peel Inlet. The western section of Lot 507 drains into the Punrack Drain Subcatchment, which flows into Lake Amarillo, one of the Serpentine Lakes.

The watercourses associated with each Section of the Western Extension are discussed below.

3.2.1. Section 1

Two unnamed tributaries of Dirk Brook flow in a westerly direction as well-defined watercourses to the north of the proposed areas of disturbance within Section 1, but do not fall within their extent. A small unnamed stream flows through the southern half of the Section and continues to the west to converge with other tributaries of Nambeelup Brook.

3.2.2. Section 2

Nambeelup Brook North Tributary flows through the south-eastern corner of Section 2 and continues to the west to converge with other tributaries and form Nambeelup Brook. A smaller unnamed tributary of Nambeelup Brook flows west through the centre of the Section.

3.2.3. Section 3

Nambeelup Brook North Tributary flows from Section 2 and continues south-westerly through the northern part of Section 3. A smaller unnamed tributary of Nambeelup Brook flows south-westerly through the Section.

3.2.4. Section 4

The largest tributary of Nambeelup Brook that crosses the Project, Balgobin Brook, flows westerly through Section 4, joining with Balgobin Brook South close to the centre of the Section which also flows westerly through the southern half of Section 4. A smaller unnamed tributary of Balgobin Brook flows westerly through the southern half of the Section.

3.2.5. Conservation Category Wetlands and Environmentally Sensitive Areas

A number of Conservation Category Wetlands (CCWs) (DBCA, 2022) and associated Environmentally Sensitive Areas (ESAs) (DWER, 2021) are located to the north and west of the proposed Western Extension, as shown on Figure 3.1. A summary of those that are located downslope of mine disturbance areas and potentially impacted by the Western Extension is provided in Table 3.1 and more information can be found in Rockwater (2021) and Ecoedge (2021, 2022), all of which report that areas of CCW they had monitored were degraded due to clearing. It should be noted that the accuracy of this assessment of affected CCWs is based on limited topographical data for determining surface water flowpaths.

Rockwater (2021) did however report that the vegetation condition within wetland 14807 (Yangedi Swamp) improved from degraded to good in 2021. At this site, vegetation condition improves during wetter periods when surface water suppresses germination of many exotic terrestrial herbs, and declines in response to the presence of aggressive weed species in drier years and during drier stages in the wetland hydroperiod. This wetland is located within Bushland Forever Site 77, where vegetation on freehold land is managed for conservation purposes.

Hydrogeological and environmental monitoring data collected during 2020 suggest that mining activities at Keysbrook have not resulted in changes to the water regime that have the potential to impact the health of groundwater dependent vegetation at wetland monitoring sites (Rockwater, 2021).

Table 3.1 Summary of Conservation Category Wetlands Potentially Impacted by the Western Expansion

Section	Subcatchment	CCW ID	Type	Management Category
1	Dirk Brook Catchments	14850	Dampland	Seasonally waterlogged
	Punrack Drain	14760 7000	Palusplain	Seasonally waterlogged
	Nambeelup Brook North	14825 14763	Palusplain	Seasonally waterlogged
		14798	Dampland	Seasonally waterlogged
2	Nambeelup Brook North	14807	Sumpland	Seasonally inundated
		14795	Palusplain	Seasonally waterlogged
3	Nambeelup Brook North	14870	Palusplain	Seasonally waterlogged
4	-	-	-	-

An assessment of the contours supplied by Doral and publicly available SRTM and satellite imagery suggests that the proposed Western Extension does not impact on the catchment of other local CCWs, such as 14887, 14772, 14894, 14802, 14803, 14805 and 14831. A number of Resource Enhancement wetlands are also located within Sections 1-3, as shown on Figure 3.1.

