Appendix A Land systems, description

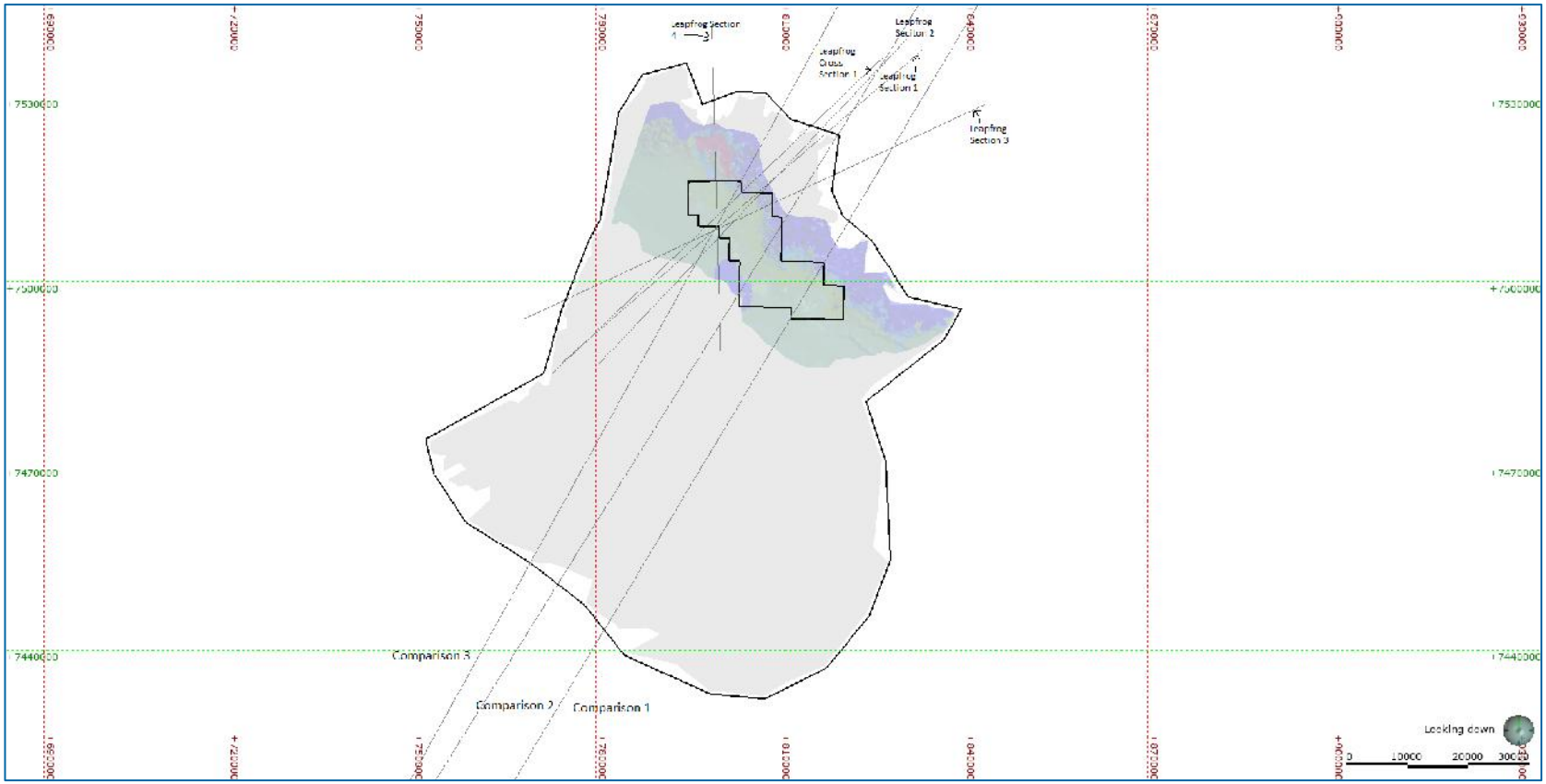
Land system	Type	Description
Adrian	6	Stony plains and low silcrete hills supporting hard spinifex grasslands: Erosional surfaces typified by rounded hills and rises. Short drainage lines with radial patterns away from rises. Soils are stony and shallow.
Billygoat	5	Dissected plains and slopes supporting hard spinifex grasslands: Erosional surfaces including extensive dissected gravelly/stony plains, minor plateaux and residual upper plains and occasional low breakaways. Narrow interfluves and slopes with dendritic drainage networks. Slopes marginal to drainage lines are often calcreted. Soils are shallow and stony/gravelly.
Bonney	6	Low rounded hills and undulating stony plains supporting soft spinifex grasslands : Erosional surfaces including low hills, undulating rises and gently undulating stony plains. Widely spaced drainage patterns of narrow drainage floors with minor channels. Upland soils are shallow and stony, with a mix of non-cracking clays, calcareous loamy earths and red loamy earths on rises and plains.
Boolgeeda	8	Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands and Mulga shrublands: Quaternary colluvium parent materials. Closely spaced dendritic and sub-parallel drainage lines. Predominantly depositional surfaces characterised by red loamy soils of variable depth.
Brockman	14	Alluvial plains with cracking clay soils supporting tussock grasslands: Depositional surfaces derived from Quaternary alluvium. Non-saline alluvial plains with clay soils and gilgai micro-relief, flanked by slightly more elevated hardpan washplains. Sluggish internal drainage with occasional channels. Soils are mainly self-mulching cracking clays and red/brown non-cracking clays, with some red loamy earths on elevated washplains.
Calcrete	18	Low calcrete platforms and plains supporting shrubby hard spinifex grasslands: Tertiary calcrete formed in detrital deposits, with minor Quaternary alluvium. Drainage is generally indistinct. Soils are mainly shallow calcareous loams (<50 cm overlying calcrete), with minor calcareous loamy earths and red shallow loams.
Coolibah	17	Floodplains with weakly gilgaied clay soils supporting Coolibah woodlands with Tussock grass understorey: Depositional surfaces; active floodplains and alluvial plains associated with the Fortescue river (i.e. non-Fortescue Marsh sections). Soil types mainly include deep red/brown non-cracking clays, with some deep red loamy duplex soils.
Cowra	15	Plains fringing the Marsh land system and supporting Snakewood and Mulga shrublands with some halophytic undershrubs: Depositional surfaces; almost level plains of non-saline and weakly saline alluvium with gravelly surfaces. Drainage foci and tracts support denser vegetation, included banded formations in some places. Soils mainly include red loamy earths and duplex types; with abundant cobbles and stony mantles. Restricted to the Fortescue Valley and considered to have elevated conservation significance (EPA 2013).
Divide	11	Sandplains and occasional dunes supporting shrubby hard spinifex grasslands: Depositional surfaces reworked by Aeolian processes. Drainage is generally indistinct. Soils are mainly red deep sands and red sandy earths, with occasional shallower soils overlying gravel or rock.
Elimunna	10	Stony plains on basalt supporting sparse Acacia and Senna shrublands and patchy tussock grasses: Mainly depositional surfaces including level to gently undulating plains with a mosaic of surface types (e.g. stony, gilgai microrelief), Wide to very wide spaced tributary drainage floors, with sluggish internal drainage patterns on gilgai plains. Mostly heavy soil types (cracking and non-cracking clays).
Fan	12	Washplains and gilgai plains supporting groved Acacia shrublands (Mulga and Snakewood) and minor tussock grasslands: Flat depositional surfaces subject to overland flow and banded vegetation formations. Soils are generally deep red loamy earths.
Fortescue	17	Alluvial plains and floodplains supporting patchy grassy woodlands and shrublands and tussock grasslands: Depositional surfaces associated with river channels and commonly subject to fairly regular flooding. Soils are mainly deep red/brown non-cracking clays and self-mulching cracking clays.
Jamindie	12	Stony hardpan plains and rises supporting groved Mulga shrublands, occasionally with spinifex understorey: Depositional surfaces including non-saline plains with hardpan at shallow depth, stony upper plains and low rises on hardpan or rock. Very widely spaced tributary drainage tracts and channels. Minor stony gilgai plains, sandy banks and low rides and hills. Shallow loamy soils (often stony/gravelly) are predominant.
Laterite	4	Laterite mesas and gravelly rises supporting Mulga shrublands: Erosional surfaces formed by dissected parts of the old Tertiary plateaux. Mesas and breakaways, gravelly footslopes and lower plains. Drainage tracts and floors with sluggish

Land system	Type	Description
		drainage or sub-parallel braided creeks (frequently saline). Soils are generally shallow sands and gravels; with red/brown cracking and non-cracking clays in low-lying areas.
Marillana	15	Gravelly plains with large drainage foci and unchannelled drainage tracts supporting Snakewood shrublands and grassy Mulga shrublands: Depositional surfaces derived from Quaternary alluvium. Sheetflow areas occur and are associated with stony surface mantles. Broad, unchannelled drainage tracts can receive more concentrated through flow. Soils are generally deep red loamy earths, duplex soils or clays. Considered to have elevated conservation significance (EPA 2013).
Marsh	20	Lakebeds and floodplains subject to regular inundation, supporting samphire and halophytic shrublands: Depositional surfaces derived from Quaternary alluvium and lacustrine deposits. Soils include red/brown clays, often with high alkalinity and gypsum content. Soils can be underlain by siliceous or calcareous hardpans.
McKay	1	Hills, ridges, plateau remnants and breakaways of meta-sedimentary and sedimentary rocks supporting hard spinifex grasslands: Erosional surfaces with moderately spaced tributary drainage patterns incised in narrow valleys in upper parts, becoming broader and more widely spaced downstream. Soils are mainly shallow and stony.
Narbung	15	Alluvial washplains with prominent internal drainage foci supporting Snakewood and Mulga shrublands with halophytic low shrubs: Almost level alluvial plains receiving overland sheetflow. Localised internal drainage, with no defined channel features. Soil types generally include red deep sandy duplex and shallow sandy duplex soils.
Newman	1	Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands. Widespread across the Pilbara region: Erosional surfaces, characterised by skeletal soils (with abundant pebbles, cobbles and stones) and frequent rock outcropping. Soils are shallow and stony.
River	17	Active floodplains and major rivers supporting grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands: Riverine environments subject to flooding, with generally deep soils of various texture classes.
Robe	3	Low limonite mesa and buttes supporting soft spinifex (and occasionally hard spinifex) grasslands: Erosional surfaces formed by partial dissection of old Tertiary surfaces. Closely to moderately spaced narrow tributary drainage floors. Soils are generally shallow and gravelly.
Rocklea	1	Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands: Erosional surfaces including hills, ridges and plateaux remnants. Tributary drainage patterns grade into broader floors and channels downslope. Soils are generally shallow with abundant basalt cobbles.
Spearhole	12	Gently undulating hardpan plains supporting groved mulga shrublands and hard spinifex: Depositional surfaces including level to gently undulating plains on hardpan. Sparse patterns of tributary drainage with restricted areas of shallow valleys and finely dissected slopes. Soils are generally red brown shallow loams with hardpans, and red loamy earths.
Turee	14	Stony alluvial plains with gilgaied and non-gilgaied surfaces supporting tussock grasslands and grassy shrublands: Mosaic depositional surfaces of low relief (hardpan, stony and gilgai plains) inter-dispersed with few drainage channels. Localised sheetflow can occur. Soils include various earths, loams and clays often with abundant surface cobbles.
Warri	18	Low calcrete platforms and plains supporting Mulga and Senna shrublands: Depositional surfaces of low relief. Calcrete layers, with narrow inter-bedded areas. Soil types mainly include calcareous shallow loams and loamy earths. Surface mantles commonly include calcrete pebbles and fragments.
Washplain	12	Hardpan plains supporting groved mulga shrublands: Depositional surfaces including alluvial level hardpan plains. Discrete drainage foci associated with groved vegetation, with some drainage tracts receiving more concentrated flow. Soils are generally deep duplex types, and red loamy earths; commonly with hardpans at depth.

Appendix B Stratigraphy review

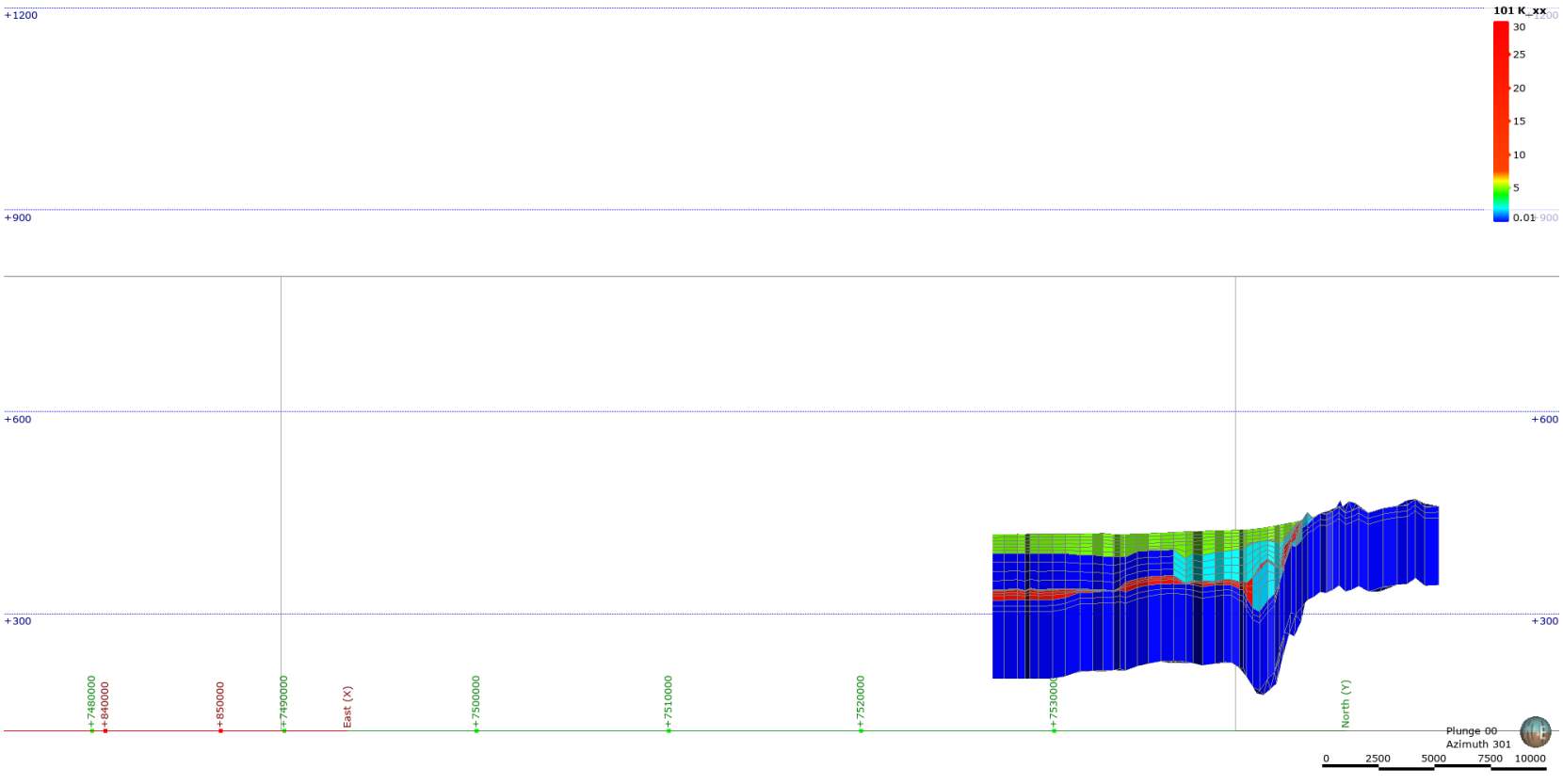
Age	Group	Formation	Member	Dominant lithology	Hydrogeology
Cainozoic	Quaternary	Eolian deposits (Qs)		Sand in sheets and longitudinal dunes	Generally unsaturated
		Alluvium (Qa, Ql, Qw)		Unconsolidated silt, sand, and gravel, in drainage channels and on adjacent floodplains	Often unsaturated, occasional aquifer, can be heterogeneous depending on texture
		Colluvium (Qc)		Unconsolidated quartz and rock fragments in soil	While unsaturated, may form localised, temporary, perched aquifers
	Tertiary Detritals (TD)	TD3		Valley-fill sandy silt (top) to clay (towards the base), calcretised in places	Generally aquitard
		Calcrete, silcrete, ferricrete		Lacustrine sediments including sheet carbonate (calcrete), Oakover Formation	Aquifer
		TD2		Channel iron deposits (CID), generally occurring at depth in palaeodrainages	Aquifer
Early Proterozoic - Archaean	Hamersley Group	Boolgeeda Iron Formation		Iron formation, pelite and chert	Low permeability material
		Woongara Rhyolite		Metamorphosed volcanicsand BIF	Low permeability material
		Weeli Wolli Formation		BIF, pelite, chert, dolerites, sills	Mostly unsaturated
		Brockman Iron Formation	Yandicoogina Shale Member	Interbedded chert and shale	Low permeability material
			Joffre Member	BIF with minor shale bands	Limited aquifer(s) in mineralised zones
			Whaleback Shale Member	Interbedded shale, chert and BIF	Low permeability
			Dales Gorge Member	Interbedded BIF and shale	Limited aquifer(s) in mineralised zones
		Mount McRae Shale		Shale and dolomitic shale with minor thinly bedded chert	Low permeability (in general), pockets of shale may form minor aquifers
		Mount Sylvia Formation		Shale, dolomitic shale, and BIF	Low permeability (in general), pockets of shale may form minor aquifers
		Wittenoom Formation	Bee Gorge Member	Graphitic shale with minor sequences of carbonate, chert, volcaniclastic rock, and BIF	Low permeability
			Paraburdoo Member	Dolomite with minor amounts of chert and shale - karstic in areas	Aquifer at regional scale, especially where karstified
			West Angela Member	Dolomite, dolomitic shale, and chert	Minor, localised aquifers
		Marra Mamba Iron Formation	Mount Newman Member	Chert, banded iron-formation, and shale	Aquifer in mineralised zones
			MacLeod Member	Well podded to laminar chert and chert BIF with shale macrobands	Low permeability
			Nammuldi Member	BIF with chert and shale	Aquifer in mineralised zones
Archaean	Fortescue Group	Jeerinah Formation	Roy Hill Shale Member	Dark-gray to black graphitic shale and chert; locally pyritic	Low permeability
			Warrie Mamber	Dolomite with inter-bedded chert (locally ferruginous), shale and mudstone	Low permeability

Appendix C Section views (Leapfrog, MODFLOW, FEFLOW)

