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Report on

UG4 LW409-414 Extraction Plan Groundwater Technical Report

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UG4 LW409-414 Extraction Plan Groundwater Technical Report

1 Introduction

The Moolarben Coal Complex (MCC) is located approximately 40 kilometres (km) north of Mudgee, New South Wales (NSW) (Figure 1.1). The MCC is operated by Moolarben Coal Operations Pty Ltd (MCO) on behalf of the Moolarben Joint Venture (Moolarben Coal Mines Pty Ltd [MCM], Yancoal Moolarben Pty Ltd [YM] and a consortium of Korean power companies). MCO, MCM and YM are wholly owned subsidiaries of Yancoal Australia Limited (Yancoal).

MCO has been granted approval under the Environmental Planning and Assessment Act 1979 to develop Stages 1 and 2 of the Moolarben Coal Project (MCP). Approval for Stage 1 of the MCP (05_0117) was granted by the Minister for Planning on 6 September 2007, with approval for Stage 2 of the MCP (08_0135) granted on 30 January 2015. Mining operations at the MCC are currently approved until 31 December 2038 with a combined coal production rate of 22 million tonnes per annum (Mtpa), in accordance with the Stage 1 and Stage 2 approvals.

The MCC comprises four approved open cut mining areas (OC1 to OC4), three approved underground mining areas (UG1, UG2 and UG4) and other mining related infrastructure including coal processing and transport facilities as shown in Figure 1.2.

The MCO commenced open cut coal mining from OC1 in May 2010, and underground mining in UG1 in 2016. First workings for UG4 mains commenced in October 2020. Secondary extraction of the first Longwall (LW) 401 in UG4 commenced in July 2022 (UG4 South). LW401 to LW404 were completed by May 2024. MCO are currently preparing an 'Extraction Plan' for LW409 to LW414 within UG4 (UG4 North). The layout of LW409 to LW414 is referred to as the Extraction Plan Layout in this report (Figure 1-3).

Since approval of Stage 1 in 2007, a large amount of additional environmental monitoring and studies have been completed in the Ulan Coalfields, including MCO's UG1/UG4 and at neighbouring Ulan and Wilpinjong mines. The additional studies and monitoring data associated with an inter-mine data sharing agreement have improved the understanding of the underground mining impacts. This contemporary knowledge, supplemented with targeted site surveys, underpins this technical report and the impact predictions, performance indicators, management/monitoring measures for the UG4 North extraction plan.

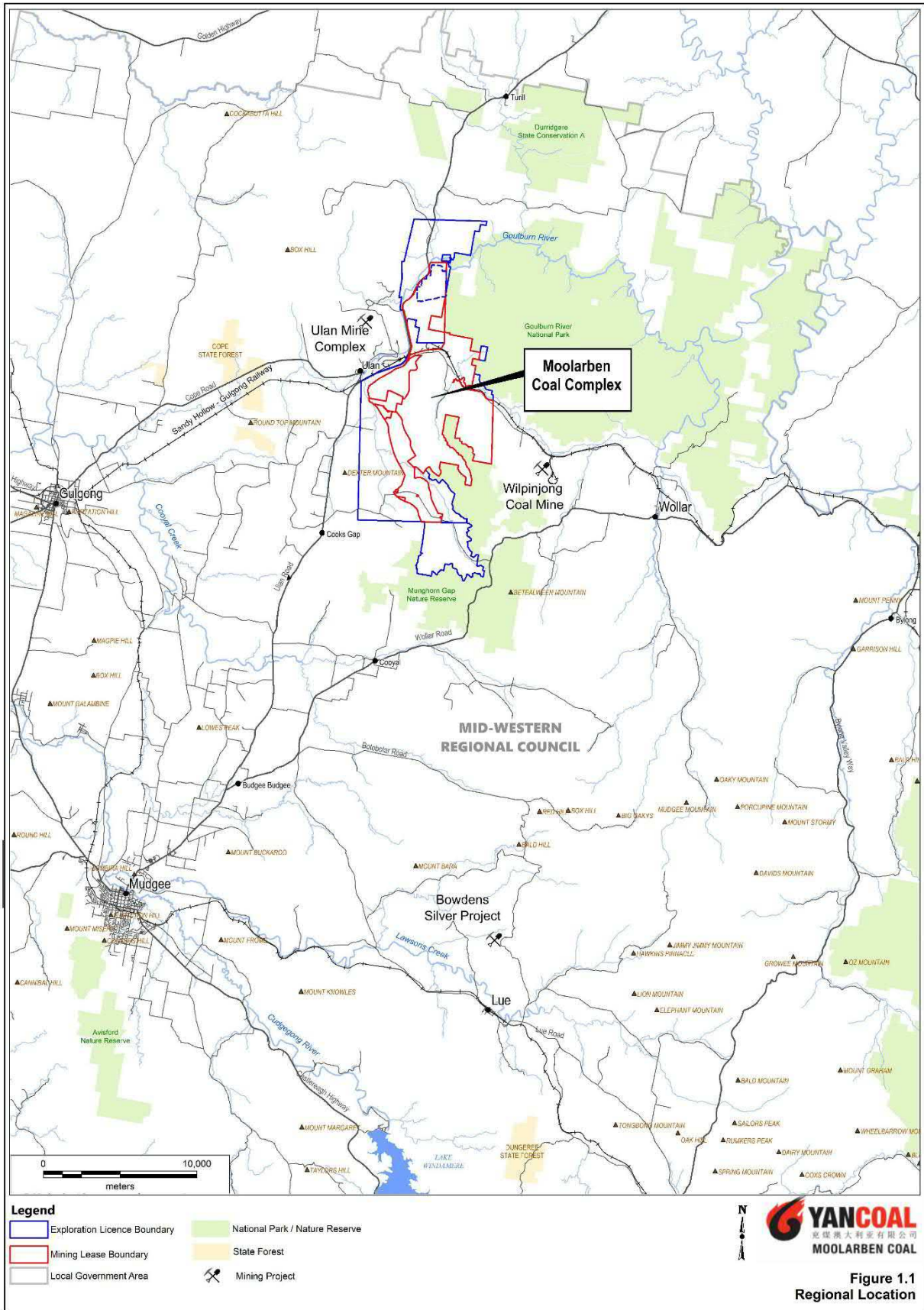


Figure 1.1 Regional Location

Figure 1.1 Regional Location

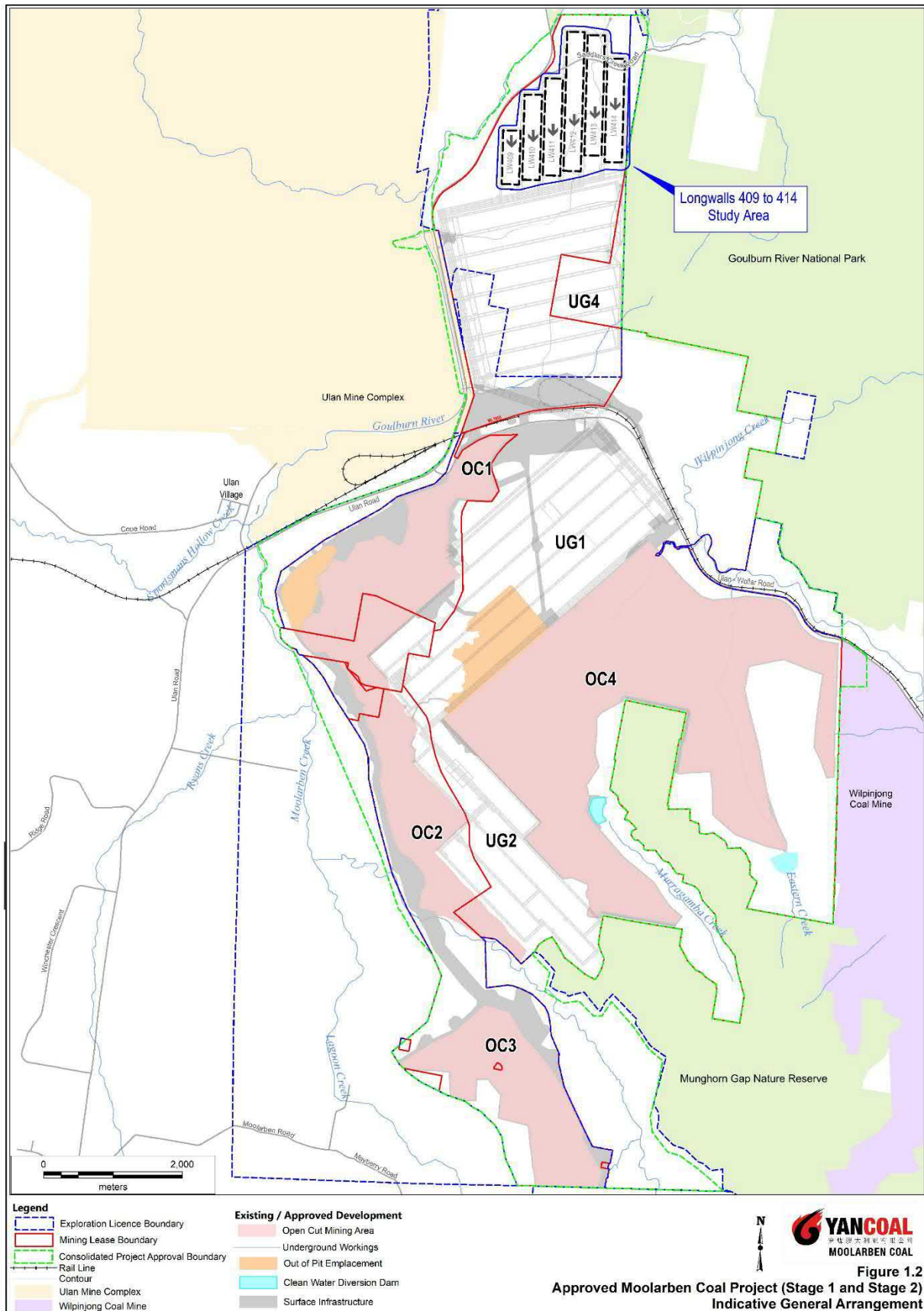


Figure 1.2 Moolarben Coal Complex Layout

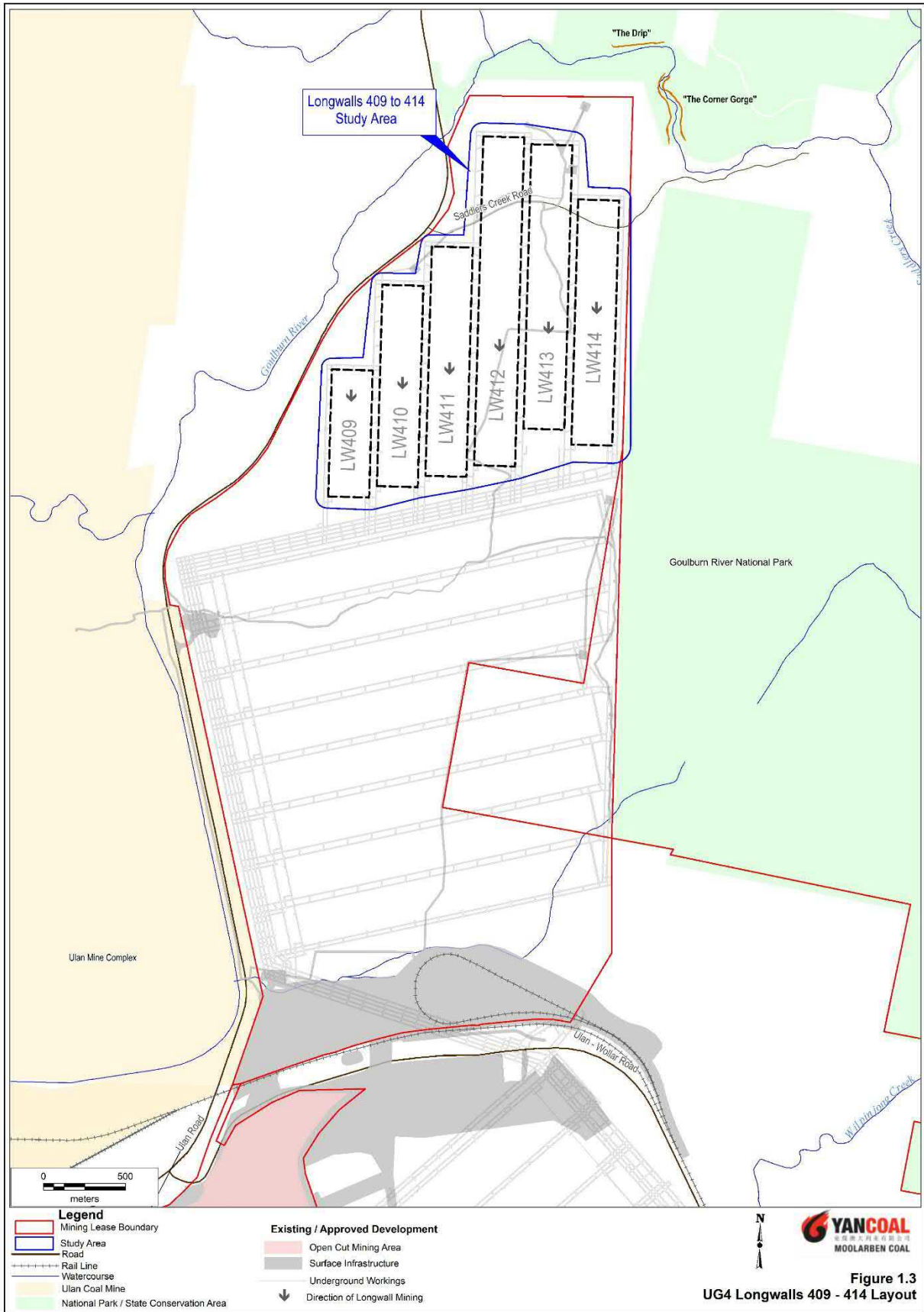


Figure 1.3 UG4 Longwalls 409 – 414

2 Objectives and scope of work

The objective of this report is to support the Extraction Plan for UG4 North. The scope of work to achieve this objective has included:

- further review of the groundwater regime in the vicinity of LW409 to LW414, including the effects of historical mining activities;
- updated modelling of potential groundwater impacts from the approved mining of UG4 North;
- consideration of cumulative impacts associated with other operations at Moolarben, Ulan Coal Complex (UCC) and Wilpinjong Coal Mine;
- estimation of inflows for LW409 to LW414 and associated water licensing requirements; and
- identification of monitoring and management measures, including Trigger Action Response Plans.

3 Mining

3.1 Previous and Current Mining Activities

The MCC is located in an established mining precinct, comprising the existing MCC as well as the UCC and Wilpinjong Coal Mine. Mining in the area has been undertaken periodically since the Ulan No. 1 Colliery was established in the 1920's, with substantial expansion occurring in the 1980's with the development of the open cut and adoption of longwall mining (Umwelt, 2009). Mining activities in the vicinity of UG4 North are summarised in Table 3.1 and shown on Figure 3.1.

Table 3.1 Extraction schedule

Mine Complex	Longwall	Coal seam	Start date	Completion date	Comment
UCC	Ulan No. 3	Ulan	1986	ongoing	-
UCC	East Pit	Ulan	1980s	ongoing	partially backfilled - now used as a tailings and mine water storage
UCC	North of East Pit – Highwall Mining	Ulan	1990s	1990s	-
MCC	OC1	Ulan	2010	ongoing	-
MCC	UG1	Ulan	Apr 2016	June 2022	-
MCC	UG4 South – LW401 – LW404	Ulan	July 2022	May 2024	-
MCC	UG4 South – LW405 – LW408	Ulan	June 2024	Est February 2026	-
MCC	UG4 North - LW409 – LW414	Ulan	Est March 2026	Est March 2028	-

In addition to these mining activities, the hydrology of the upper reaches of the Goulburn River have been altered by historic development within the catchment including:

- construction of Moolarben Dam;
- construction of the Goulburn River Diversion; and
- discharges of treated water from the UCC and MCC.

The Moolarben Dam was constructed on Moolarben Creek in 1957 and has significantly altered flows from Moolarben Creek into the Goulburn River. The Goulburn River Diversion was constructed around the UCC East Pit in the 1980s altering the flow-path, size and geometry of the Goulburn River channel. MCC commenced discharges of water to the Goulburn river upstream of UG4 in 2020, with UCC also discharging water to the Goulburn River.

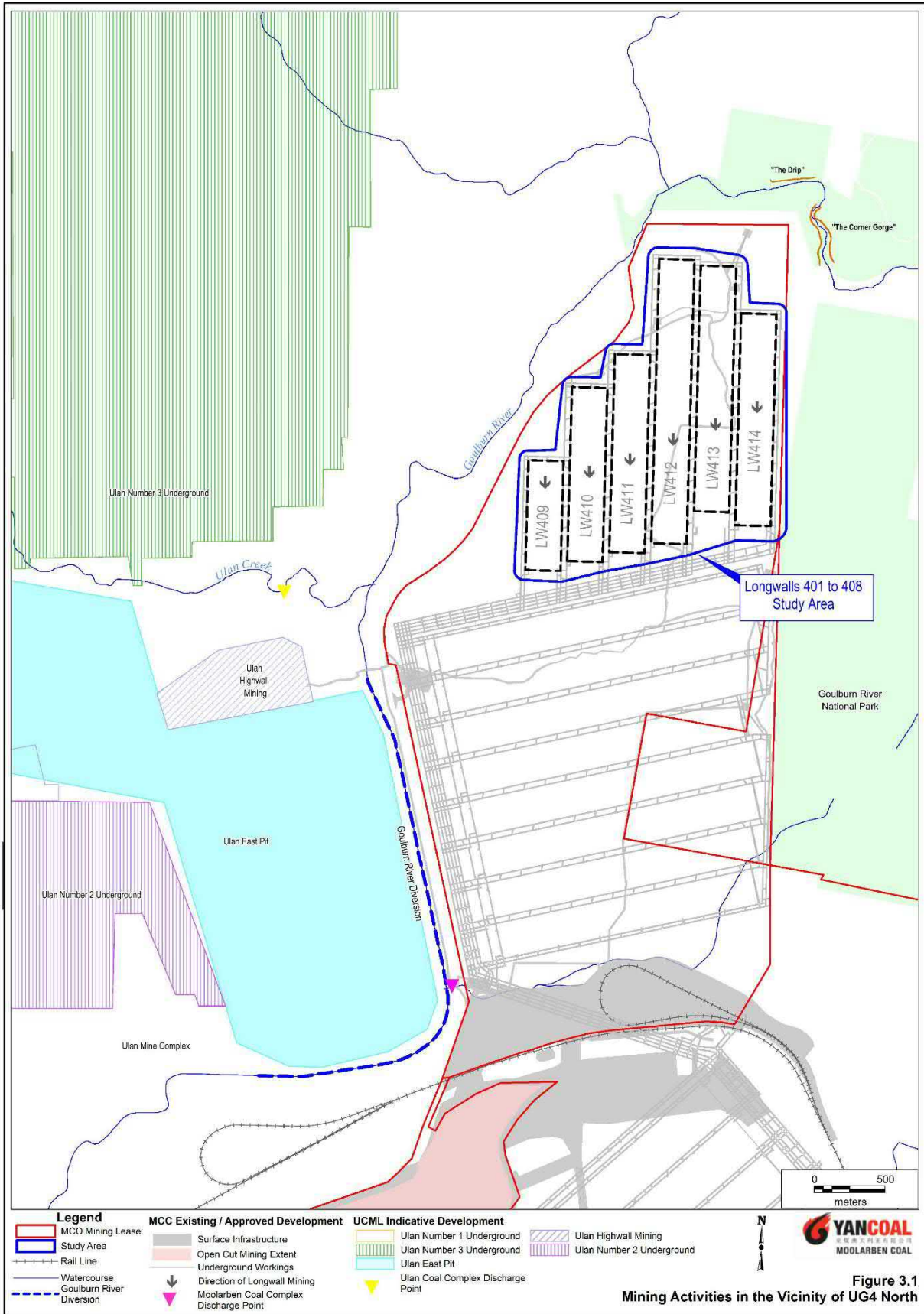


Figure 3.1 Mining Activities in the Vicinity of UG4 North

3.2 Planned mining at UG4 North

Longwall mining at UG4 North will occur in the Ulan Seam, which has been historically mined at both MCC and UCC (Section 3.1). The layout of LW409 to LW414 is shown in Figure 3.1. The Extraction Plan Layout is the same as the currently approved layout, with the exception of Longwall 413, which will be shorter at the southern end by 125 m, and Longwall 414, which will be 20 m shorter at the northern end. The longwall panel dimensions are provided in Table 3.2.

Table 3.2 Geometry of LW409 to LW414 based on the Extraction Plan Layout

Longwall	Void length including installation heading (m)	Void width including first workings (m)	Tailgate chain pillar width (m)
LW409	787	260	-
LW410	1241	260	35
LW411	1411	260	35
LW412	2022	260	35
LW413	1750	260	35
LW414	1509	260	35

The surface elevation directly above the proposed longwalls in the Extraction Plan Layout varies from about 495 m above the Australian Height Datum (mAHD) above the southern end of LW414, to 395 mAHD above the northern end of LW412. The depth of cover to the Ulan Seam varies between about 120 m near the end of LW412 to 215 m at the end of LW414.

The seam floor within the mining area generally dips from the southwest towards the northeast at around 1.6 %. The thickness of the Ulan Seam D-working section within the extents of the proposed longwalls varies between 2.8 m and 3.1 m. The approved and proposed mining height for the longwalls is 3.0 m.

4 Groundwater Regime

4.1 Groundwater Monitoring Network

MCO operates in accordance with an approved complex-wide Water Management Plan (including a complex-wide Groundwater Management Plan), which has been prepared to address the current statutory obligations contained in the conditions of the NSW Project Approval (05_0117) (as modified) and NSW Project Approval (08_0135) (as modified).

Groundwater Levels

The current groundwater monitoring program for the measurement of groundwater levels is detailed in the complex-wide Groundwater Management Plan. The groundwater monitoring program piezometers listed in the complex-wide Groundwater Management Plan are monitored manually (monthly), or continuously using electronic dataloggers. The groundwater monitoring network comprises both conventional stand pipe monitoring bores and vibrating wire piezometers.

In addition to the groundwater monitoring program under the Water Management Plan, MCO has established additional piezometers for other operational and project purposes. While this section of the report describes the groundwater monitoring program, all available groundwater data from MCO has been utilised for modelling and impact assessment purposes.

Groundwater Quality

Groundwater quality is also analysed in samples collected from standpipe monitoring bores listed in the complex-wide Groundwater Management Plan. Water samples are collected six-monthly and sent for laboratory analysis. EC and pH are also measured at the time of water quality sampling.

Investigation Trigger Levels

MCO has established water level and quality threshold values that, when exceeded, trigger review of water level and water quality data to determine potential causes and inform consideration of response actions, if required. The trigger level thresholds for groundwater levels and water quality are provided in the complex-wide Groundwater Management Plan. Investigation trigger values are part of a Trigger Action Response Plan (TARP) that are designed to identify the potential for performance criteria to be exceeded. Investigation triggers are not confirmation of an exceedance.

Groundwater levels within the Permian coal measures strata are extensively affected by past mining, and will continue to undergo further depressurisation due to ongoing mining at the UCC, MCC and the Wilpinjong Coal Mine. Accordingly, investigation trigger levels have not been set for the majority of monitoring piezometers within the Permian and Ulan Seams.

4.2 Hydrogeology

Regional groundwater investigations were carried out to support environmental impact assessments and approvals for the MCC Stage 1, Stage 2 and OC3 Extension Project. These investigations included:

- Moolarben Coal Project – Groundwater Assessment (Dundon and Associates, 2006);
- Moolarben Stage 2 – Groundwater Assessment (Aquaterra, 2008);
- Moolarben Complex Stage 2 – Preferred Project Report – Groundwater Impact Assessment (RPS Aquaterra, 2011);
- Moolarben Coal Project Stage 1 Optimisation Modification – Groundwater Impact Assessment (AGE, 2013);
- Moolarben Coal Complex UG1 Optimisation Modification – Groundwater Assessment (Dundon Consulting, 2015);
- Moolarben Coal Open Cut Optimisation Modification – Groundwater Impact Assessment (HydroSimulations, 2017);
- Moolarben Coal Complex UG2 Modification – Groundwater Review for UG2 Modification (AGE, 2021);
- Moolarben Coal Complex OC3 Extension Project – Groundwater Impact Assessment (AGE, 2022a);
- Technical Memorandum for Moolarben Coal Complex UG2 Modification (AGE, 2022b); and
- UG4 LW401-408 Extraction Plan Revised Groundwater Technical Report (AGE, 2023).

A range of groundwater studies have also been completed for the UCC and Wilpinjong Coal Mine. Since 2007, contemporary knowledge of the groundwater system has improved significantly, through further exploration drilling, geophysical surveying to map subsurface features, the construction of new groundwater monitoring infrastructure, ongoing monitoring, additional hydraulic testing, the analysis of groundwater trends in response to mining, and additional numerical groundwater modelling studies. Cumulatively, the completion of these studies has advanced the knowledge base of the groundwater system significantly and has informed various monitoring and management measures.

4.2.1 Hydrostratigraphic Units

The MCC is located in the Western Coalfields on the north-western edge of the Sydney-Gunnedah Basin, which contains sedimentary rocks of Triassic and Permian age, including coal measures. The main hydrogeological units within and surrounding the MCC include:

- Quaternary alluvium associated with the present day drainage system;
- Tertiary alluvium associated with a palaeochannel system not related to the present day drainage;
- Jurassic aged Pilliga sandstone and Purlewaugh siltstone, consisting of coarse grained quartzose sandstone, lithic sandstone, conglomerates, claystone and shale;
- Narrabeen Group - Triassic sandstone consisting of quartzose sandstone and lithic sandstone;
- Illawarra Coal Measures (ICM) - Permian coal measures, which includes the Ulan Seam near the base of the unit;
- Marrangaroo Conglomerate – Permian aged conglomerate; and
- Basement – Units that include Carboniferous volcanics and the Gulgong or Ulan Granite.

Quaternary Alluvium

Quaternary alluvial deposits in the vicinity of the MCC are associated with the Goulburn River, Moolarben Creek, Lagoon Creek and Wilpinjong Creek. The alluvium comprises fine to coarse grained sands and gravels within a silt/clay matrix.

Limited alluvial material is present along the Goulburn River Diversion, which was constructed in Permian bedrock and is now overlain by a layer of sediment. Alluvial sediments are more predominant upstream of the Diversion, in the natural river channel. The extent and thickness of the Quaternary alluvium is shown on Figure 4.1 and on the hydrogeological cross section (B-B') presented in Section 4.4.

Tertiary sediments

Tertiary sediments associated with the palaeochannel are remnants of an inactive river or stream channels that have been filled in, or buried by younger sediment. The infill sediments consist of poorly sorted- semi-consolidated quartzose sands and gravels in a clayey matrix. The sediments are unsaturated across a large proportion of the MCC, while between UG4 and UG1 (Figure 4.2), they host the regional water table in some areas. This is shown on hydrogeological cross section (B-B') presented in Section 4.4.

Jurassic Formations

The Jurassic Formations do not exist in the MCC area, but occur as caps on Triassic strata in more elevated areas to the north. The Pilliga Sandstone is the youngest consolidated formation and comprises cross-bedded sequences of ferruginous, coarse grained quartzose sandstone, conglomerates, claystone and shale. The underlying Purlewaugh Formation comprises siltstone, mudstone and fine to medium grained lithic sandstone. The Purlewaugh Siltstone is a low permeability unit that likely forms an aquitard (MER 2009).

Triassic Narrabeen Group

Triassic aged sandstones overly the Permian coal measures. Large extents of the Triassic strata are naturally unsaturated, especially the higher and more permeable upper Triassic quartzose. For example, data from monitoring point PZ 127 VWP 43 m located above UG1 indicates that the Triassic sandstone above UG1 was unsaturated prior to underground mining. The same applies to the north of LW412 in UG4 North, where data from PZ 128 VWP 20m show the sensor has been unsaturated for the entire period of monitoring.

Where saturated the Triassic sandstones provide some water supply potential for bores, however the sandstone is generally low yielding. RPS Aquaterra (2011) reported a median hydraulic conductivity for the Triassic sandstone of 0.3 m/day based on six hydraulic tests results, which suggests the sandstone has a modest permeability. The Triassic sandstone supports a small number of stock and domestic bores on private properties to the north of the MCC. Groundwater within the Triassic sandstones north of the Goulburn River also supports the local and culturally sensitive water feature on the Goulburn River known as The Drip, which is located on the northern side of the Goulburn River (Figure 4.5). Perching of low salinity groundwater above the Permian ICM seems to be relatively common in the region, which is not unexpected given the significant contrast in hydraulic conductivity of the units. A number of small springs / seeps were identified to the west and south of the OC3 extension project, where low salinity groundwater discharges to the surface at a break in slope along the interface between the Triassic sandstone, and the low permeability Permian ICM. These sites are located over 13 km from UG4 but indicate a similar groundwater flow mechanism.

Illawarra Coal Measures

The Permian aged ICM are present across the MCC. The coal measures conformably underlie the Triassic Narrabeen Group and comprise interbedded claystones, siltstones, fine to coarse grained sandstones and coal seams, including the Ulan Seam.

Groundwater storage and movement occurs within the coal seam cleats and fissures, and to a lesser degree within fractures associated with faults intersecting the seams. Other sediments in the coal overburden and interburden sequence are relatively impermeable and tend to behave as aquitards. Some Permian sandstones yield minor groundwater, although in the mined section of the coal measures these are rare.

The Permian strata can be categorised into the following hydrogeological sub-units:

- very low permeability and very low yielding to essentially dry sandstone and siltstone, that comprises the majority of the Permian interburden / overburden; and
- low to moderately permeable coal seams, which are the principal water bearing strata within the ICM.

The Permian coal seams are hydraulically confined to semi-confined by the low permeability non-coal units. The Permian strata are commonly dewatered directly above mining activities in UG1 and UG4, and are depressurised in a zone locally around the mining footprint.

Marrangaroo Conglomerate and Shoalhaven Group

The Marrangaroo Conglomerate, which is a conglomerate or sandstone in this area, sits around 5 m below the Ulan Seam floor (MCO, 2022). Regionally the Marrangaroo Conglomerate is known to be moderately permeable and considered an aquifer in some local areas being able to sustain reliable yields to bores.

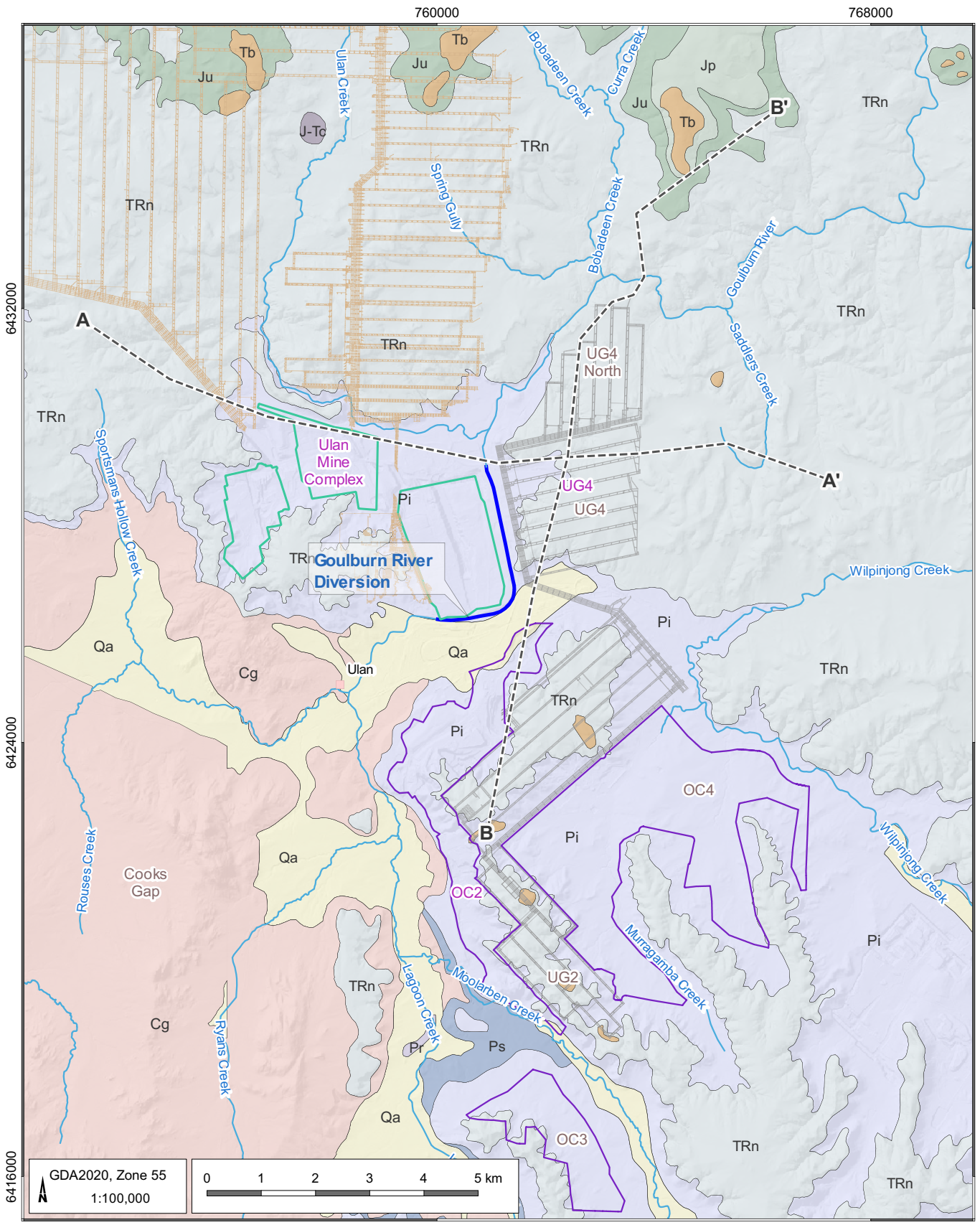
Hydrogeological data from six piezometers at the MCC that have been completed in the Marrangaroo Conglomerate indicate that the unit has a relatively low permeability, with very limited water supply potential.

Beneath the Marrangaroo Conglomerate lies the Shoalhaven Group which comprises a fine-grained silty marine sandstone. Marine sediments of the Shoalhaven Group have reportedly been intersected in some drill holes in the southern part of the MCC, however limited data is available on this unit.

The Nile Sub-Group underlies the Marrangaroo Conglomerate. Investigations at neighbouring Wilpinjong mine indicate it is relatively impermeable and of almost no influence on the flow processes at the site (Wilpinjong Coal, 2005).

Basement

The basement underlying the Shoalhaven Group consists of Carboniferous monzonite and granite. These basement rocks are clearly visible in outcrop around the weir located on Moolarben Dam. The Carboniferous aged Granite (Cg) shown on Figure 4.1 is the most significant basement unit in the Moolarben area with extensive outcropping occurring at greater than 3 km to the southwest of UG4.



LEGEND

- Populated place
- UG Mine Plan
- Drainage
- Hydrogeological Cross Section
- Approved OC Extent
- Ulan Underground Mine Plan

Hydrogeological Cross Sections

Section A-A' (refer to Figure 4.7)
 Section B-B' (refer to Figure 4.8)

Western Coalfield (north) Regional Geology (1:100k)

- Qa - Quaternary alluvium
- Tb - Tertiary basalts
- J-Tc - Jura-Tertiary volcanics
- Jp - Pilliga Sandstone
- Ju - Purlawaugh Formation
- TRn - Triassic Narrabeen Group
- Pi - Illawarra Coal Measures
- Ps - Shoalhaven Group
- Pr - Rylstone Volcanics
- Cg - Carboniferous granite

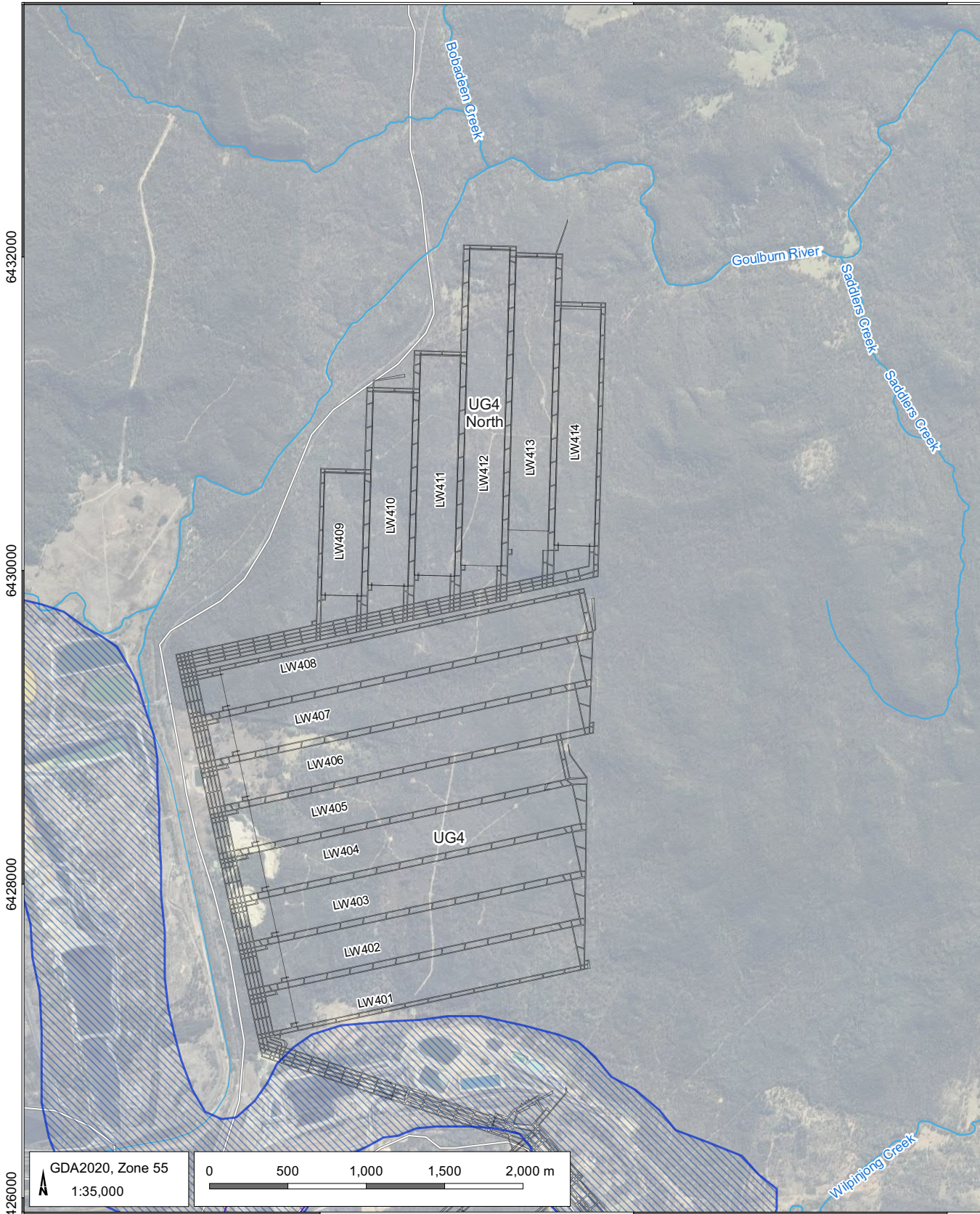
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Regional Mapped Surface Geology (showing transects for Figure 4 10 and Figure 4 11)



DATE
16/09/2024

FIGURE No:
4.1



LEGEND

- Drainage
- UG Mine Plan
- Paleochannel extent

UG4 LW409-414 Extraction Plan Groundwater Technical Report (MOO5004.001)

Paleochannel extent in the UG4 area



DATE
12/09/2024

FIGURE No:
4.2

Groundwater Productivity

The NSW *Aquifer Interference Policy* (AIP) describes water licensing and assessment processes for aquifer interference activities within NSW (NSW Department of Primary Industries – Office of Water, 2012). Groundwater sources within the AIP are categorised into either “highly productive” or “less productive” categories. Highly productive groundwater is defined in the AIP as a groundwater source that is declared in the Regulations, and is to be based on the following criteria:

- a) has total dissolved solids of less than 1,500 mg/L, and
- b) contains water supply works that can yield water at a rate greater than 5 L/sec.

Given the AIP definition, none of the hydrogeological units surrounding the MCC are considered to be highly productive. A combination of low permeability and/or observed groundwater salinity effectively classifies the units as ‘less productive’.

Figure 4.3 presents the reported airlift yields for all groundwater bores at the MCC, as obtained from individual bore logs, and reports. Figure 4.3 represents only those holes where an airlift yield was recorded. A high proportion of the drilled holes during piezometer construction encountered no significant groundwater during the drilling process, and as such, the median estimates are biased to the high side, particularly for the lower permeability units such as the Permian ICM and basement.

While two airlift yields greater than 5 L/sec have been reported, the process of airlifting can produce yields which are higher than the yield which can be pumped from water supply bores for sustained periods. This is due to a combination of reasons, including the inflation of airlift yields due to wellbore storage effects, increased depth of testing (airlifting can occur from the base of a bore, while submersible pumps are typically set above the well screen and thus have reduced available drawdown) and aquifer and well losses which occur during sustained production. Both aquifer and well losses which develop during production reduce the amount of available drawdown within a production bore over time, thus the planned production rate becomes lower as the planned length of operation increases.

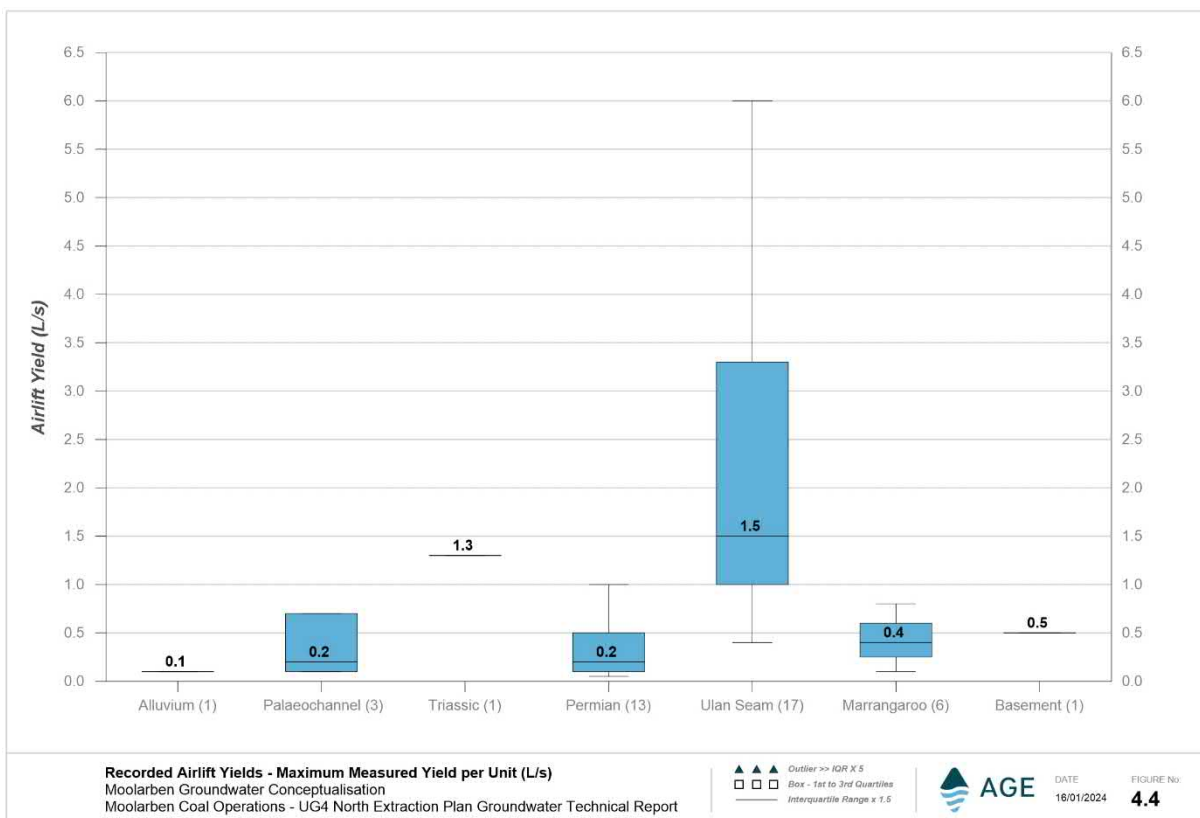


Figure 4.3 Recorded Airlift Yields

4.2.2 Recharge and discharge

Recharge to the groundwater system occurs by the direct infiltration of rainfall and downward percolation through the near surface weathered rock, and alluvium where present. Recharge to the deeper units within the Permian coal measures occurs by downward seepage into the units where they subcrop beneath the alluvium or through weathered rock cover.

Figure 4.4 provides estimates of groundwater recharge to each of the main hydrostratigraphic units at MCC. Estimation was based on the chloride mass balance method, using depositional chloride rates from Davies and Crosbie (2014). Monitoring sites were selected where each of the units monitored were either subcropping or had a screened interval that was only marginally below the water table. The median value as a percentage of annual rainfall is illustrated for each hydrogeological unit.

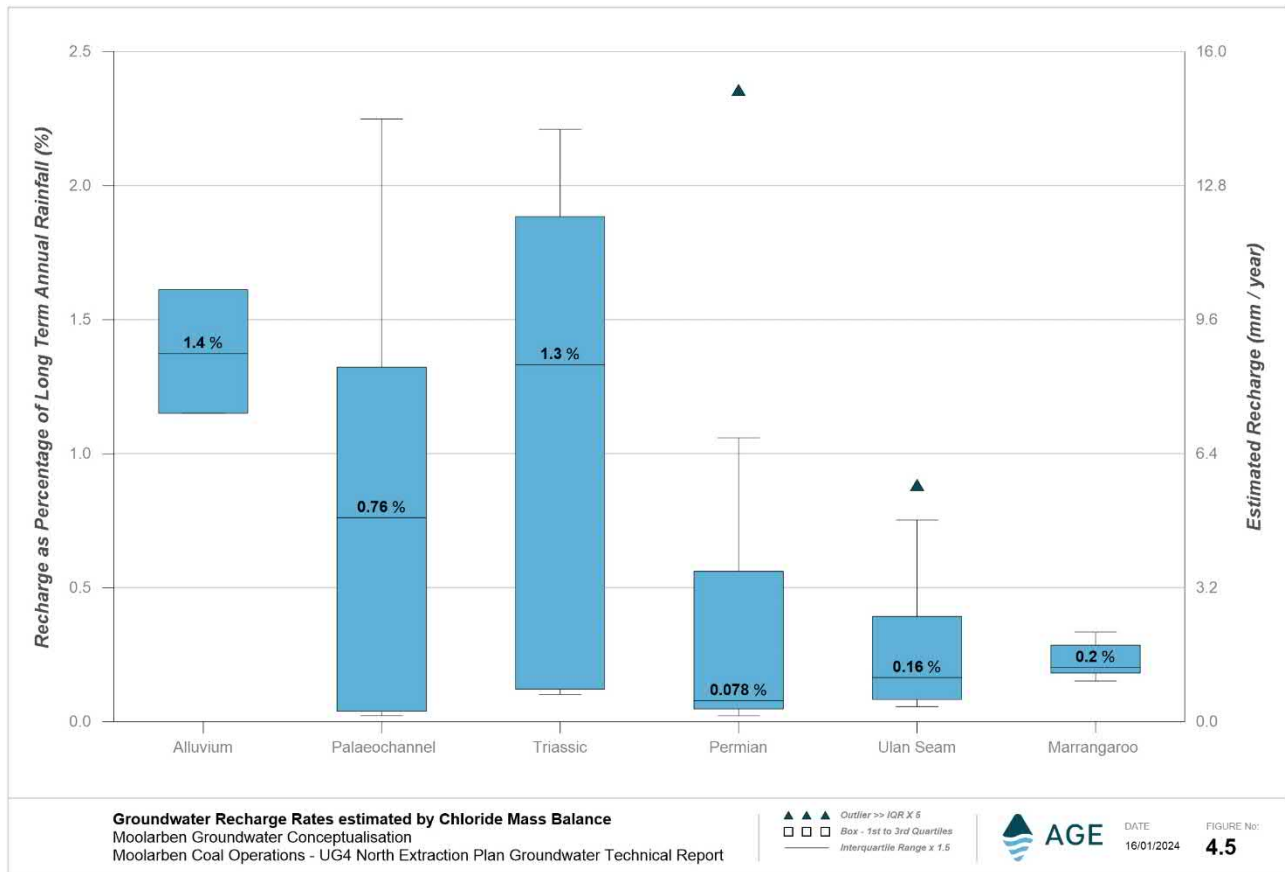


Figure 4.4 Groundwater Recharge Rates estimated by Chloride Mass Balance

Recharge to the groundwater system at the MCC is estimated to be less than 2% of annual rainfall. This estimate aligns with estimates at the adjacent UCC by Mackie Environmental Research (2009). Mackie (2009) reported that water tables and groundwater pressures in the saturated strata are sustained by rainfall infiltration to the regolith, with estimates of recharge to Triassic and Permian strata varying from close to zero, to no more than about 2% of annual rainfall.

4.2.3 Groundwater and Surface Water Interaction

The local drainage network in the vicinity of the UG4 is shown on Figure 4.5. The Goulburn River is the main watercourse in the vicinity of UG4. As discussed previously the Goulburn River has been heavily modified, initially firstly by the construction of Moolarben Dam by Ulan Power Station in 1957, and subsequently by a diversion of the river around the mining surface facilities and historical open cut mining at the UCC.

Moolarben Dam has a catchment area of approximately 110 km² and is located in the upper reaches of the Goulburn River, near the UCC and MCC. It has been identified that the dam has a considerable volume of seepage through the dam wall, estimated at 129 ML during 2017.

The Goulburn River Diversion was approved as part of UCC operations and was completed in 1982. It diverts a 3.6 km length of the Goulburn River around the UMC East Pit, to a location approximately 700 m east of the river's original flowpath (Ecological Australia, 2018) (Figure 4.5). Plate 4.1 shows the Goulburn River Diversion west of LW401.

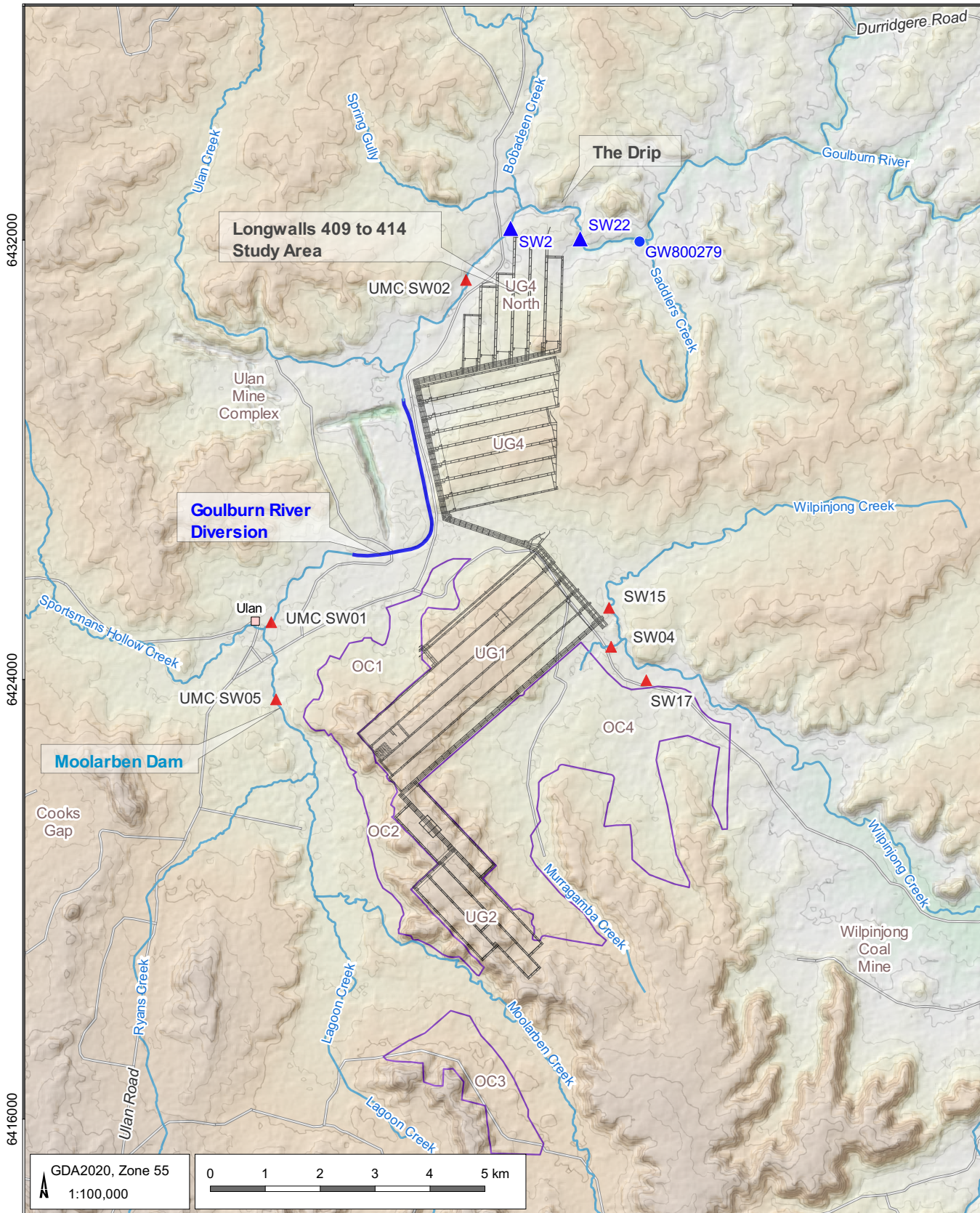
The Goulburn River Diversion has been characterised by Advisian (2017) as having:

- a significantly altered flow regime due to the construction of Moolarben Dam and UCC/MCC discharges;
- a channel bed formed in natural sandstone bedrock with a rocky base covered with a layer of sediments;
- a generally uniform, well vegetated channel with trapezoidal channel dimensions, river bank heights varying from 4 m to 20 m, and channel bed widths varying from 30 m to 40 m; and
- an aquatic ecology diversity reflective of a disturbed environment that does not provide habitat for threatened aquatic ecology species.

Further downstream of the diversion, the Goulburn River becomes a broad, well vegetated channel formed in natural surface soils and has a coarse sandy base. The channel contains various sand bars, elongated permanent pools and rocky outcrops (Advisian, 2017; Plate 4.2).

Moolarben Creek is a primary tributary of the upper Goulburn River catchment and flows in a northerly direction to join the Goulburn River. Tributary creeks are generally ephemeral, and flow in response to significant rainfall runoff events and for a limited duration. The Goulburn River in the vicinity of the MCC is essentially perennial, although some anecdotal evidence suggests it has ceased to flow historically through prolonged periods of drought. Approved UCC and MCC mine discharges of treated water increase the persistence of flows in the Goulburn River. MCC discharges commenced in 2020 and occur upstream of UG4 within the diversion.

The western headwaters of the Wilpinjong Creek overlie a palaeochannel that may represent an ancient course of the Goulburn River. The palaeochannel is infilled with at least 5 m of alluvium which is generally fine-grained, comprising sands, silts and clays (Dundon and Associates, 2006).



LEGEND

- Populated place
- ▲ Flow gauging stations
- ▲ Gauging station
- Private bore
- Drainage
- Road
- UG Mine Plan
- Approved OC Extent

Elevation (mAHD)

- 300
- 400
- 500
- 600
- 700

UG4 LW409-414 Extraction Plan Groundwater Technical Report (MOO5004.001)

Topography and Drainage



DATE 06/09/2024

FIGURE No: 4.5



Plate 4.1 Goulburn River Diversion West of LW401 (Advisian, 2017)



Plate 4.2 Goulburn River (Natural) Downstream of UG4 (Advisian, 2017)

In November 2023 MCO installed two additional gauging stations, namely SW2 and SW22 (Figure 4.5), and two shallow standpipe monitoring bores PZ237A and PZ234A, to compare surface / groundwater levels at two locations along the Goulburn River, as a commitment from the UG4 LW401 to LW408 Extraction Plan Process.

Figure 4.6 and Figure 4.7 show the data collected at each pair of surface water / groundwater monitoring points. Figure 4.8 shows the location of each surface water-groundwater monitoring pair, and the observed surface water / groundwater type of relationship / gradient. The collected data indicates that:

- at the SW2 station, which is located approx. 230 m north-west of LW412, the Goulburn River is gaining, with an observed hydraulic gradient around 0.6% in June 2024; and
- at the SW22 station, which is located approx. 490 m north-east of LW414, the Goulburn River is a losing river, with an observed hydraulic gradient around 0.09% in June 2024.

Whilst the difference between groundwater levels and surface water levels illustrated in Figure 4.6 and Figure 4.7 provides an indication of gaining/losing conditions along the Goulburn River it is important to consider the relative location of the groundwater and surface water measurement points, and water table surface around the river. Gauging station SW22 is located about 100 m upstream of groundwater monitoring bore PZ234A, and therefore a lower water level within the river would be expected immediately adjacent to the groundwater monitoring bore indicating a steeper hydraulic gradient, but still gaining conditions within the river. Regardless of this the observed relationship between groundwater and surface water levels at the PZ234A / SW22 pair will be useful for understanding any future potential influence from the UG4 North mining activities on interconnectivity between groundwater and the Goulburn River.

The PZ237A / SW2 pair is characterized by an average observed gradient around 0.5%, which is slightly lower than the regional hydraulic gradients observed in the Triassic at the PZ103C / PZ101C pair ($\approx 0.8\%$).