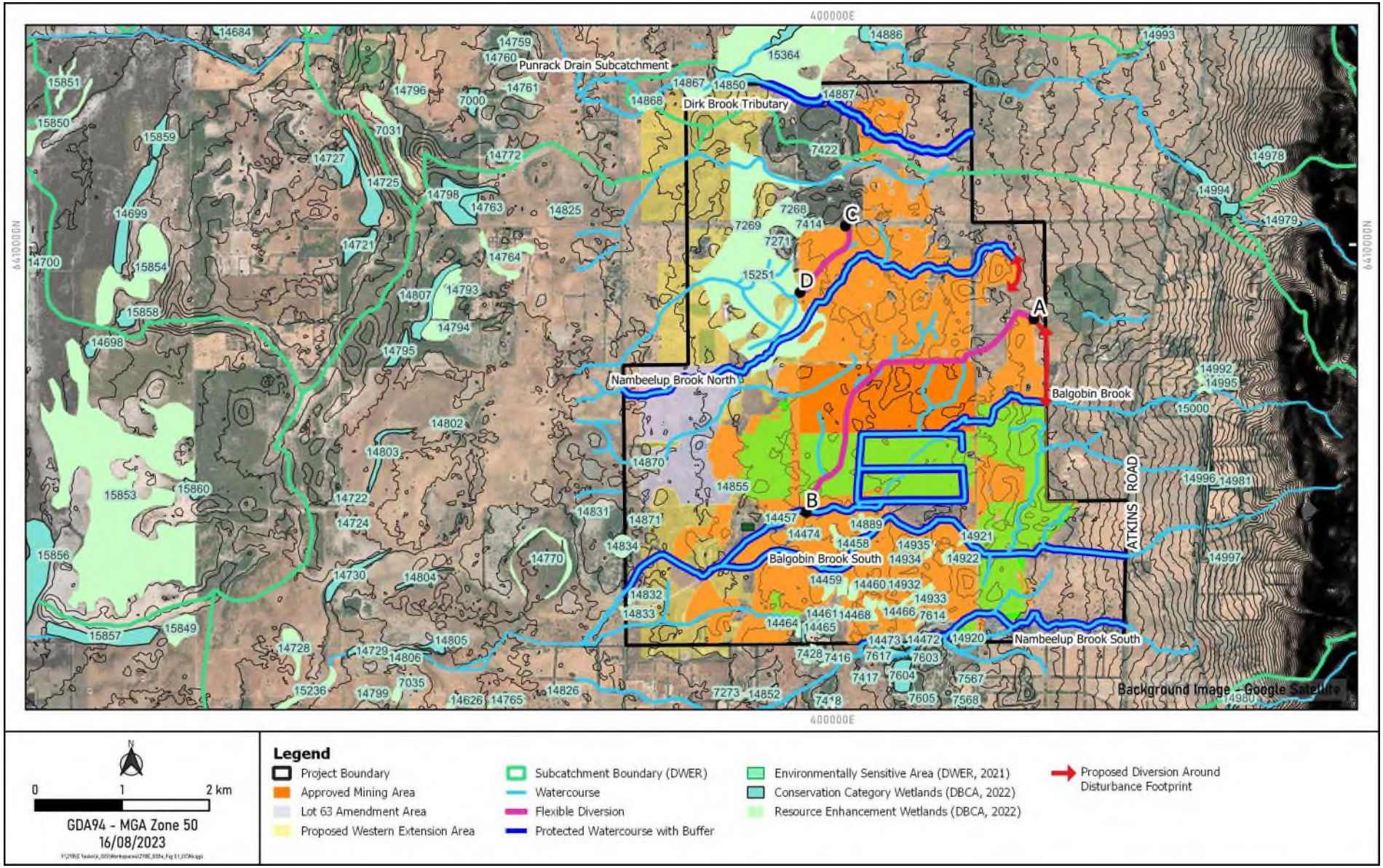

Figure 3.1 Conservation Category Wetlands

3.3. Threatened and Priority Ecological Communities

As reported by Ecoedge (2022), ecological communities are defined as "*…naturally occurring biological assemblages that occur in a particular type of habitat. They are the sum of species within an ecosystem and, as a whole, they provide many of the processes which support specific ecosystems and provide ecological services*". Threatened Ecological Communities (TECs) may be listed under one of three conservation categories: Critically Endangered (CR), Endangered (EN) and Vulnerable (VU). Priority flora is under consideration for future declaration as "Threatened flora", dependent on more information. Species classified as Priority One to Three (referred to as P1, P2 and P3) require further survey to determine their status. Priority Four (P4) species are adequately known rare or Threatened species that require regular monitoring.

A summary of Threatened and Priority Ecological Communities and Threatened and Priority flora located within and/or downstream of each Section of the Western Extension is provided in Table 3.2, based on Figures 3.2 and 3.3 from Ecoedge (2022). Figure 3.2 and Figure 3.3 show that there is one TEC (SCP15), which includes one P4 priority flora located downstream of Section 1 to the west, within the Nambeelup Brook catchment. Although not shown on these figures, there is one TEC (SCP FCT 3c) in good condition, located to the east of the south-eastern corner of the same Section, but the topographical data available suggests that they are not connected in terms of surface water flows (up-gradient).

Table 3.2 TEC and Priority Flora Communities Downstream of the Western Extension

Section	Community Classification	Description
1	TEC (SCP15)	Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain (SCP15)
	P4	None provided
2	P1, P2, P3	None provided
3	-	-
4	P2	None provided