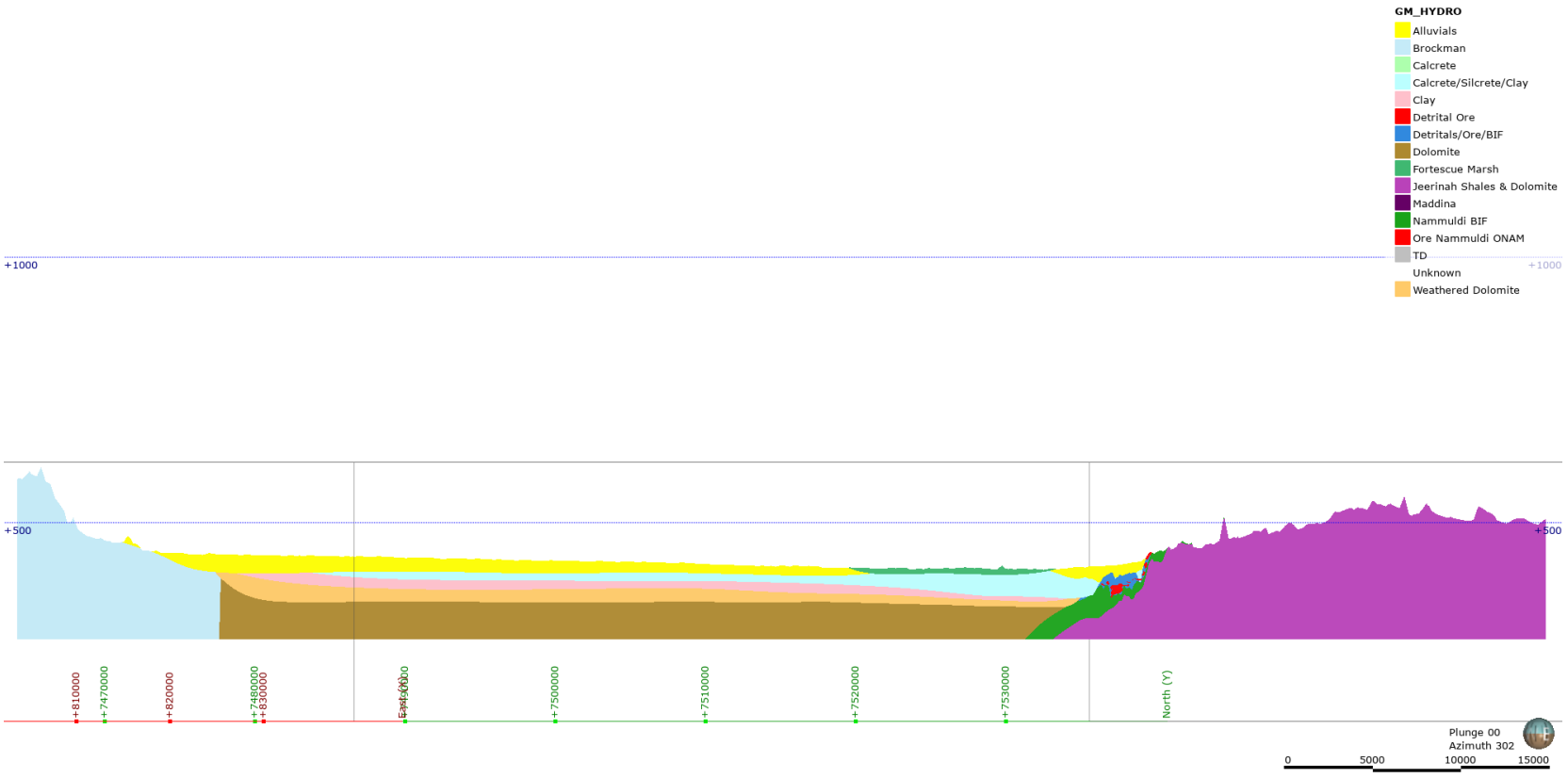


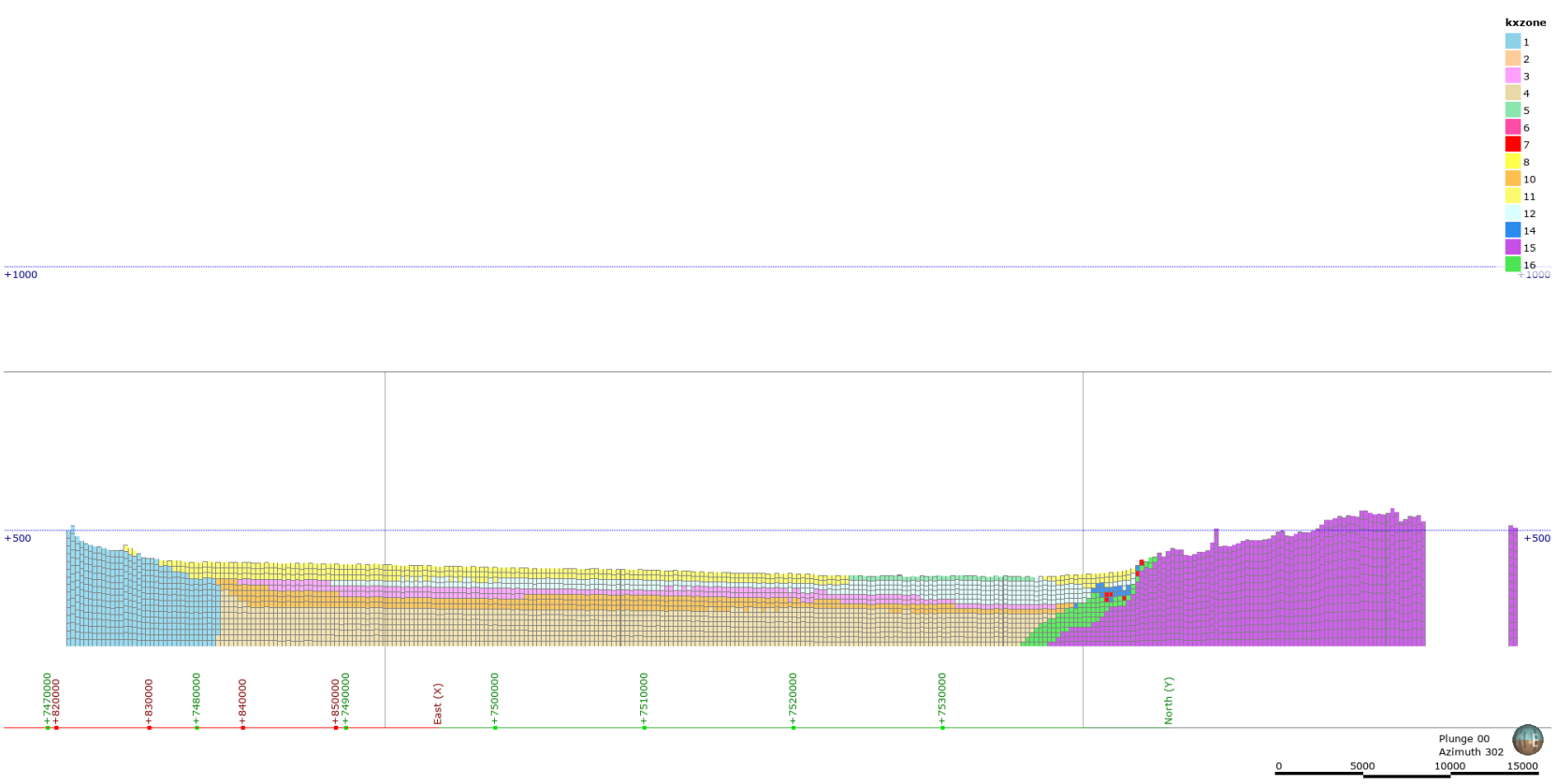
Locations of comparative sections

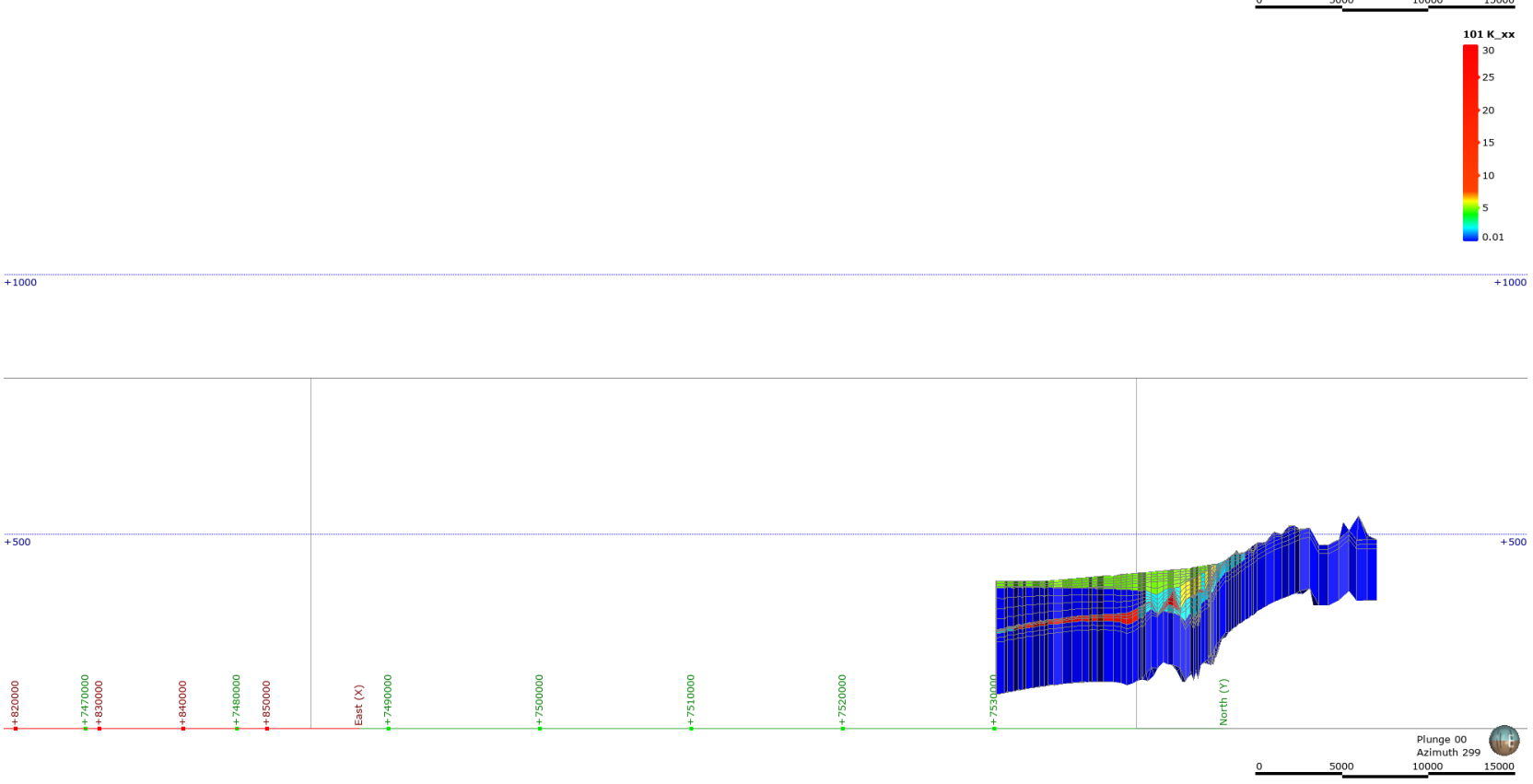
Comparison Section 1



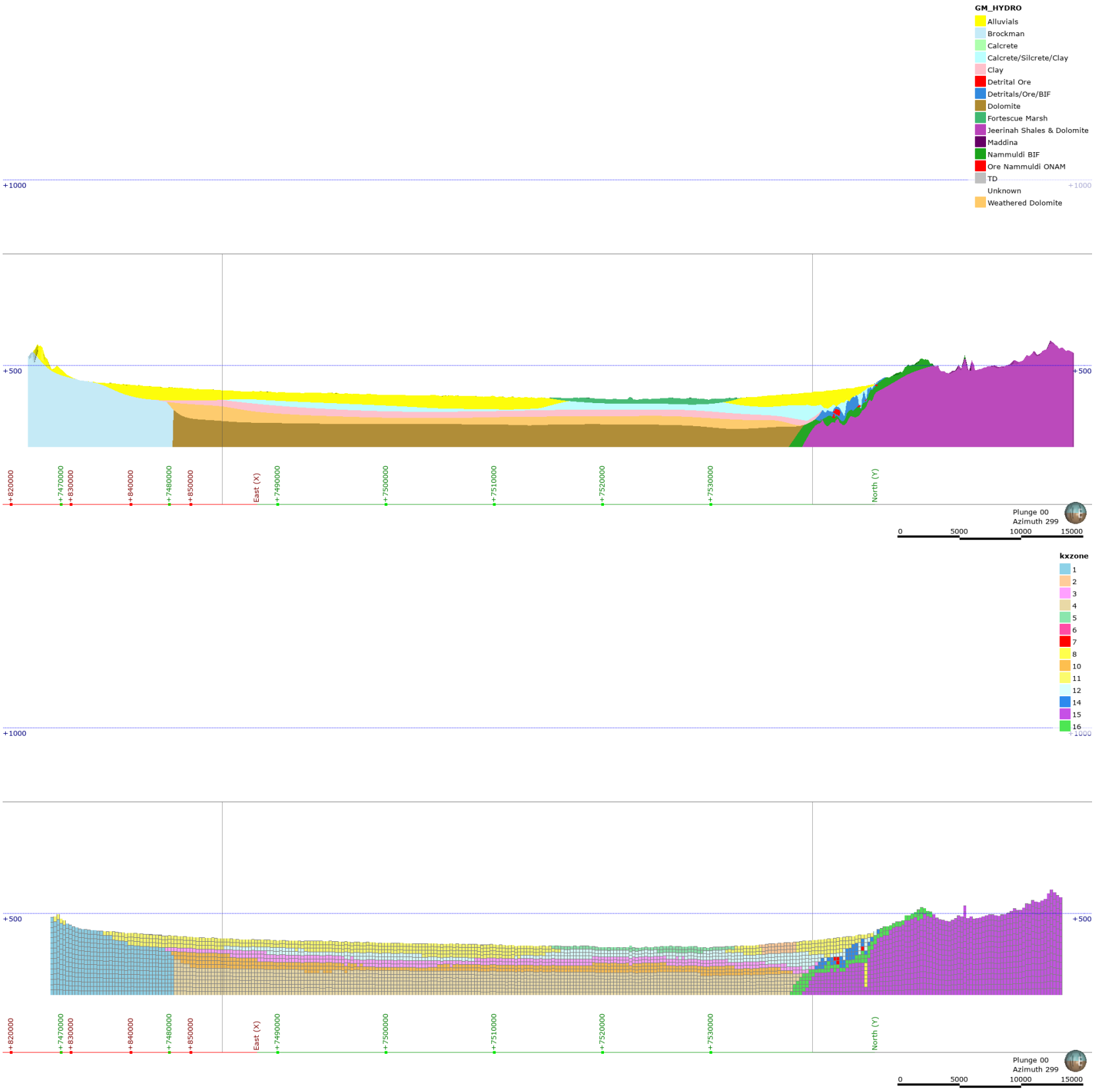
Comparison Section 2

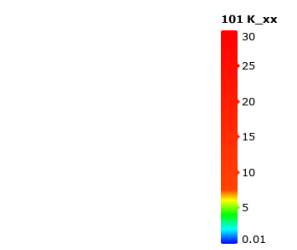


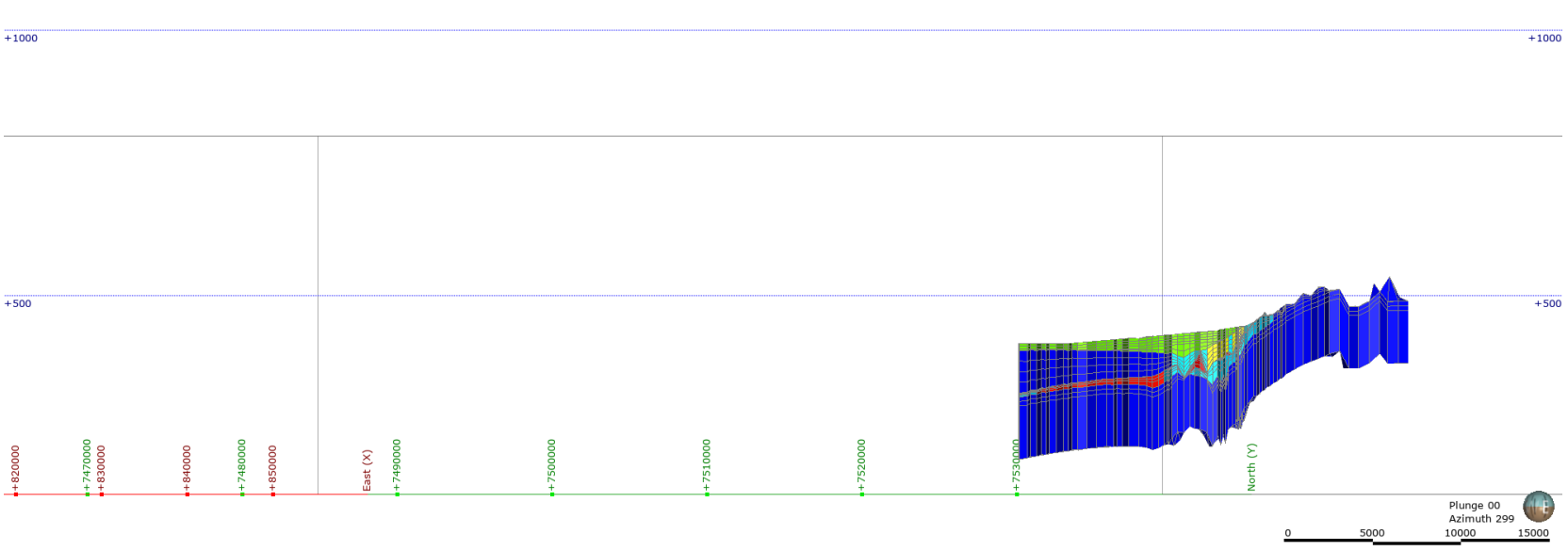




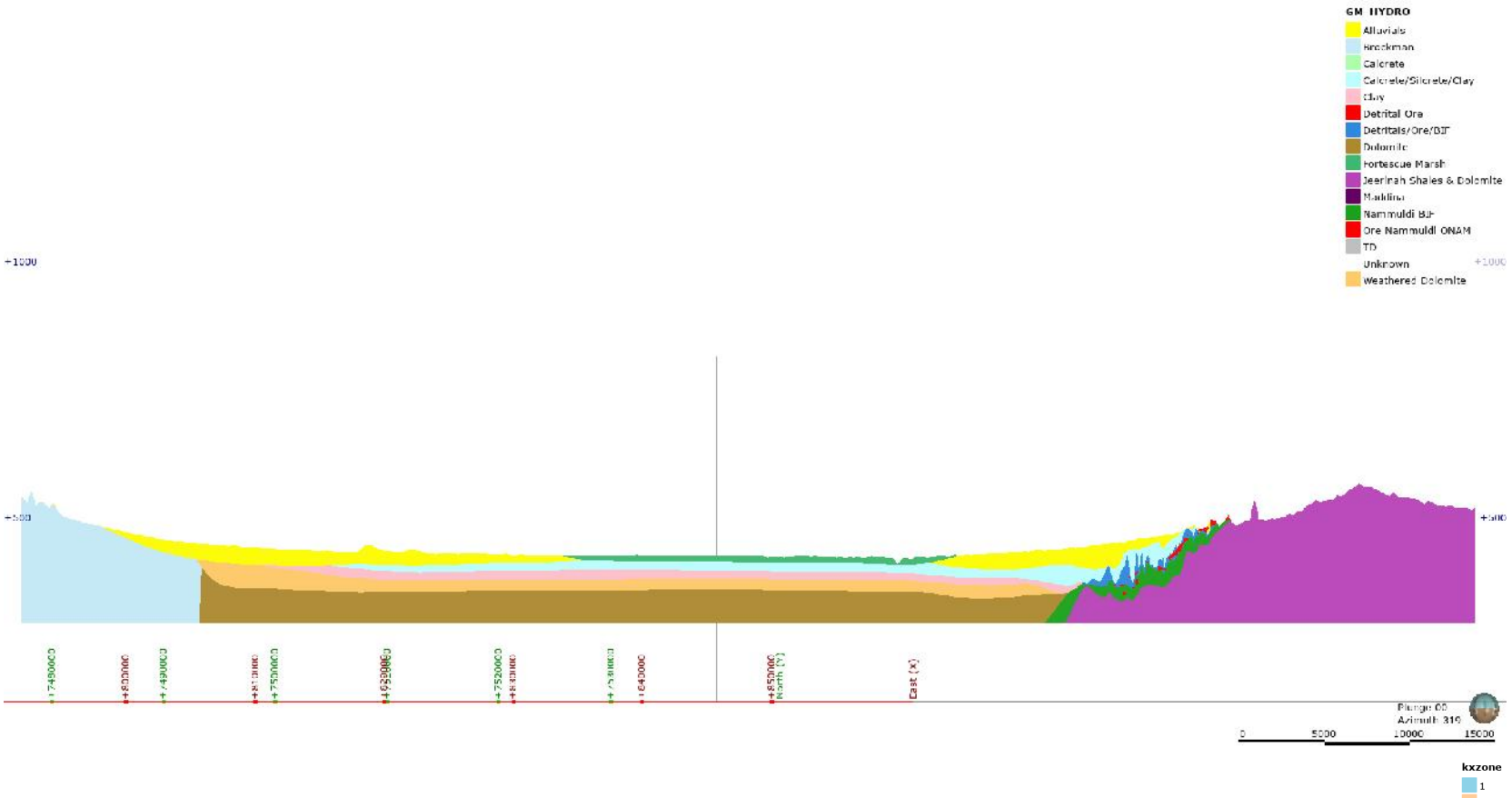
Comparison Section 3

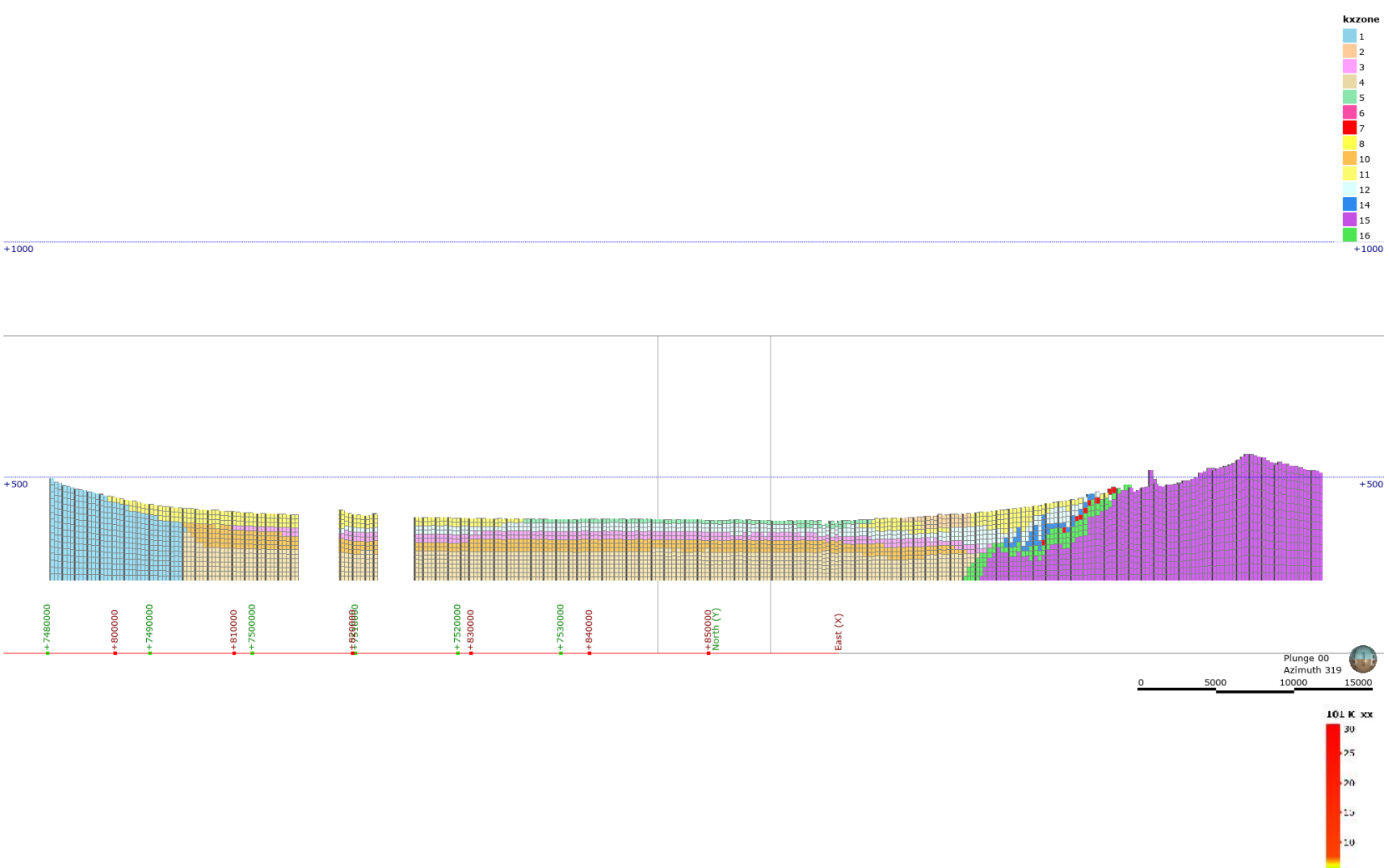






Leapfrog Section 1





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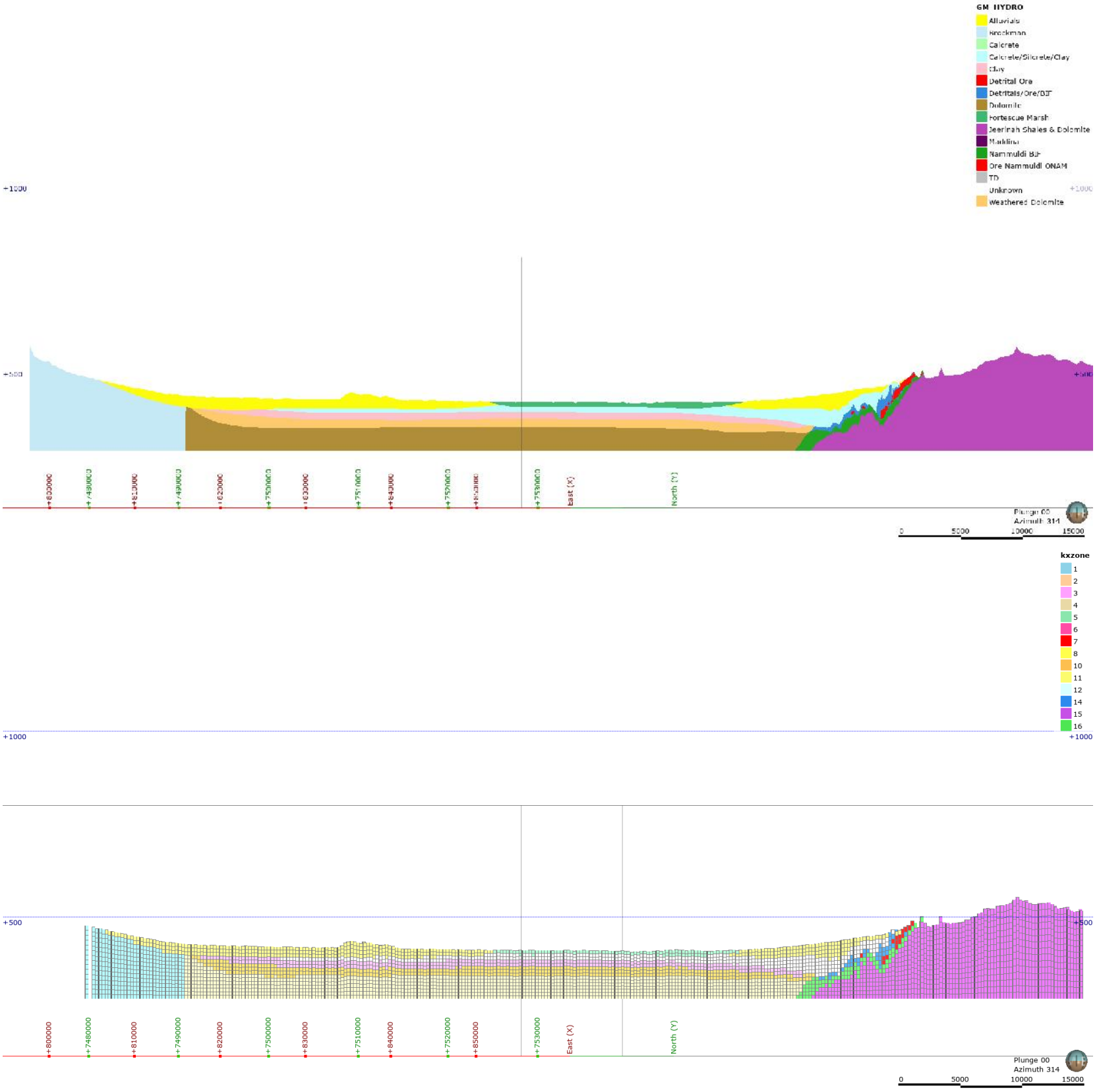
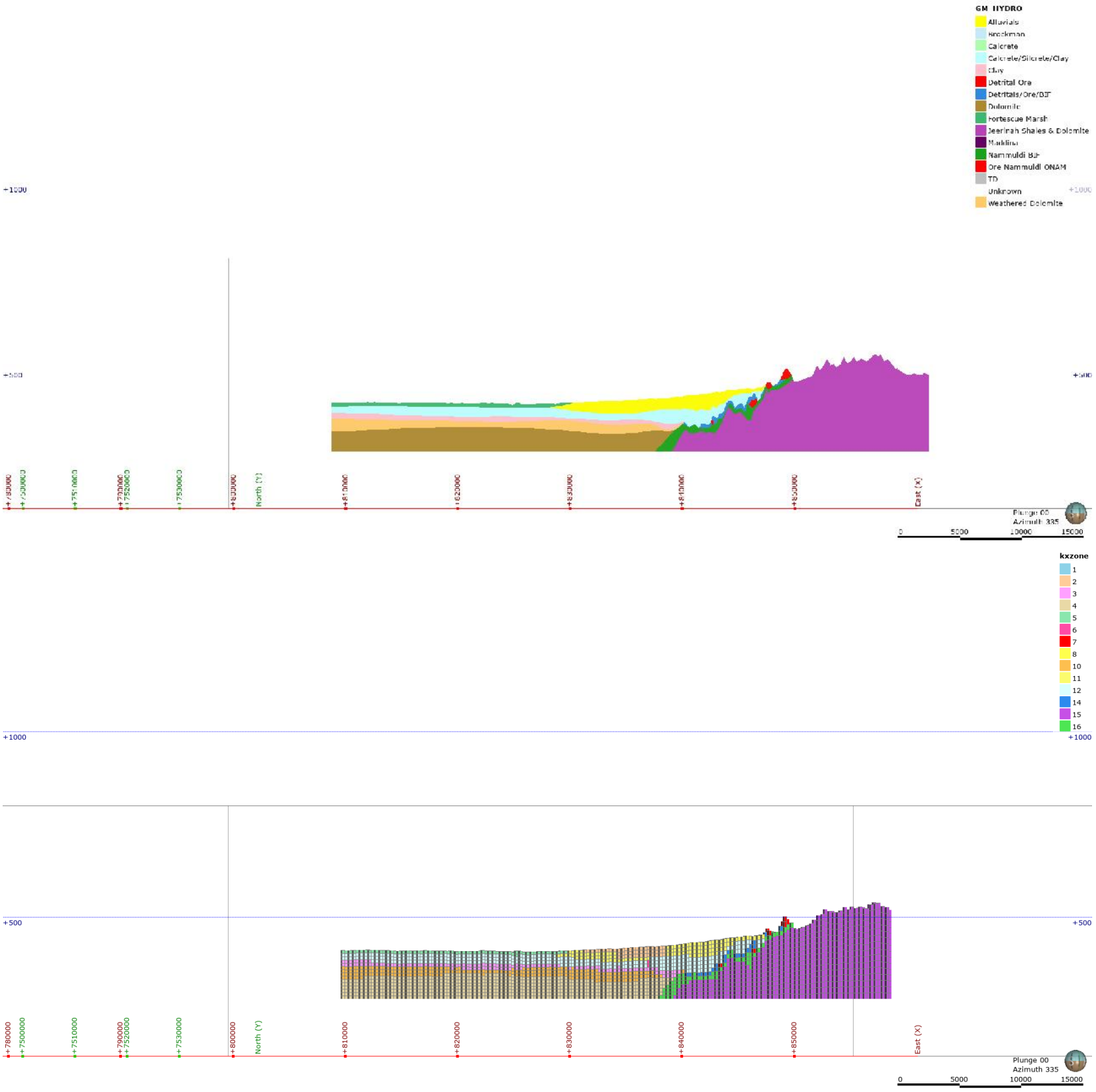
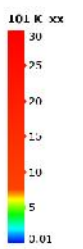
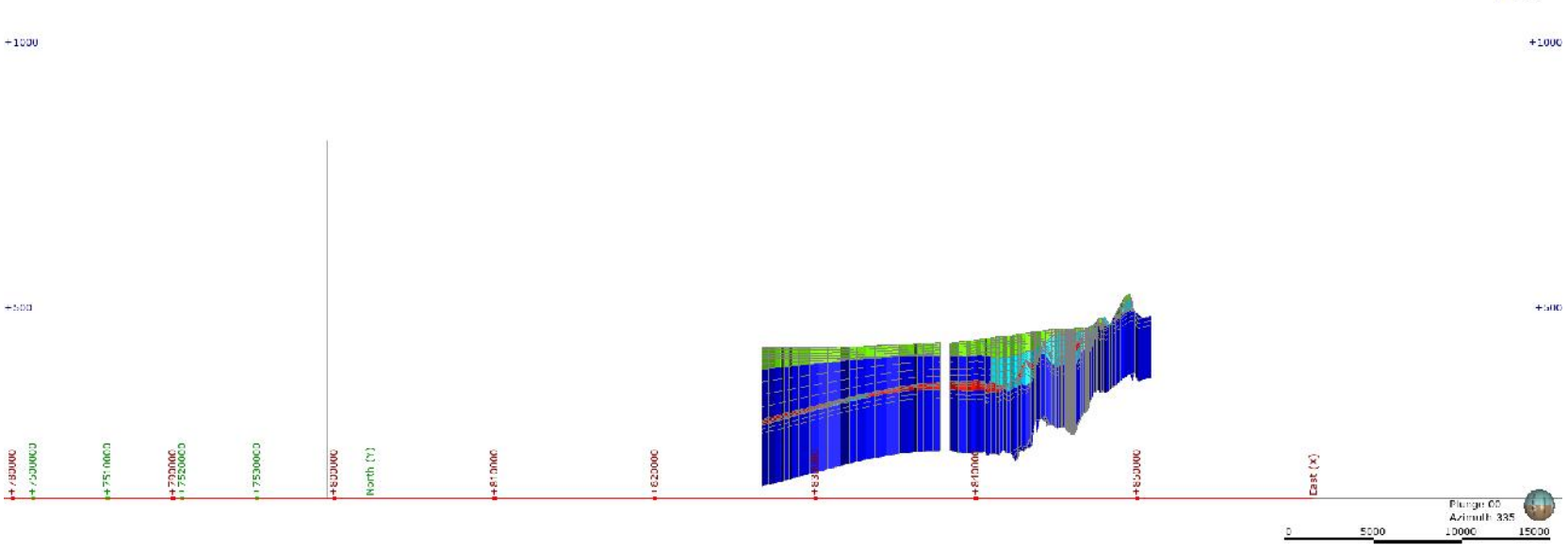


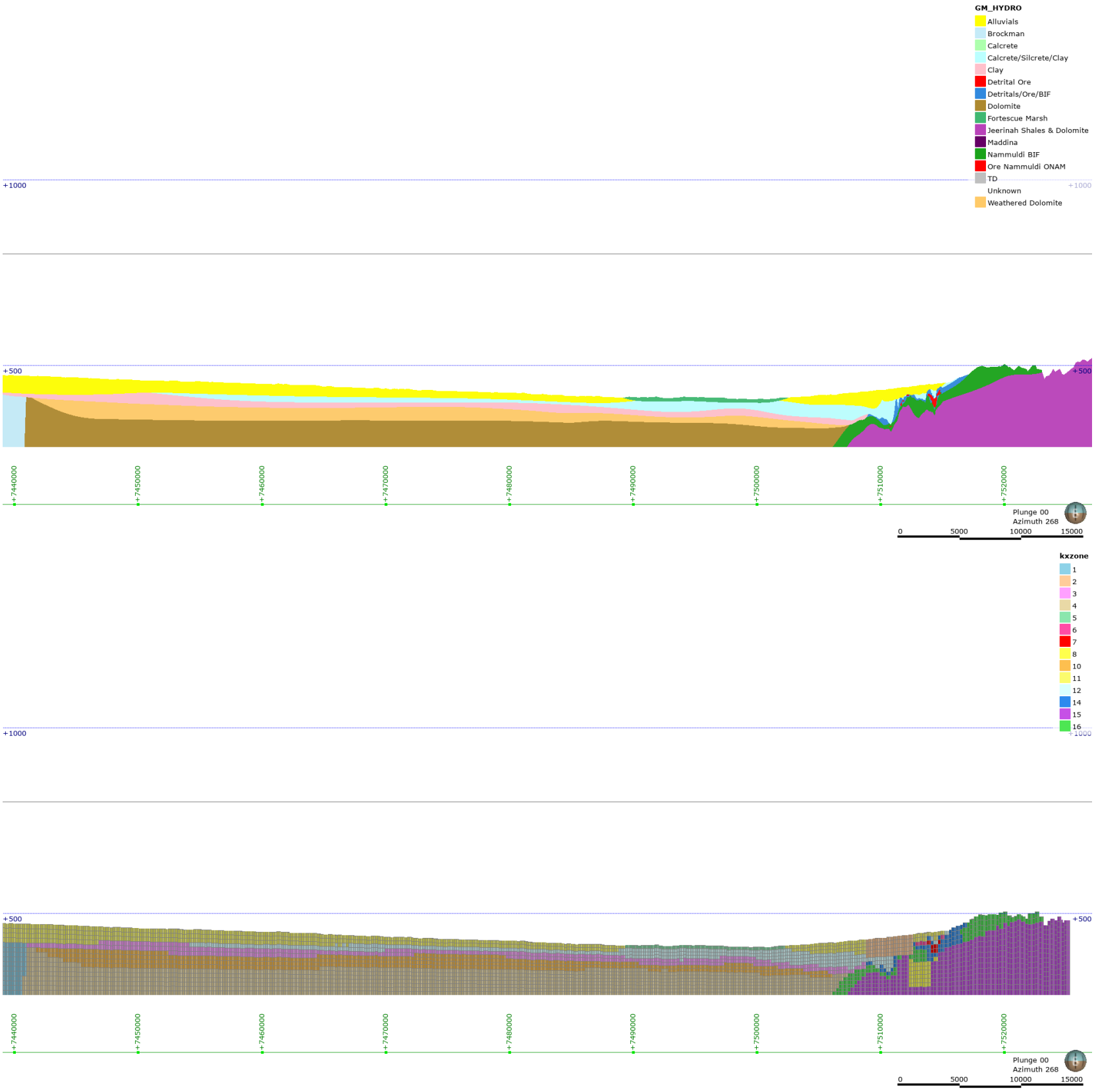
Leapfrog Section 3



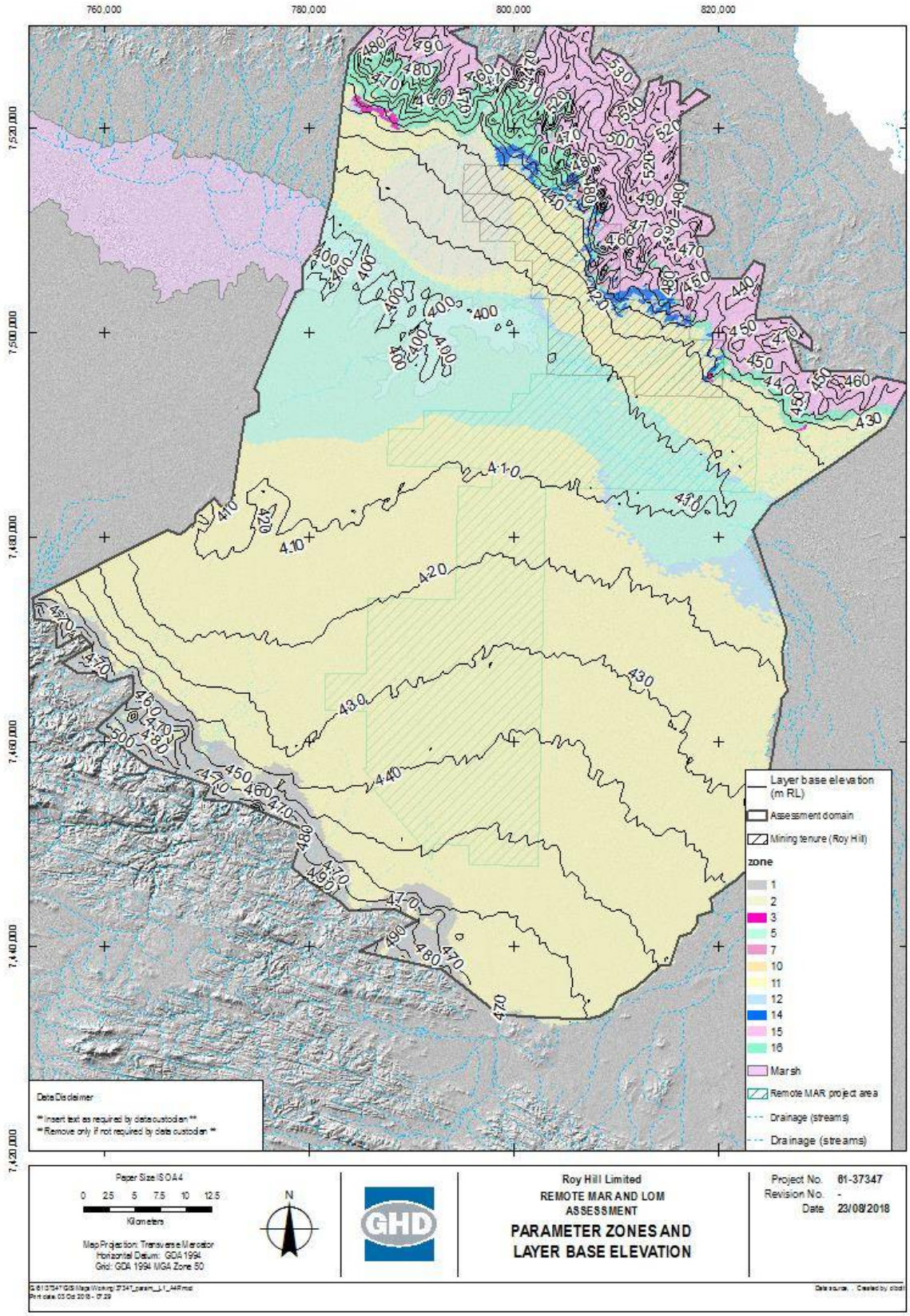




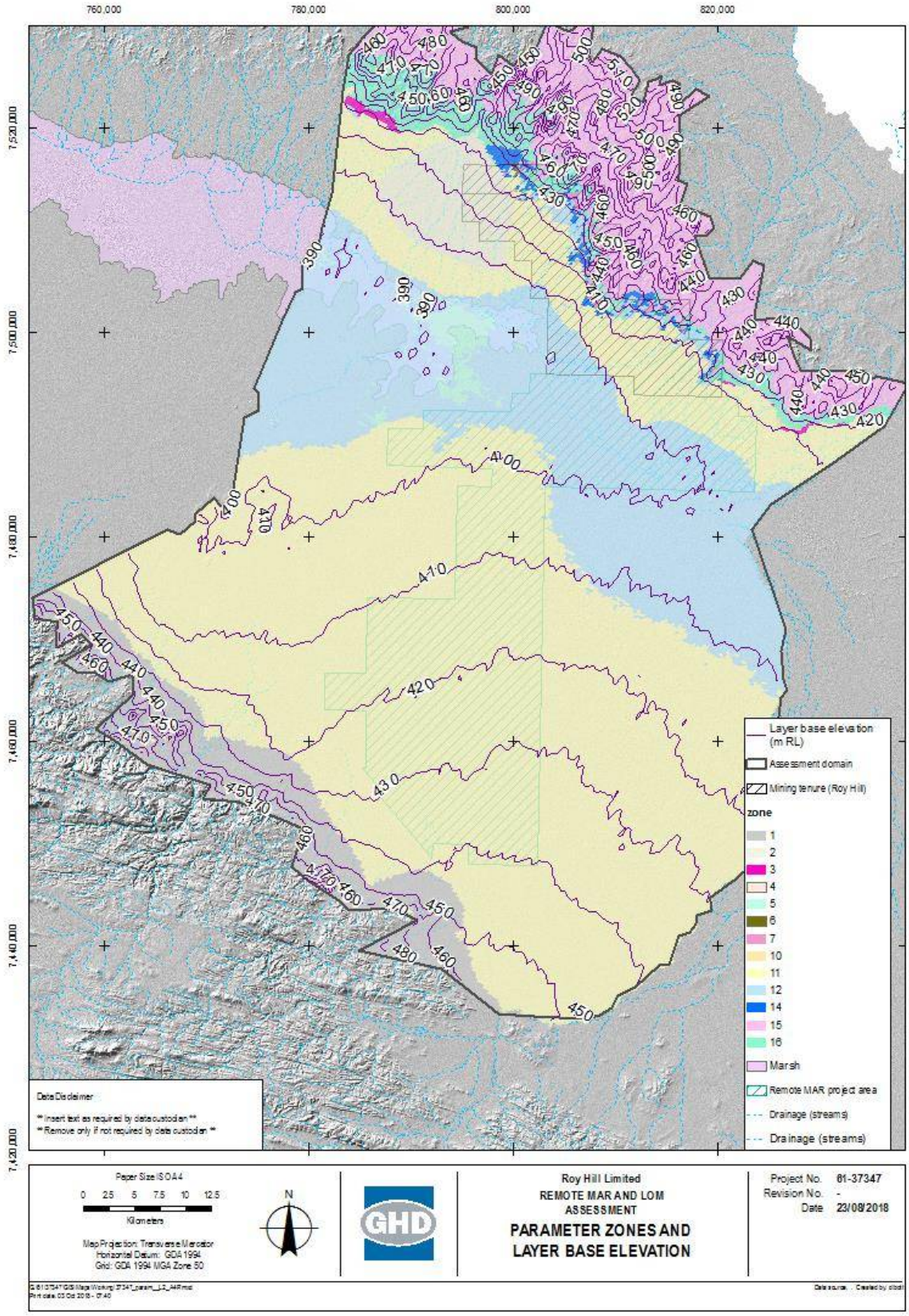
Leapfrog Section 4



Appendix D Hydraulic property zone maps



Parameter zone spatial delineation and base elevations, model layer 1



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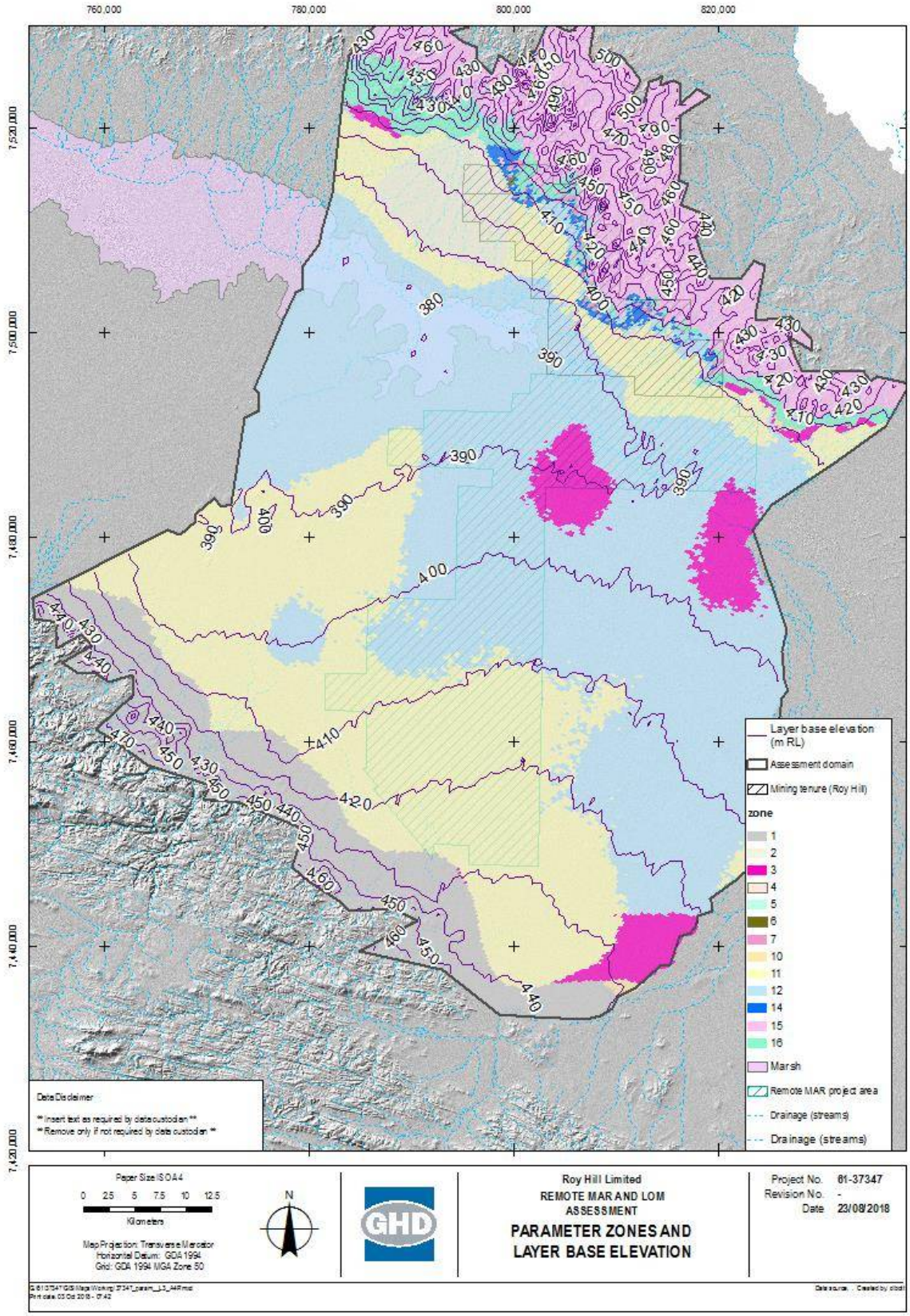

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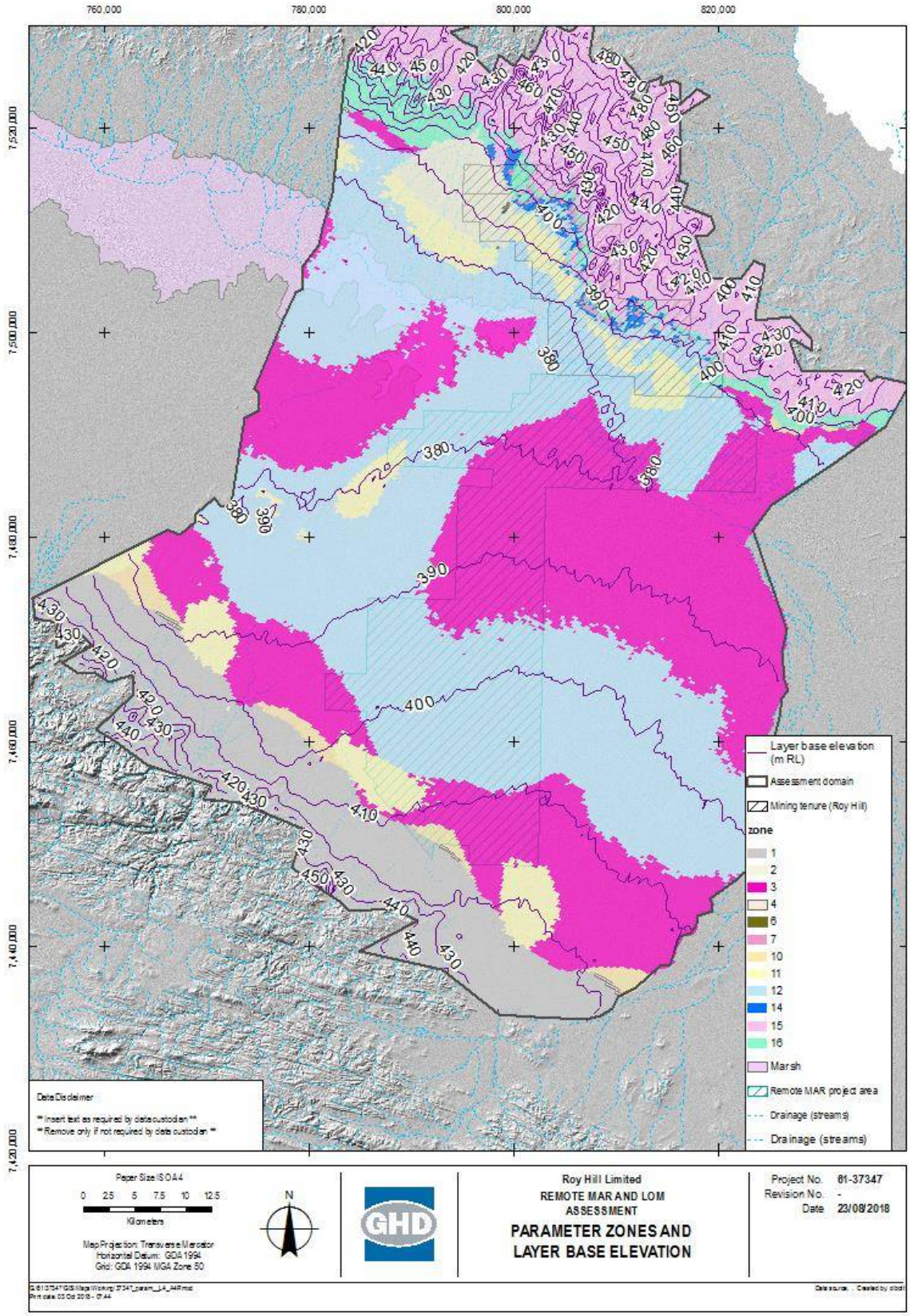

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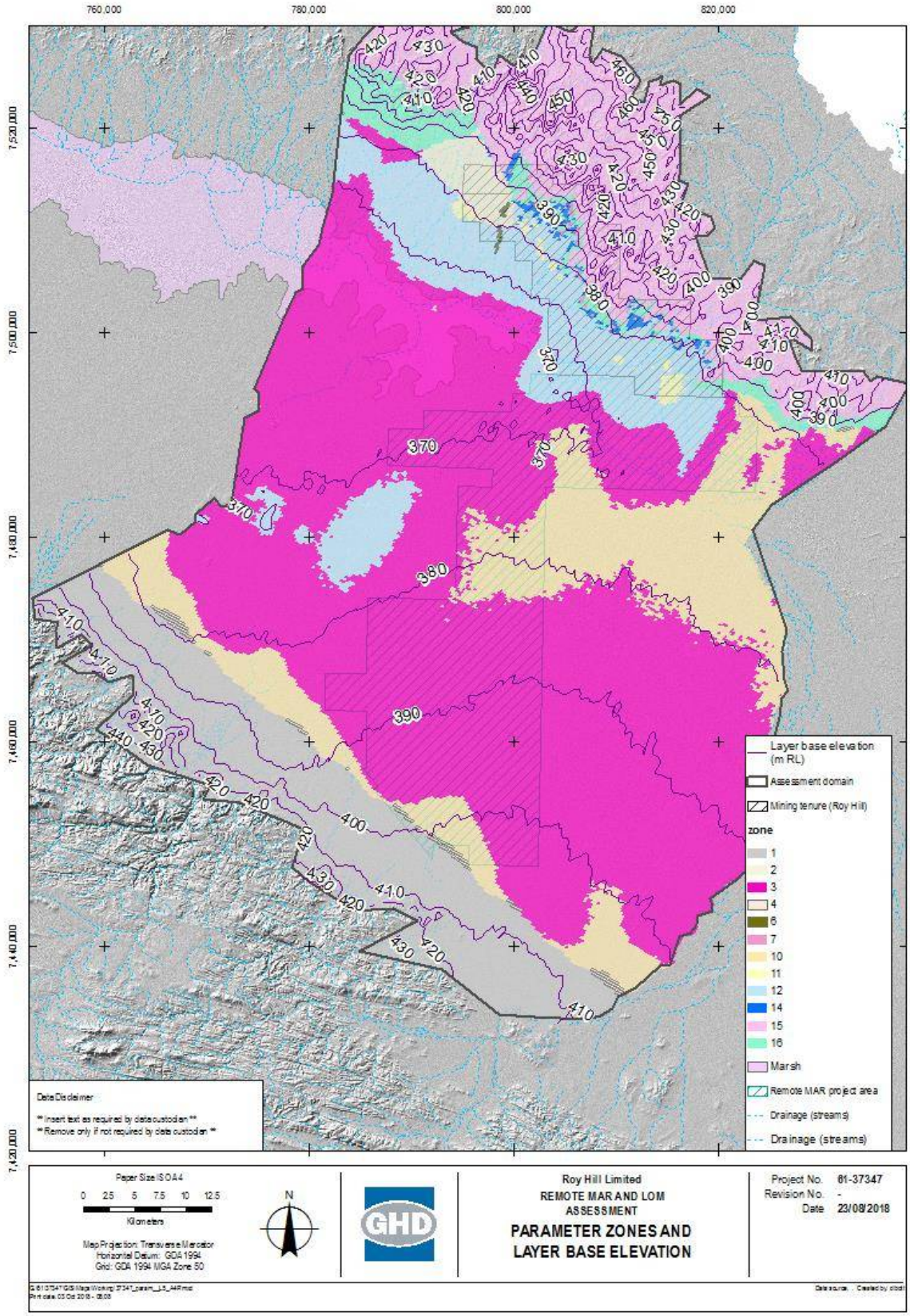

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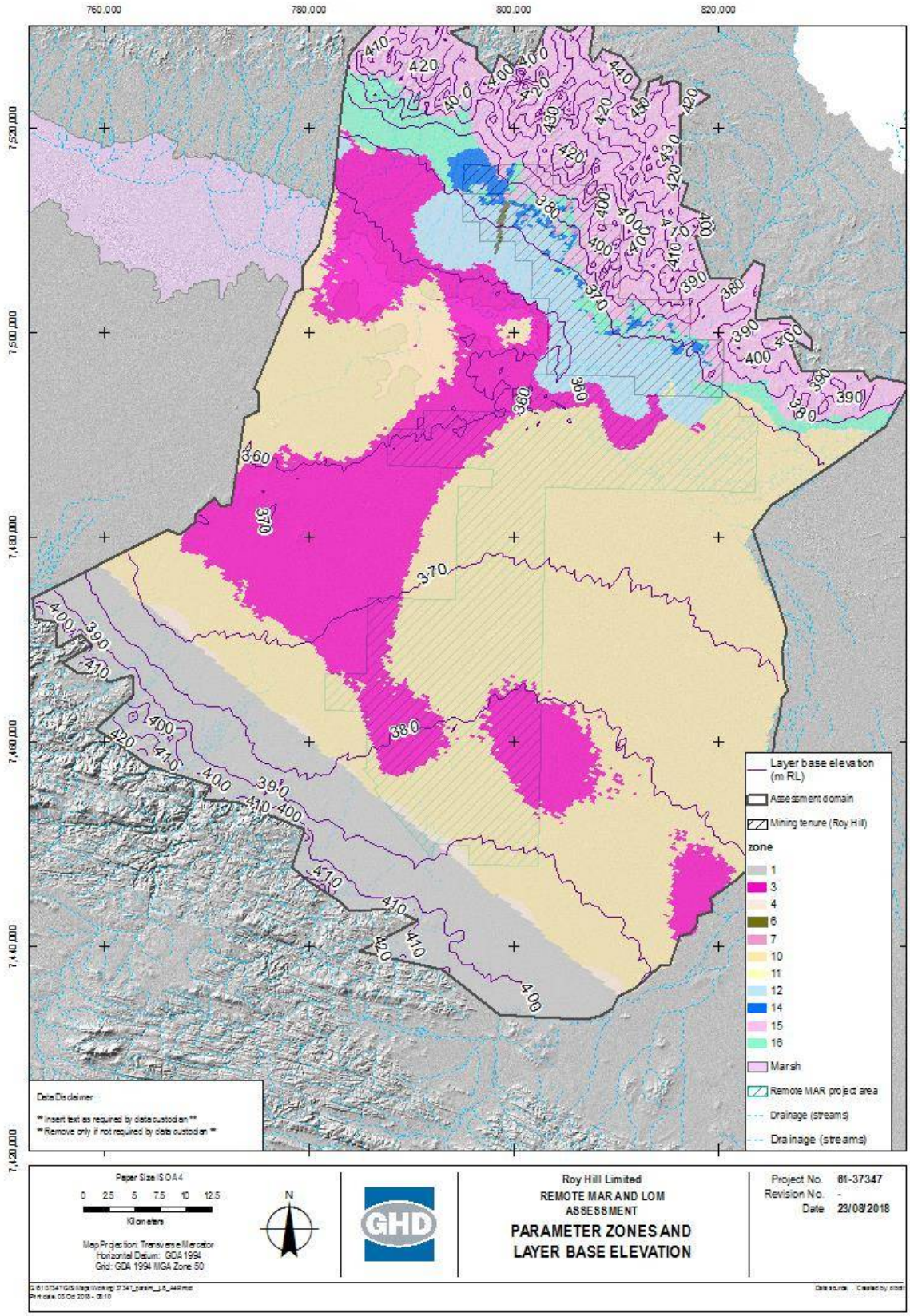