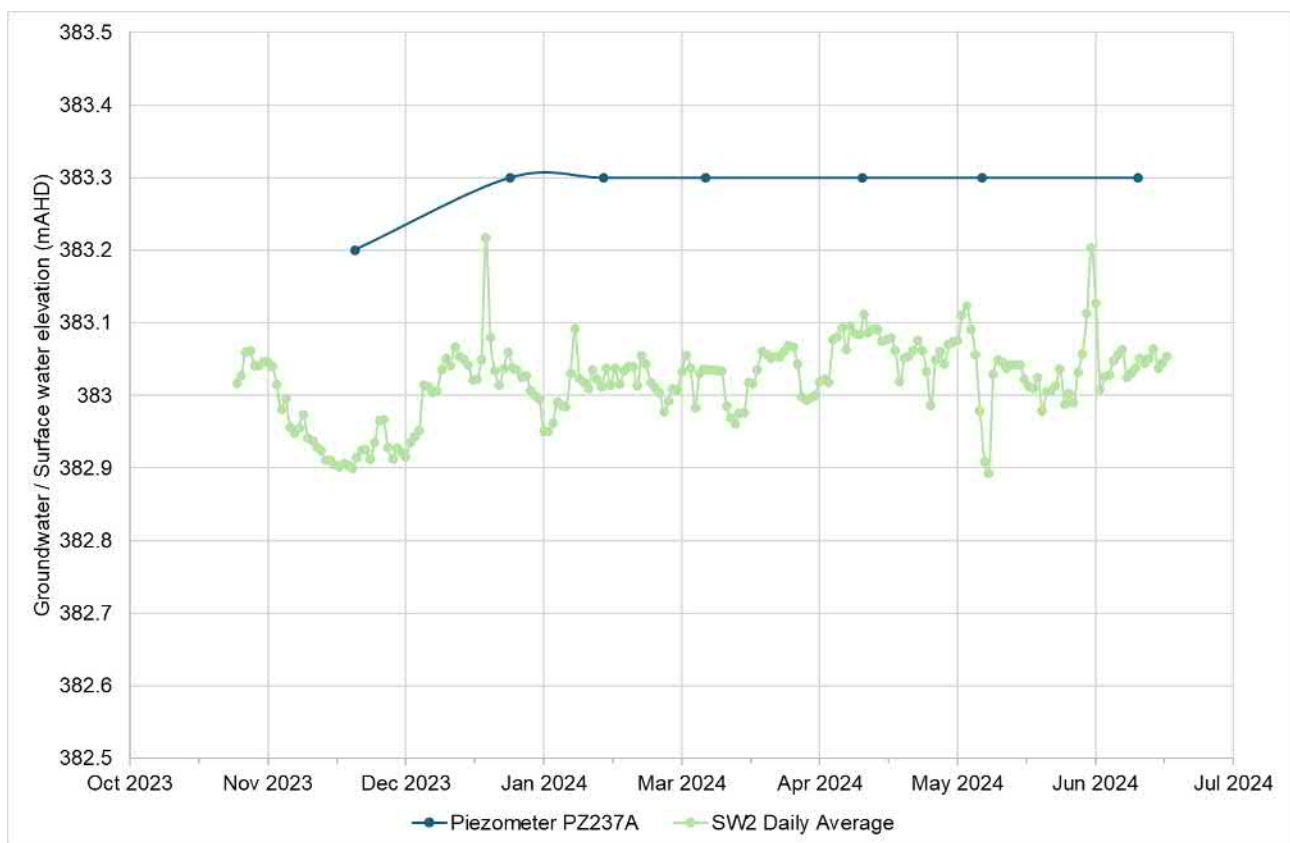


Figure 4.6 PZ237A / SW2 water level comparison

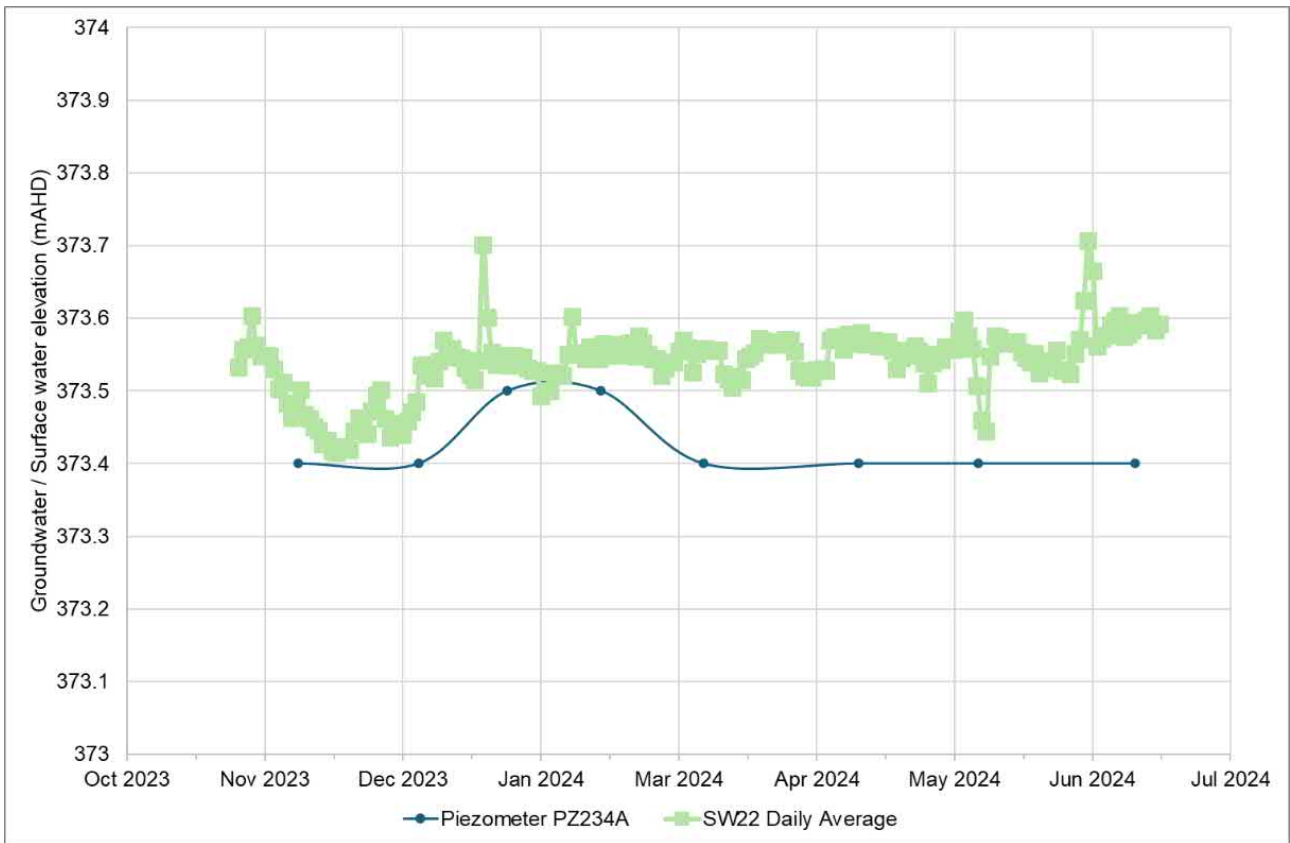
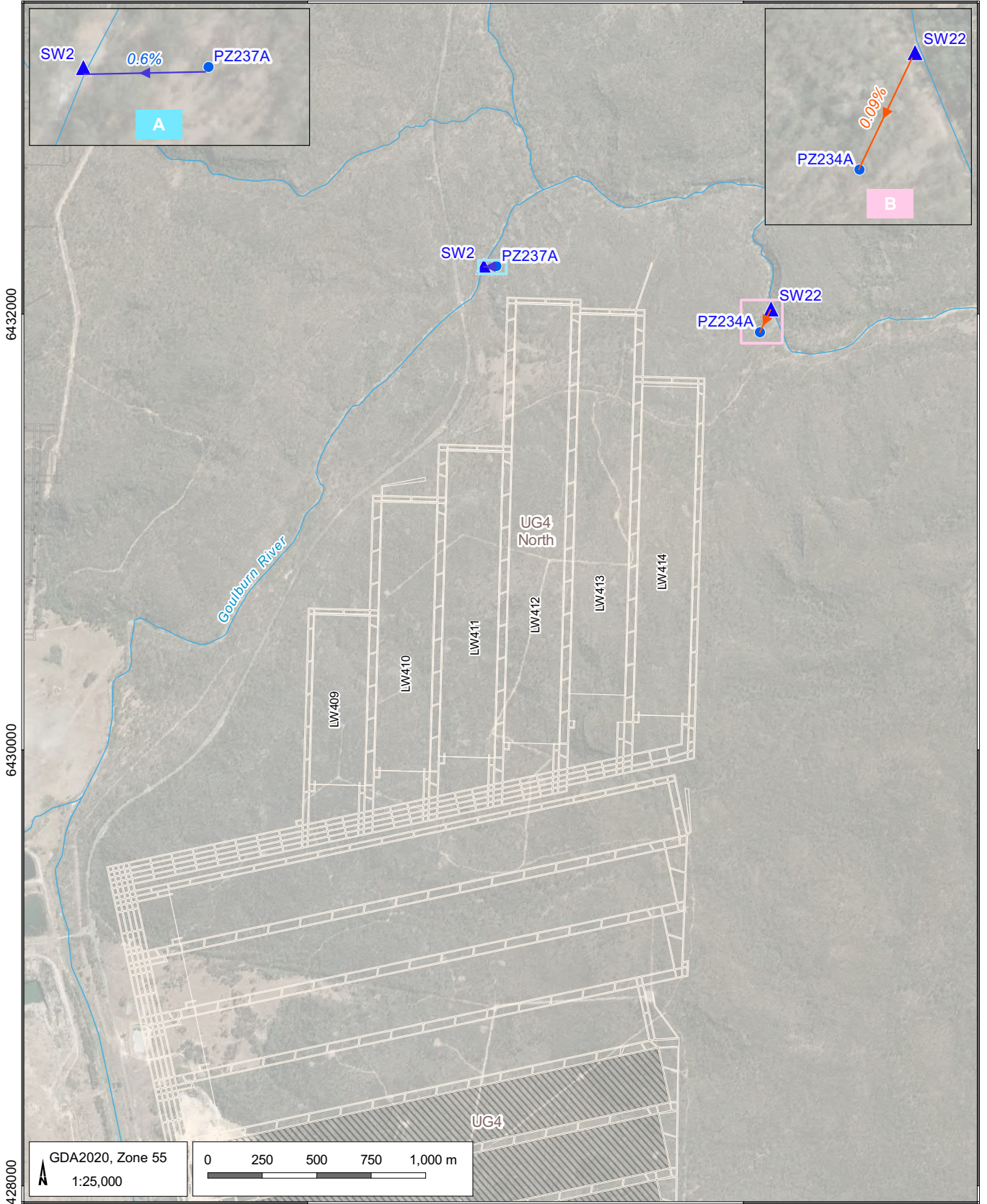
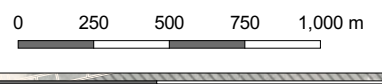


Figure 4.7 PZ234A / SW22 water level comparison



GDA2020, Zone 55
1:25,000



LEGEND

- UG4 Mine Plan
- Drainage
- Mine Extent (May 2024)
- Inset A
- Inset B
- Groundwater monitoring bore
- Gauging station

Hydraulic Gradient (%)

- Gaining
- Losing

UG4 LW409-414 Extraction Plan Groundwater
Technical Report (MOO5004.001)

**Surface Water / Groundwater
Interaction**



AGE

DATE
06/09/2024

FIGURE No:
4.8

4.3 Groundwater Receptors

4.3.1 Groundwater users

Groundwater usage in the area is primarily mine dewatering for the MCC and the neighbouring UCC and Wilpinjong Coal Mine.

There is one private bore in the vicinity of the MCC, located to the east of UG4 North (Figure 4.5). The bore is a relatively shallow bore (24 m) installed within Triassic strata and connected to the river alluvium. The location and baseline condition of this bore is summarised in Table 4.1.

Table 4.1 Baseline condition of privately owned water supply bores

Work ID	Licence No.	Easting	Northing	Bore Type	Hydrogeological Unit	Water Level (m AHD)	EC ($\mu\text{S/cm}$)	pH
GW800279	80BL236762	765208	6431971	Domestic	Triassic Narrabeen Group	371 (2020)	730	6.00

Notes: EC = electrical conductivity.
 $\mu\text{S/cm}$ = microSiemens per centimetre.
m AHD = metres Australian Height Datum.

4.3.2 Groundwater dependent ecosystem / assets

Groundwater Dependent Ecosystems (GDEs) are ecosystems that require access to groundwater to meet all or some of their water requirements on a permanent or intermittent basis for maintenance of the ecosystems (Richardson et al., 2011). The Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009 identifies the closest high priority GDE to the Goulburn River is the Wappinguy Spring, which is located approximately 28 km north from the Goulburn River at its closest point, and well outside the impacts expected to be generated by UG4 North.

Mapping from the Groundwater Dependent Ecosystems Atlas (Bureau of Meteorology, 2024) identifies the Goulburn River as a low to moderate potential aquatic GDE, as well as vegetation identified as low to high potential terrestrial GDEs in the vicinity of UG4. The significant depth to water in more elevated areas of the catchments such as the UG4 area where the depth to the water table is approximately 25 m to 65 m indicates that GDEs are unlikely to be present in these areas.

Springs and groundwater seeps in nearby creek valleys and localised pools and soaks along the creeks support riparian vegetation. None of these features constitute high priority GDEs listed under the Water Sharing Plans relevant to the MCC.

4.3.2.1 The Drip

The Drip is a cliff face seepage feature located approximately 700 m north of LW413 adjacent to the northern side of the Goulburn River (Figure 4.5 and Plate 4.3). The Drip forms a groundwater dependent ecosystem with local cultural and indigenous significance.

Groundwater discharges from The Drip are conceptualised to originate from perching of groundwater in zones that are exposed in the cliff faces. The perching occurs in the Triassic Narrabeen Group sediments and is formed by accumulations of groundwater above less permeable horizons in the Triassic sequence. Groundwater seepage from The Drip occurs at an elevation of approximately 387 to 388 mAHD. The bed of the Goulburn River at that location is approximately 380 mAHD.

In their advice on the Moolarben OC3 Extension Project, the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (2023) stated The Drip:

“is fed by a local shallow aquifer within the Triassic Sandstone on the far side of the Goulburn River (see recent work in ACARP 2022). Environmental tracers undertaken indicate The Drip seepage is distinctive from deeper aquifers, is a localised flow and is probably a perched aquifer.”



Plate 4.3 The Drip along the Goulburn River (MSEC, 2024)

The previous groundwater technical report (AGE, 2023) concluded that The Drip will not be affected by the MCC. This is because the Goulburn River effectively forms a hydraulic boundary in the Triassic lithic sandstone and groundwater within shallow alluvial sediments along the Goulburn River would buffer any drawdown from UG4 North. The main mechanisms for potential impacts to affect The Drip, would be through the enhancement of the vertical permeability of the Triassic sandstone (on the northern side of the Goulburn River), or through a reduction in groundwater recharge which supplies flow to The Drip. Neither of these mechanisms are possible from the underground mining of LW409 to LW414. The work of ACARP (2022) which concludes The Drip is probably a localised perched aquifer is a logical conclusion based on the available lines of evidence and as such The Drip is a localised groundwater feature effectively structurally immune from the impacts of mining that are predicted to occur predominantly at depth.

4.4 Estimated UG4 Groundwater Drawdown in Triassic Sandstone

First workings for UG4 commenced in October 2020, with secondary extraction of the first longwall LW401 in July 2022. Longwall LW404 was completed in May 2024 and secondary extraction is occurring in LW405 at the time of writing (September 2024).

Appendix A contains hydrographs that compare groundwater levels for the Triassic monitoring bores located in the UG4 area with the Cumulative Rainfall Departure (CRD). When groundwater level trends deviate from the rainfall trend after October 2020, these departures are identified with a vertical line on each hydrograph. Groundwater drawdown was calculated for each monitoring point, by subtracting the latest reduced standing water level (RSWL) from the RSWL at the time groundwater level trends deviate from climatic trends. Sites where groundwater level data has not been recorded recently, or the analysis could not be completed with a sufficient confidence are flagged on the figures or omitted from the analysis. This method provides a useful estimate of mining induced drawdown given the absence of pre-mining baseline data due to the long history of mining in the area.

Figure 4.9 shows the estimated observed groundwater drawdowns in the Triassic Sandstone related to LW401 to LW404 operations at each monitoring point as of May 2024. Groundwater drawdown within the Triassic sandstone is evident in the data only at monitoring bores PZ194B and PZ195, which are located close to UG4 LW402 and LW404 respectively. PZ 192 VWP 68m has recorded a period of drawdown in 2024, followed by full recovery. The cause of this response is unclear, but could be related to any drilling activities local to the borehole.

Localised drawdown around the mining areas aligns with model predictions, which predict depressurisation of the Triassic immediately above and adjacent to the goaf, but do not predict extensive lateral drawdown away from the goaf in the Triassic strata. In the Ulan Seam and Permian more laterally extensive drawdown away from the goaf area is predicted.

760000

762000

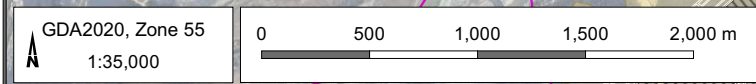
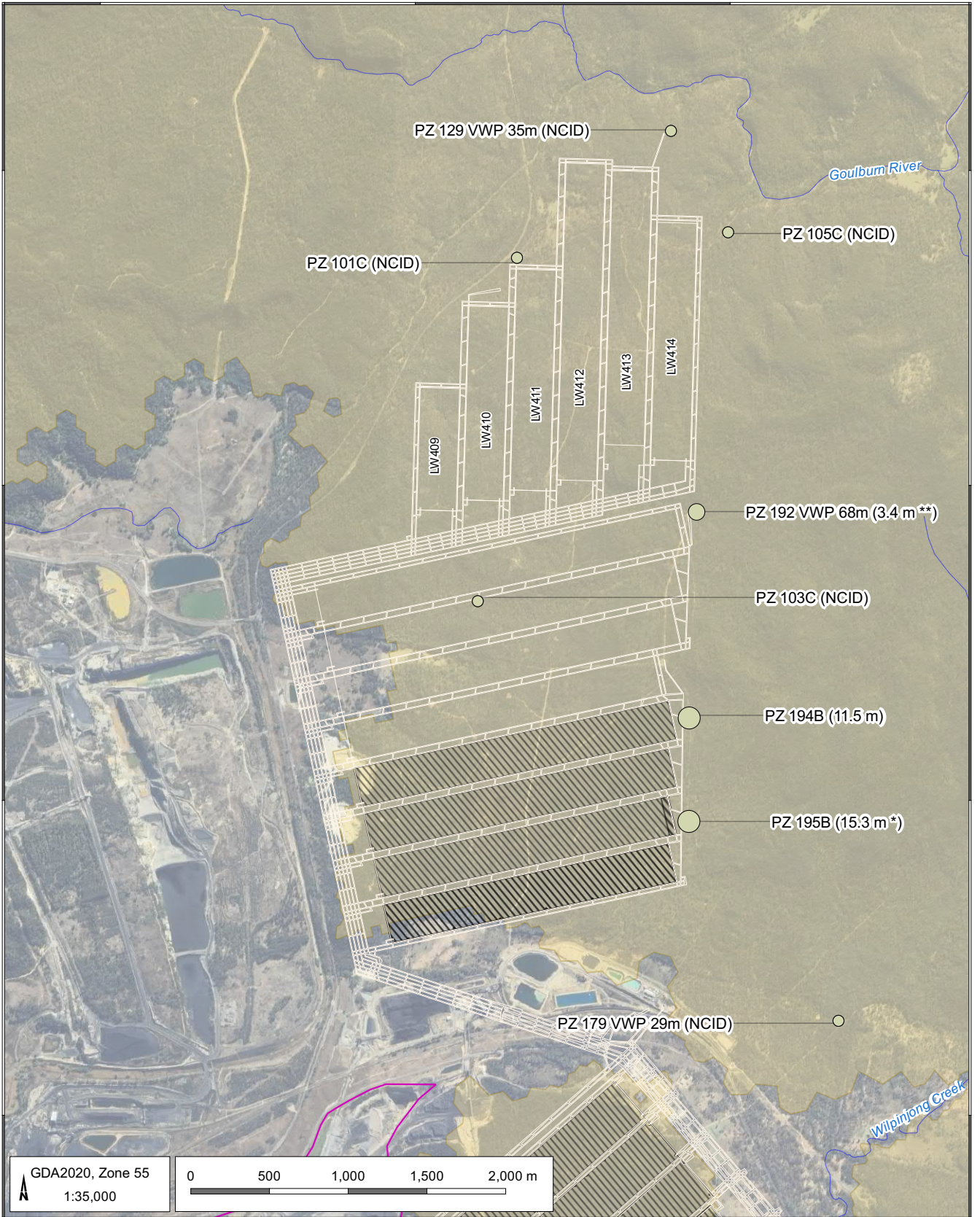
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LEGEND

- Drainage
- UG Mine plan
- Approximate Extent of OC Mining 2023
- Modelled Triassic Extent
- UG4 Mined LW as of May 2024

Estimated Triassic Drawdown (m)

- 0 to 2 m
- 2 to 5 m
- 5 to 20 m
- 20 to 30 m
- 30 to 52 m

UG4 LW409-414 Extraction Plan Groundwater Technical Report (MOO5004.001)

Estimated Observed Triassic Drawdown related to UG4 LW401 to LW404 operations



DATE
02/10/2024

FIGURE No:
4.9

NCID: No Clearly Identifiable Drawdown as at May 2024

** Indicates Lower Confidence Estimate

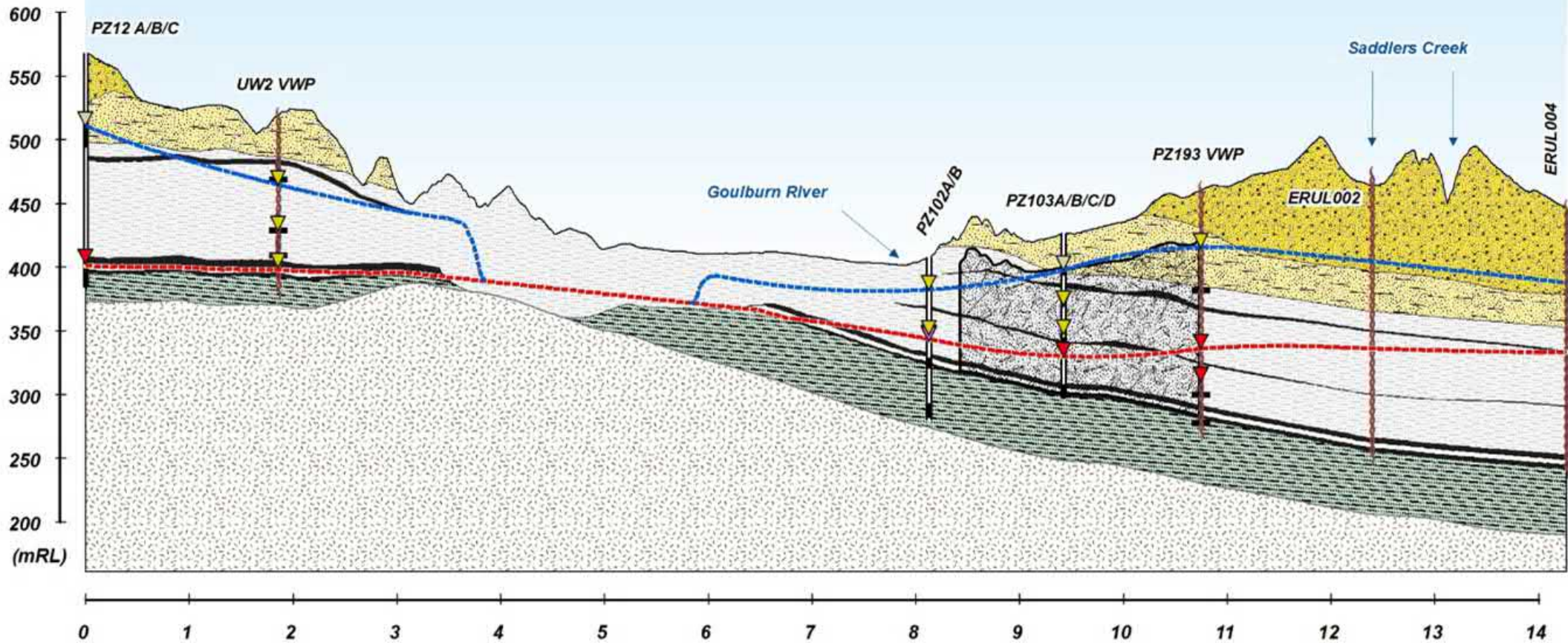
* Indicates a dry bore

4.5 Conceptual Groundwater Model Updates

Two hydrogeological sections which illustrate the features of the groundwater system in proximity to UG4 North are provided in Figure 4.10 and Figure 4.11. The location of the cross sections Transect A-A' and Transect B-B' are shown on Figure 4.1. The following can be inferred from the sections:

- there has been depressurisation of Permian strata surrounding UG4, as a result of previous and current mining operations;
- groundwater levels in the Permian strata and Ulan seam have responded to these historic mining activities, however there is no evidence of extensive groundwater drawdown occurring within the Triassic sandstone water table;
- multilevel sensors record a vertical downwards hydraulic head gradient, which indicates that the area receives groundwater recharge, and flow is downwards to the Ulan Seam;
- groundwater levels in the shallow Permian can approach similar levels to those in the Triassic sandstone, however there is a greater separation of heads at depth within the Permian ICM;
- large masses of the Triassic strata are naturally unsaturated;
- the Goulburn River Diversion is not directly connected to the water table adjacent UG4 North;
- the Goulburn River is likely a gaining stream near The Drip;
- baseflow within the Goulburn River Catchment is influenced by both natural groundwater discharges to the river and approved discharges of mine water;
- the height of fracturing above UG4 North is predicted using the Ditton and Merrick method (Ditton and Merrick, 2014) to extend to the water table, which may facilitate dewatering of the saturated rock mass directly overlying UG4 North. Therefore, predictions of fracture height from other empirical methodologies that indicate a greater height of fracturing will have limited effect on the predicted impacts of mining at UG4 North;
- only one major geological structure is currently inferred to intersect the UG4 workings and this fault which spans LW405 to LW408 is thought to have limited vertical extent, and no mapped offset within LW405 or LW408. Observations when mining through similar minor faults which traverse the UG4 highway indicated the faults result in limited water make, with flows subsiding over a relatively short period of time; and
- available lines of evidence indicate The Drip is a perched water table within the Triassic sandstone and effectively disconnected from the underlying regional water table. As a result, depressurisation caused by mining at UG4 North will not impact the water supply to The Drip.

A A'

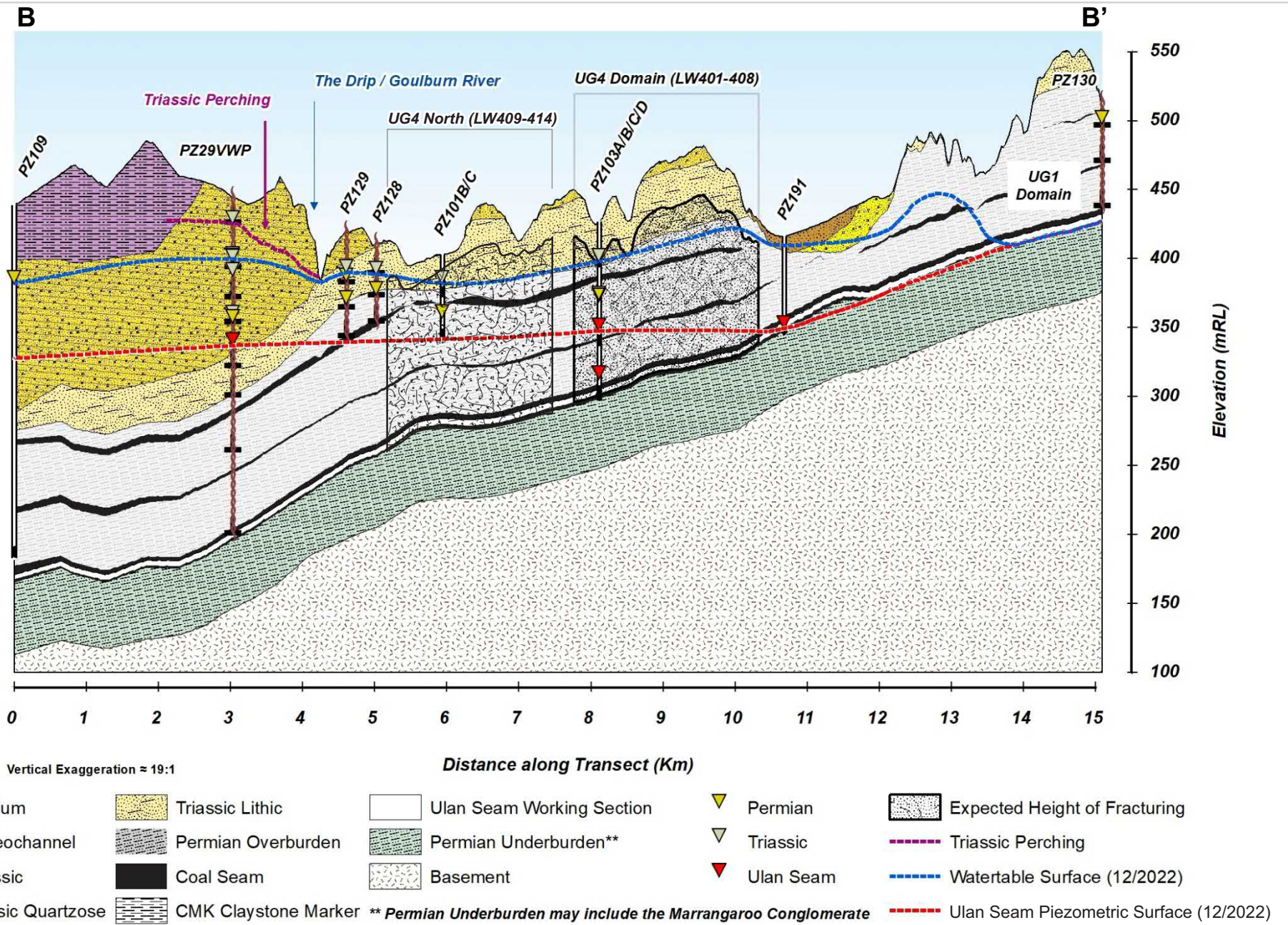


Distance along Transect (Km)

- | | | | | |
|--------------------|---------------------------|-----------------------|-----------|-------------------------------|
| Triassic Quartzose | Coal Seam | Permian Underburden** | Triassic | Expected Height of Fracturing |
| Triassic Lithic | CMK Claystone Marker | Basement | Permian | Watertable Surface |
| Permian Overburden | Ulan Seam Working Section | | Ulan Seam | Ulan Seam Piezometric Surface |

** Permian Underburden may include the Marrangaroo Conglomerate

Hydrogeological Cross Section A-A' (Refer to Figure 4.1 for Location)
 Moolarben Groundwater Conceptualisation
 UG4 LW409-414 Extraction Plan Groundwater Technical Report (MOO5004.001)



Hydrogeological Cross Section B-B' (Refer to Figure 4.1 for Location)
 Moolarben Groundwater Conceptualisation
 UG4 LW409-414 Extraction Plan Groundwater Technical Report (MOO5004.001)

5 Groundwater Predictions

Predictions of the impact on UG4 North on the groundwater regime are provided in the following sections. The predictions are based on the understanding of the groundwater regime summarised in previous sections, groundwater trend observations, and the recently updated numerical model of the site (AGE, 2023).

5.1 Summary of model features

The MCC numerical model was last updated during 2023. This model was updated to reflect changes in the conceptual model, and further history matching conducted to incorporate system knowledge from additional groundwater level and mine inflow observations. The updated model was used to provide groundwater impact predictions for the UG4 LW401 to LW408 Extraction Plan (AGE, 2023). The main model features (setup, timing and recalibration) are summarised in the following sections, while a detailed description of the 2023 groundwater model update is provided in AGE (2023).

5.1.1 Model setup

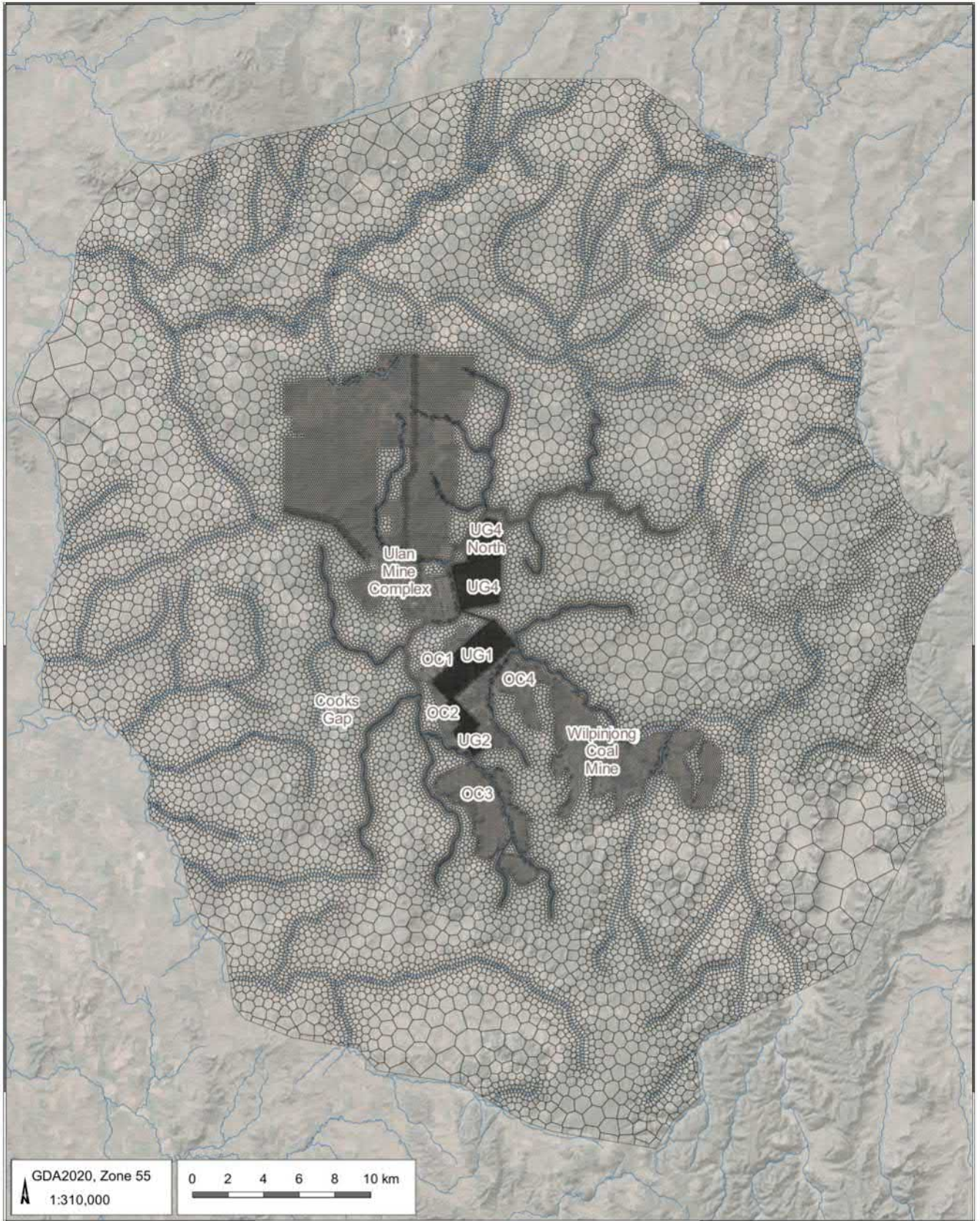
The model utilises the MODFLOW-USG code to simulate groundwater flow in the region. This model code was considered suitable to meet the model objectives because it:

- allows the use of an unstructured mesh where cells can be refined around localised features such as rivers, alluvial aquifers and mining areas, and larger cells used where refinement is not required;
- does not need layers to be continuous over the model domain, allowing layers to stop where geological units pinch out or outcrop, such as coal seams and alluvium;
- effectively reduces the number of cells (with the refinement and pinching options applied) which means faster model run times and a greater number of calibration runs can be completed; and
- better represents flow transfer processes between systems such as bedrock and alluvial groundwater systems, through the pinching out of layers, compared to earlier versions of MODFLOW.



The input files for the MODFLOW-USG model were created using custom Fortran and Python code and run with a MODFLOW-USG edition of the Groundwater Data Utilities by Watermark Numerical Computing (<https://pesthhomepage.org/programs>). The mesh was generated using Algomesh by HydroAlgorithmics.

The extent of the model is approximately 60 km north to south by 50 km west to east. The model comprises of 460,147 cells and the model mesh is presented in Figure 5.1. The model domain was discretised and arranged into 19 layers comprising up to 44,503 cell nodes in each layer with the dimensions of the cells varying according to the features that required representation. The following cells dimensions were adopted:

- MCC underground mining areas – 50 x 50 m square cells aligned to the principal axis of UG4 North;
- UCC underground mining areas – 120 m hexagonal cells;
- open cut mining areas – 120 m hexagonal cells;
- surface drainage lines near to the UG4 – approximately 100 x 100 m Voronoi cells; and
- surface drainage lines far from the UG4 – approximately 200 x 200 m Voronoi cells.



LEGEND

-  Drainage line
-  Model mesh

UG4 LW409-414 Extraction Plan Groundwater Technical Report (MOO5004.001)

Model Mesh (Regional View)



DATE
16/01/2024

FIGURE No:
5.1

The numerical groundwater model includes vertical discretisation, consisting of 19 layers representing the main hydrostratigraphic units in the area. The uppermost layers represent the shallow Quaternary alluvium and colluvium sediments, with the lowest layers representing the deep Permian coal measures and Marrangaroo Conglomerate. Table 5.1 lists each model layer and the hydrostratigraphic layer it represents.

Table 5.1 Model layers and hydrogeological units

Model layer	Hydrostratigraphic layer
1	Alluvium and colluvium
2	Palaeochannel
3	Tertiary basalt
4	Jurassic Pilliga/Purlewaugh Fm
5, 6, 7	Triassic sandstone (quartzose)
8, 9	Triassic sandstone (lithic)
10, 12, 14	Permian overburden
11, 13	Permian coal seams
15, 17, 18	Permian Ulan Seam
16	Permian clay interburden
19	Permian underburden

5.1.2 Model timing

The model timing was designed to represent seasonal variability in recharge and observed groundwater responses. The calibration involved an initial steady state calibration to obtain pre-mining conditions, followed by a transient history-matching using water level measurements from the monitoring network. Any mining prior to 1984 was not represented, but it is expected any historical effects from this mining would be reflected in the monitoring data used in the groundwater model. Mining prior to 1984 is limited to relatively small-scale mining undertaken at the UCC that would not have a material effect on water levels in the vicinity of the of the Moolarben mining areas.

The transient model was set up as follows:

- 31 Dec 1983 – steady state stress period (1 day);
- 1 Jan 1984 to 31 Dec 1998 – pre-calibration phase of four 5-yearly stress periods;
- 1 Jan 1999 to 31 Dec 2004 – one 6-year stress period;
- 1 Jan 2005 to 30 March 2023 – calibration phase of 219 monthly stress periods;
- 1 May 2021 to 31 Dec 2036 – predictive phase of 55 quarterly stress periods; and
- 1 Jan 2037 to 31 Dec 2712 – 675 years recovery period of 15 stress periods.

The initial transient stress periods (5-yearly and subsequent 6-year stress period) were selected based on a review of available mining information, and the temporal distribution of observation data.

5.1.3 Model recalibration

The groundwater model was calibrated (AGE, 2023) with automated parameterisation software (PEST) (Doherty, 2015) using the latest available MCC groundwater level and flow data. Hydraulic properties and groundwater recharge rates were varied during the model calibration. The pilot point multiplier method was used to represent spatially varying hydraulic properties.

Recalibration was performed using a simulation that represents both the pre-mining steady state, and a transient historical period (1984 to 2023). Observations from the recently constructed monitoring bores and vibrating wire piezometers were also included in the model recalibration. The model was calibrated to replicate both observed groundwater levels and observed groundwater inflows to the underground operations. Modelled baseflow to the Goulburn River and Moolarben Creek were also included to confirm predictions were commensurate with the conceptual model of MCC.

One of the statistical measures recommended by the Australian groundwater modelling guidelines (Barnett et. al., 2012) to measure the success of history matching is the Scaled Root Mean Squared Error (SRMS). The SRMS of the model was 5.5 %. A value of SRMS below 10% generally is typically targeted as part of a groundwater modelling exercise. Figure 5.2 provides a scatter gram comparing the modelled and observed heads.

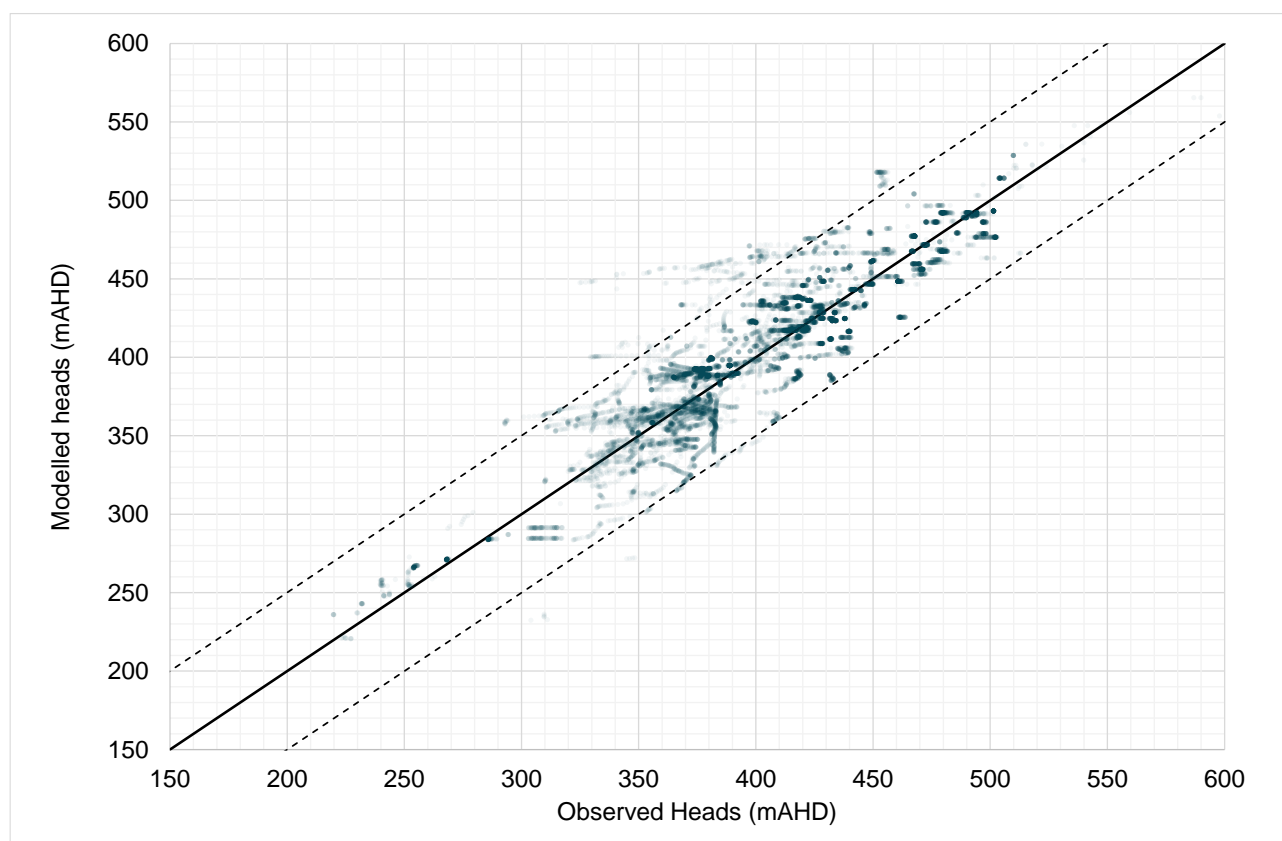


Figure 5.2 Calibration Scatter Plot

The model's performance was also assessed by history matching the inflows observed from workings at UG1 and first workings associated with UG4 with model predictions. Groundwater inflow to UG1 & UG4 first workings during 2022 were estimated at 3,700 ML/yr or about 10 ML/d. Over the same period, modelled inflows peaked at 11.9 ML/d, averaging 7.4 ML/d from UG1 and UG4 combined.

The updated model calibration was peer reviewed by Brian Barnett, Groundwater Modeler from Jacobs Consulting, the Independent Advisory Panel for Underground Mining, and the Department of Planning, Housing and Infrastructure – Water in 2023.

The calibrated parameter ranges adopted for horizontal hydraulic conductivity (Kh) are provided in Table 5.2, the adopted ratio of Kv/Kh in Table 5.3, the specific yield (Sy) per in Table 5.4, specific storage (Ss) in Table 5.5, and rainfall infiltration factors in Table 5.6.

Table 5.7 presents the average calibrated hydraulic parameters per layer. The Kh value of the coal seams was limited to a maximum of 0.8 m/day. Figure 5.3 shows the locations of the pilot points.

Table 5.2 Calibration ranges for Kh

Layer	Hydrostratigraphy	Kh (m/day) minimum	Kh (m/day) maximum
1	Alluvium	3.50E-01	3.50E+01
1	Colluvium	5.00E-02	5.00E+00
2	Palaeochannel	5.00E-03	5.00E-01
3	Tertiary basalt	1.00E-04	1.00E-02
4	Jurassic Pilliga/Purlewaugh Fm	1.00E-04	1.00E-02
5, 6, 7	Triassic sandstone (quartzose)	1.00E-03	1.00E-01
8, 9	Triassic sandstone (lithic)	5.00E-05	5.00E-03
10, 12, 14	Permian overburden	1.25E-06	1.25E-04
11, 13	Permian coal seams	1.00E-06	1.00E-04
15, 17, 18	Permian Ulan Seam	8.60E-06	8.00E-01
16	Permian clay interburden	1.00E-05	1.00E-03
19	Permian underburden	1.00E-05	1.00E-03

Table 5.3 Calibration ranges for Kv/Kh

Layer	Hydrostratigraphy	Kv/Kh minimum	Kv/Kh maximum
1	Alluvium	1.00E-03	1.00E-01
1	Colluvium	1.00E-03	1.00E-01
2	Palaeochannel	1.00E-03	1.00E-01
3	Tertiary basalt	5.00E-03	5.00E-01
4	Jurassic Pilliga/Purlewaugh Fm	1.00E-05	1.00E-03
5, 6, 7	Triassic sandstone (quartzose)	1.00E-03	1.00E-01
8, 9	Triassic sandstone (lithic)	1.00E-03	1.00E-01
10, 12, 14	Permian overburden	1.00E-03	1.00E-01
11, 13	Permian coal seams	1.00E-03	1.00E-01
15, 17, 18	Permian Ulan Seam	5.00E-02	5.00E+00
16	Permian clay interburden	1.00E-03	1.00E-01
19	Permian underburden	1.00E-03	1.00E-01

Table 5.4 Calibration ranges for Sy

Layer	Hydrostratigraphy	Sy minimum	Sy maximum
1	Alluvium	1.00E-02	5.00E-01
1	Colluvium	8.00E-04	4.00E-02
2	Palaeochannel	1.80E-03	1.80E-01
3	Tertiary basalt	2.00E-03	2.00E-01
4	Jurassic Pilliga/Purlewaugh Fm	1.00E-03	1.00E-01
5, 6, 7	Triassic sandstone (quartzose)	3.00E-03	3.00E-01
8, 9	Triassic sandstone (lithic)	1.00E-03	1.00E-01
10, 12, 14	Permian overburden	1.50E-03	1.50E-01
11, 13	Permian coal seams	2.00E-03	2.00E-01
15, 17, 18	Permian Ulan Seam	2.00E-03	2.00E-01
16	Permian clay interburden	1.50E-03	1.50E-01
19	Permian underburden	5.00E-04	5.00E-02

Table 5.5 Calibration ranges for Ss

Layer	Hydrostratigraphy	Ss (m ⁻¹) minimum	Ss (m ⁻¹) maximum
1	Alluvium	1.30E-06	1.30E-04
1	Colluvium	5.00E-07	5.00E-05
2	Palaeochannel	5.00E-07	5.00E-05
3	Tertiary basalt	5.00E-07	5.00E-05
4	Jurassic Pilliga/Purlewaugh Fm	5.00E-07	5.00E-05
5, 6, 7	Triassic sandstone (quartzose)	1.00E-06	1.30E-05
8, 9	Triassic sandstone (lithic)	8.00E-07	8.00E-05
10, 12, 14	Permian overburden	2.30E-07	1.00E-05
11, 13	Permian coal seams	2.30E-07	2.00E-05
15, 17, 18	Permian Ulan Seam	2.30E-07	2.00E-05
16	Permian clay interburden	2.30E-07	1.00E-05
19	Permian underburden	2.30E-07	1.00E-05

Table 5.6 Calibration ranges for rainfall infiltration factors

Recharge zone	Infiltration factor minimum	Infiltration factor maximum
Quaternary alluvium	9.74E-03	2.44E-01
Quaternary colluvium	9.80E-05	2.45E-03
Palaeochannel	2.00E-03	5.00E-02
Tertiary basalt	4.00E-04	1.00E-02
Jurassic Pilliga and Purlewaugh Fm	1.40E-05	3.50E-04
Triassic sandstone (quartzose)	1.52E-04	3.81E-03
Triassic sandstone (lithic)	2.02E-05	5.04E-04
Permian overburden	1.71E-07	4.27E-06
Permian coal	1.99E-08	4.97E-07
Permian Marrangaroo conglomerate	7.42E-09	1.86E-07
The Drip	8.00E-03	2.00E-01

Table 5.7 Calibrated hydraulic parameters

Layer	Hydrostratigraphy	Kh (m/day)	Kv (m/day)	Sy	Ss (m ⁻¹)
1	Alluvium	4.29E+00	4.37E-02	1.22E-01	1.57E-05
1	Colluvium	5.65E-01	5.46E-03	9.55E-03	6.34E-06
2	Palaeochannel	6.20E-02	5.95E-04	2.06E-02	5.94E-06
3	Tertiary basalt	1.22E-03	5.72E-05	2.42E-02	6.52E-06
4	Jurassic Pilliga/Purlewaugh Fm	1.11E-03	1.10E-07	1.01E-02	5.60E-06
5, 6, 7	Triassic sandstone (quartzose)	1.15E-02	1.21E-04	3.37E-02	1.00E-05
8, 9	Triassic sandstone (lithic)	5.43E-04	5.46E-06	1.07E-02	8.29E-06
10, 12, 14	Permian overburden	1.34E-05	1.35E-07	1.55E-02	1.05E-06
11, 13	Permian coal seams	1.06E-05	1.04E-07	2.14E-02	2.01E-06
15, 17, 18	Permian Ulan Seam	6.14E-01*	1.01E-01	2.01E-02	2.01E-06
16	Permian clay interburden	1.02E-04	1.01E-06	1.52E-02	1.04E-06
19	Permian underburden	1.00E-04	1.01E-06	4.97E-03	9.69E-07

Notes: * A reduction in hydraulic conductivity due to coal cleats closing under increasing overburden pressure generally occurs where, K_h of the coal seam decreases proportionally with depth from the ground surface.

The equation used to represent a declining K_h with depth in the Ulan Seam was as follows:

$$K_h = K_0 \cdot e^{sd}$$

where K_0 is a base hydraulic conductivity value of (15 m/d), s is the slope (-0.005), and d is the depth (m) below ground surface.

750000

765000

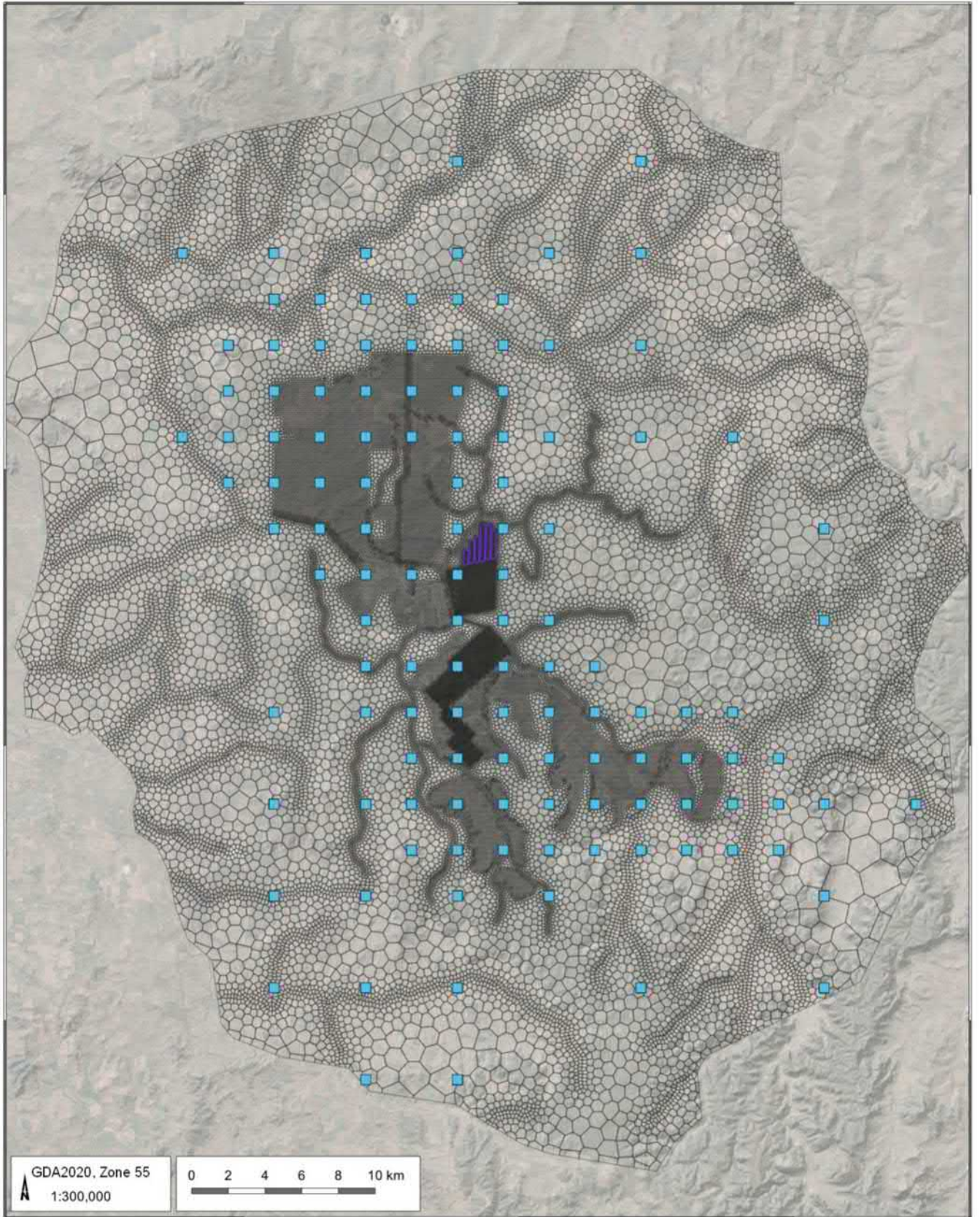
780000

6450000

6435000

6420000

6405000



GDA2020, Zone 55
 1:300,000



LEGEND

- Pilot point
- Model mesh
- UG4 LW409-414

UG4 LW409-414 Extraction Plan Groundwater
 Technical Report (MOO5004.001)

Pilot Point Locations



DATE
 16/01/2024

FIGURE No:
5.3

The water budget over the transient calibration period (1984 to 2023) is summarised in Table 5.8, which shows the average fluxes during the model simulation.

Table 5.8 Modelled water budget

Parameter	In (ML/day)	Out (ML/day)	In - Out (ML/day)
Storage	21.14	0.66	20.48
Rivers	0.10	25.00	-24.9
Rainfall recharge	23.19	-	23.19
Evapotranspiration	-	1.77	-1.77
General head boundaries (across edge of model domain)	111.05	12.03	99.02
Drains (inflow to mine workings)	-	119.06	-119.06
Total	155.48	158.52	-3.04

5.1.4 Calibration hydrographs

Hydrographs that compare the simulated and observed groundwater levels at all available groundwater monitoring sites are included within Appendix B. The ability of the numerical model to predict impacts from approved mining at UG4 on the Triassic groundwater system is discussed further here.

Figure 5.4 and Figure 5.5 compare the predicted and observed groundwater levels at monitoring locations PZ194B and PZ195B. The hydrographs show the model generally replicates the slope of the groundwater level decline observed within these monitoring sites in close proximity to UG4.

As summarised in Section 4.4, monitoring sites PZ194B and PZ195B are the only two monitoring sites where groundwater drawdown of the Triassic strata due to UG4 has been identified within the monitoring network. These sites are located close to the longwall panels mined in UG4 as of May 2024. Whilst the model predicts the slope of drawdown well, it conservatively overpredicts the amount of total drawdown by about 65%. At monitoring site PZ103C, which is located around 875 m north of the mined longwall panels as at May 2024, the absence of impacts on groundwater levels is well represented by the model (Figure 5.6).

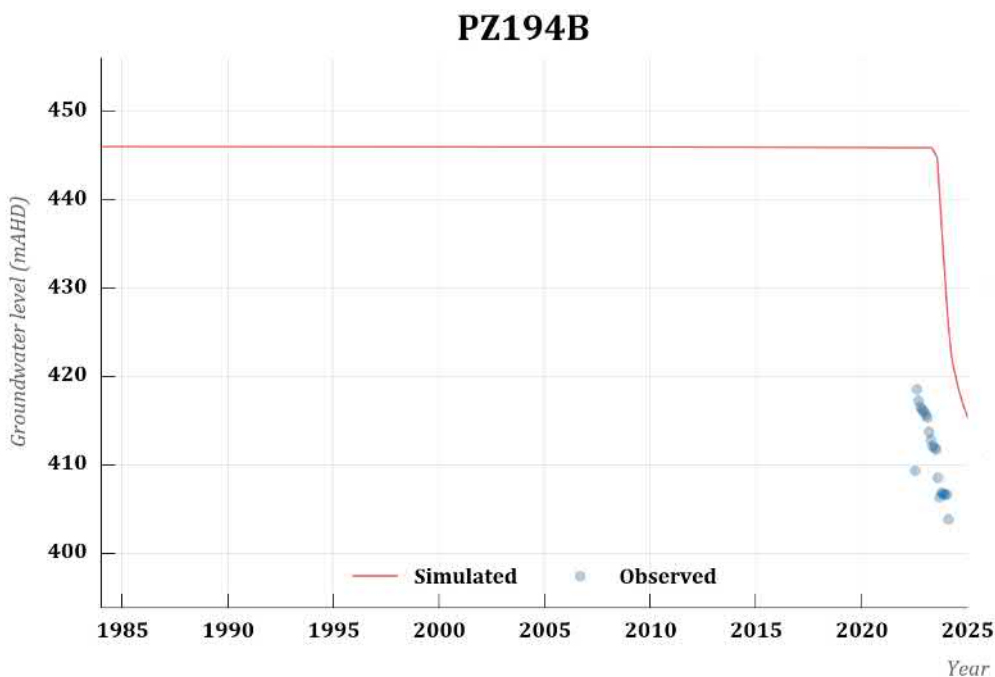


Figure 5.4 Calibration hydrograph for bore PZ 194B

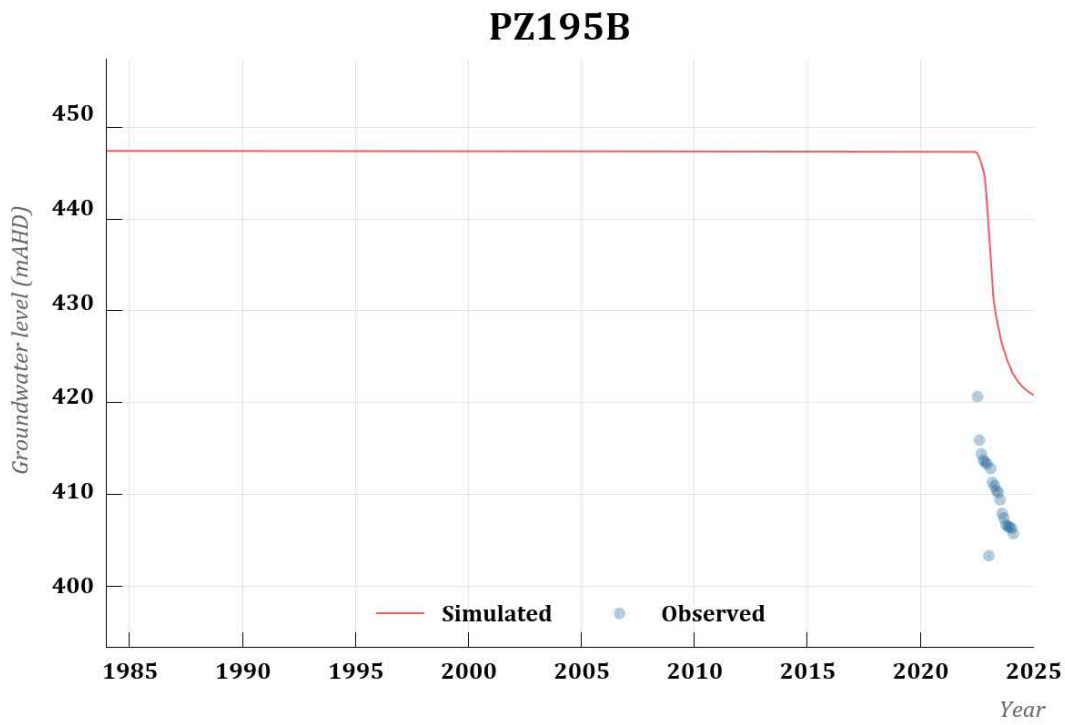


Figure 5.5 Calibration hydrograph for bore PZ 195B

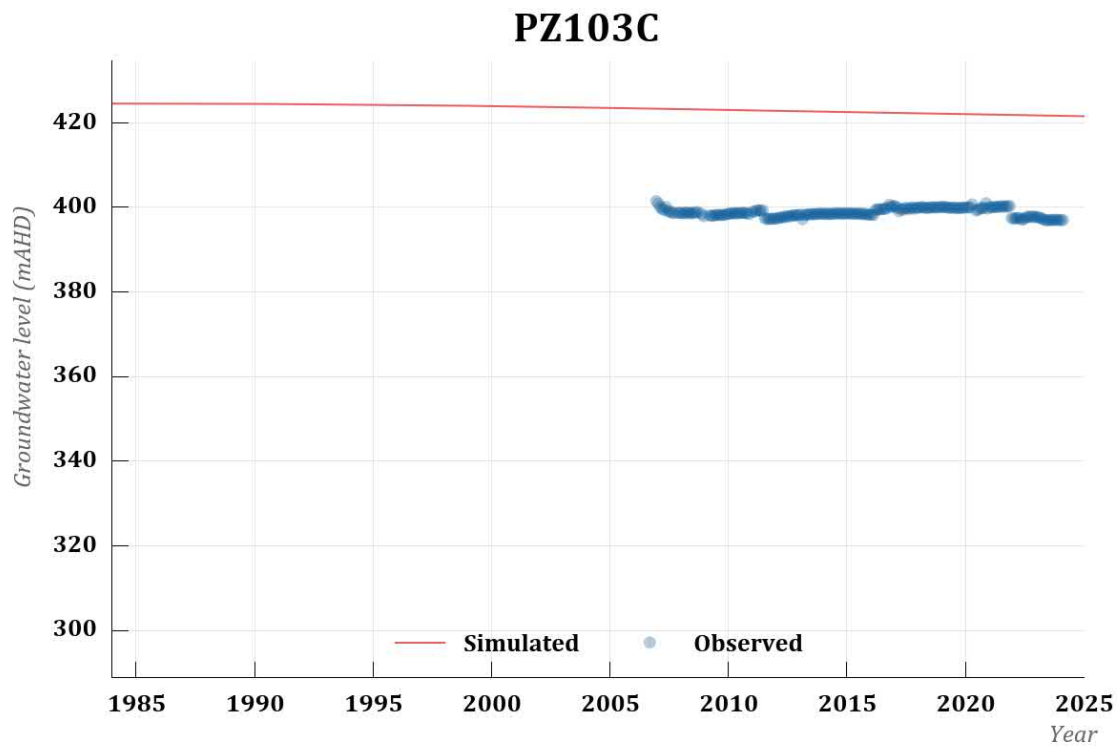


Figure 5.6 Calibration hydrograph for bore PZ 103C

5.2 Subsidence model updates

Mine Subsidence Engineering Consultants (MSEC) assessed the magnitude of subsidence as part of the UG4 North Extraction Plan. MSEC (2024) concluded:

- It is considered unlikely that fracturing of the bed of the Goulburn River would occur due to the Extraction Plan Layout based on the magnitude of expected movements and the offset distances from the Goulburn River. If fracturing were to occur, it is likely that the fractures will be localised in nature and relatively minor in size, and represent no greater than negligible impact.
- It is expected that the majority of the bedrock in the bed of the river will be covered with alluvial deposits. Minor fractures that potentially develop outside extracted longwalls are not generally associated with any increased rate of diversion of surface water into near-surface substrata.
- With no known significant geological features located near the longwalls, the risk of impact from anomalous movements at The Drip and Goulburn River Gorge is considered remote. Due to the significant distance and predicted low magnitude of predicted far-field movement at the cliffs, mining related impacts to The Drip and Goulburn River Gorge due to the extraction of UG4 North are considered unlikely to occur.