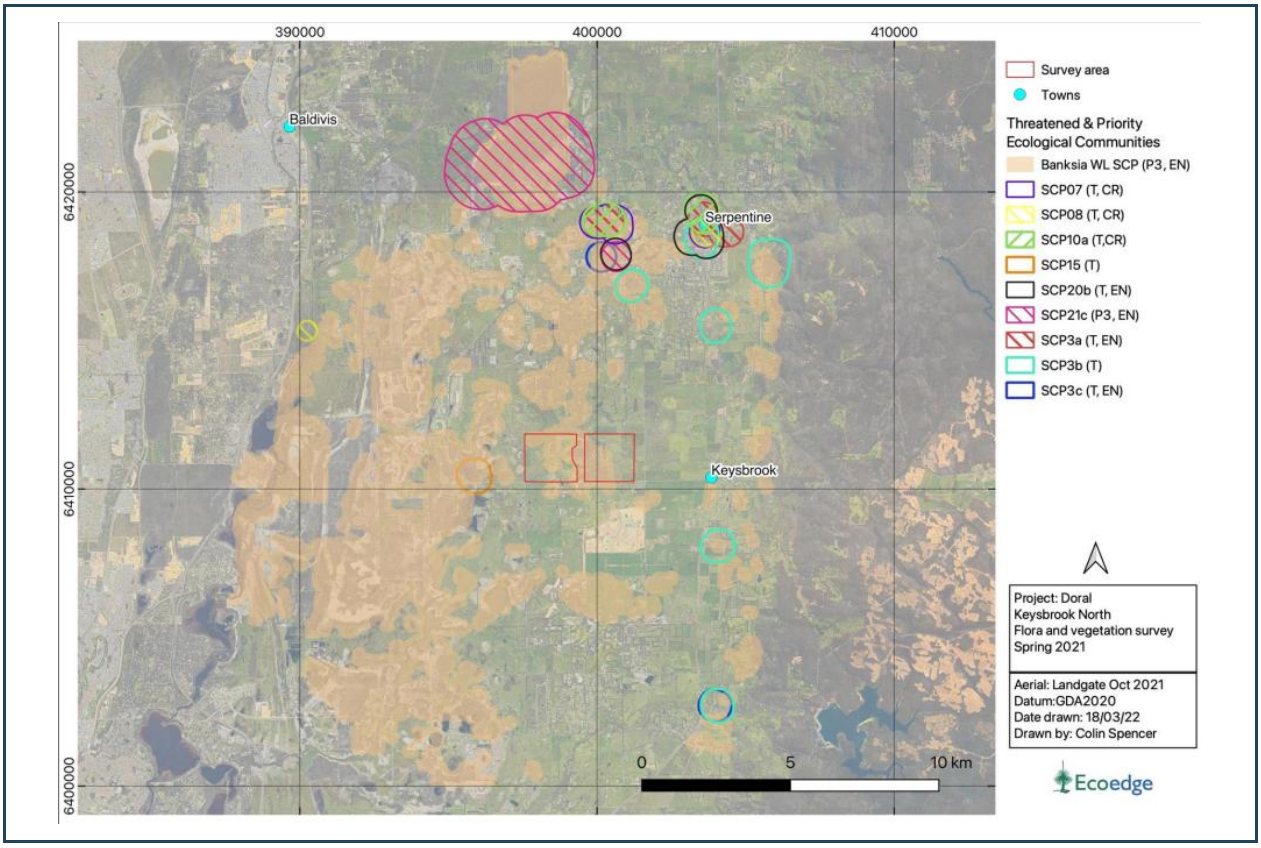

Figure 3.2 Desktop Search Results of TEC's and PEC's (Ecoedge, 2022)

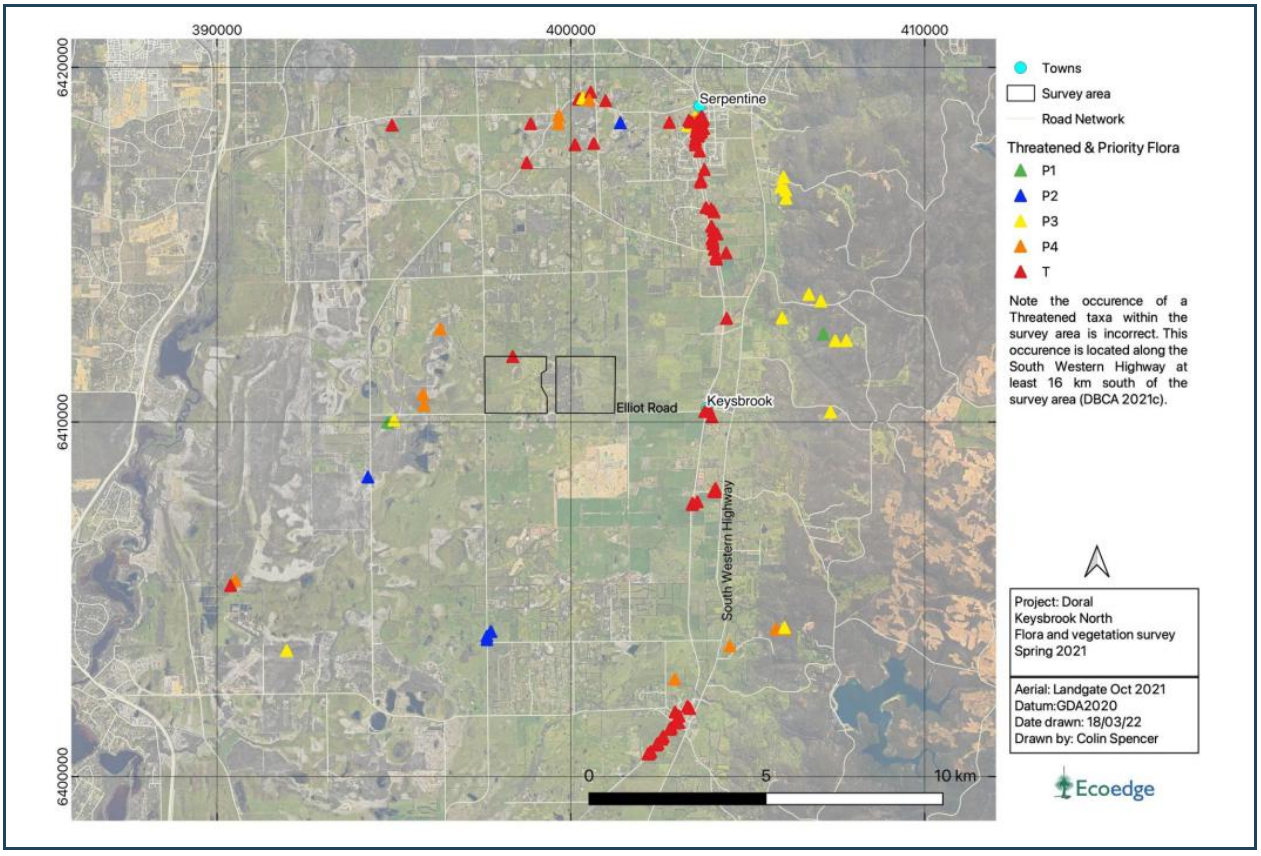

Figure 3.3 Desktop Search Results of Threatened and Priority Flora (Ecoedge, 2022)

4. SURFACE WATER MANAGEMENT

4.1. Management of Watercourses Crossing the Project

As per the WMP (MBS, 2015), inflows from external catchments will either be diverted as clean water away from the disturbed mining area and back into a watercourse downstream, or flow through the mine site but remain separate from it. Other minor creek lines will be included in the mining activities, but then reinstated during rehabilitation.