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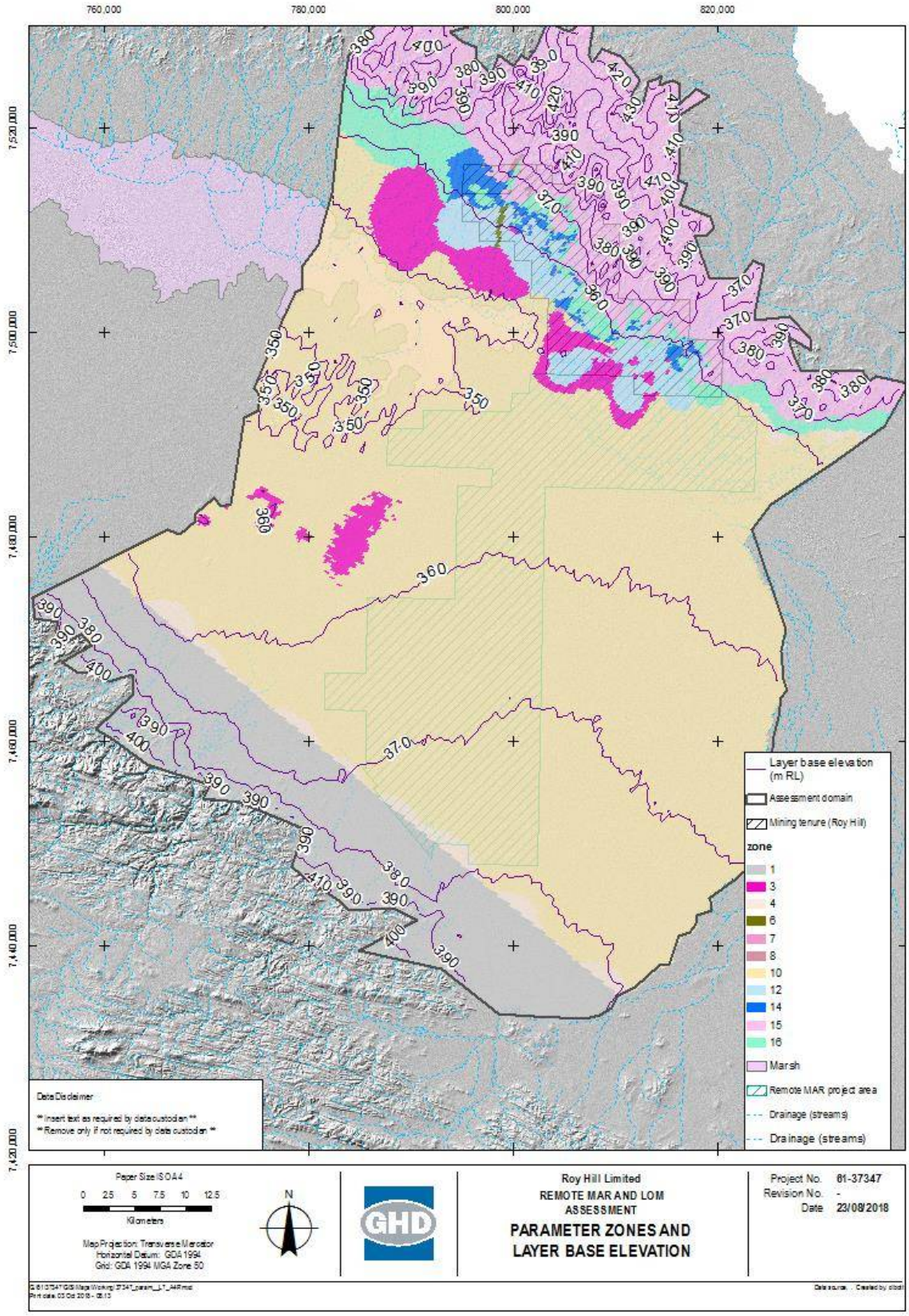

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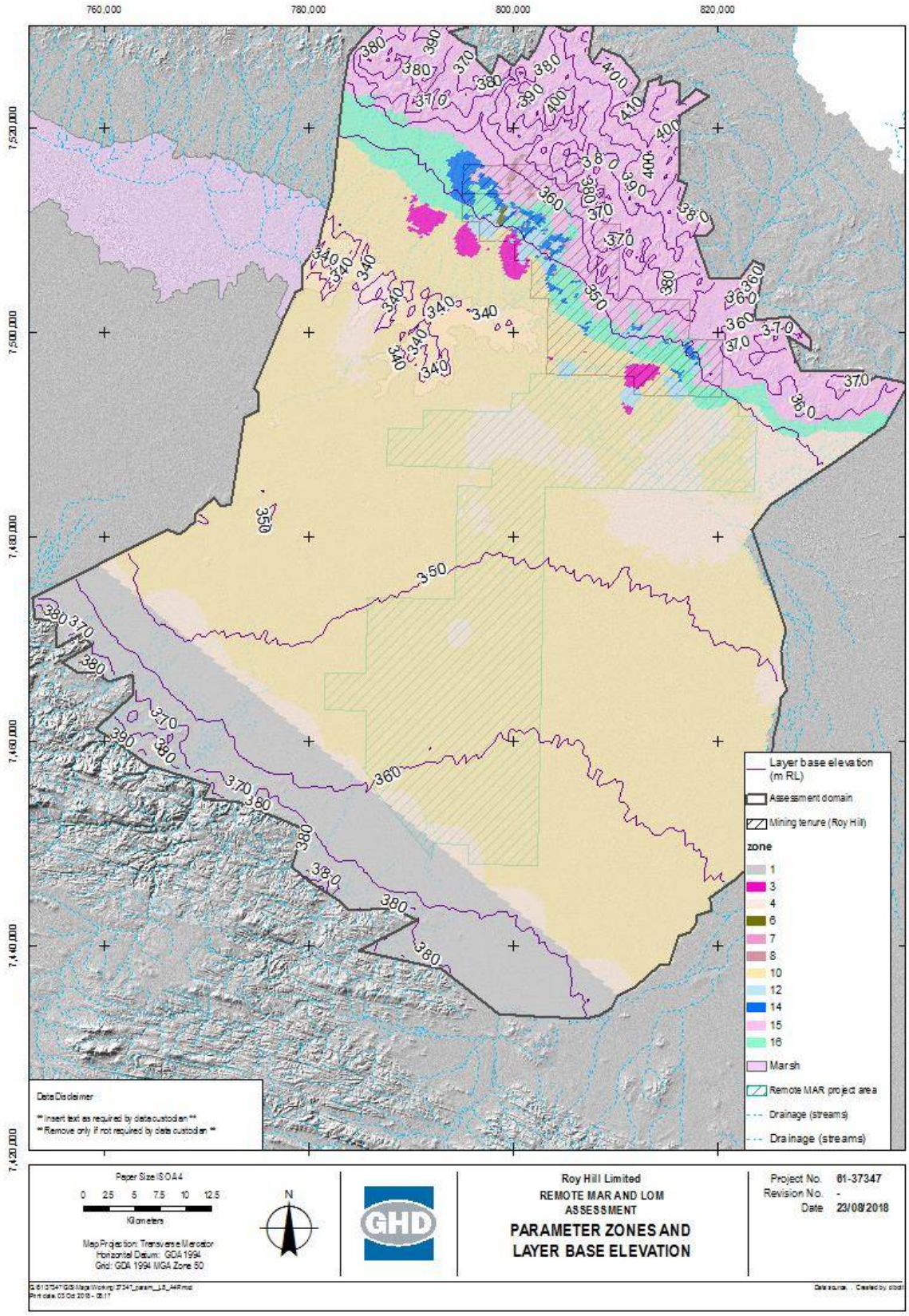
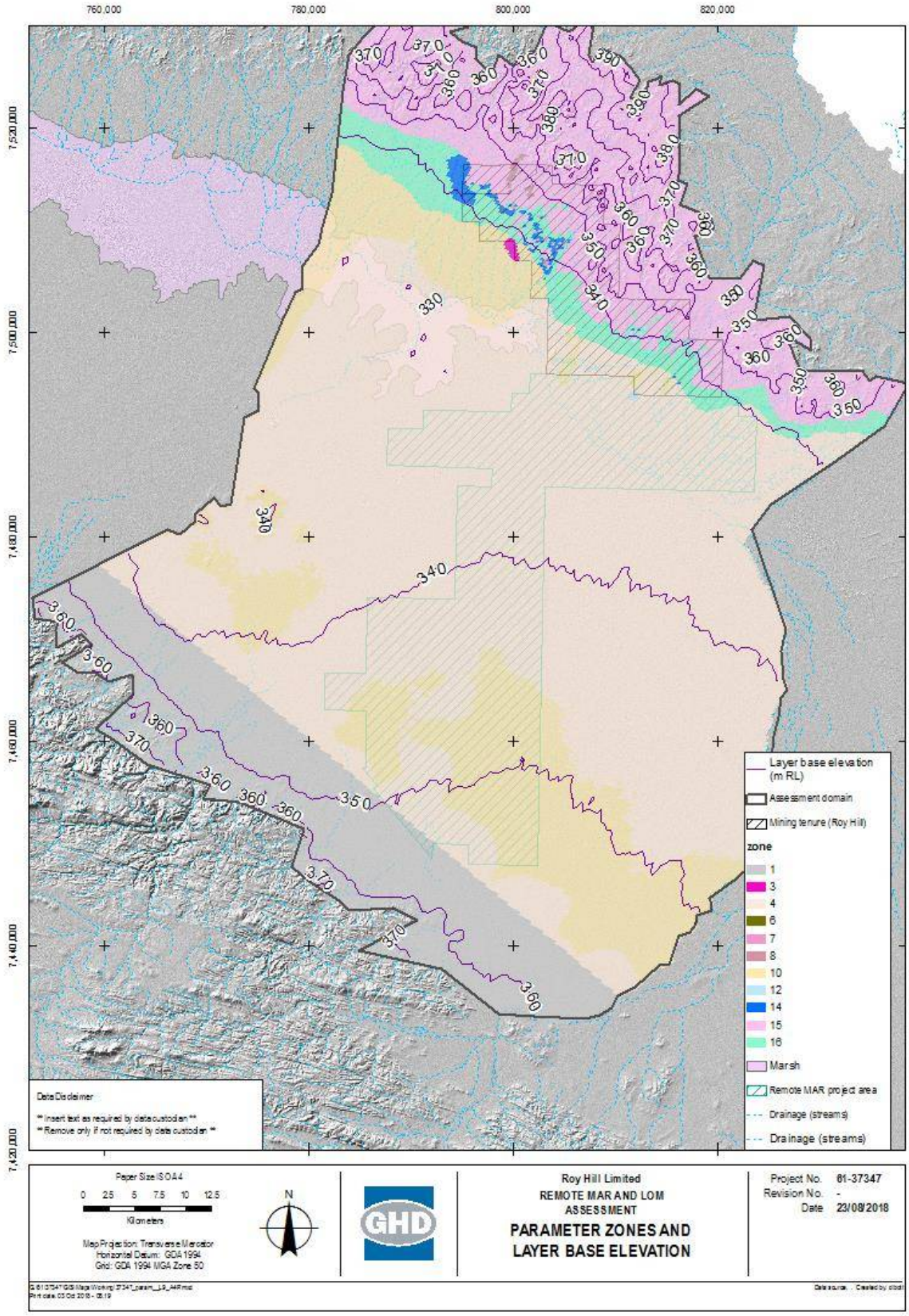
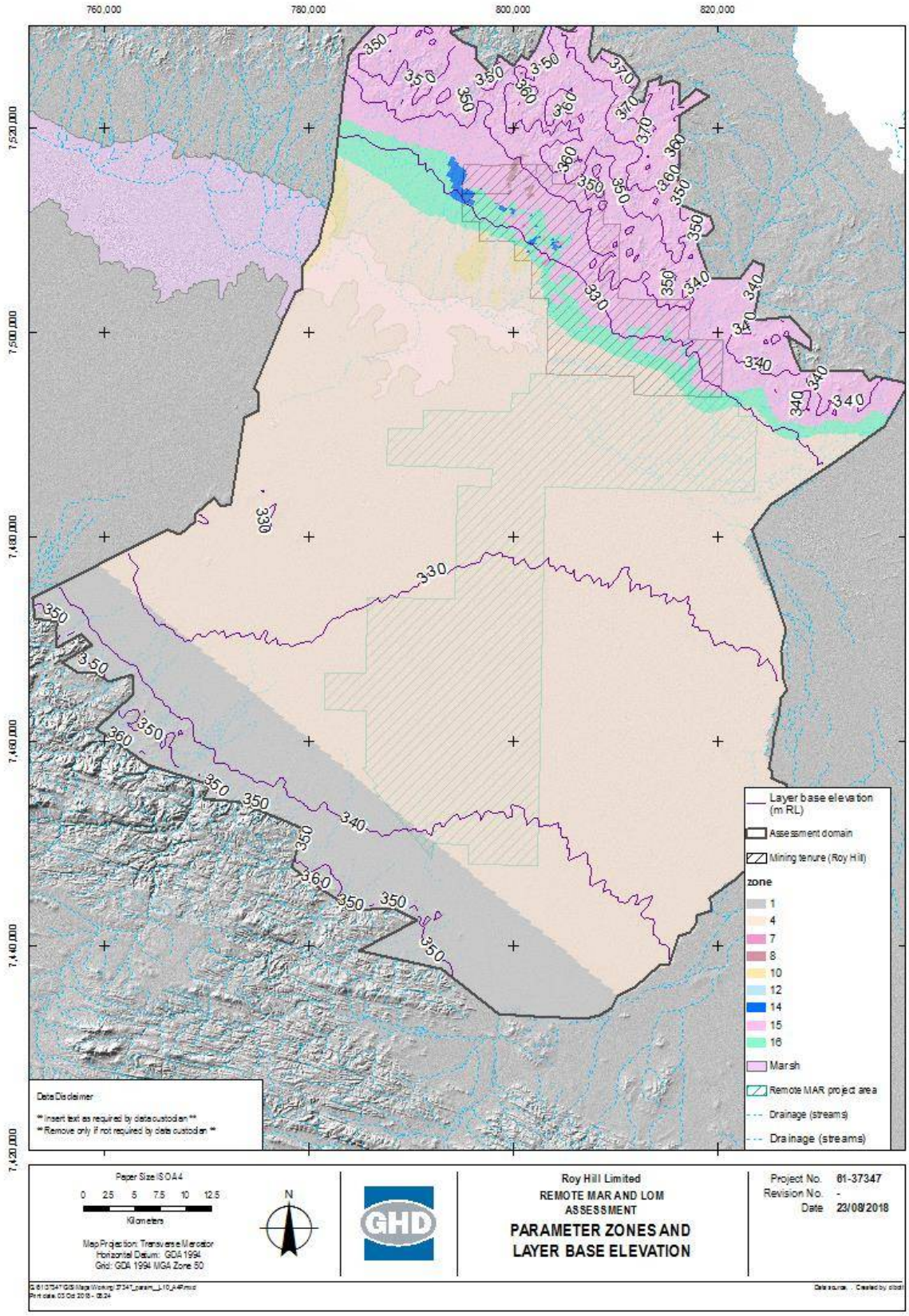


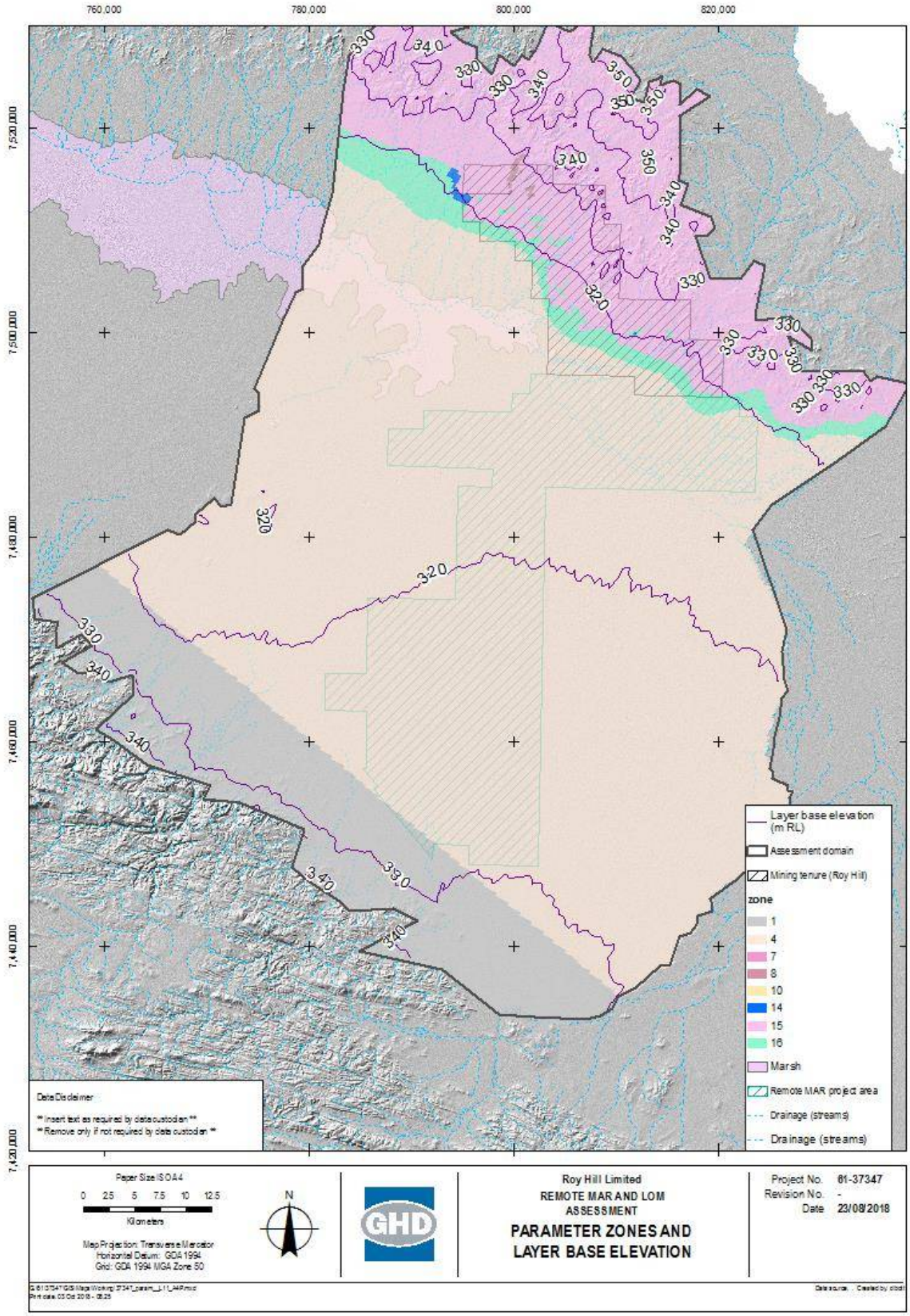
Parameter zone spatial delineation and base elevations, model layer



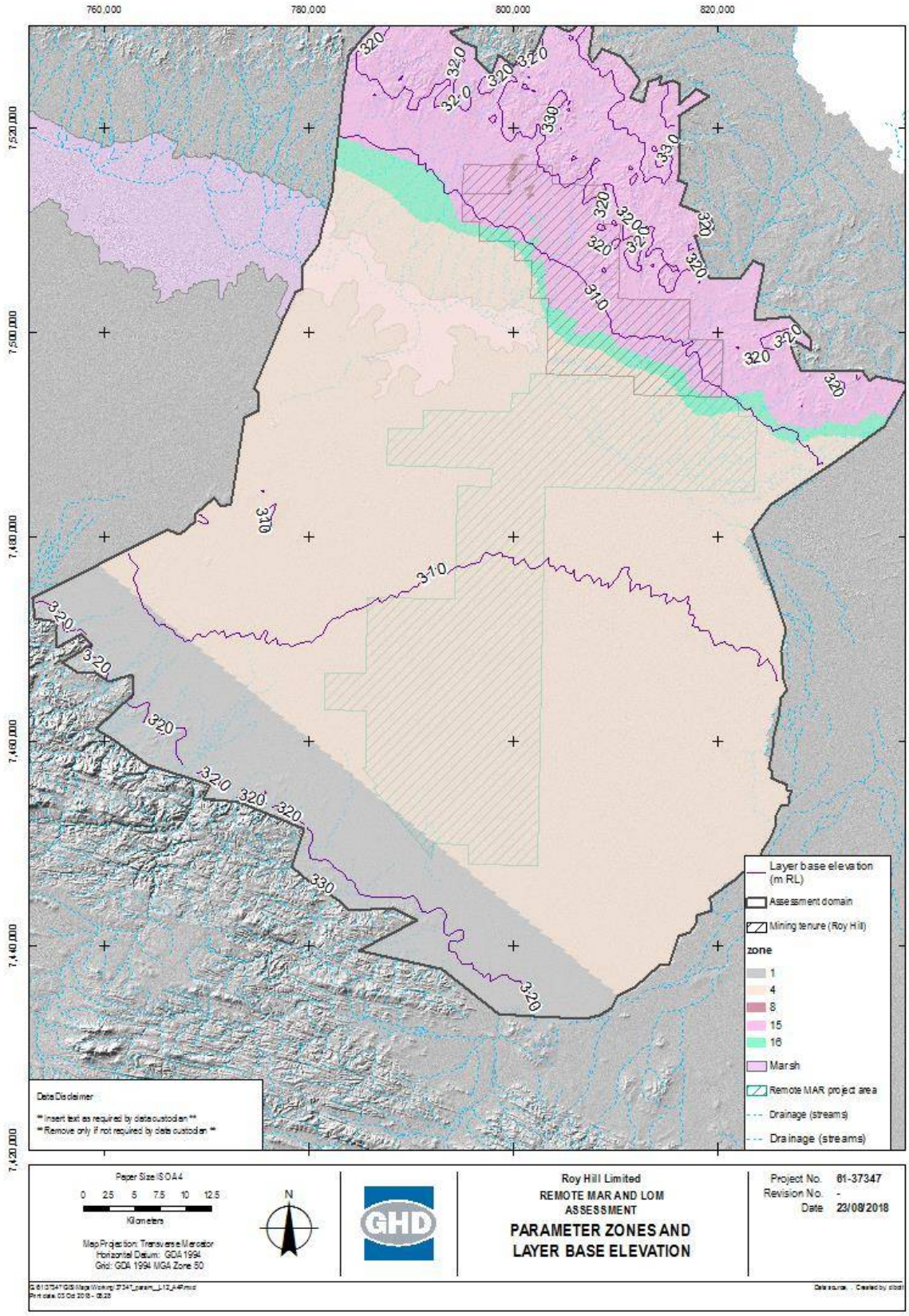
Parameter zone spatial delineation and base elevations, model layer 9



Parameter zone spatial delineation and base elevations, model layer 10



Parameter zone spatial delineation and base elevations, model layer 11



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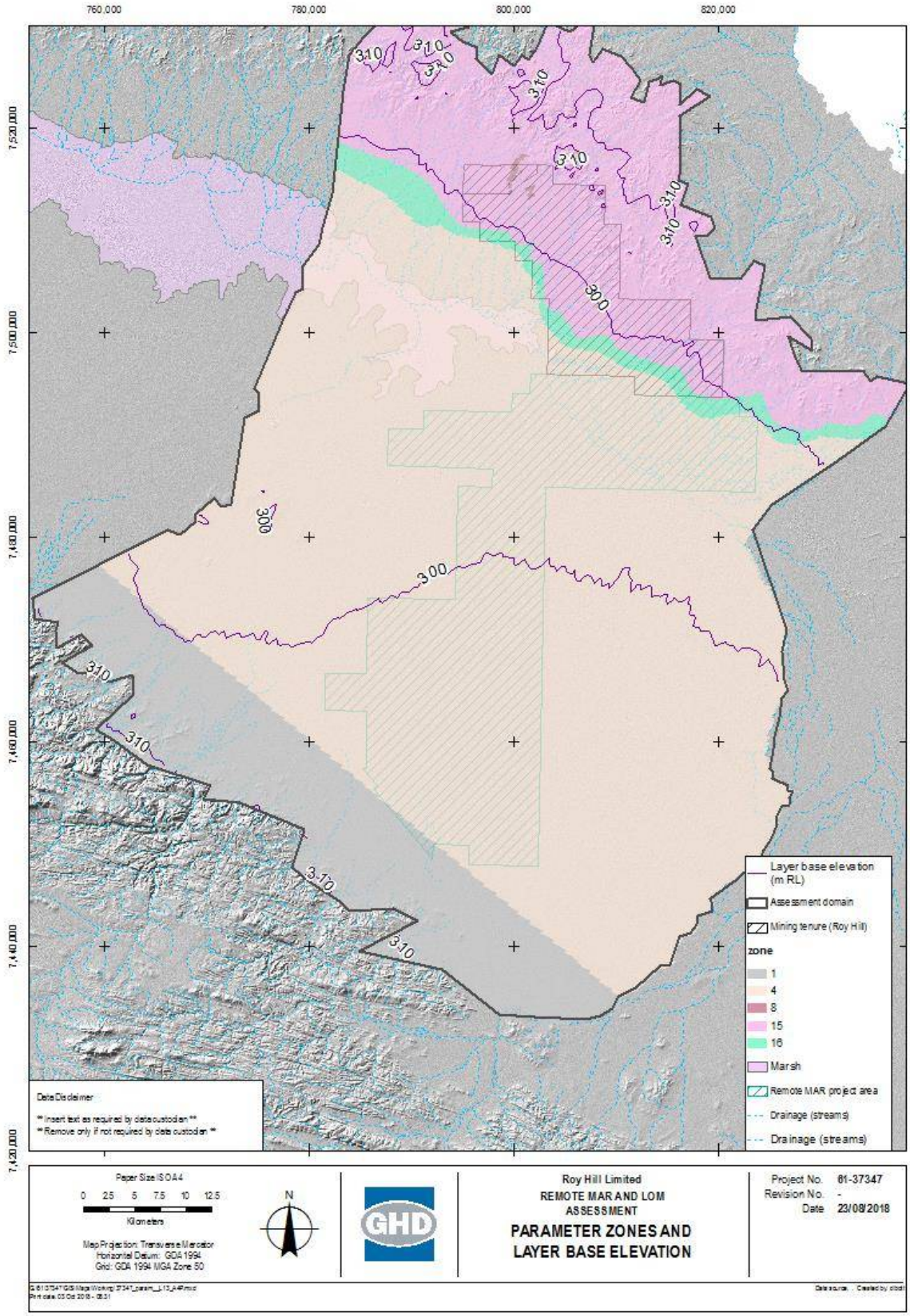

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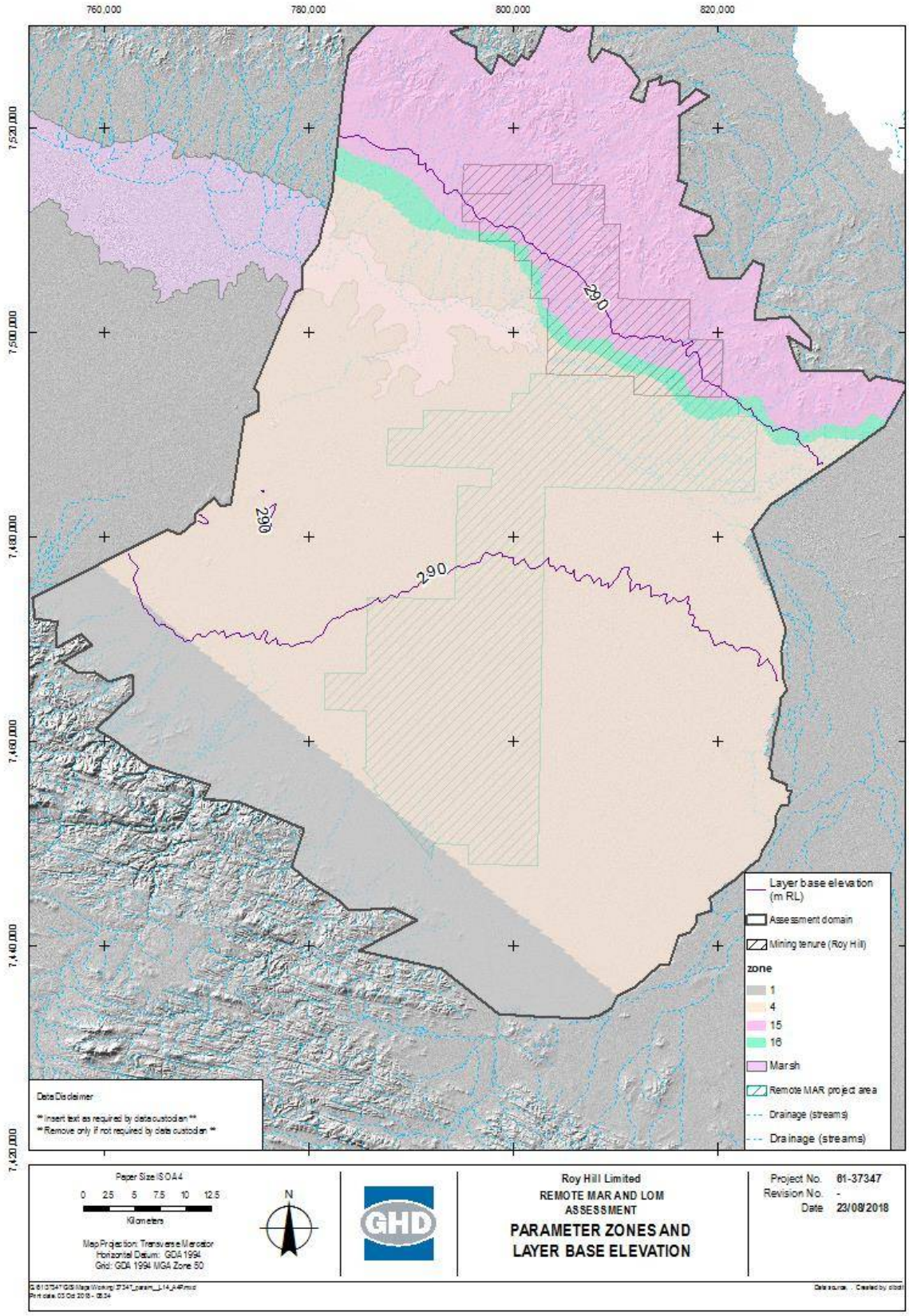
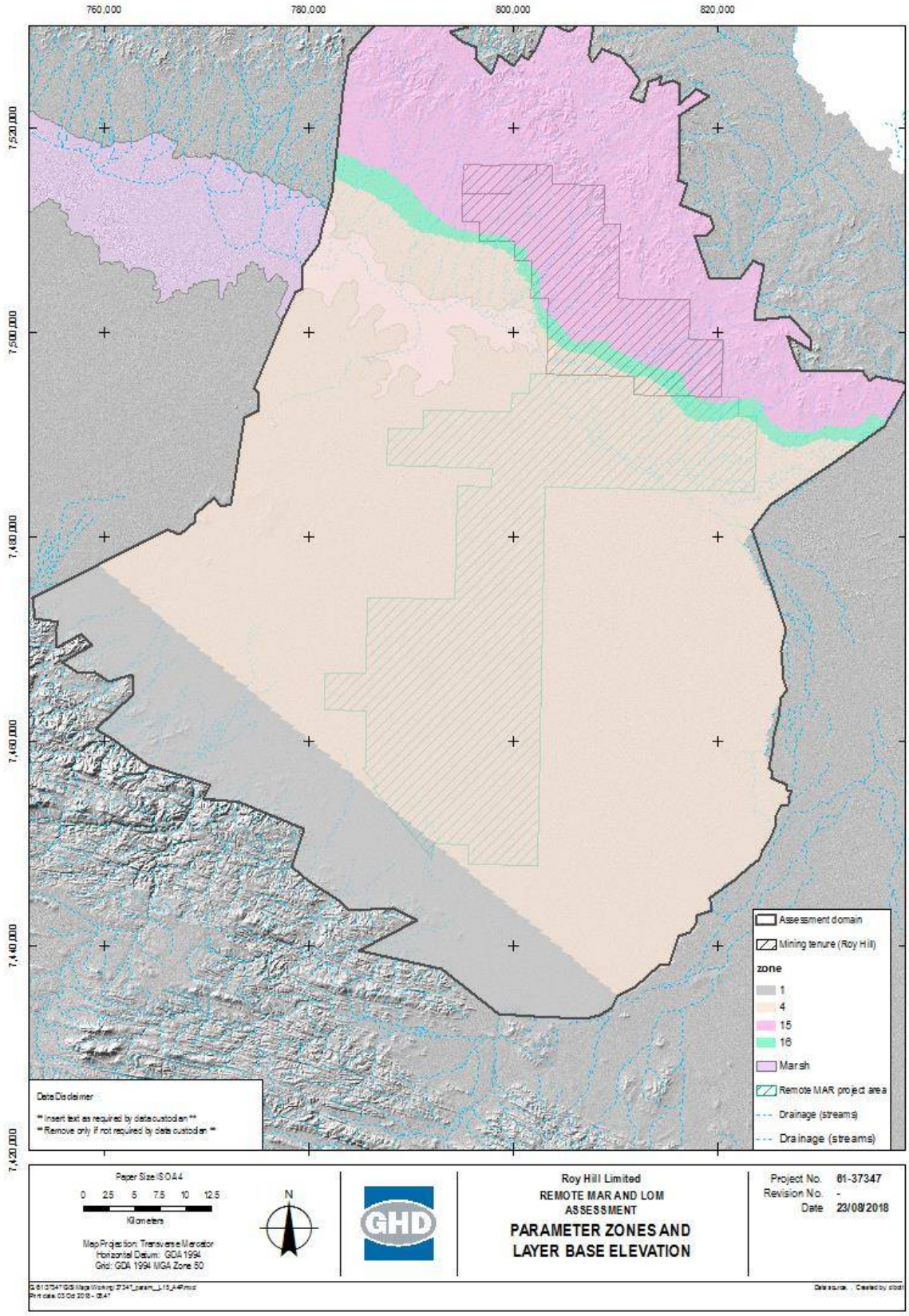
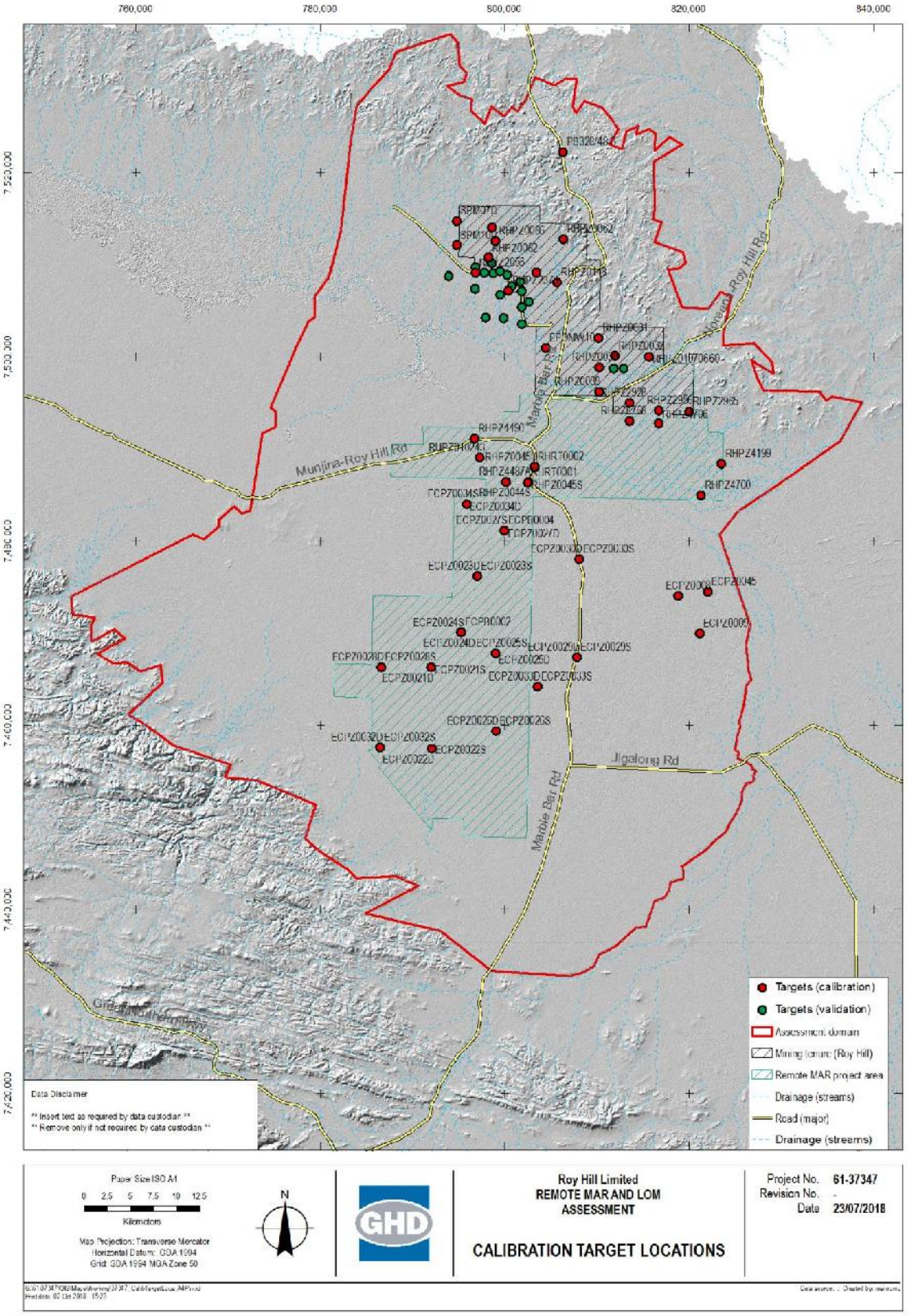