5.3 Fracturing and depressurisation

During longwall mining, the removal of coal causes the overburden to subside into the spent longwall void (goaf). The resultant strain imposed on the rock strata develops a fracture network of varying connectivity according to the height above the longwall panel. The thickness of the mined section, the effective width of the longwall panel, and the geological properties of the overburden all influence the degree of fracturing which results from the collapsing of the longwall panel (post mining).

Figure 5.7 shows a schematic of the fracture network and identified zones which are produced above a collapsed longwall panel.

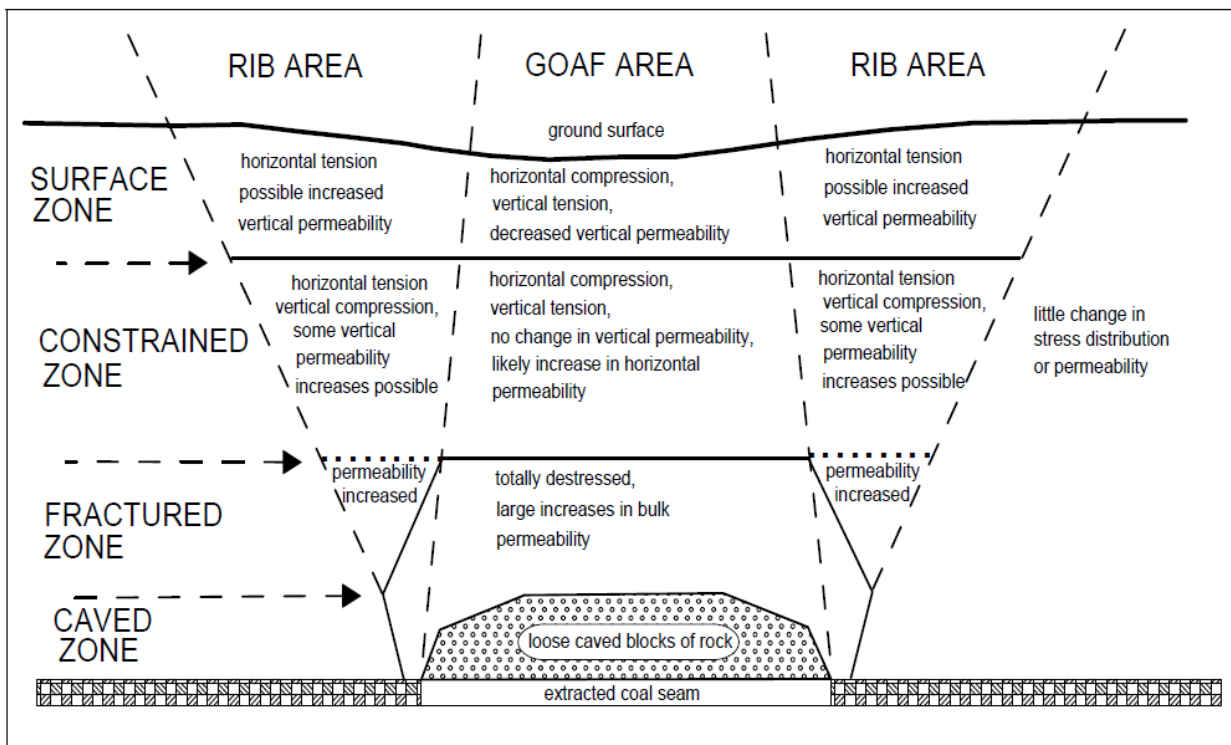


Figure 5.7 Processes which occur above a longwall panel (Forster and Enever, 1992)

In the Moolarben numerical model the fractured zone was represented by adjustments to the hydraulic properties to reflect the changes which occur within the developed fractured zone. Dewatering was simulated in the coal seam layers through the application of the MODFLOW drain boundary condition. The properties of the model layers above the mined coal seam were adjusted at the time mining occurs to represent the fracturing which occurs in response to longwall mining.

The hydraulic properties were altered to represent a gradual reduction in the influence of fracturing above the mined seam. The changes in the hydraulic properties was more significant immediately above the mined coal seam, then reducing with height towards the top of the fracture zone.

Figure 5.8 shows the estimated fracture height determined from the width of the longwall panel, the thickness of the mined seam and the depth/nature of the overburden material. Figure 5.9 presents the estimated depth from the land surface to the top of the fracture zone. It indicates that continuous fracturing is not predicted to occur at the land surface, with the zone of continuous fracturing being 16 m deep or more. The estimated height of fracturing is also shown on the hydrogeological cross sections (Figure 4.10 and Figure 4.11).



LEGEND

- Surface water drainage
- Longwall panel outline (LW409 - LW414)
- UG4

- Moolarben Mining Lease
- Ulan mine area

Fracture Height above the Ulan Seam (m)

- 90 - 110
- 110 - 120
- 120 - 130
- 130 - 140
- 140 - 150
- 150 - 160

UG4 LW409-414 Extraction Plan Groundwater Technical Report (MOO5004.001)

Estimated fracture height above the Ulan Seam



DATE 06/09/2024

FIGURE No: 5.8



LEGEND

- Surface water drainage
- Longwall panel outline (LW409 - LW414)
- UG4

- Moolarben Mining Lease
- Ulan mine area

Depth to the Top of the Fracture Zone (m)

- 15 - 20
- 20 - 30
- 30 - 35
- 35 - 40
- 40 - 50
- 50 - 63

UG4 LW409-414 Extraction Plan Groundwater Technical Report (MOO5004.001)

Estimated depth to top of fracture zone from surface



DATE
06/09/2024

FIGURE No:
5.9

5.4 Predicted impacts – to end of LW414

The updated numerical model was used to provide predictions of the potential impact UG4 North will have on the groundwater regime, including predicted:

- groundwater inflows into UG4 North;
- effects of UG4 North on the shallow water table, and groundwater pressure responses in the deeper strata;
- water losses and water take from the water bearing units in the vicinity of UG4 North; and
- losses to baseflow and water take estimates for water licensing requirements.

The model scenarios in Table 5.9 were created and used in various combinations to assess the impacts described above.

Table 5.9 Model predictive scenarios

Model Setup	Model Description
1	No Mining – simulates no mining in the model domain.
2	Approved Mining – represents all currently approved and proposed mining at the MCC including UG4 North, as well as the approved mining at UCC and Wilpinjong.
3	No UG4 North – represents all currently approved and proposed mining at the MCC except UG4 North, and also includes cumulative impacts from UCC and Wilpinjong mines.
4	No Moolarben – represents only the approved Ulan and Wilpinjong mines.

Model timing is detailed in Section 5.1.2 and mining of UG4 North is modelled from 1 December 2025 until 28 February 2028.

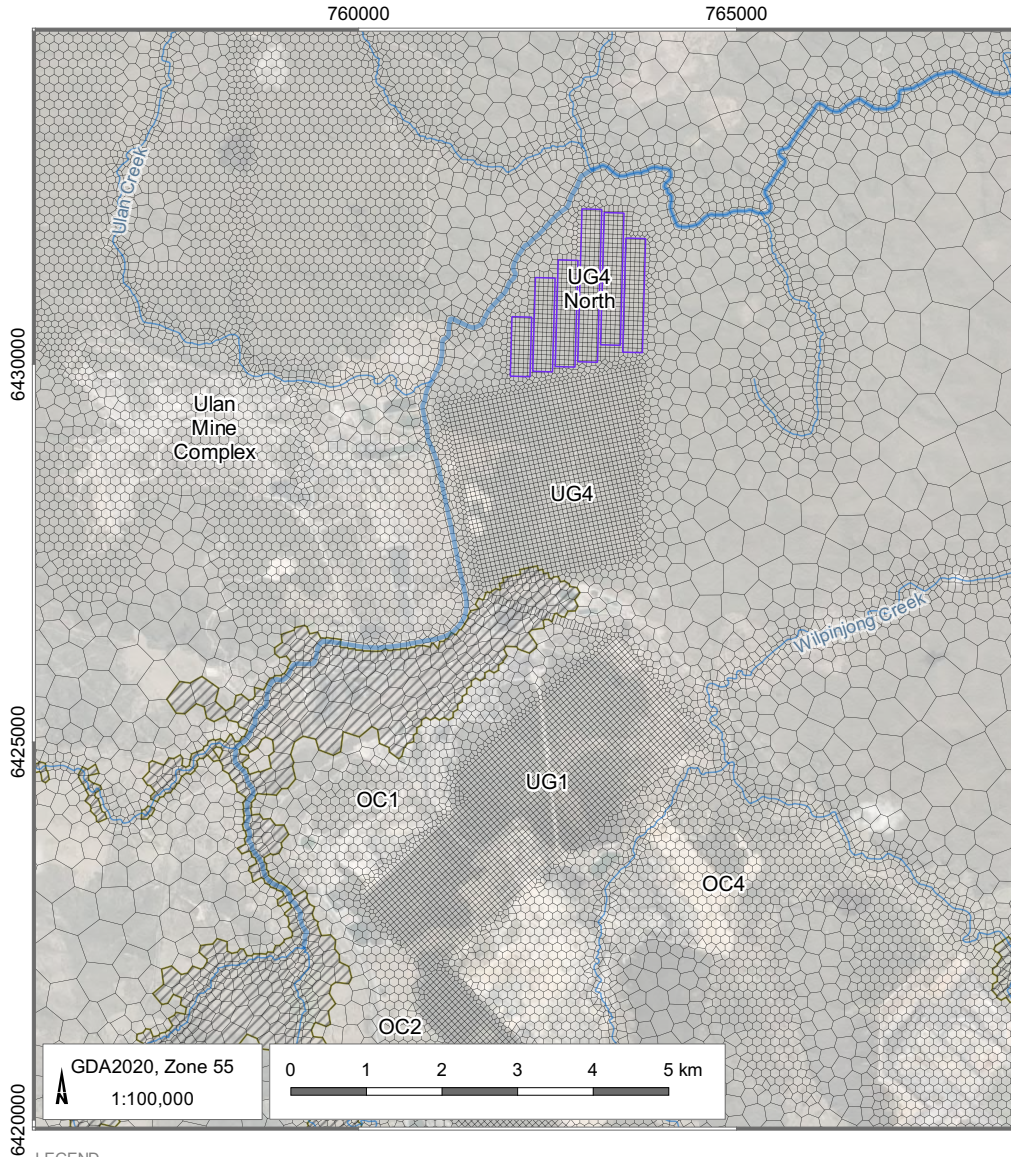
5.4.1 Drawdown

Predicted drawdown was determined using the combination of model predictions summarised in Table 5.9 and contours prepared for the key hydrostratigraphic units. Drawdown surfaces are a composite of the maximum drawdown values predicted at each model cell, at any time over the period of mining. The actual duration and timing of the maximum predicted drawdown within each cell varies depending on the proximity of mining over the life of UG4 North. Drawdown maps were prepared for the following hydrostratigraphic units:

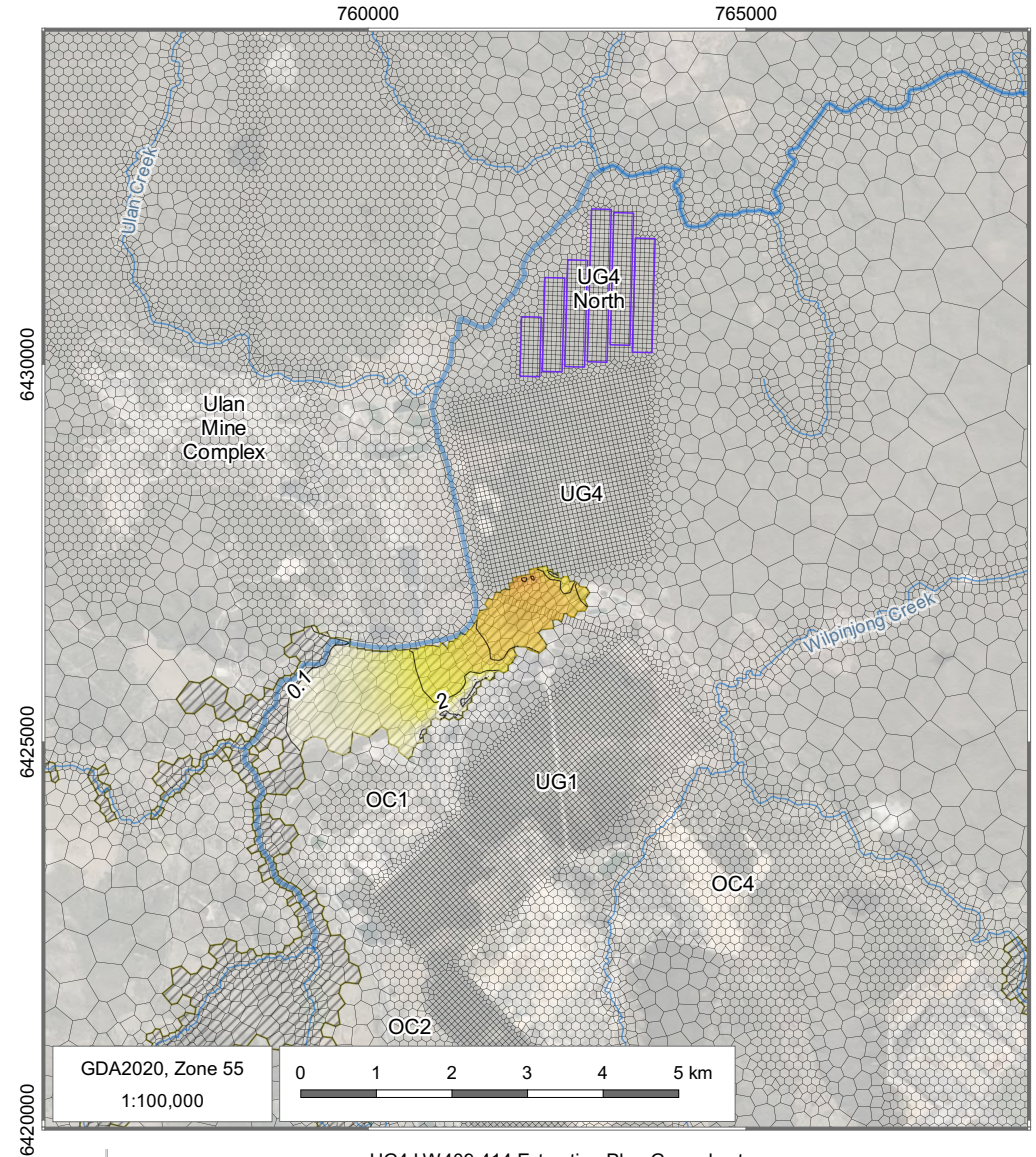
- Quaternary alluvium – Layer 1;
- Palaeochannel – Layer 2;
- Jurassic Purlawaugh and Piliga Formations – Layer 4;
- base of Triassic quartzose sandstone – Layer 7;
- base of Triassic lithic – Layer 9;
- base of Permian overburden – Layer 14; and
- Ulan Seam – Layer 17.

These maps are shown as Figure 5.10 to Figure 5.17, which contain two windows showing the maximum predicted drawdown due to UG4 North in the left window and the cumulative drawdown from the approved MCC, and neighbouring mines Ulan Coal Complex and Wilpinjong Coal Mine in the right window.

UG4 LW409-414 only



Cumulative



- LEGEND
- Drawdown contour (m)
 - Minor drainage
 - Goulburn River
 - ▭ UG4 LW409-414
 - ▭ Model mesh
 - ▨ Quaternary alluvial extent

Drawdown (m)	
0.1	10
1	20
2	50
5	



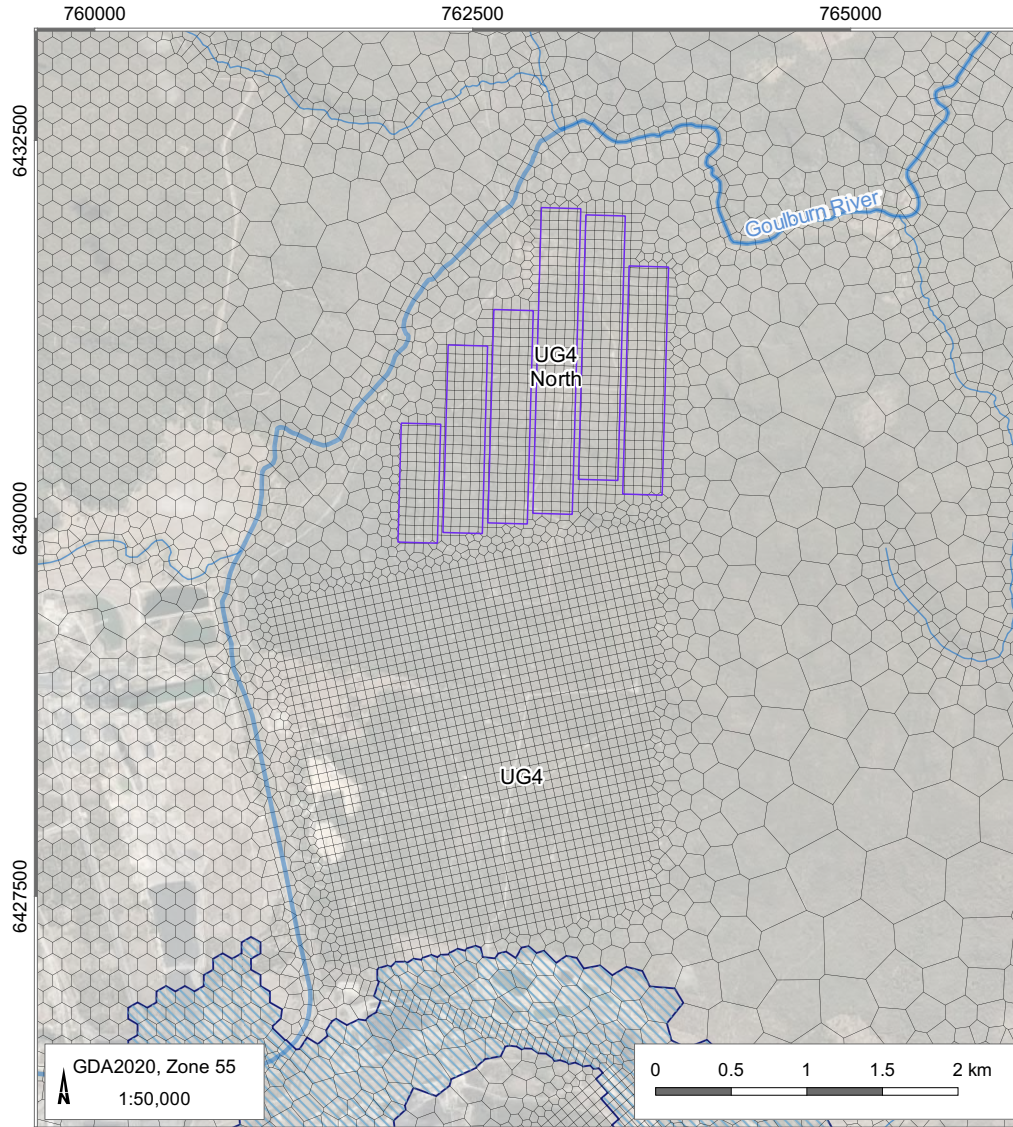
UG4 LW409-414 Extraction Plan Groundwater Technical Report (MOO5004.001)

Maximum Predicted Drawdown in Quaternary Alluvium until End of Mining

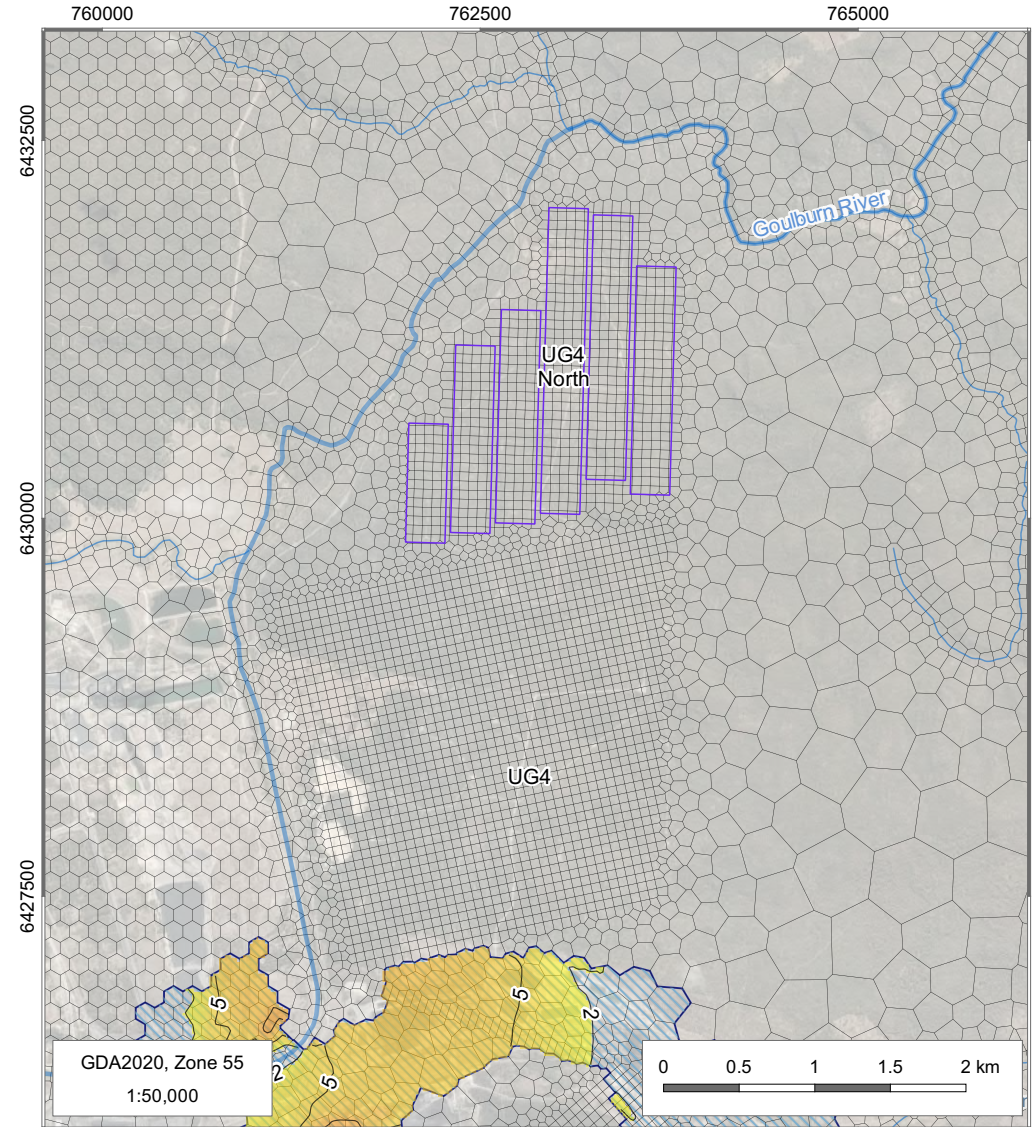
DATE
06/09/2024

FIGURE No:
5.10

UG4 LW409-414 only



Cumulative



LEGEND

- Drawdown contour (m)
- Minor drainage
- Goulburn River
- UG4 LW409-414
- Model mesh
- Paleochannel extent

Drawdown (m)	
2	50
5	100
10	200
20	500



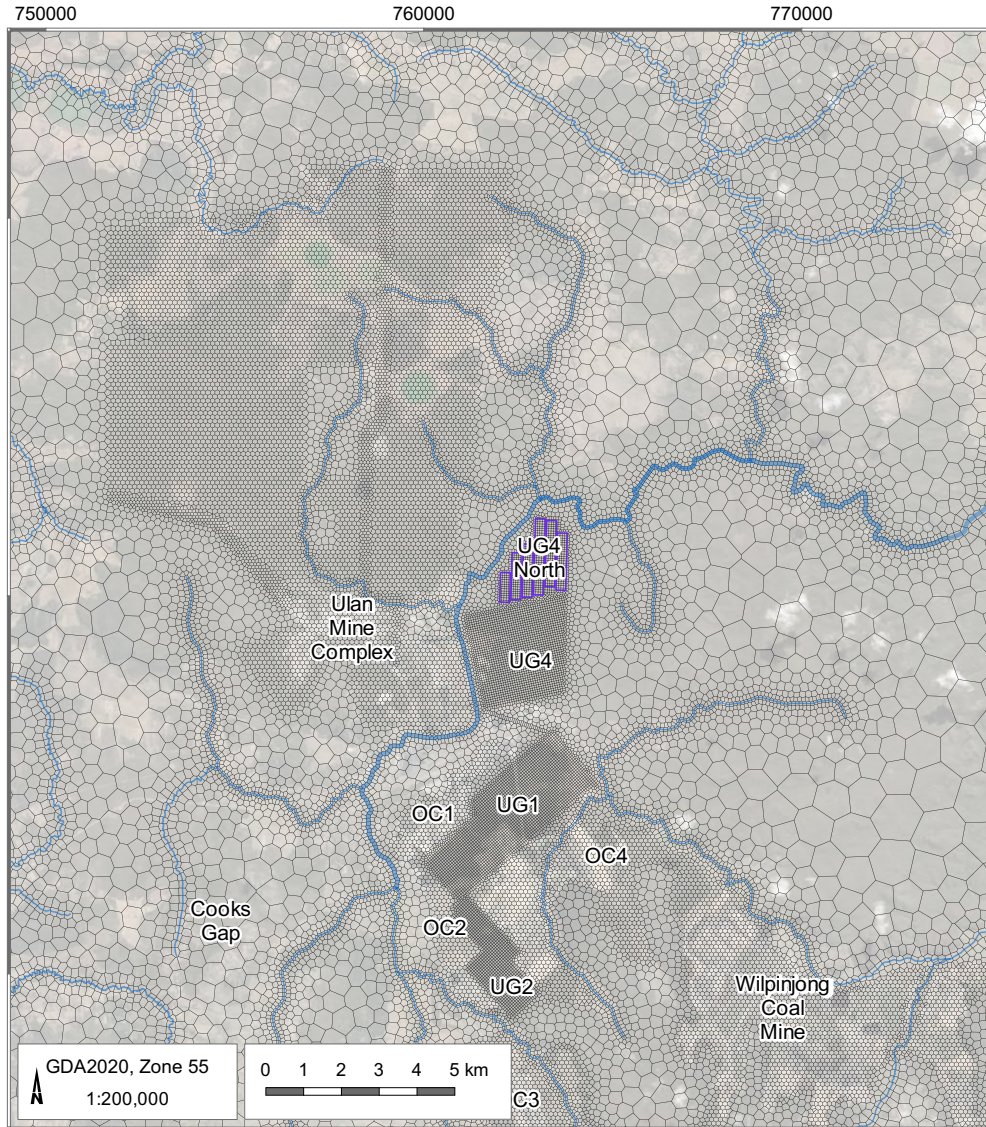
UG4 LW409-414 Extraction Plan Groundwater
Technical Report (MOO5004.001)

**Maximum Predicted Drawdown in
Palaeochannel until End of Mining**

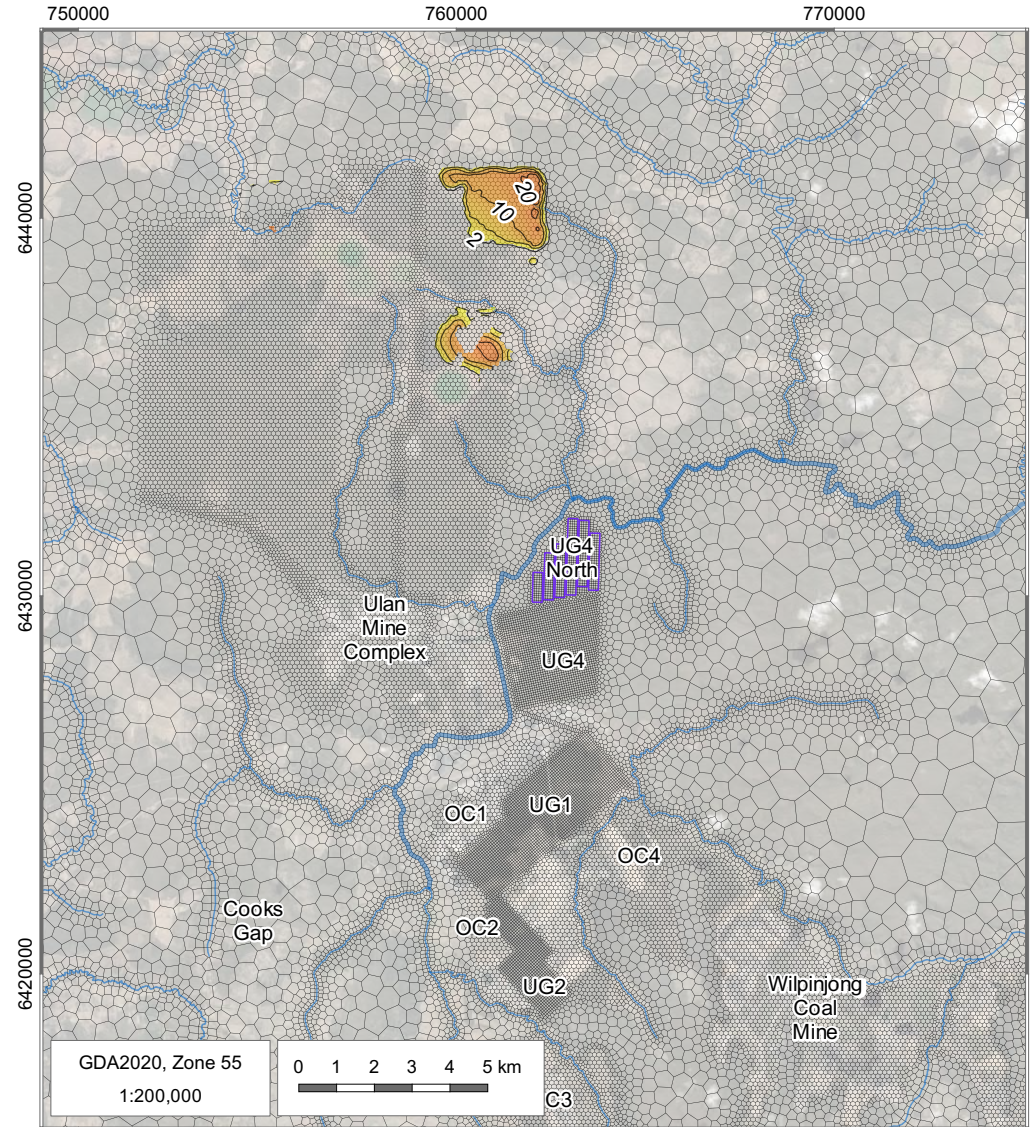
DATE
06/09/2024

FIGURE No:
5.11

UG4 LW409-414 only



Cumulative



LEGEND

- Drawdown contour (m)
 - Minor drainage
 - Goulburn River
 - ▭ UG4 LW409-414
 - ▭ Model mesh
- | Drawdown (m) | |
|--------------|-------|
| ▭ 2 | ▭ 50 |
| ▭ 5 | ▭ 100 |
| ▭ 10 | ▭ 200 |
| ▭ 20 | ▭ 500 |



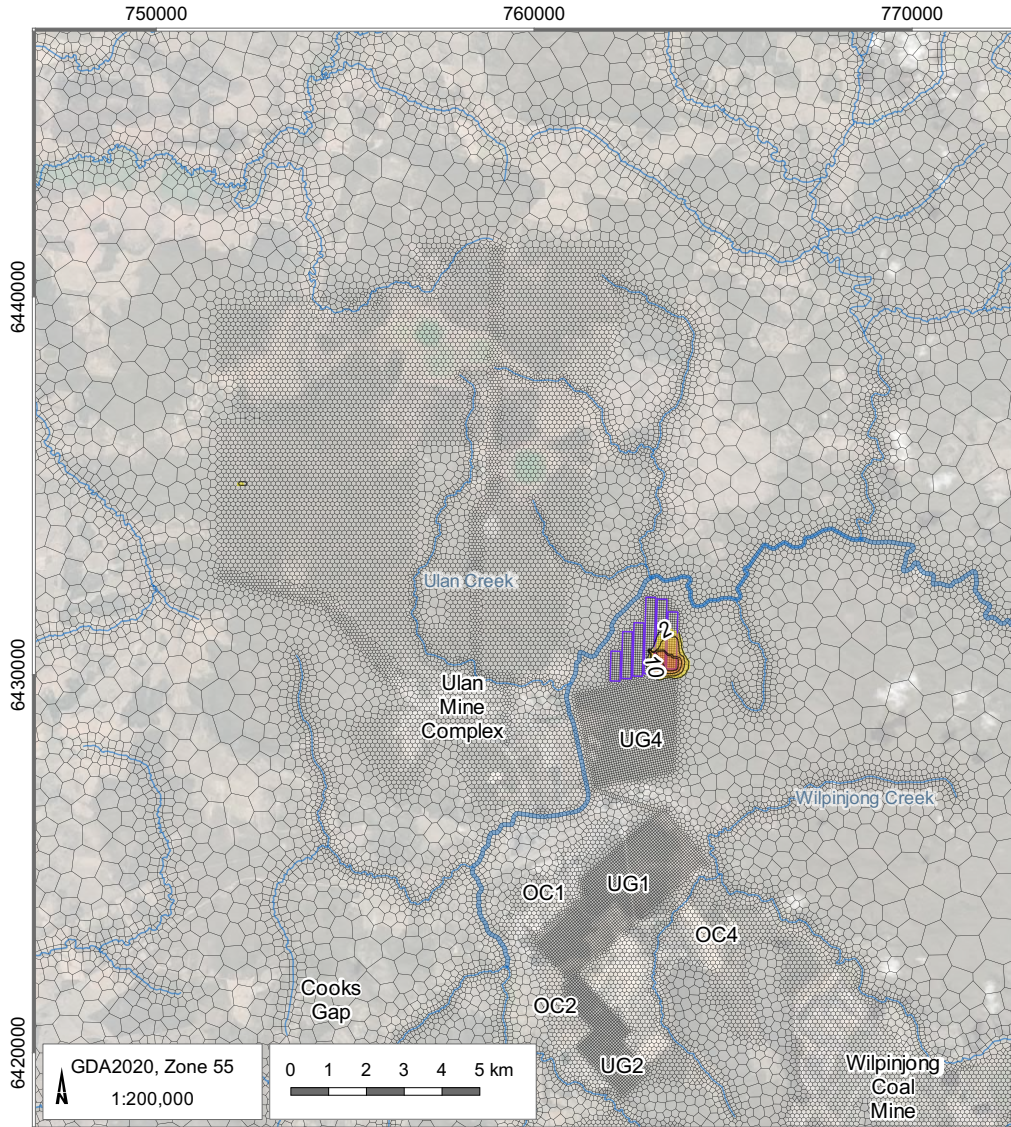
UG4 LW409-414 Extraction Plan Groundwater
Technical Report (MOO5004.001)

**Maximum Predicted Drawdown in
Jurassic Pilliga & Purlewaugh
Formations until End of Mining**

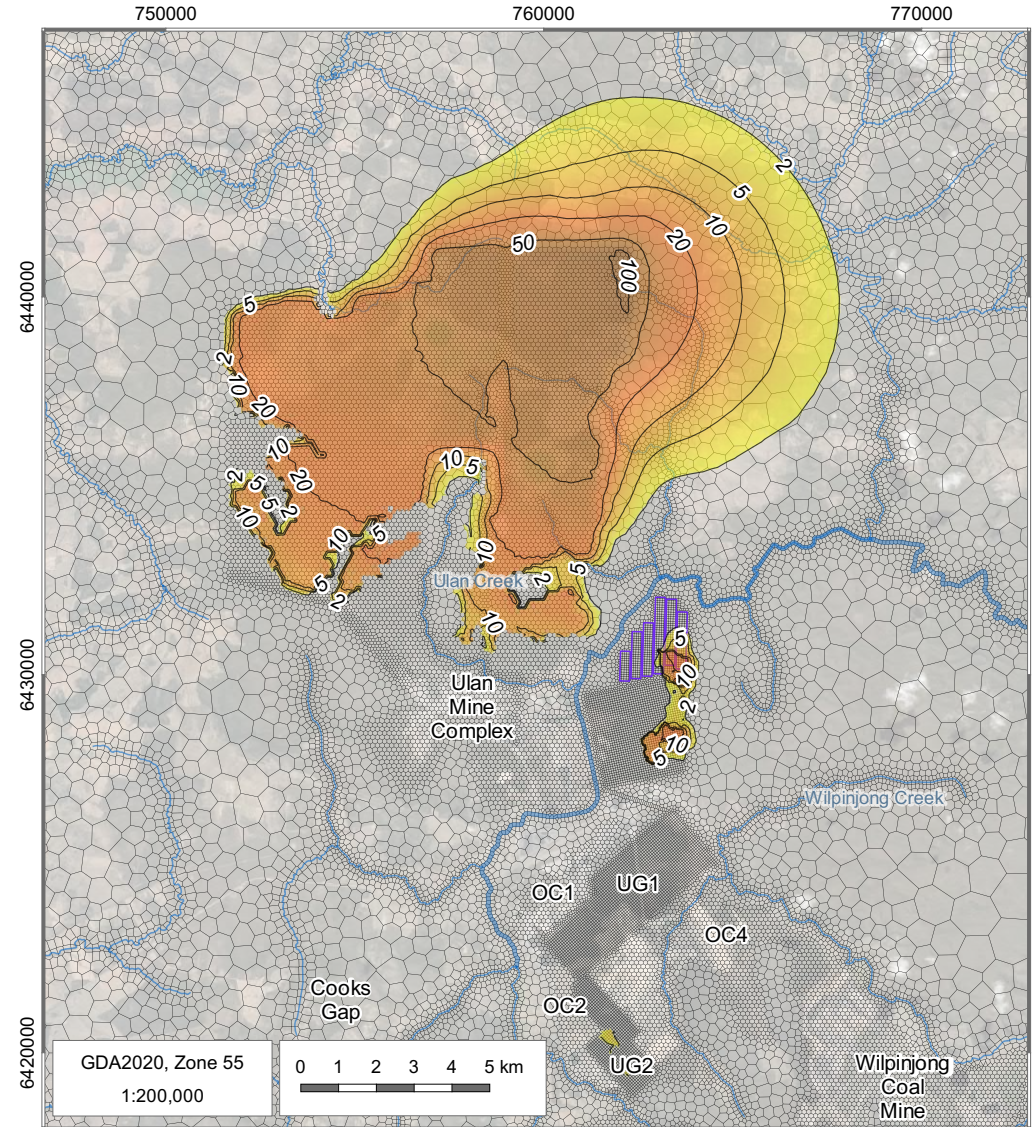
DATE
06/09/2024

FIGURE No:
5.12

UG4 LW409-414 only



Cumulative



LEGEND

- Drawdown contour (m)
 - Minor Drainage
 - Goulburn River
 - ▭ UG4 LW409-414
 - ▭ Model mesh
- | Drawdown (m) | |
|---------------------|-----|
| 2 | 50 |
| 5 | 100 |
| 10 | 200 |
| 20 | 500 |



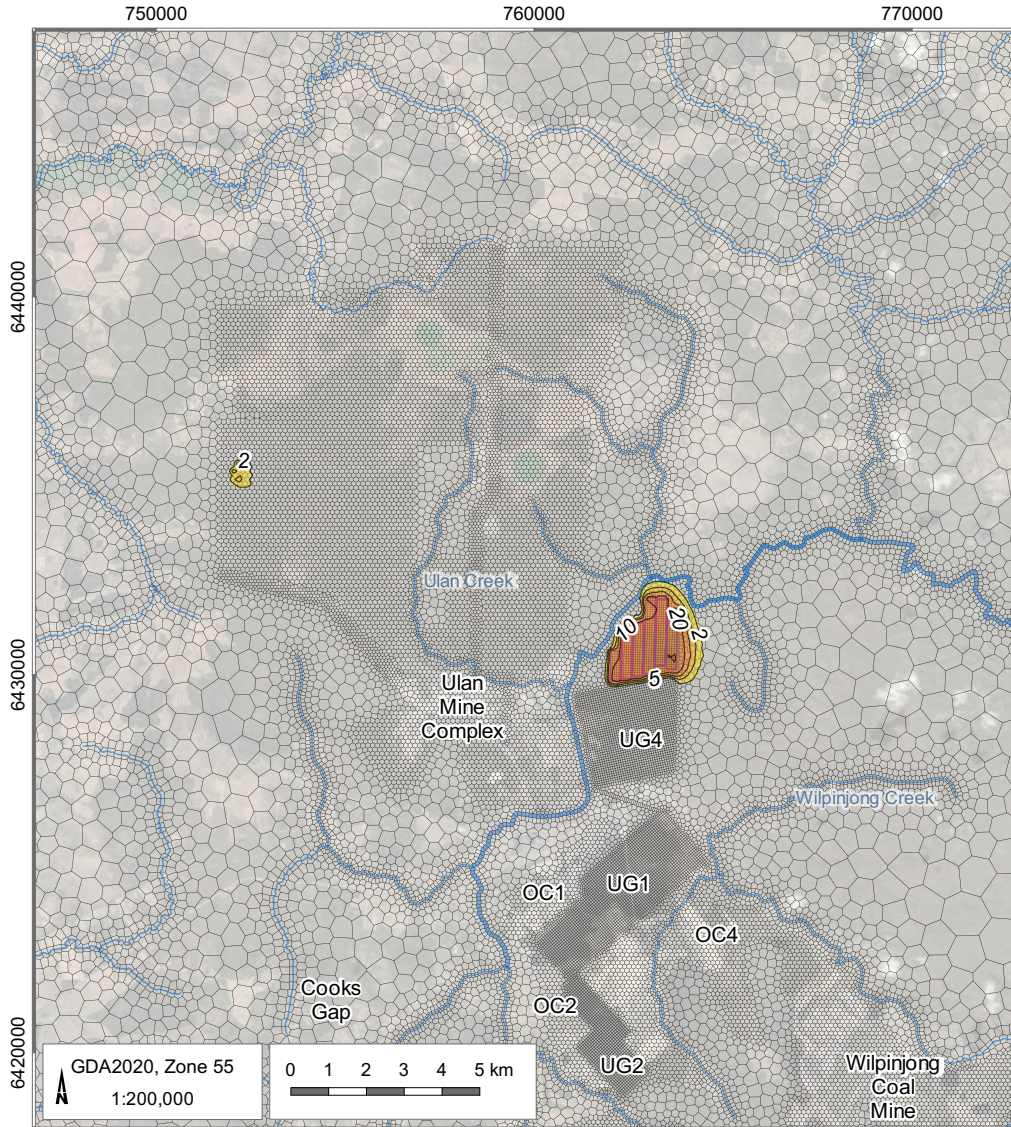
UG4 LW409-414 Extraction Plan Groundwater
Technical Report (MOO5004.001)

**Maximum Predicted Drawdown in
Triassic Sandstone (Quartzose) until
End of Mining**

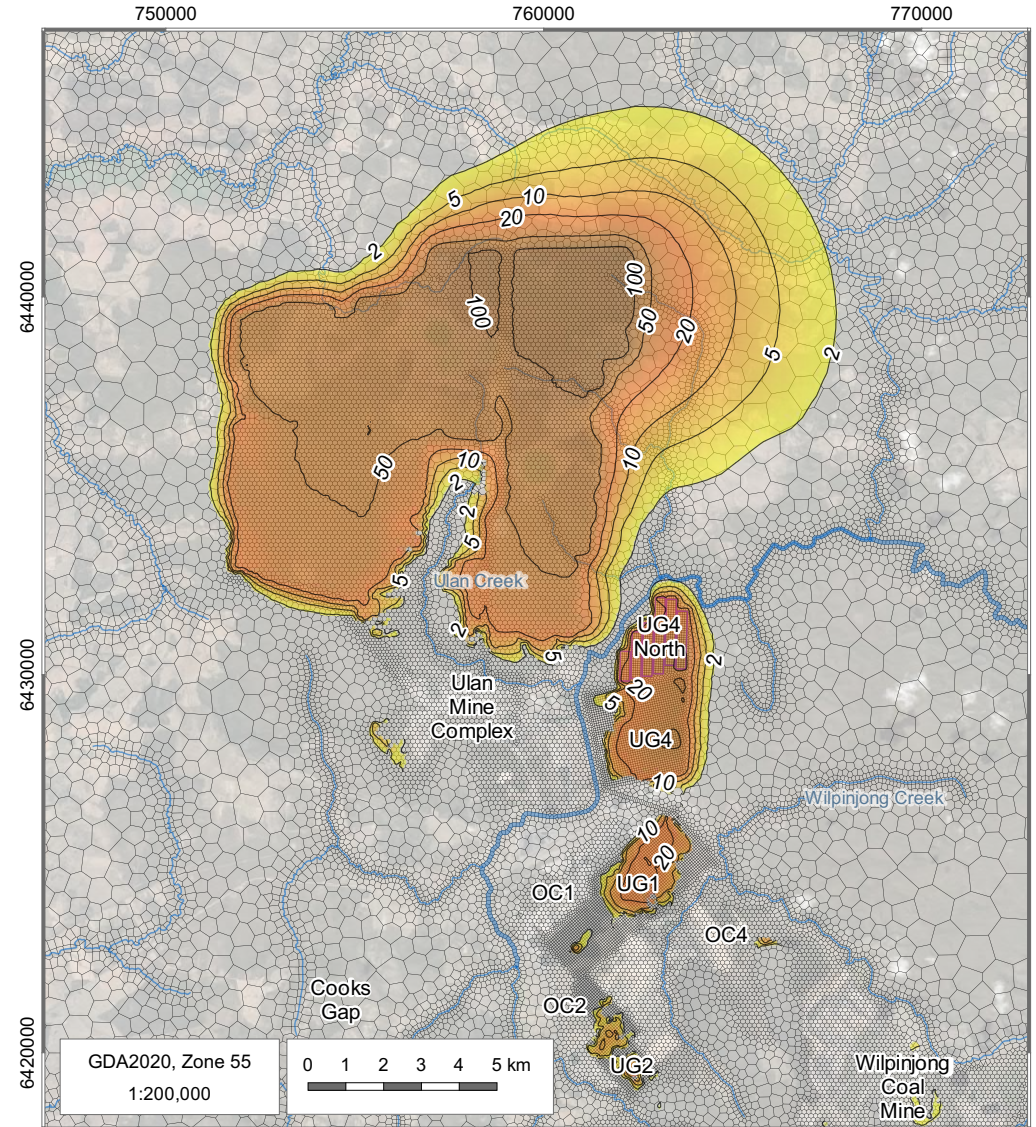
DATE
06/09/2024

FIGURE No:
5.13

UG4 LW409-414 only



Cumulative



LEGEND

- Drawdown contour (m)
 - Minor Drainage
 - Goulburn River
 - UG4 LW409-414
 - Model mesh
- | Drawdown (m) | |
|--------------|-----|
| 2 | 50 |
| 5 | 100 |
| 10 | 200 |
| 20 | 500 |



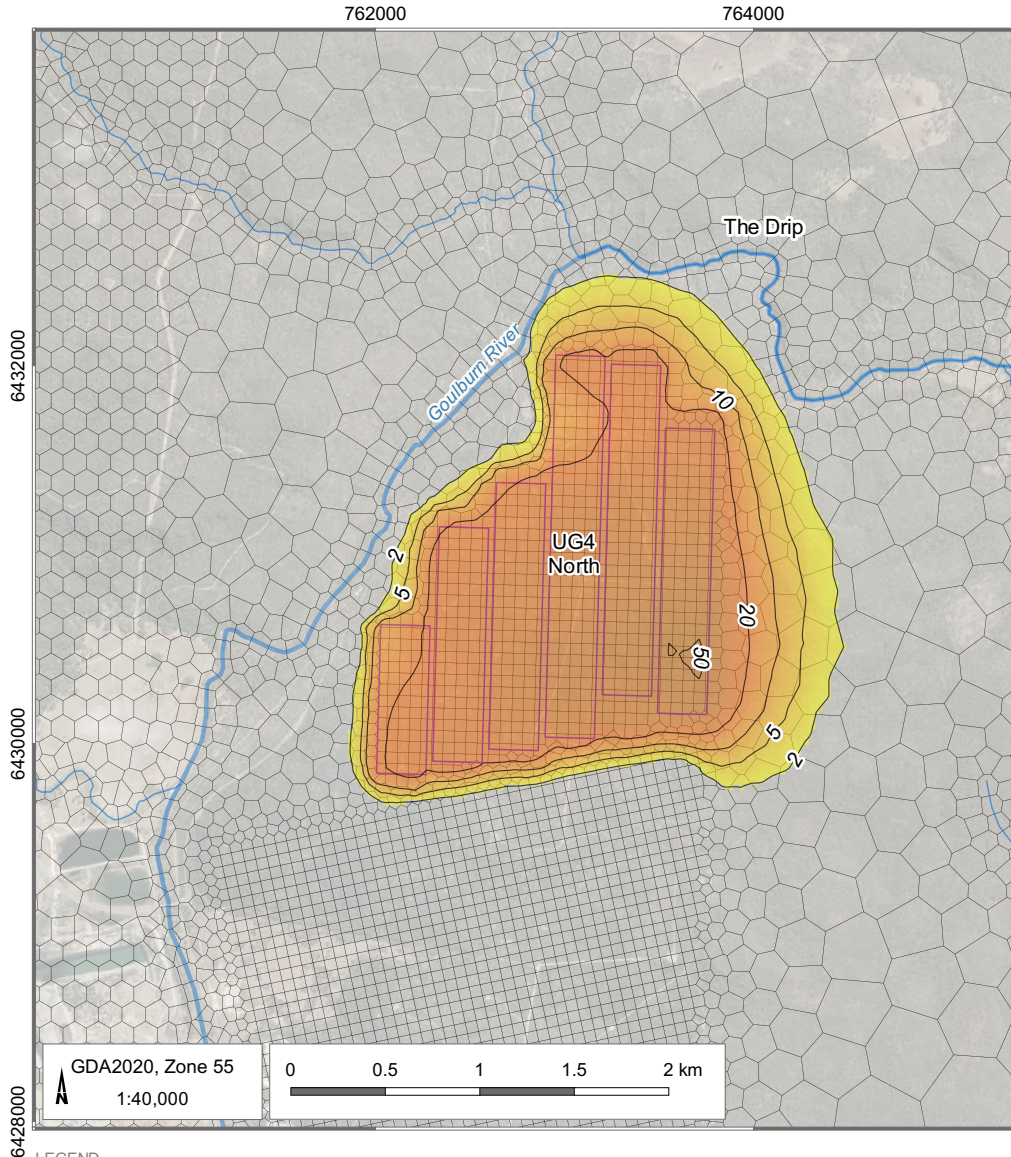
UG4 LW409-414 Extraction Plan Groundwater
Technical Report (MOO5004.001)

**Maximum Predicted Drawdown in
Triassic Sandstone (Lithic) until End of
Mining**

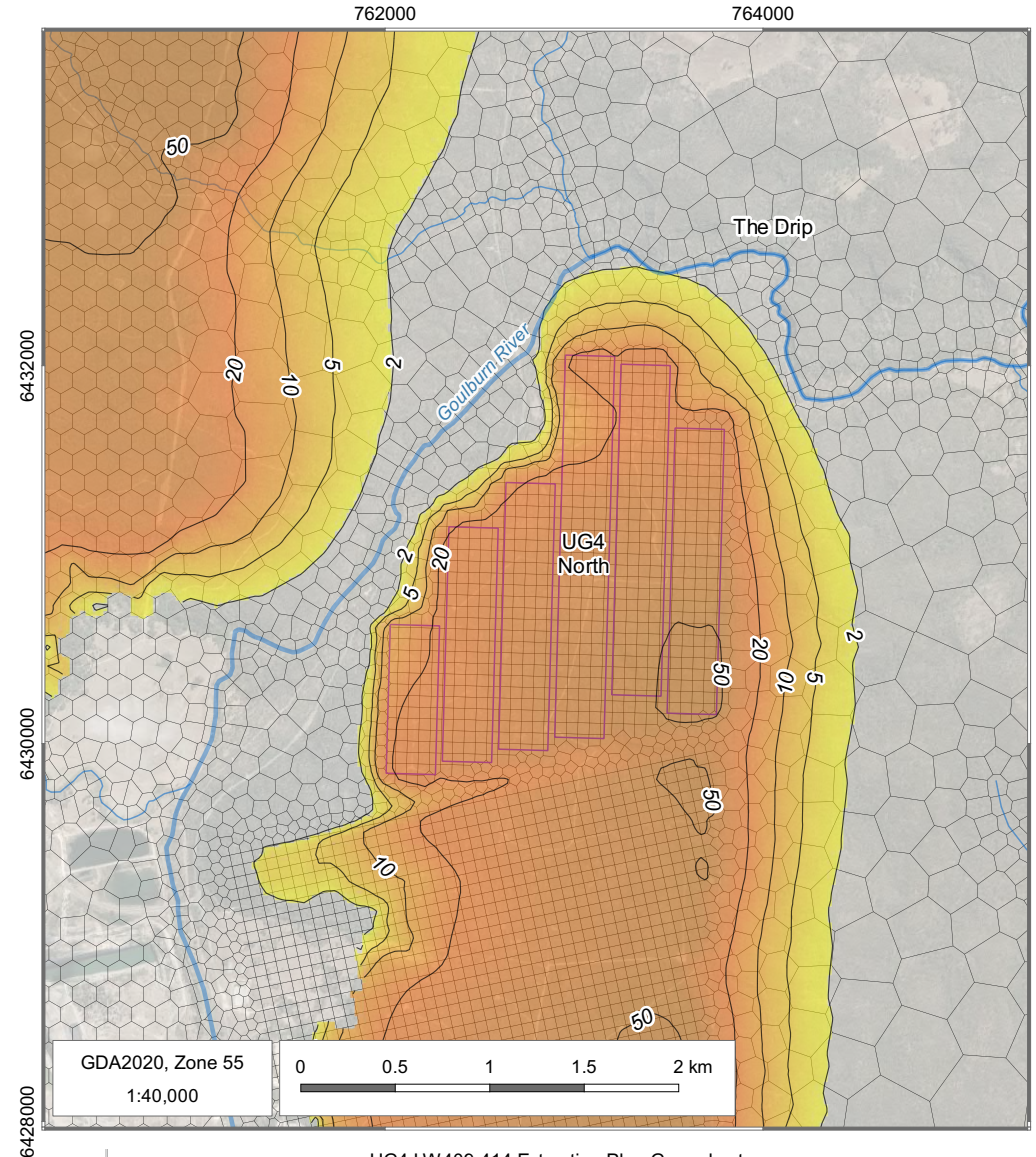
DATE
06/09/2024

FIGURE No:
5.14

UG4 LW409-414 only



Cumulative



LEGEND

- Drawdown contour (m)
 - Minor Drainage
 - Goulburn River
 - ▭ UG4 LW409-414
 - ▭ Model mesh
- | Drawdown (m) | |
|--------------|-----|
| 2 | 50 |
| 5 | 100 |
| 10 | 200 |
| 20 | 500 |



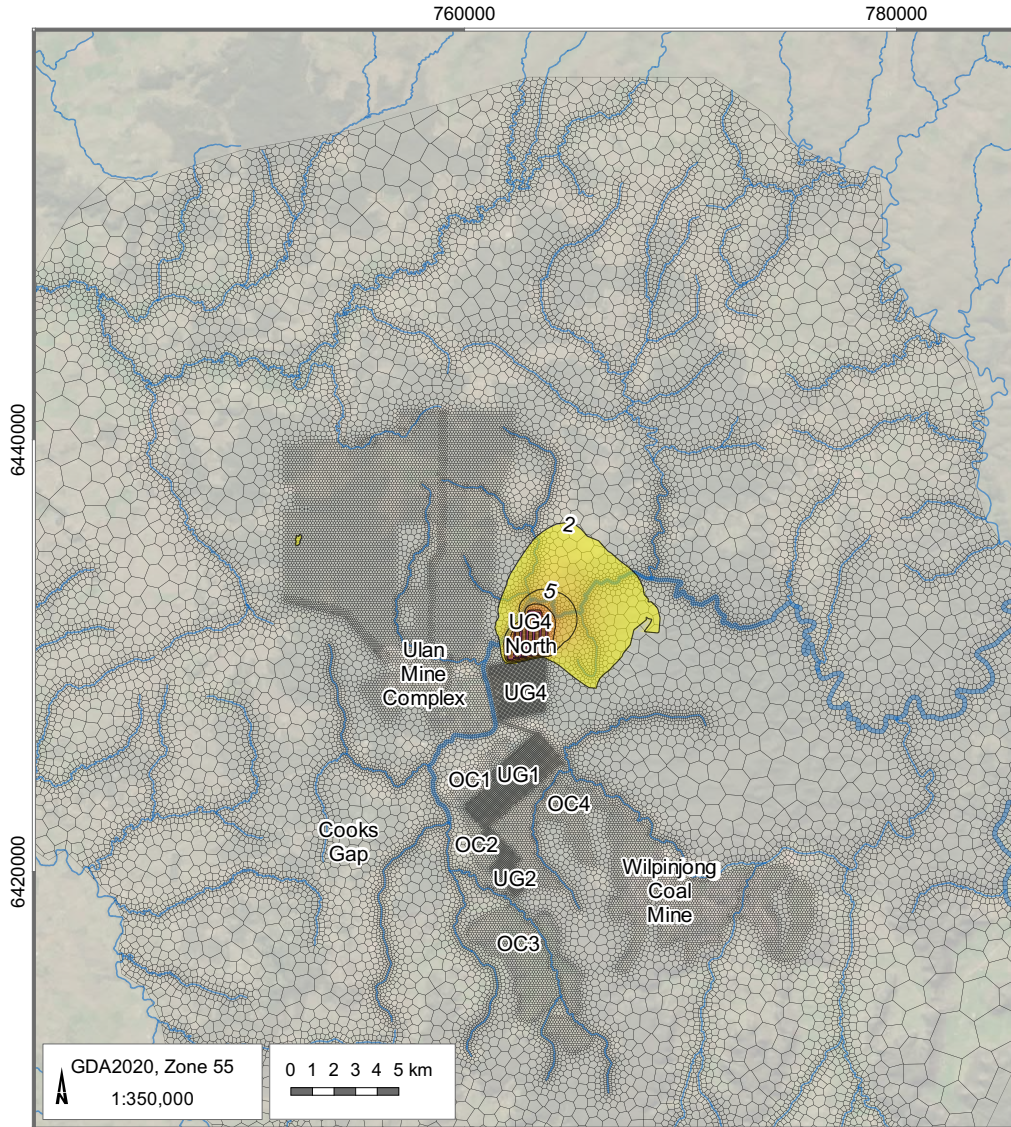
UG4 LW409-414 Extraction Plan Groundwater Technical Report (MOO5004.001)

Maximum Predicted Drawdown in Triassic Sandstone (Lithic) until End of Mining (zoomed)