4.1.1. Watercourse Classifications

Watercourse classifications reported by MBS (2006, 2015) are presented in Table 4.1, along with their management philosophies which are discussed in more detail in the following sections.

Table 4.1 Watercourse Classifications (MBS, 2006 2015)

Watercourse Category	Peak flows (m^3/s)	Watercourses	Management Philosophy	Section
Major	2-5	Balgobin Brook North Dandalup River Tributary	Watercourse buffers	4 -
Medium	1-2	Dirk Brook Tributary Nambeelup Brook North Tributary Balgobin Brook South Tributary Nambeelup Brook South Tributary	Watercourse buffers	1 2, 3 4 -
Minor	<1	Unnamed	Diversion of upstream catchments	All

4.1.2. Watercourse Buffers

Watercourses categorised as Major and Medium, with peak flows greater than one cubic metre per second, will have 10 m buffers (MBS, 2006) and be bunded off and protected from disturbed mine areas.

4.1.3. Diversion of Upstream Catchments

Minor Watercourses passing through the Project with peak flows of less than one cubic metre per second are generally shallow and poorly defined (MBS, 2006, 2015). Flow in minor watercourses and sheet flow in between watercourses can be managed by bunding of the operational areas and construction of diversion drains; only minimal earthworks will be necessary due to the low flows carried by these watercourses. These diversions are to ensure that inflows from the upstream catchments do not contribute runoff to the 'Disturbance Footprint' inflows.

Where practical, these diversions should be constructed to ensure minimum erosion potential and to direct drainage back to its natural drainage line downstream at a velocity and depth that can be accommodated without increased scour. Diversions should be in place for the minimum time necessary and removed as soon as possible as part of progressive rehabilitation. During landform restoration, drainage will be re-established along original drainage lines. Contours of the restored landforms and drainage lines will be returned to pre-mining levels as closely as possible. (MBS, 2015).

MBS (2006) determined that the effects of drainage diversions on runoff volumes and flow rates at the regional scale are expected to be minor because:

- Only a small proportion of the total Project area catchments will be disturbed at any time.
- Surface water diverted around an active mine pit will be redirected back into the natural drainage line downstream.

4.1.4. Section Requirements

A summary of the watercourse management requirements for each Section is provided in Table 4.2 and presented on Figure 4.1 and Figure 4.2. Diversions for upstream catchments are proposed on the Figures, however the shape of the mine footprints within Sections 3 and 4 in particular do not allow for Life of Mine diversions to be proposed. It is recommended that progressive diversions are used around the mine footprint development in the areas indicated on Figure 4.2.

Table 4.2 Western Extension Watercourse Management

Section	Watercourse	Management (refer Figure 4.1)
1	Unnamed stream	Diversion J-K
2	Nambeelup Brook North Tributary	Buffer
	Unnamed stream	Diversion D-E
3	Nambeelup Brook North Tributary	Buffer
	Unnamed stream	Diversion L-M
4	Balgobin Brook Balgobin Brook South	Buffer
	Unnamed stream	Buffer*

* No buffer has been directly recommended for this watercourse however the mine disturbance area footprint appears to include one.