Parameter zone spatial delineation and base elevations, model layer 14



Parameter zone spatial delineation and base elevations, model layer 15

Appendix E Groundwater elevation calibration hydrographs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Munjina-Roy Hill Rd
Marble Bar Rd
Jigalong Rd
Great Northern Hwy
Targets (calibration)
Targets (validation)
Assessment domain
Mining tenure (Roy Hill)
Remote MAR project area
Drainage (streams)
Road (major)
Drainage (streams)
Data Disclaimer
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** Remove only if not required by data custodian **
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Kilometers
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50
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GHD
Roy Hill Limited
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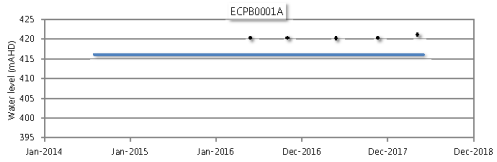
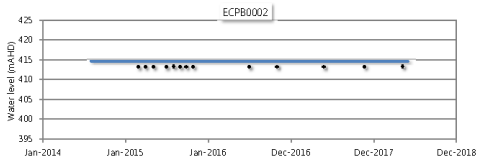
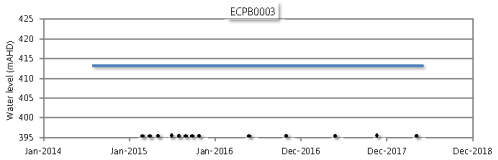
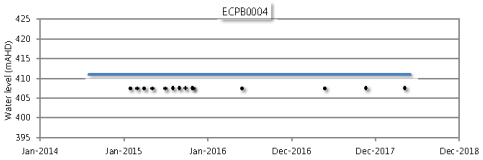
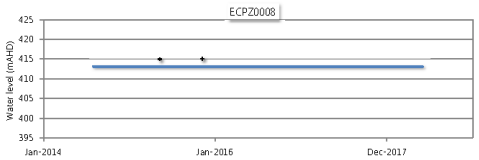
CALIBRATION TARGET LOCATIONS
Project No. 61-37347
Revision No. -
Date 23/07/2018

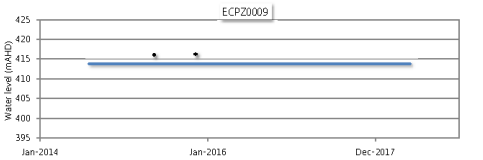


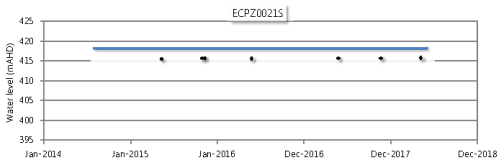


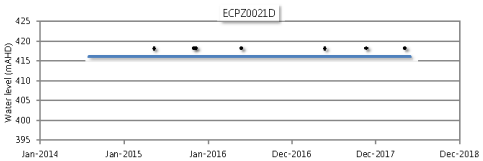


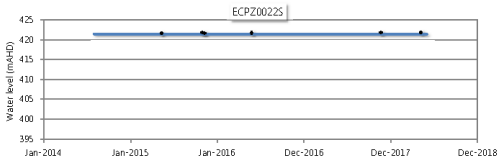


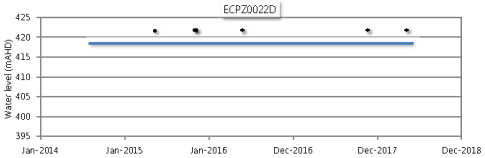


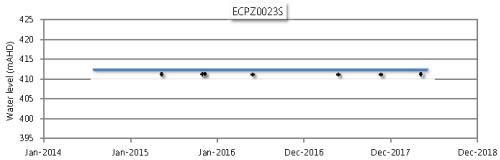


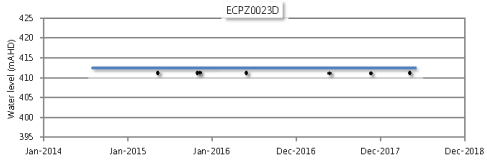


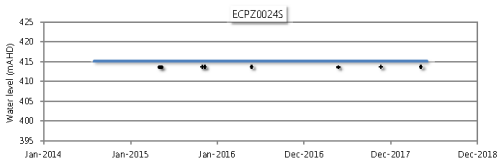


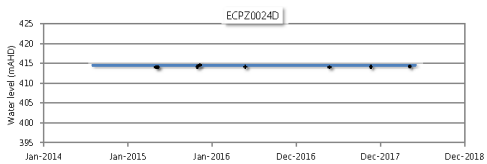


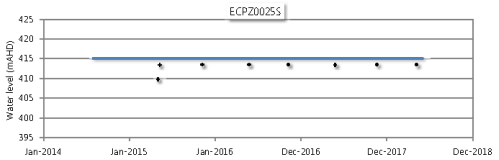


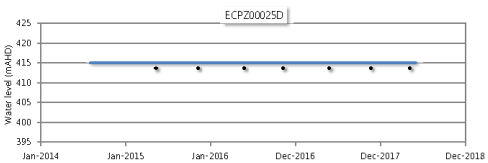












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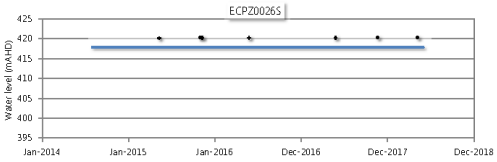

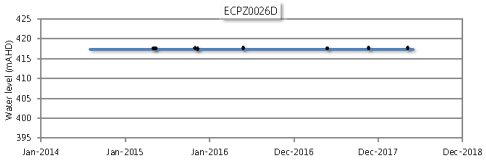

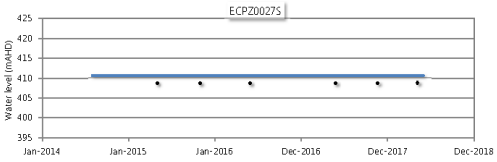

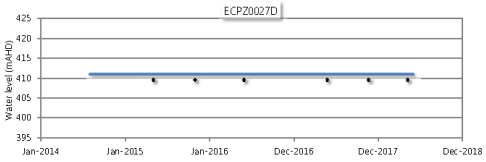

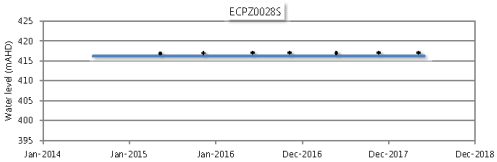

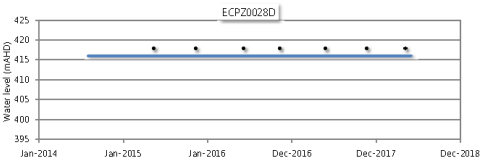

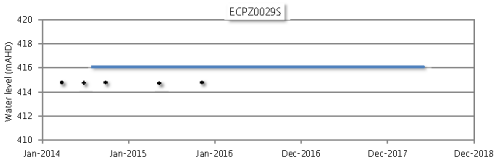

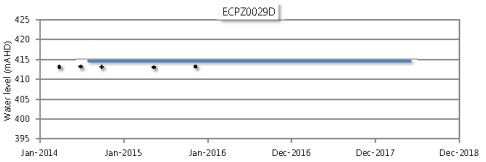

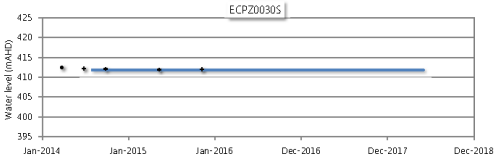

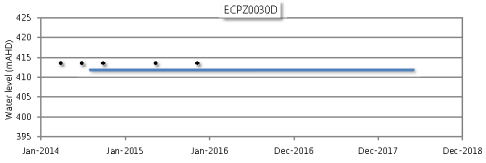

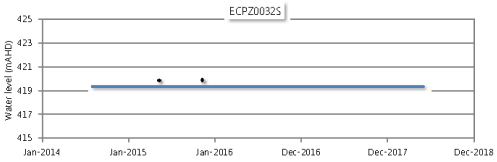

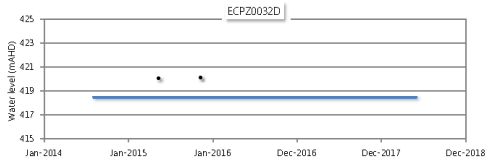

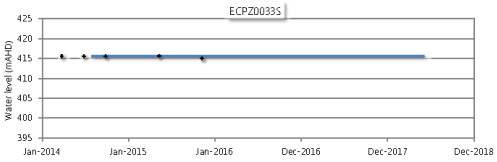

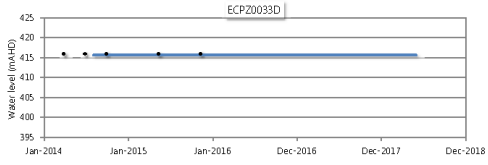

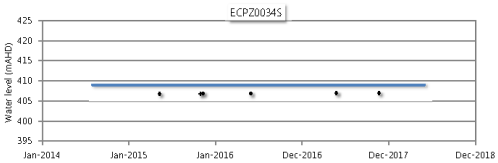

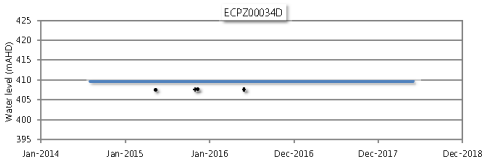

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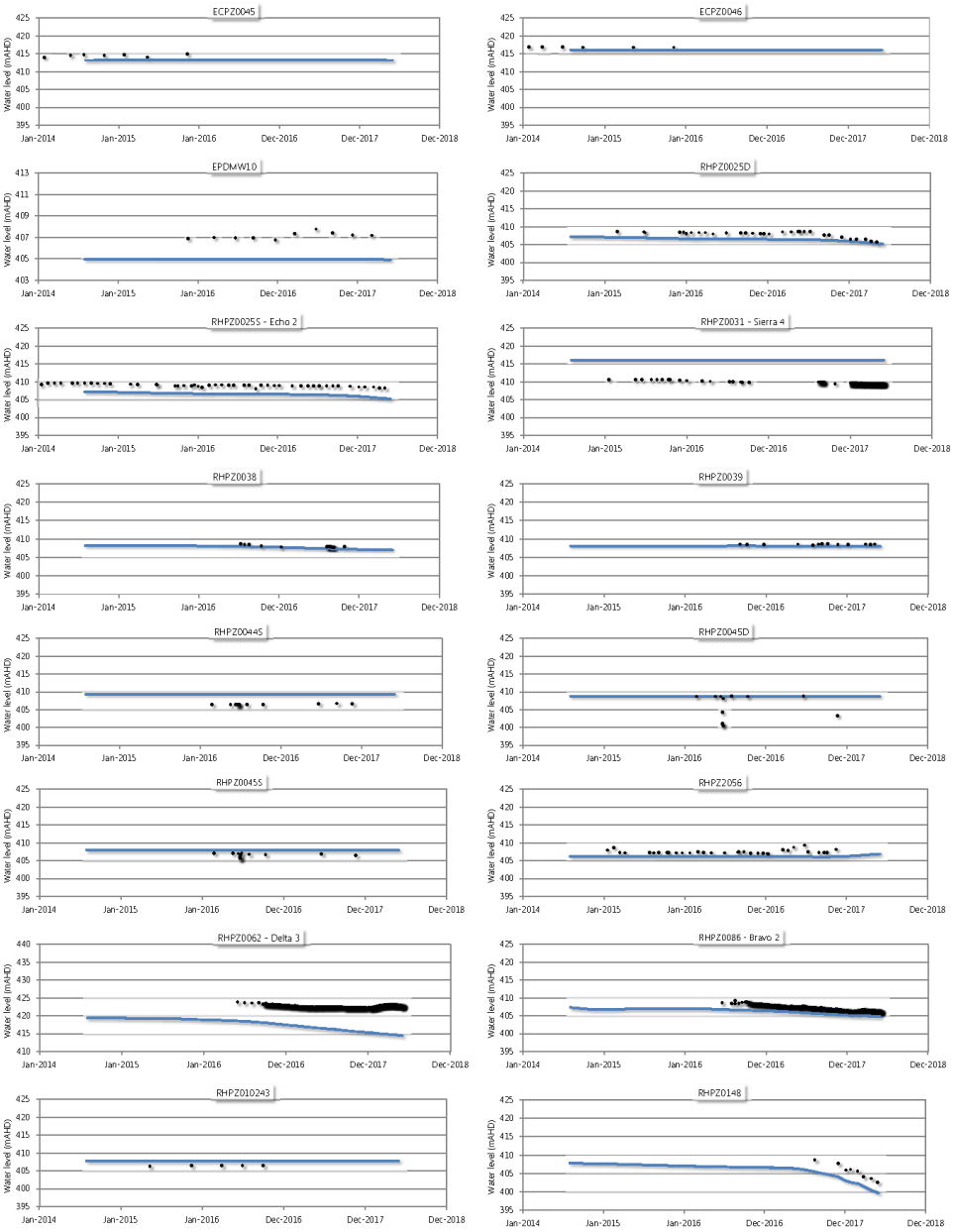

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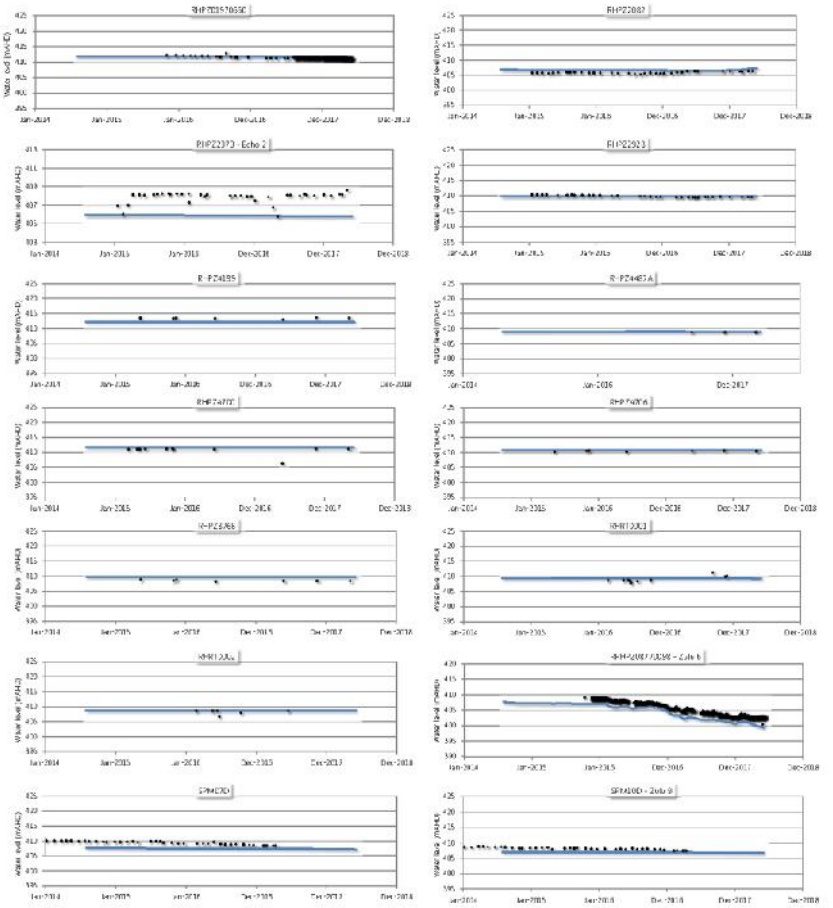
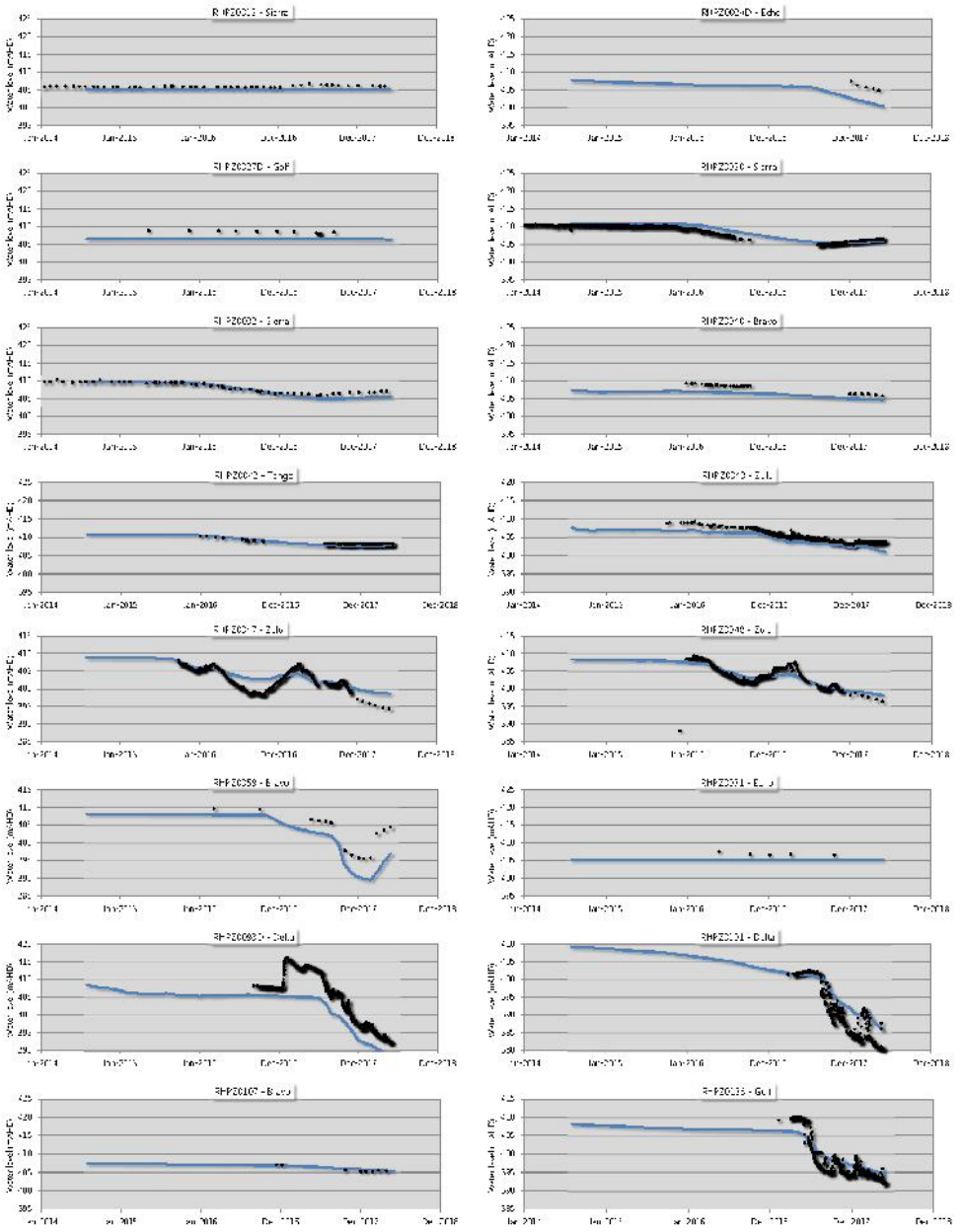
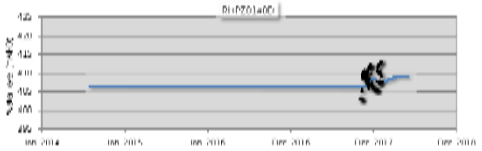
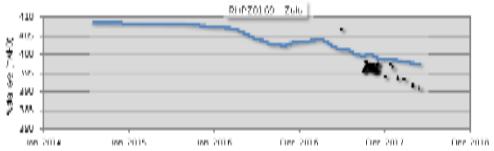
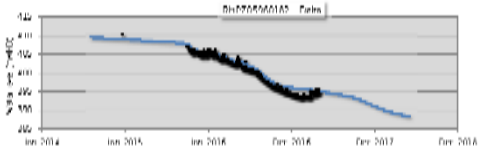




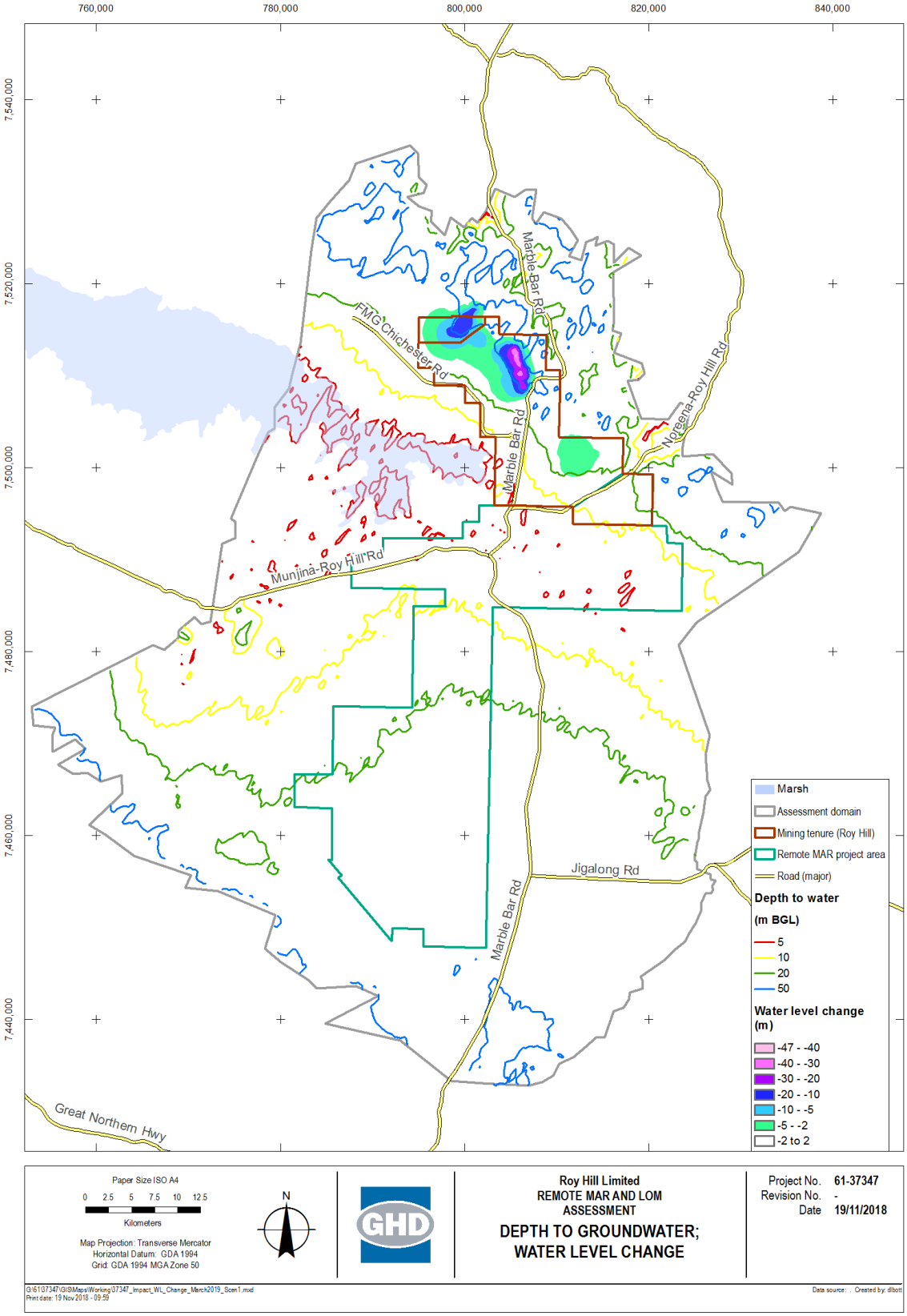






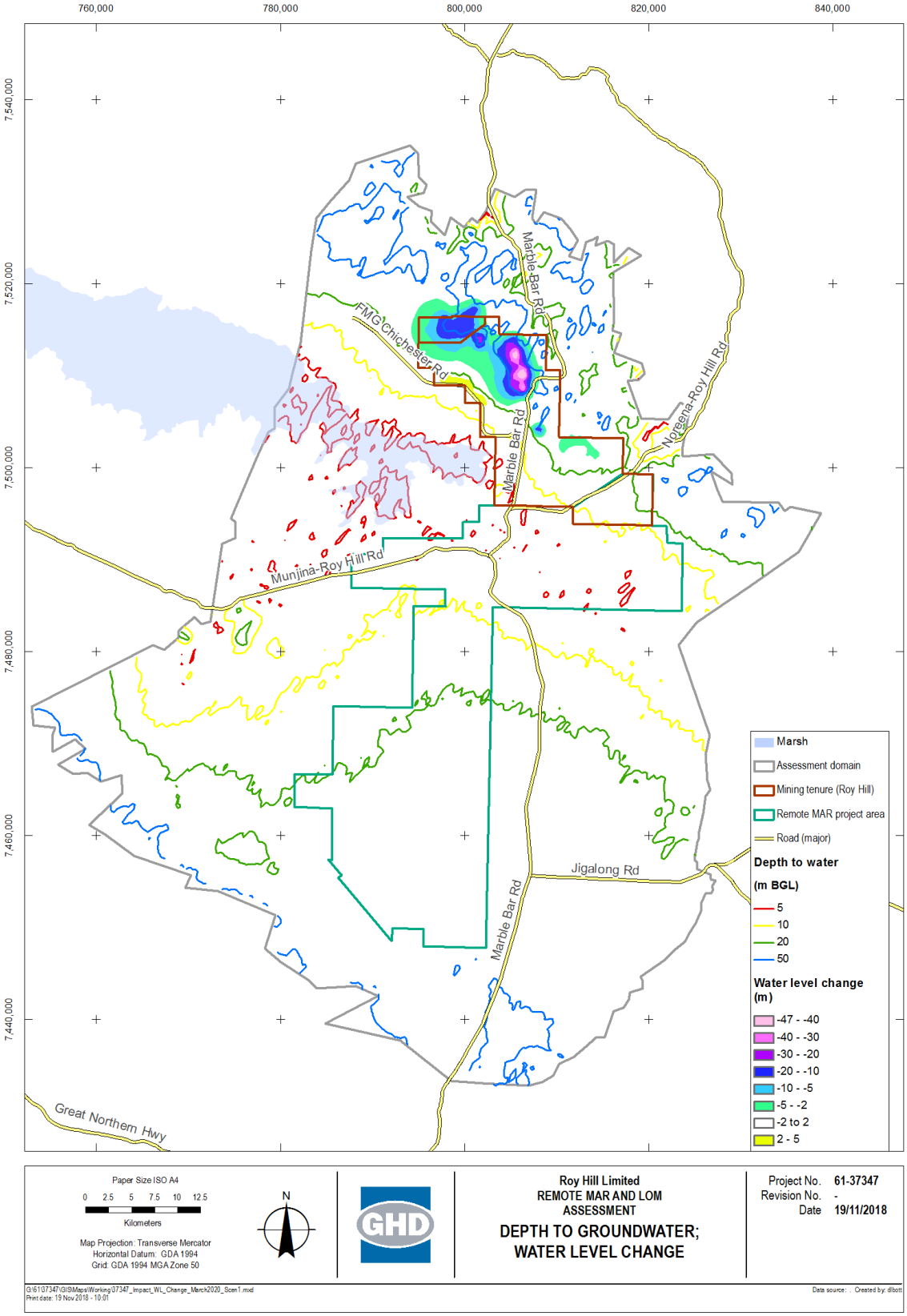
Appendix F Maps of predicted water level change and depth to groundwater for management simulations

Scenario 1: Dewatering and injection in mining area (SWIB and MPIB)



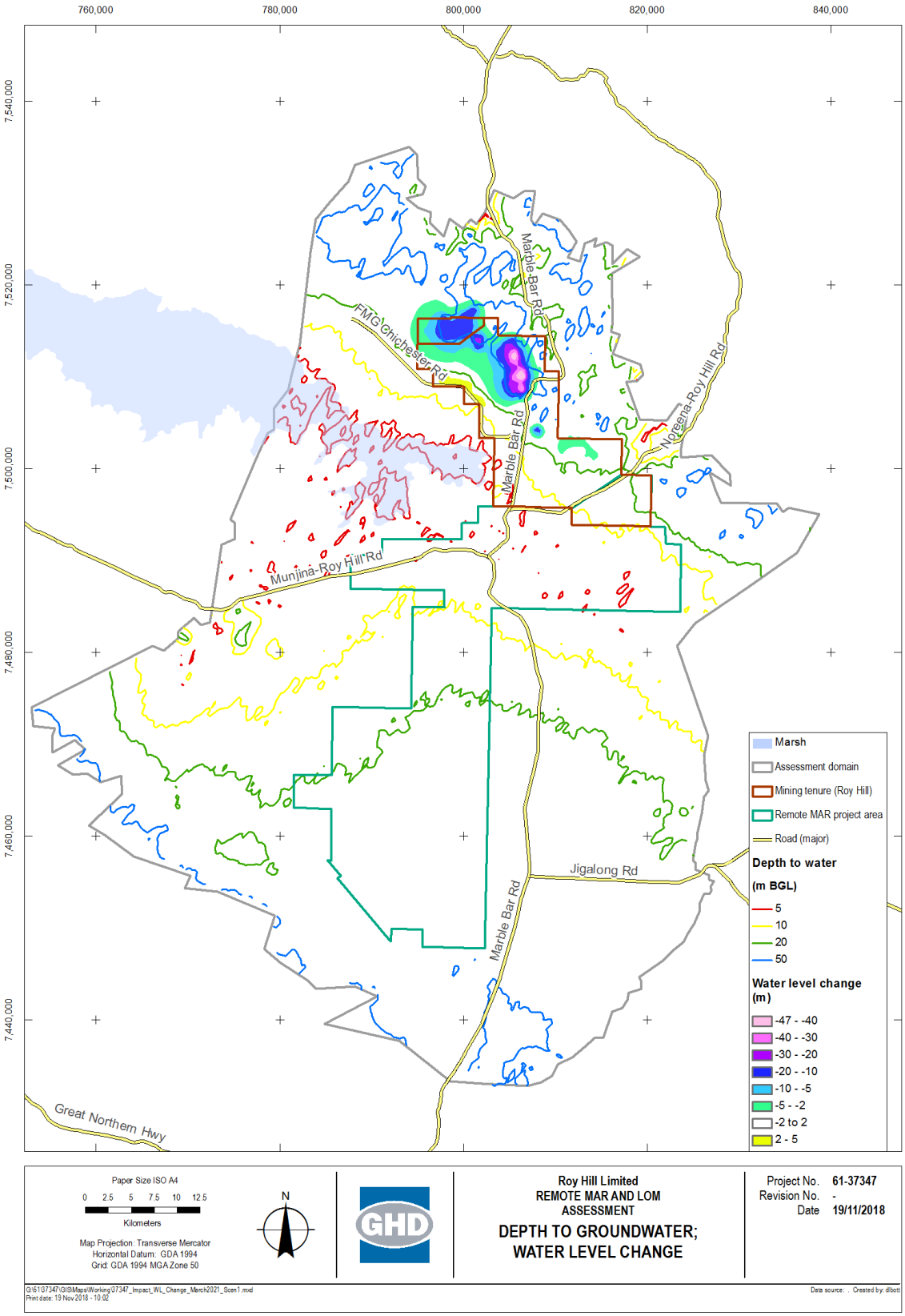
Depth to groundwater; water level change, March 2019

Scenario 1: Dewatering and injection in mining area (SWIB and MPIB)



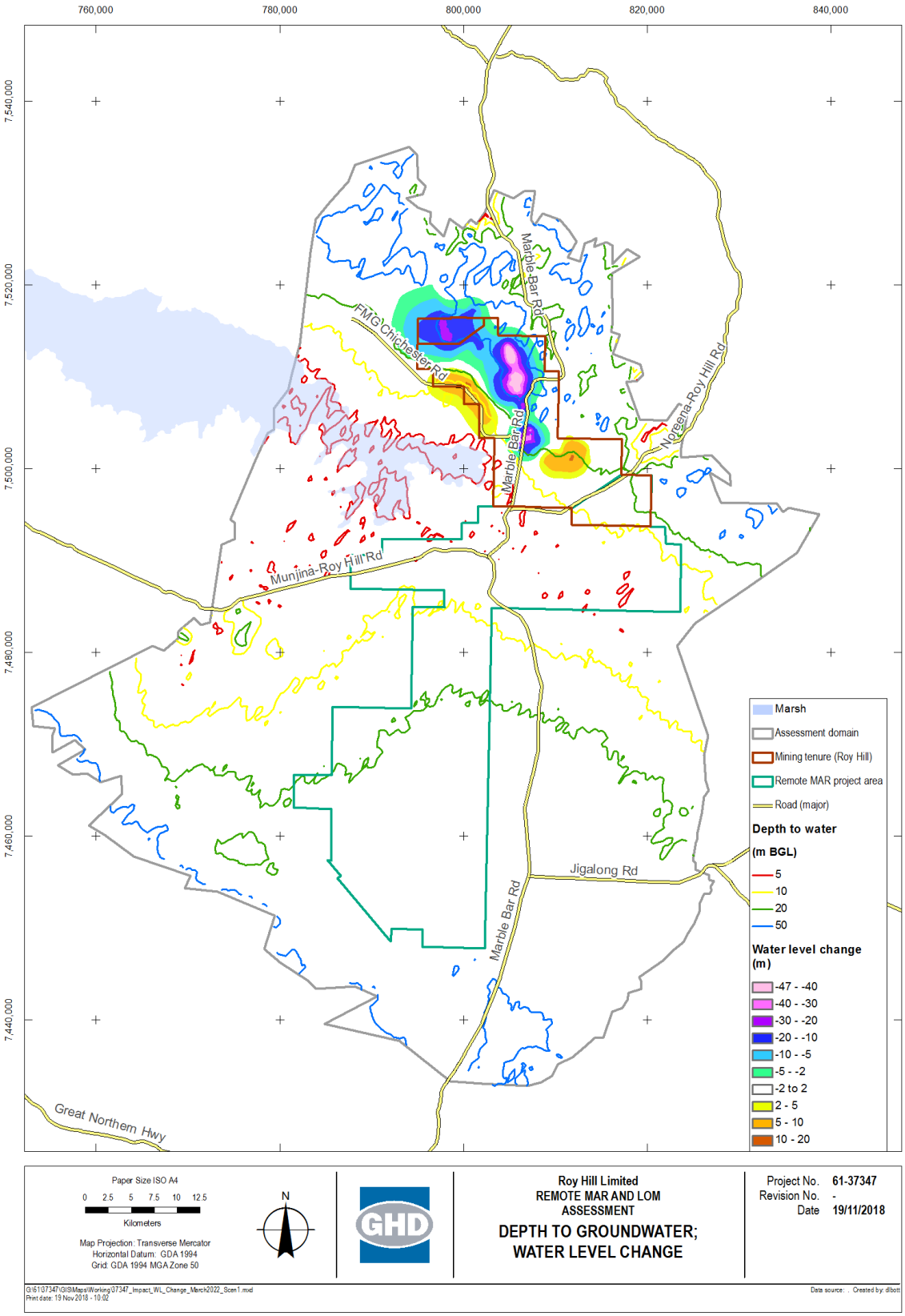
Depth to groundwater; water level change, March 2020

Scenario 1: Dewatering and injection in mining area (SWIB and MPIB)



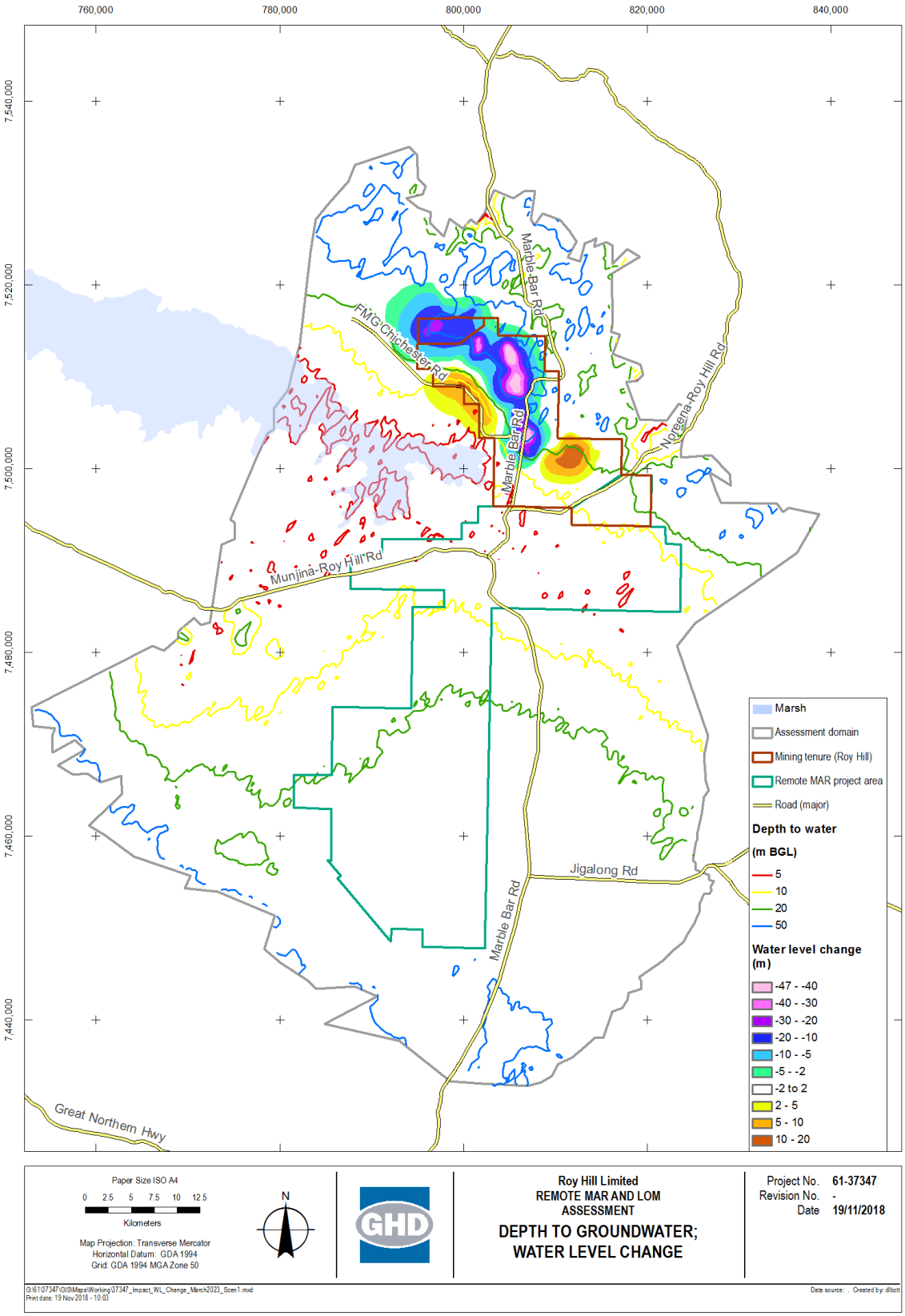
Depth to groundwater; water level change, March 2021

Scenario 1: Dewatering and injection in mining area (SWIB and MPIB)