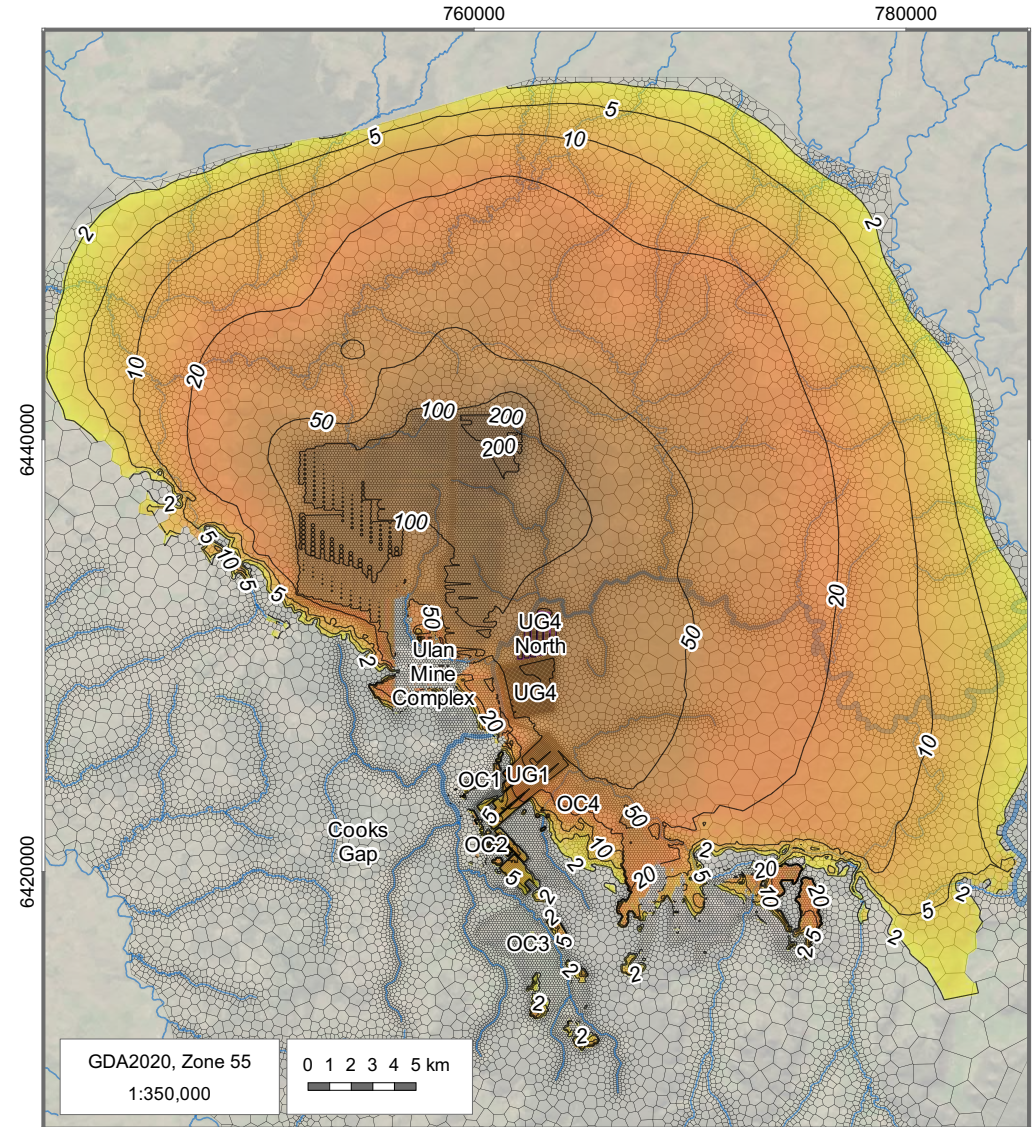
DATE
11/09/2024

FIGURE No:
5.15

UG4 LW409-414 only



Cumulative



LEGEND

- Drawdown contour (m)
 - Minor Drainage
 - Goulburn River
 - ▭ UG4 LW409-414
 - ▭ Model mesh
- | Drawdown (m) | |
|--------------|-----|
| 2 | 50 |
| 5 | 100 |
| 10 | 200 |
| 20 | 500 |



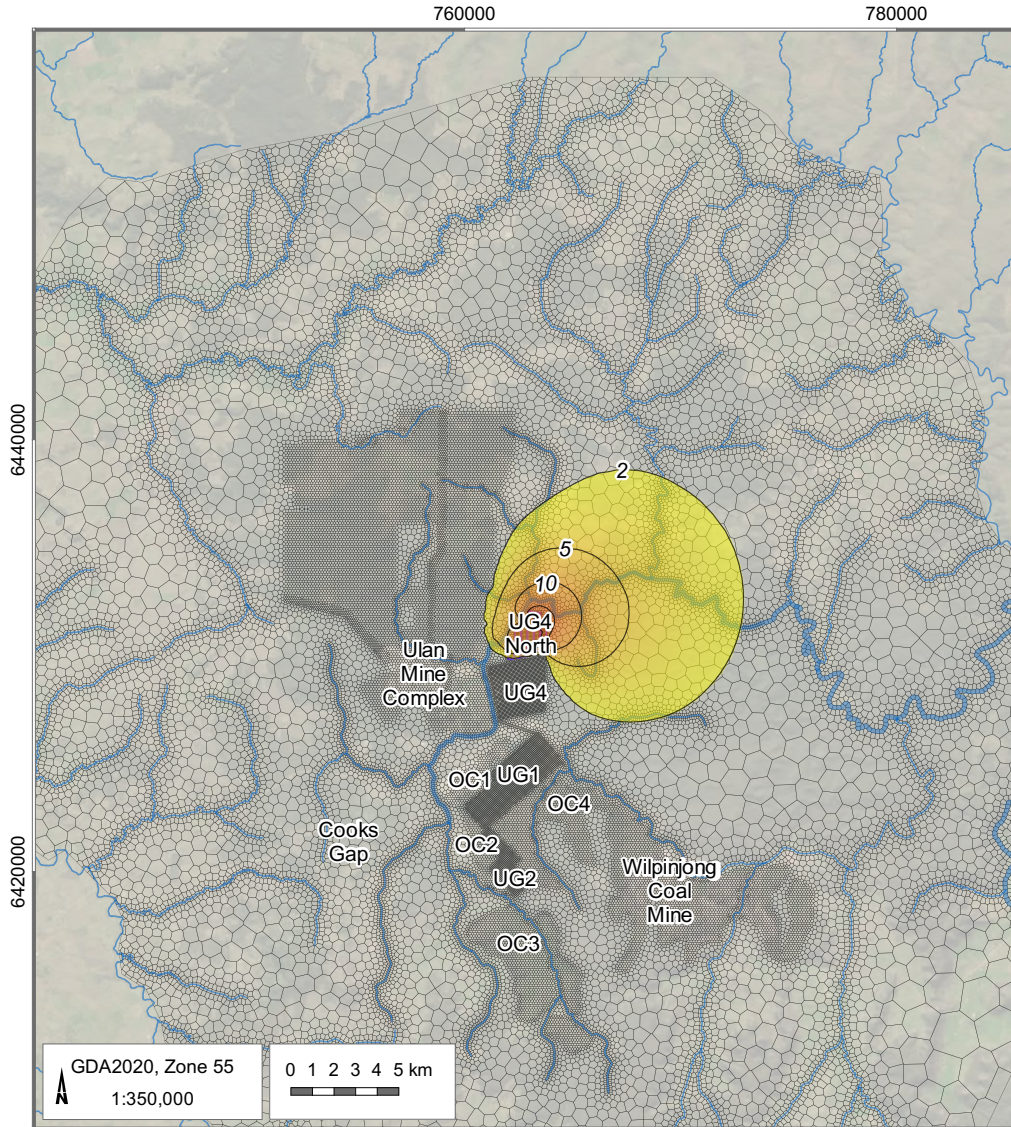
UG4 LW409-414 Extraction Plan Groundwater
Technical Report (MOO5004.001)

**Maximum Predicted Drawdown in Base
of Permian Overburden until End of
Mining**

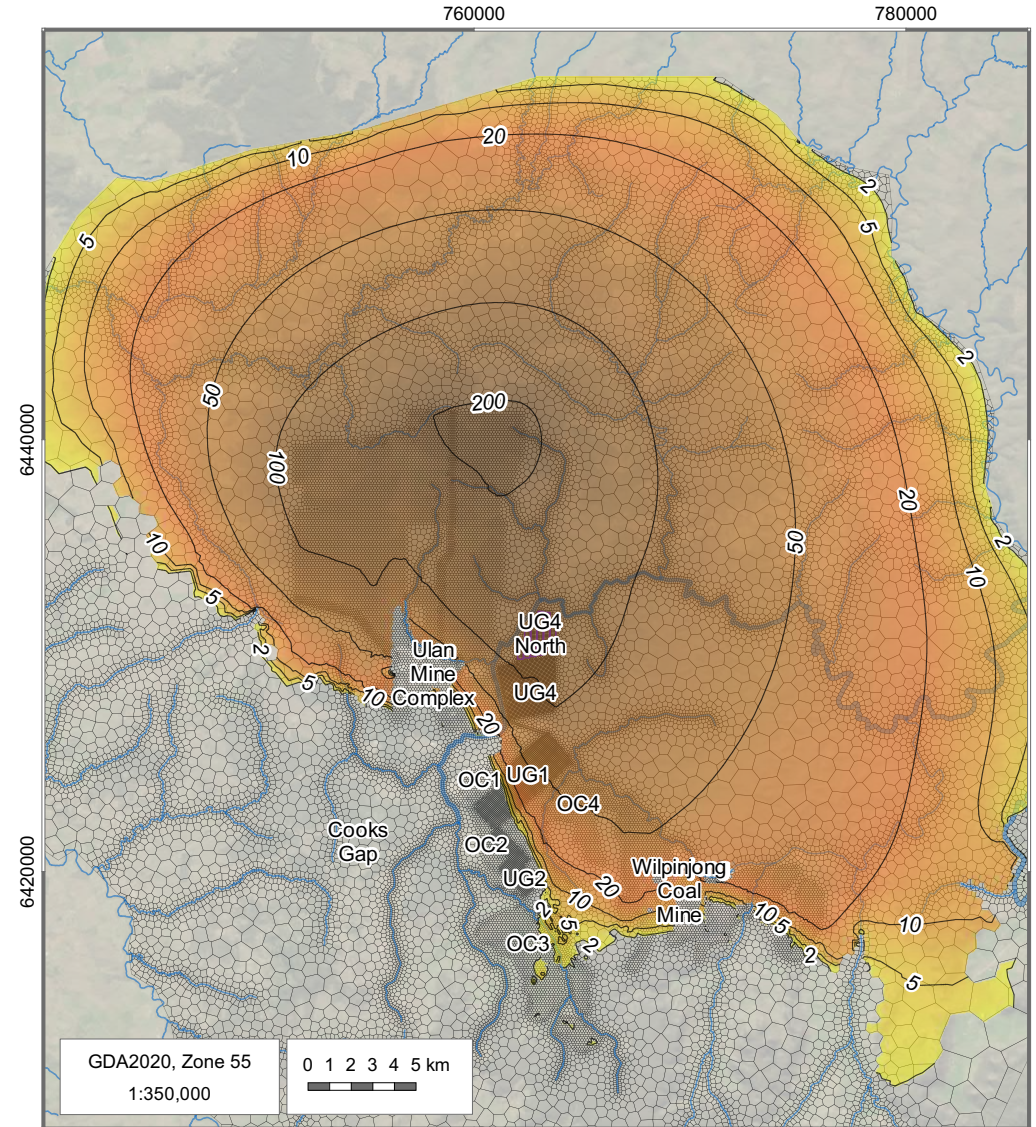
DATE
06/09/2024

FIGURE No:
5.16

UG4 LW409-414 only



Cumulative



LEGEND

- Drawdown contour (m)
 - Minor Drainage
 - Goulburn River
 - UG4 LW409-414
 - Model mesh
- | Drawdown (m) | |
|--------------|-----|
| 2 | 50 |
| 5 | 100 |
| 10 | 200 |
| 20 | 500 |



UG4 LW409-414 Extraction Plan Groundwater
Technical Report (MOO5004.001)

**Maximum Predicted Drawdown in Ulan
Seam WS2 until End of Mining**

DATE
06/09/2024

FIGURE No:
5.17

The component of drawdown attributable to UG4 North only is generally limited west of UG4 North due to the north-eastward dip of Permian and Triassic strata and the subcrop of the Ulan Seam south-west of UG4. As a result, the contribution of groundwater drawdown from UG4 North to cumulative drawdown outside of the UG4 North footprint from the approved MCC and surrounding mines is limited for most hydrostratigraphic units.

Groundwater drawdown within the Permian ICM due to UG4 North is predicted to generate localised cumulative impacts. The drawdown predictions show the extent of the 2 m drawdown contour within the Permian strata extends up to 5.5 km from UG4 North, while regionally cumulative drawdown of greater than 50 m is not uncommon.

The maps illustrate that drawdown will propagate more extensively within the Ulan Seam than other hydrostratigraphic units because the coal seams form a confined aquifer that responds rapidly to pressure loss and is subject to greater drawdown at the coal face compared to shallower hydrostratigraphic units.

The model predicts negligible groundwater drawdown of the unconfined water table in the vicinity of the Goulburn River resulting from the mining of UG4 North. The predicted water take from Goulburn River is discussed in Section 5.4.4.

5.4.2 Private bores

The closest privately owned bore to UG4 North is License 80BL236762, which is approximately 1.5 km to the east of LW414 (Figure 4.5). The cumulative groundwater drawdown predicted at this bore whilst mining UG4 North is limited (i.e. $\approx 0.3\text{m}$).

5.4.3 Inflows

Predicted groundwater inflows for mining activities are presented for the MCC (including UG4 North), and for UG4 North separately in Table 5.10. Predicted groundwater inflows to UG4 North are shown graphically in Figure 5.18.

Table 5.10 Predicted groundwater inflows to mining areas

Water Year	MCC (ML)	UG4 North (ML)
2025/26	3,025	828
2026/27	3,466	2,371
2027/28	3,580	2,142

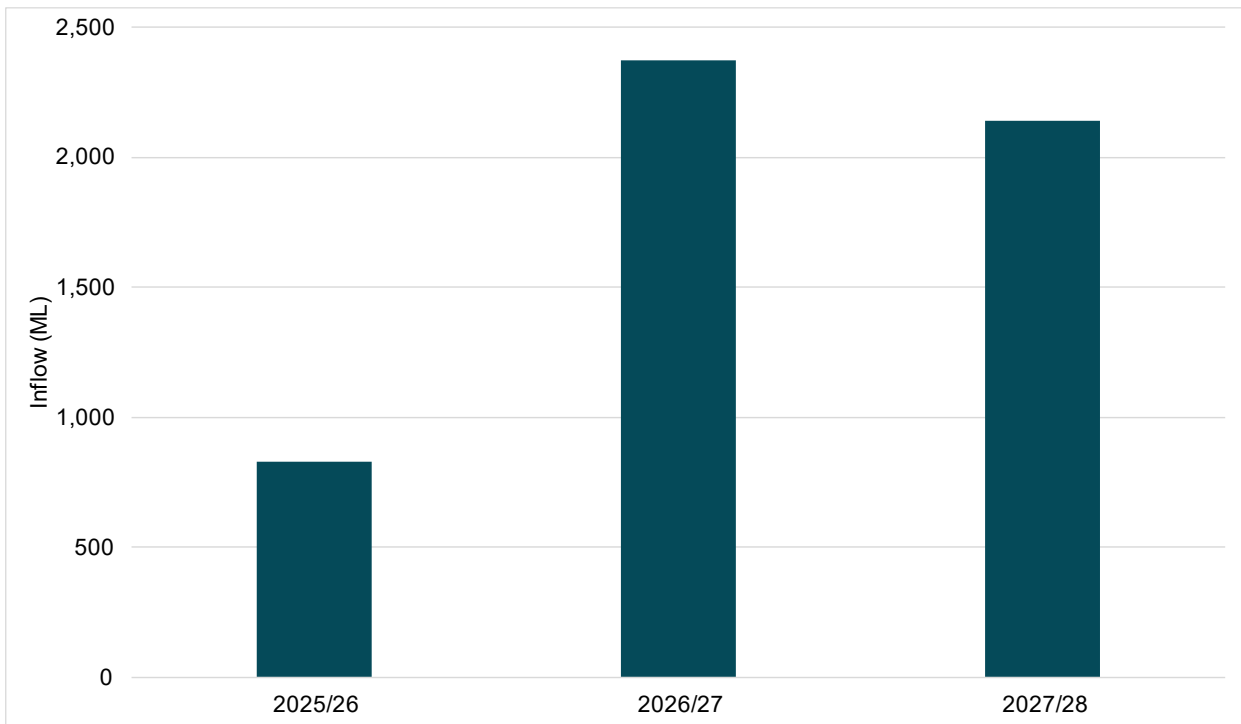


Figure 5.18 Groundwater Inflows UG4 North

The maximum predicted annual inflow volume to UG4 North is 2,371 megalitres and is predicted to occur in the 2026/27 water year.

5.4.4 Interception of baseflow

Underground mining and associated mine induced dewatering and fracturing will lower the water table in and around the mine, altering hydraulic gradients in the groundwater regime. This variation could temporarily divert water that might have historically migrated to surface drainages and become baseflow.

The numerical model represents baseflow within the Goulburn River with a positive stage height in the model. In this circumstance when and where the water table simulated in the model is lower than the river water level the river will act as a losing stream and baseflow will seep into the underlying aquifer. If the water table is lowered further beneath a losing stream due to mining, then any resultant increase to the seepage rate will also contribute to the total net baseflow take.

Predicted baseflow changes were extracted from the approved mining and 'no UG4 North' simulations to determine the change in baseflow due to mining of UG4 North. The results from this simulation and the baseflow changes are summarised below in Table 5.11.

Table 5.11 shows that the predicted changes to baseflow are limited, and in reality, below the accuracy of the model to predict. These small predicted changes would be undetectable in the Goulburn River in reality.

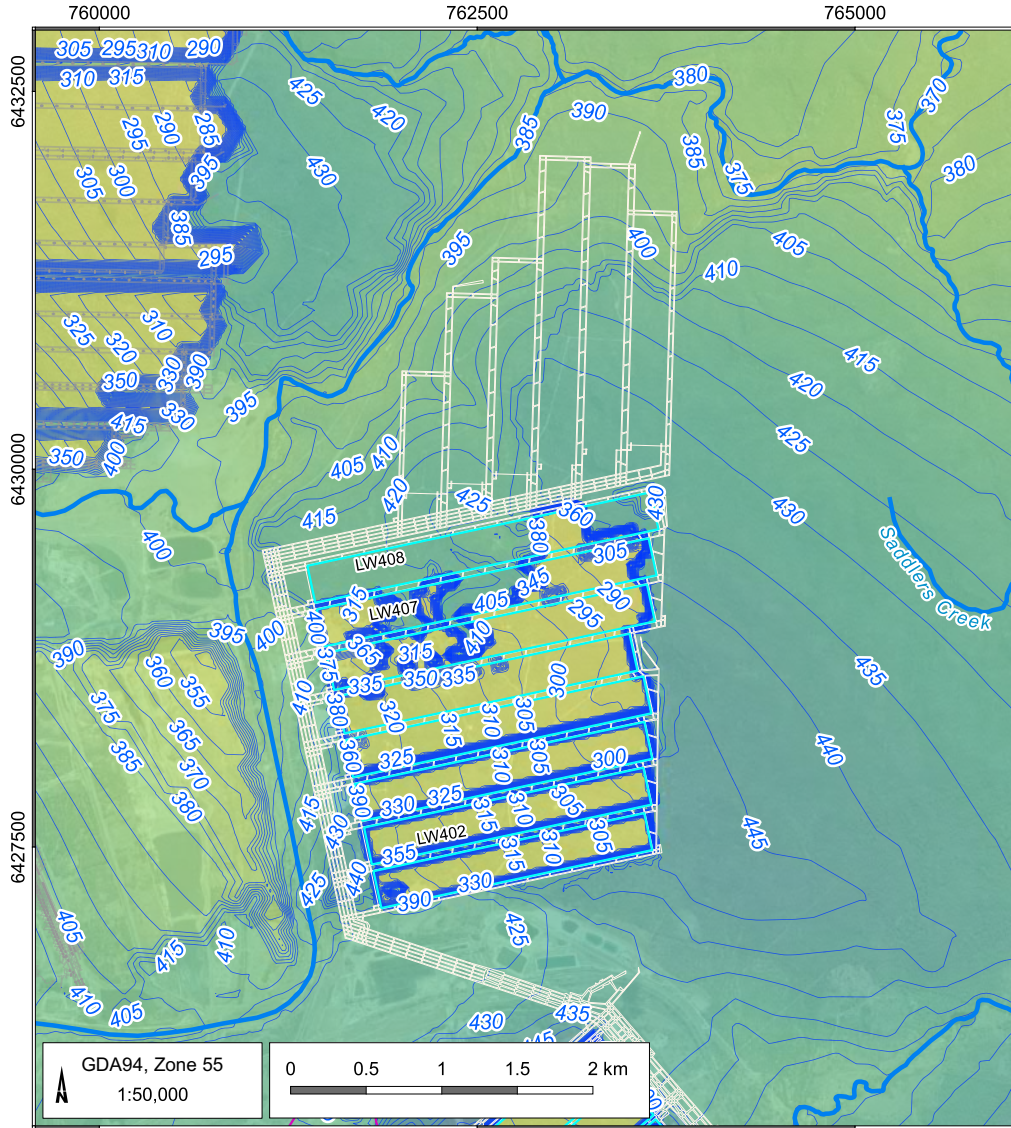
Table 5.11 Predicted baseflow reduction due to mining of UG4 North

Water year	Net baseflow take in Upper Goulburn River water source (ML)
2025/26	0
2026/27	0.4
2027/28	0.2
2028/29	0.8
2029/30	0.1
2030/31	0.1
2031/32	0.3
2032/33	0.4
2033/34	0.5
2034/35	0.5
2035/36	0.5
2036/37	0.3

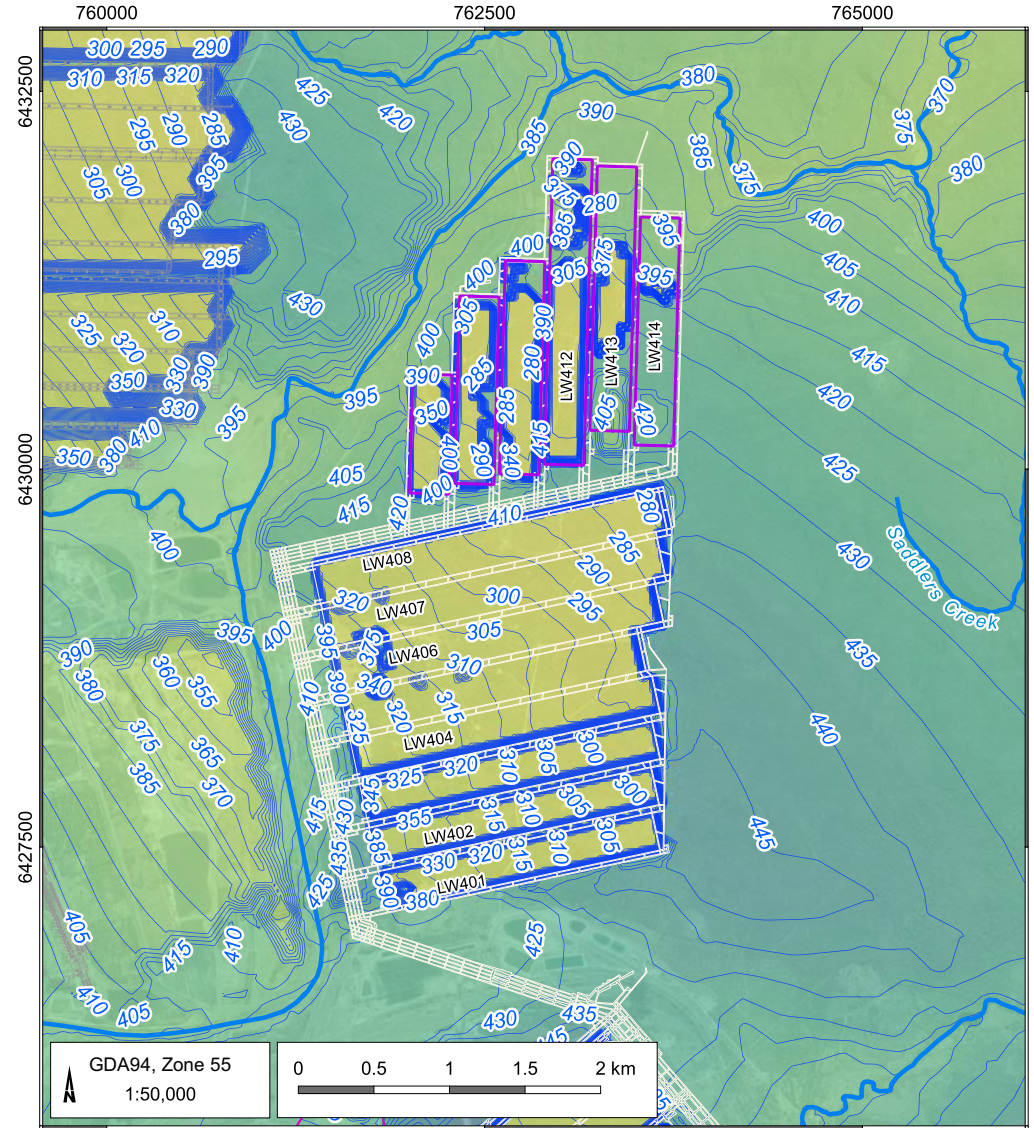
Figure 5.19 displays on the left hand-side the predicted water table prior to the commencement of UG4 North (December 2025), while on the right hand-side the water table one month after the end of the UG4 North mining (February 2028). This comparison highlights that UG4 North mining produces a steep water table gradient close to the mine footprint, while moving toward the Goulburn River its impact on the water table is negligible/absent. As a result, the Goulburn River is not predicted to change from a gaining stream to a losing streaming from the UG4 North mining during the active mining period.

This is consistent/reflective of the predicted drawdown in Figure 5.14, which shows drawdown in the Triassic is not predicted to extend significantly beyond the mine footprint. This prediction is also supported by observations to date.

Predicted Water Table at the Beginning of LW409-414



Predicted Water Table at the End of LW409-414



LEGEND

- UG Mine plan
- Drainage
- Contour line
- Mine Extent (End of LW408)
- Mine Extent (End of LW414)
- Approximate Extent of OC Mining 2023

Water table (mAHD)

- | | | | |
|--|-----|--|-----|
| | 214 | | 480 |
| | 345 | | 510 |
| | 390 | | 560 |
| | 430 | | 741 |
| | 450 | | |



Groundwater Assessment for Moolarben UG4
Compliance Conditions (MOO5001.001)

**Predicted Water Table at the Beginning
and at the End of LW409-414**

DATE
11/09/2024

FIGURE No:
5.19

Table 5.12 provides the annual predicted baseflow to the Goulburn River 'reach' as illustrated in Figure 5.21 for both the Approved Mining and No UG4 North scenarios. Figure 5.20 displays the predicted baseflow in the Goulburn River reach and illustrates that UG4 North is not expected to have a significant impact on baseflows to the Goulburn River over and above cumulative impacts.

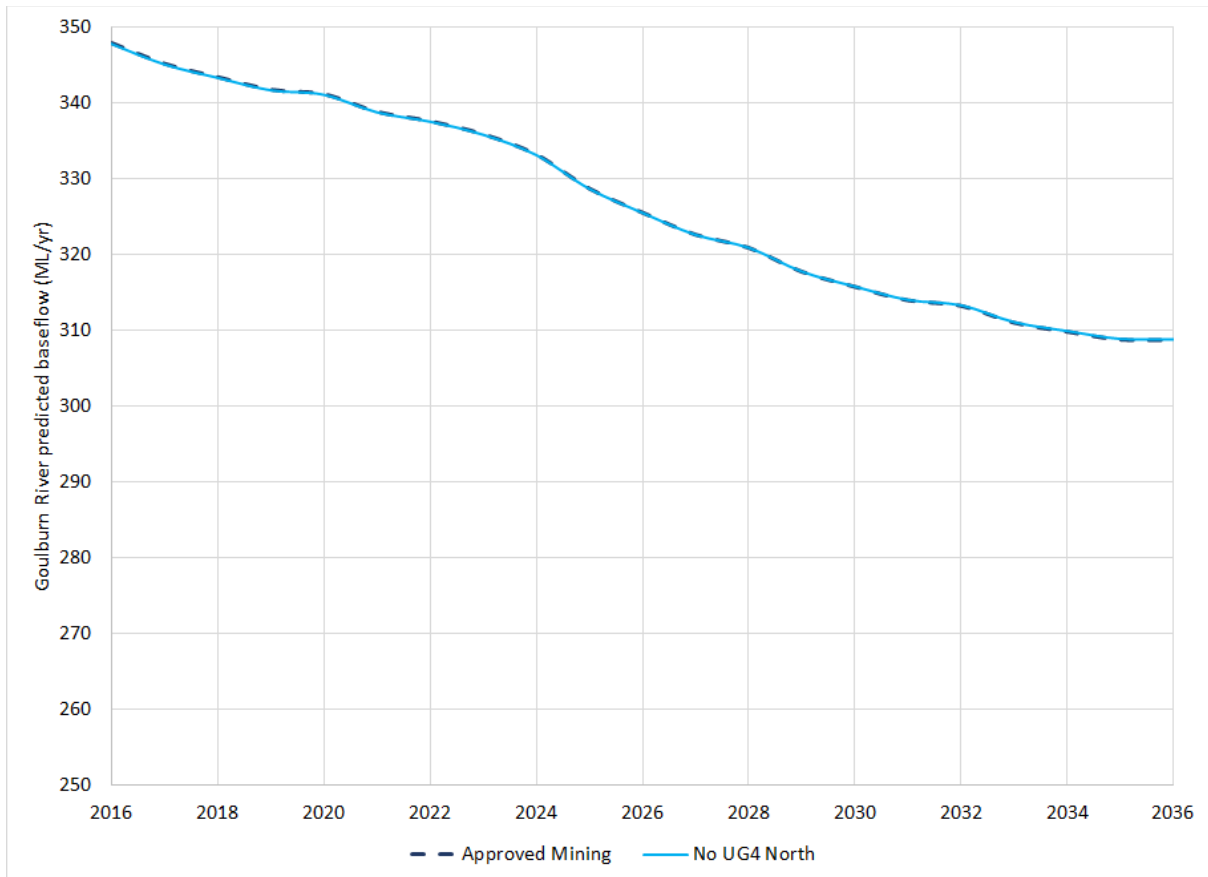


Figure 5.20 Goulburn River annual predicted baseflow

Table 5.12 Goulburn River annual predicted baseflow and predicted baseflow loss

Water year	Goulburn River baseflow (Approved Mining scenario) (ML)	Goulburn River baseflow (No UG4 North scenario) (ML)	Baseflow loss attributable to UG4 North (ML)
2025/26	325.5	325.5	0.0
2026/27	322.6	322.6	0.0
2027/28	320.9	320.9	0.0
2028/29	317.7	317.8	0.1
2029/30	315.8	315.8	0.0
2030/31	314.0	314.0	0.0
2031/32	313.3	313.3	0.0
2032/33	311.0	311.1	0.1
2033/34	309.9	309.9	0.0
2034/35	308.8	308.9	0.1
2035/36	308.8	308.8	0.0
2036/37	154.9	155.0	0.1

Figure 5.21 presents the baseflow loss to all river cells hosted within the Goulburn River Water Source, whereas Table 5.12 presents the baseflow loss to the specific reach of Goulburn River as shown in Figure 5.21. As such, predictions in Table 5.12 may include sections of the Goulburn River which are hosted by the Sydney Basin-North Coast Groundwater Source.

Groundwater modelling indicates that mining at UG4 LW409-414 would result in a negligible impact on the Goulburn River, which complies with the subsidence performance measure “Negligible impact or environmental consequences” associated with the Goulburn River and the bed of the Goulburn River (Condition 73, Schedule 3 of Project Approval (05_0117)).

760000

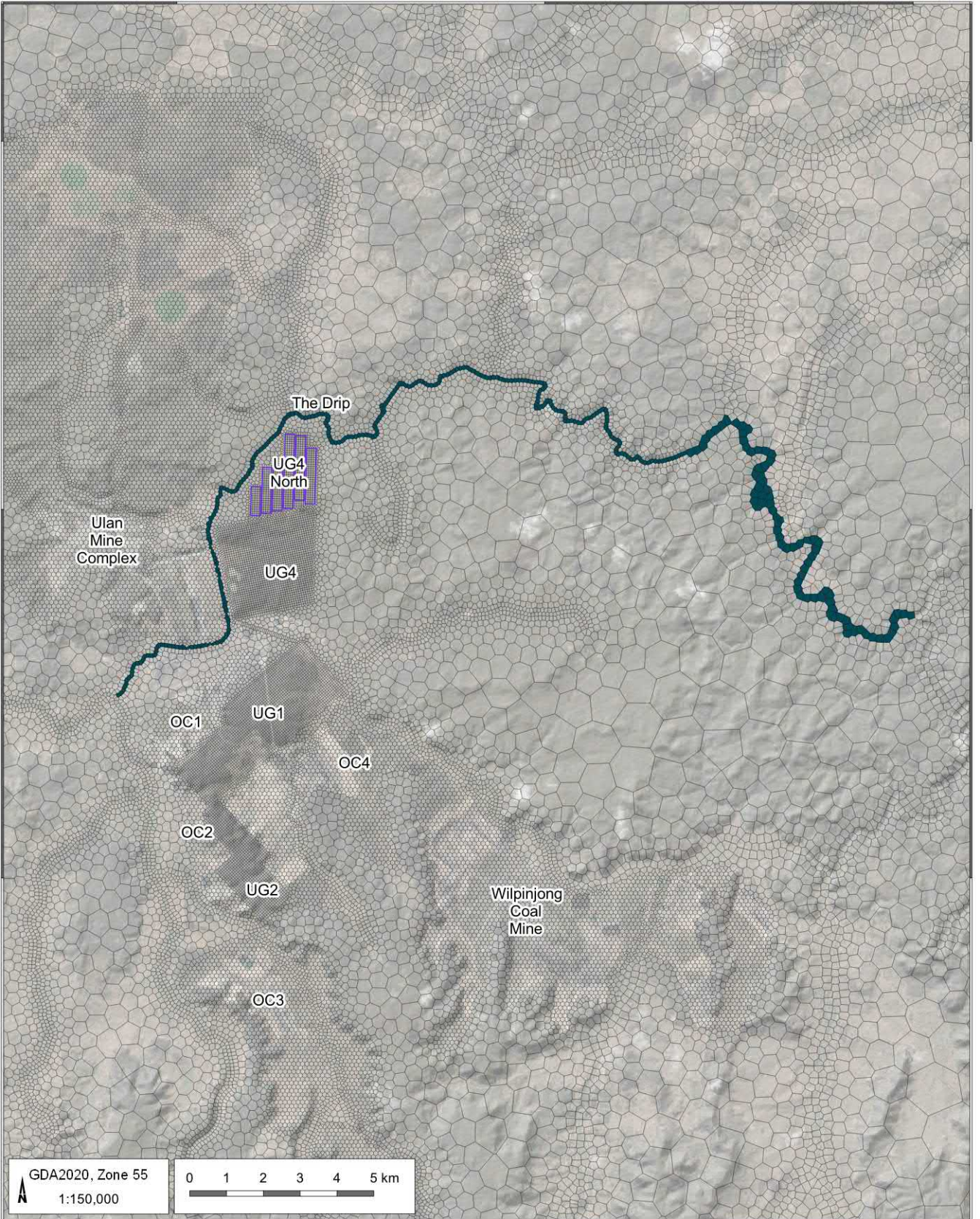
770000

780000




6440000

6430000

6420000



LEGEND

-  Goulburn River model cell
-  Model mesh
-  UG4 LW409-414

UG4 LW409-414 Extraction Plan Groundwater Technical Report (MOO5004.001)

Goulburn River Model Cells



DATE
06/09/2024

FIGURE No:
5.21

5.5 Assessment of Performance Measures associated with The Drip

Based on its elevation in relation to the regional water table, The Drip is conceptualised as a spring fed by shallow groundwater that is perched above the regional groundwater system on a relatively impermeable layer of lithic Triassic sandstone that prevents water from percolating vertically. It is therefore considered likely to be hydraulically isolated from the regional groundwater system that is impacted by mining.

In their advice on the Moolarben OC3 Extension Project, the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (2023) stated The Drip:

“is fed by a local shallow aquifer within the Triassic Sandstone on the far side of the Goulburn River (see recent work in ACARP 2022). Environmental tracers undertaken indicate The Drip seepage is distinctive from deeper aquifers, is a localised flow and is probably a perched aquifer.”

To conservatively assess potential impacts at The Drip, this feature was represented within the numerical model using the MODFLOW river package, with a stage elevation equal to the seepage surface elevation at the cliff face (i.e. 387.5 mAHD). The groundwater model therefore represents The Drip as connected to the regional water table rather than being a perched water system. The predictions of impacts at The Drip determined by the model are therefore conservative.

Figure 5.22 shows a Section line through the model from The Drip to UG North where model predictions were extracted to illustrate the predicted impacts on The Drip, assuming it is connected to the regional water table.

Figure 5.23 shows the predicted pore pressure at the end of UG4 North along the vertical section from the model. Figure 5.24 shows the predicted water table surface along the same section line for model scenarios that include and exclude UG4 North.

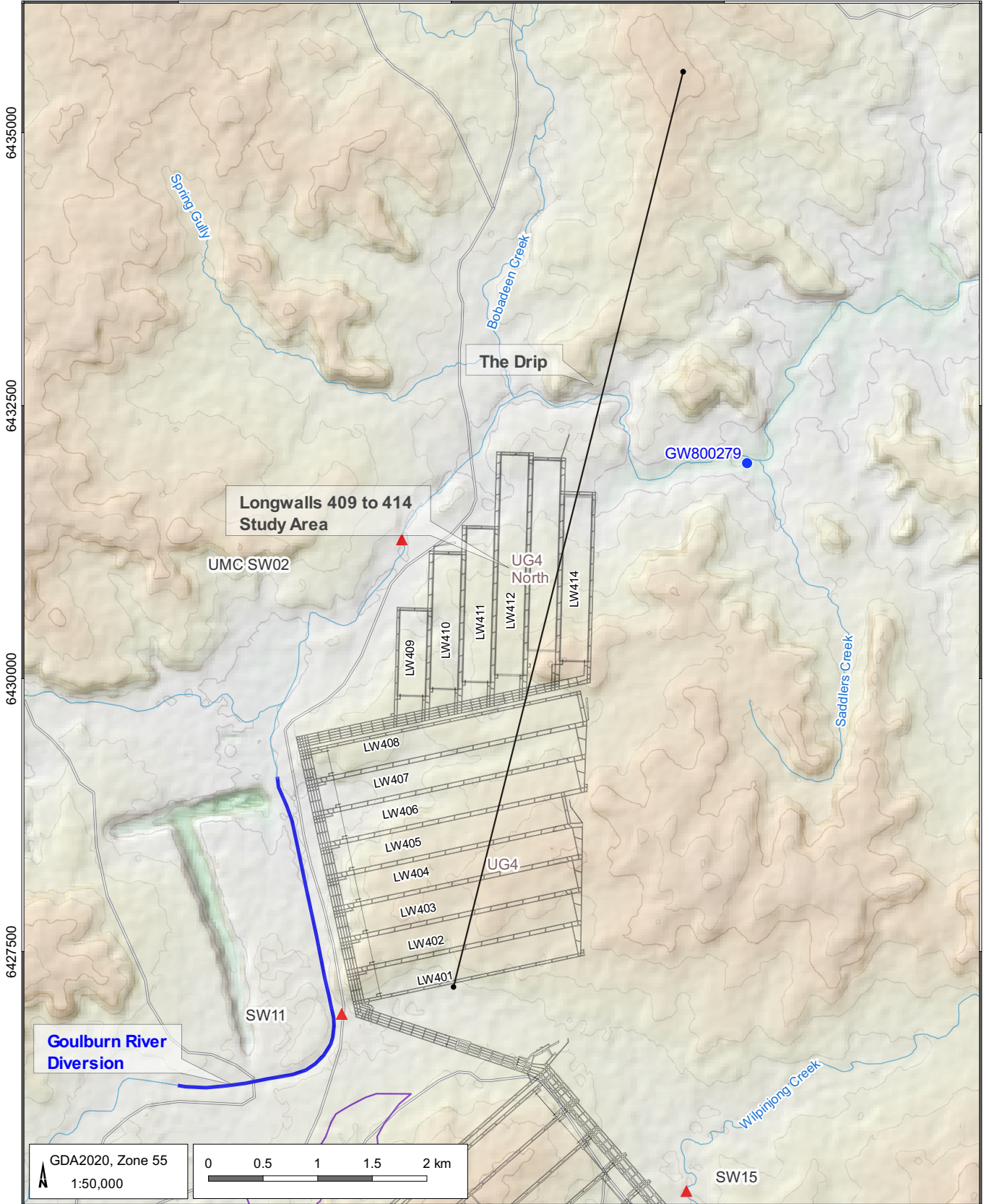
Figure 5.23 highlights that the area where the pore pressure is reduced to zero occur where mining is represented within the numerical model through active coal seam dewatering and induced drainage of the fracture network. The height of fracturing above UG4 (LW401-408 and LW409-414) is predicted to intercept the water table, as shown in Figure 4.10 and Figure 4.11, causing almost the complete dewatering of the overlying rock mass. The depressurisation propagates along the coal seam, although it is dampened by the dip of the Ulan Seam towards the northeast, which results in hydraulic conductivity reducing. The depressurisation within the overburden strata is less extensive as propagation of drawdown is retarded by the lower permeability overburden strata. As a result, the UG4 North mining is not predicted to cause any measurable impact on the water table in the Goulburn River area where The Drip is located, as shown in Figure 5.24. Figure 5.24 illustrates the predicted phreatic surface contours of two different scenarios, the model scenarios that include UG4 North perfectly overlap in The Drip area.

Groundwater modelling indicates even if The Drip has connectivity with the regional water table, mining at UG4 LW409-414 would not impact the shallow groundwater levels in this area, which results in a compliance with the subsidence performance measure “*Nil impact on the water supply to The Drip*” associated with The Drip (Condition 73, Schedule 3 of Project Approval (05_0117)).

76000

76250

76500



GDA2020, Zone 55
1:50,000



LEGEND

- Populated place
- ▲ Flow gauging stations
- Private bore
- Drainage
- Road
- UG Mine Plan
- Approved OC Extent
- Pore pressure cross section location

Elevation (mAHD)

- 300
- 400
- 500
- 600
- 700

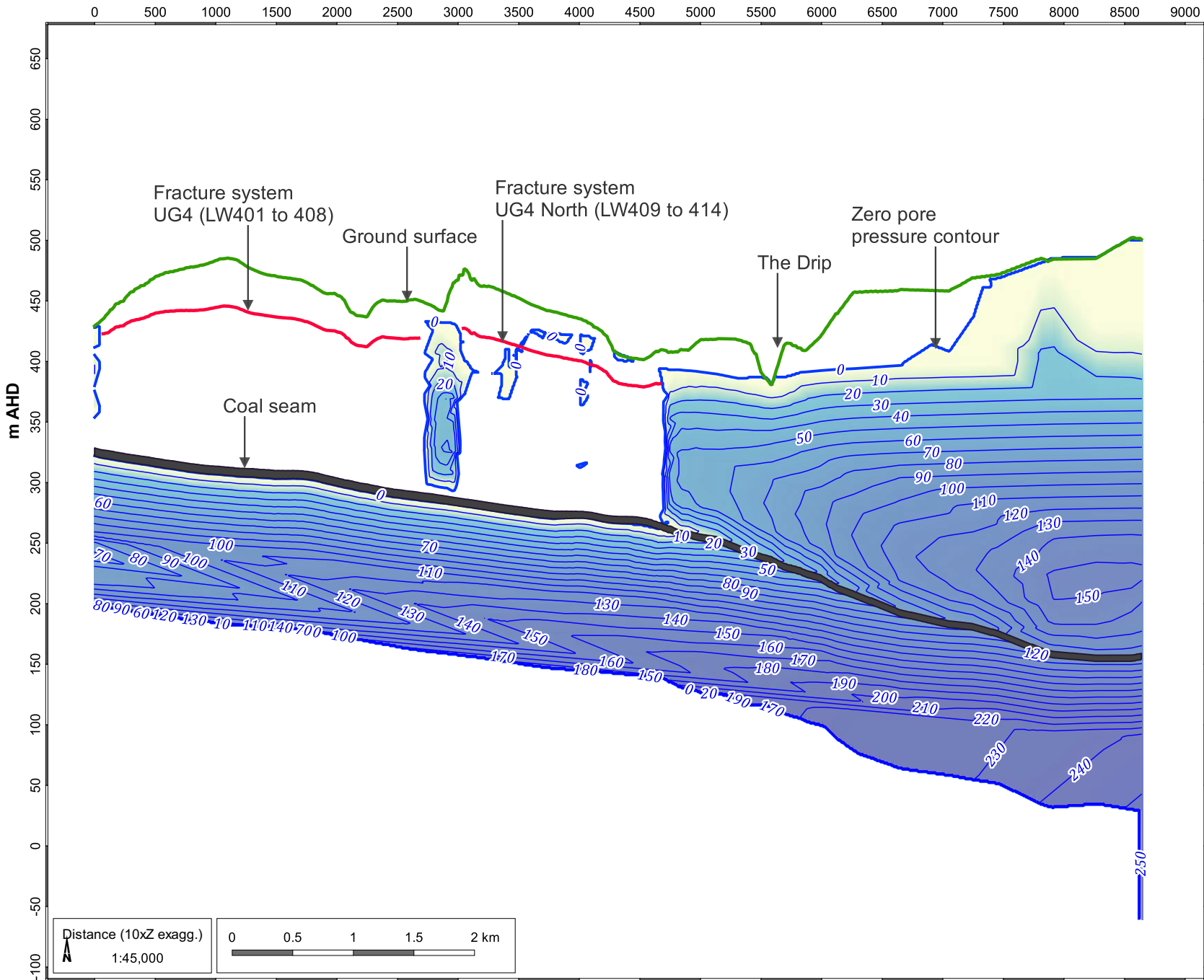
UG4 LW409-414 Extraction Plan Groundwater
Technical Report (MOO5004.001)

Location of the pore pressure section



DATE
06/09/2024

FIGURE No:
5.22



LEGEND

- Ground surface
- Fracture system
- Pore pressure contour line
- Zero pore pressure contour line
- Target coal seam

Pore pressure (m)

- 0
- 10
- 20
- 50
- 100
- 200

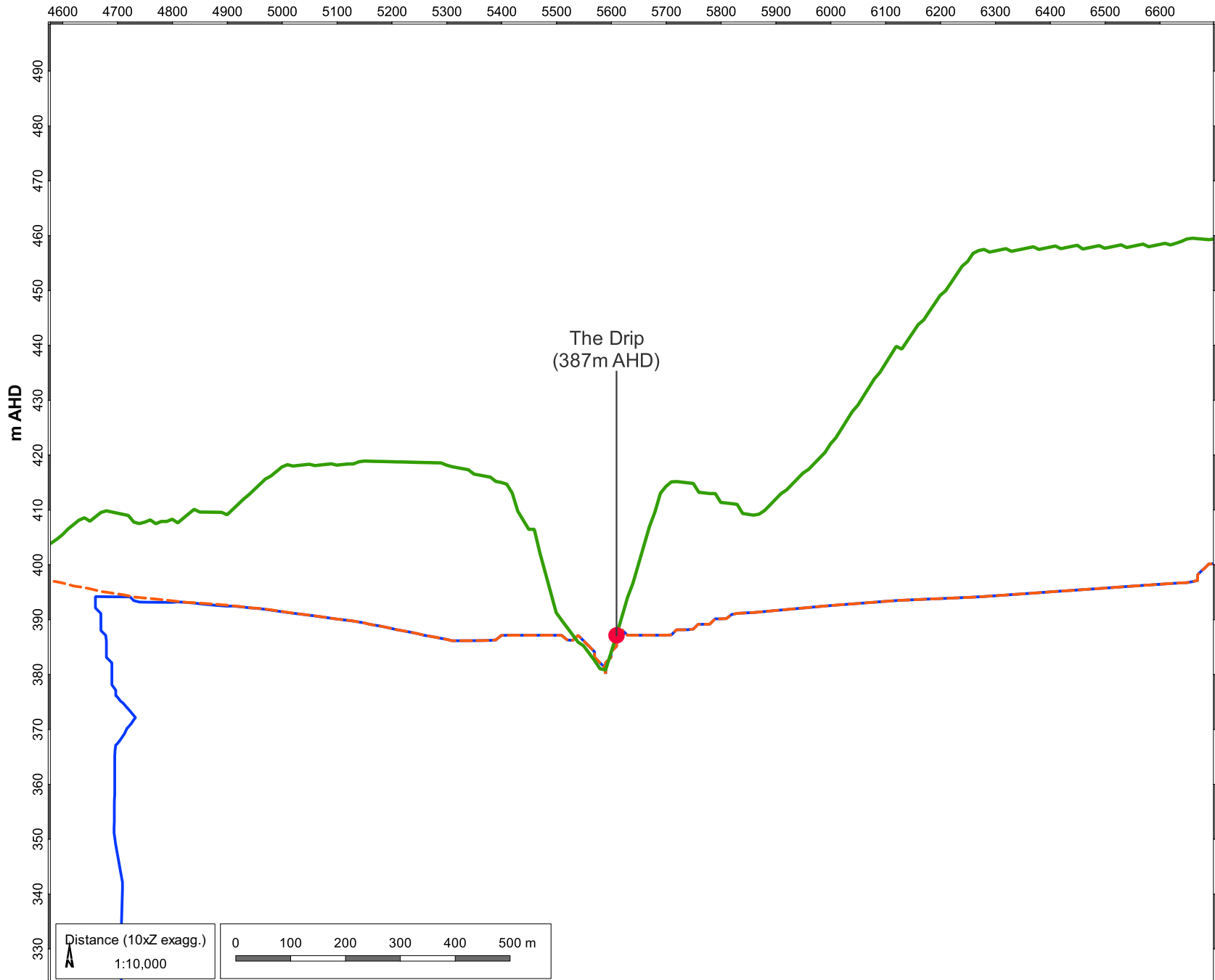
UG4 LW409-414 Extraction Plan Groundwater
Technical Report (MOO5004.001)

**Predicted pore pressure at the
end of UG4 North (2028)**



DATE
16/09/2024

FIGURE No:
5.23



LEGEND
 — Ground surface
 — Cumulative scenario phreatic surface
 — No UG4 North scenario phreatic surface

UG4 LW409-414 Extraction Plan Groundwater
 Technical Report (MOO5004.001)

**UG4 North mining impact on
 predicted pore pressure (2028)**

DATE
 16/09/2024



FIGURE No:
5.24

Distance (10xZ exagg.)
 1:10,000

©2024 Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) - www.ageconsultants.com.au; Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006
 G:\Projects\MOO5004.001 Moolarben UG4 North Extraction Plan\3_GIS\Workspaces\001_Deliverable\105.24_MOO5004_UG4 North mining impact on predicted pore pressure (February 2028).gqz

6 Water licensing requirements

Mining of UG4 North will result in a direct take of groundwater from the Sydney Basin-North Coast Groundwater Source, which is regulated under the *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016*.

The subsidence and fracturing associated with longwall mining will provide increased connection to overlying and underlying strata, and the hydraulic gradients will result in the flow of groundwater to the mine area. This flow results in indirect take from the surrounding strata. The amount of incidental water take from surrounding groundwater sources has been estimated by comparing model scenarios (Table 5.9). Using this process, both the direct and indirect water take has been estimated, by isolating the influence and contribution of the UG4 North longwall panels.

MCO plans for its future licensable take by:

- review of groundwater modelling predictions;
- updates to the groundwater model, when required, with associated licence re-forecasting; and
- annual reporting, for the period 1 January to 30 June, and 1 July to 31 December, which enables a 6-month period to plan for expected water take for the next 'water year', which is based on financial years.

6.1.1 Direct take

The predicted direct water take from mining activities for MCC including UG4 North, and for UG4 North only is provided in Table 6.1.

Table 6.1 Predicted direct take from the Sydney Basin-North Coast Groundwater Source

Water Year	MCC Take (ML)	UG4 North Take (ML)
2025/26	2,601	828
2026/27	3,004	2,371
2027/28	3,079	2,142

The predicted peak take from the Sydney Basin-North Coast Groundwater Source whilst mining UG4 North is estimated to be 3,079 ML per annum.

6.1.2 Indirect take

Mine dewatering at MCC has indirect impact on two water sources that are regulated under the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2022*. The peak impacts are presented below in Table 6.2.

Table 6.2 Peak water take from the Upper Goulburn River and Wollar Creek Water Sources

Water Source	MCC Peak Take (ML/year)	UG4 North Peak (ML/year)
Upper Goulburn River Water Source	254 (2028/29)	0.8 (2028/29)
Wollar Creek Water Source	282 (2026/27)	0.5 (2028/29)

Modelled MCC peak take from the Upper Goulburn River Water Source is 250 ML per annum, while the modelled MCC peak take from the Wollar Creek Water Source is 282 ML per annum.

7 Groundwater Monitoring, Management and Triggers

7.1 Proposed Groundwater Monitoring

The groundwater monitoring network in the vicinity of UG4 is shown in Figure 7.1.

Additional monitoring sites are planned to be established as part of the UG4 LW409-414 Extraction Plan. These additional monitoring points are designed to monitor potential impacts on the Goulburn River and on The Drip. The following additional monitoring points are proposed:

- Site 1 (PZ-G): This site will comprise a shallow standpipe monitoring bore and one VWP. Indicative site details are provided in Table 7.1;
- Site 2 (PZ128): This site will comprise two standpipe monitoring bores and one VWP. Indicative site details are provided in Table 7.1; and
- Site 3 (PZ129): This site will comprise two standpipe monitoring bores and one VWP. Indicative site details are provided in Table 7.1.

In addition to these three sites, the shallow standpipe monitoring bore PZ-A will be established as a commitment from the LW401-LW404 Extraction Plan.

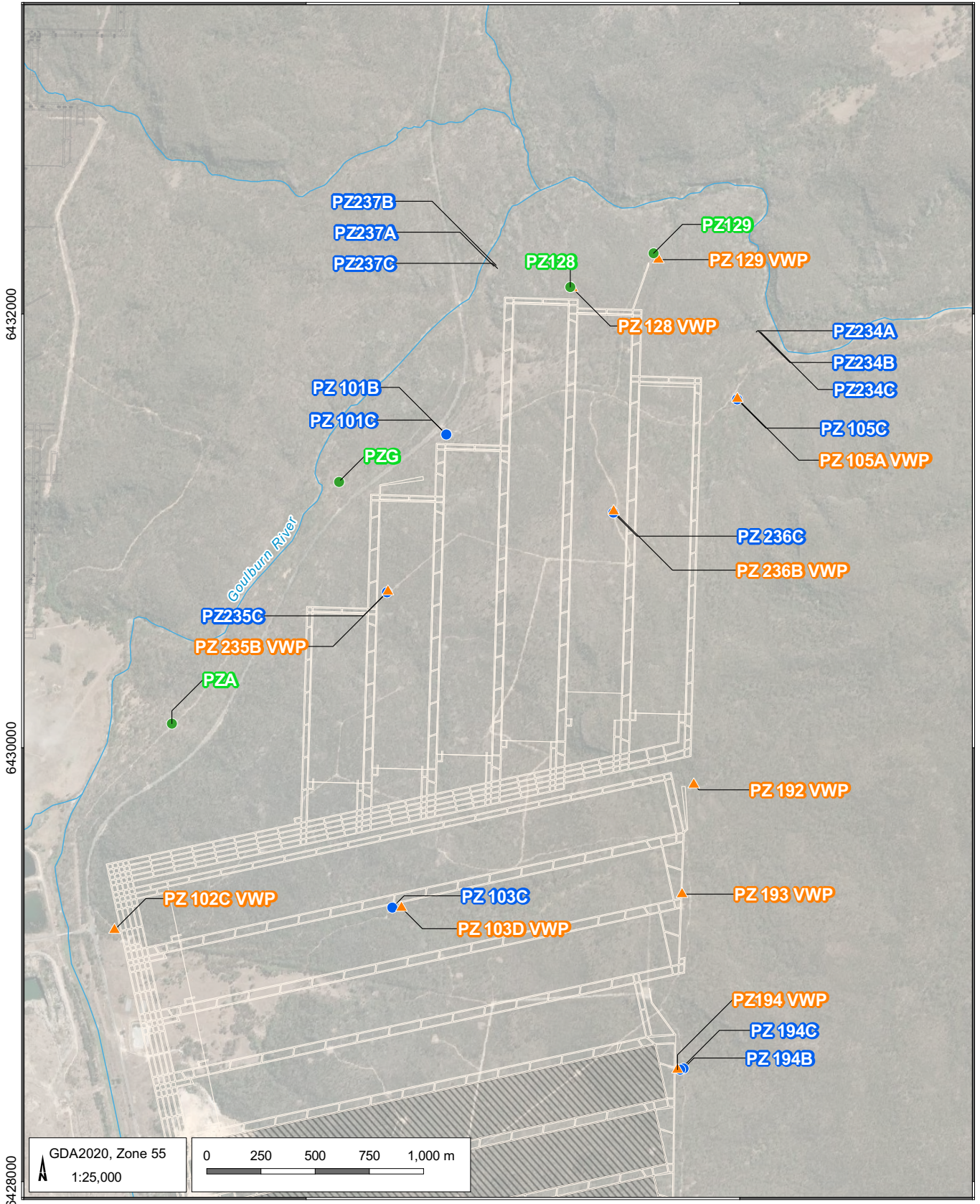
The additional monitoring points should be established prior to secondary extraction of LW409, to provide sufficient time to collect data and establish appropriate triggers for the mining of LW409-414. As some sites are located in proximity to existing VWPs it is possible that water level changes associated with installing the new bores are detected. Any short term effects are expected to be readily identifiable and separated from climatic or mining effects.

The proposed additional sites' locations are indicative as they will need to complete the MCO Ground Disturbance Permit (GDP) approval processes. The sites' indicative locations are shown in Figure 7.1, with site details provided in Table 7.1. The design of each site is based on the preliminary location and may change if the sites need to be adjusted during the GDP process.

Once the VWP bores at Site 2 and Site 3 have been installed, the existing PZ 128 VWP and PZ 129 VWP will be decommissioned.

Table 7.1 Additional monitoring site details

Site	Bore ID	Type	Purpose	Hole depth (m)	Target strata	Geology	PVC Screen / VWP sensor depth (mbgl)
PZ-G	PZ-G SP1	Standpipe	Trigger	37	Permian	Weathered Zone	34 - 37
	PZ-G VWP	VWP	Monitoring	130	Permian	Weathered Zone	35
			Monitoring			Irondale Seam	69
			Monitoring			Ulan Overburden	90
			Monitoring			Ulan Seam	112
			Monitoring			Permian Underburden	125
PZ128	PZ128 SP1	Standpipe	Monitoring	30	Triassic	Weathered Zone	27 - 30
	PZ128 SP2	Standpipe	Trigger	45	Triassic	Triassic Lithic	42 - 45
	PZ128 VWP2	VWP	Monitoring	160	Permian	Triassic Lithic	43
			Monitoring			Irondale Seam	104
			Monitoring			Ulan Overburden	125
			Monitoring			Ulan Seam	147
		Monitoring			Permian Underburden	155	
PZ129	PZ129 SP1	Standpipe	Monitoring	40	Triassic	Weathered Zone	37 - 40
	PZ129 SP2	Standpipe	Trigger	65	Triassic	Triassic Lithic	62 - 65
	PZ129 VWP2	VWP	Monitoring	180	Permian	Triassic Lithic	63
			Monitoring			Irondale Seam	123
			Monitoring			Ulan Overburden	143
			Monitoring			Ulan Seam	167
		Monitoring			Permian Underburden	175	



LEGEND

- UG4 Mine Plan
- Drainage
- Mine Extent (May 2024)
- Groundwater Monitoring Network Site**
- Standpipe
- VWP
- Proposed site monitoring bore

UG4 LW409-414 Extraction Plan Groundwater Technical Report (MOO5004.001)

Existing and proposed monitoring bore locations



AGE

DATE
04/10/2024

FIGURE No:
7.1

7.2 Trigger Action Response Plan

Condition 73, Schedule 3 of Project Approval (05_0117) outlines subsidence performance measures relevant to the preparation of Extraction Plans. These performance measures relate to direct subsidence impacts and have been addressed in MSEC (2024). Condition 73, Schedule 3 of Project Approval (05_0117) outlines subsidence performance measures for Natural and Heritage Features. Performance measures relevant to groundwater are summarised in Table 7.2.

Table 7.2 Subsidence Performance Measures

Feature	Performance Measure
The Drip and Goulburn River Gorge	Nil impact on the water supply to The Drip
Goulburn River and the bed of the Goulburn River	Negligible impact or environmental consequences. Remain outside the zone of recorded subsidence damage for longwall mining.

In addition to the above, Condition 77(h)(iv) of Project Approval (05_0117) requires Extraction Plans include a program to predict, manage and monitor impacts on privately-owned groundwater bores.

7.2.1 The Drip

Groundwater discharge at The Drip is derived from a perching of groundwater within the Triassic Narrabeen Group sediments which is considered likely to be hydraulically isolated from the regional groundwater system that is impacted by mining. Groundwater modelling indicates even if The Drip has connectivity with the regional water table, mining at UG4 LW409-414 would not impact the shallow groundwater levels in this area (Section 5.5) and therefore mining at UG4 LW409-414 would result in nil impact on the water supply to The Drip. Triggers thresholds are provided for proposed bore PZ129 SP2 in Section 7.3 to provide an early indication of any potential impacts on the water supply to The Drip.