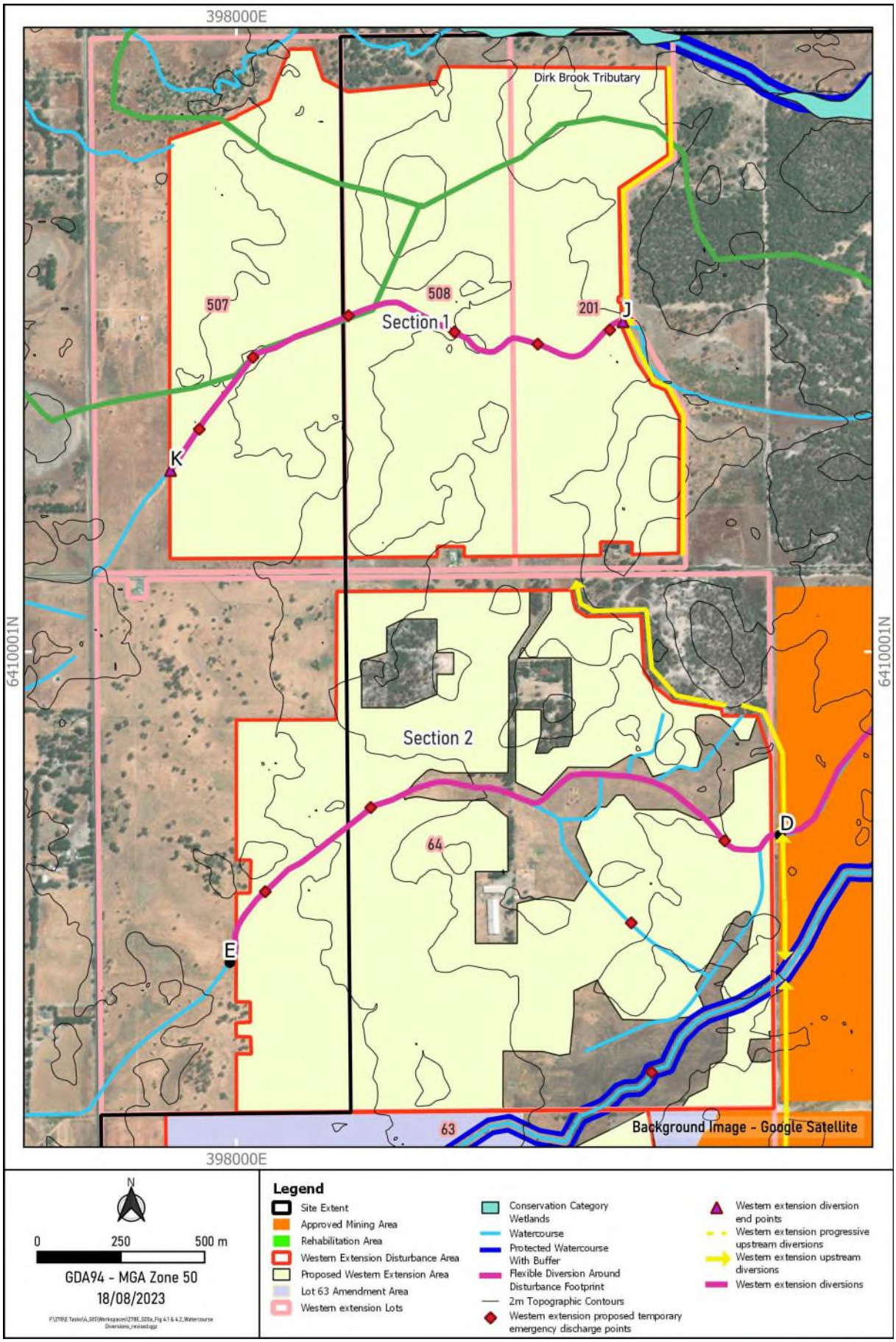

Figure 4.1 Western Extension Watercourse Management – Sections 1 and 2

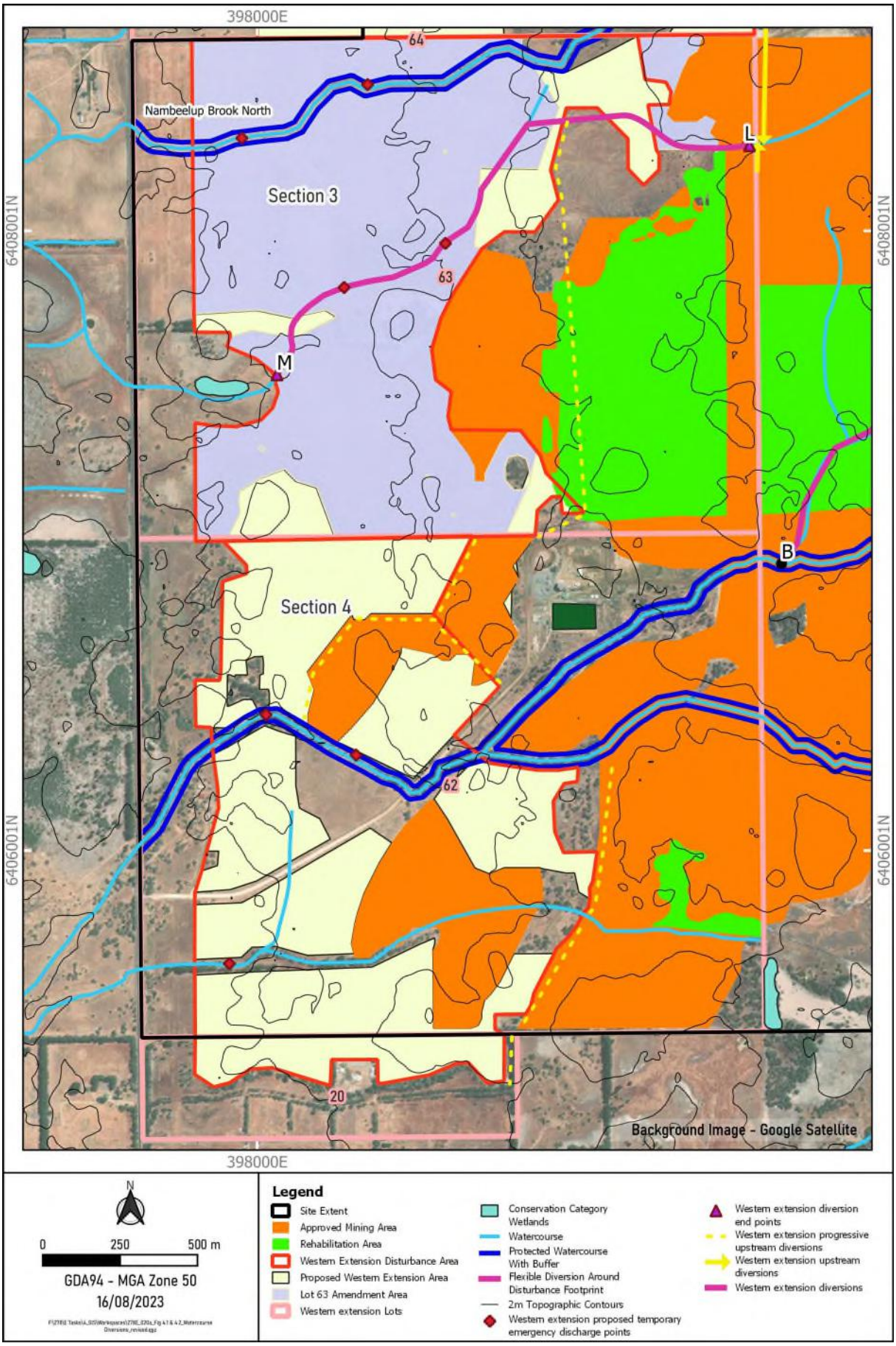

Figure 4.2 Western Extension Watercourse Management – Sections 3 and 4

4.2. Mine Catchment Runoff and Discharge Points

Runoff from the Project area will continue to be collected in the Process Water Dam (a series of 3 dams with overflow channels between them and a combined capacity of 74ML), located near the primary processing plant, as discussed in AQ2 (2020) and MBS (2015); Doral will ensure that this has sufficient capacity to accommodate the Western Extension.

Consistent with previously approved areas, it is assumed that runoff from within the Western Extension is to be captured in a 'return water settling pond' prior to being pumped via the dewatering system to be harvested and stored in the Process Water Dam. If a rainfall sequence causes runoff from the disturbed areas to be in excess of water demand requirements, (i.e., where pumping to the Process Water Dam would cause levels to rise above normal operating levels), pumping to local emergency discharge locations is proposed instead. In the event of surplus water volumes being released into the environment, any surplus water discharged off the site at the local emergency discharge locations would have naturally entered the waterways anyway and changes in flooding regime (other than minor local effects) are unlikely to occur. The mitigation measures required are those at the overflow release points into the environment.

To keep any emergency discharge returning to the same tributary as per the existing hydrological regime, Doral have proposed an additional 10 temporary emergency discharge points, as shown on Figure 4.1 and Figure 4.2, to allow for progression as the mining front moves in stages across the Western Extension. It should be noted that 8 temporary emergency discharge points within Section 3 have already been proposed as part of the Lot 63 amendment and are shown on Figure 4.2. The operation of any of these would be the same as has been applied to date and the receiving environment of adjacent points would be the same whichever is adopted. Some of the proposed discharge points are into minor watercourses which will be progressively diverted during mining, however they may be used prior to the diversion.

4.3. Management of Mine Water

The WMP (MBS, 2015) defines the approach to be adopted for management of mine water and it is assumed that this will continue to be applied within the Western Extension. The WMP states that mining areas will have ring drains installed with a sump on the pad perimeter. Tails decant sumps will be installed in tailing areas within the mine void. Water from these sumps will be transferred to the process circuit. The mine void will be bunded to prevent surface inflows from adjacent areas. 'V' drains will be installed to divert surface flows around assets and operating areas.