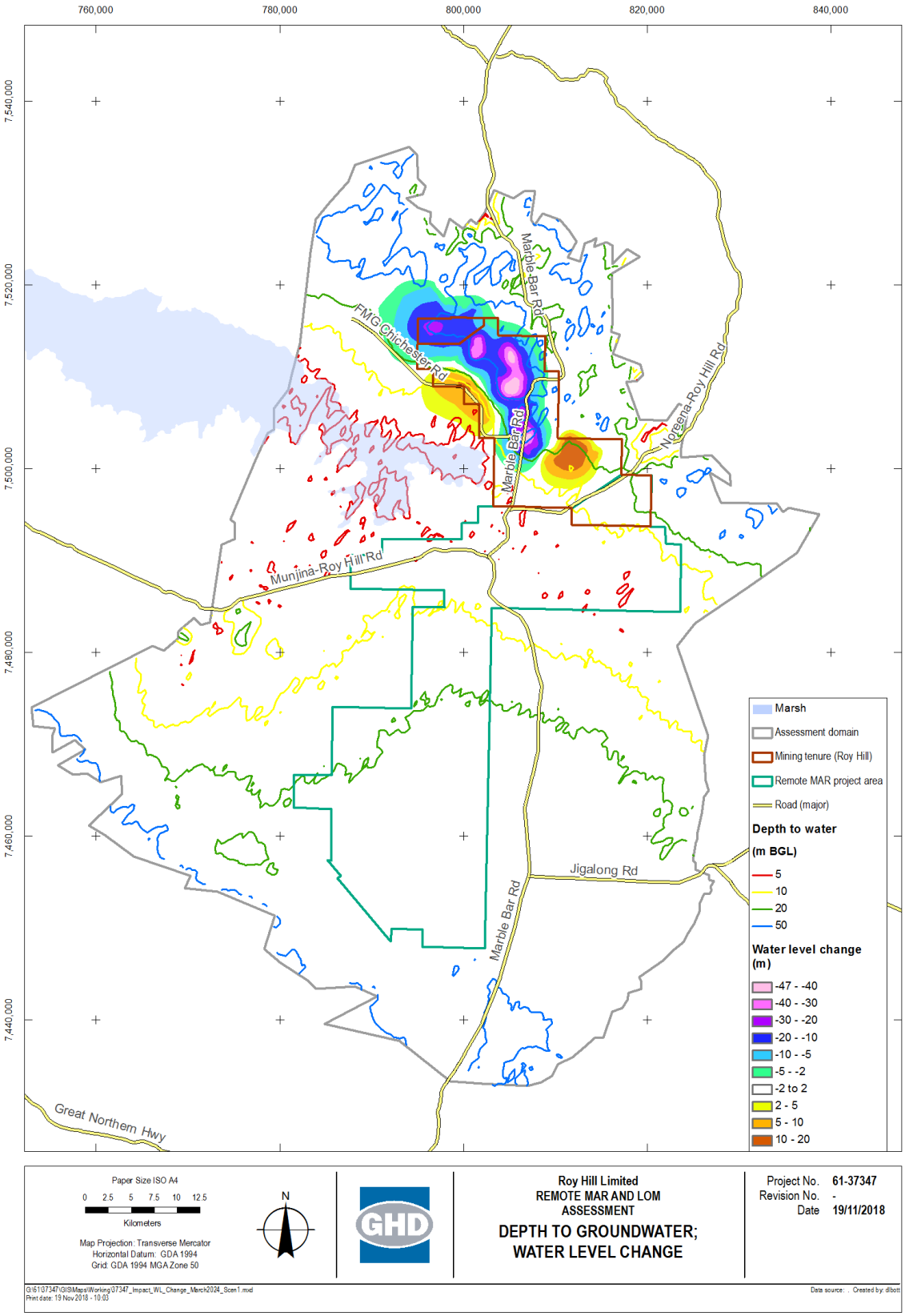
Depth to groundwater; water level change, March 2022

Scenario 1: Dewatering and injection in mining area (SWIB and MPIB)



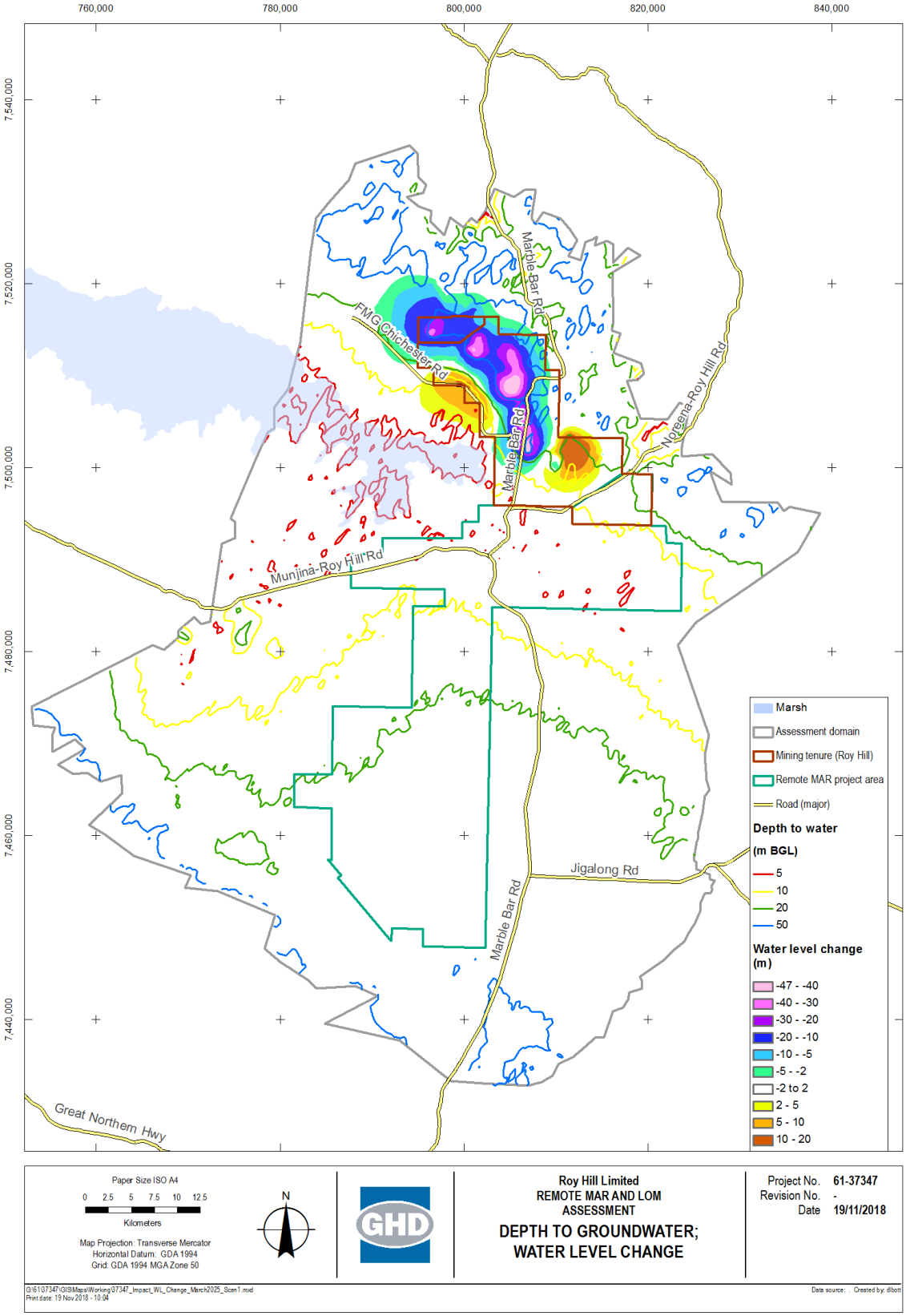
Depth to groundwater; water level change, March 2023

Scenario 1: Dewatering and injection in mining area (SWIB and MPIB)



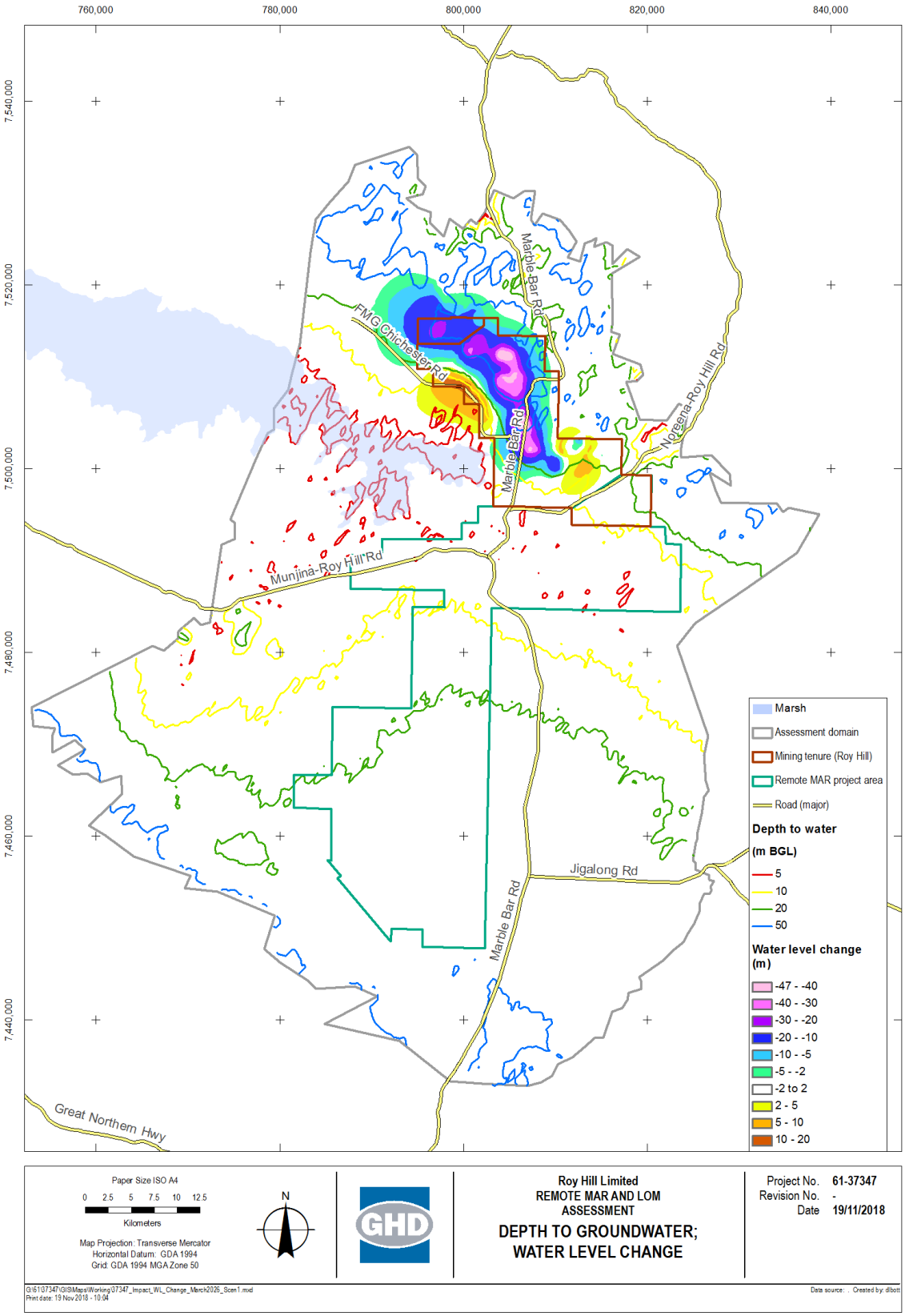
Depth to groundwater; water level change, March 2024

Scenario 1: Dewatering and injection in mining area (SWIB and MPIB)



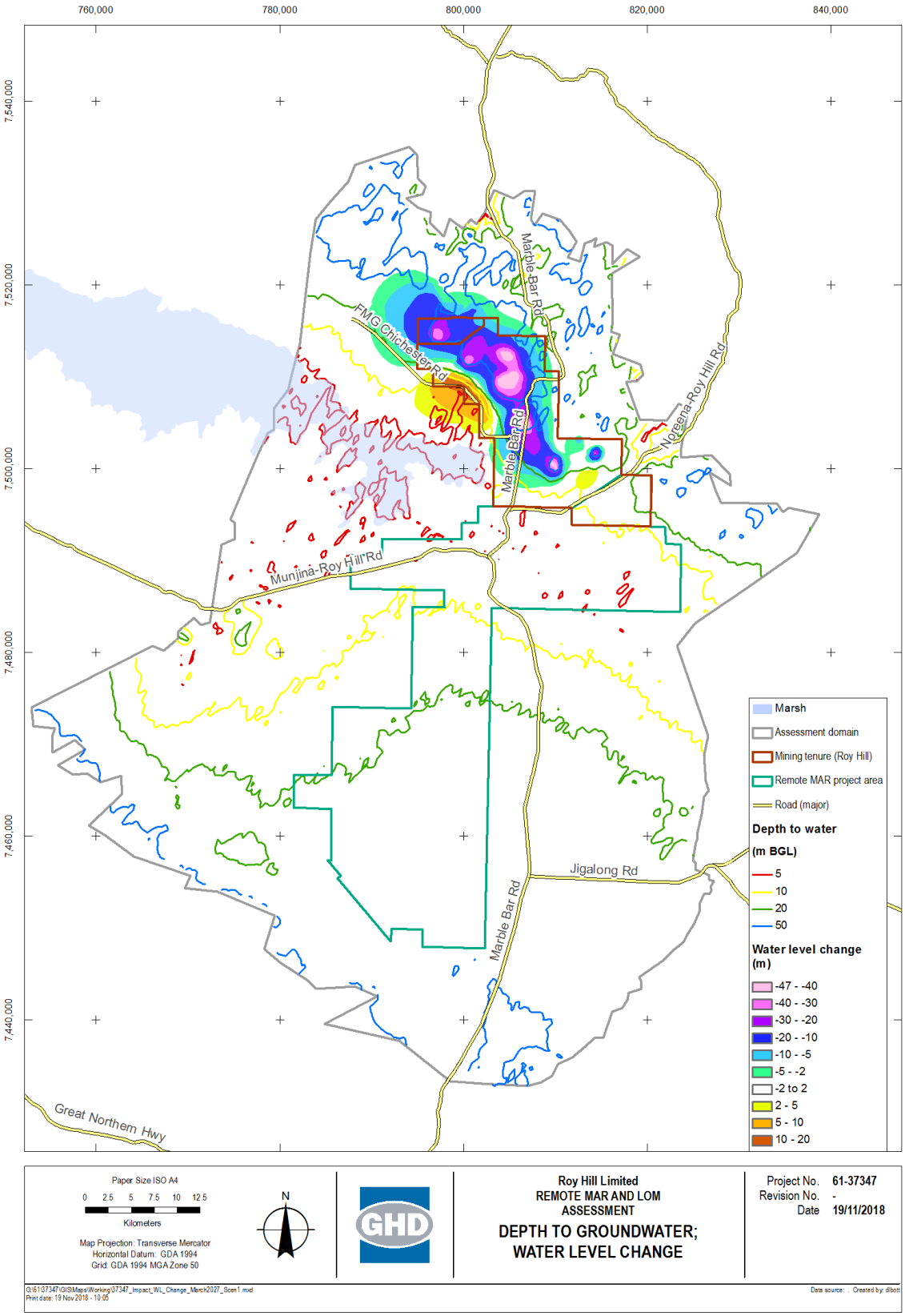
Depth to groundwater; water level change, March 2025

Scenario 1: Dewatering and injection in mining area and RMAR North (SWIB, MPIB)



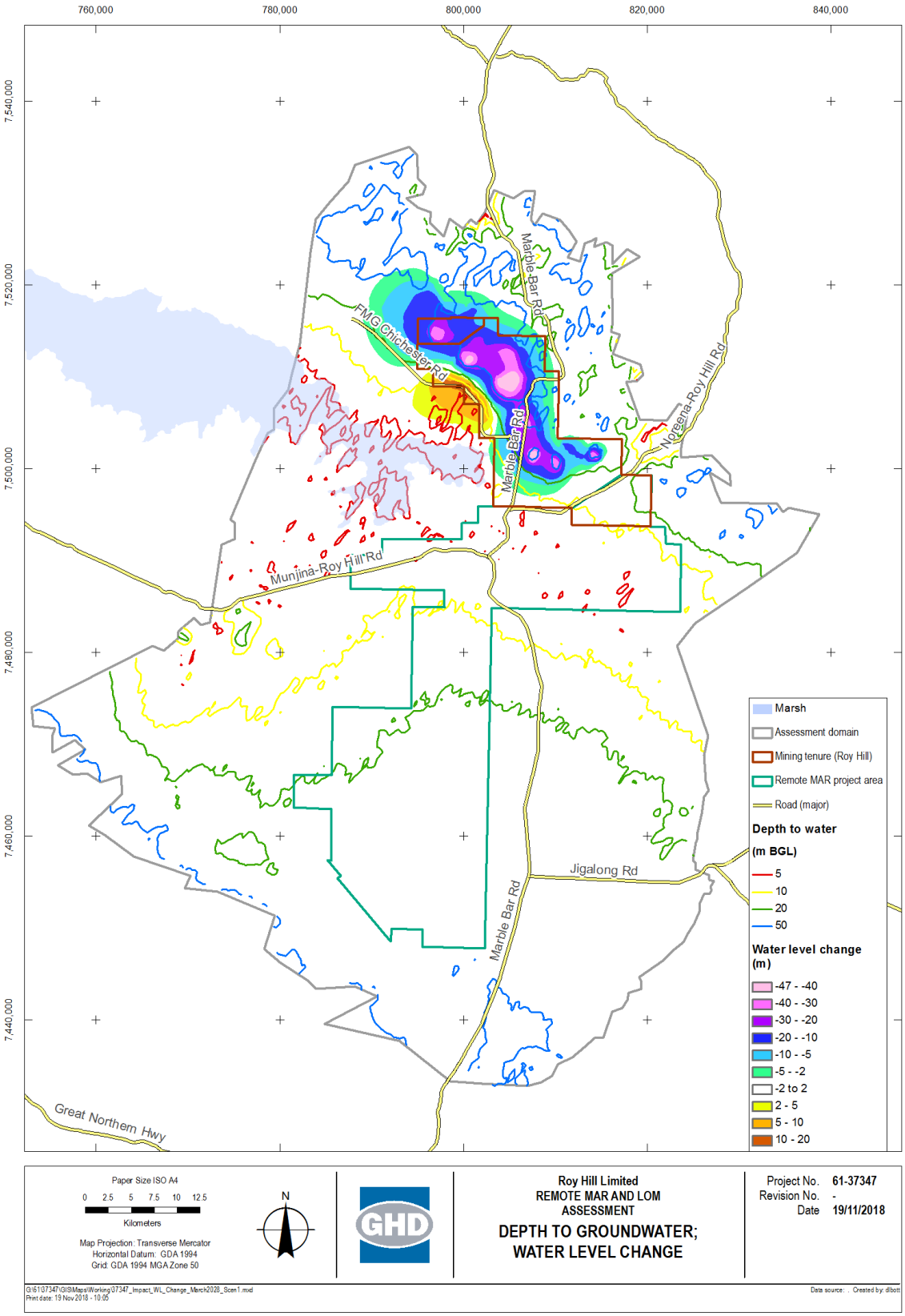
Depth to groundwater; water level change, March 2026

Scenario 1: Dewatering and injection in mining area (SWIB and MPIB)



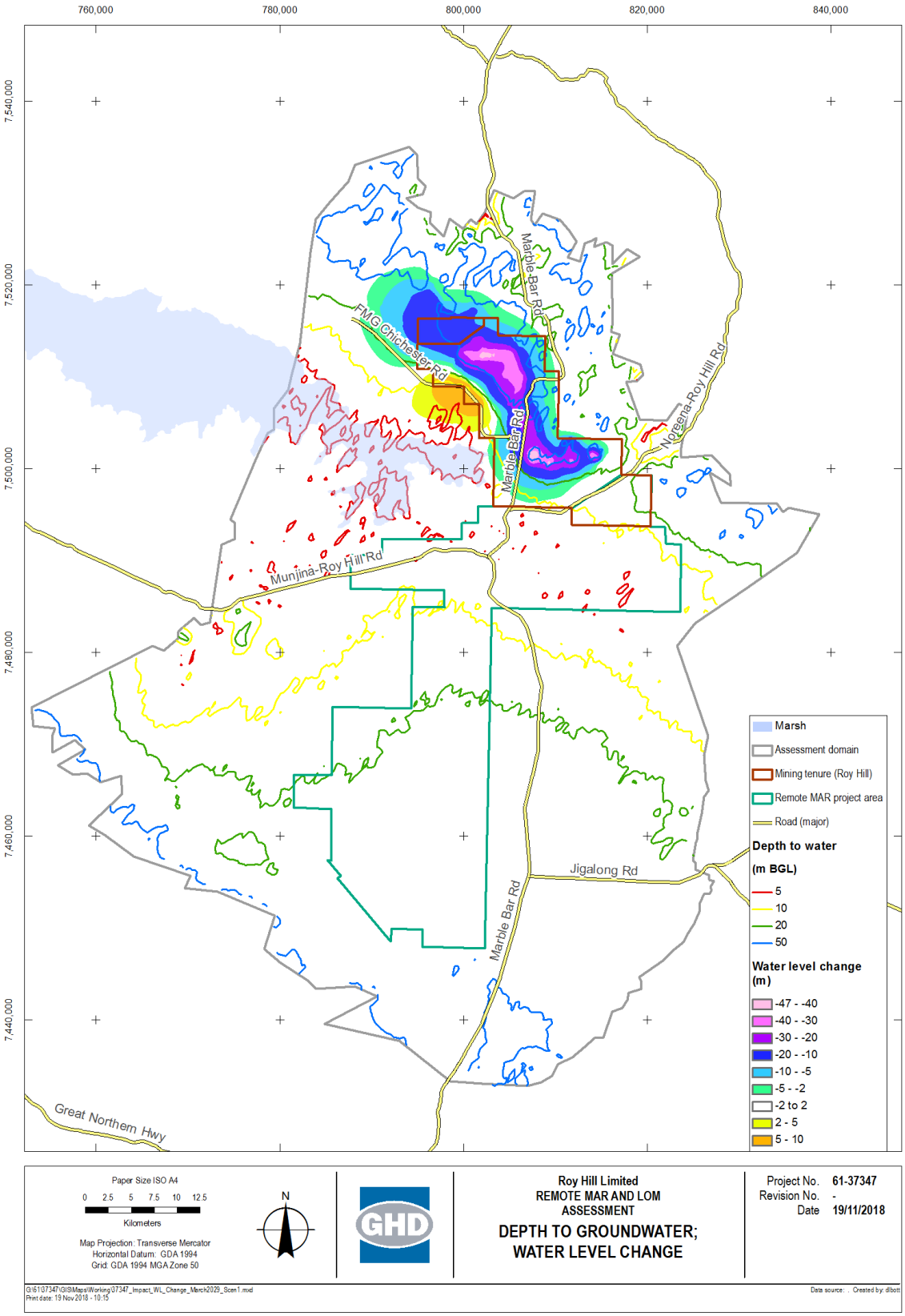
Depth to groundwater; water level change, March 2027

Scenario 1: Dewatering and injection in mining area (SWIB and MPIB)



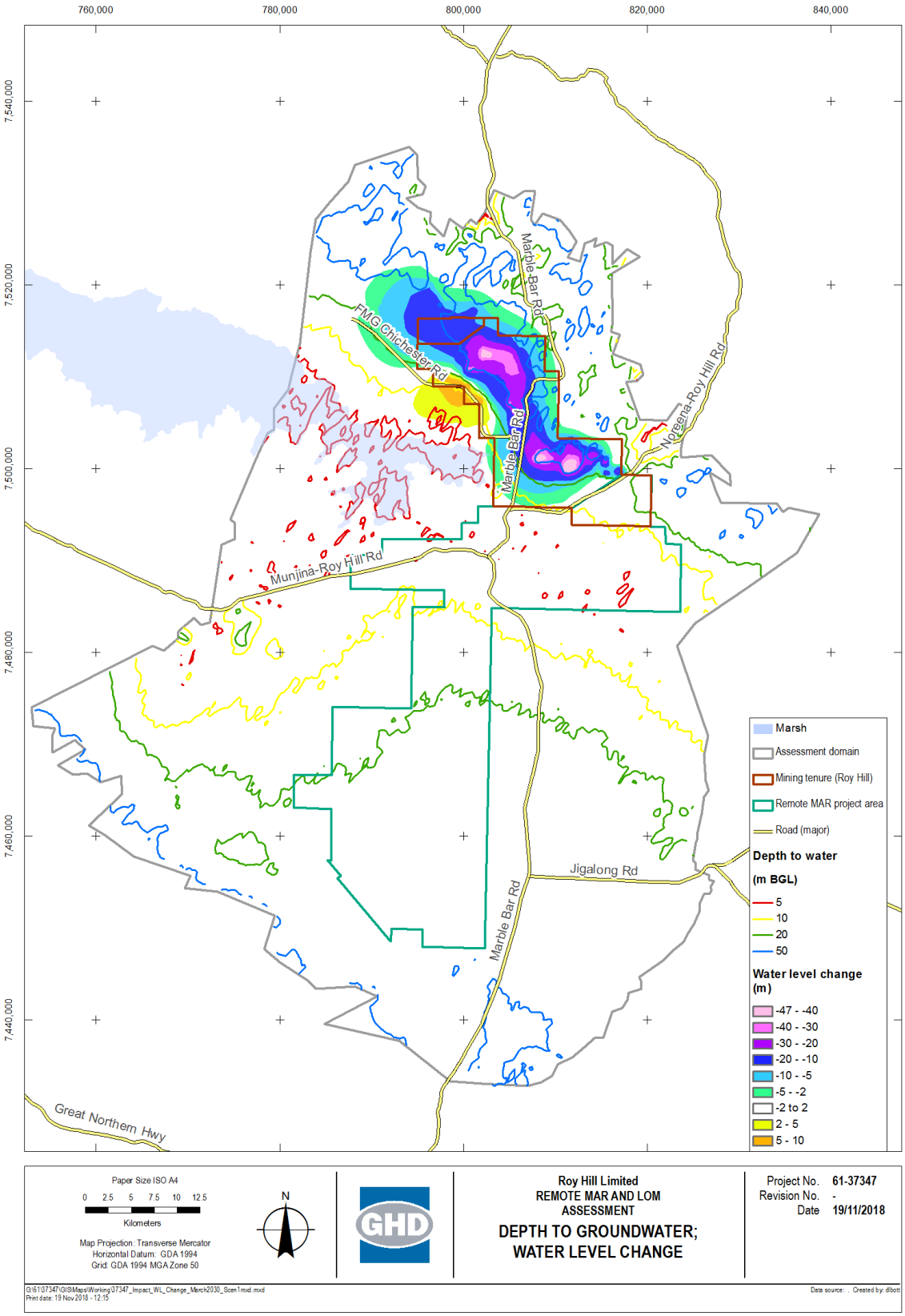
Depth to groundwater; water level change, March 2028

Scenario 1: Dewatering and injection in mining area (SWIB and MPIB)



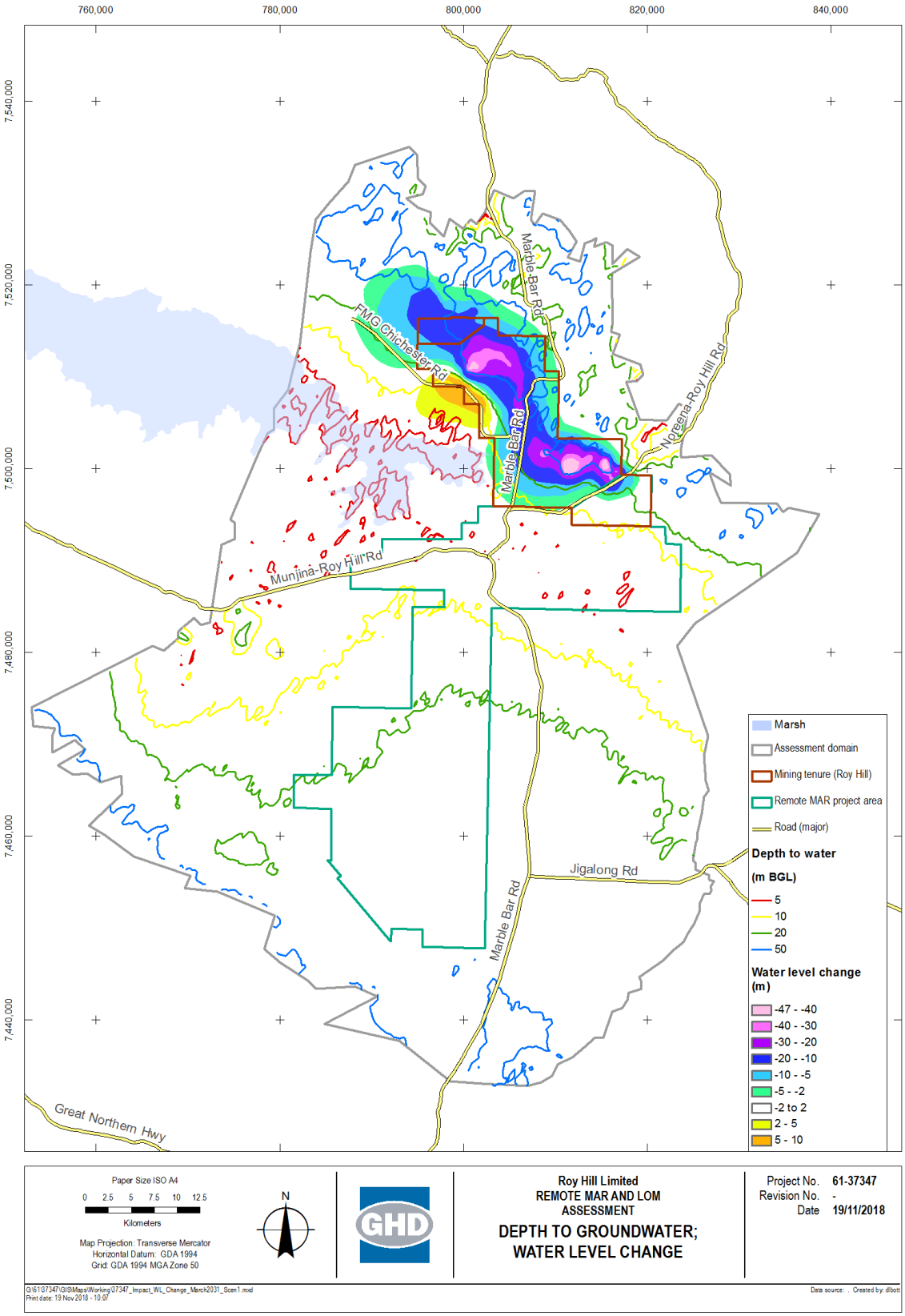
Depth to groundwater; water level change, March 2029

Scenario 1: Dewatering and injection in mining area (SWIB and MPIB)



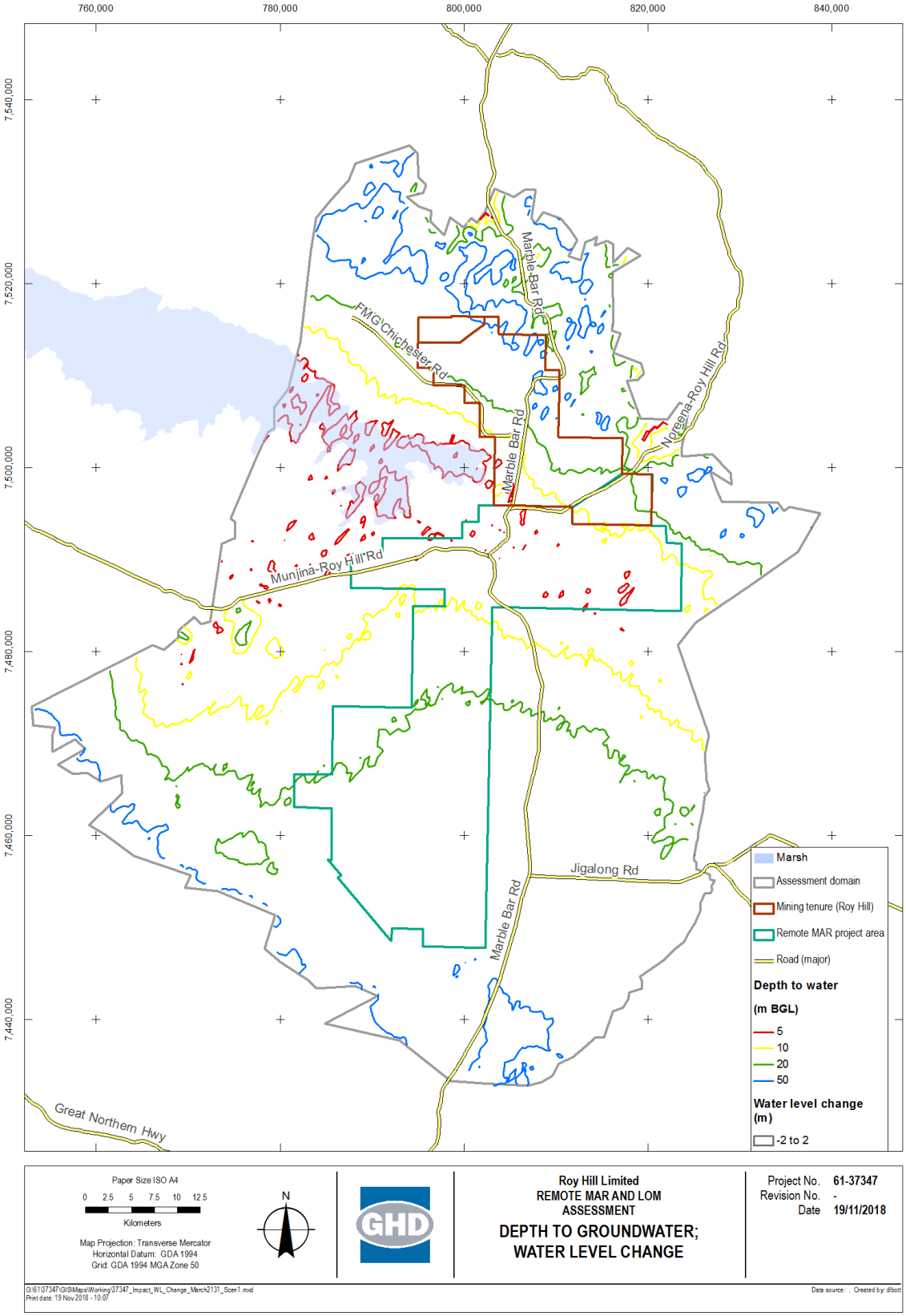
Depth to groundwater; water level change, March 2030

Scenario 1: Dewatering and injection in mining area (SWIB and MPIB)



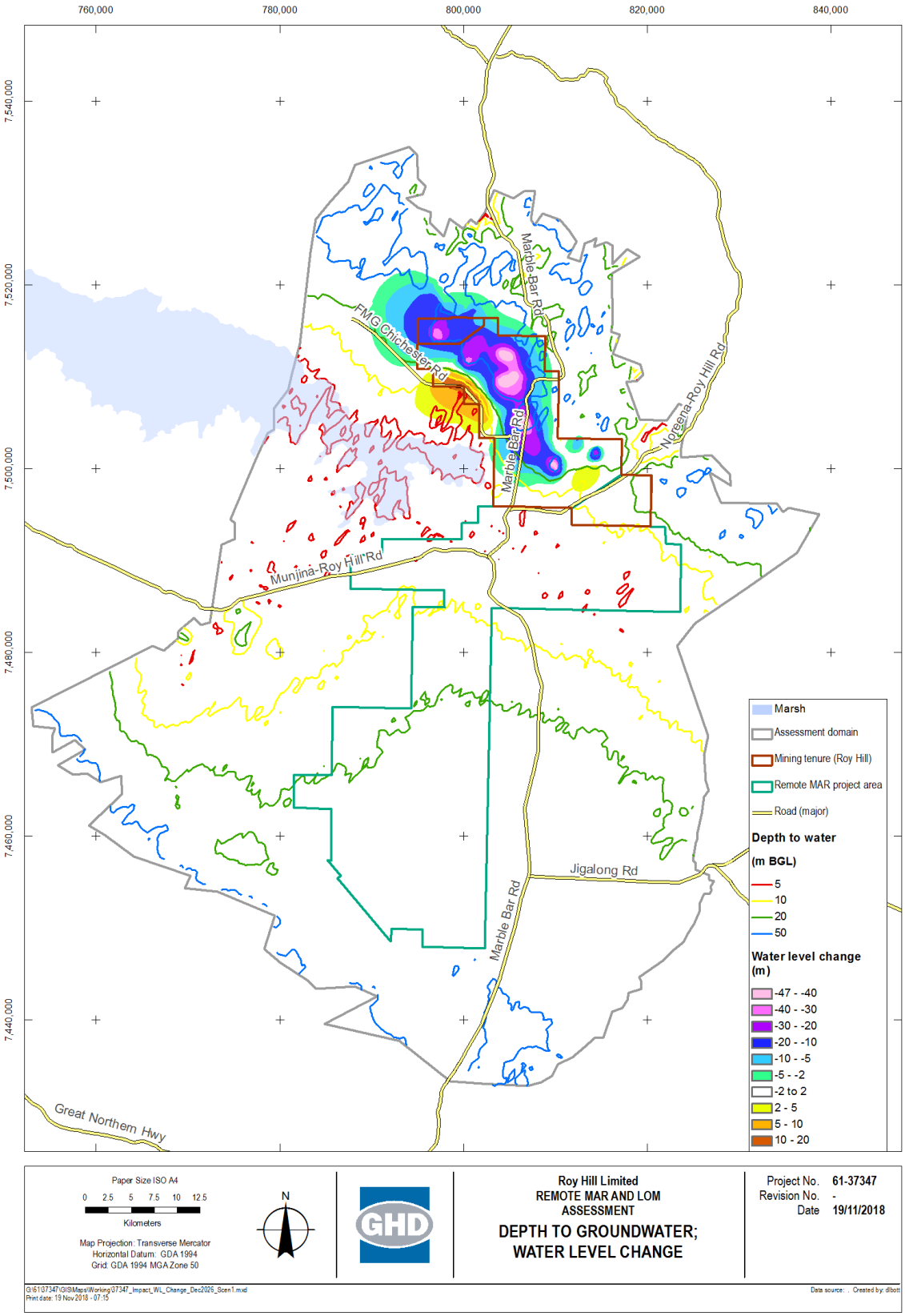
Depth to groundwater; water level change, March 2031

Scenario 1: Dewatering and injection in mining area (SWIB and MPIB)



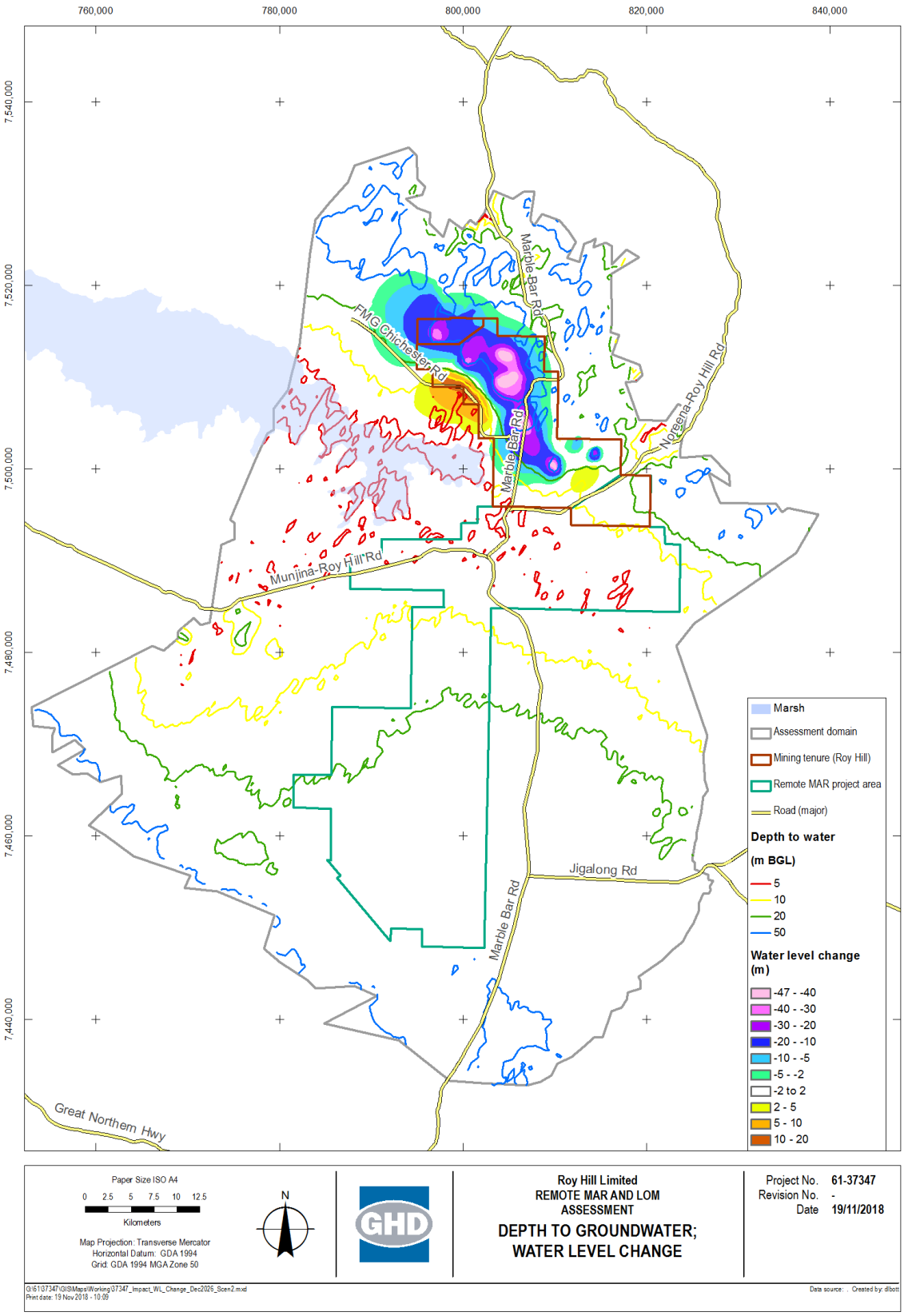
Depth to groundwater; water level change, March 2131 (100 years post closure)