7.2.2 Goulburn River

The observed data (Section 4.2.3) indicates that the Goulburn River is a gaining river in the UG4 North area. Updated groundwater modelling indicates that mining at UG4 LW409-414 would result in a negligible impact or environmental consequence on the Goulburn River. Triggers thresholds are provided at bore PZ237A and PZ234A in Section 7.3 to provide an early indication of any potential impacts on the Goulburn River.

7.2.3 Private bores

No private bores are predicted to experience greater than minimal impact (i.e. drawdown greater than 2 m, as defined in the NSW Aquifer Interference Policy) due to the MCC (Section 5.4.2). Notwithstanding, Groundwater Level Investigation Triggers have been established at monitoring bores to provide an early indication of a potential exceedance of the AIP criteria at a private bore (i.e. these monitoring bores are located significantly closer to the UG4 LW409-414 mine workings than any private bores and would therefore experience any mining-related impact well in advance of that impact occurring at a private bore).

7.3 Groundwater Investigation Triggers

The performance measures and groundwater investigation thresholds form the basis of a trigger action response plan (TARP) that outlines actions and responses in the event trigger thresholds are exceeded. Figure 7.2 illustrates the TARP process graphically.

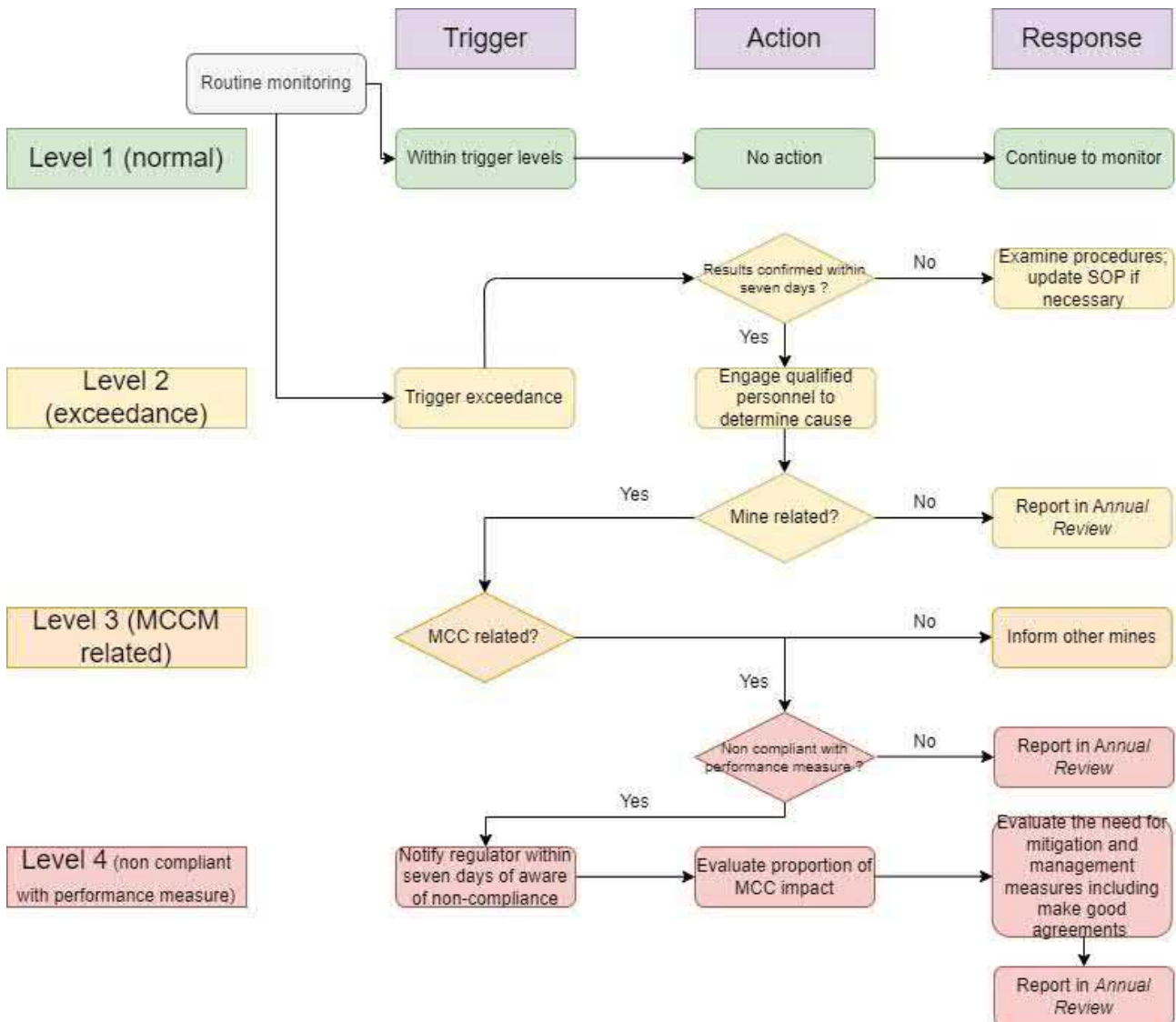


Figure 7.2 Trigger Action Response Process

Groundwater Level Investigation Triggers relevant to the extraction of LW409 to 414 have been developed based on the updated groundwater model predictions with the objective of identifying potential impacts from LW409 to LW414. Groundwater level investigation triggers are based on the predicted groundwater drawdown, and are presented in Table 7.3.

Interim trigger levels were established at the monitoring locations PZ234A and PZ237A based on the available monitoring data. Definitive triggers levels would also be established at the monitoring locations PZ-G SP1, PZ128 SP2, PZ129 SP2, PZ234A and PZ237A once sufficient baseline data has been collected.

Table 7.3 Interim Groundwater Investigation Triggers

Piezometer	Screened Unit	Model layer	Monitored Interval (mbgl)	Minimum observed level (mAHD)	Predicted max cumulative drawdown (m)	Recommended Investigation Trigger Level (mAHD)
PZ105C	Triassic*	9	20 – 28	373.7	8.62	365.08
PZ128 SP2	Triassic	9	-	-	13.10	****
PZ129 SP2	Triassic	9	-	-	3.35	****
PZ234A	Triassic	9	15 - 18	373.4	1.89	371.51***
PZ237A	Triassic	8	14 - 17	382.3	0.27	382.03***
PZ-G SP1	Permian	10	-	-	4.36	****

Note: * Screened interval for PZ105C also includes a small portion of underlying Permian.

** Bore to be installed.

*** Interim trigger level. Final trigger level will be established once sufficient baseline data has been collected.

**** Trigger level will be established once sufficient baseline data has been collected.

In the event that two consecutive groundwater level monitoring results exceed the investigation trigger levels at the monitoring locations specified in Table 7.3, MCO would implement the TARP. These actions will identify if the investigated trigger exceedances is related to permanent mining induced effects, or more short term temporary effects such as climatic variations, drilling of adjacent dewatering bores or drilling of piezometers.

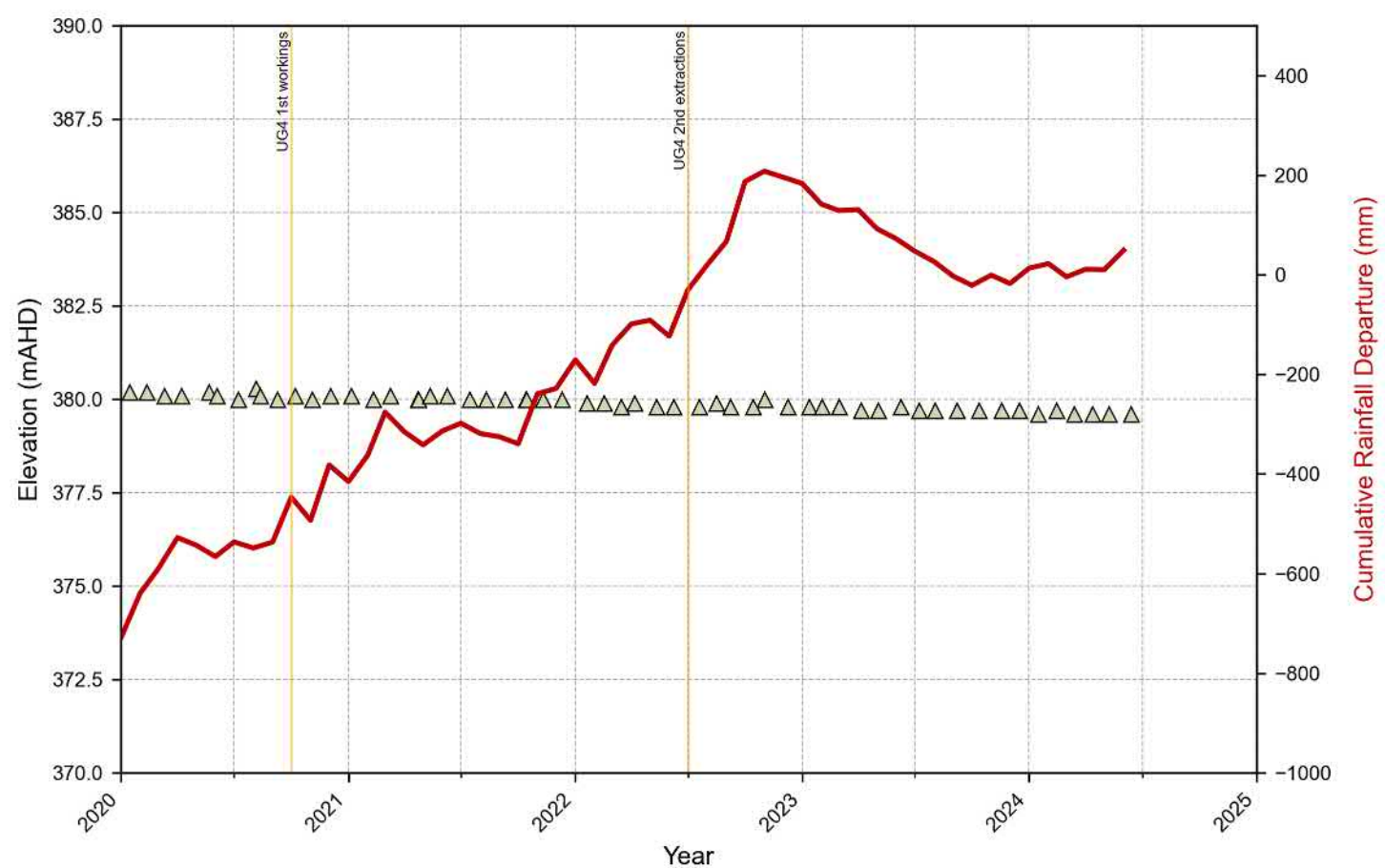
8 References

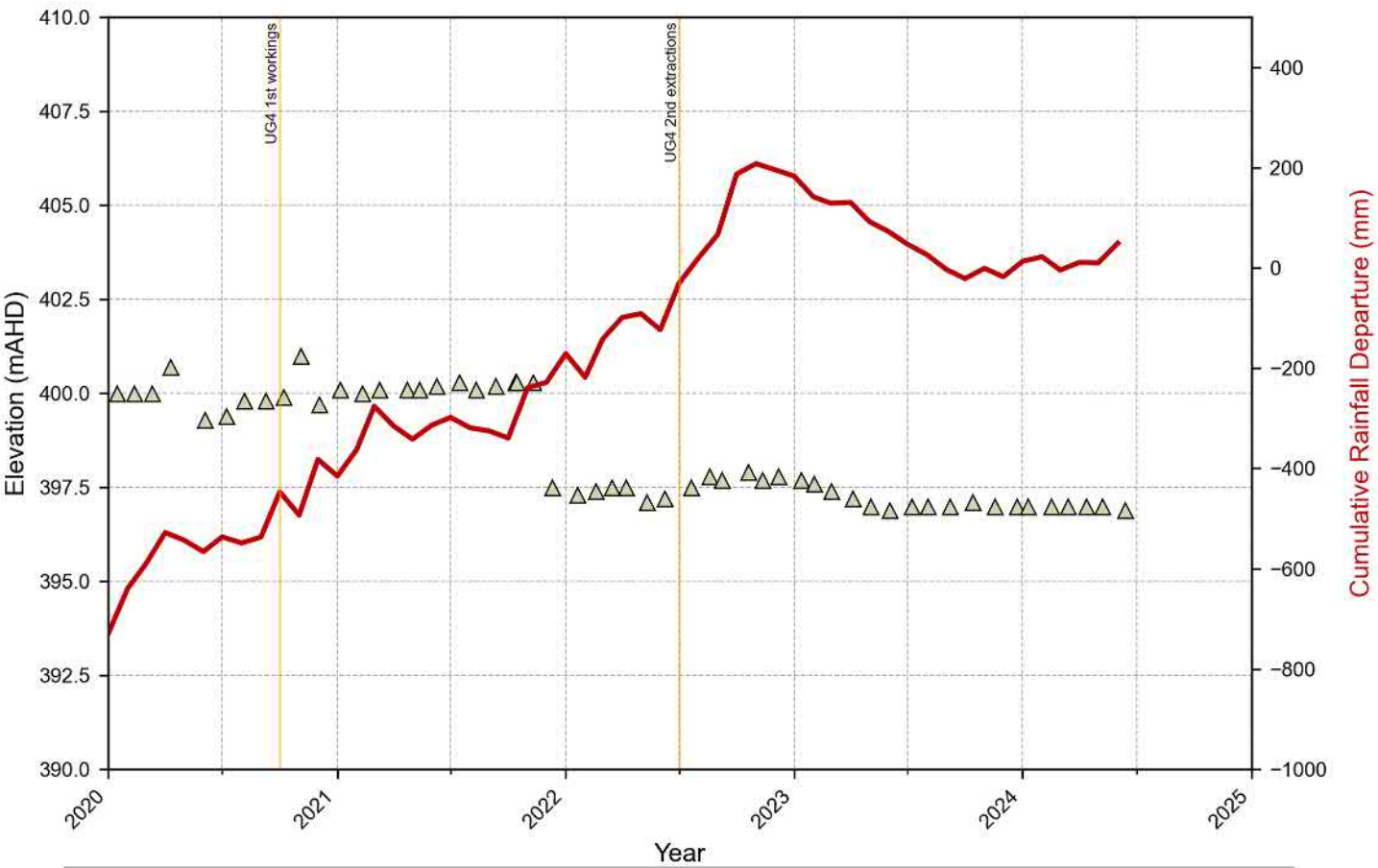
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Appendix A

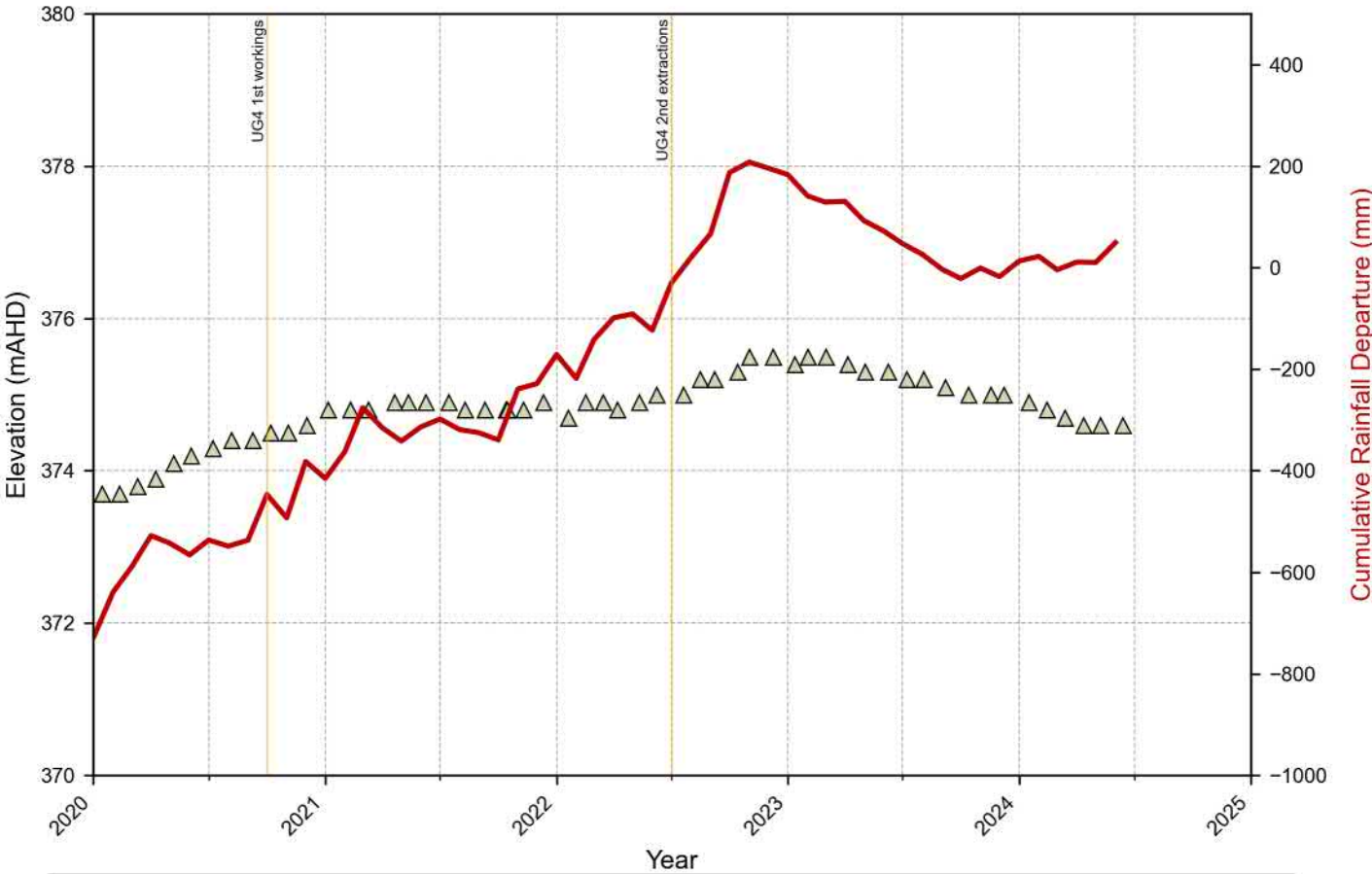
UG4 Triassic Groundwater Monitoring Hydrographs





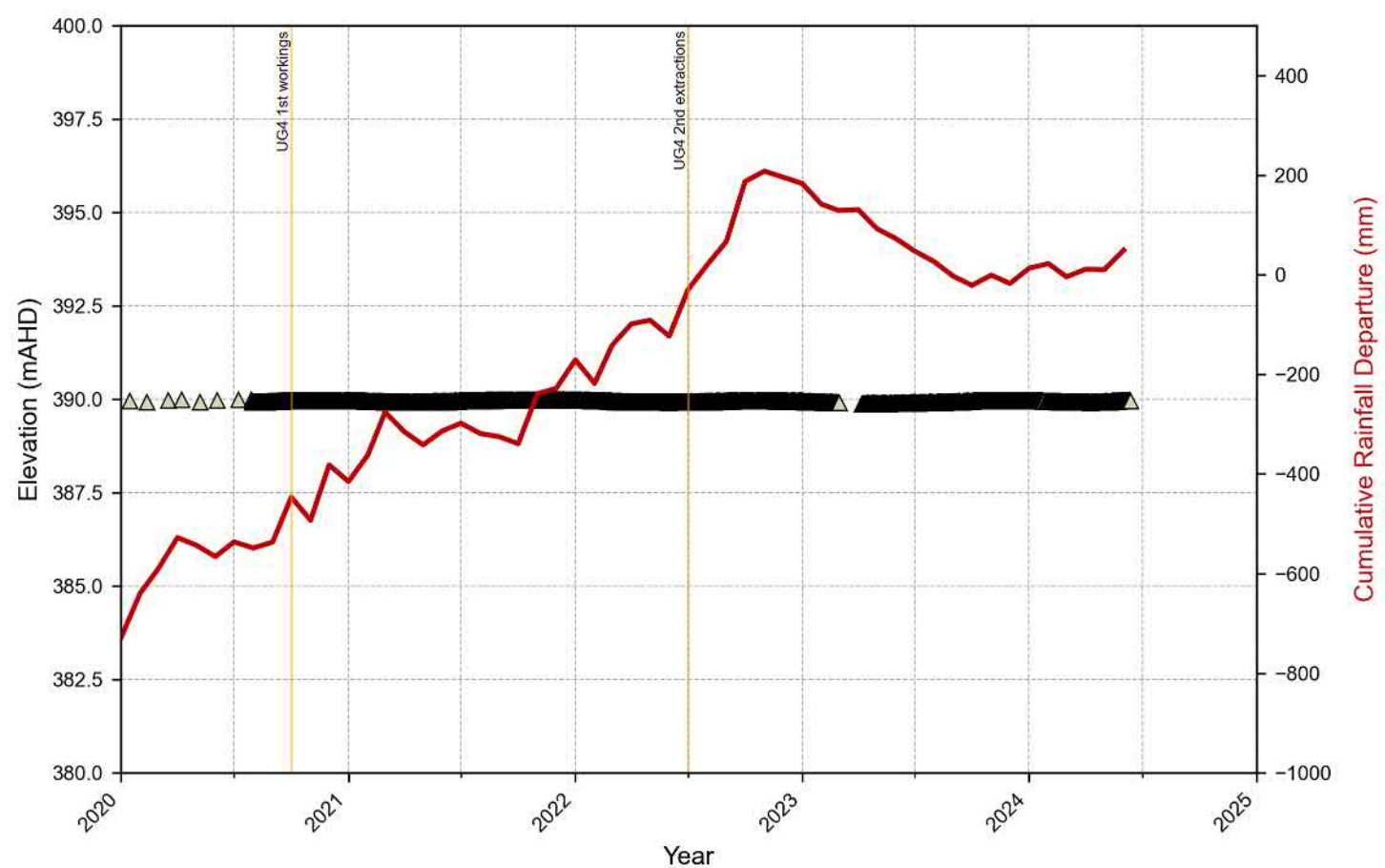
Groundwater Level Data for Piezometer PZ103C
 Moolarben Groundwater Monitoring - Triassic
 Moolarben Coal Operations - UG4 North Extraction Plan Groundwater Technical Report

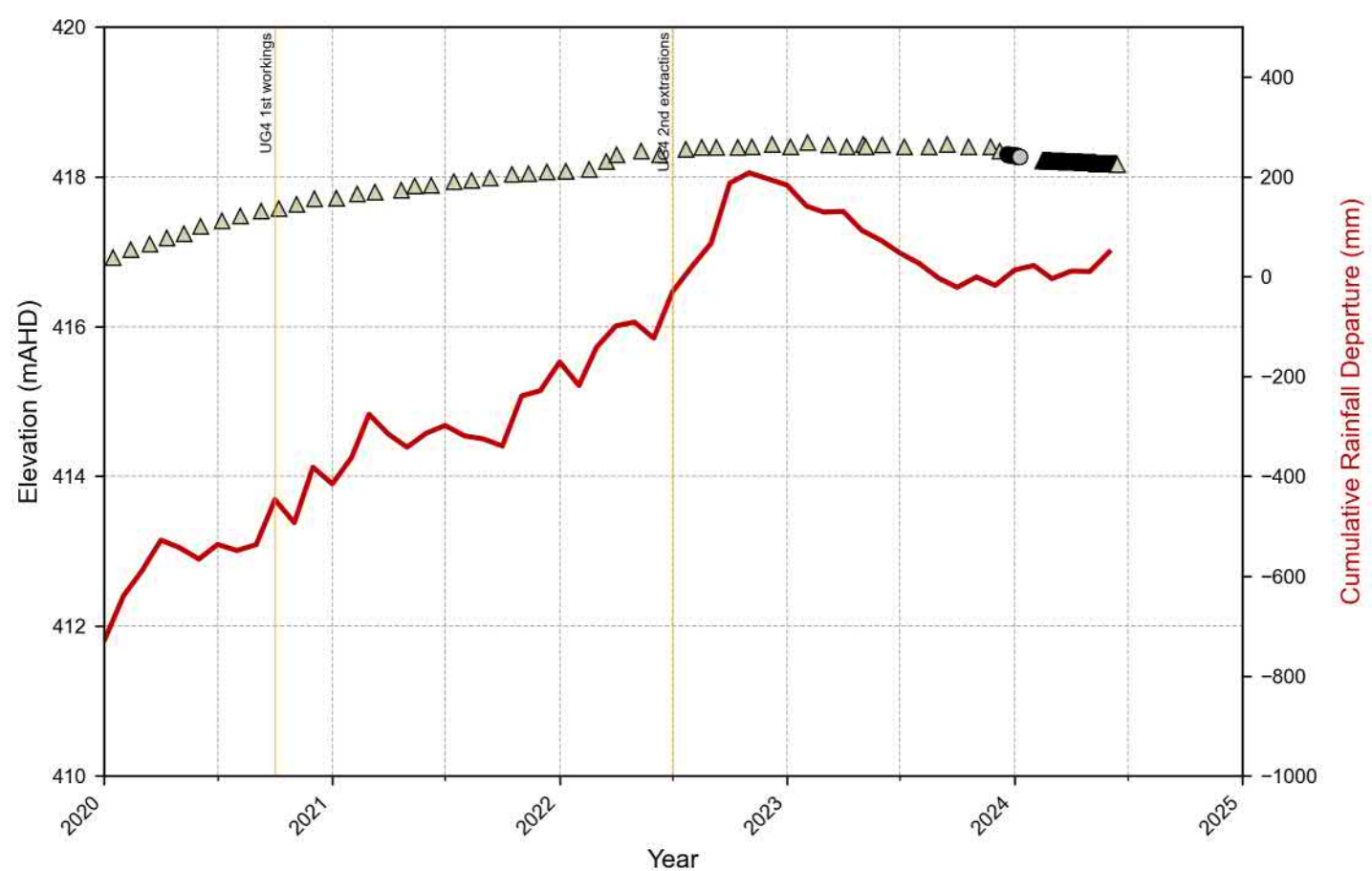
△ Water level



Groundwater Level Data for Piezometer PZ105C
 Moolarben Groundwater Monitoring - Triassic
 Moolarben Coal Operations - UG4 North Extraction Plan Groundwater Technical Report

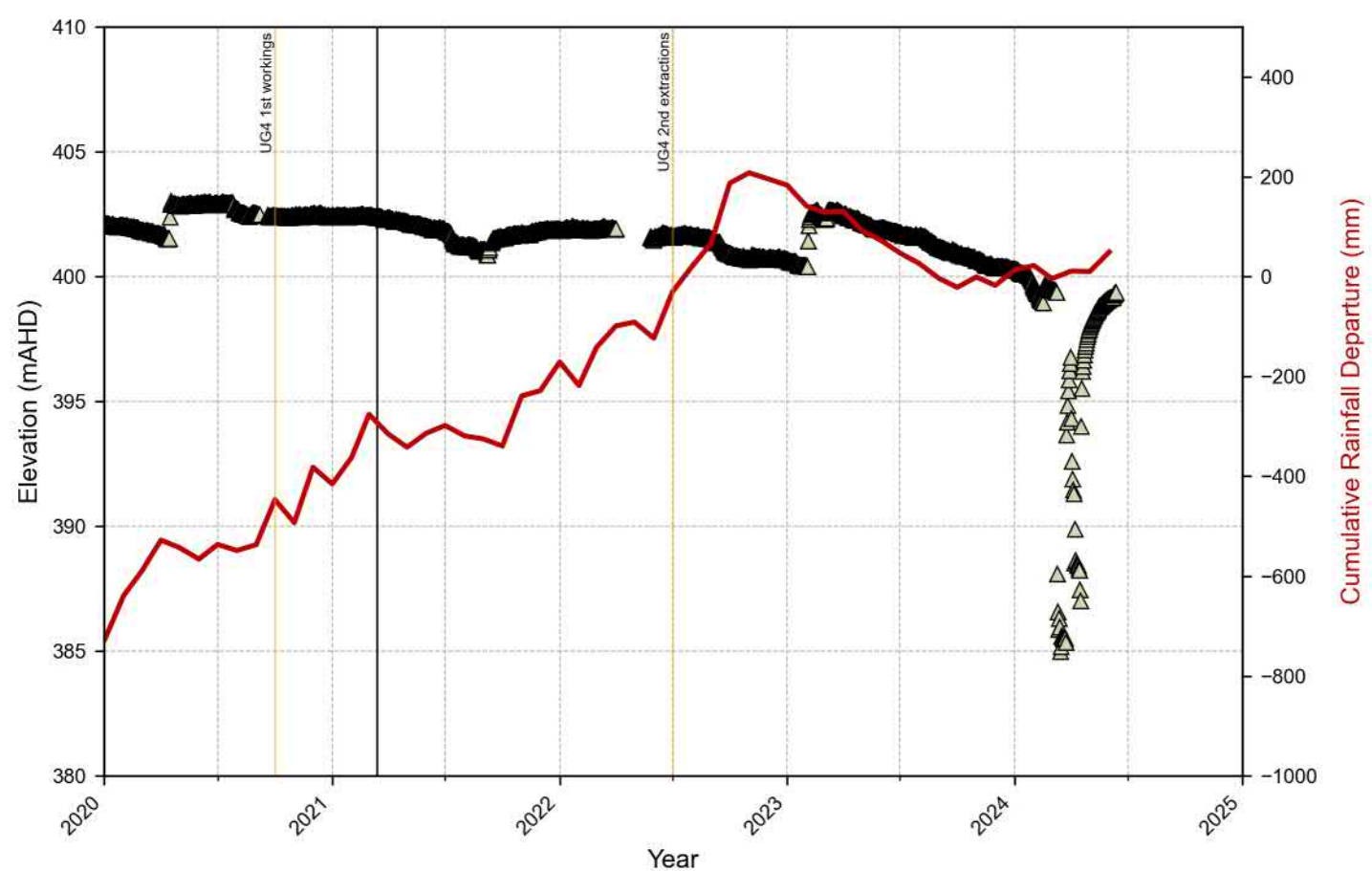
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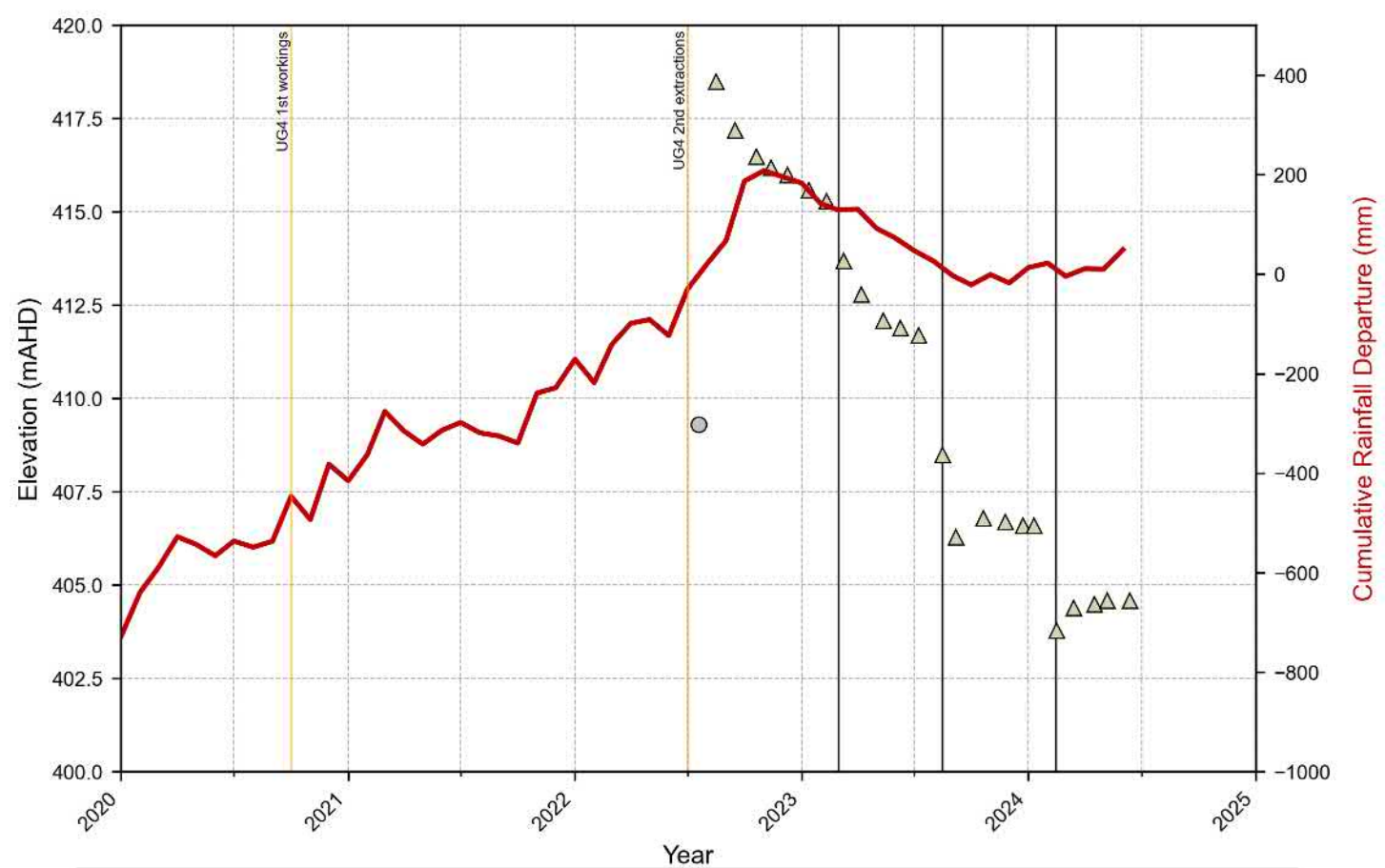
Groundwater Level Data for Piezometer PZ179 VWP 29m
 Moolarben Groundwater Monitoring - Triassic
 Moolarben Coal Operations - UG4 North Extraction Plan Groundwater Technical Report

- ▲ Water level
- Anomalous reading



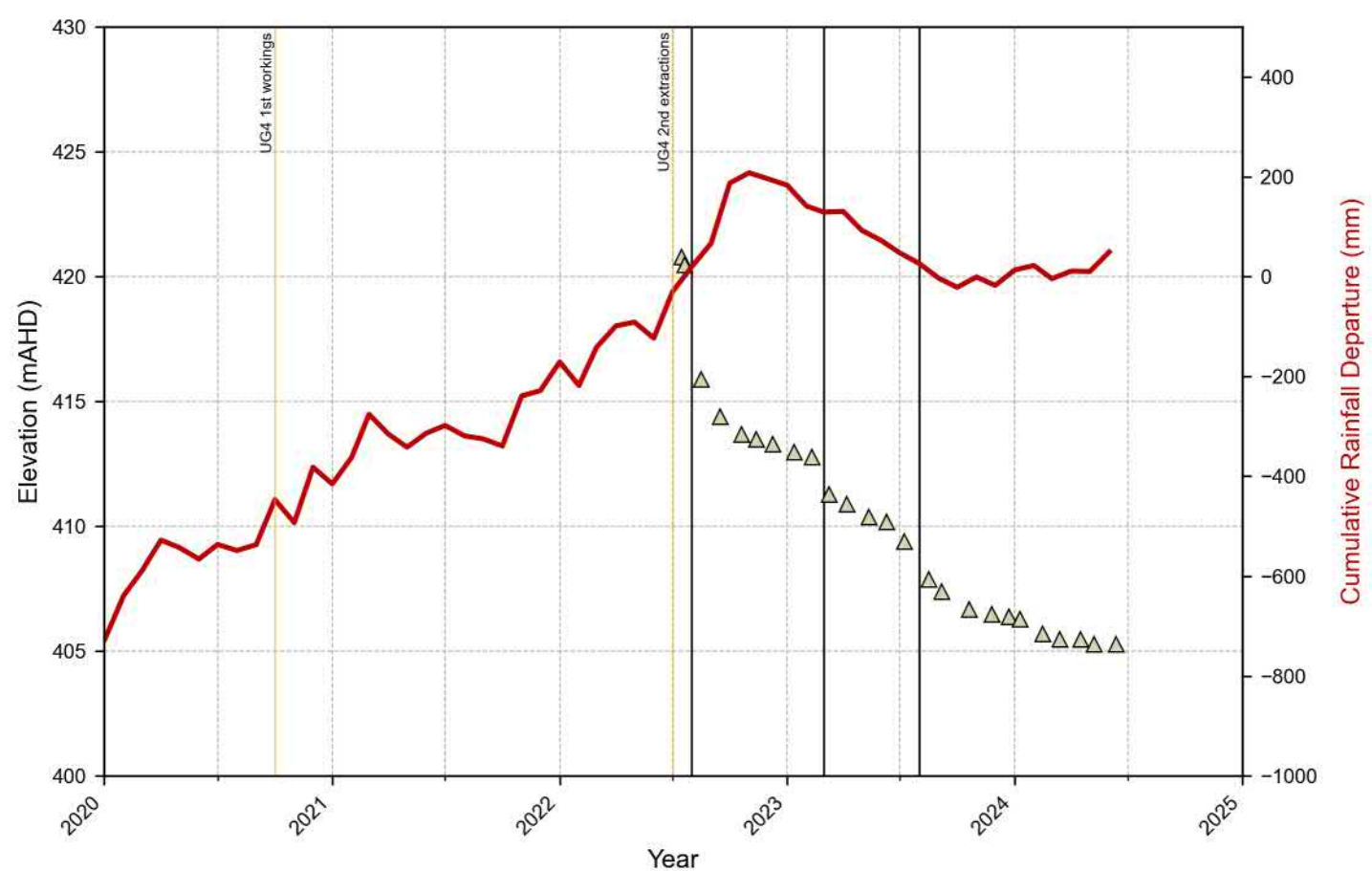
Groundwater Level Data for Piezometer PZ192 VWP 68m
 Moolarben Groundwater Monitoring - Triassic
 Moolarben Coal Operations - UG4 North Extraction Plan Groundwater Technical Report

△ Water level
 — Inferred Departure from Climate Response



Groundwater Level Data for Piezometer PZ194B
 Moolarben Groundwater Monitoring - Triassic
 Moolarben Coal Operations - UG4 North Extraction Plan Groundwater Technical Report

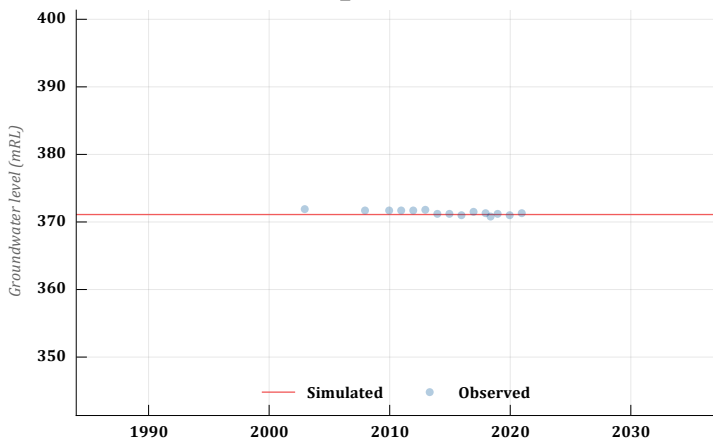
- ▲ Water level
- Anomalous reading
- Inferred Departure from Climate Response