MBS (2006) recommended that surface water quality impacts can be minimised by the following measures:

- Isolating infrastructure areas that have the potential to contaminate surface water.
- Constructing sediment sumps, silt and oil traps where necessary to remove sediments or pollutants from runoff before water enters local drainage.
- Immediate clean-up of any spills of contaminants, such as oil or fuel.

The major water quality issue in the area is the high levels of nutrients. Mining is unlikely to have any effect on nutrient levels in runoff, but care should be taken in rehabilitation activities to minimise actions that could raise nutrient levels such as use of excessive fertiliser.

As a result of heavy rainfall events, there is the potential for increased turbidity from recently rehabilitated areas that are not yet fully stabilised. Sedimentation basins should be constructed where required to reduce turbidity before release to the environment. The Water and Rivers Commission Water Quality Protection Guideline 11 lists criteria for TDS and total suspended solids (TSS) in mine discharge water to not cause an increase above 10% of seasonal background levels.

4.4. Water Quality

The existing regional water quality relative to the Project was discussed by MBS (2006, 2015). The Statewide River Water Quality Assessment (DoW 2007) shows water quality data for Nambeelup Brook (Site 614063), located 10 kilometres downstream (southwest) of the Project was of neutral pH, with very high nitrogen and phosphorus concentrations and high turbidity. This shows water quality has been affected by historic and existing land uses prior to any mining taking place.

As noted in the DWER Licence Appendix, the process ponds act as sedimentation basins, settling suspended solids prior to overflow. Based on monitoring undertaken in relation to the Project as a whole, a pH and a TSS exception was recorded in comparing the pond water quality with the water quality in the environment. In general, the measured background and pond water quality values reflect the disturbed nature of the receiving environment. As such, the consequence of captured water released into the environment is considered to be local only, with no significant impact on water quality (AQ2, 2020).

Figure 4.3 shows existing surface water monitoring sites that were proposed by previous studies, along with new locations proposed for the Western Extension, which should be monitored for the same parameters and at the same frequency as the existing sites. The proposed sites are located either upstream of proposed mine disturbance areas (Sections 1 and 4) or downstream at the western edge of the Lot boundaries.