Scenario 1: Dewatering and injection in mining area (SWIB and MPIB)



Depth to groundwater; water level change, December 2026

Scenario 2: Dewatering and injection in mining area (SWIB and MPIB), surplus disposal in RMAR North



Depth to groundwater; water level change, December 2026

Scenario 2B: Dewatering and injection in mining area (SWIB and MPIB), surplus disposal in RMAR North and in RMAR South (20 ML/d)

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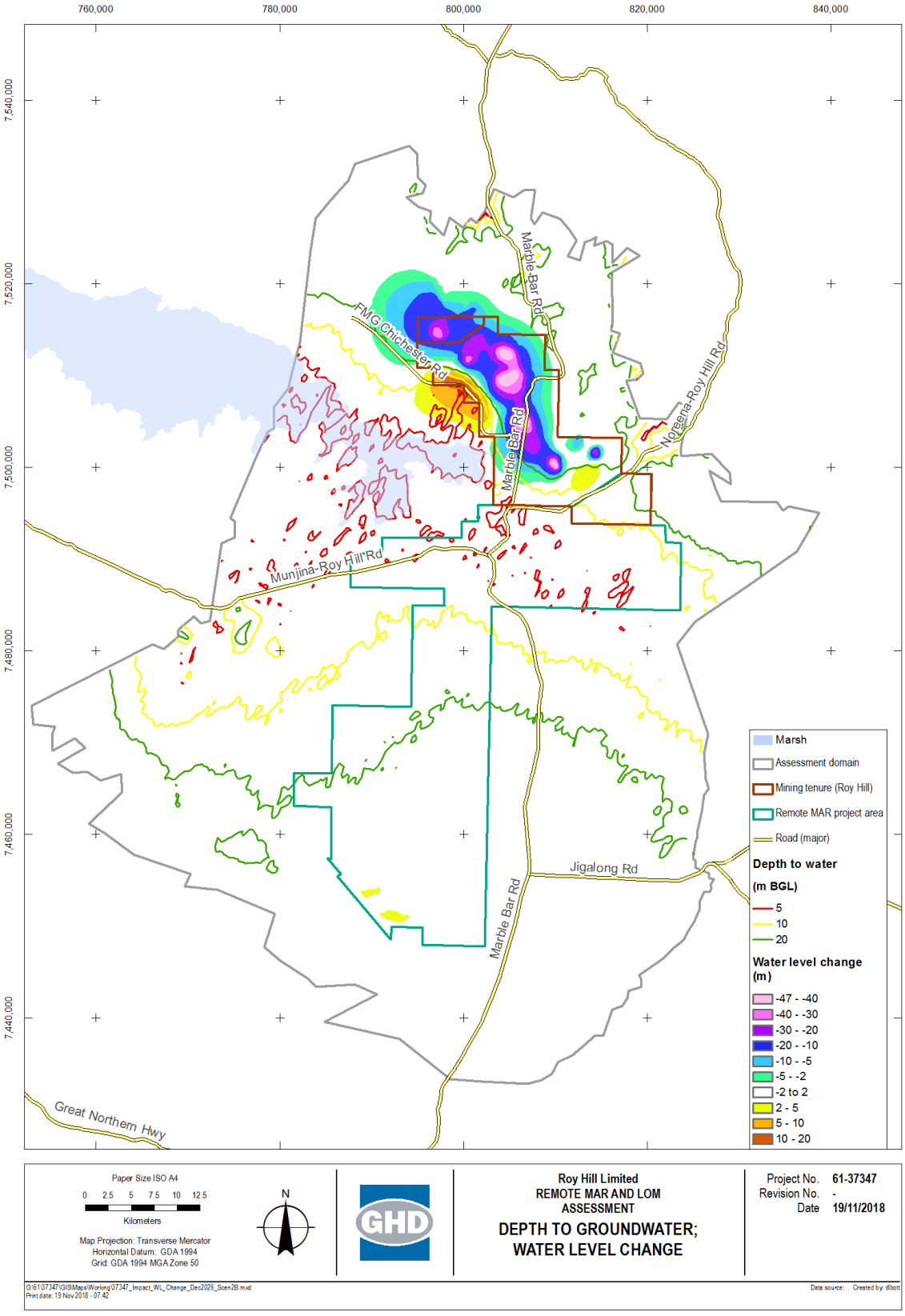
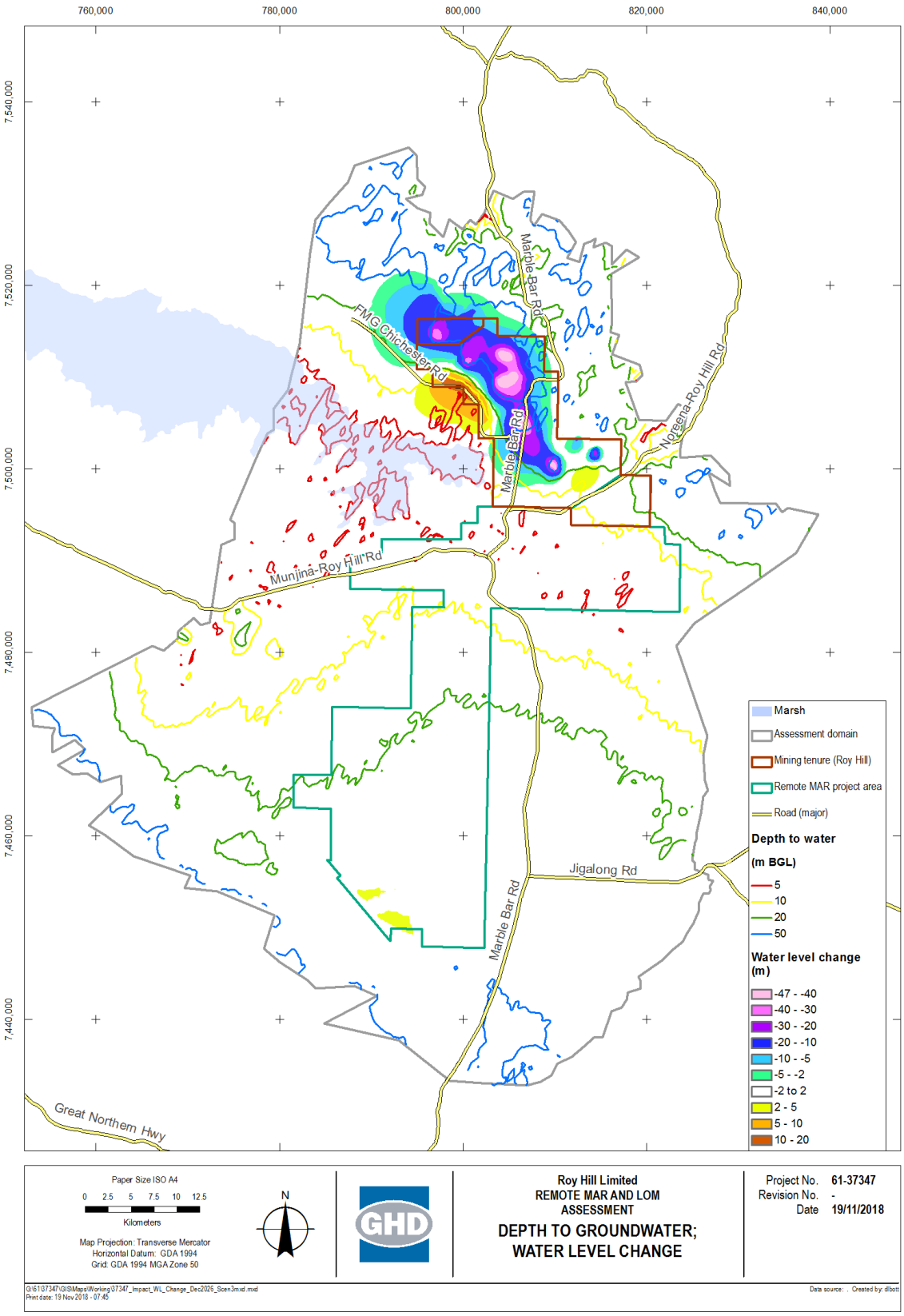


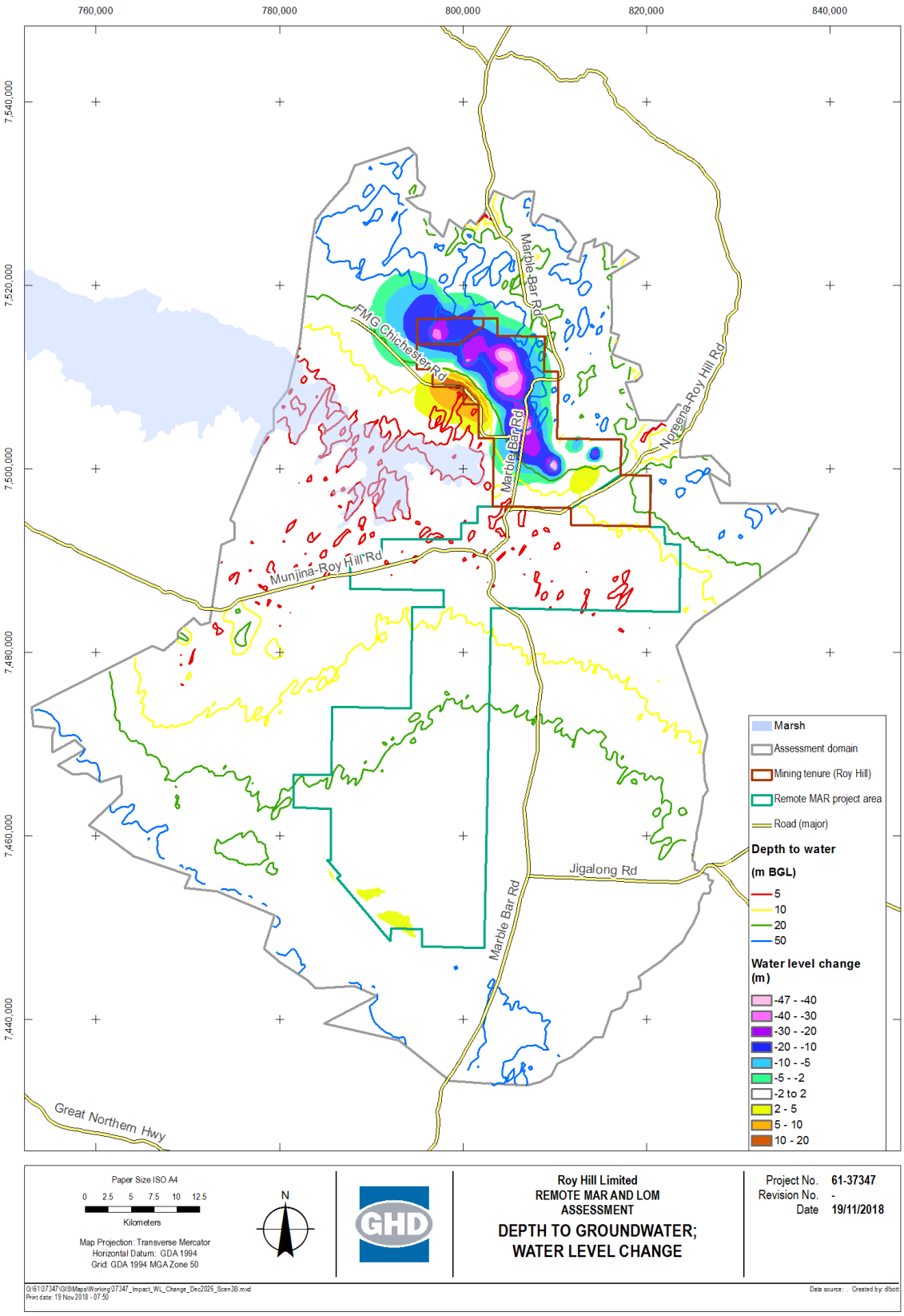
Depth to groundwater; water level change, December 2026

Scenario 3: Dewatering and injection in mining area (SWIB and MPIB), surplus disposal in RMAR South



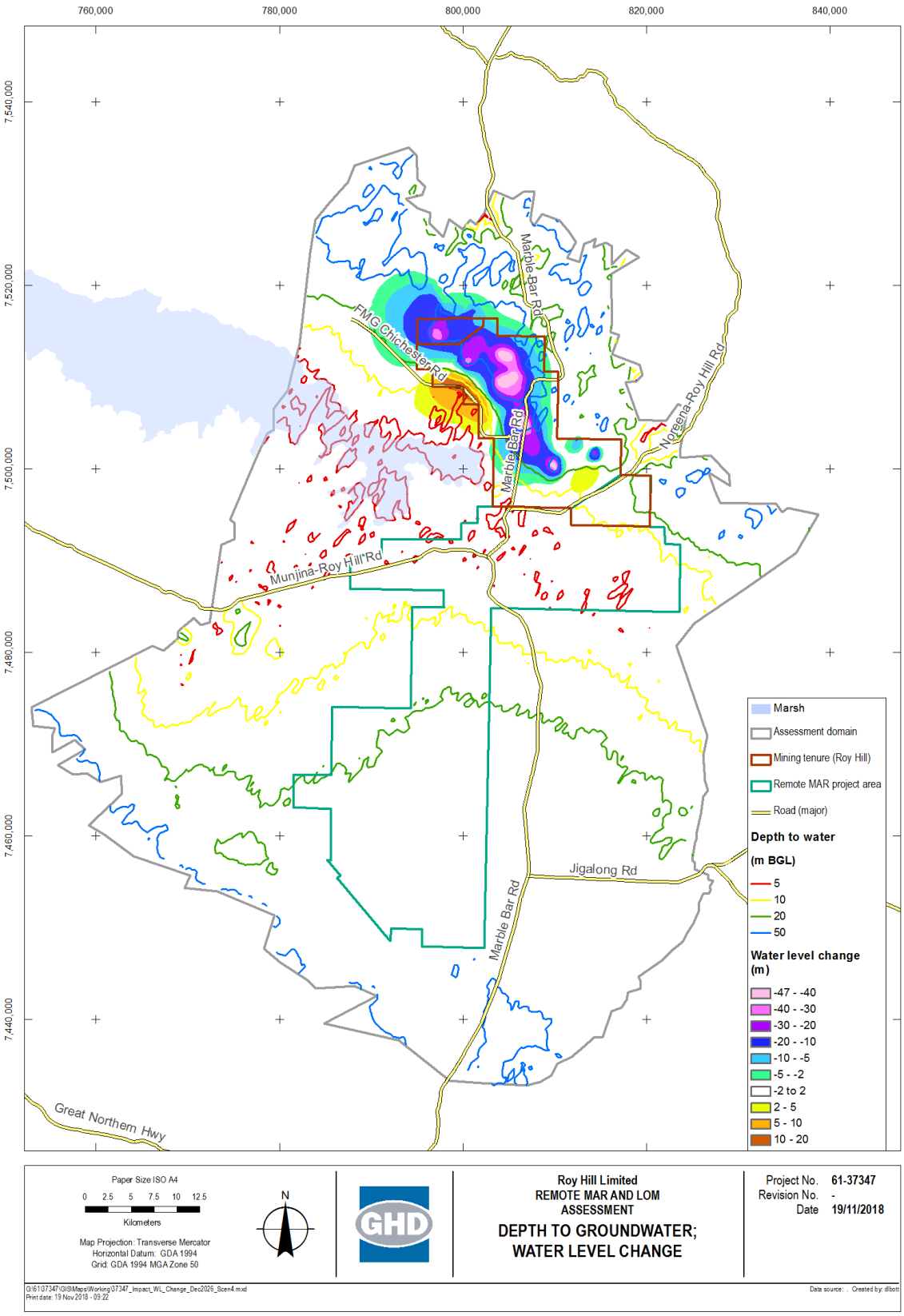
Depth to groundwater; water level change, December 2026

Scenario 3B: Dewatering and injection in mining area (SWIB and MPIB), surplus disposal in RMAR South and in RMAR North (20 ML/d)



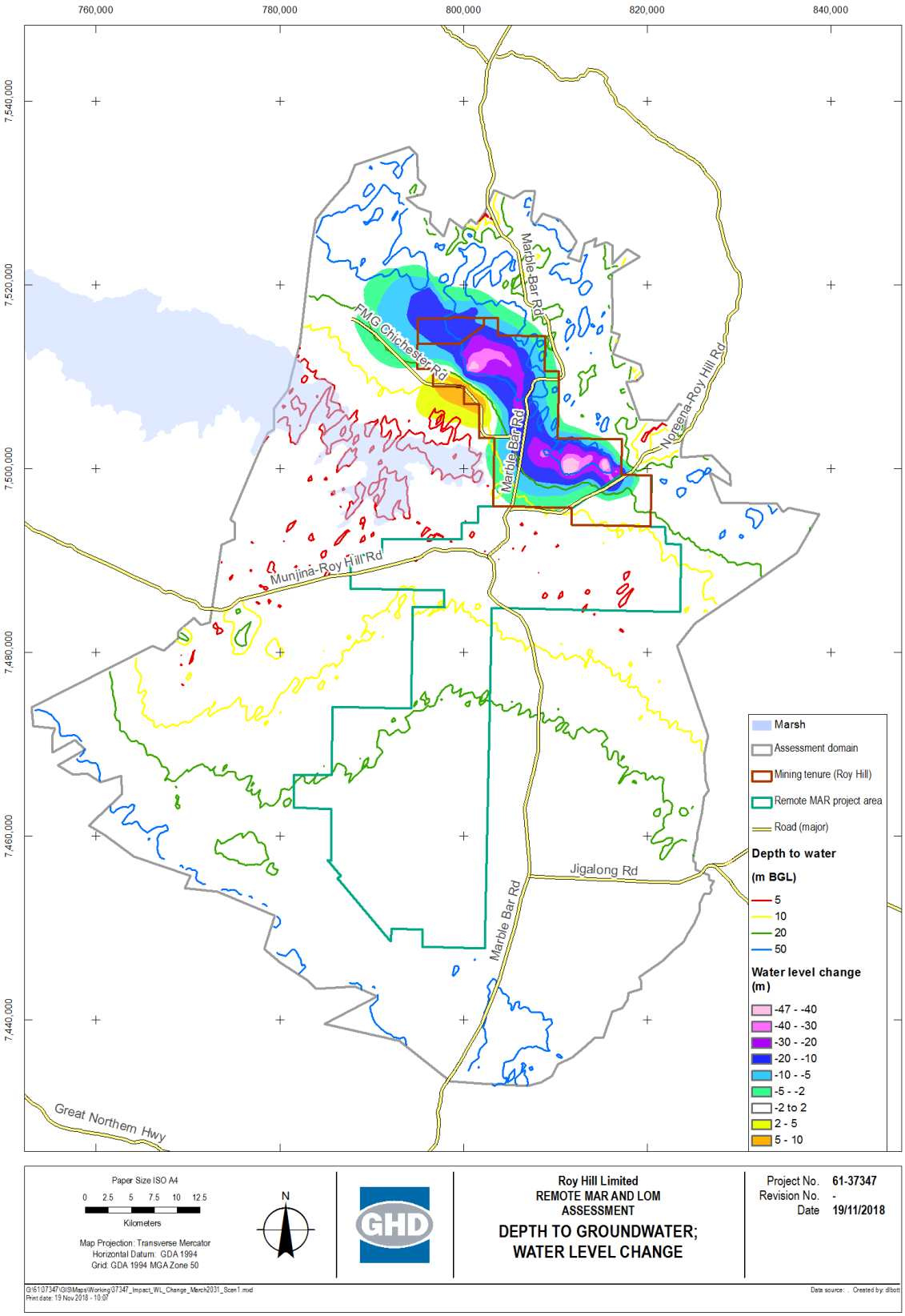
Depth to groundwater; water level change, December 2026

Scenario 4: Dewatering and injection in mining area (SWIB and MPIB), surplus disposal in RMAR North; abstraction from Stage 2 borefield (40 ML/d)



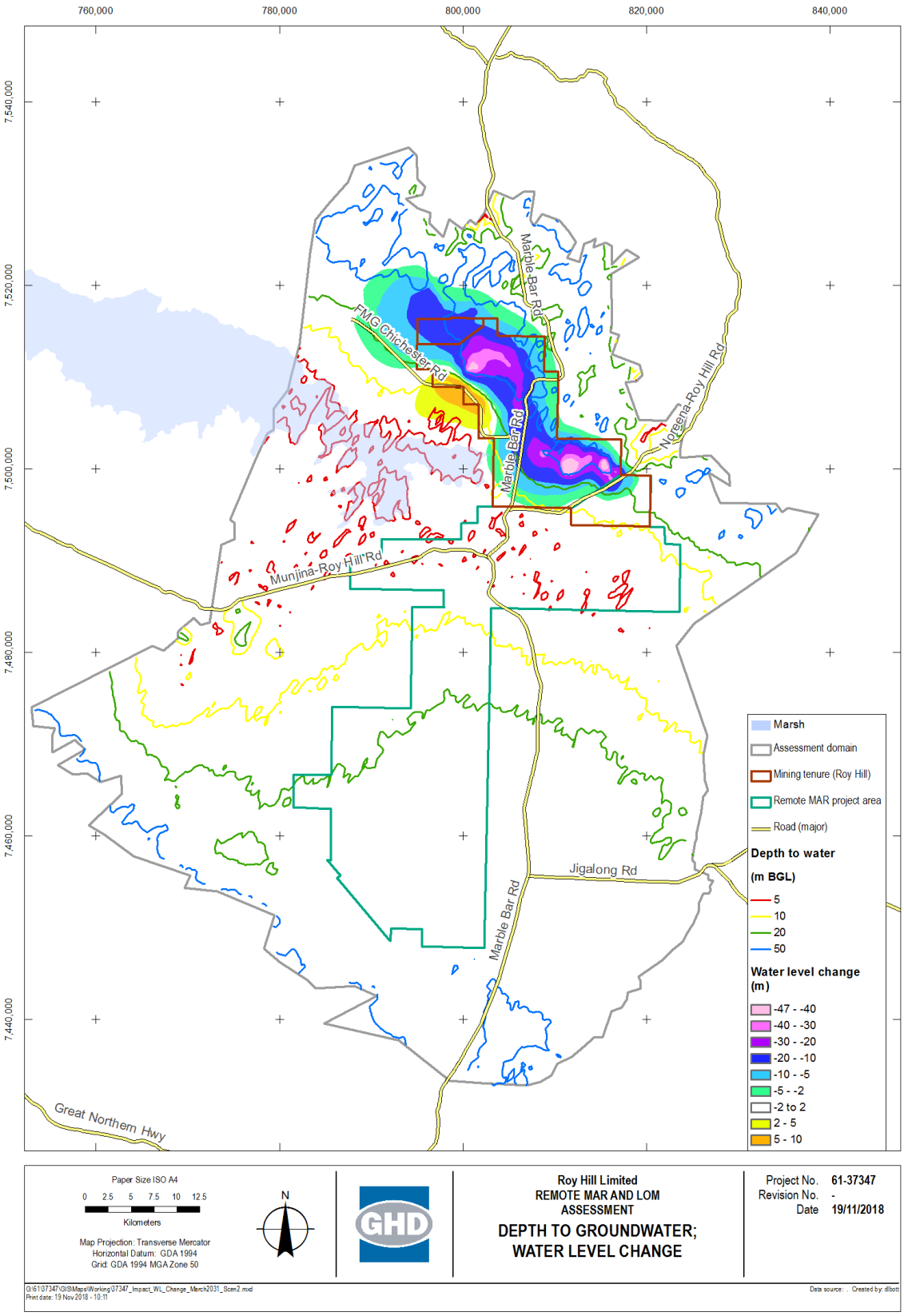
Depth to groundwater; water level change, December 2026

Scenario 1: Dewatering and injection in mining area (SWIB and MPIB)



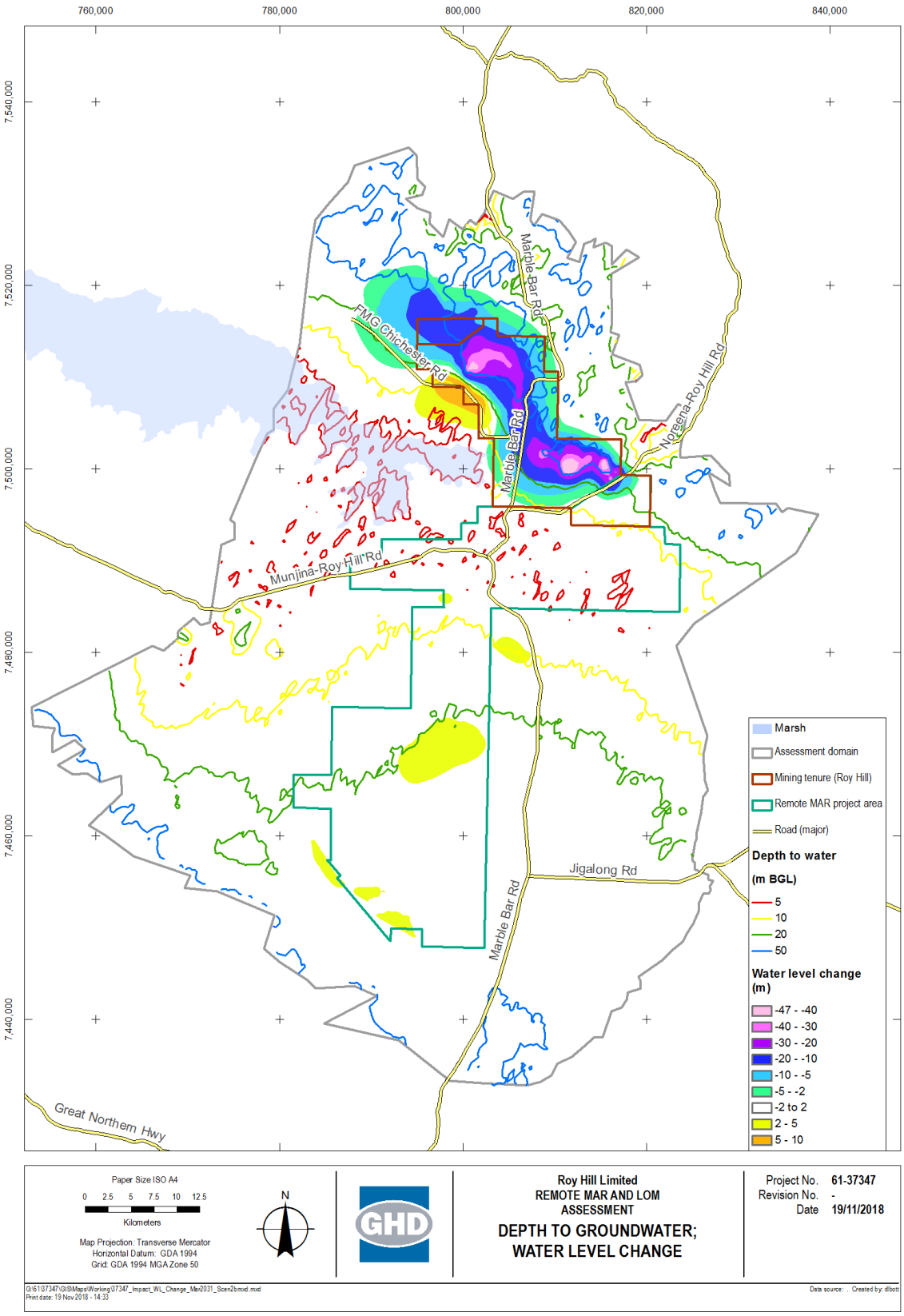
Depth to groundwater; water level change, March 2031

Scenario 2: Dewatering and injection in mining area (SWIB and MPIB), surplus disposal in RMAR North



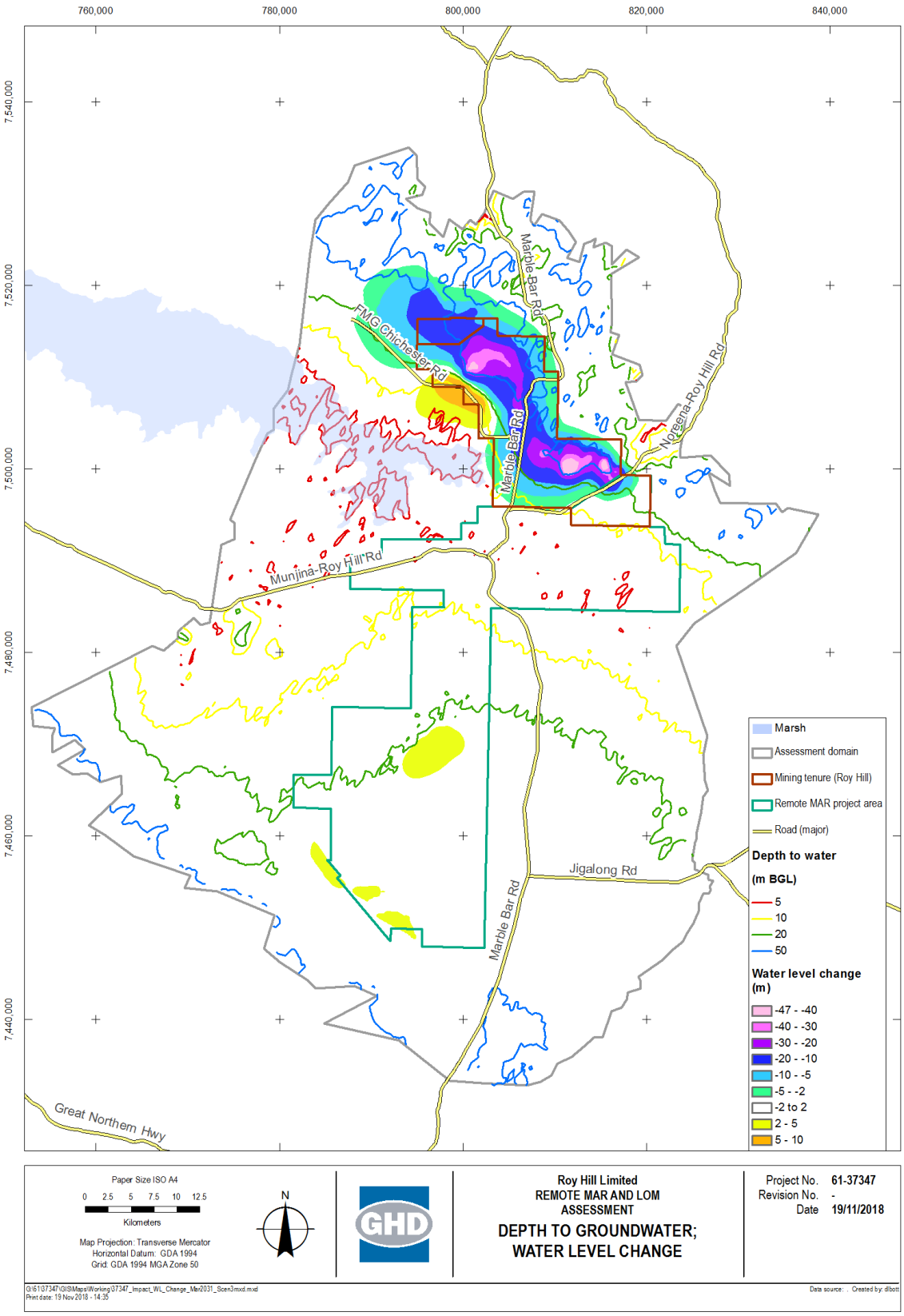
Depth to groundwater; water level change, March 2031

Scenario 2B: Dewatering and injection in mining area (SWIB and MPIB), surplus disposal in RMAR North and in RMAR South (20 ML/d)



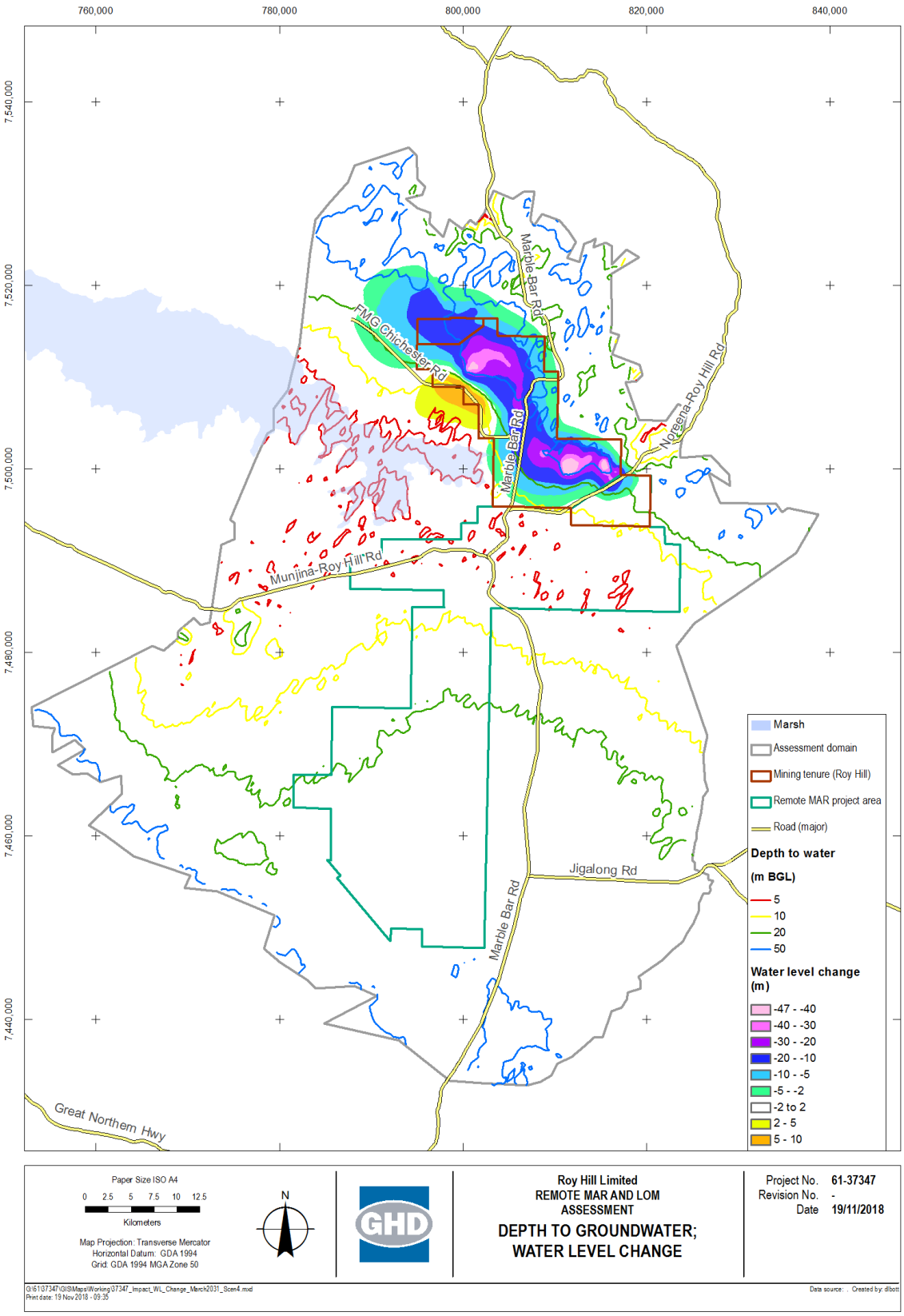
Depth to groundwater; water level change, March 2031

Scenario 3: Dewatering and injection in mining area (SWIB and MPIB), surplus disposal in RMAR South



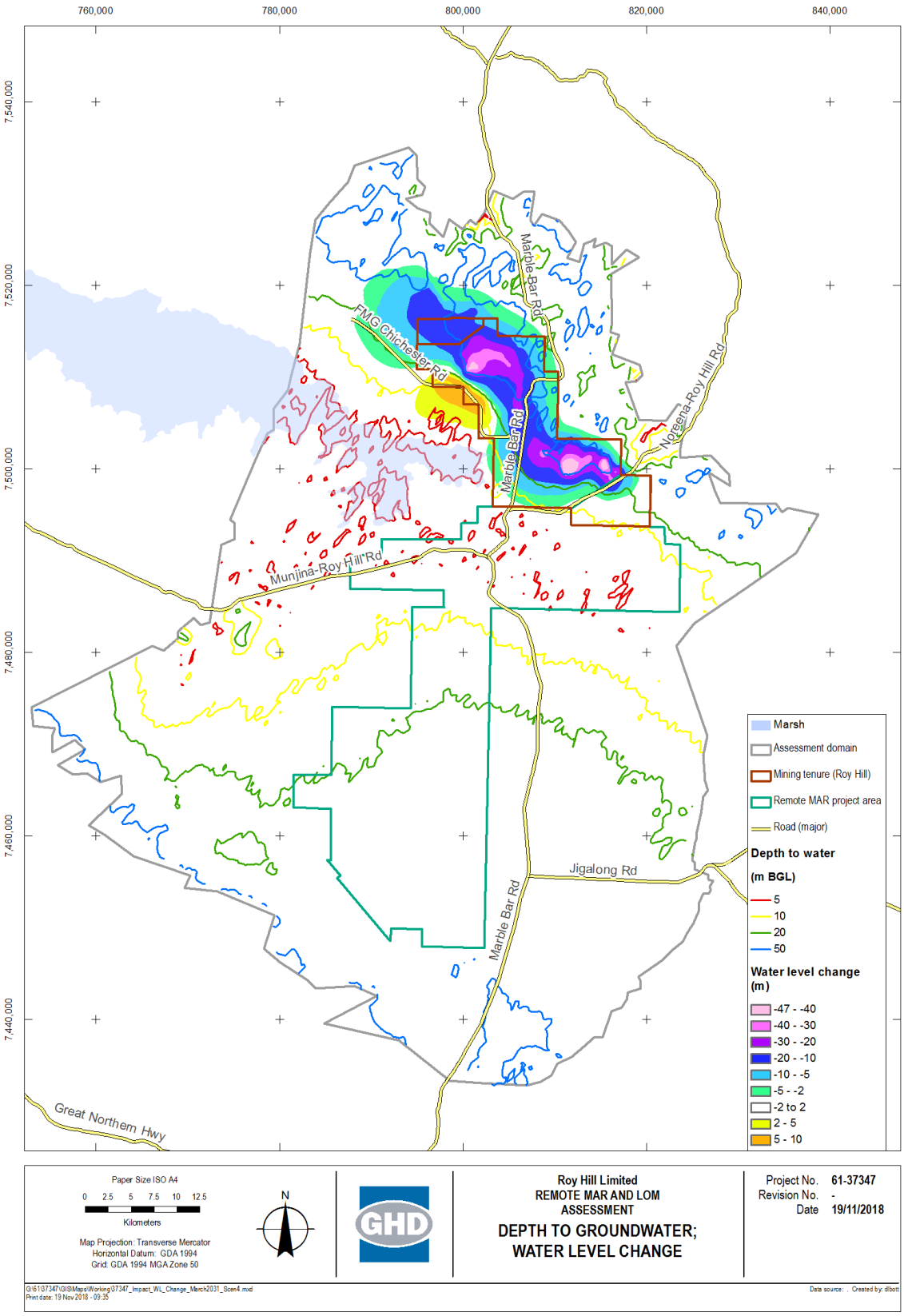
Depth to groundwater; water level change, March 2031