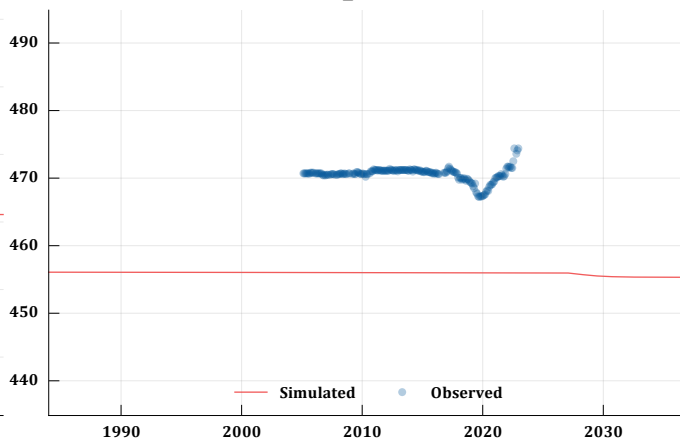
Appendix B

Calibration Hydrographs

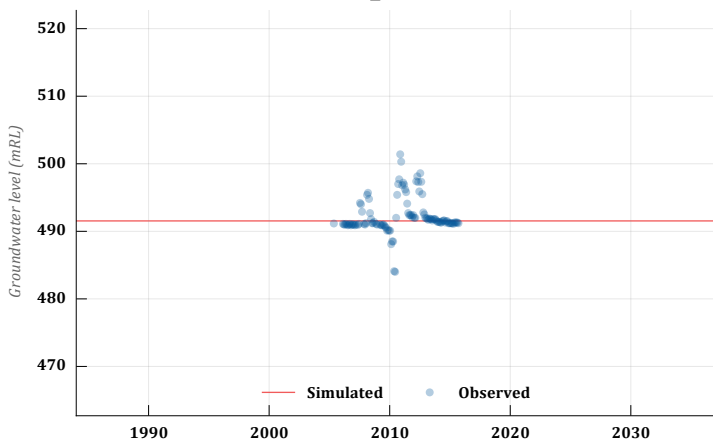
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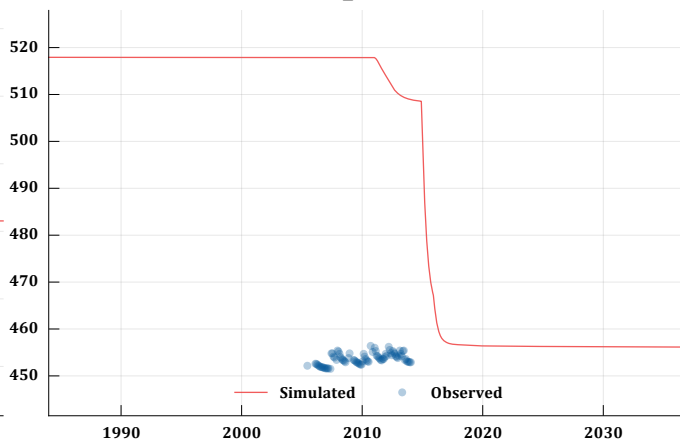
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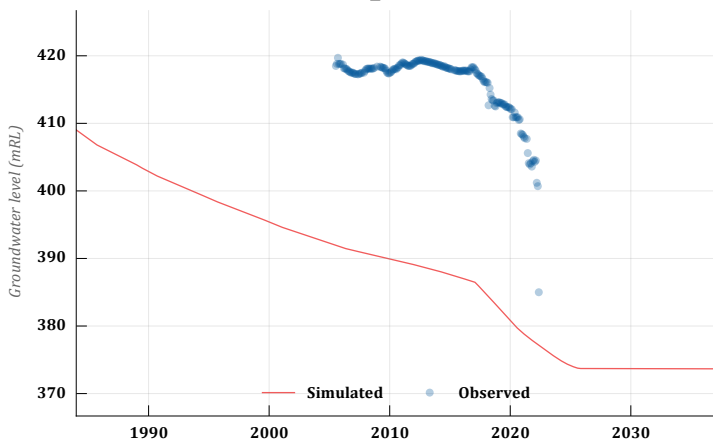
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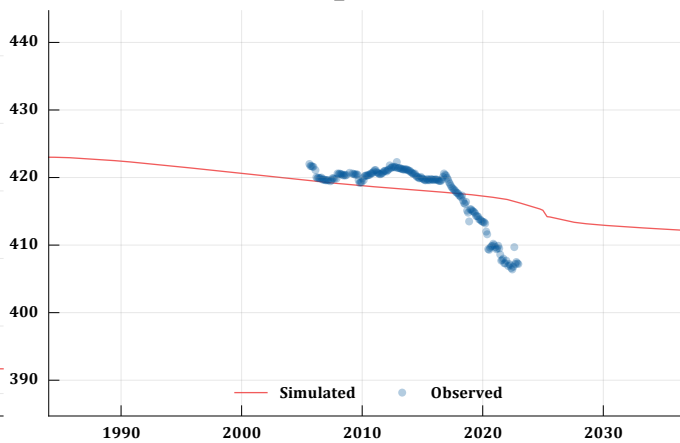
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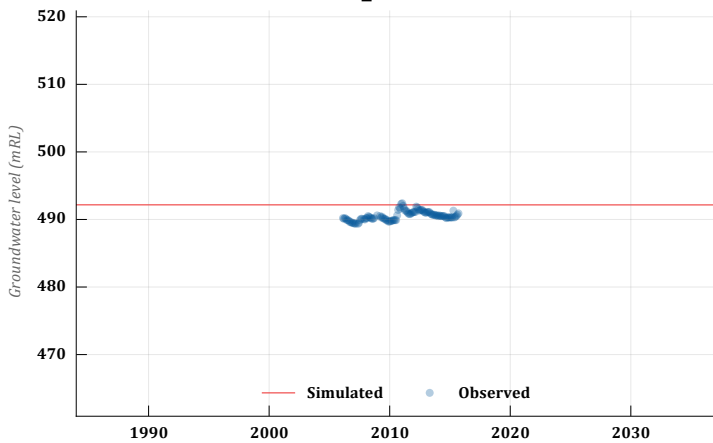
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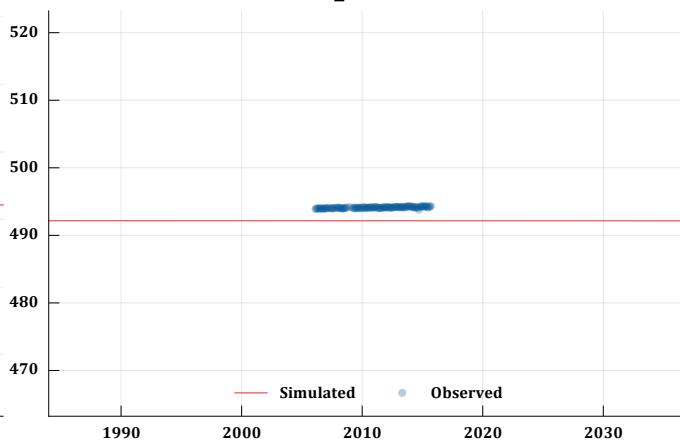
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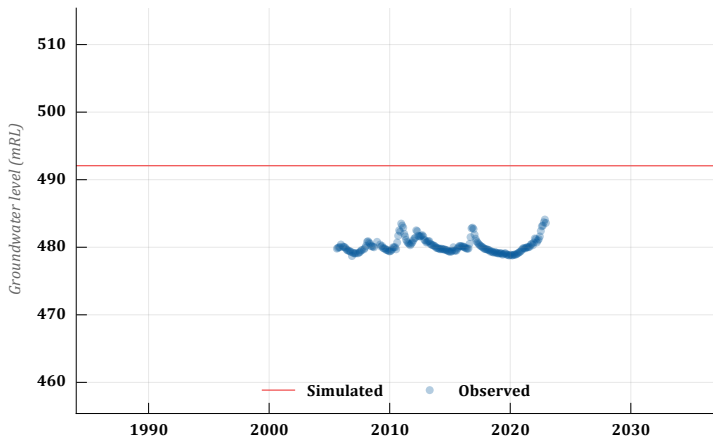
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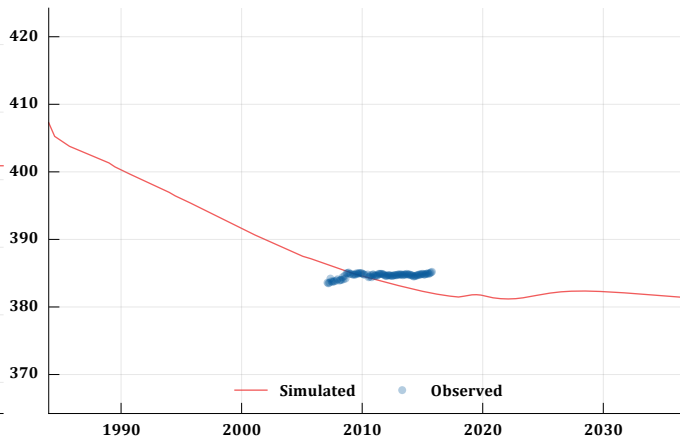
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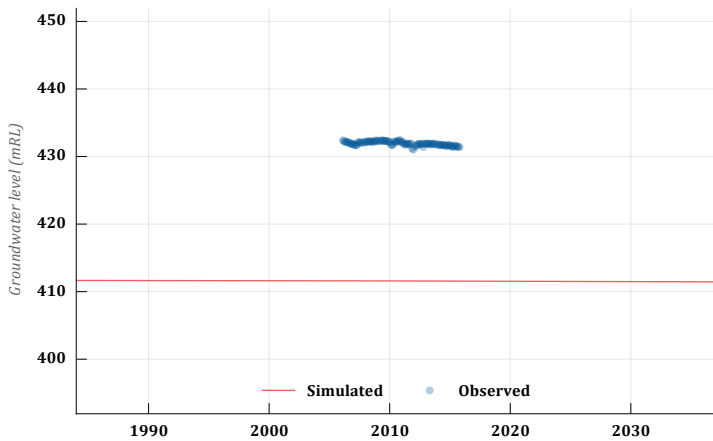
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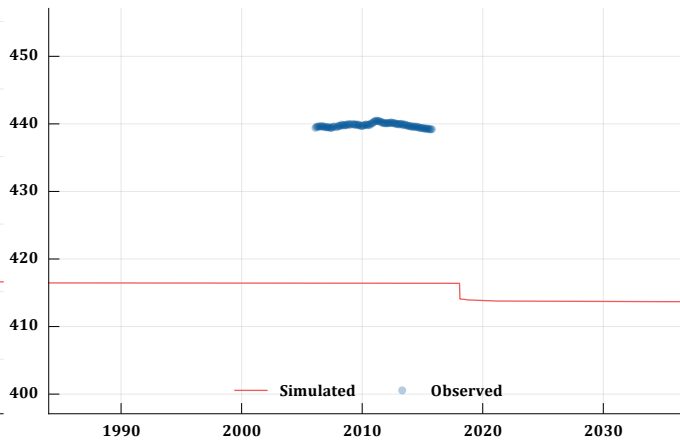
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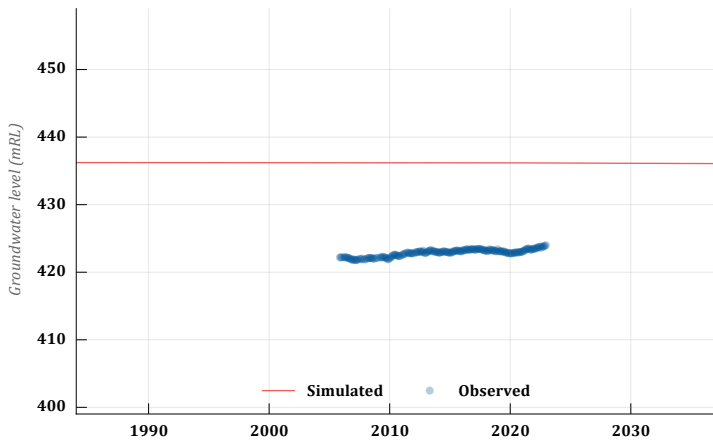
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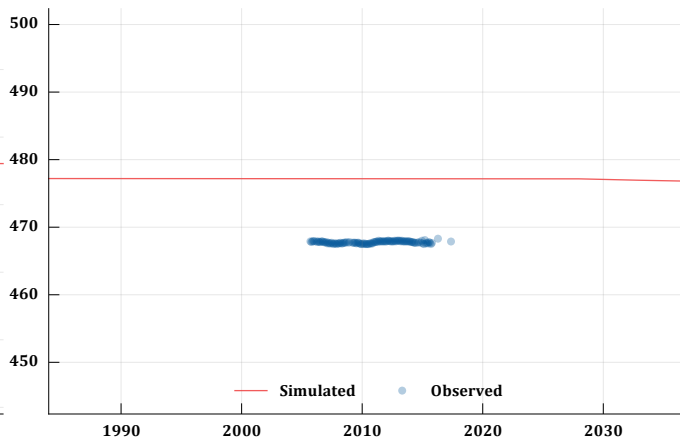
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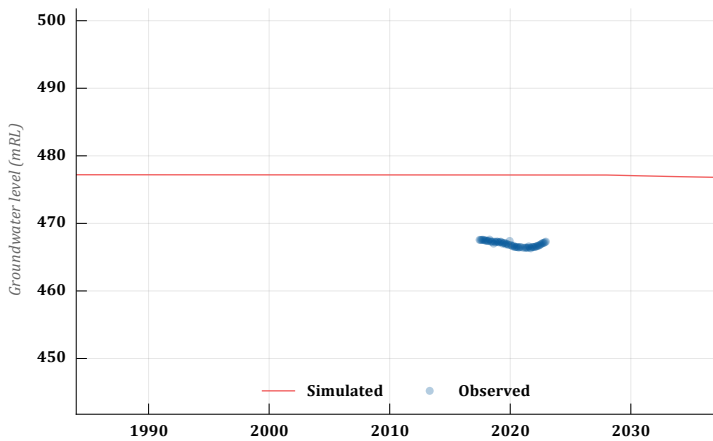
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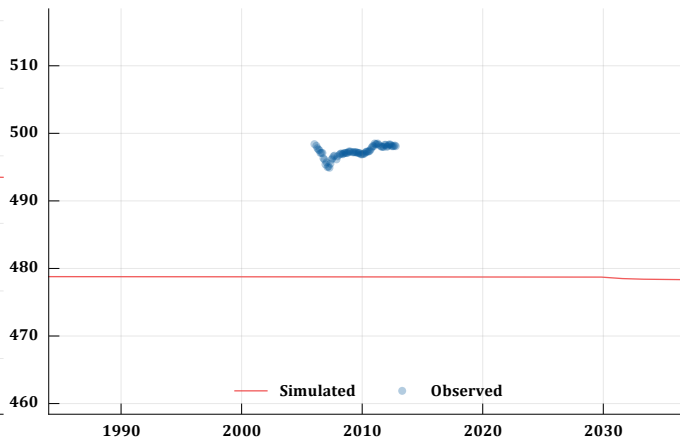
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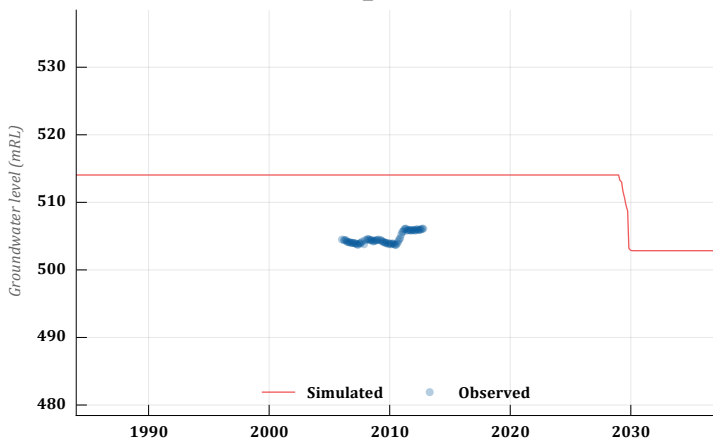
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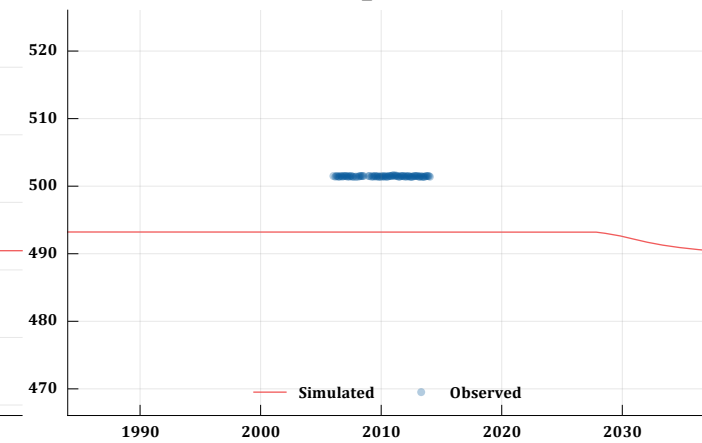
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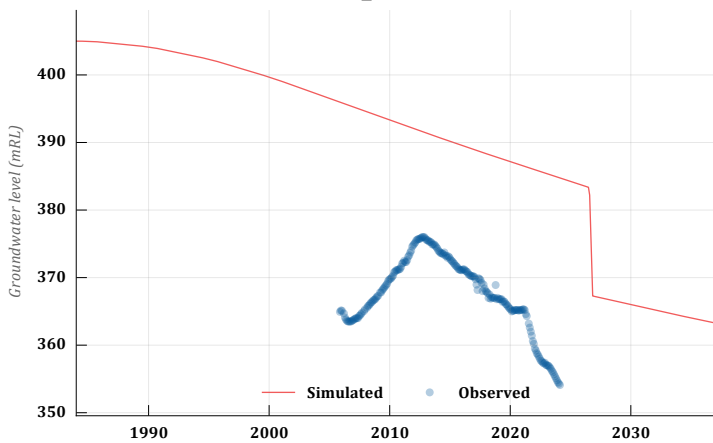
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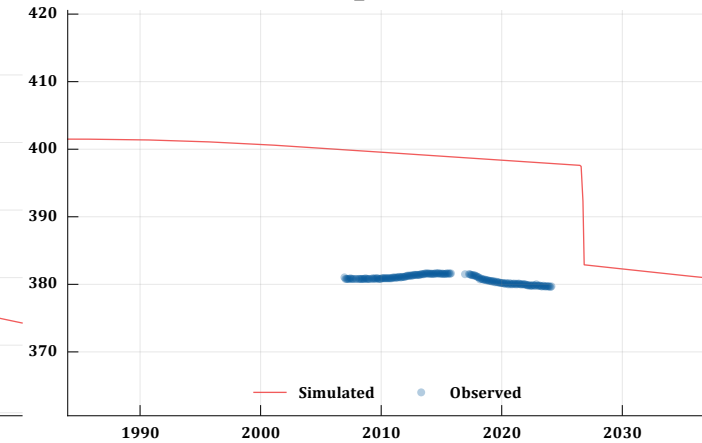
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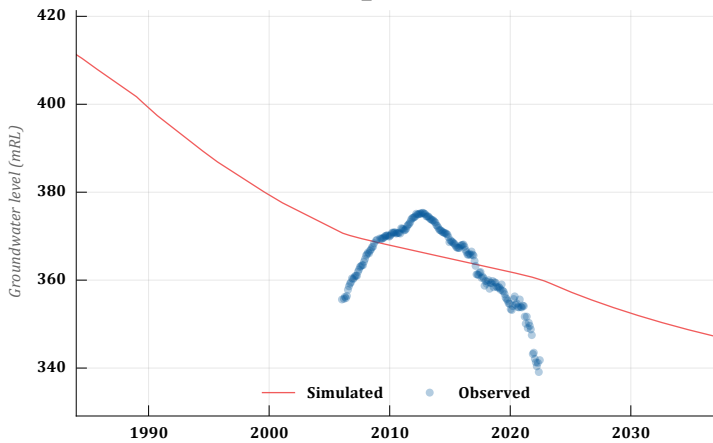
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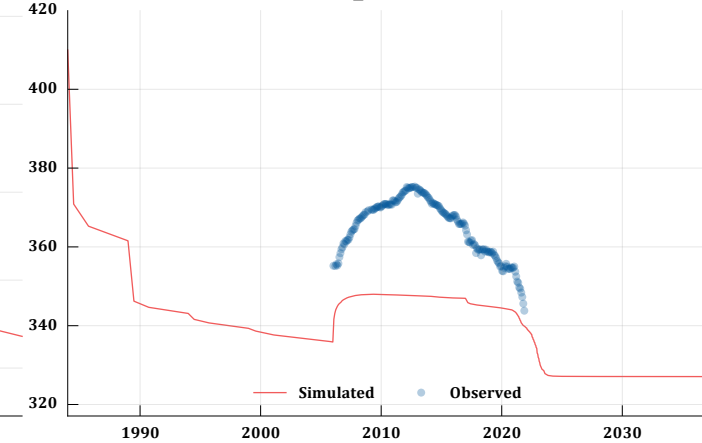
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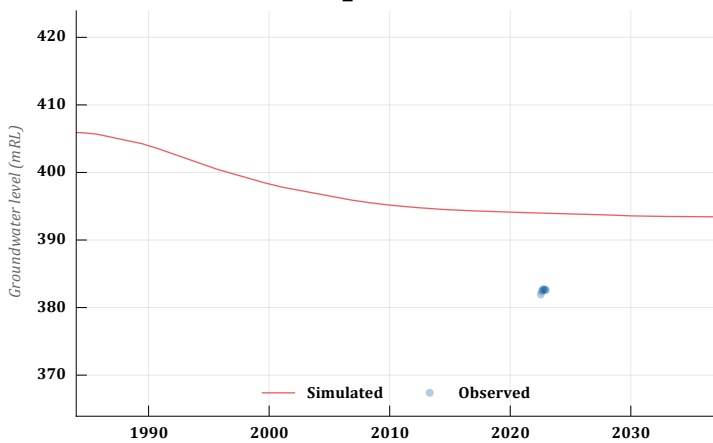
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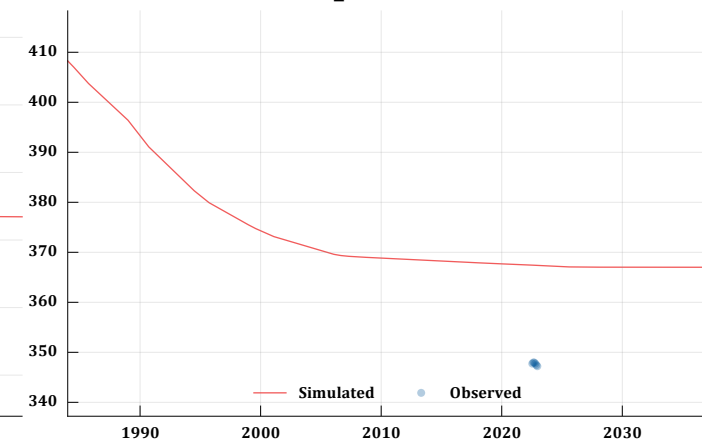
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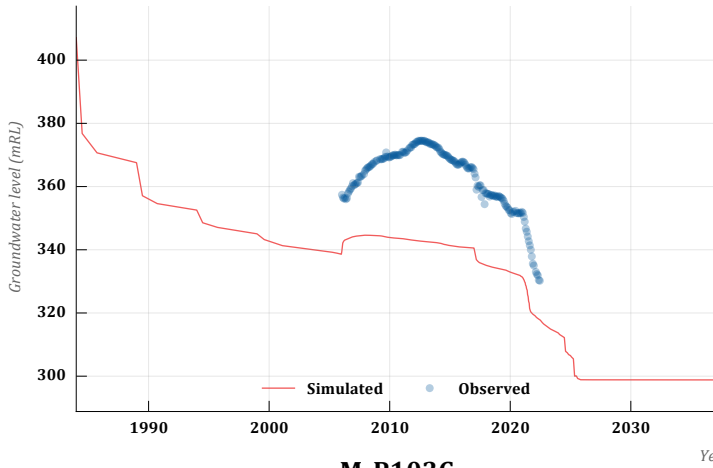
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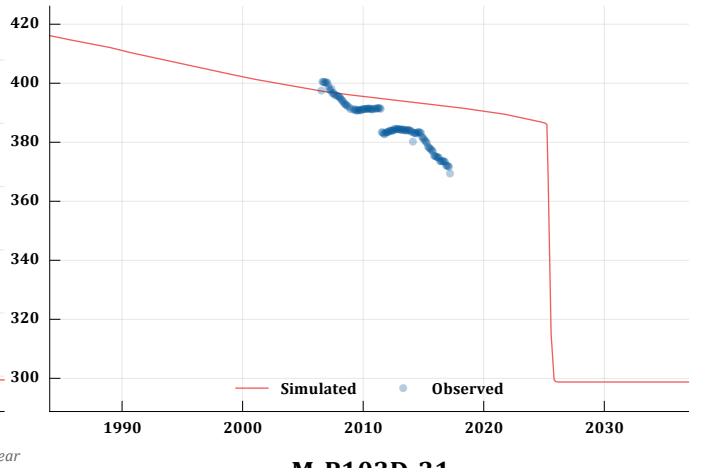
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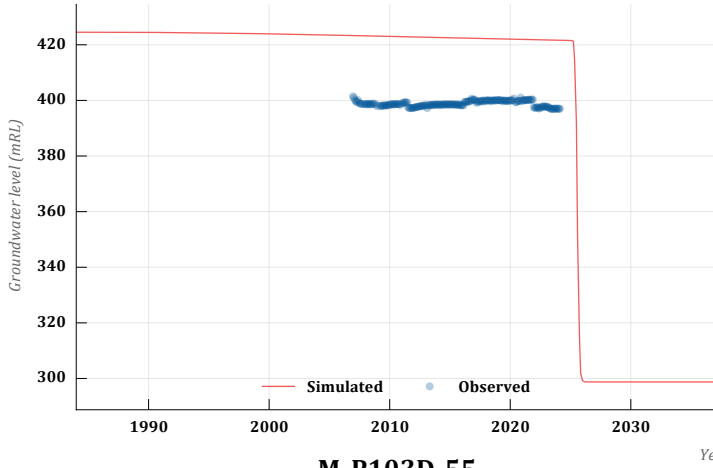
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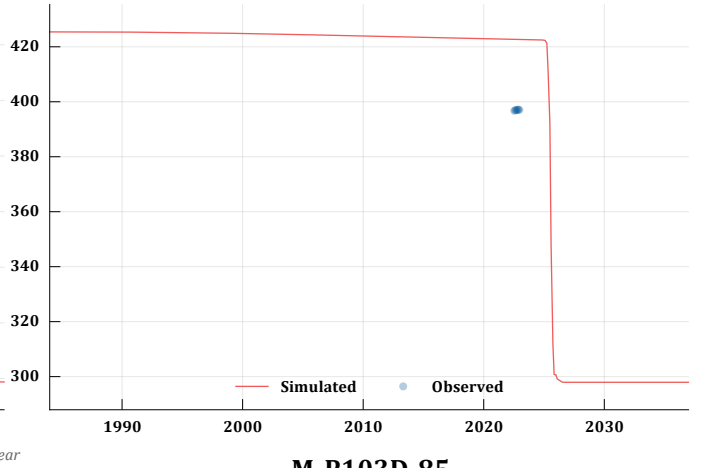
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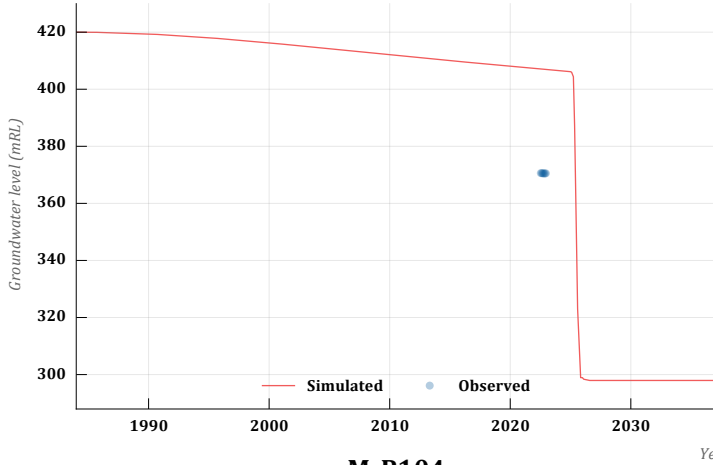
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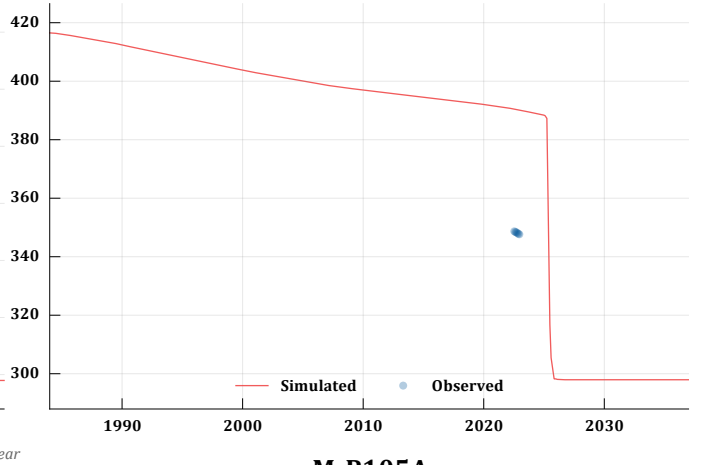
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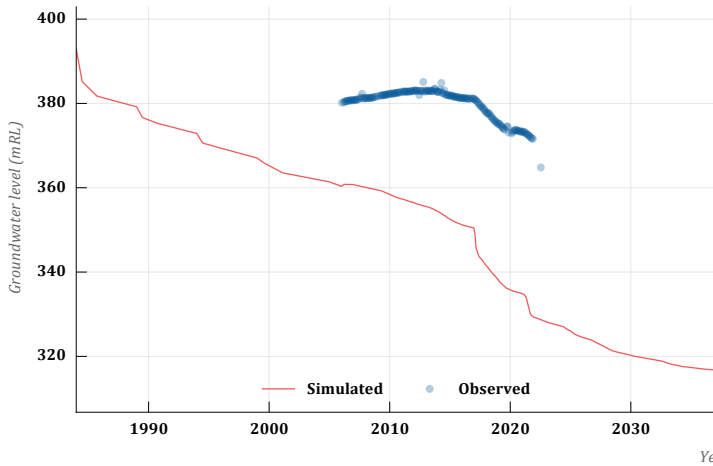
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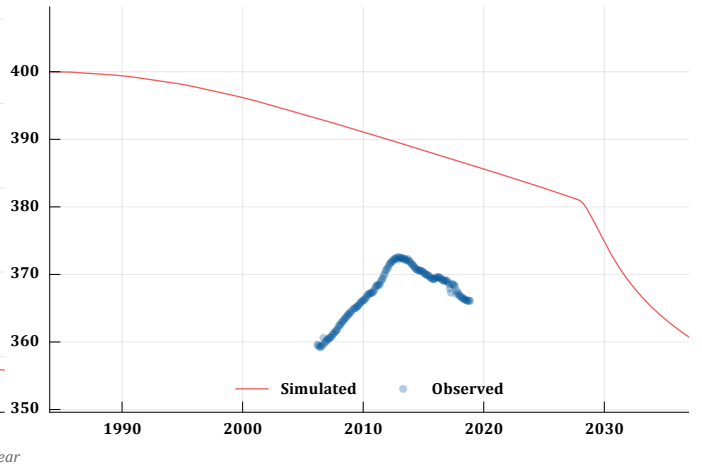
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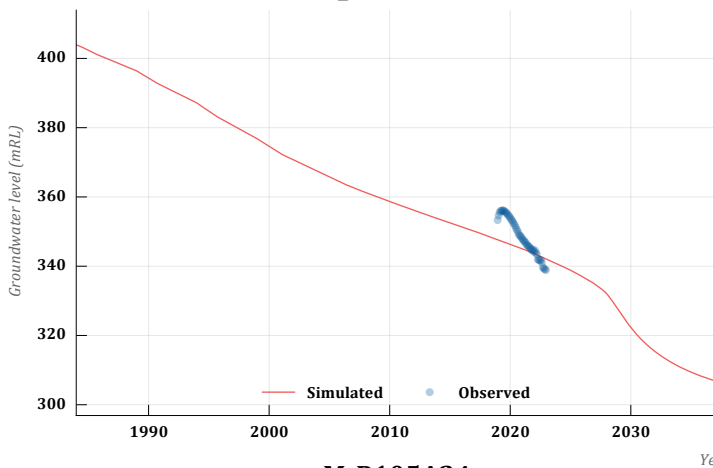
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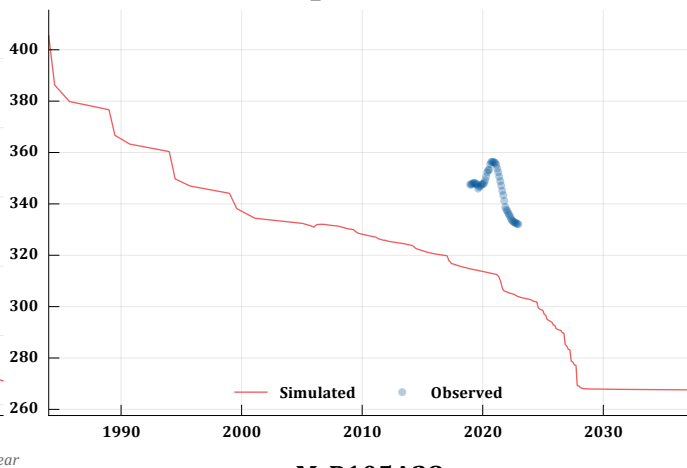
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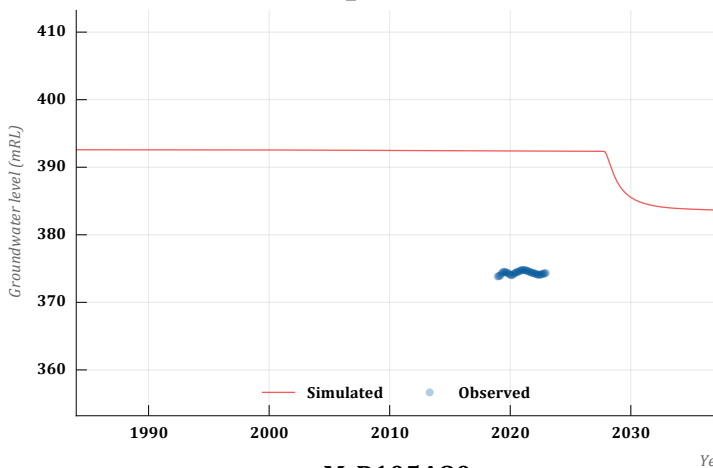
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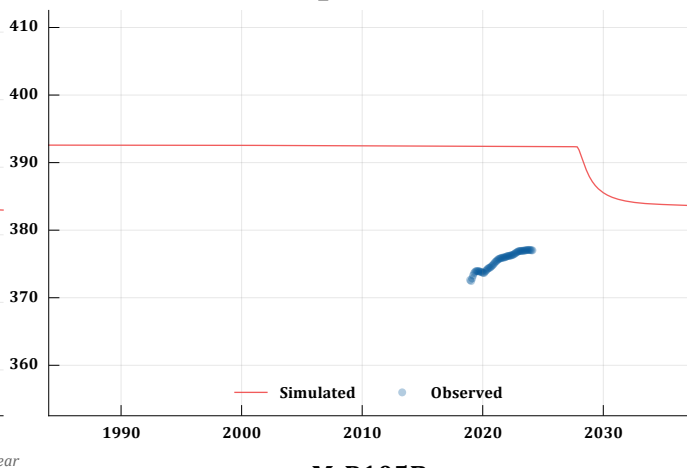
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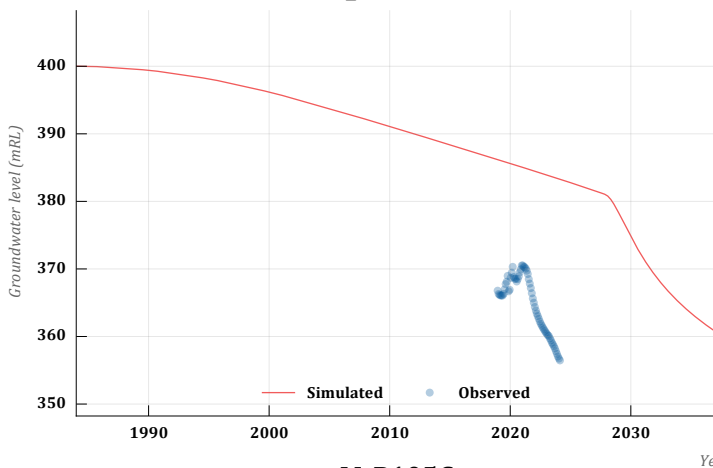
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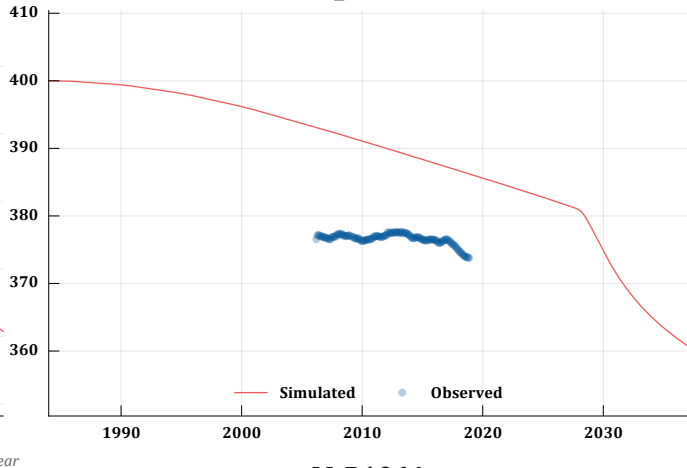
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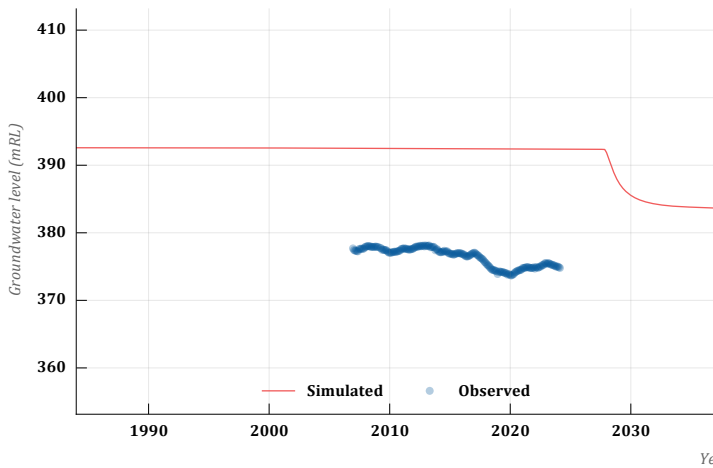
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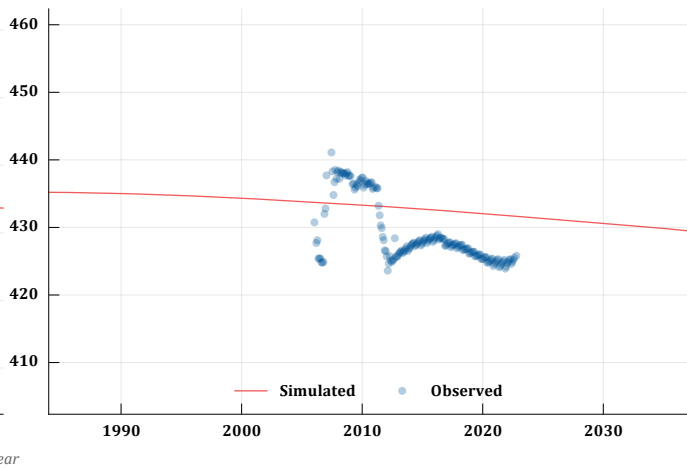
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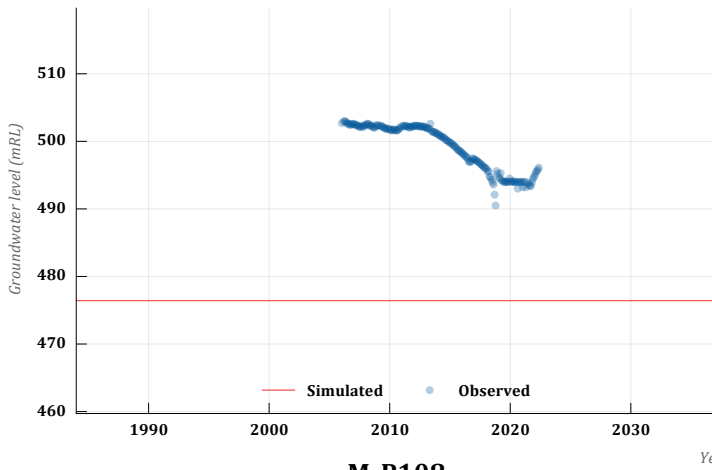
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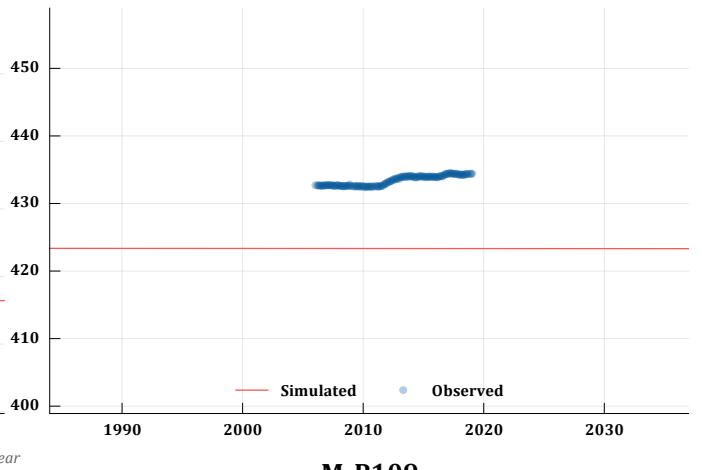
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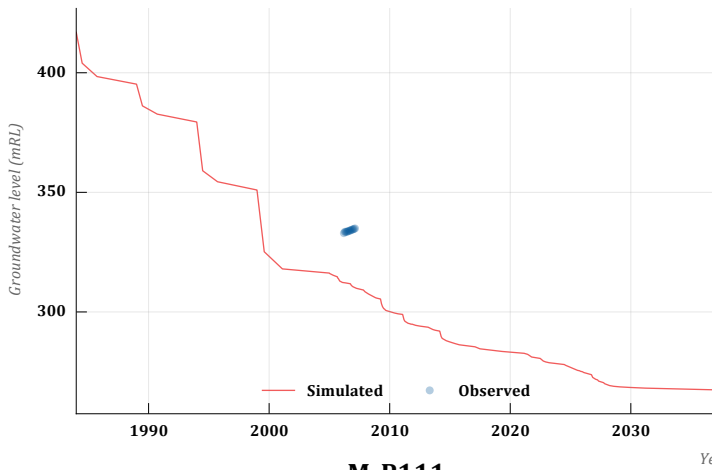
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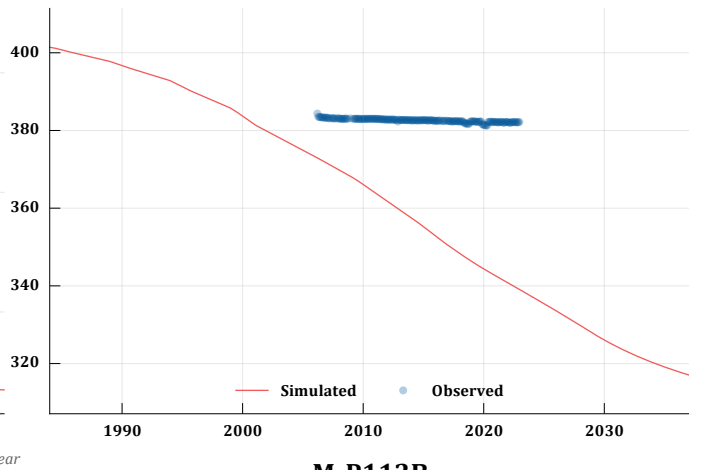
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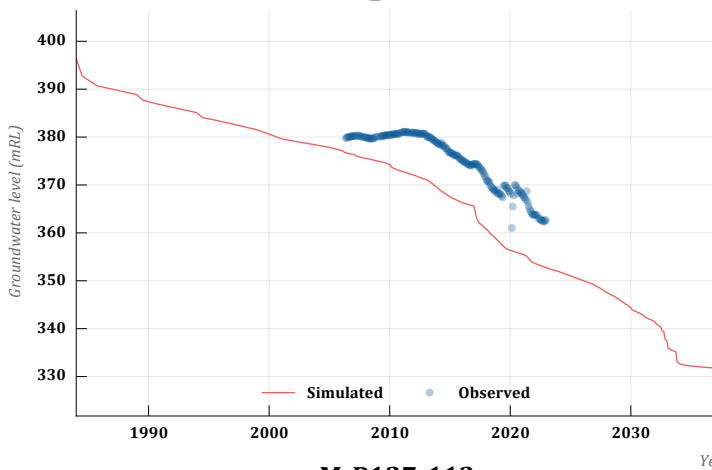
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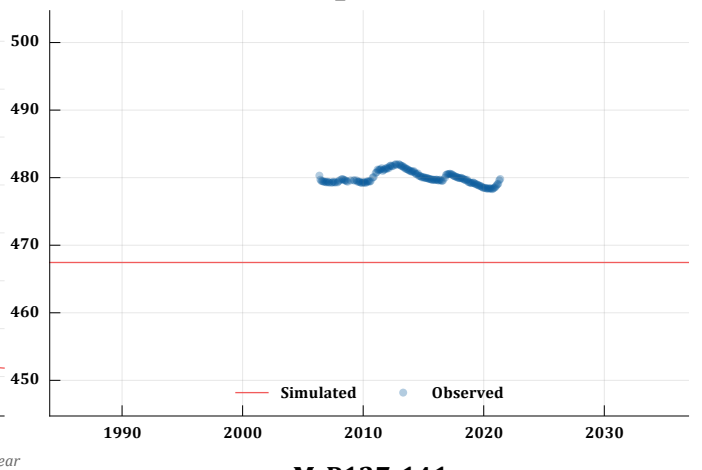
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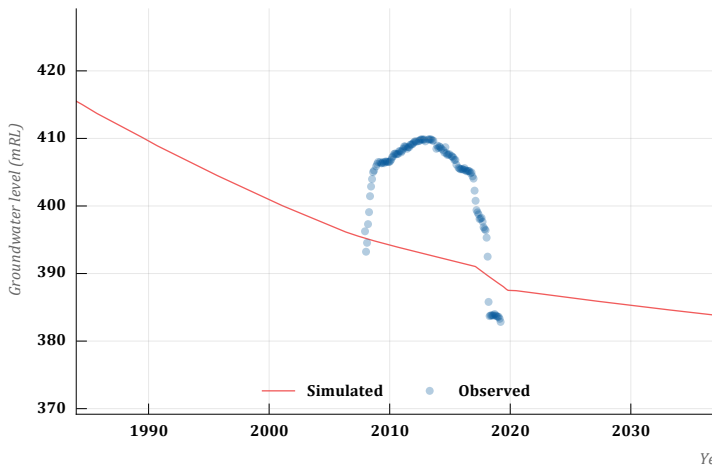
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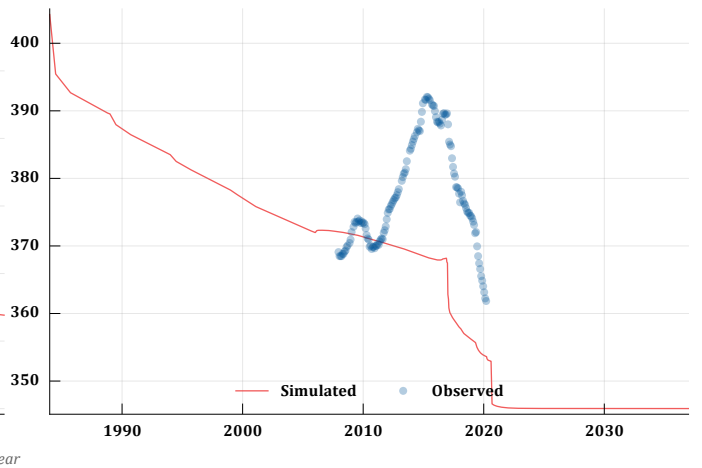
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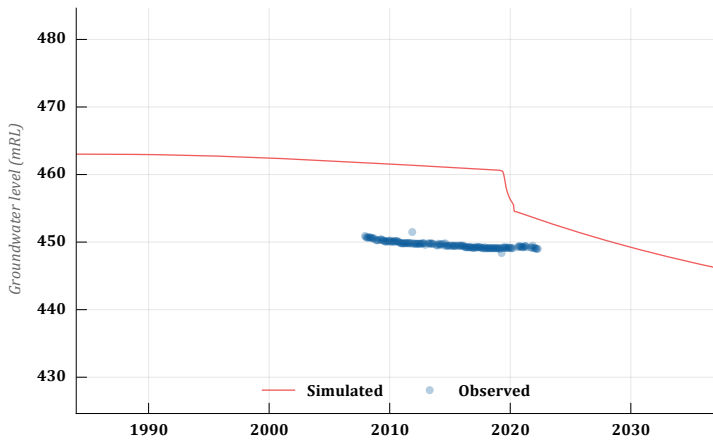
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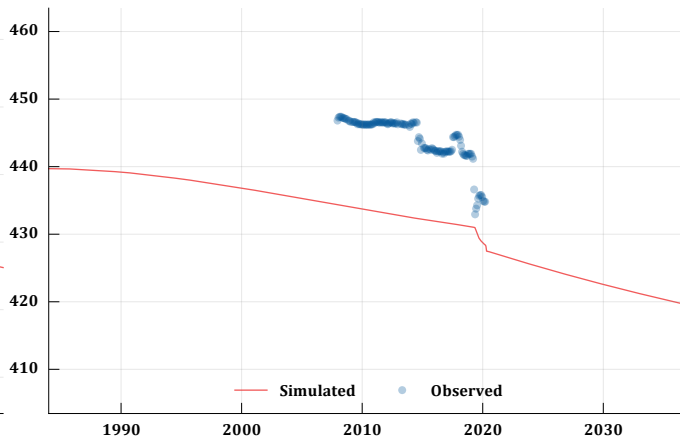
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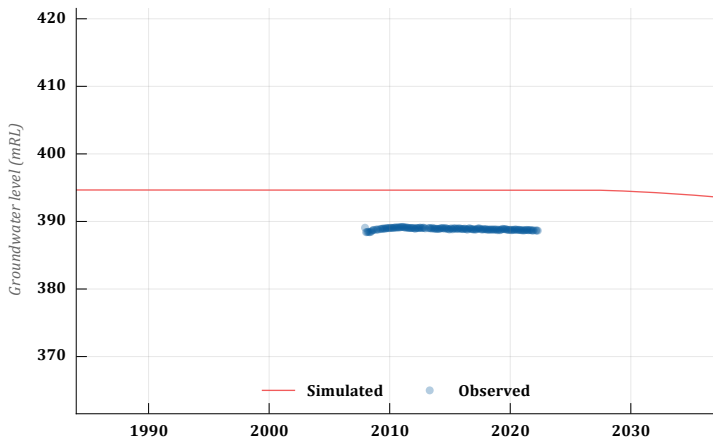
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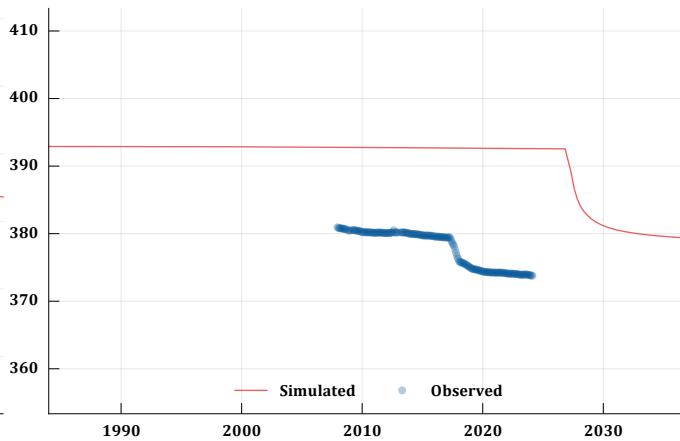
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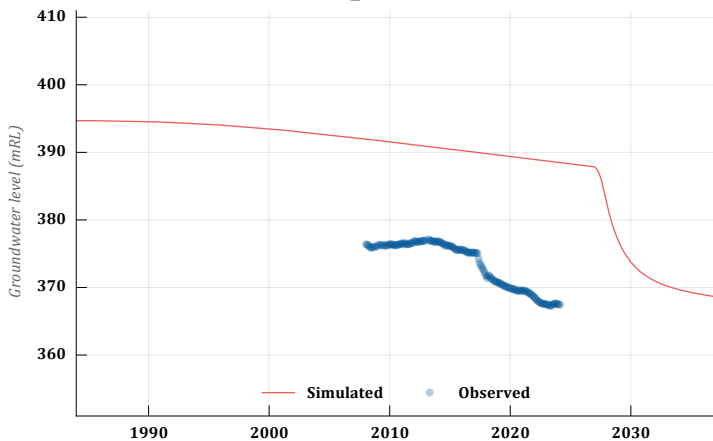
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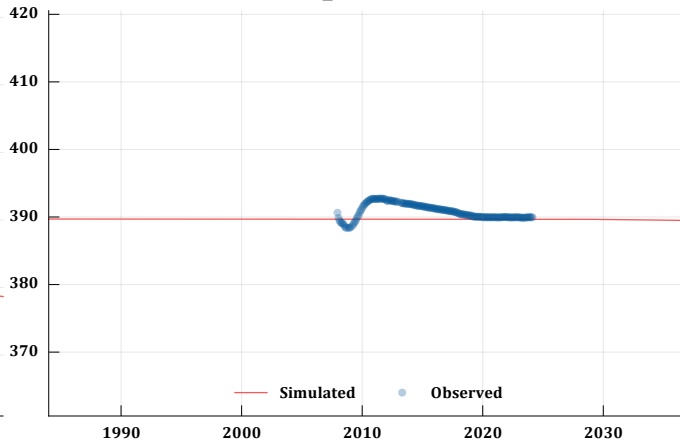
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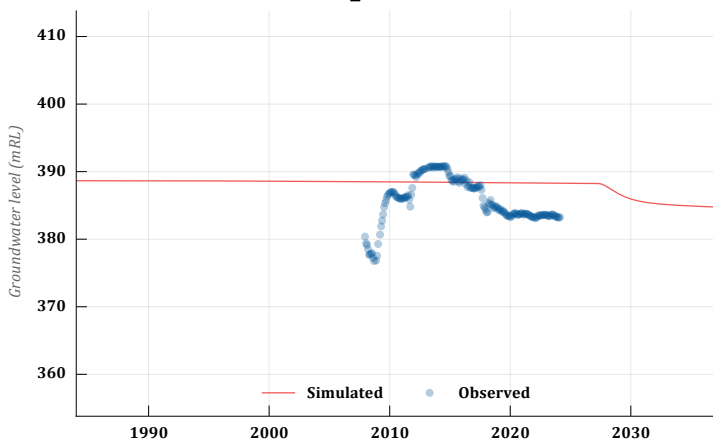
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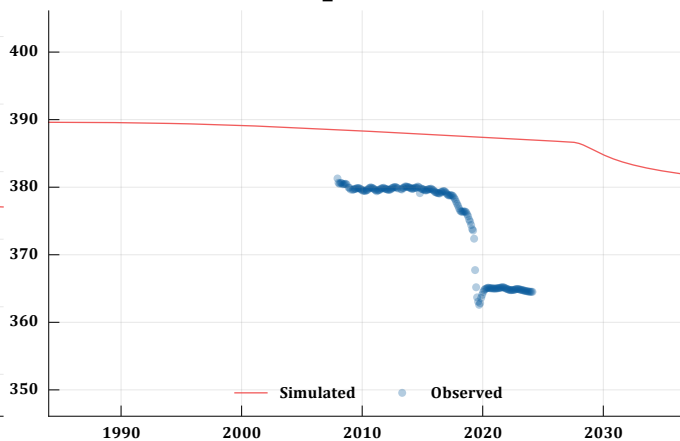
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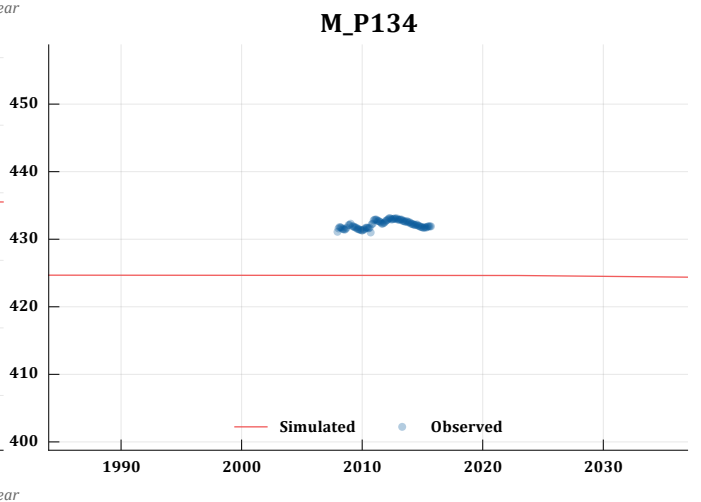
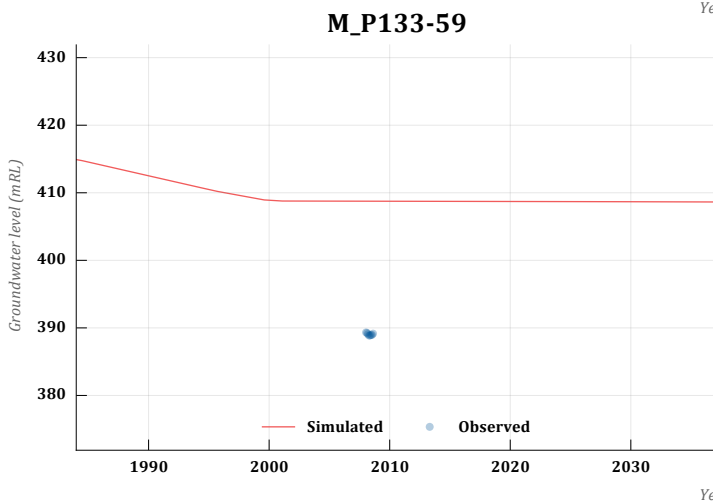
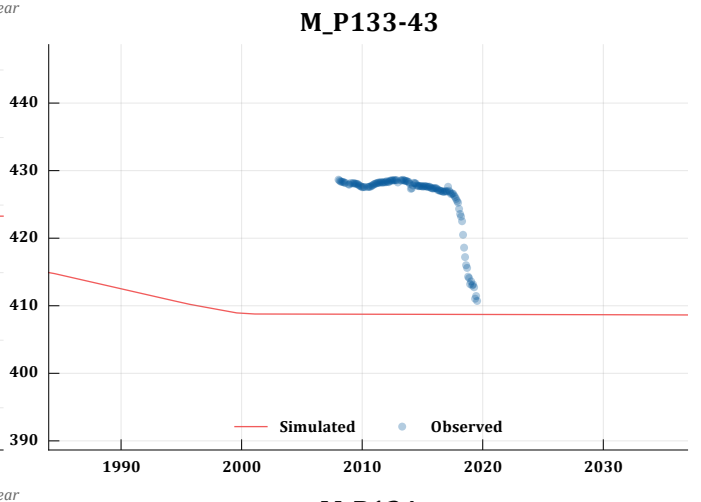
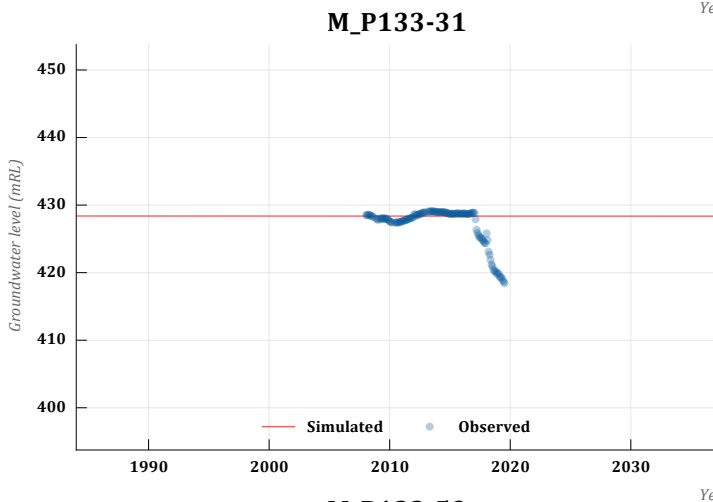
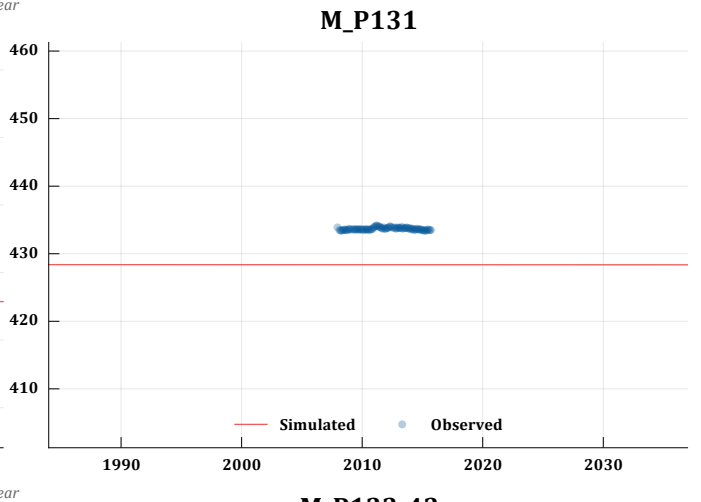
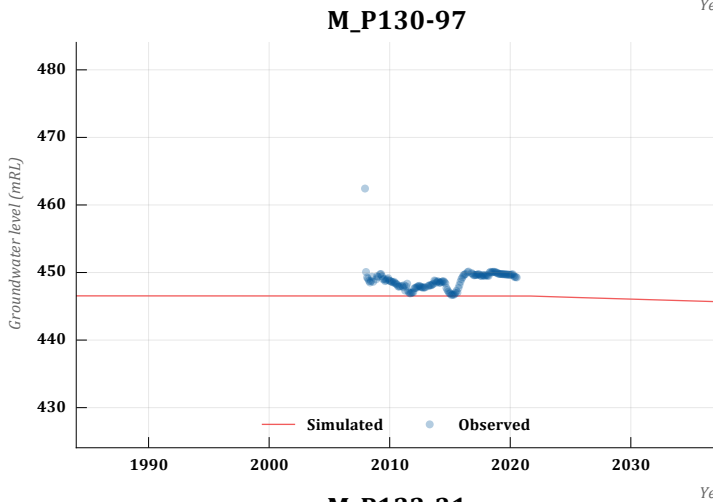
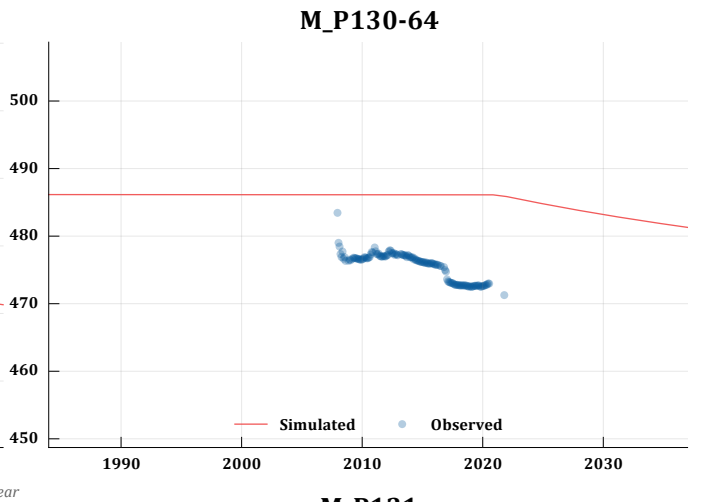
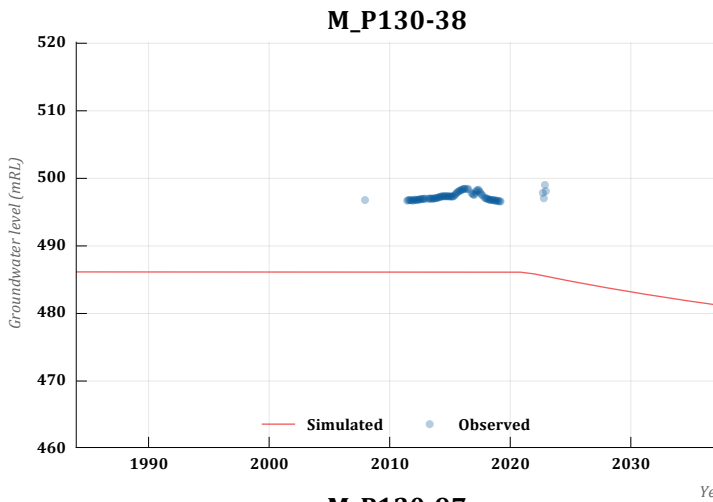


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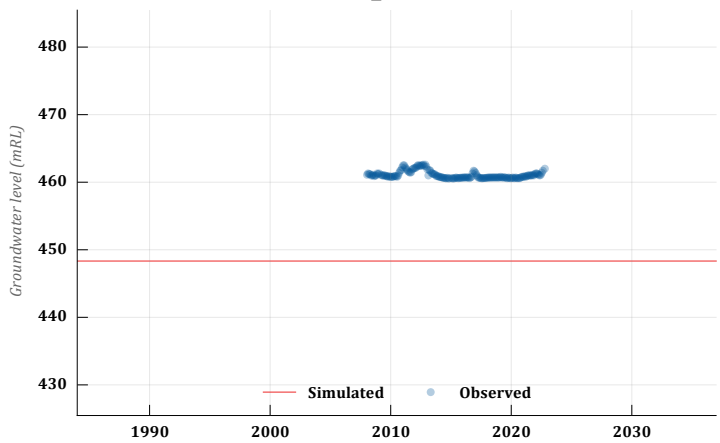


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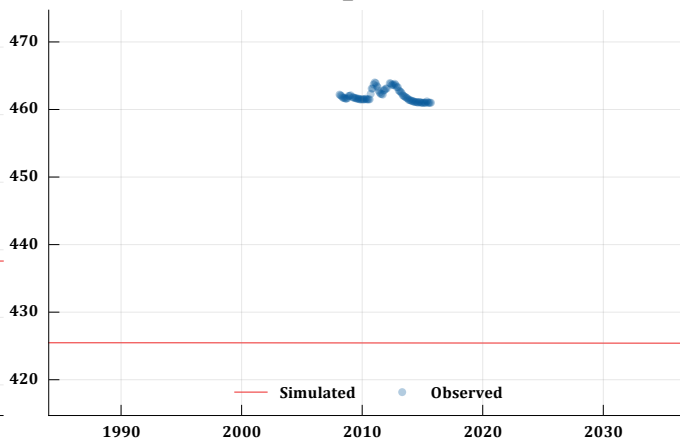




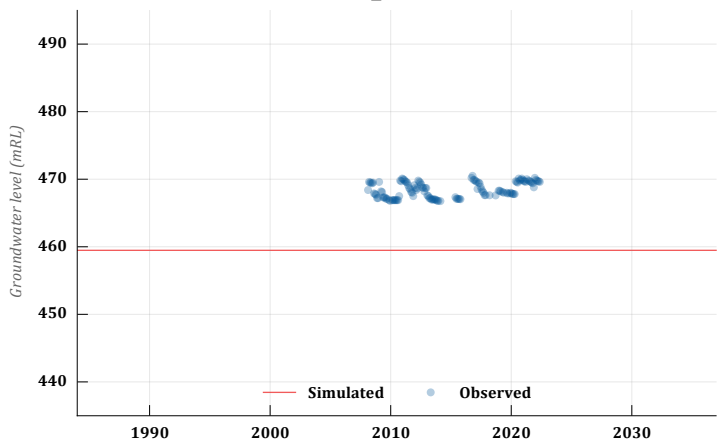
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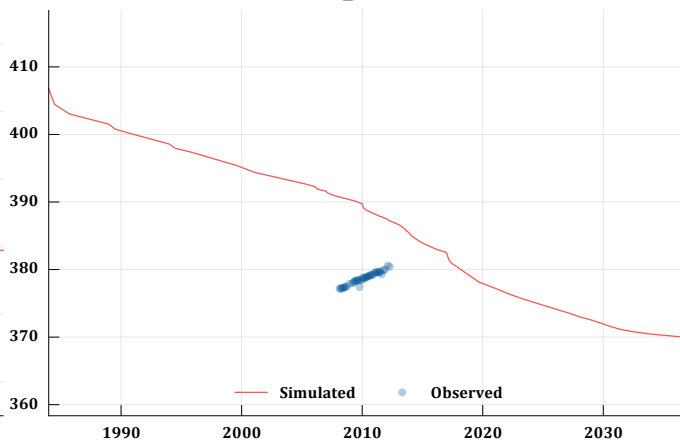
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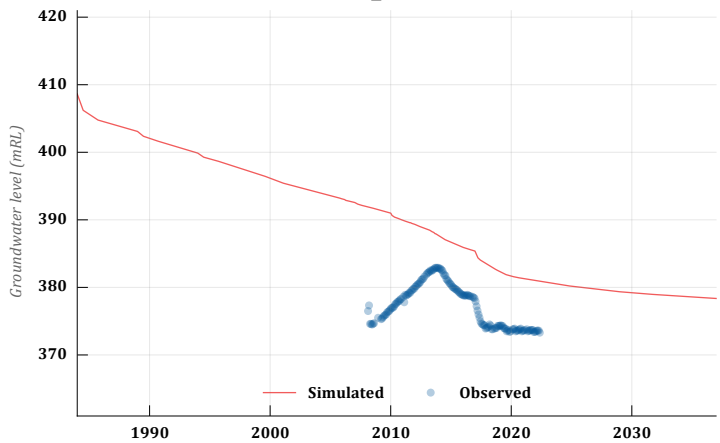
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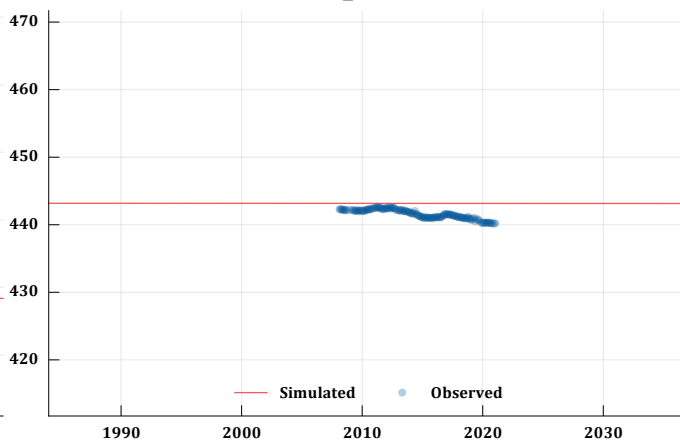
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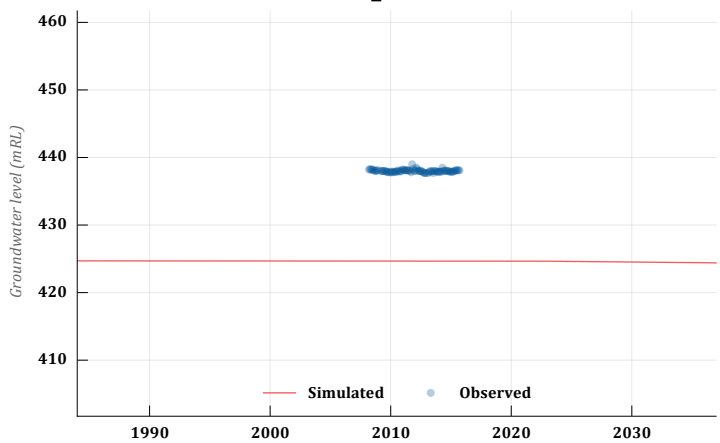
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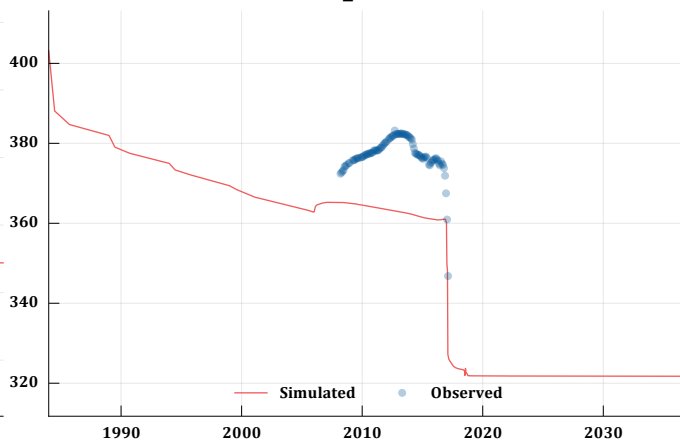
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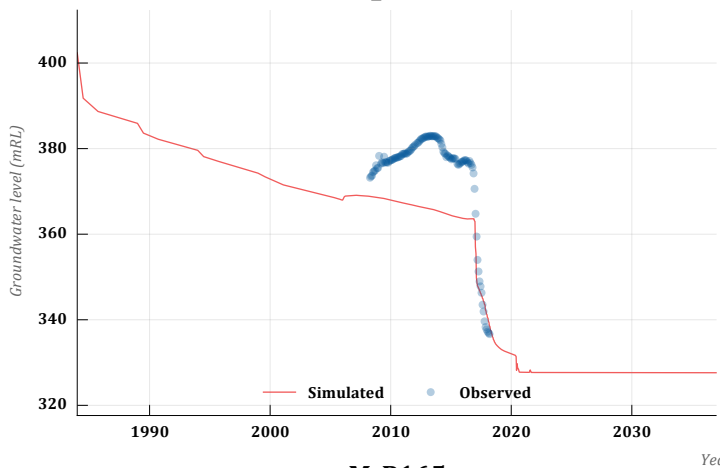
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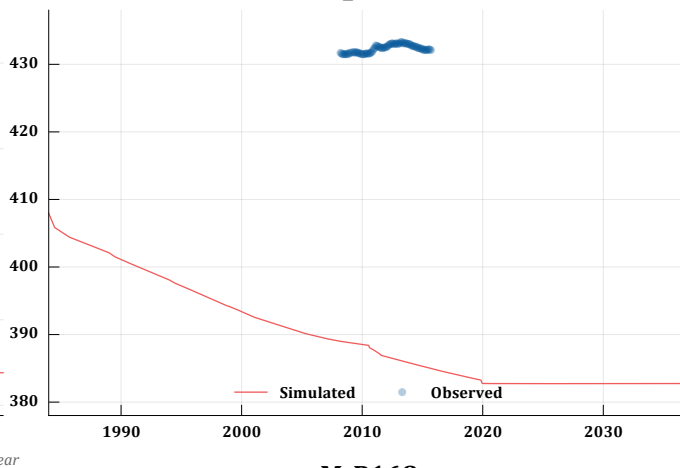
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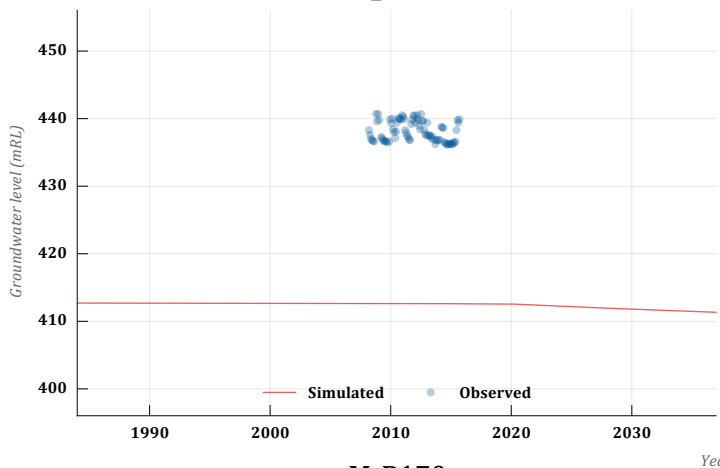
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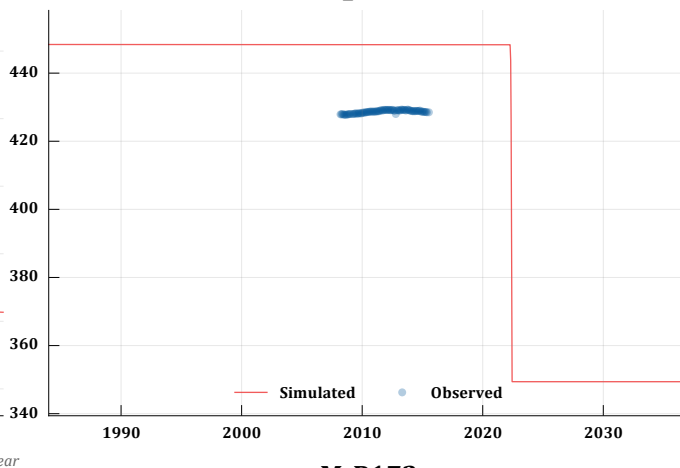
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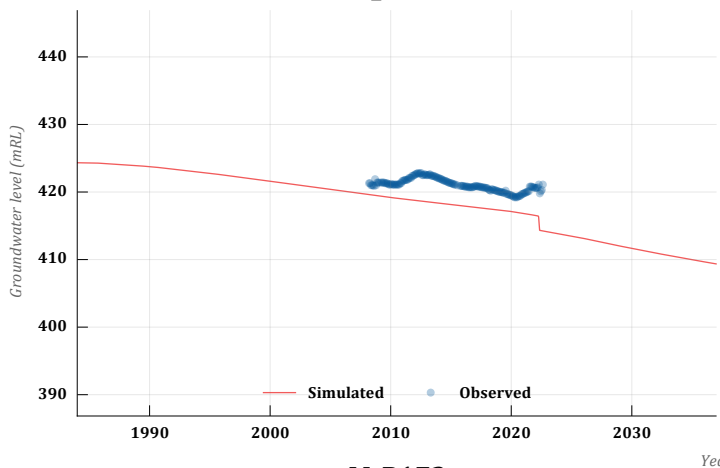
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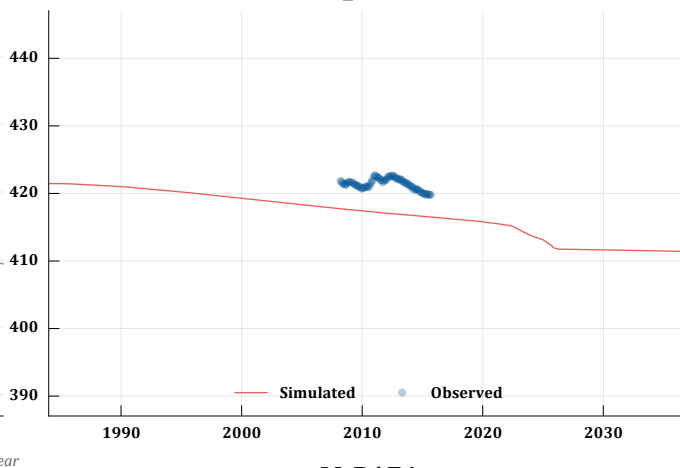
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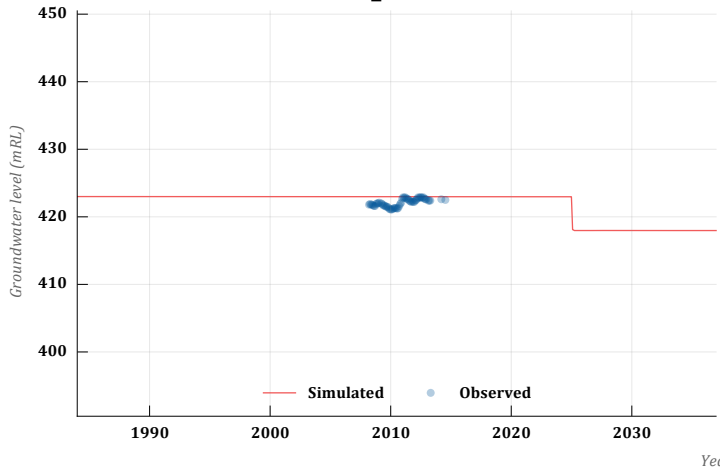
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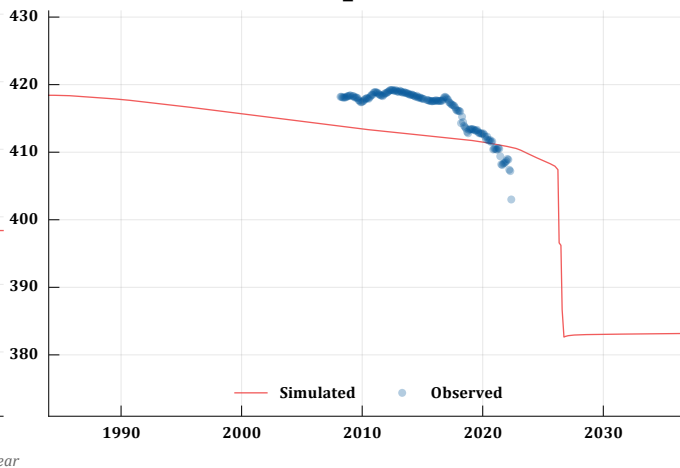
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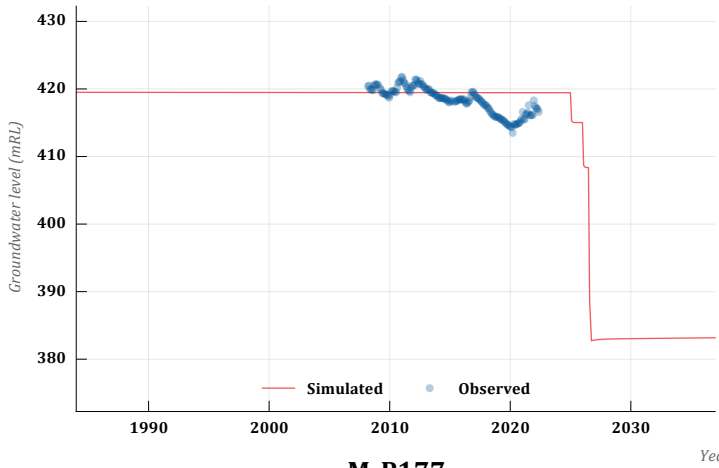
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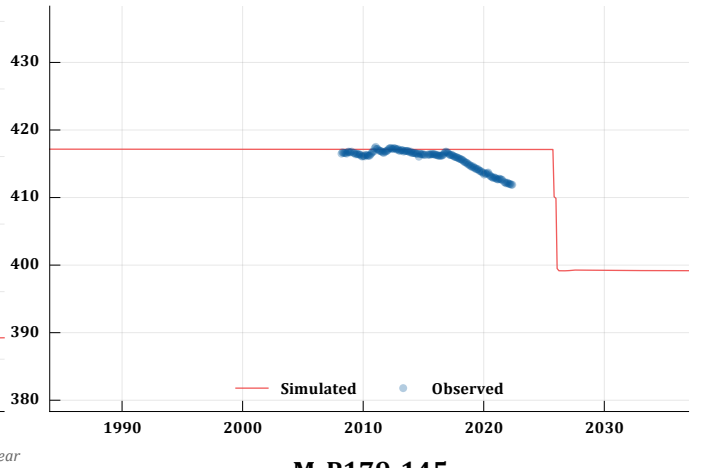
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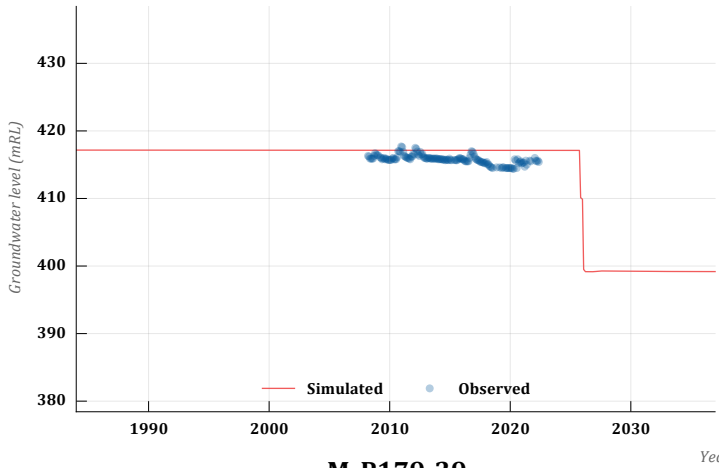
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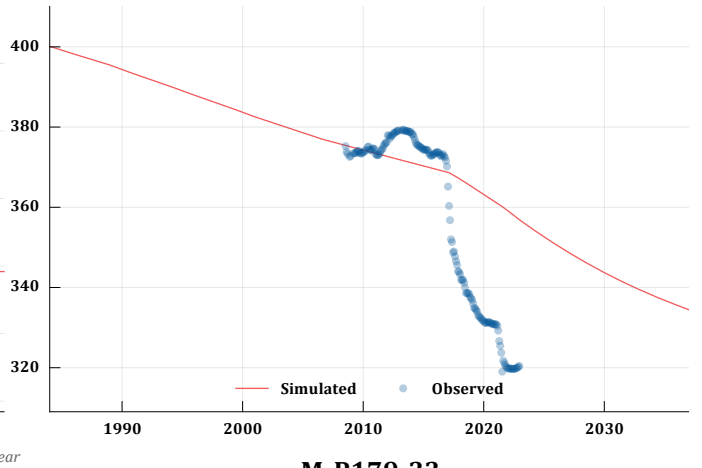
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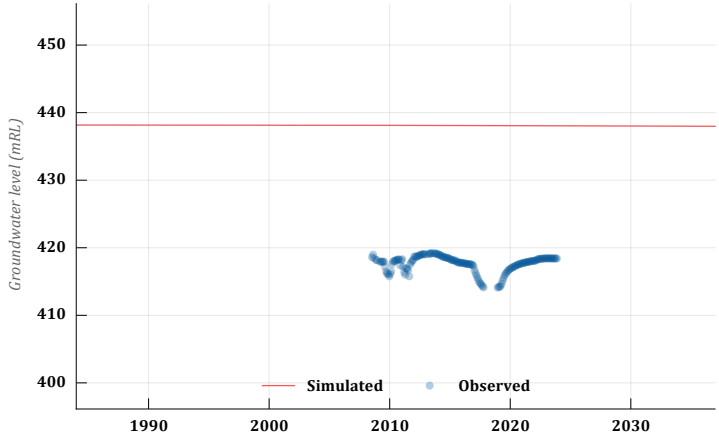
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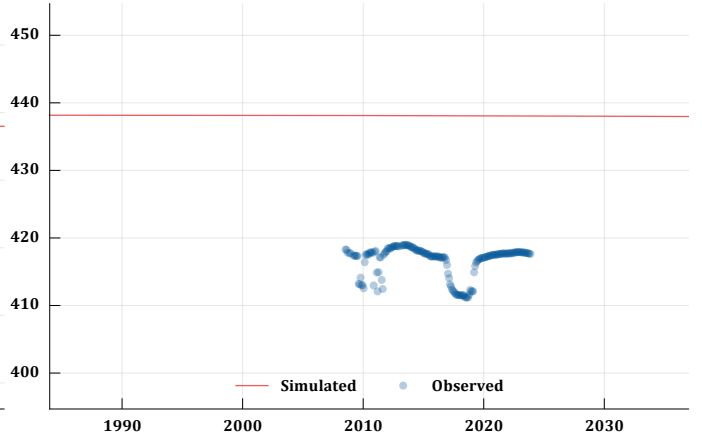
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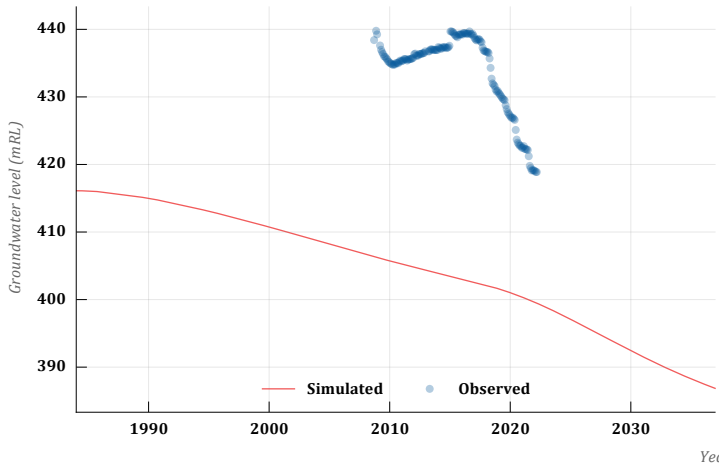
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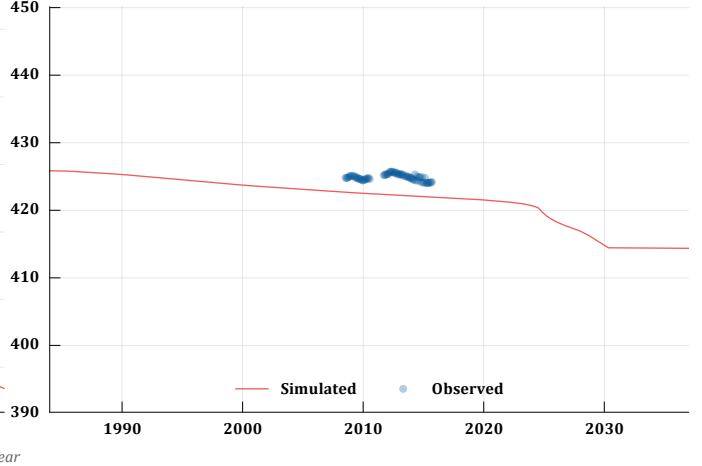
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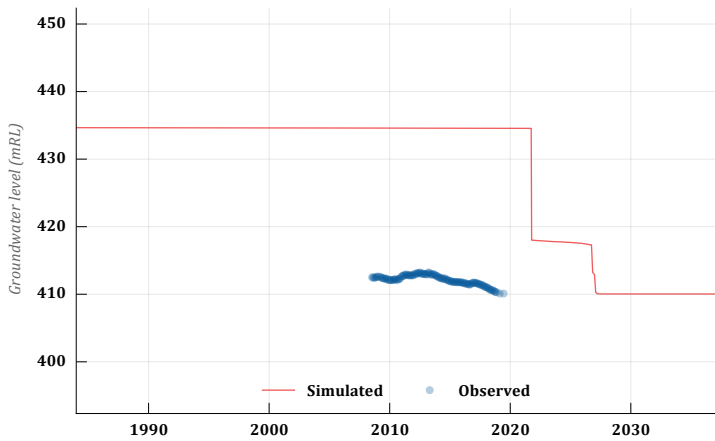
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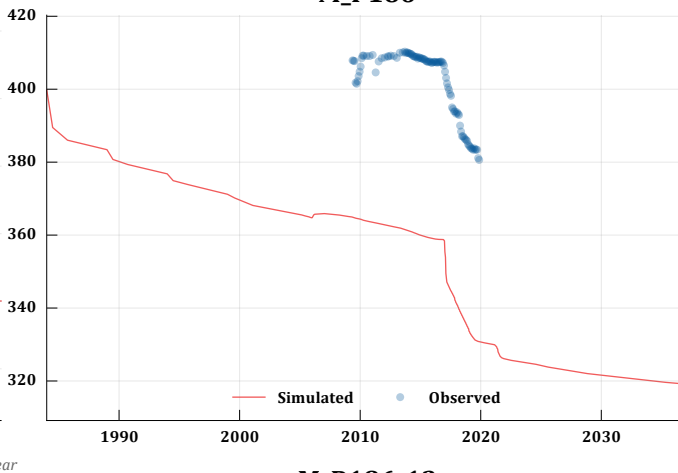
M_P181