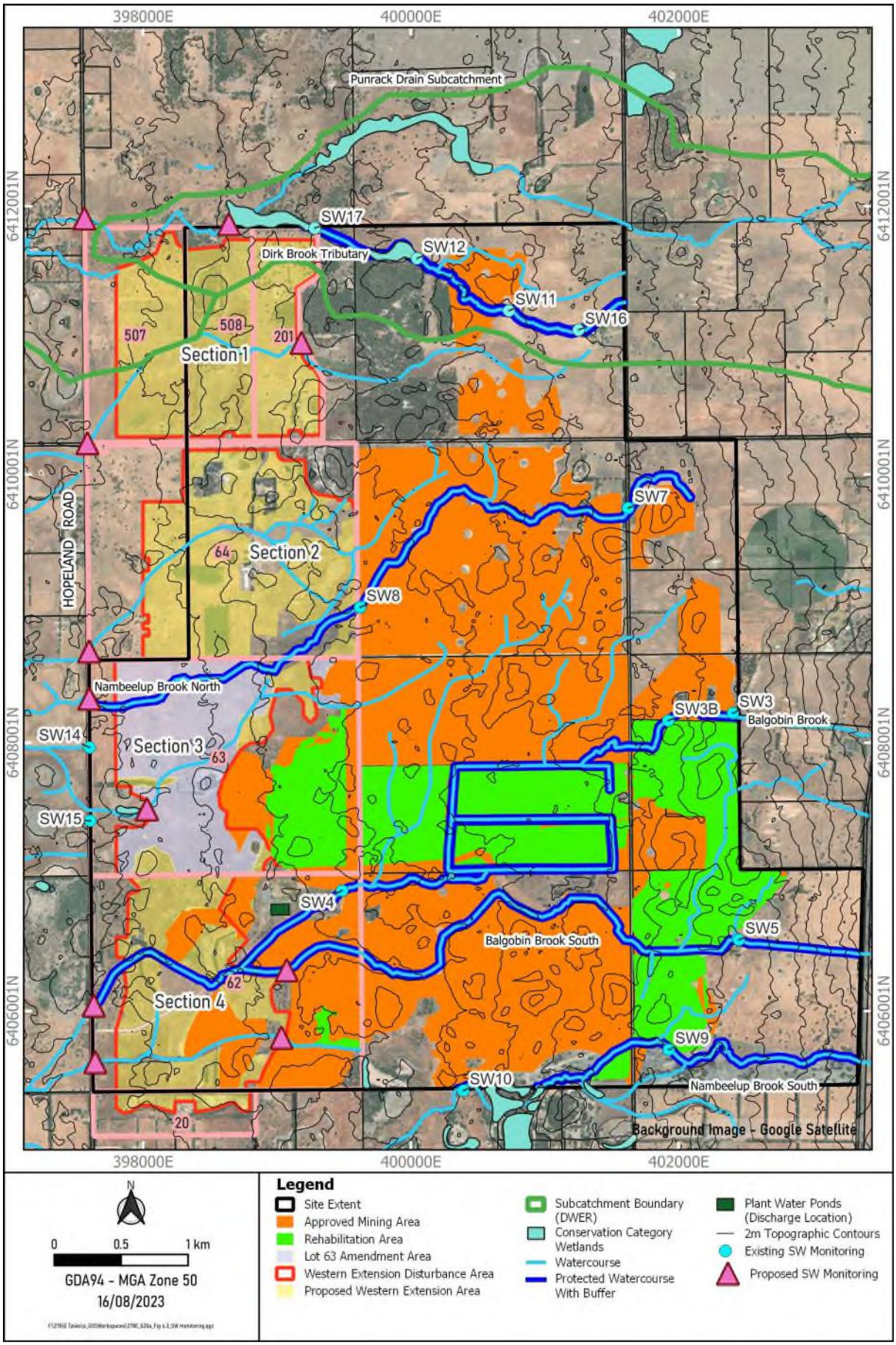

Figure 4.3 Surface Water Monitoring

5. POTENTIAL IMPACTS ON TECS AND CCWS

The WMP (MBS, 2015) discusses potential impacts of the Project on CCWs and native vegetation, including lowering of the water table, changes to water quality and reduced health and condition. Due to the requirement to capture and retain water onsite, a reduction in flow to these areas should also be considered.

The 0.5m and 2m contour information provided by Doral has been used to delineate the surface water catchments for CCWs/TEC that are potentially impacted by the Western Extension (refer to Figure 5.1). The potential reductions in catchment areas due to mine disturbance are presented in Table 5.1. Note that the accuracy of the delineated catchments is limited by the available topographic data and there is potentially considerable uncertainty in their sizes.

Based on the limited topographic data available, the proposed mining area of Section 1 has the most significant impact on downstream CCWs as all of the disturbance area sits within CCW catchments. It causes approximately 21% reductions in the catchments of 14825 and 17% of the combined area of 14763/14798. The proposed additional mining area of Lot 63 (Section 3) does not cause any additional reduction in the catchment of 14870. It should be noted that the catchment delineations suggests that no TECs are impacted by the proposed Western Extension development (Figure 5.1).

This assessment takes into consideration areas that are being coincidentally backfilled and/or restored and are therefore also removed from the catchment.

Table 5.1 Possible Reductions in CCW and TEC Catchment Areas

Section	CCW/TEC	Total Catchment Area (km^2)	Total Possible Mining Area in Catchment (km^2)	Reduction in Catchment Area (%)
1	7000	0.9	0.1	12
	14825	6.5	1.4	21
	14850	23.9	0.04	<1
	14763 14798	7.9	1.4	17
	14760	26.5	0.2	1
2	14825	6.5	0.3	4
	14763 14798	7.9	0.3	3
	14807 14795	3.7	0.1	3
3	14870	0.7	0.2	0
4	-	-	-	-

Given these potential reductions in catchment area it is therefore recommended that, in addition to the SW monitoring recommended above, in line with the WMP (MBS, 2015), the presence or absence of standing surface water in the CCWs potentially impacted by the project should be recorded monthly. The WMP also makes recommendations relating to vegetation monitoring of the small Dirk Brook CCW.