Scenario 3B: Dewatering and injection in mining area (SWIB and MPIB), surplus disposal in RMAR South and in RMAR North (20 ML/d)



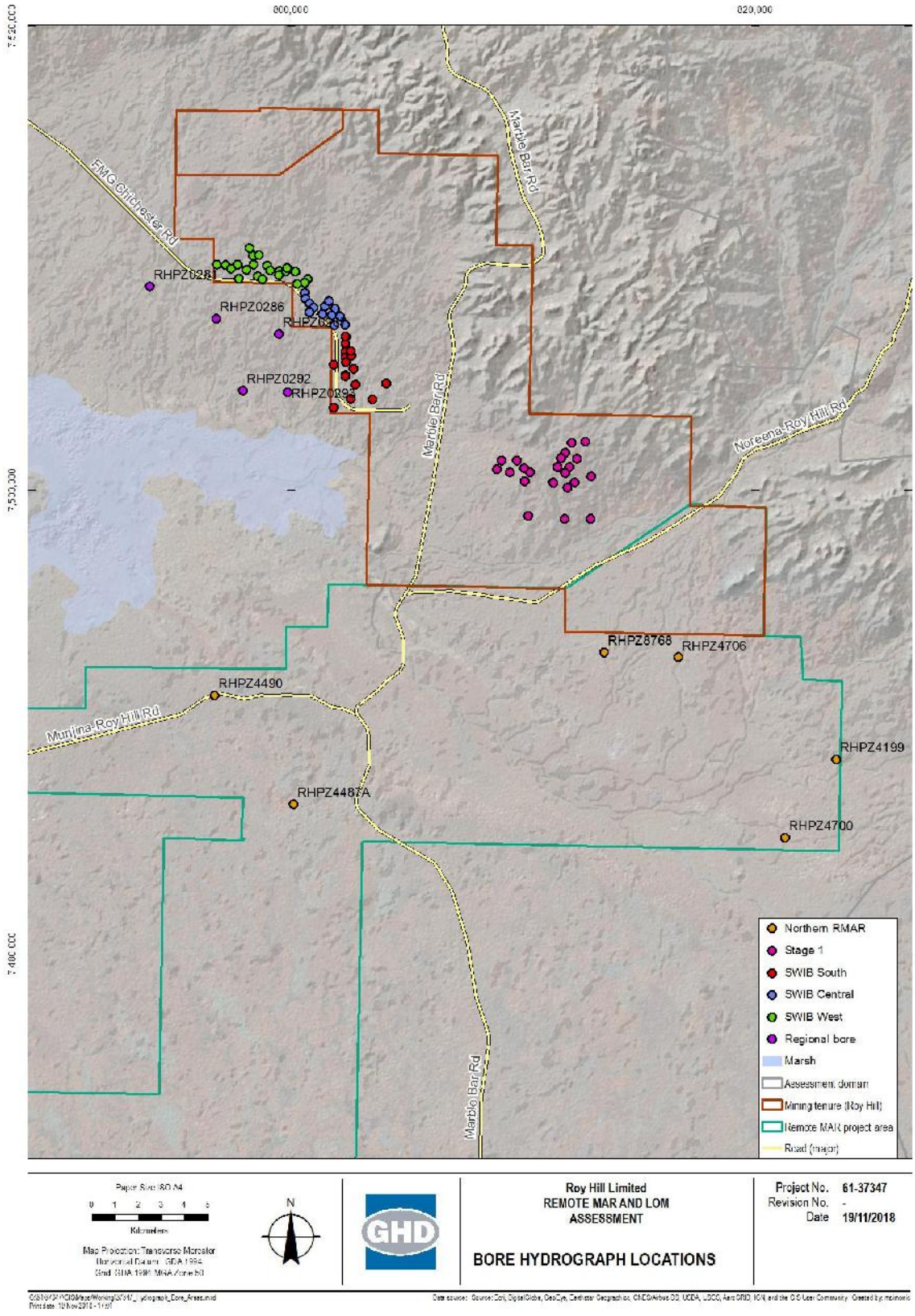
Depth to groundwater; water level change, March 2031

Scenario 4: Dewatering and injection in mining area (SWIB and MPIB), surplus disposal in RMAR North; abstraction from Stage 2 borefield (40 ML/d)



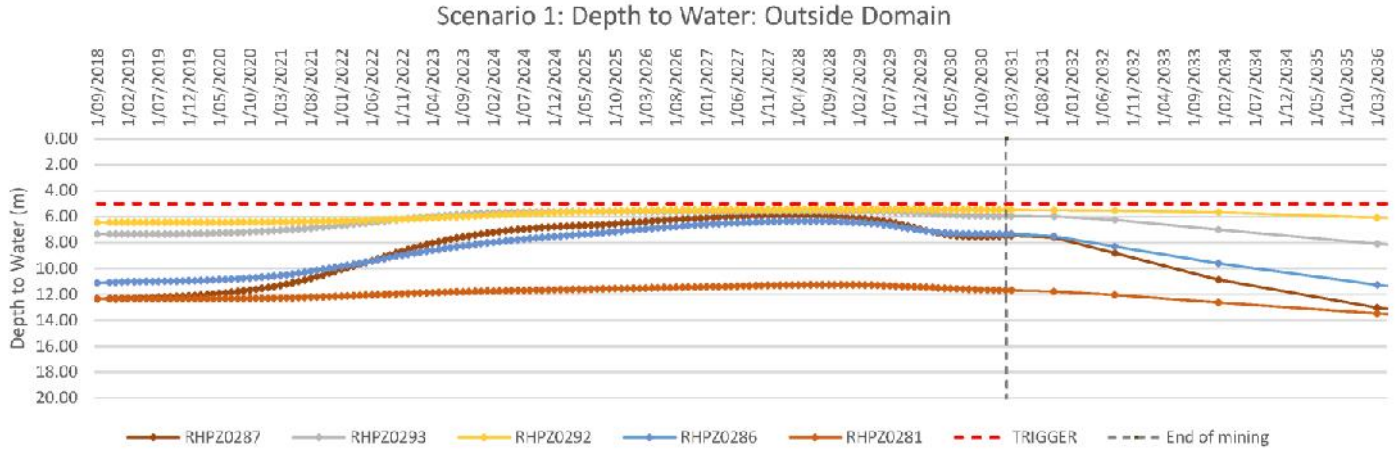
Depth to groundwater; water level change, March 2031

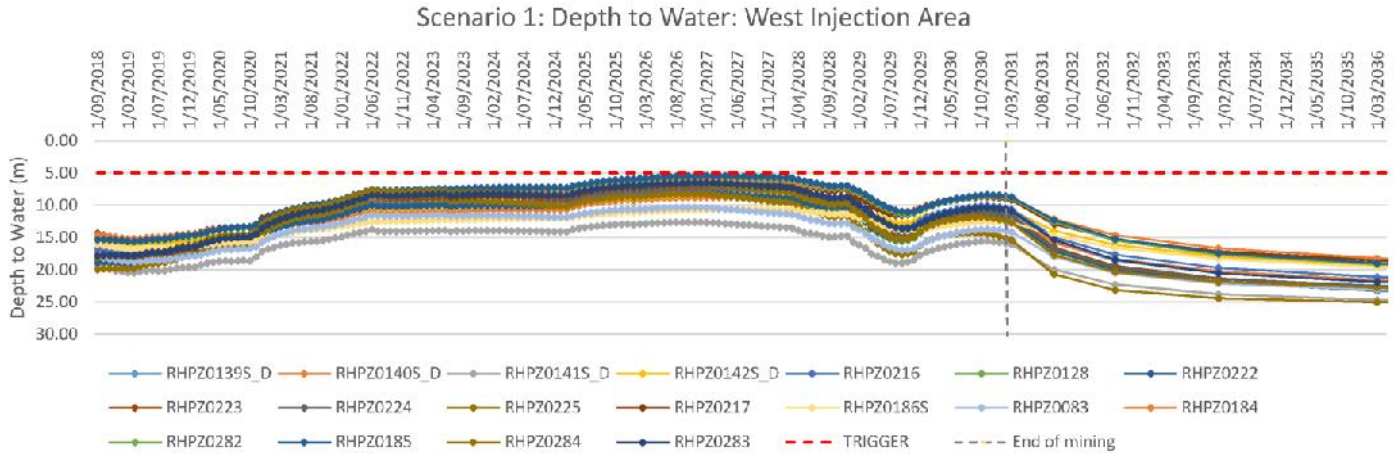
Maps of predicted water level change and depth to groundwater for management simulations



Predicted depth to water

Roy Hill - Remote MAR Study
Hydrographs





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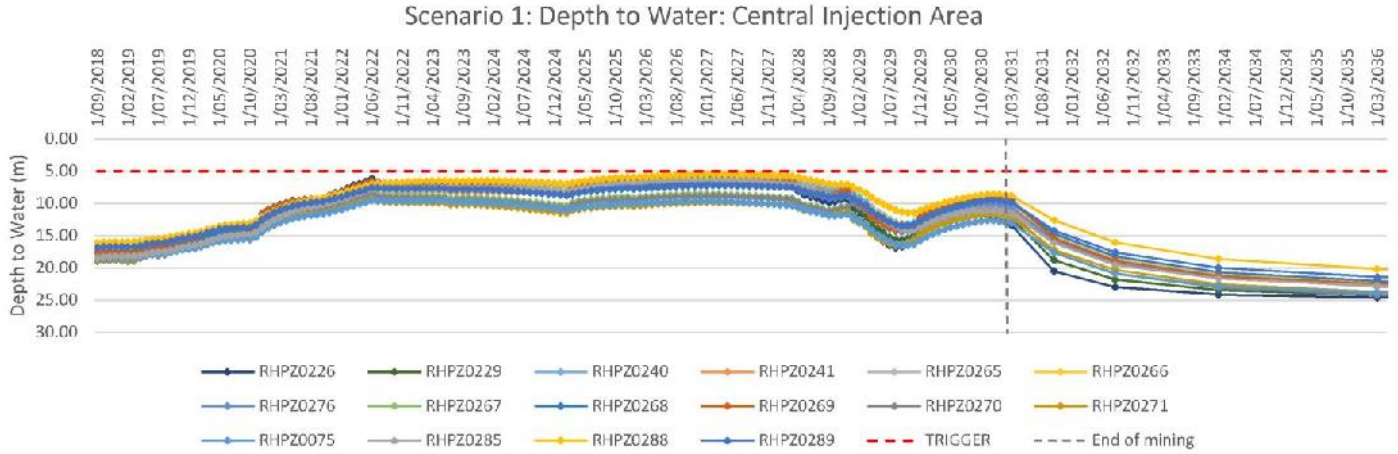

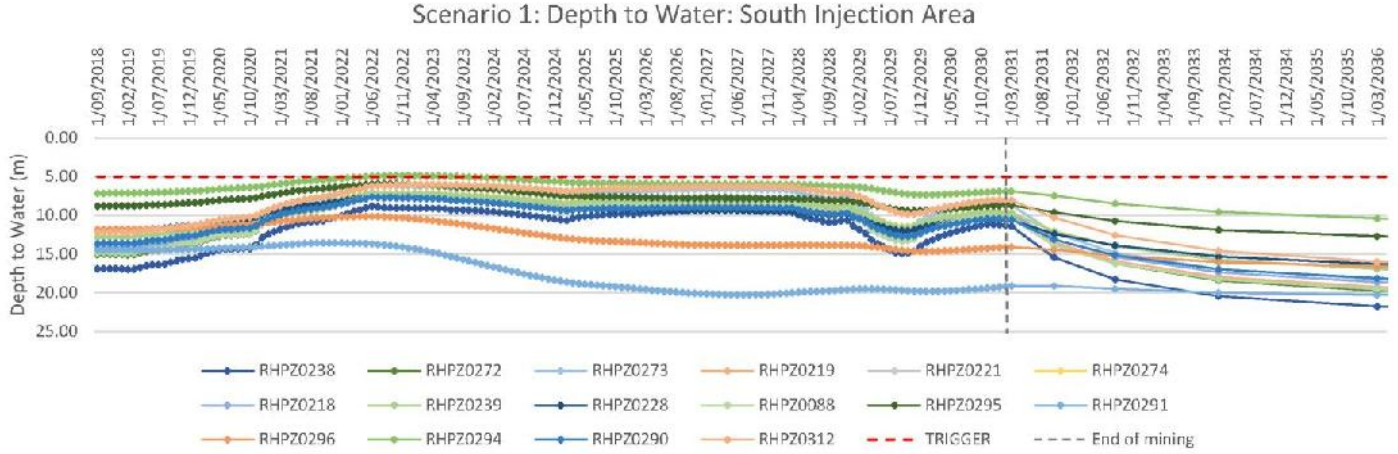

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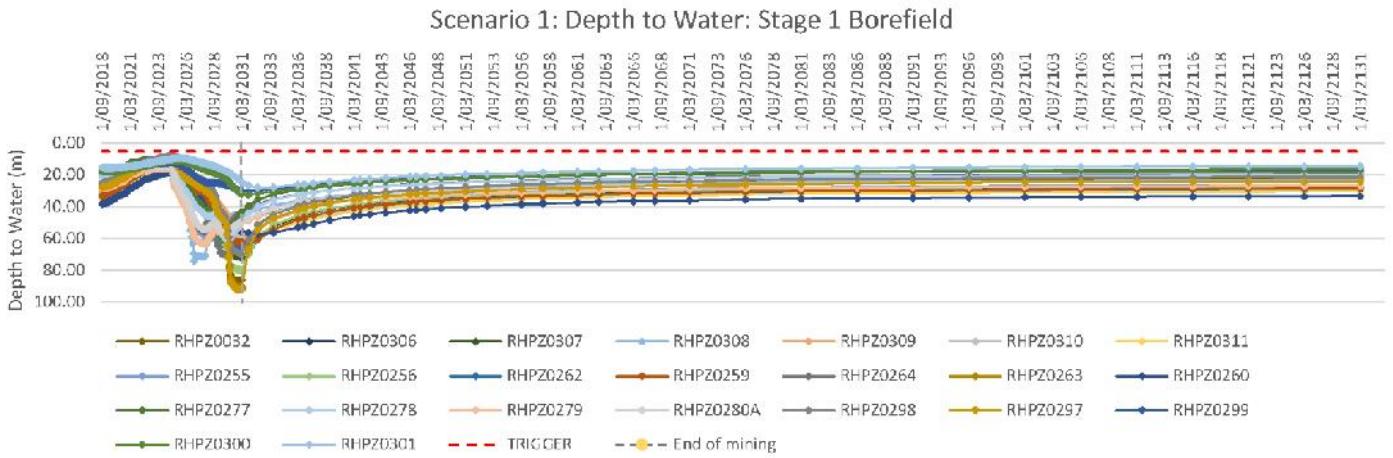

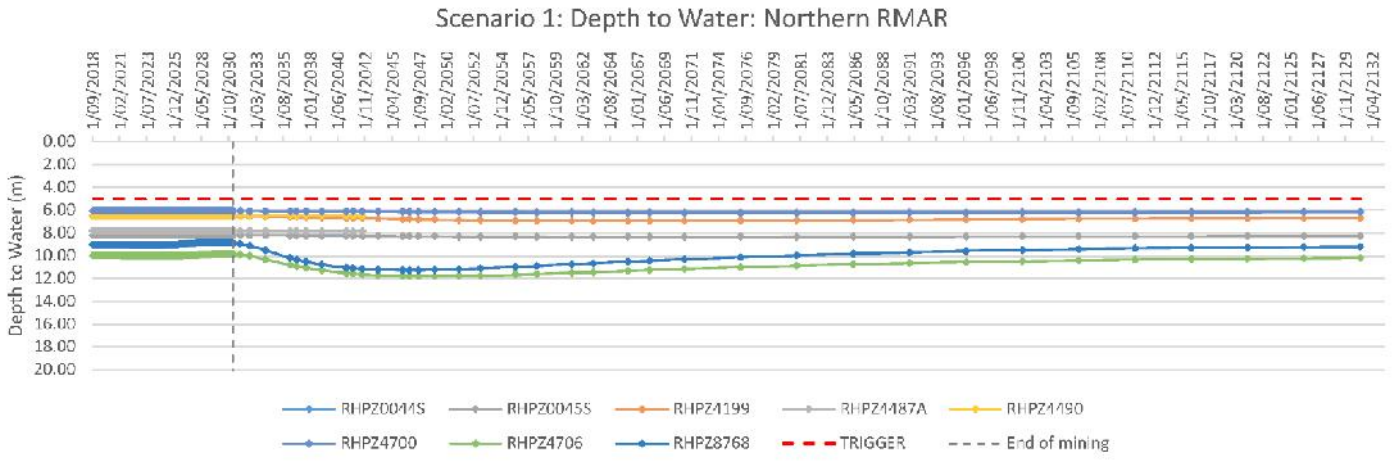

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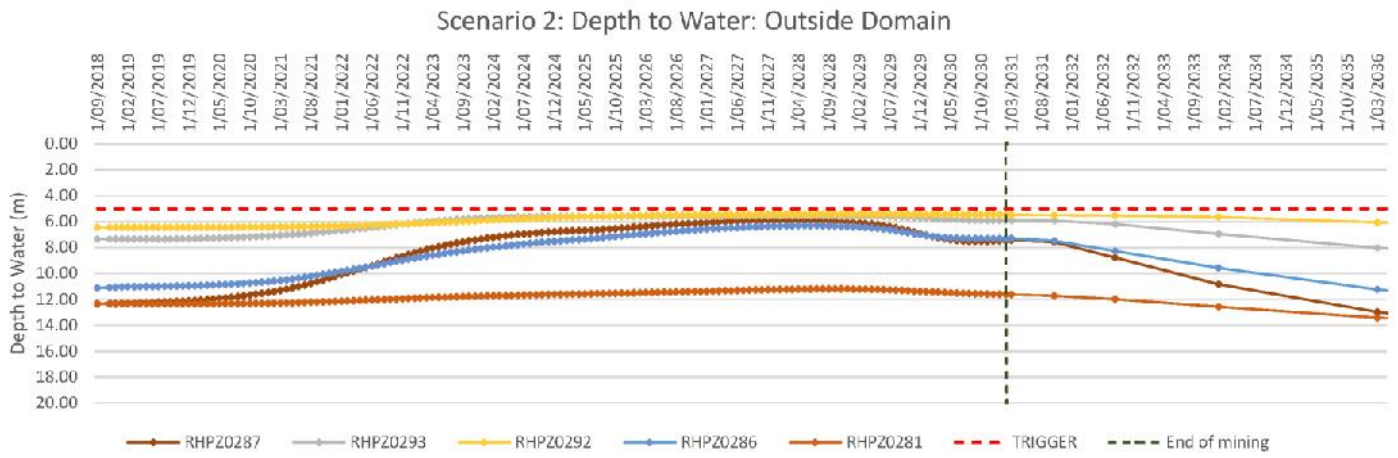

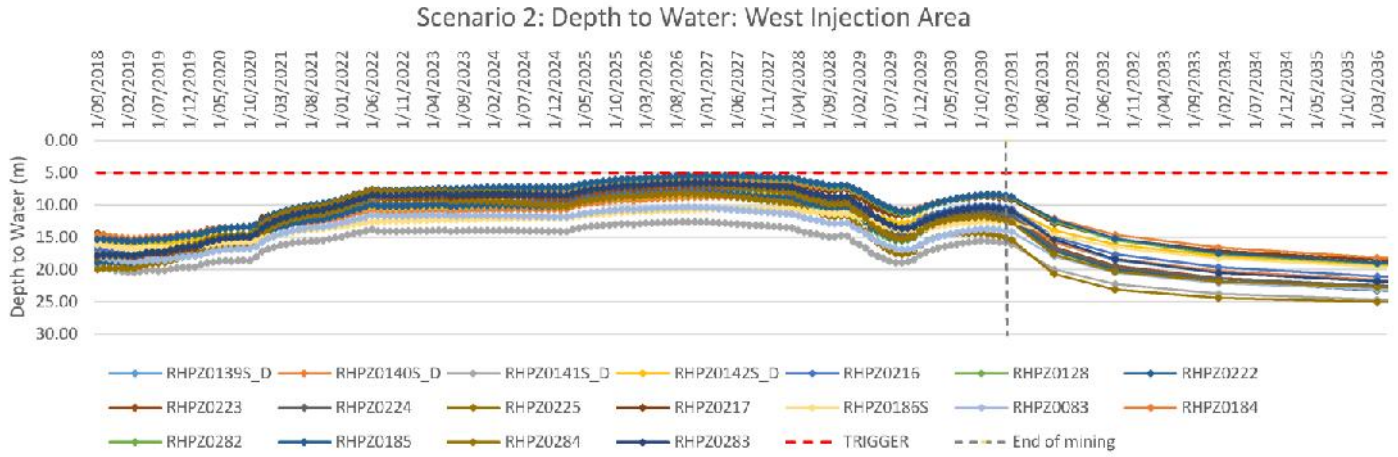

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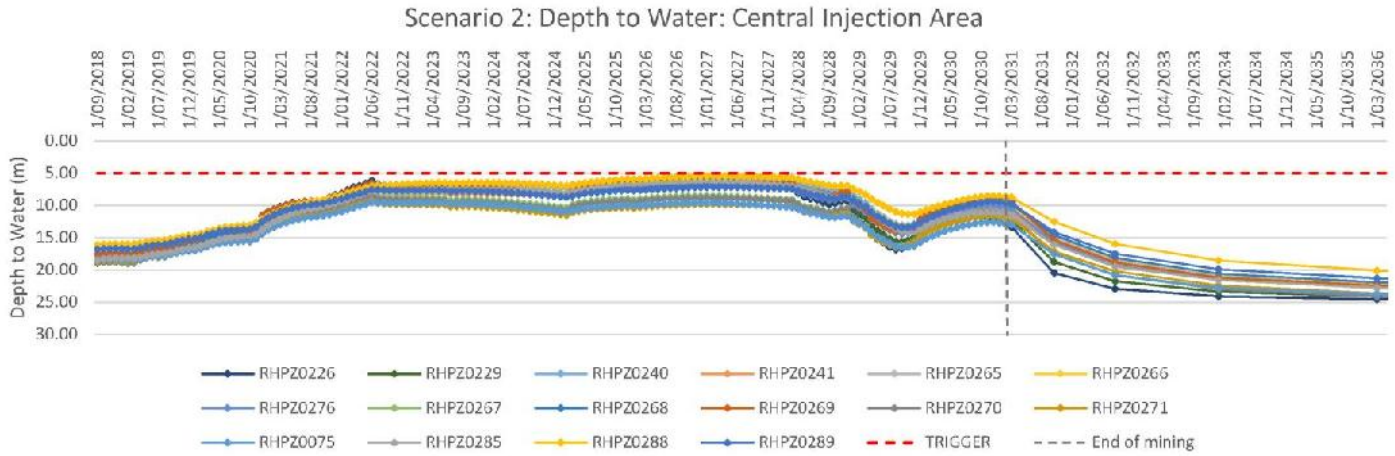

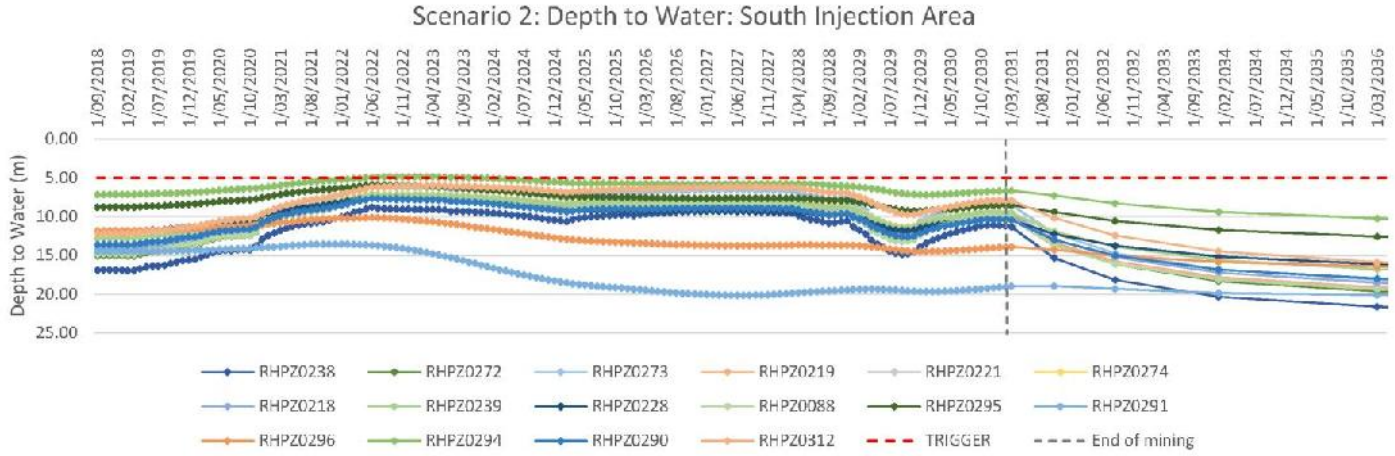

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Predicted depth to water

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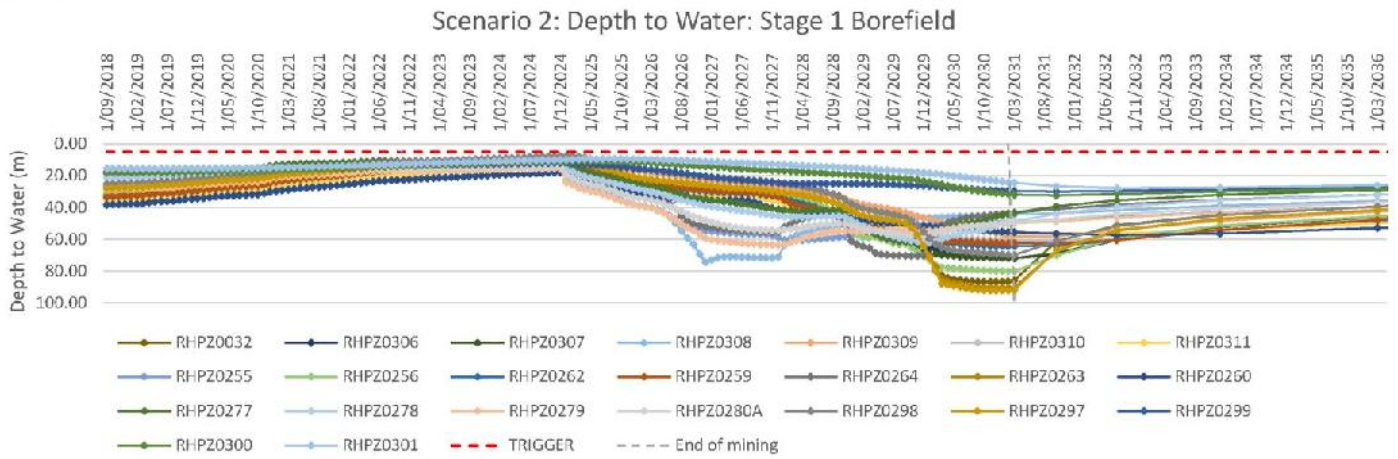

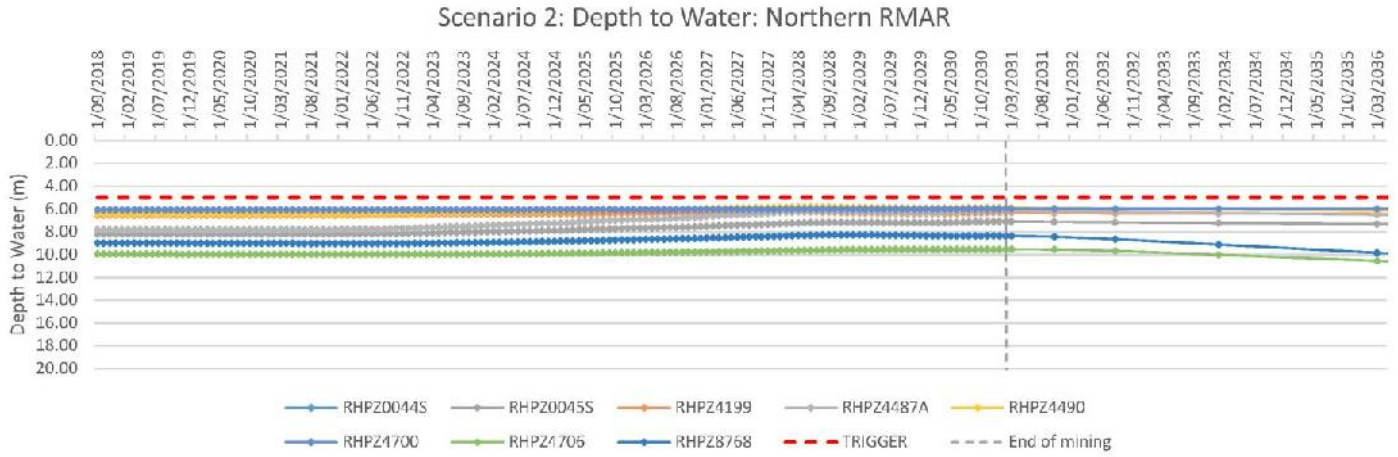

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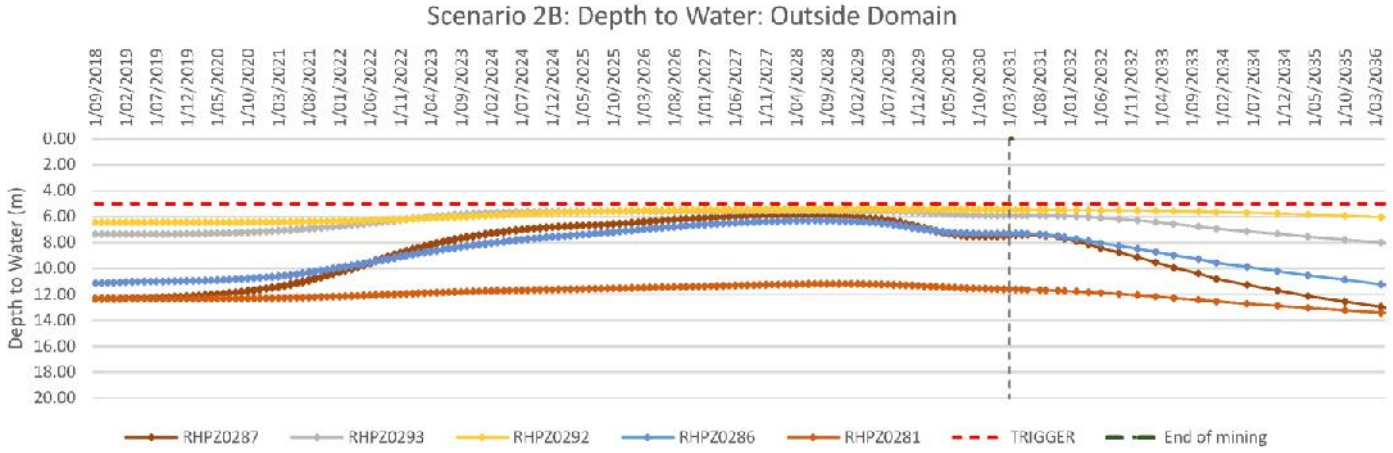

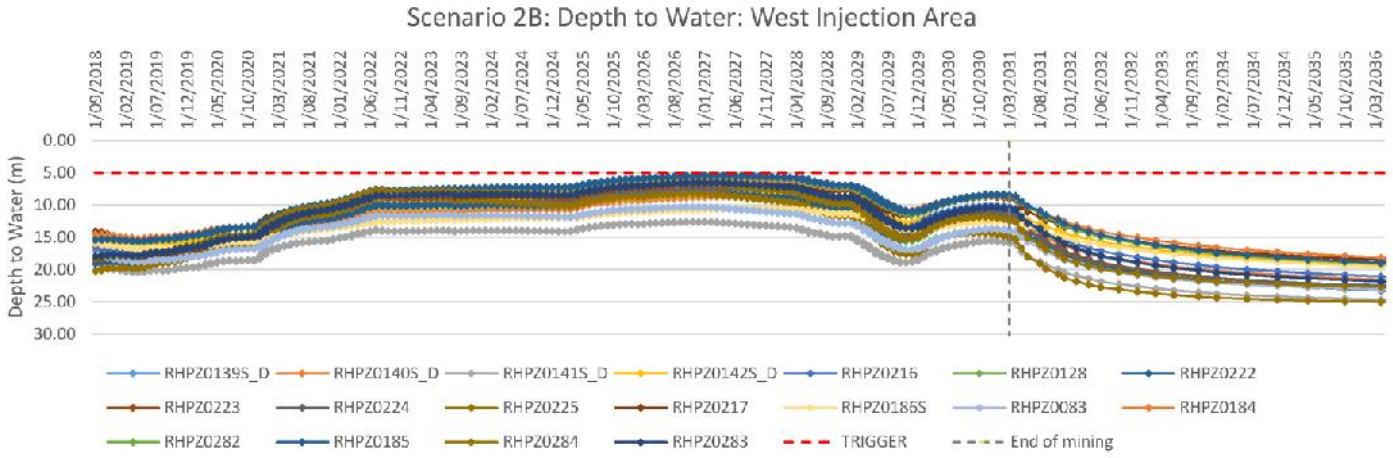

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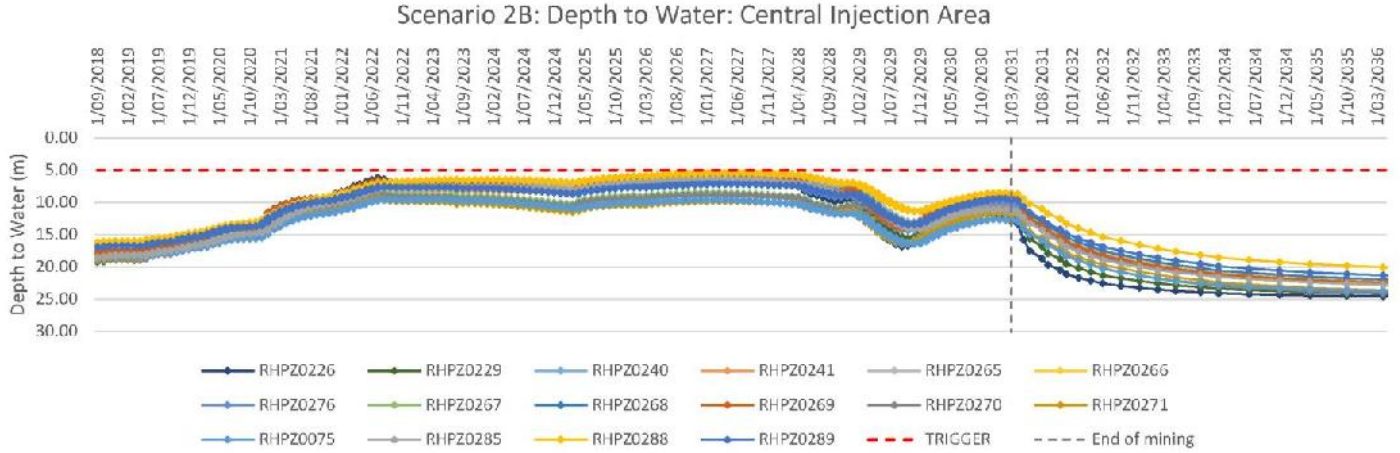

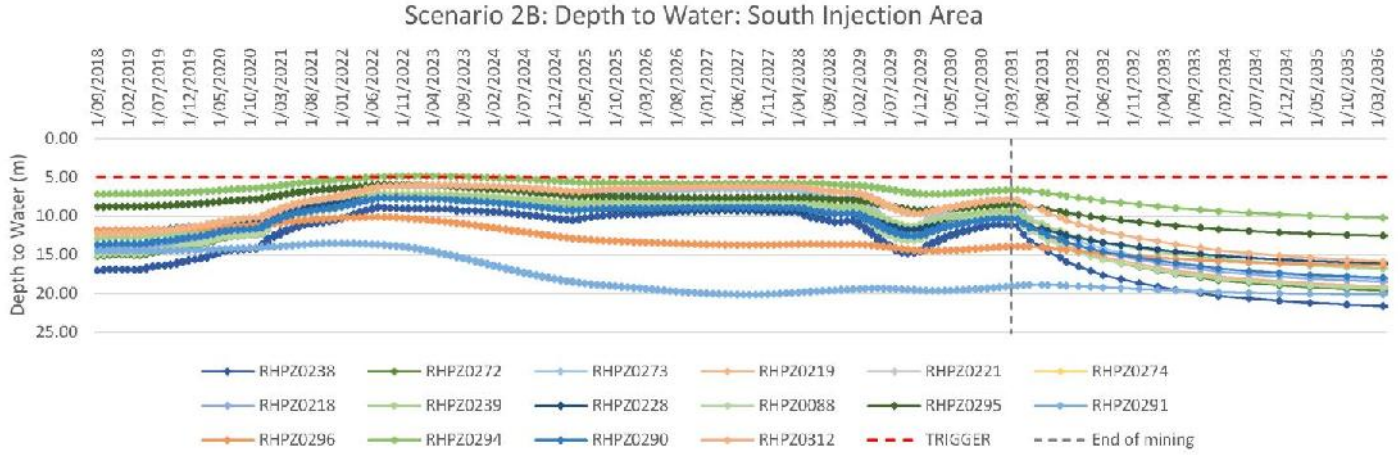

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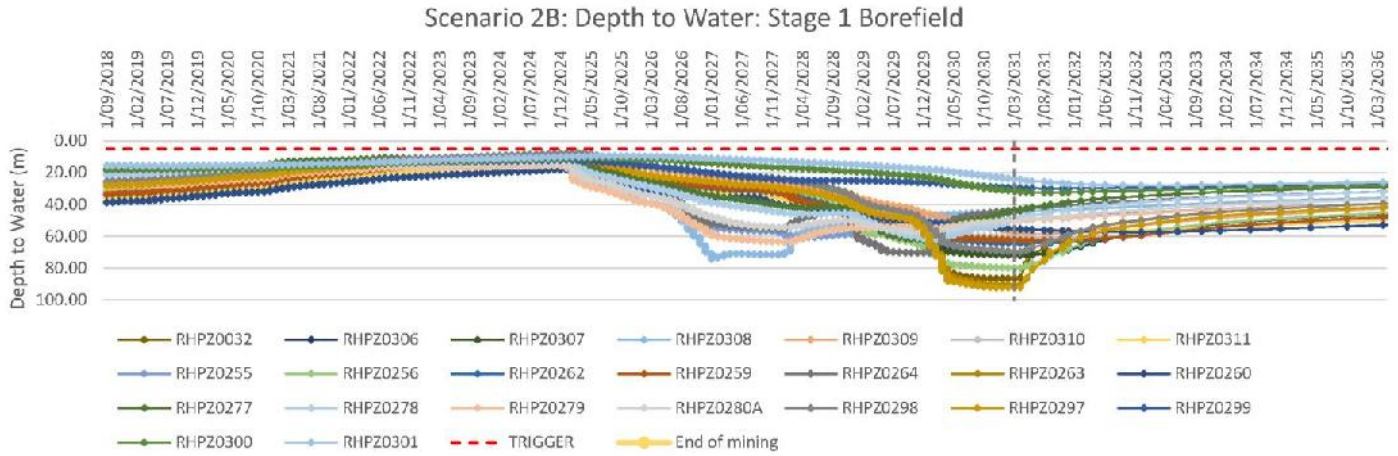