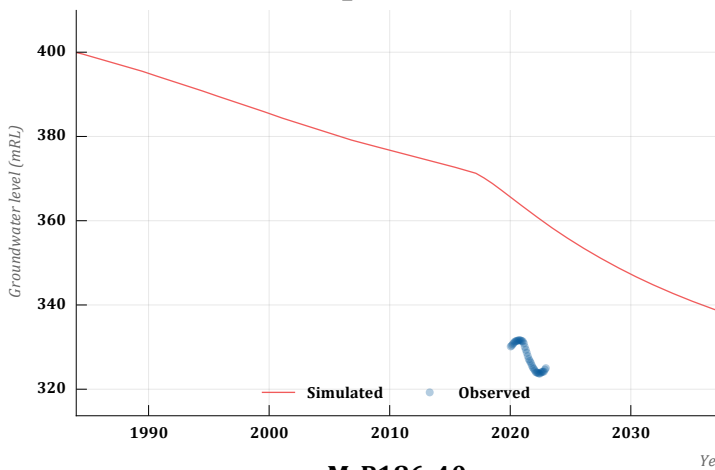
M_P184



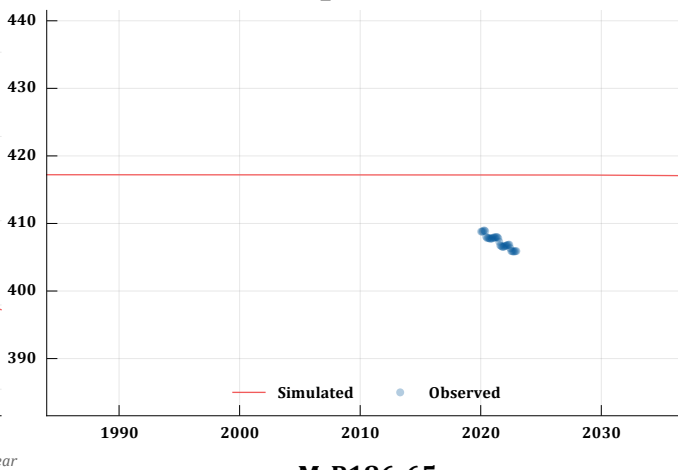
M_P186



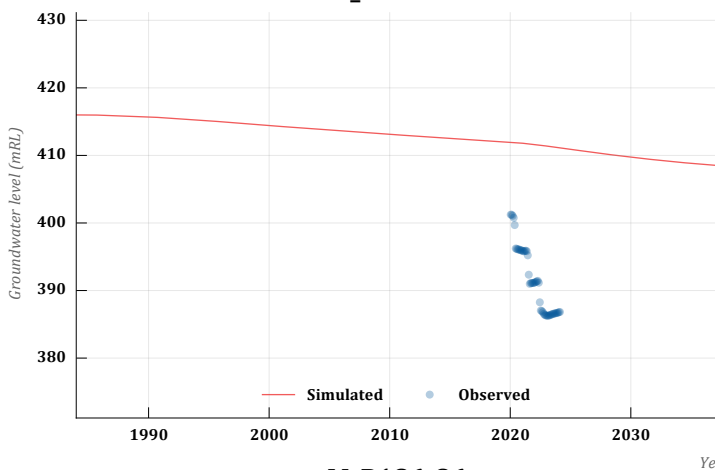
M_P186-118



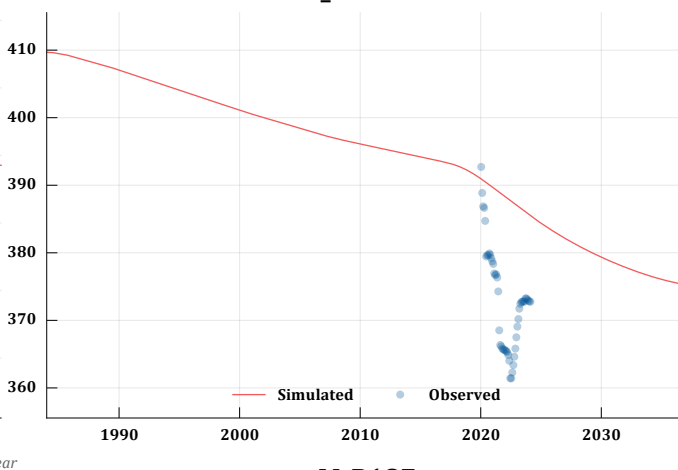
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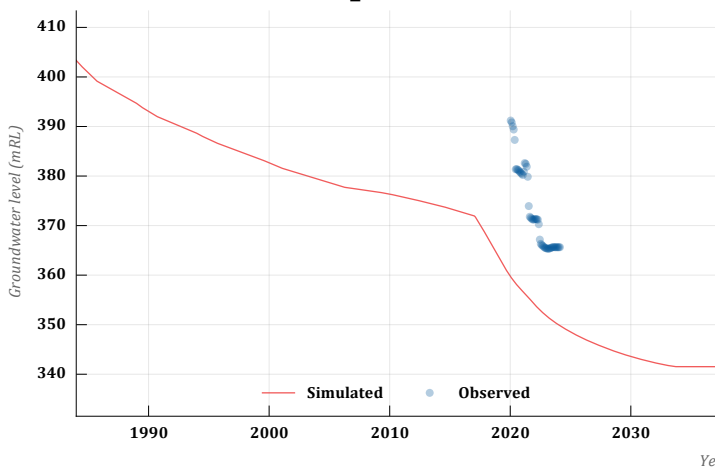
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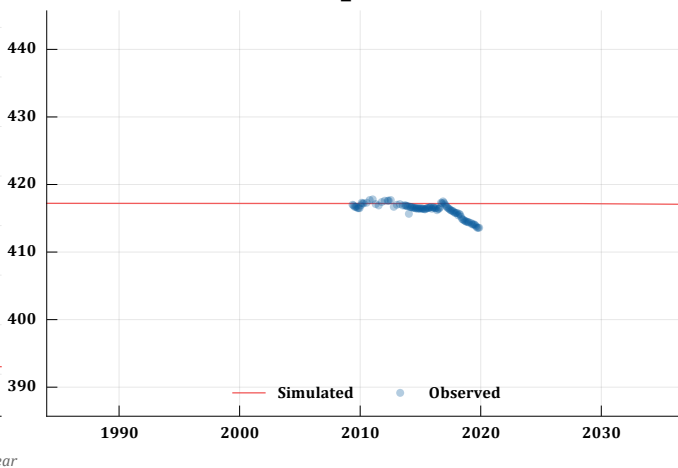
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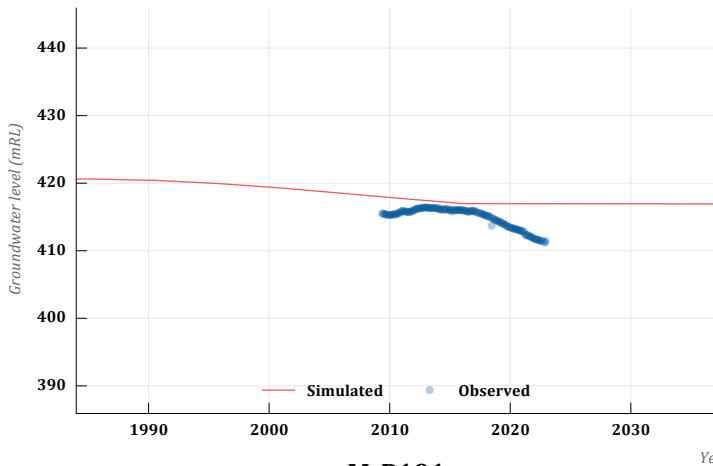
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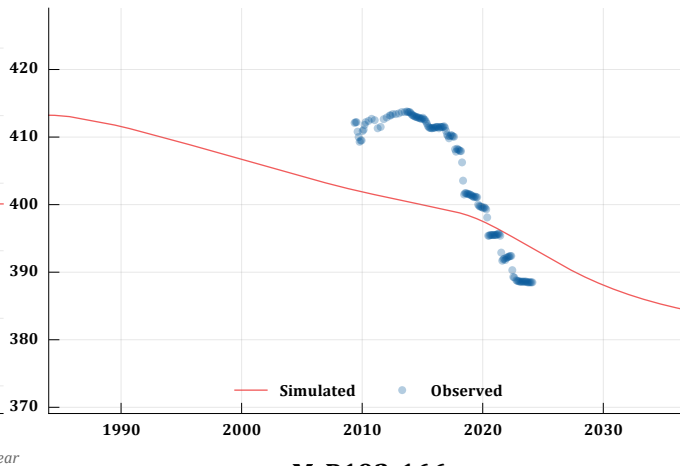
M_P187



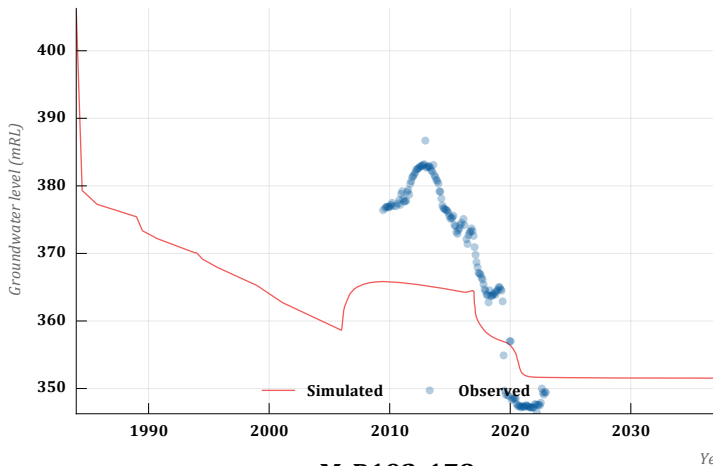
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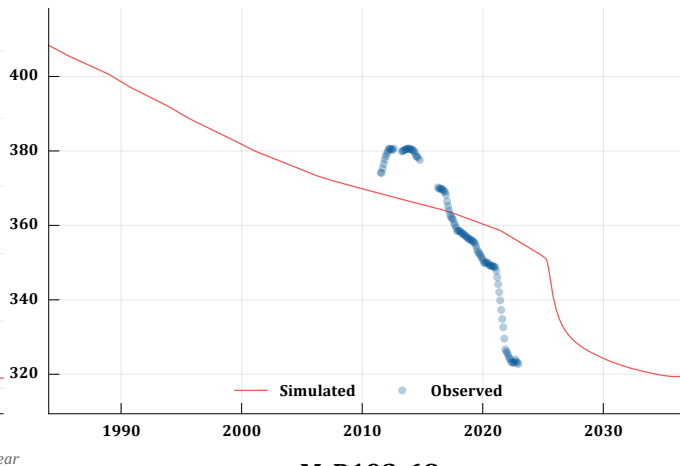
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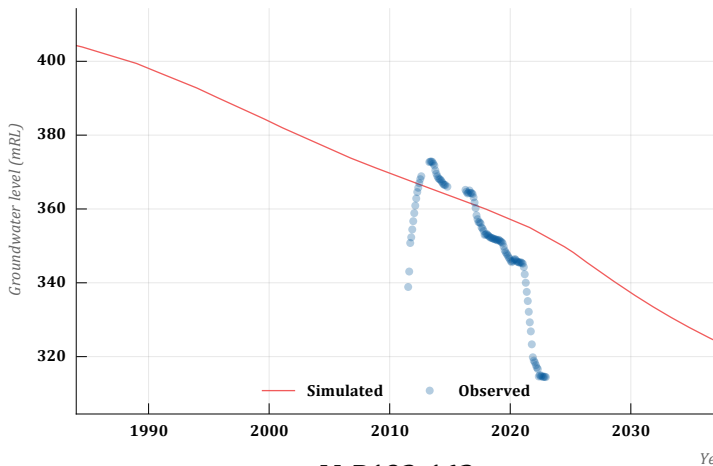
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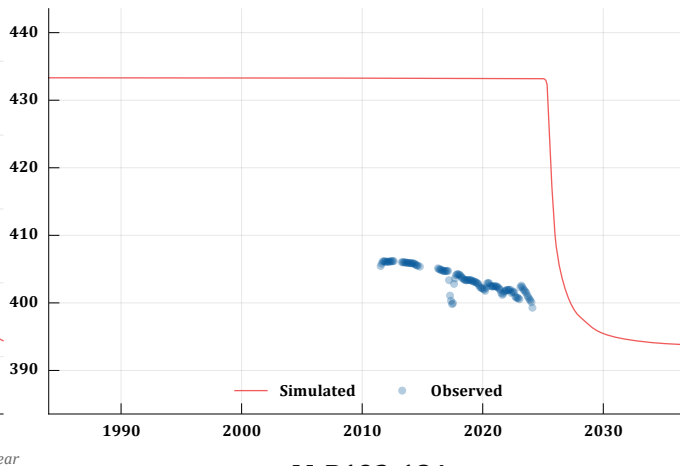
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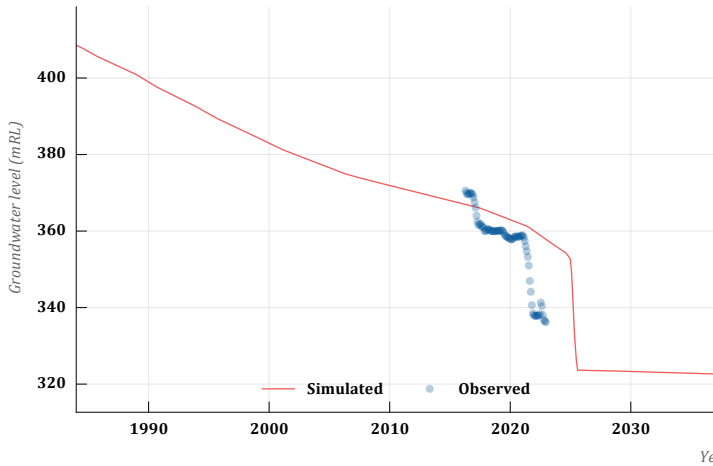
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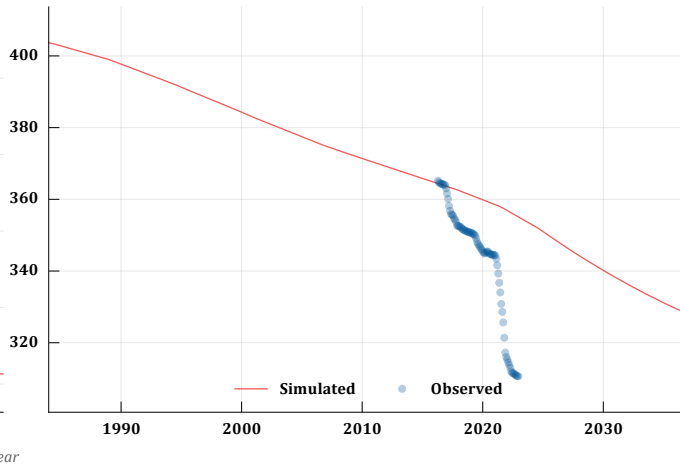
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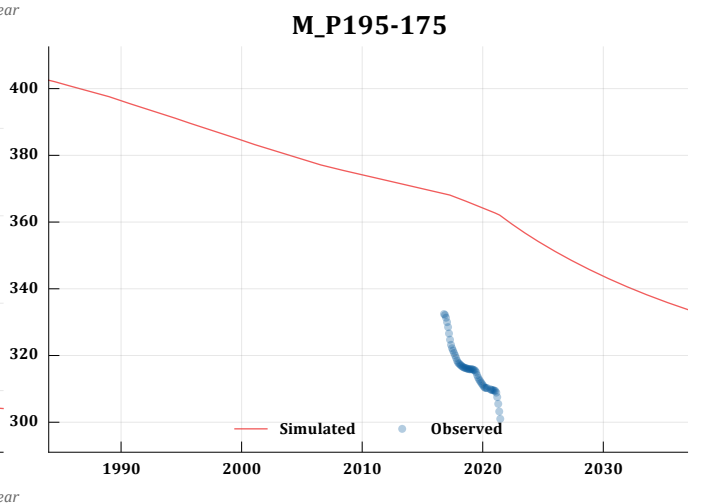
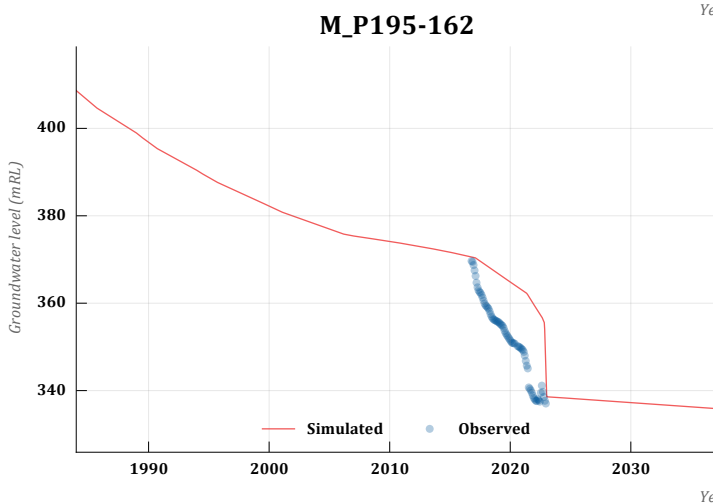
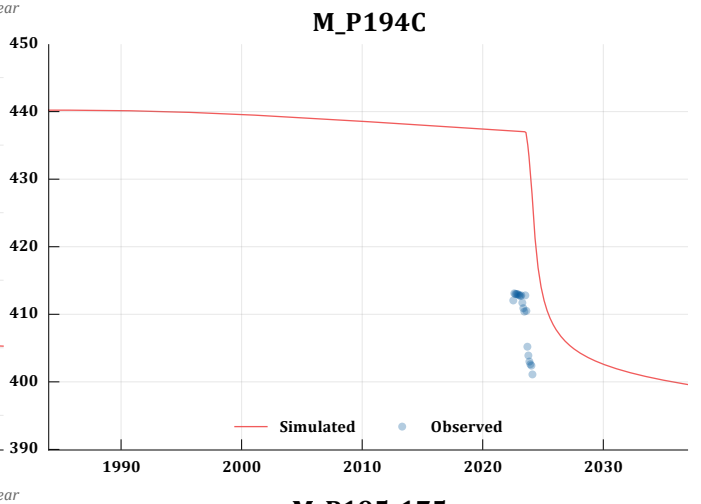
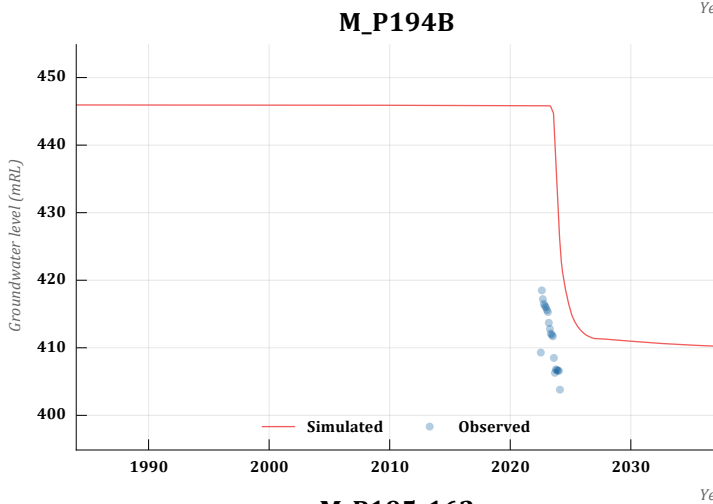
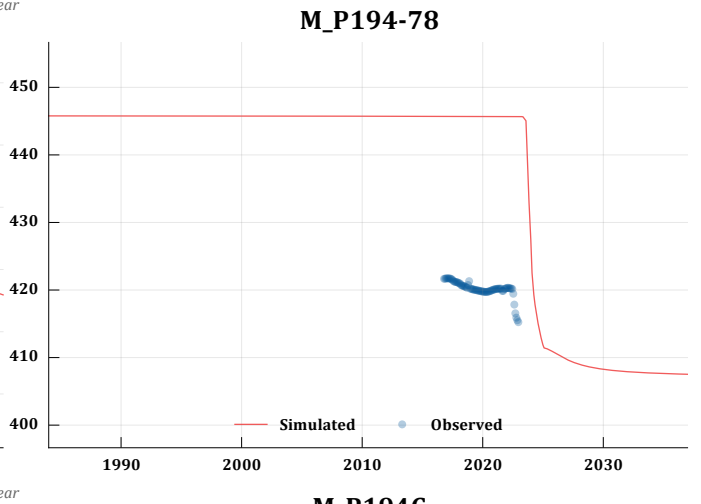
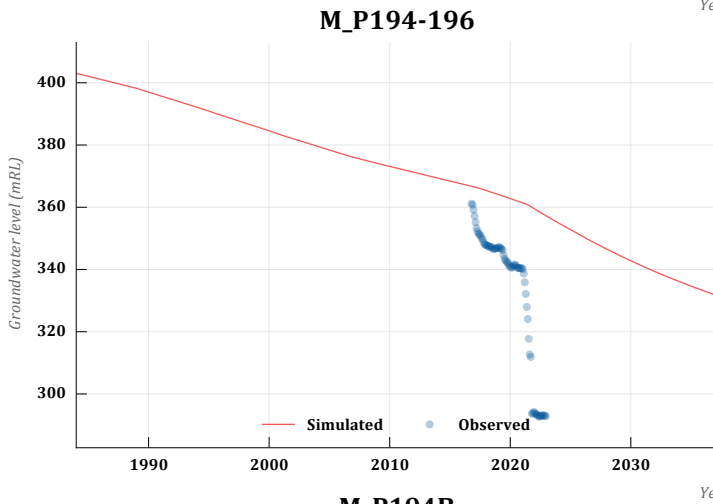
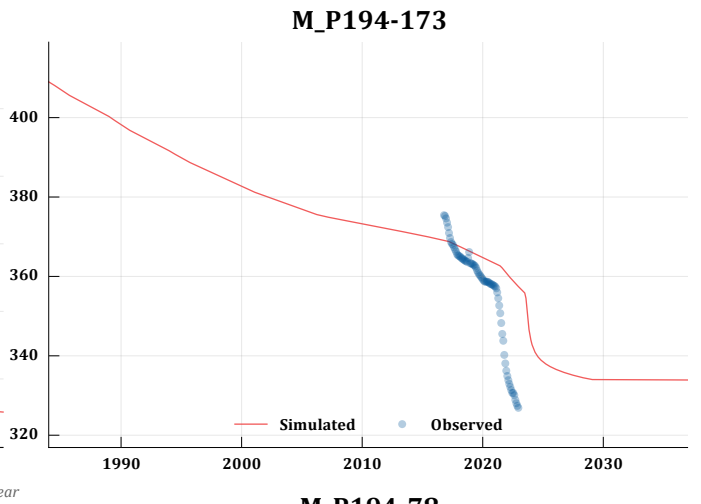
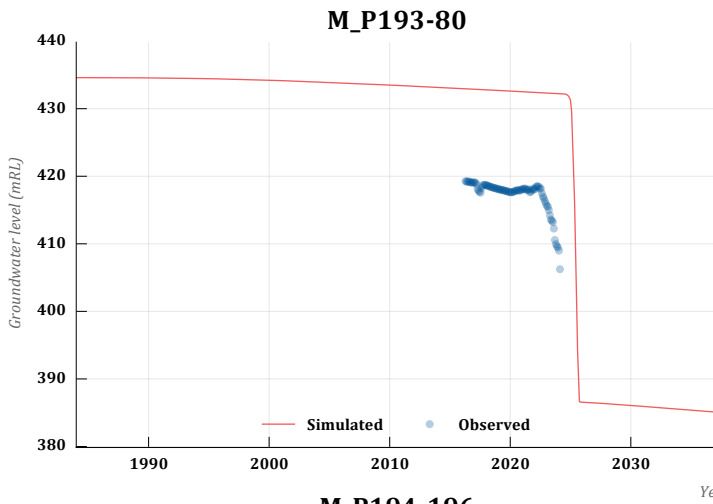


M_P193-162

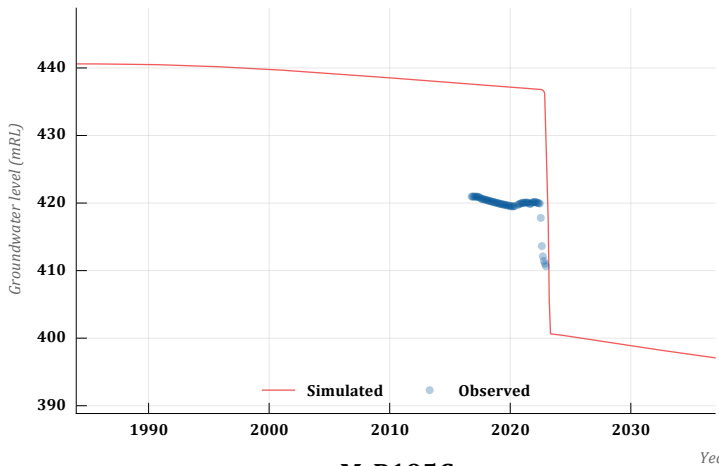


M_P193-184

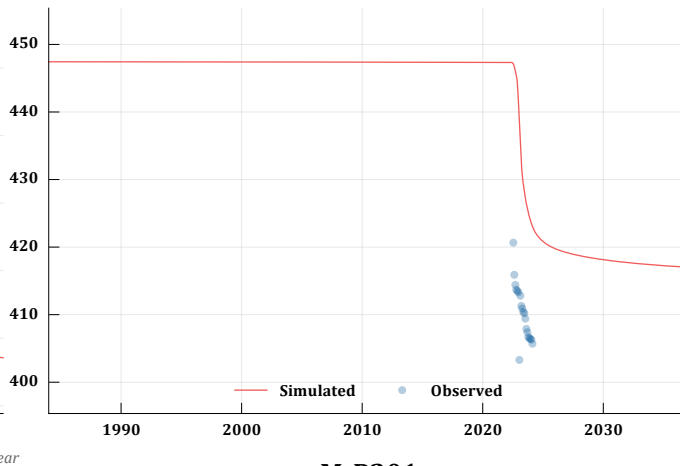




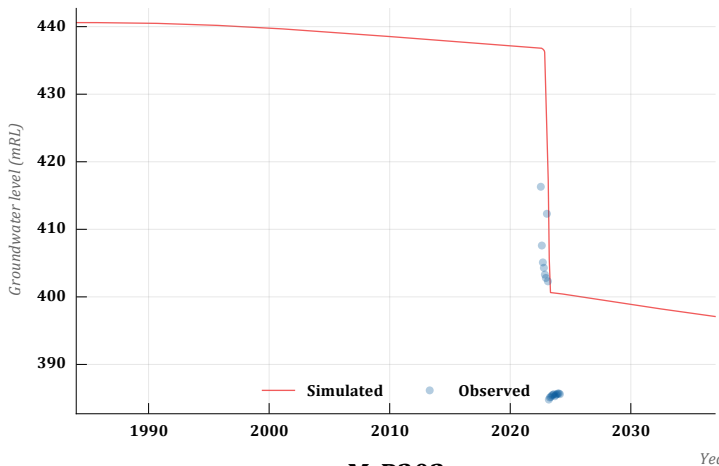
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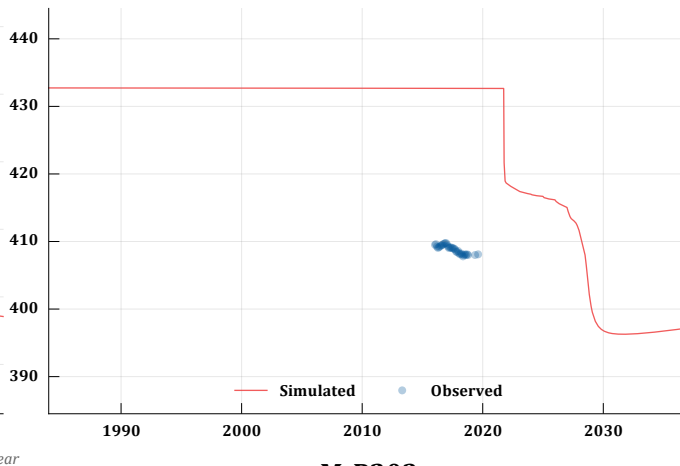
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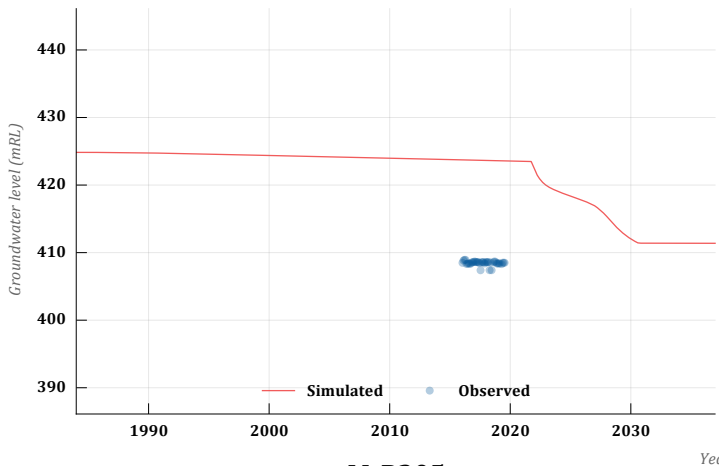
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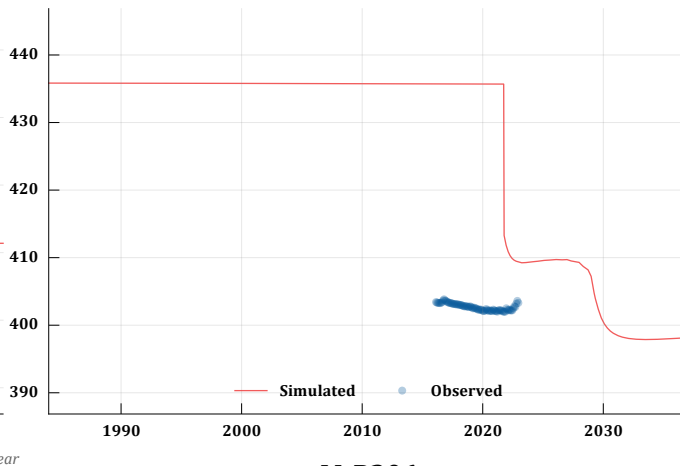
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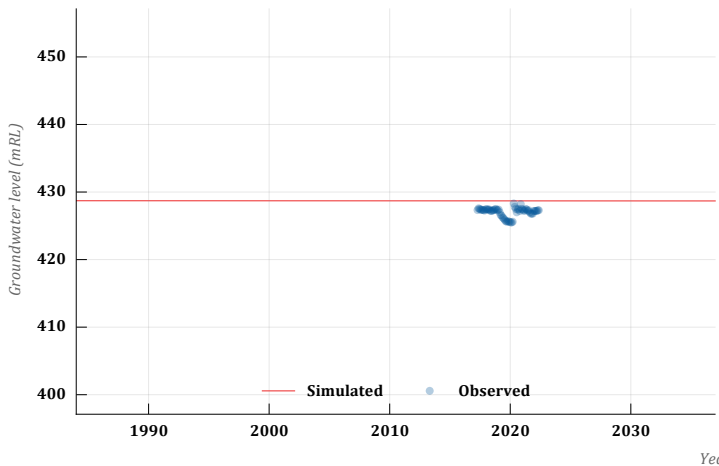
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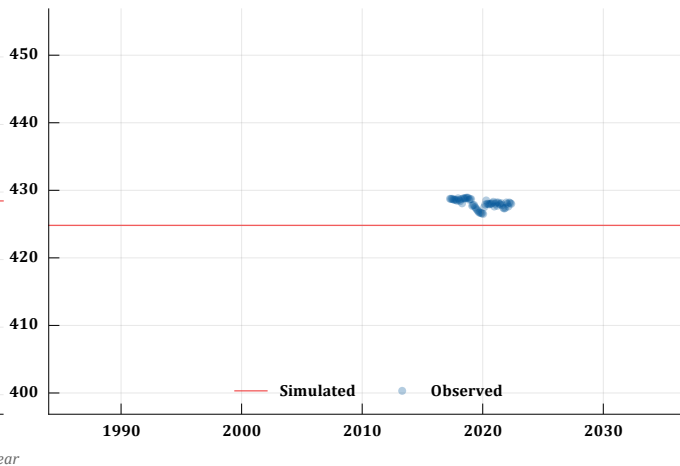
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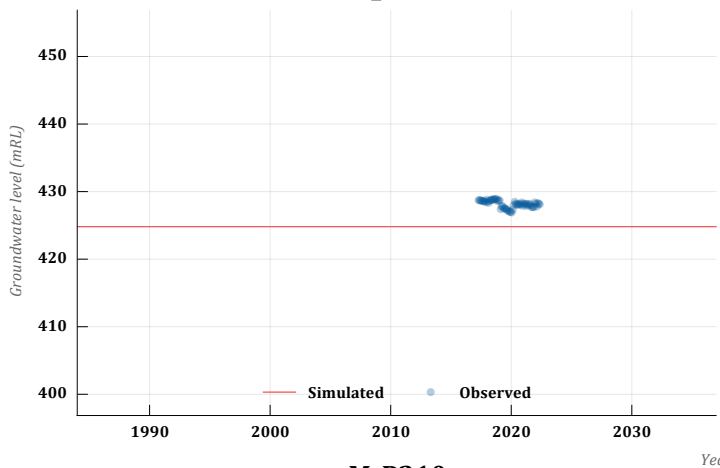
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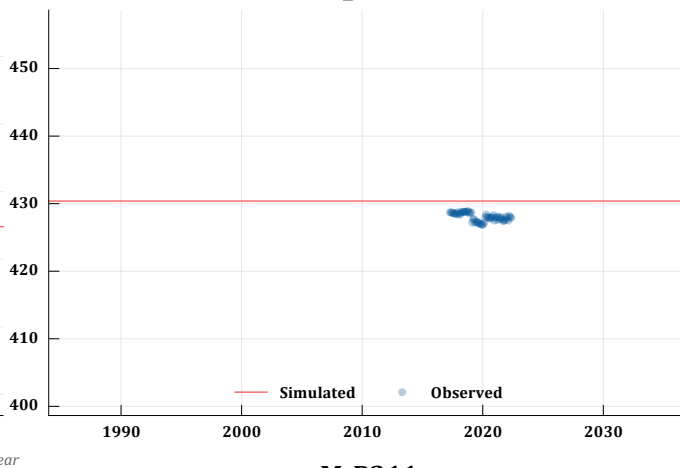
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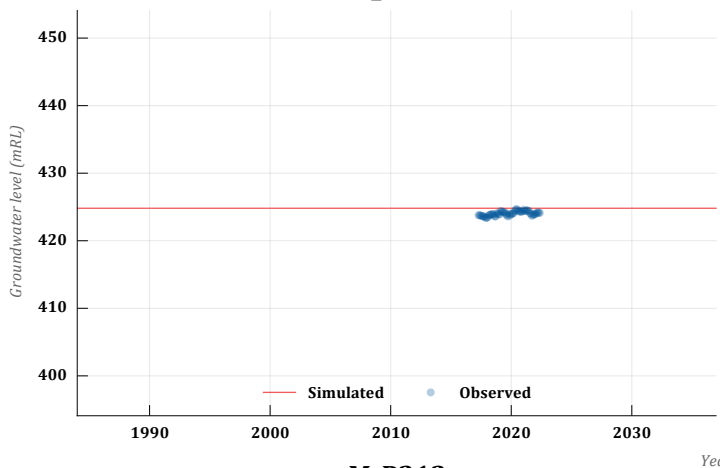
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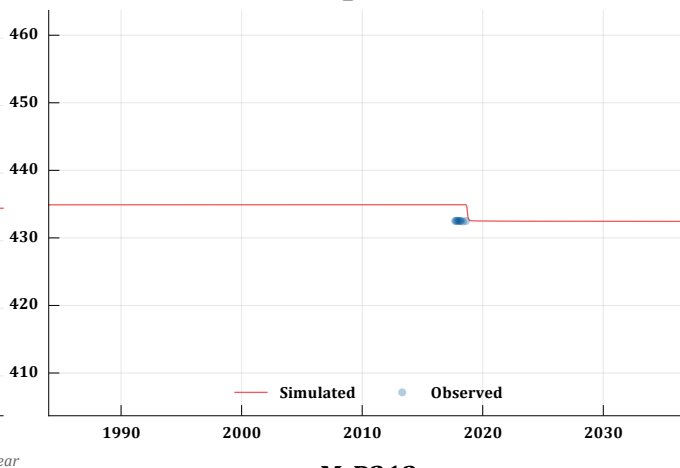
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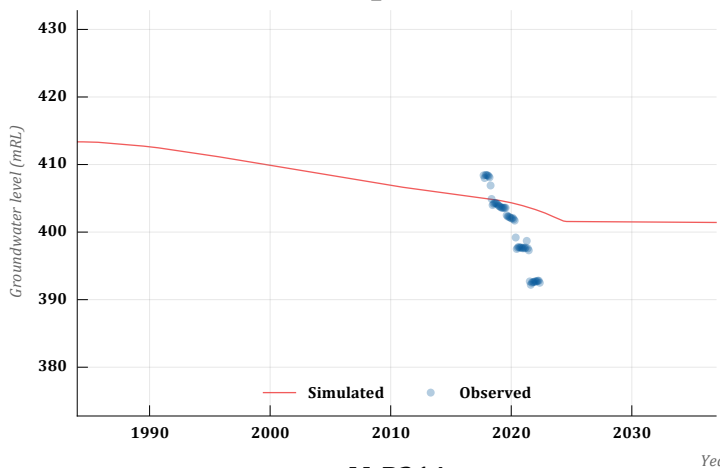
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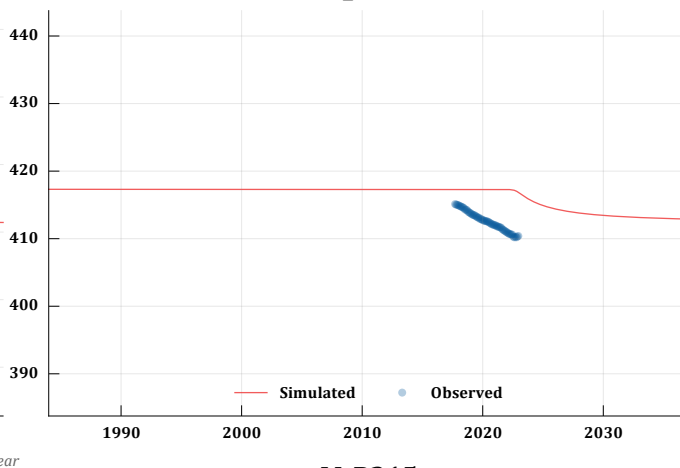
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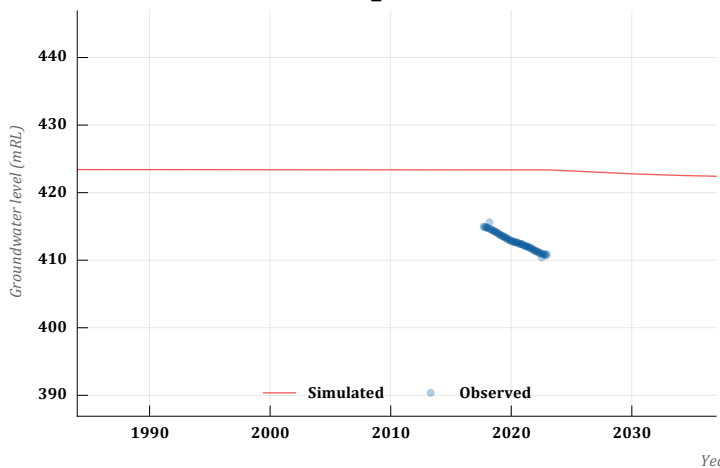
M_P212



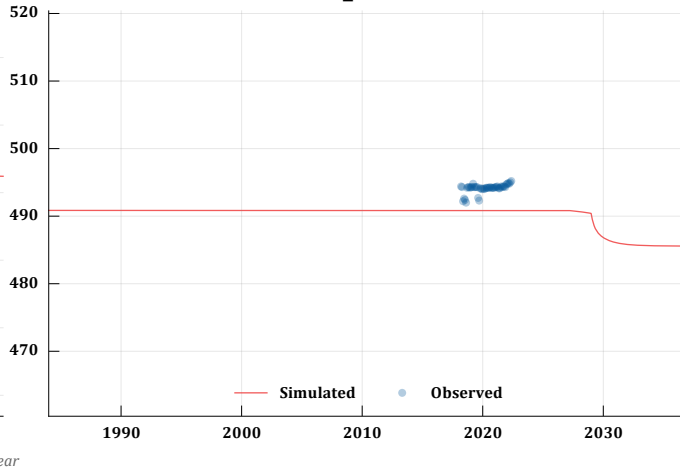
M_P213

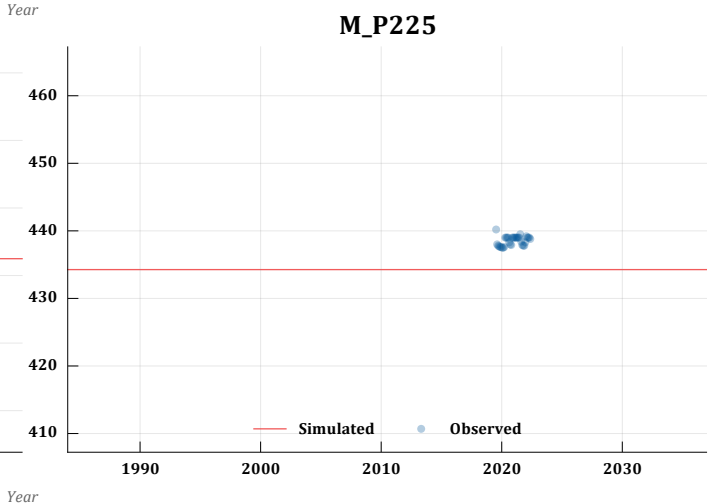
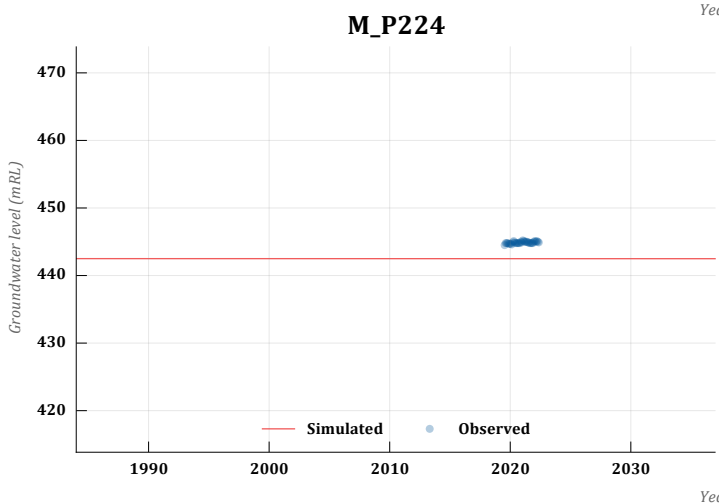
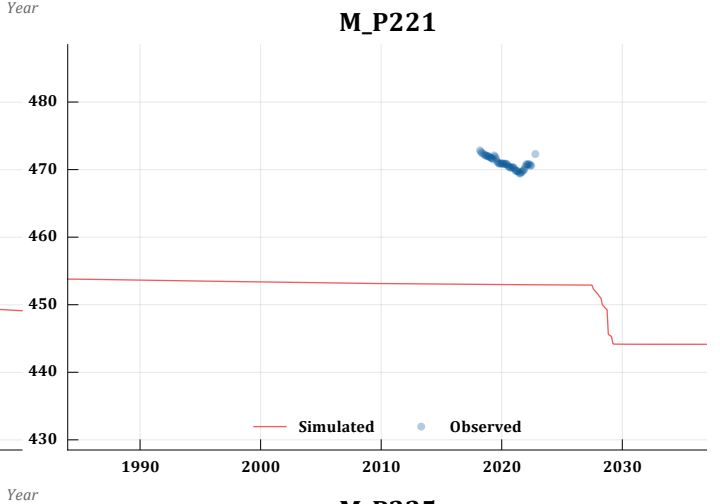
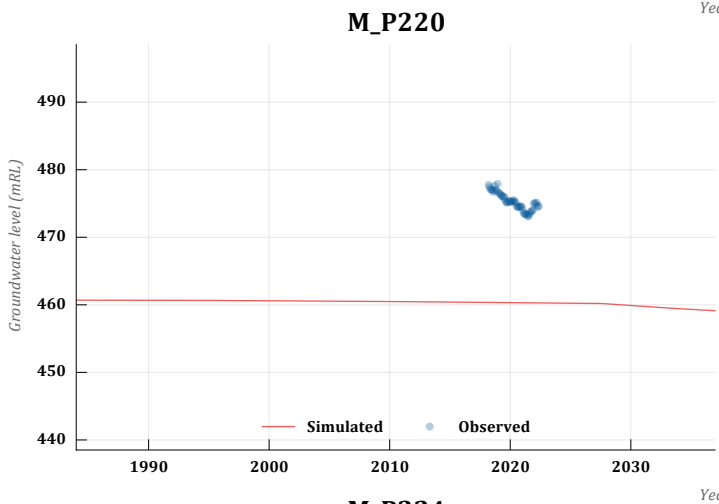
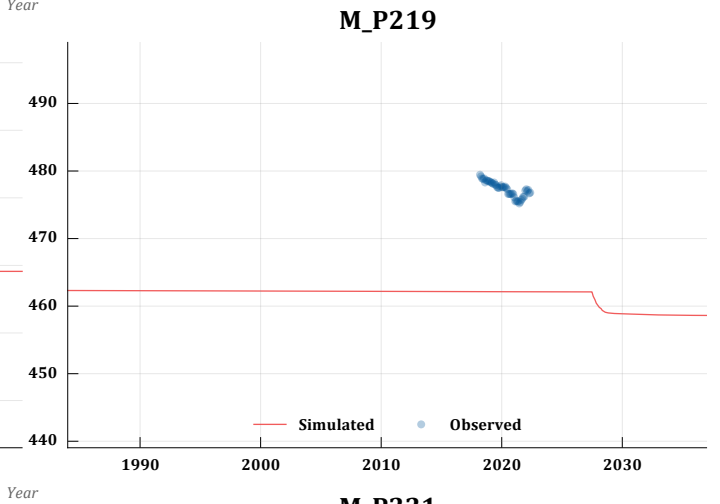
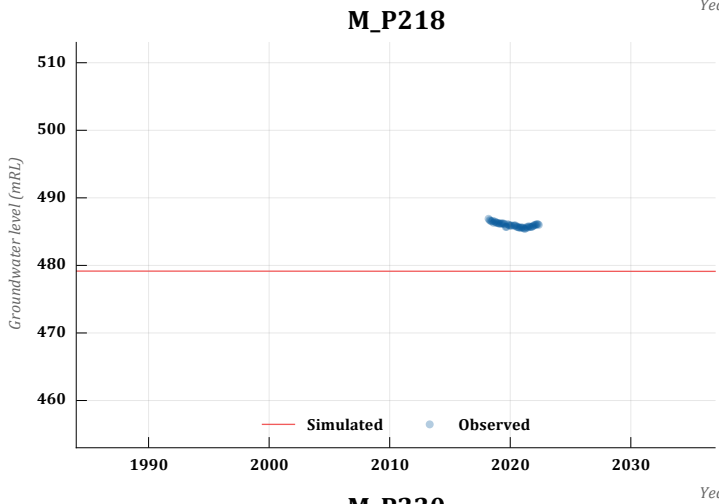
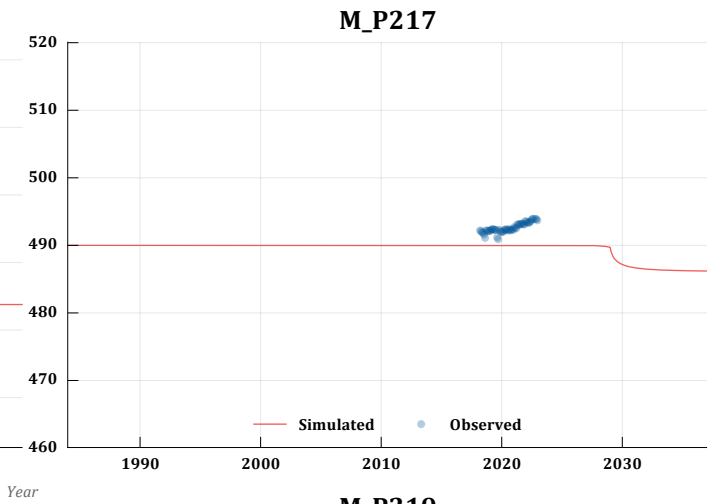
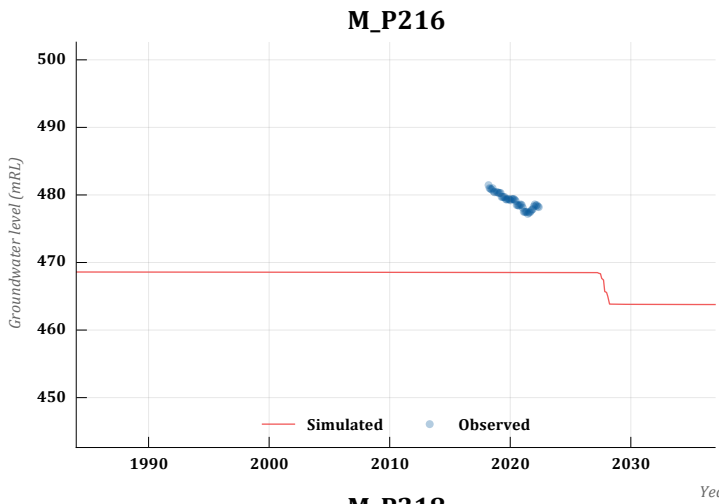