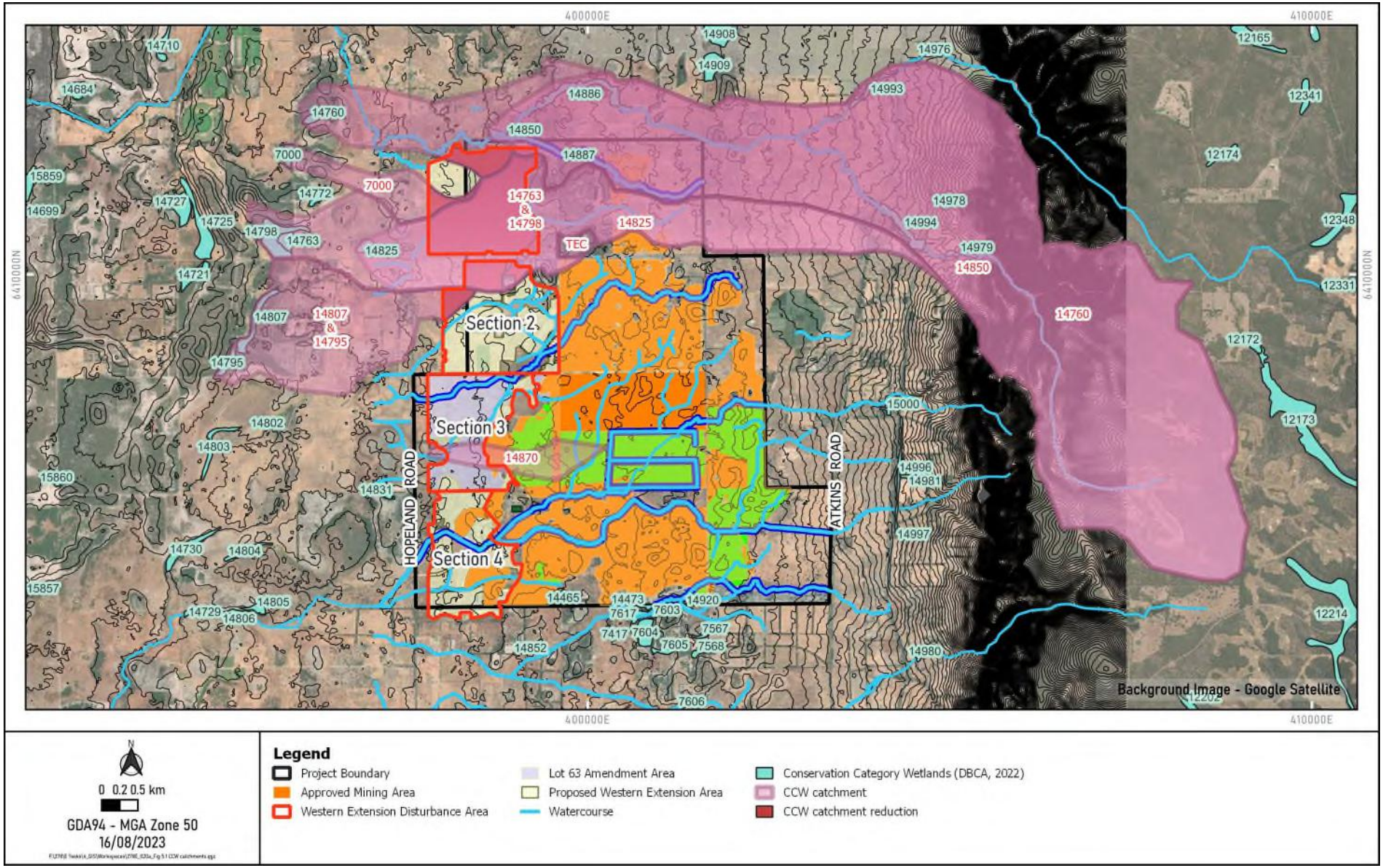

Figure 5.1 CCW and TEC Catchments

6. CONCLUSIONS

This assessment considers the potential changes to the surface water environment as a result of the proposed Western Extension of the Project, which has been broken down into four progressively mined Sections. It has been assumed that the surface water management philosophy of the Project has remained unchanged from that reported in the WMP (MBS, 2015) and by AQ2 (2020). As a result, the buffer zone surrounding Major and Medium watercourses will continue to apply, protecting them from disturbance. The smaller watercourses flowing across the Western Extension will be diverted around mining areas and subsequently restored, minimising the impact on downstream flows.

Any surface water runoff from disturbed areas within the mine site will be collected and added to the process water circuit. Ten temporary emergency discharge locations for the Western Extension have been suggested by Doral. Where release of surface water to the environment does occur, there is unlikely to be material change to the flooding regime downstream, as the discharge of water to the environment is returning catchment yield to the natural downstream hydrological environment, which had been removed by the development. Monitoring within the existing operations indicates the water quality in the mine ponds is similar to the background water quality in the receiving environment and release of the water would therefore not have a significant impact on downstream water quality.

The main potential impact of the expanded mining area is due to the removal of catchment runoff that would have previously reached the CCWs downstream, particularly due to Sections 1 and 2. There is no potential impact to any TECs identified due to reduction in catchment area. Recommendations have been made for additional SW monitoring locations to monitor the effects of operations within the Western Extension and identify potential impacts on the CCWs, along with monthly observations of the presence or absence of water within them.

7. REFERENCES

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