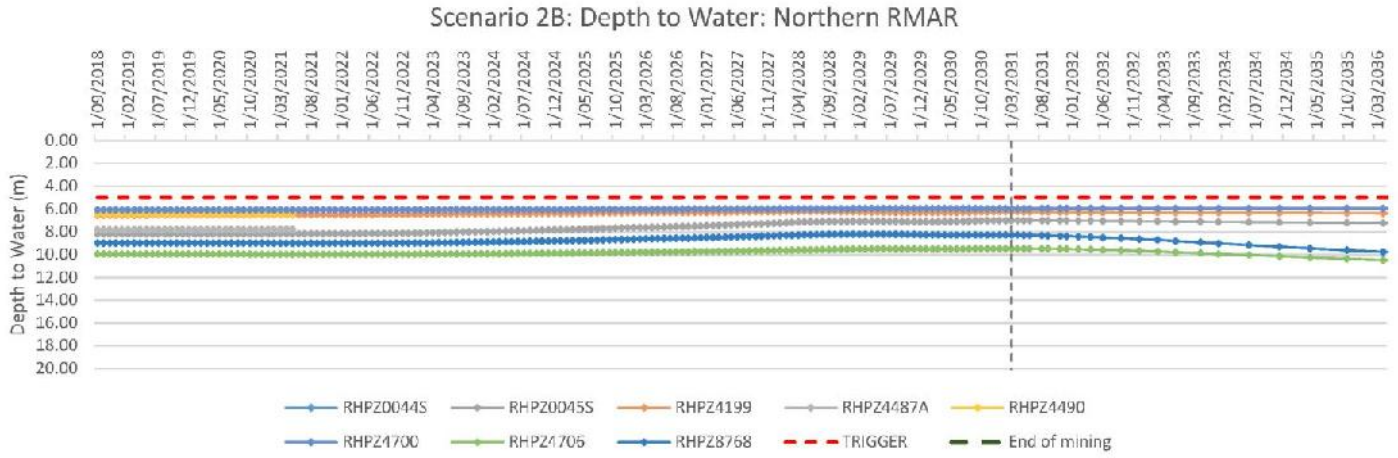

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Predicted depth to water

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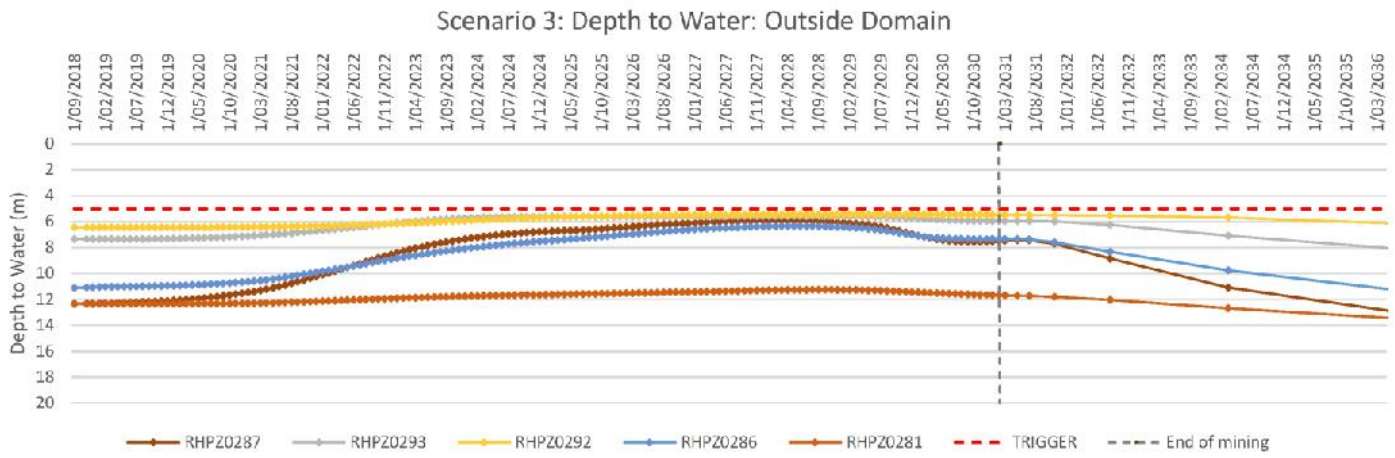

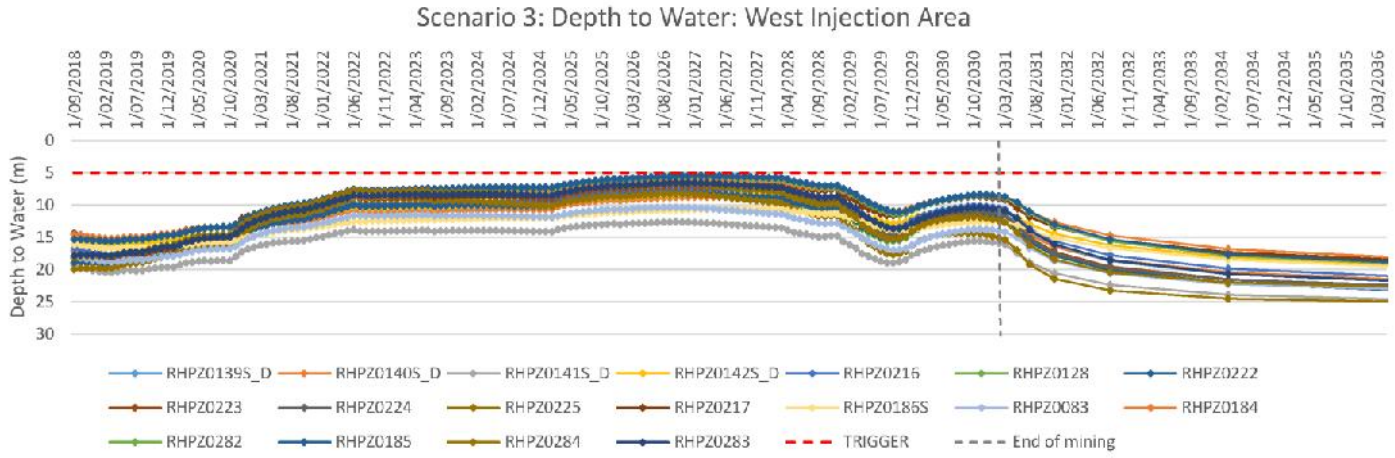

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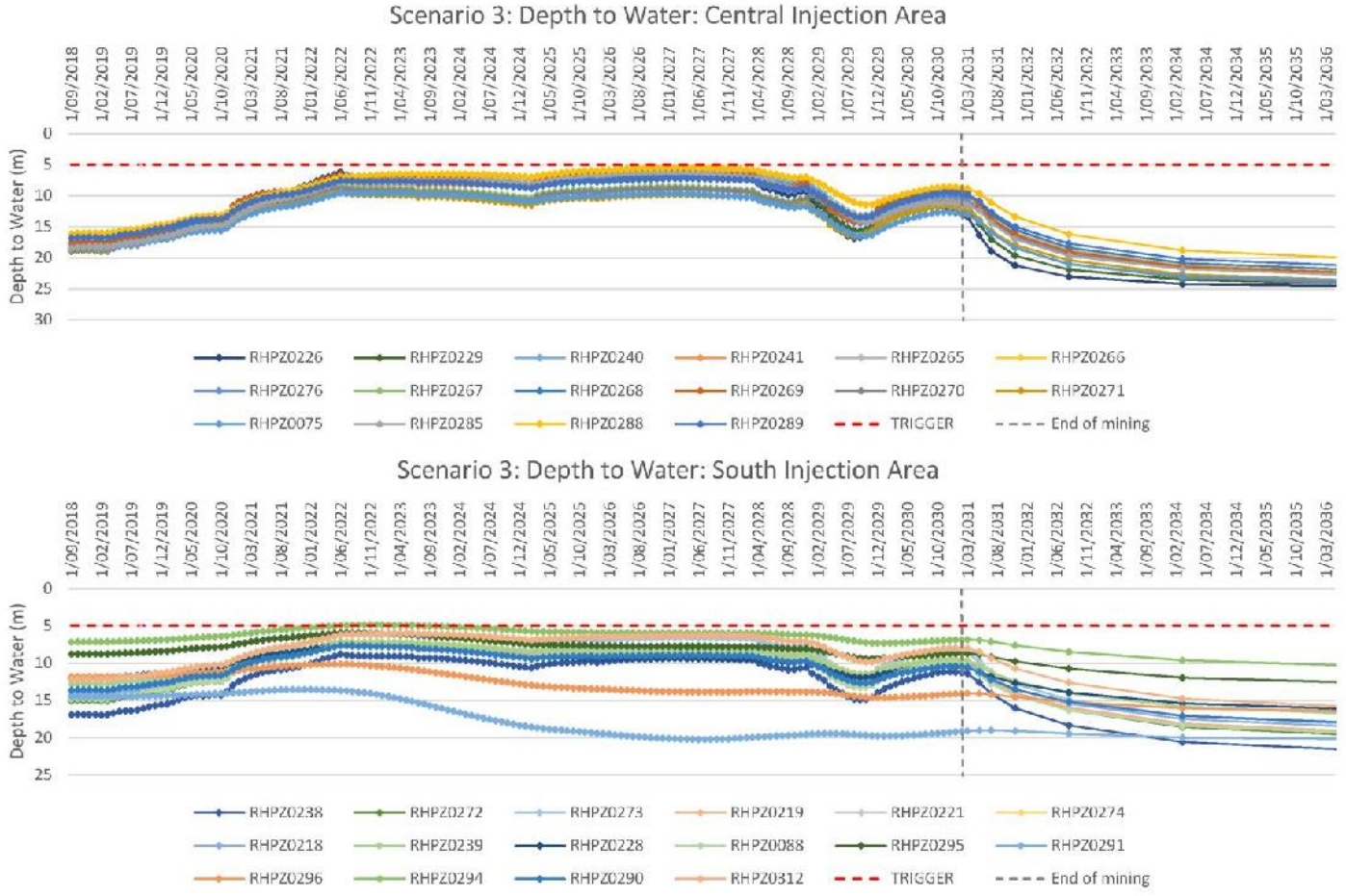
Predicted depth to water

Roy Hill - Remote MAR Study
Hydrographs



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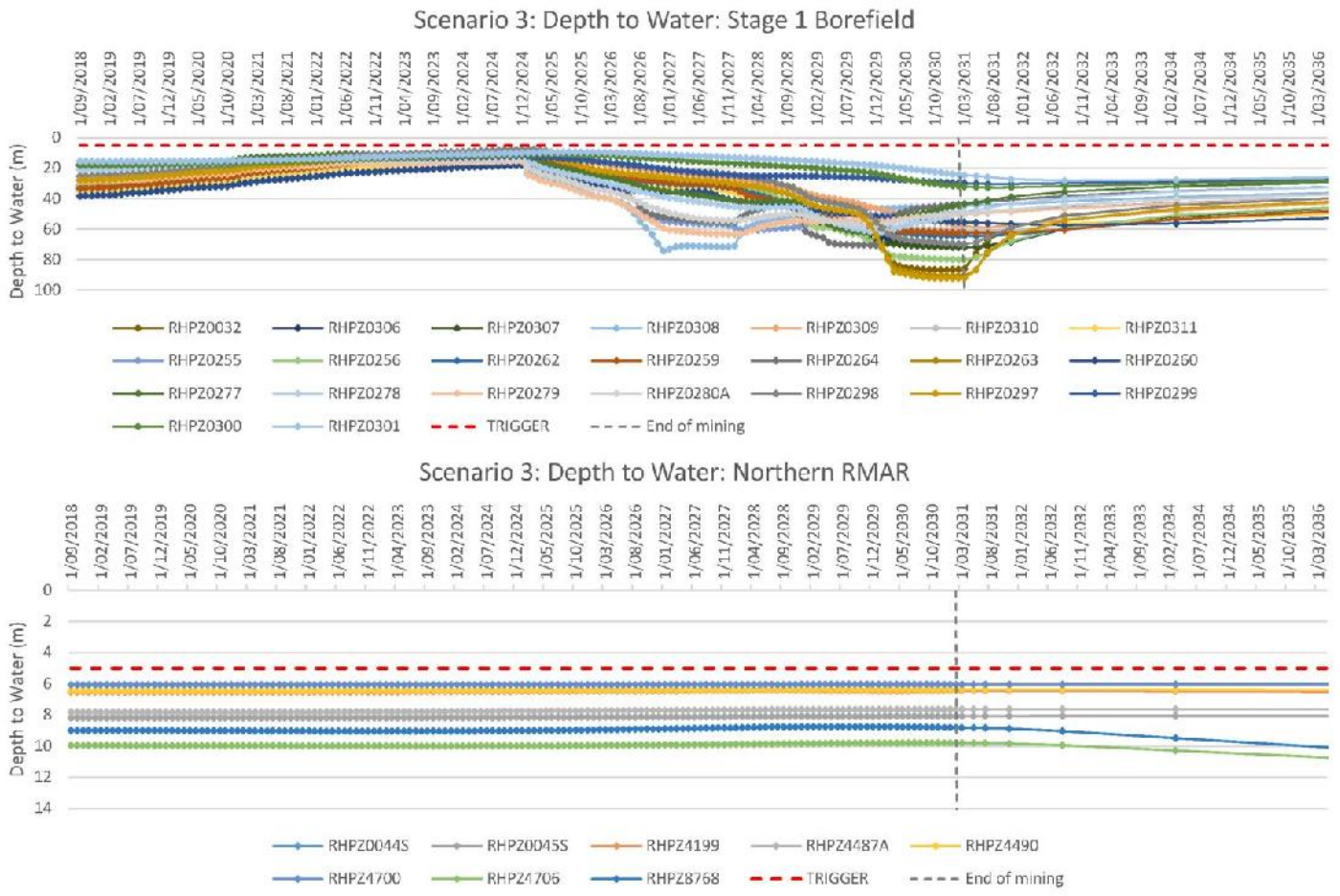

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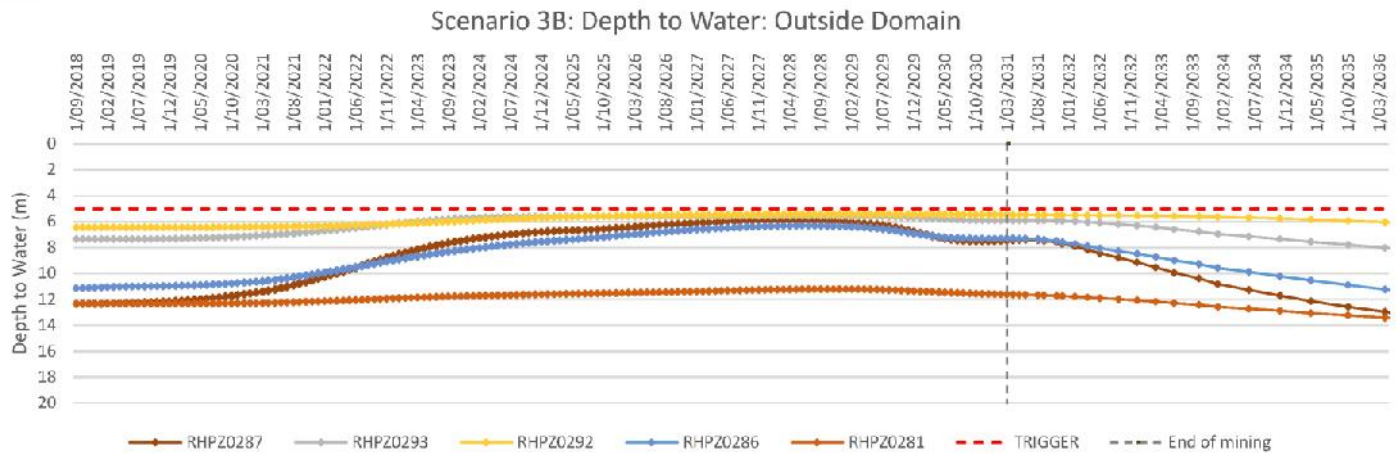

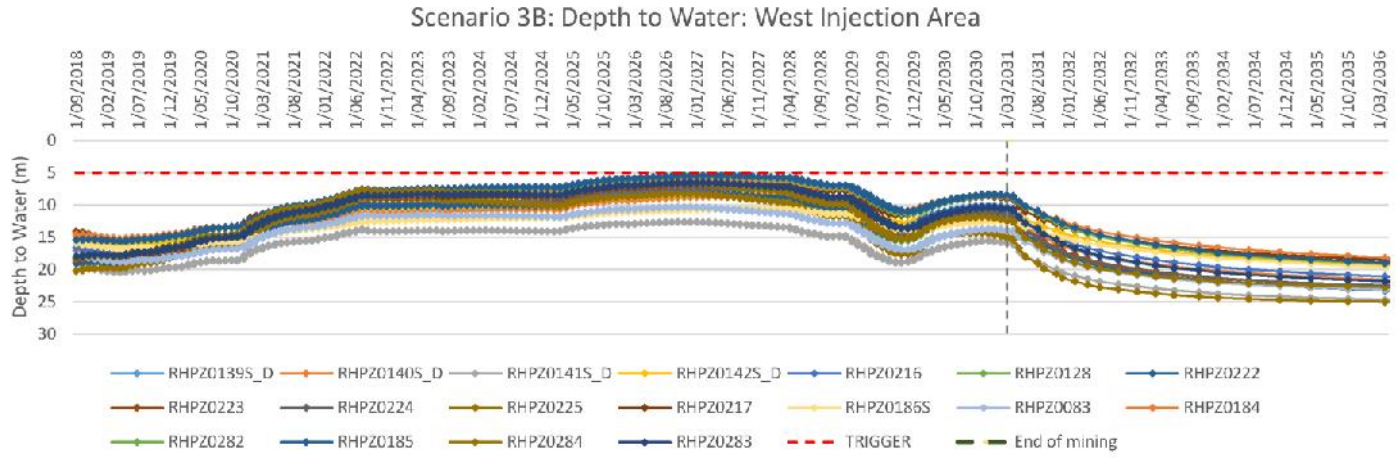

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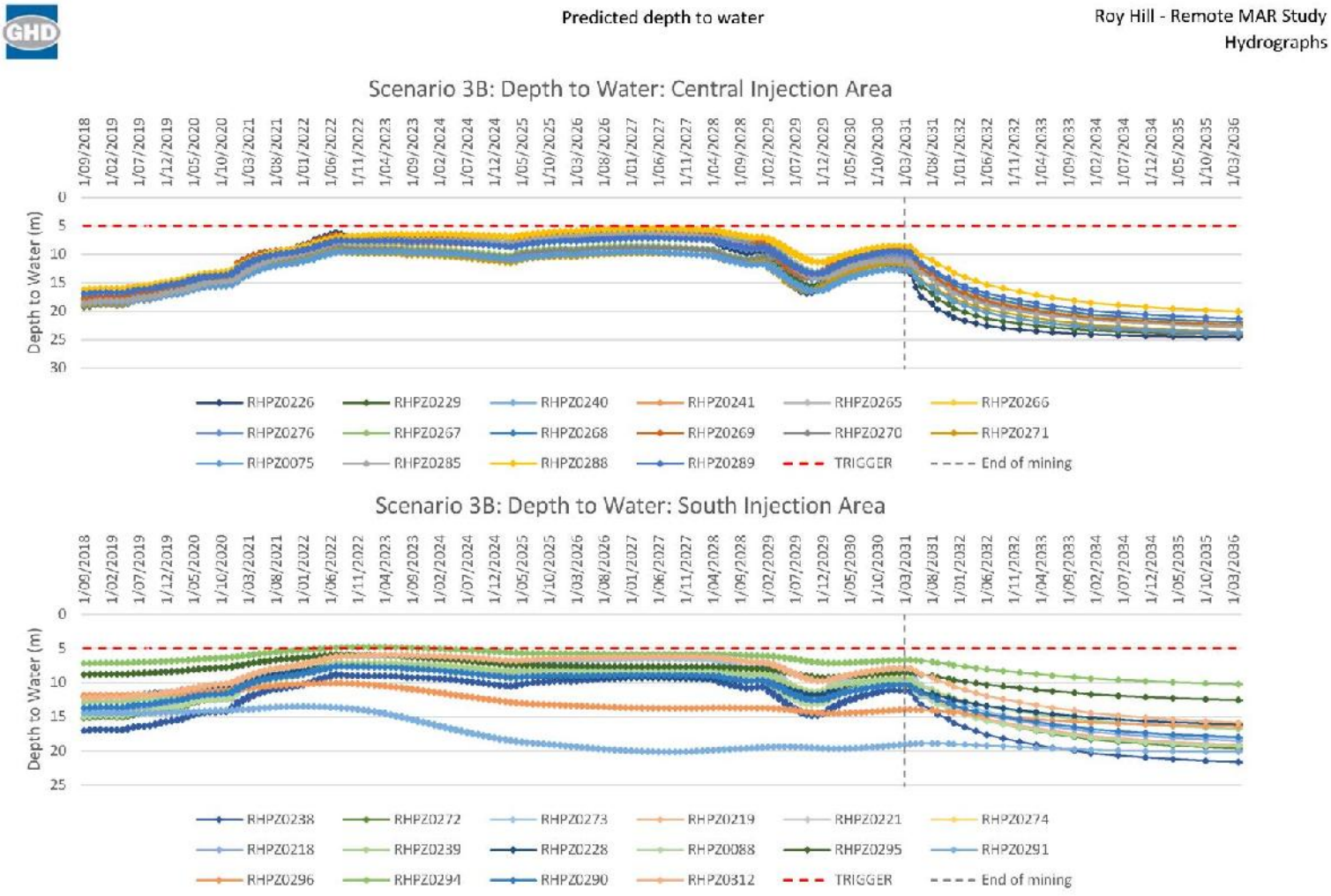
Predicted depth to water
Roy Hill - Remote MAR Study
Hydrographs
Scenario 3B: Depth to Water: Central Injection Area
Depth to Water (m)
RHPZ0226
RHPZ0229
RHPZ0240
RHPZ0241
RHPZ0265
RHPZ0266
RHPZ0276
RHPZ0267
RHPZ0268
RHPZ0269
RHPZ0270
RHPZ0271
RHPZ0075
RHPZ0285
RHPZ0288
RHPZ0289
TRIGGER
End of mining
Scenario 3B: Depth to Water: South Injection Area
Depth to Water (m)
RHPZ0238
RHPZ0272
RHPZ0273
RHPZ0219
RHPZ0221
RHPZ0274
RHPZ0218
RHPZ0239
RHPZ0228
RHPZ0088
RHPZ0295
RHPZ0291
RHPZ0296
RHPZ0294
RHPZ0290
RHPZ0312
TRIGGER
End of mining
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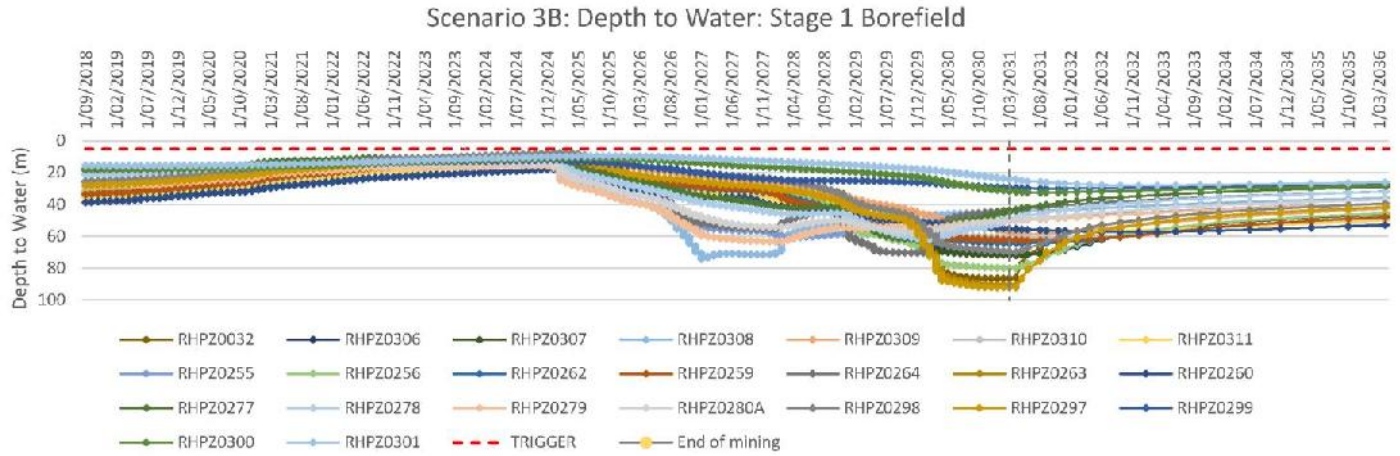

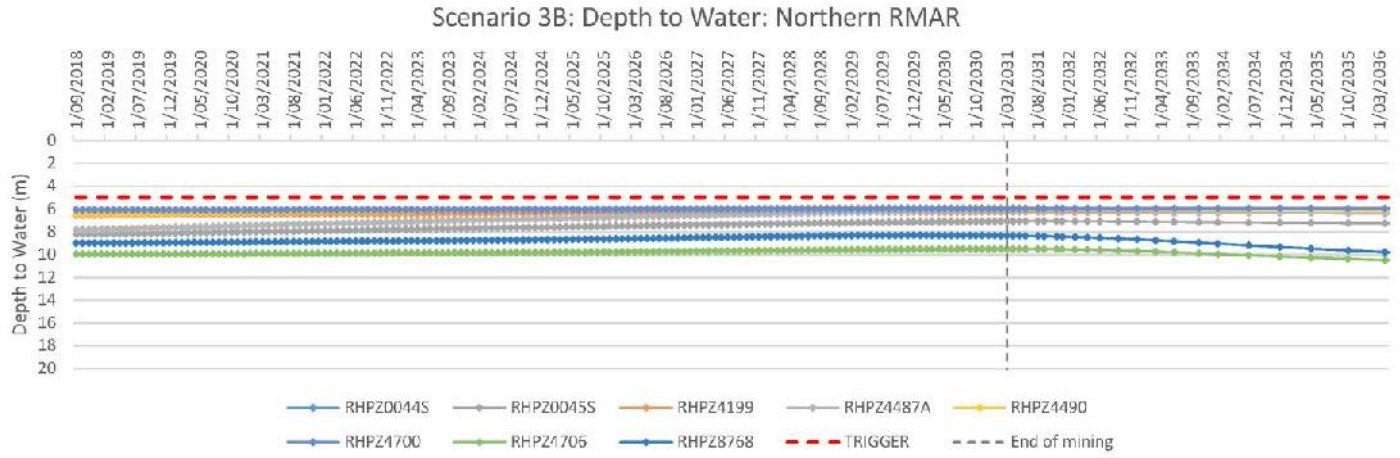

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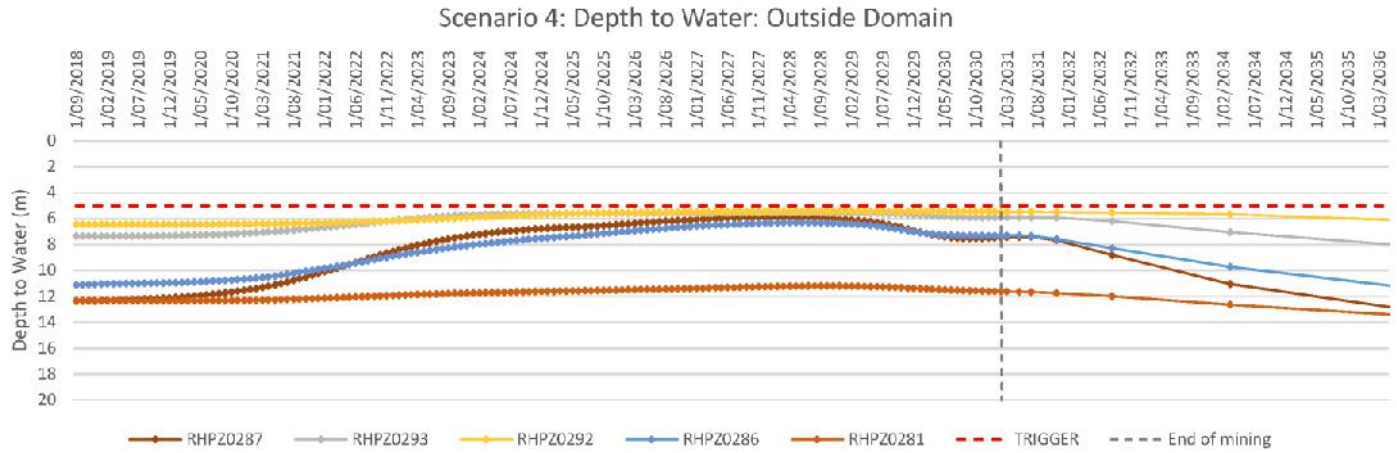

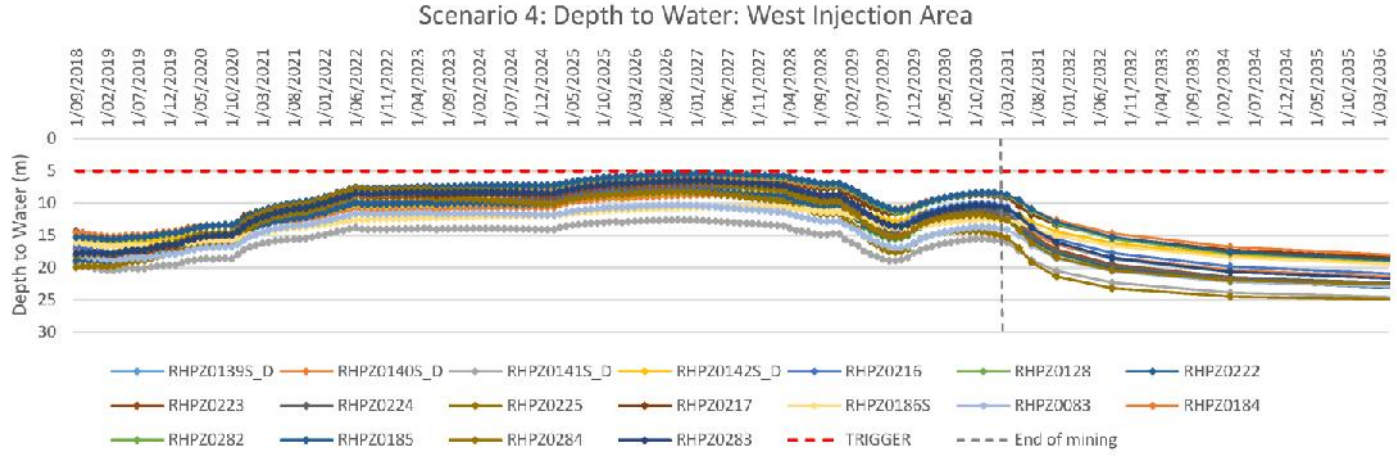

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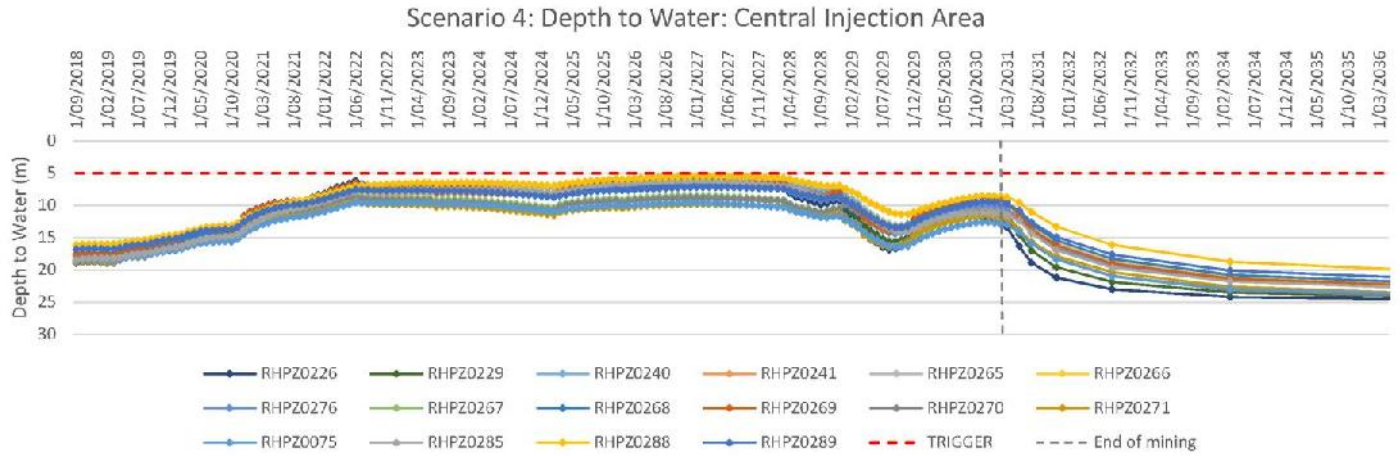

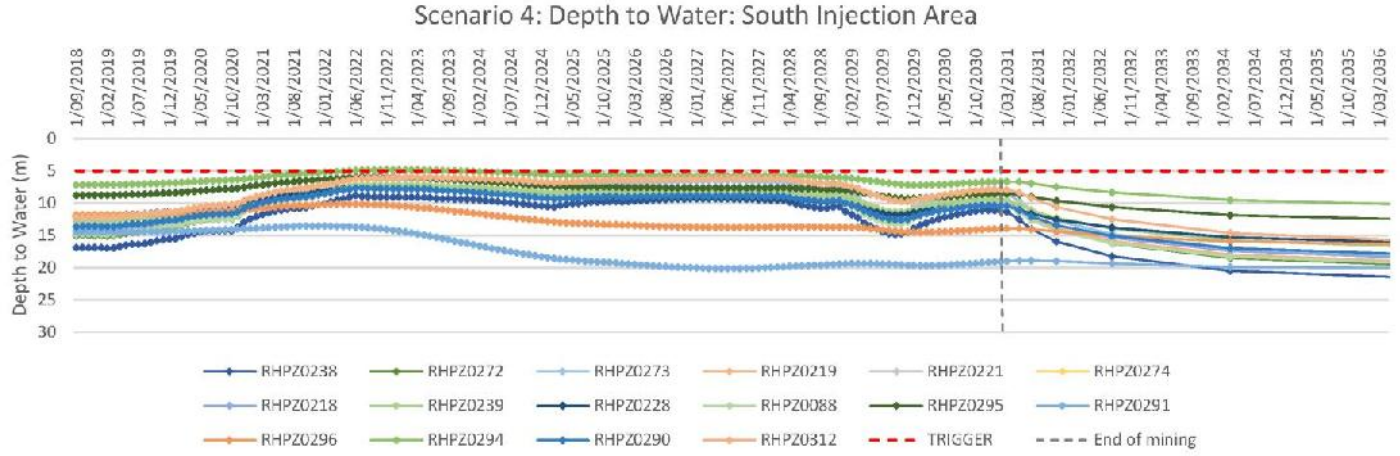

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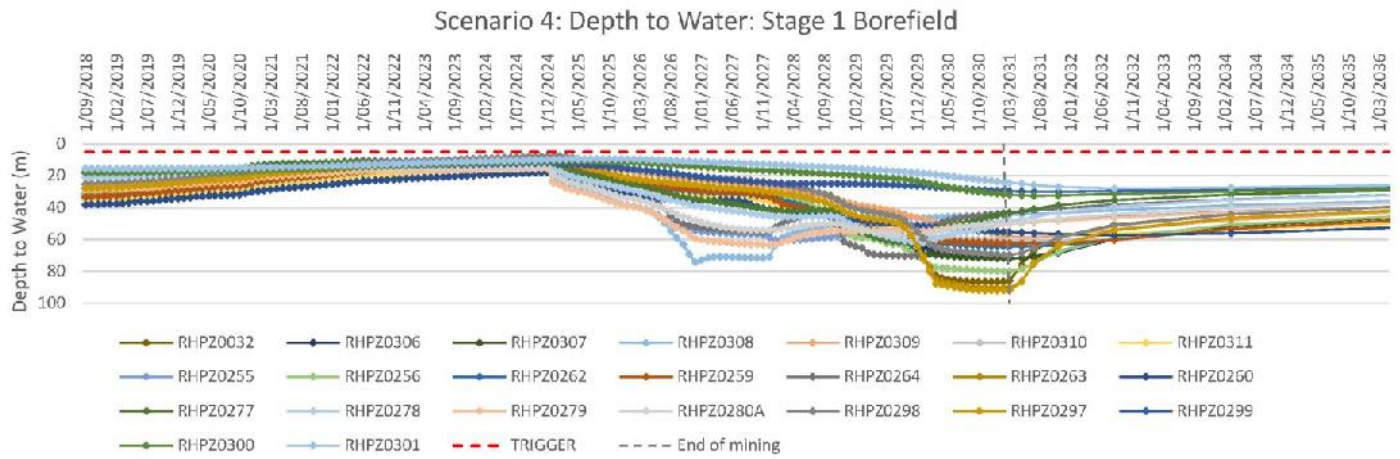

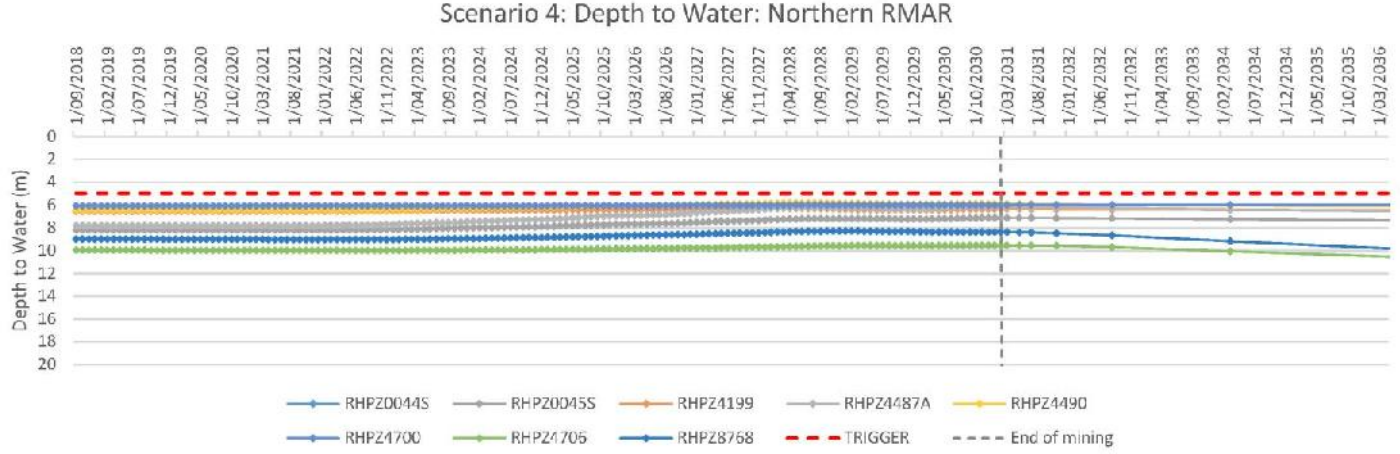

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GHD, 999 Hay Street, Perth, WA 6000
P.O. Box 3106, Perth WA 6832
T: 61 8 6222 8222 F: 61 8 6222 8555 E: permail@ghd.com.au

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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	MS	BWJ/GF				12/10/18
B	MS	BWJ/SB/BK				15/10/18
C	MS	BWJ/SB/BK				19/11/18
D	MS	BWJ/BK				30/11/18
0	M Simonic	BWJ/BK				4/12/18
1	M Simonic	BWJ/BK		P Hamer		15/01/19

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