M_P214

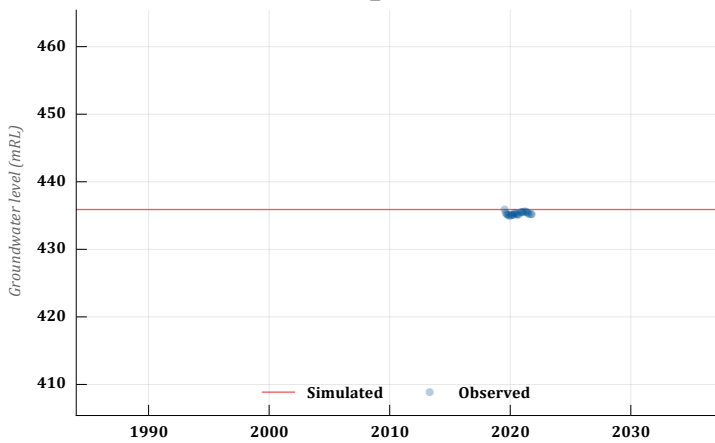


M_P215

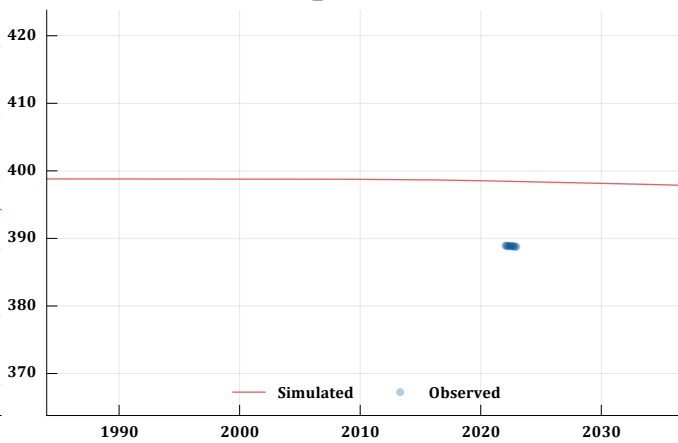




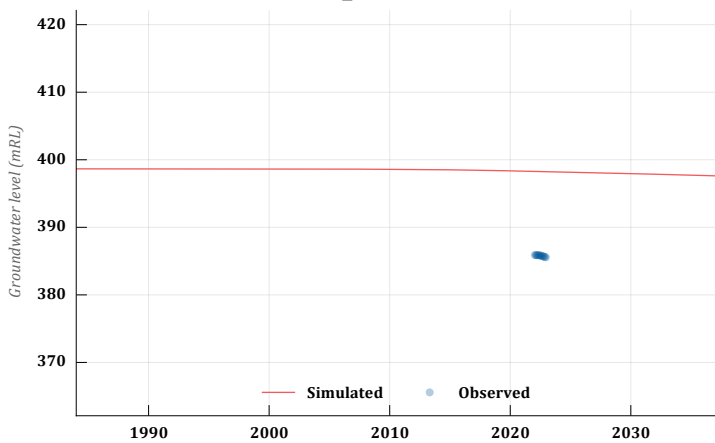
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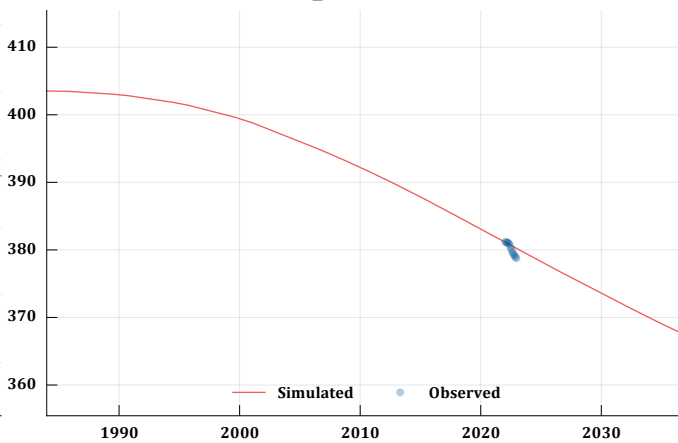
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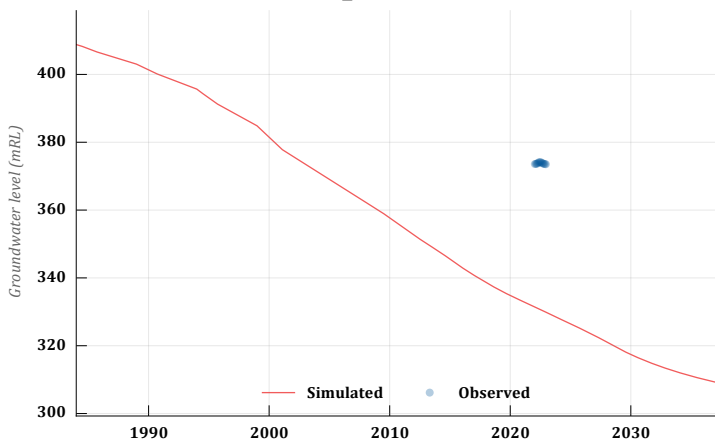
M_P229-198



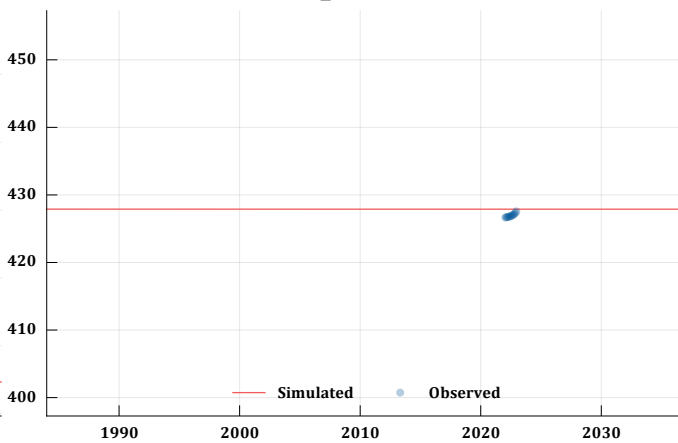
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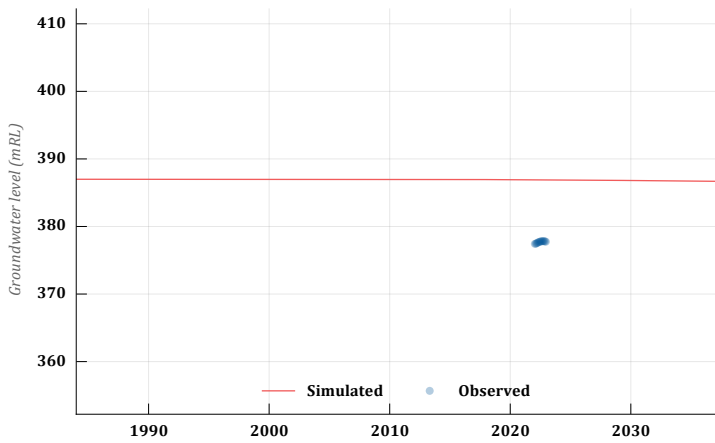
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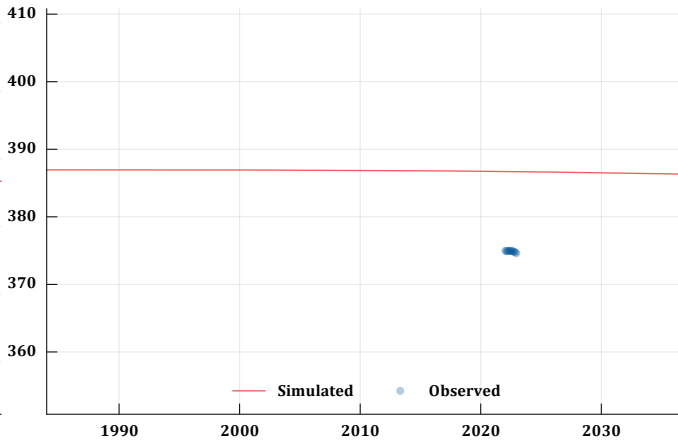
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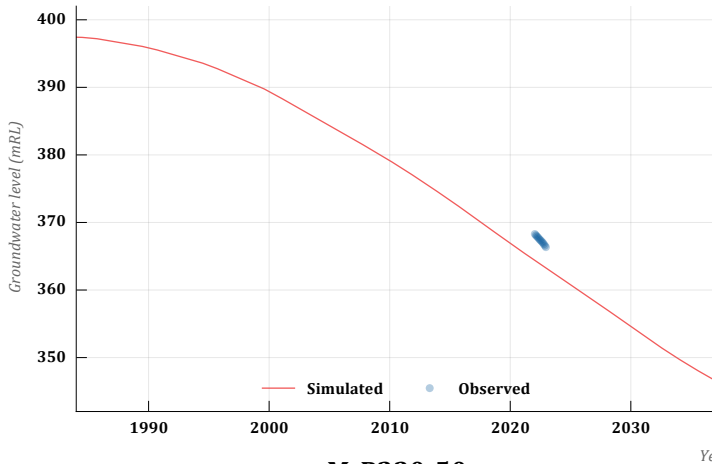
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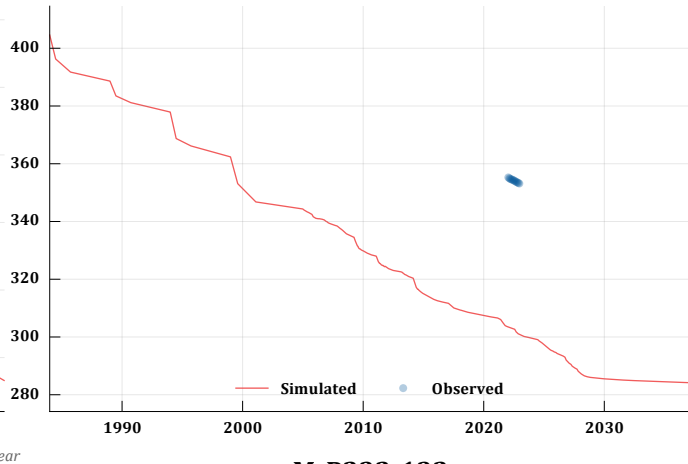
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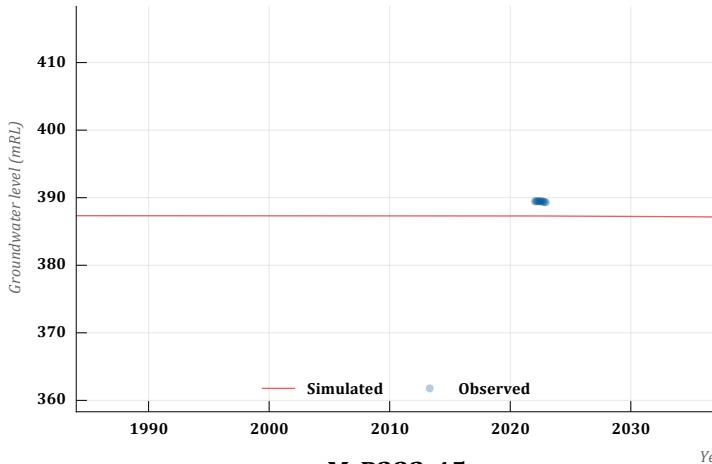
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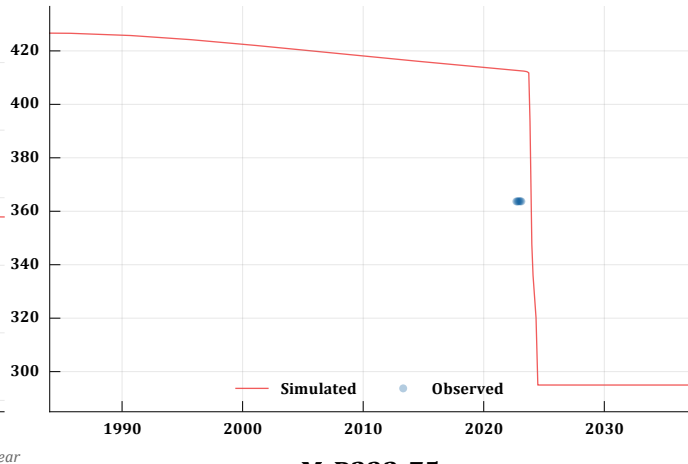
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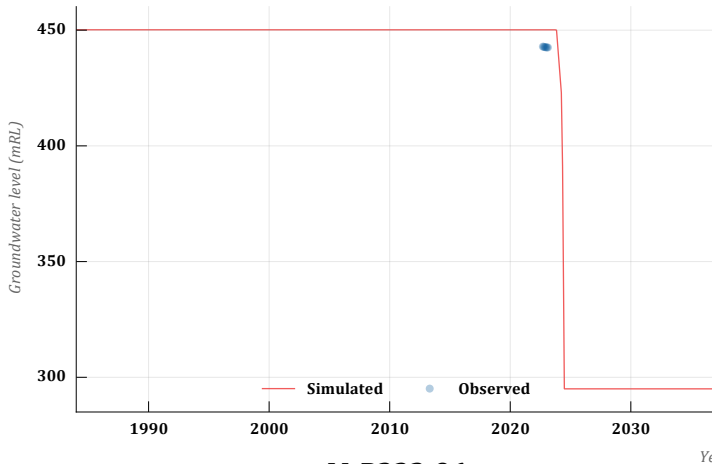
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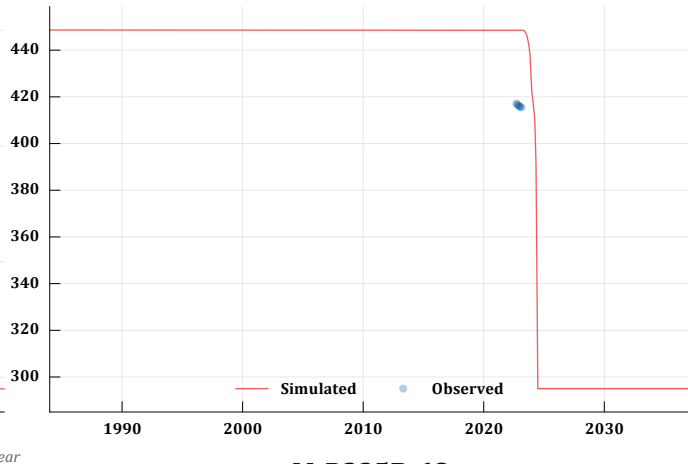
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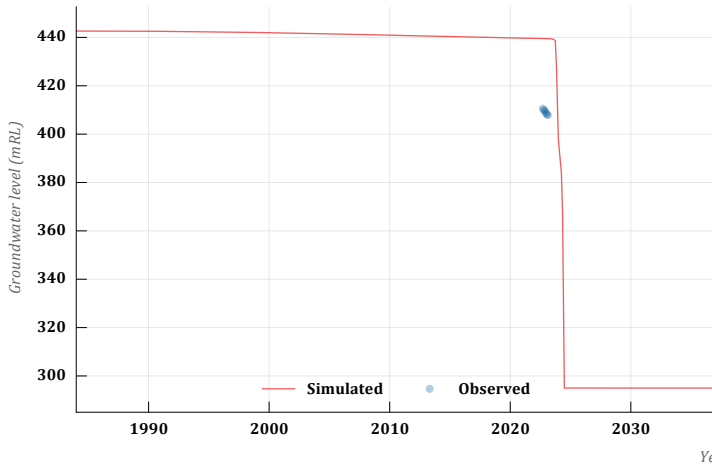
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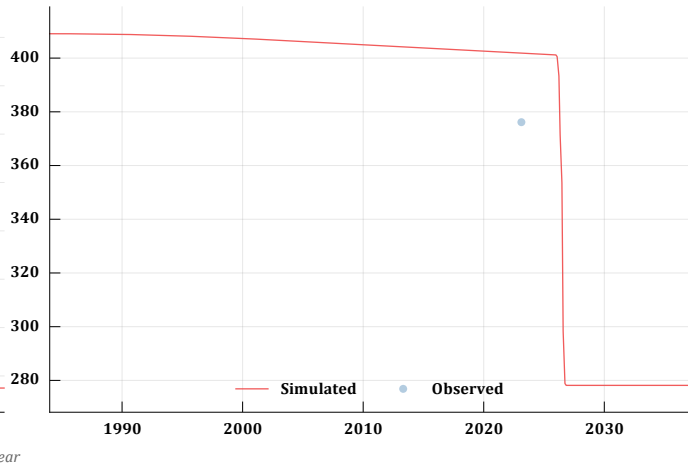
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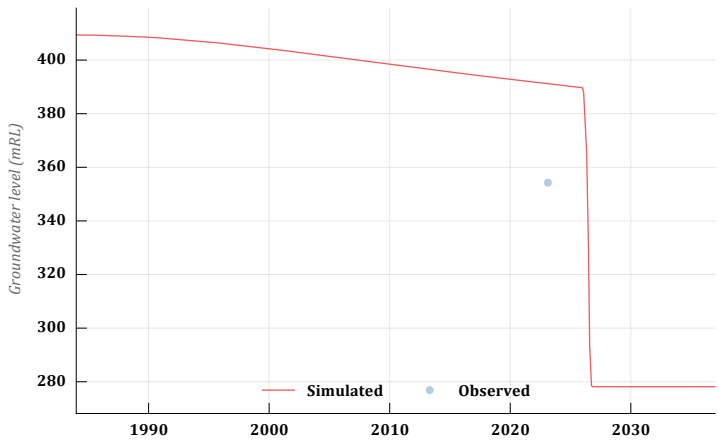
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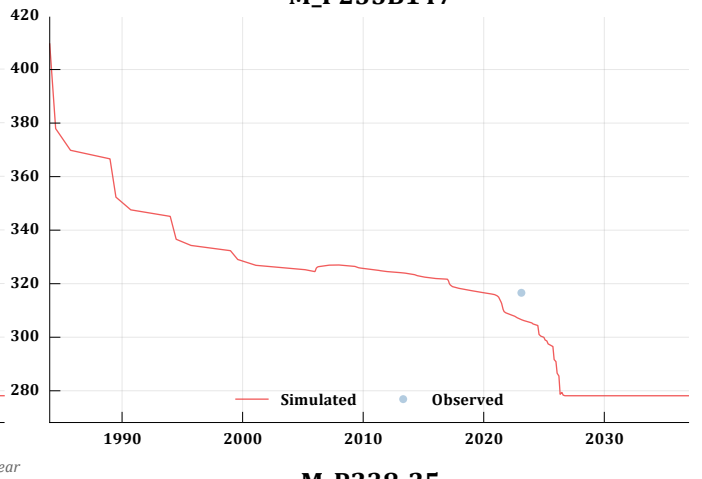
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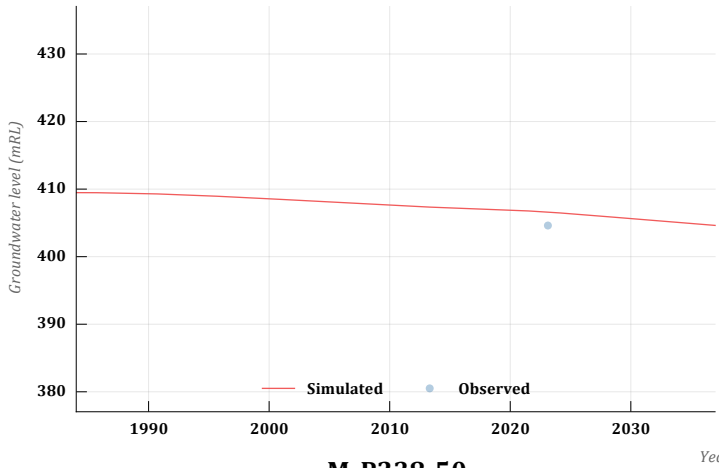
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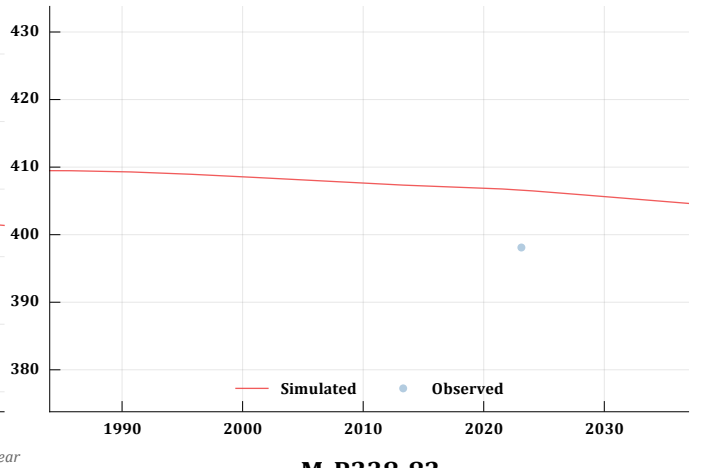
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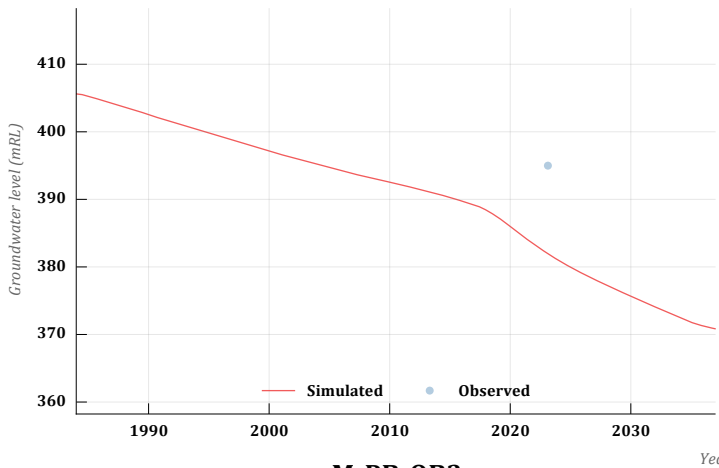
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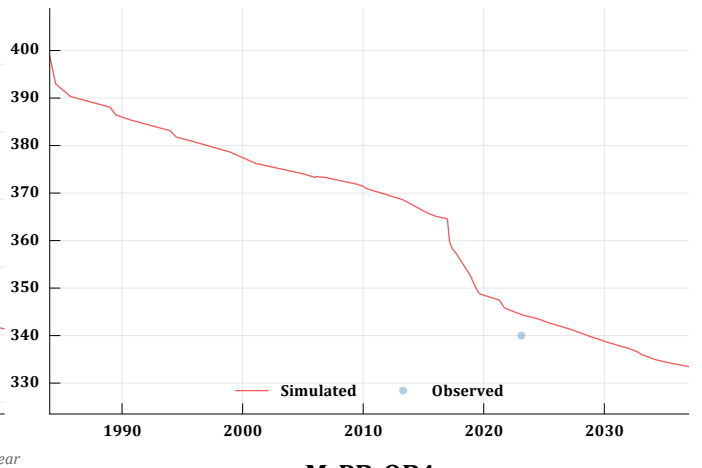
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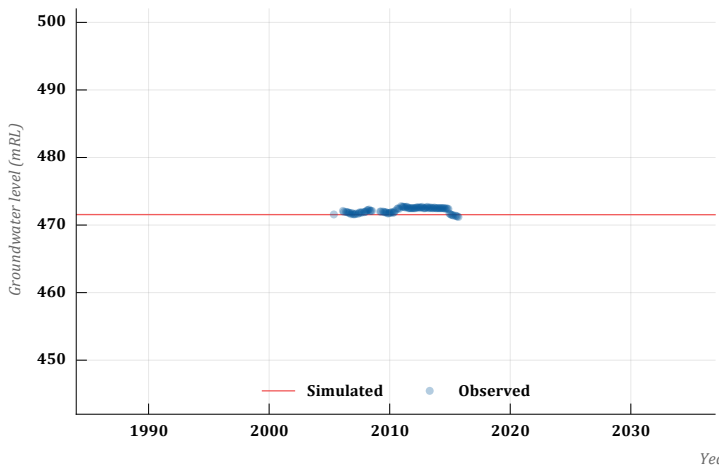
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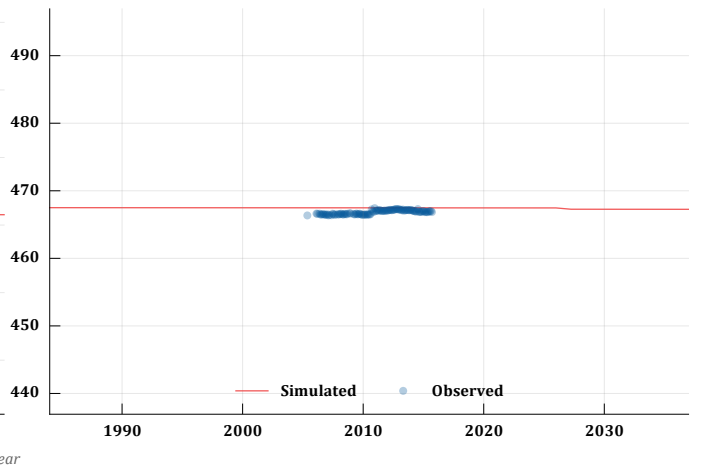
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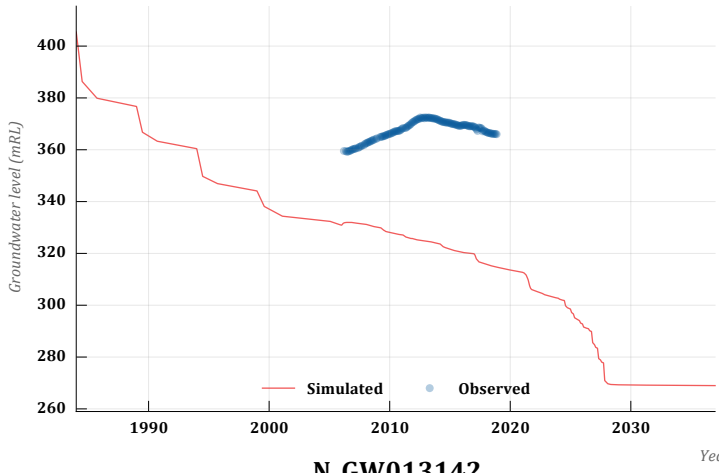
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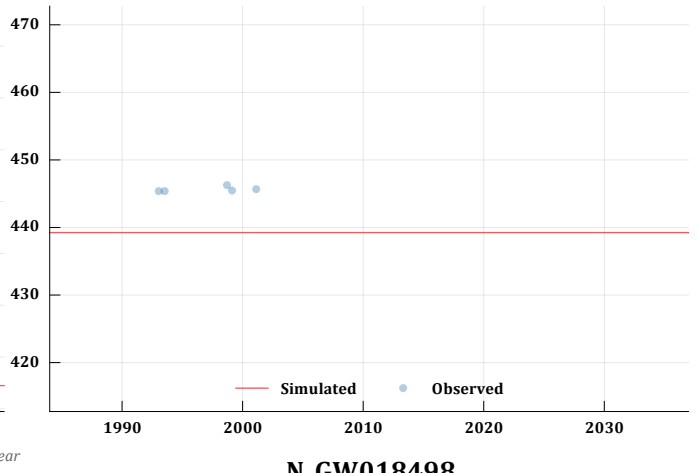
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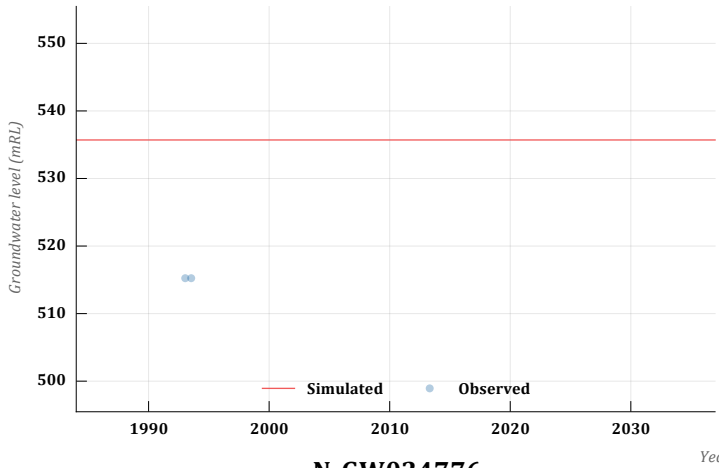
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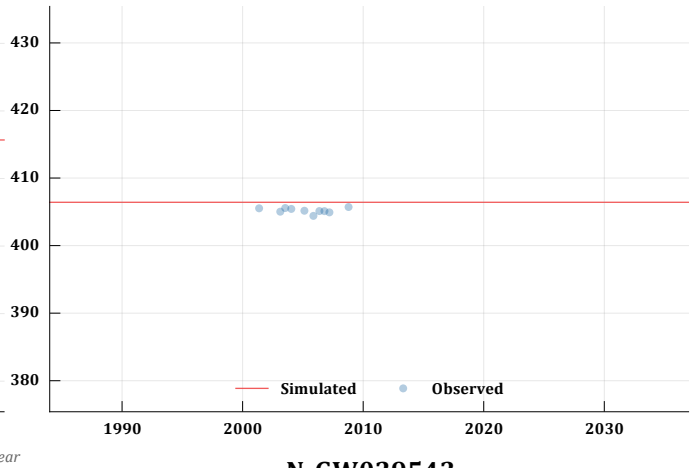
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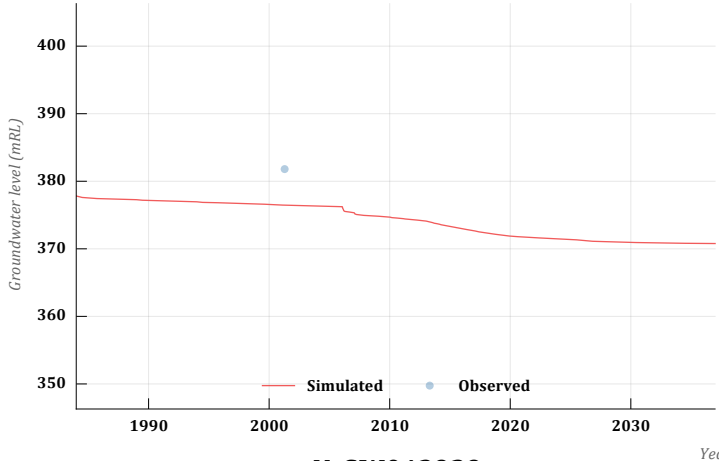
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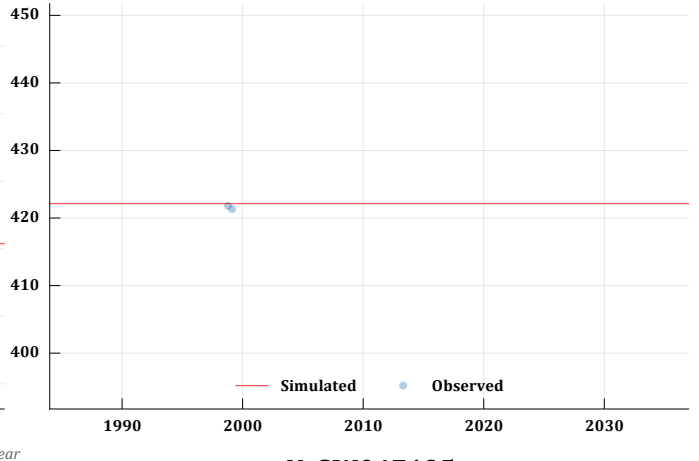
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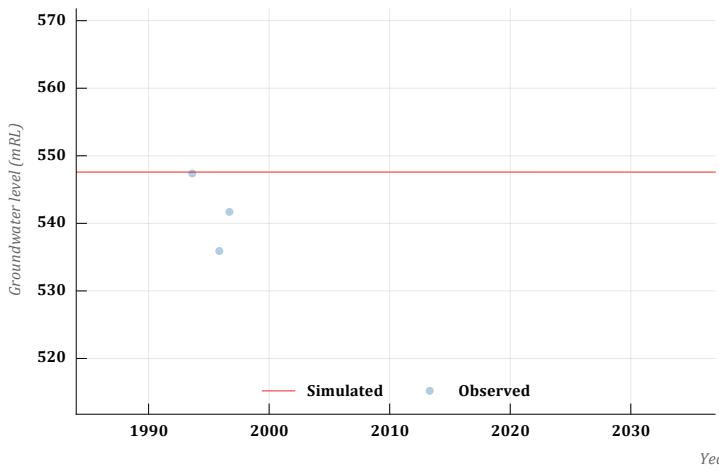
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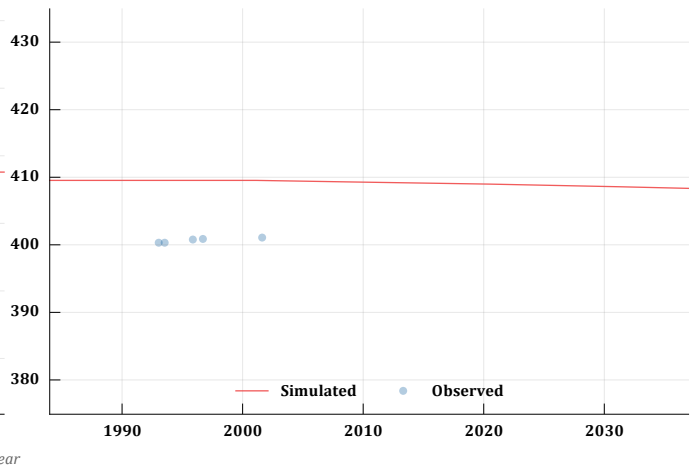
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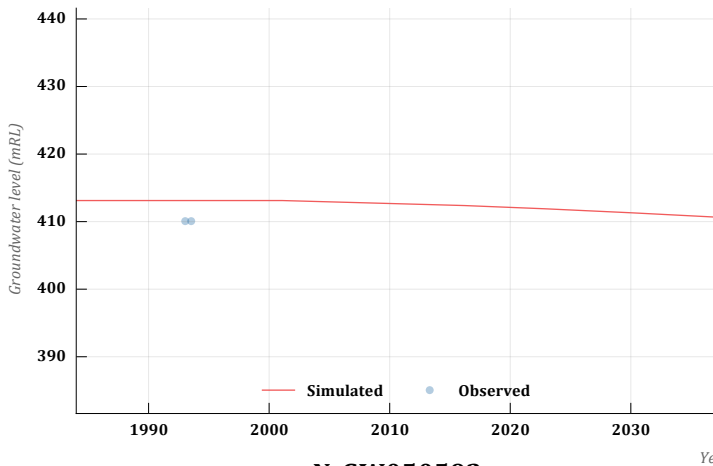
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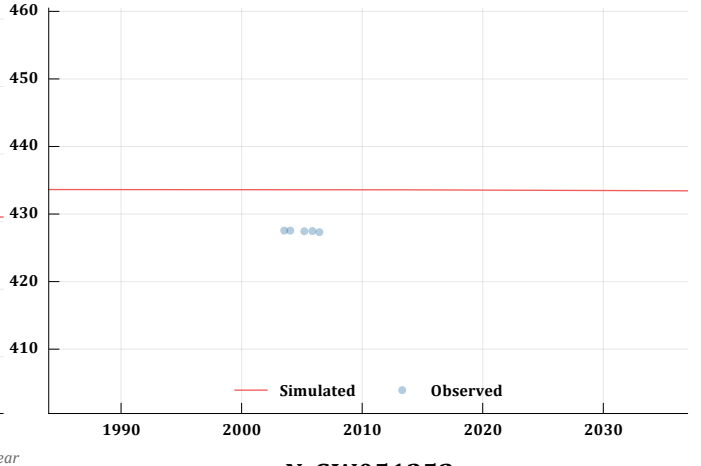
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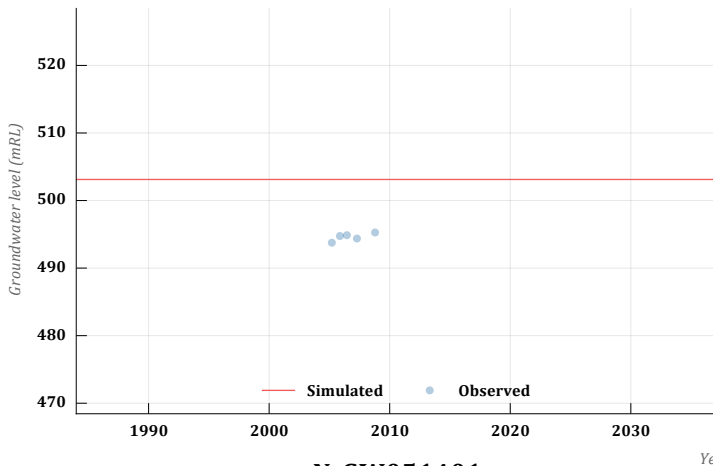
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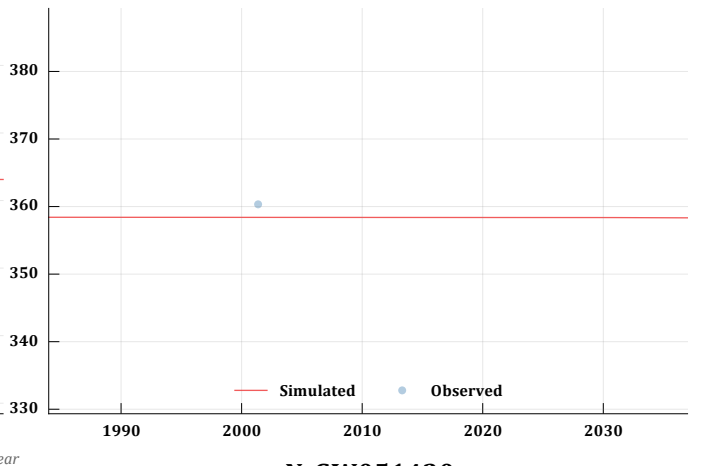
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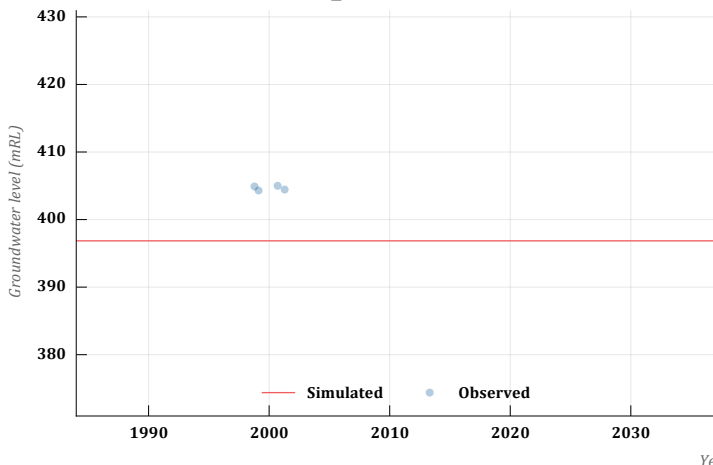
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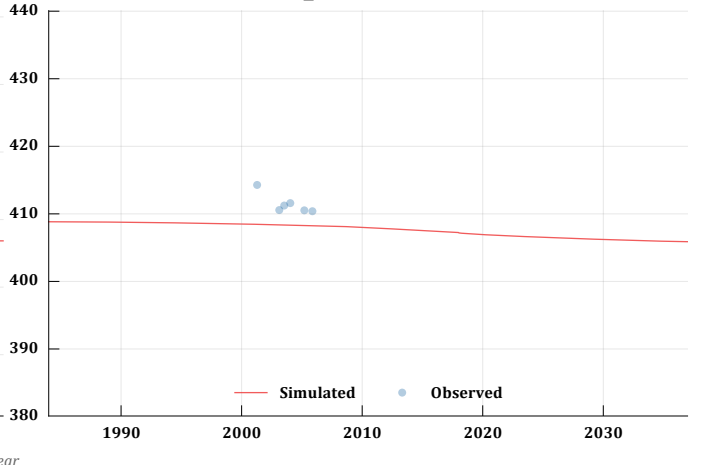
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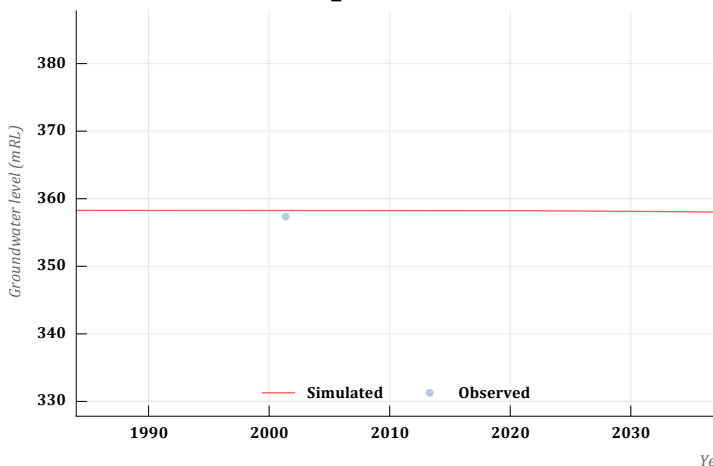
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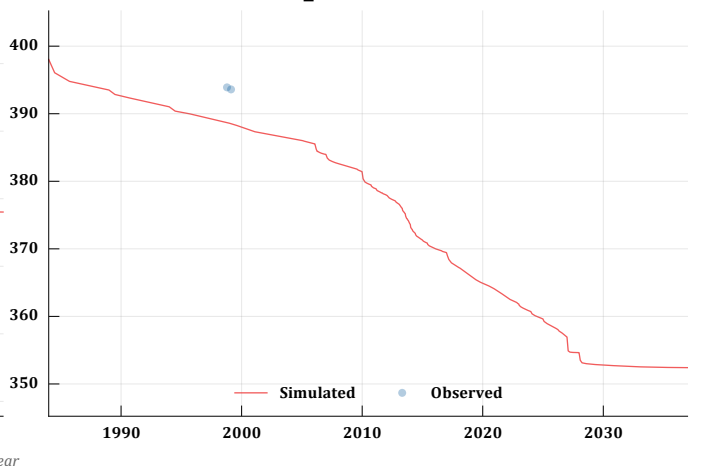
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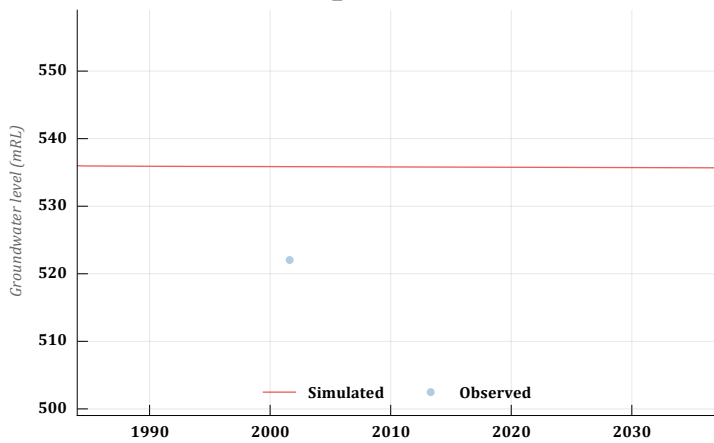
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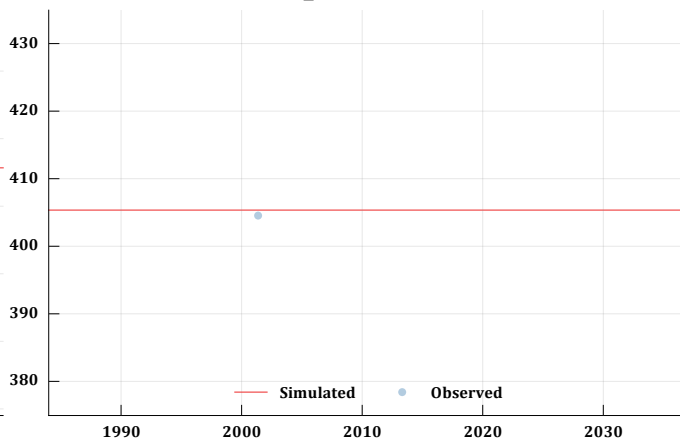
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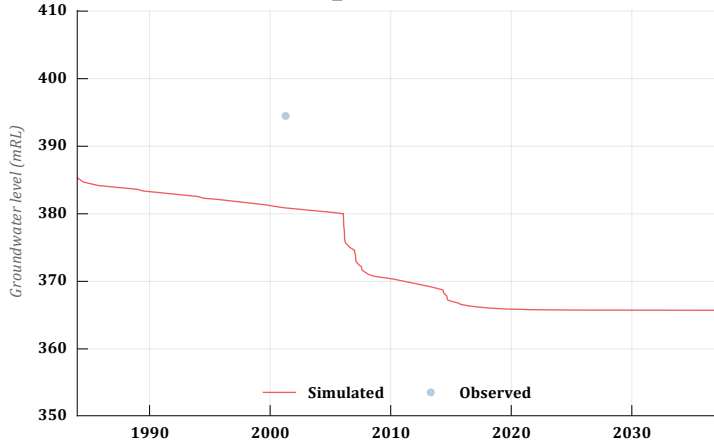
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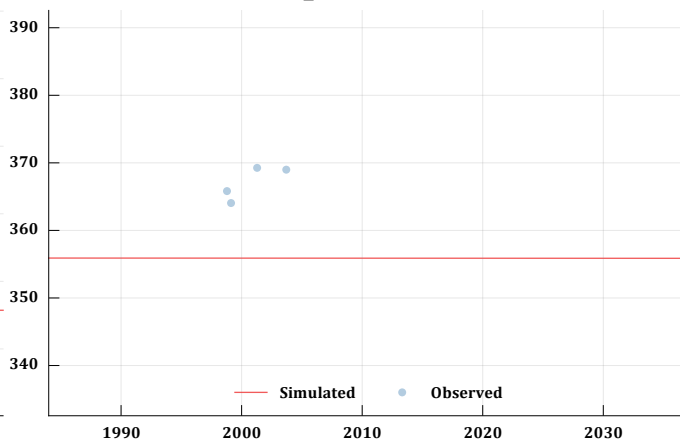
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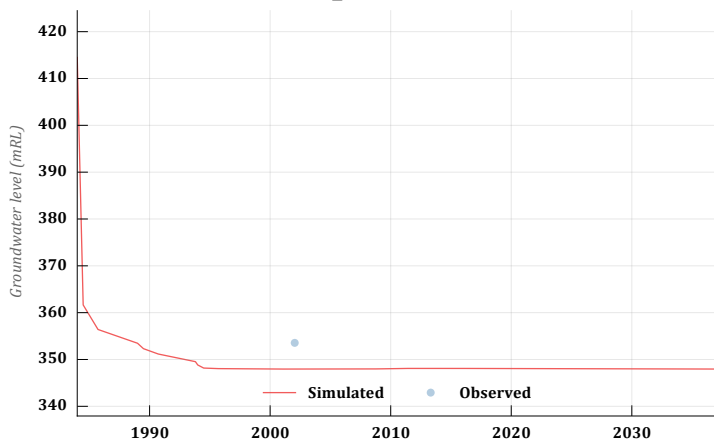
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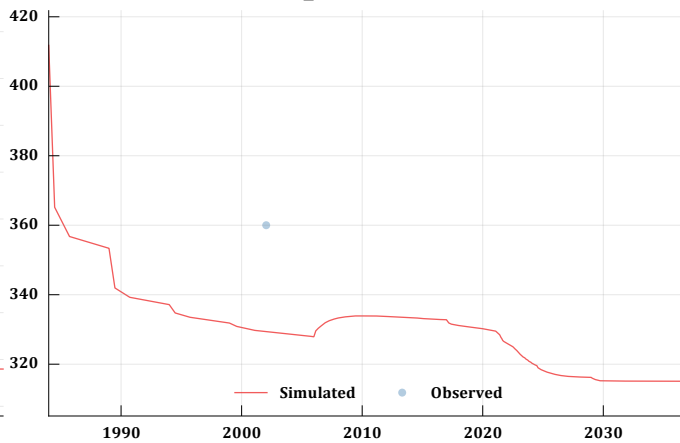
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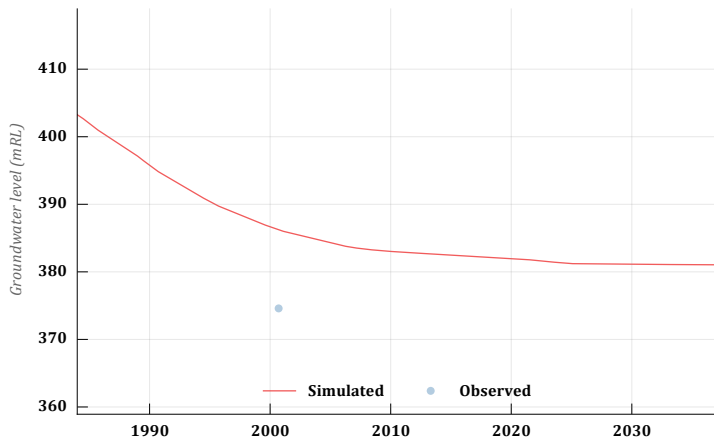
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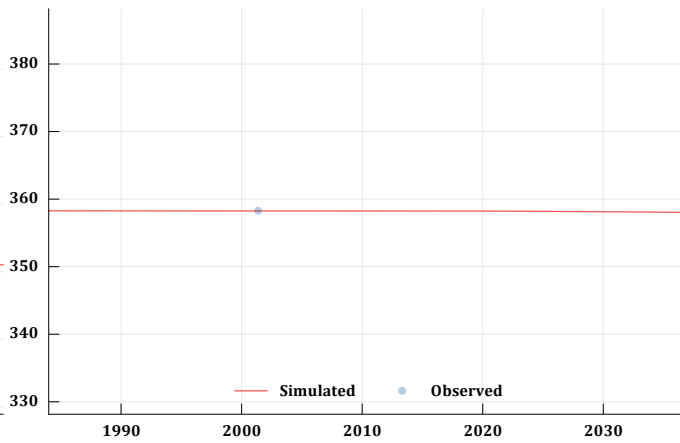
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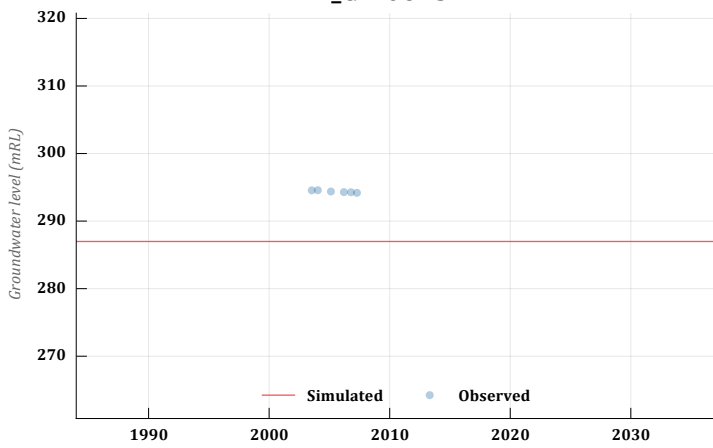
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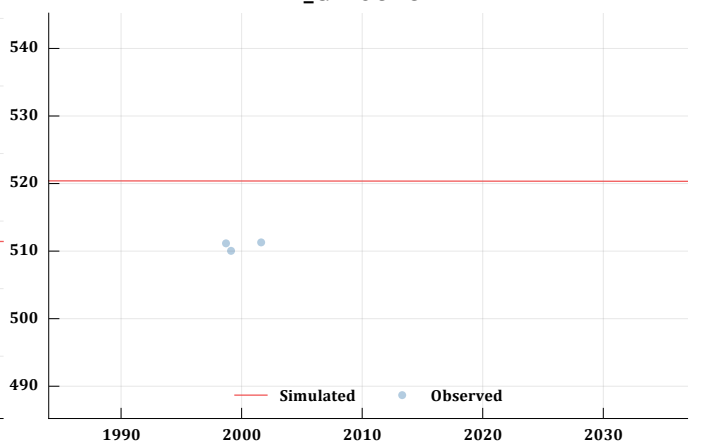
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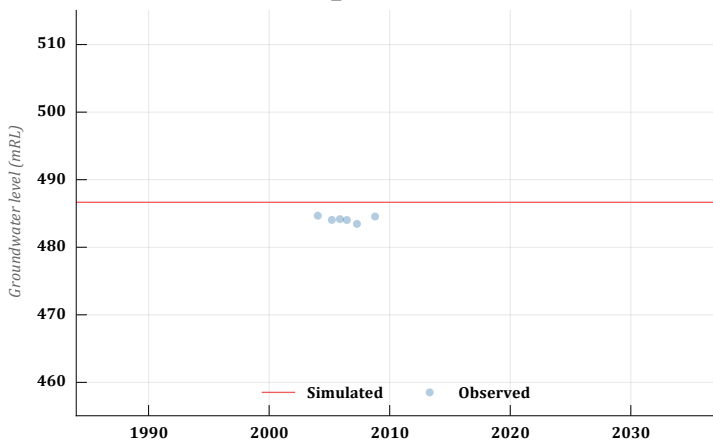
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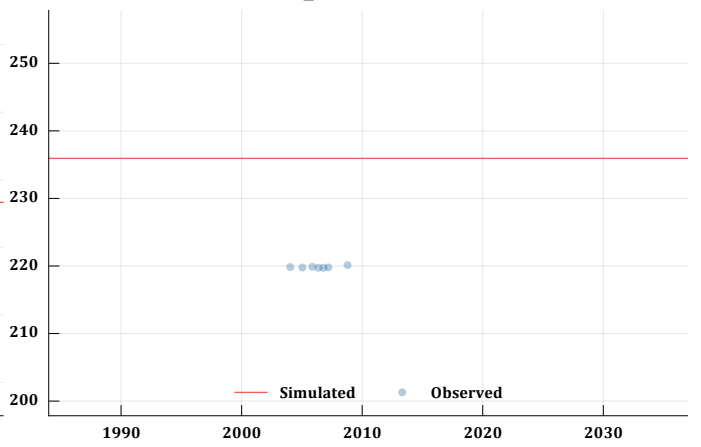
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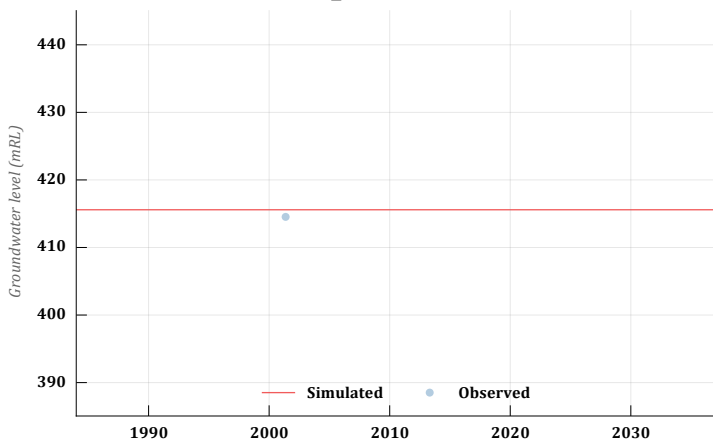
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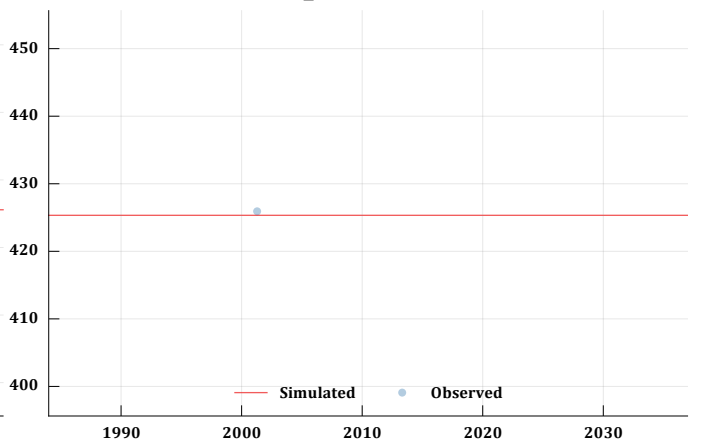
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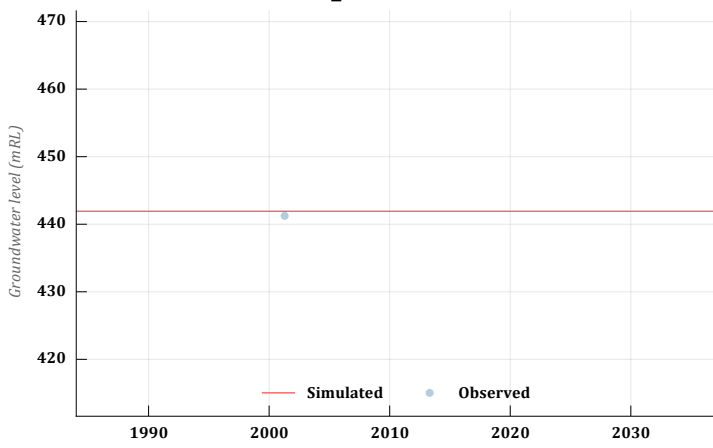
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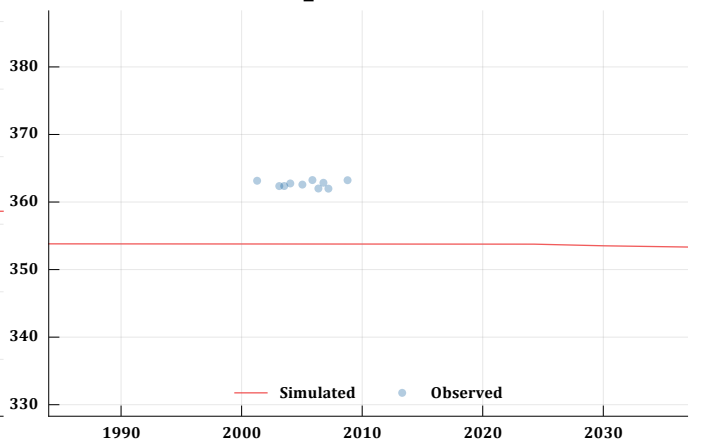
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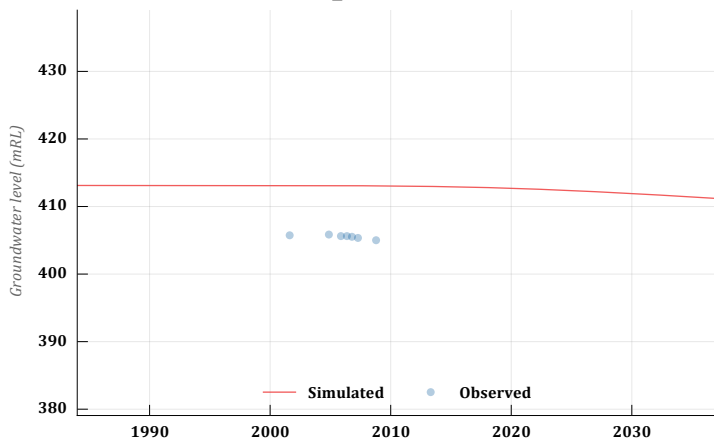
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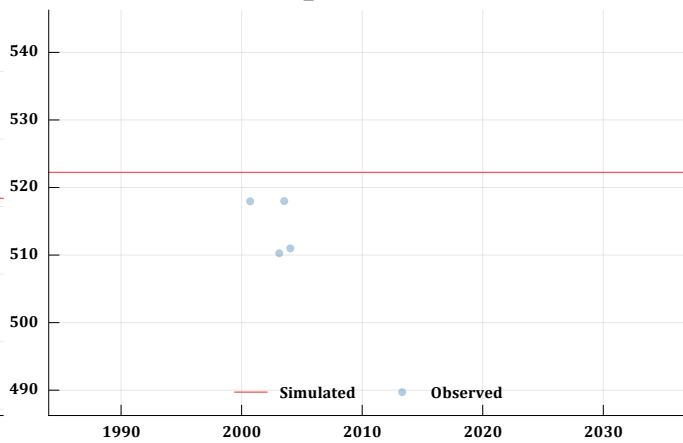
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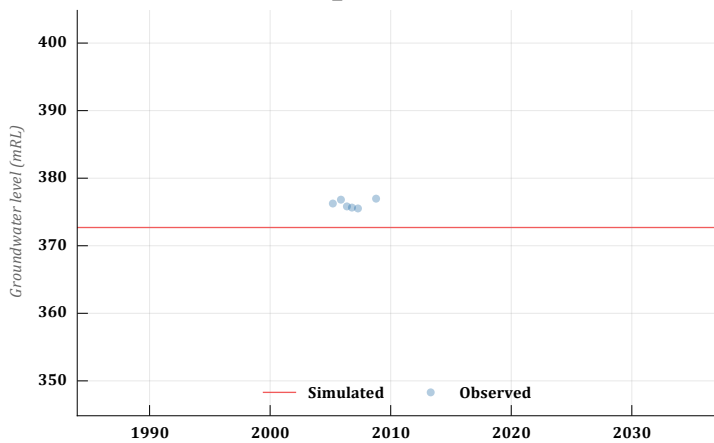
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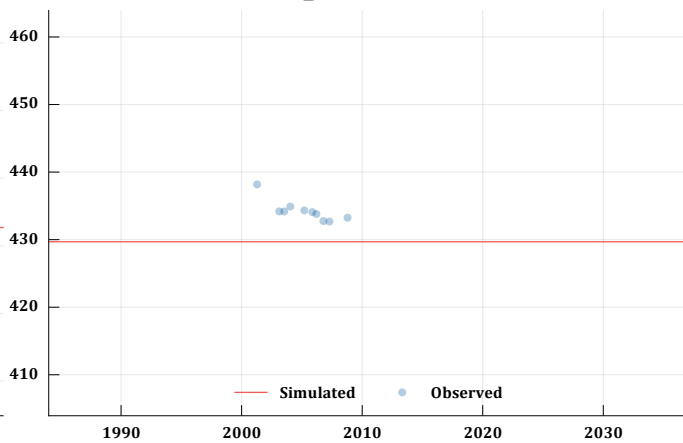
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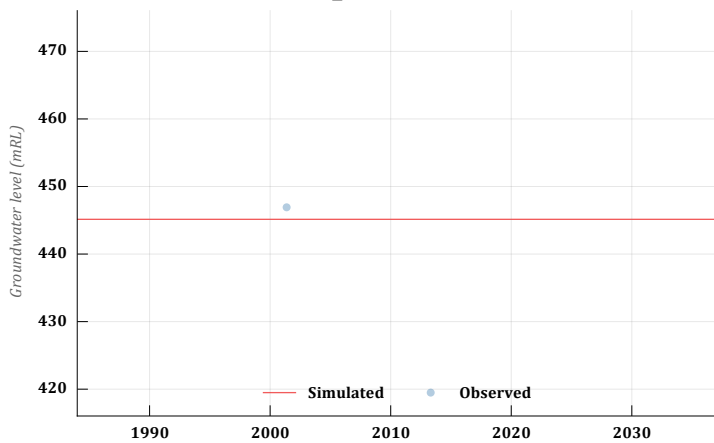
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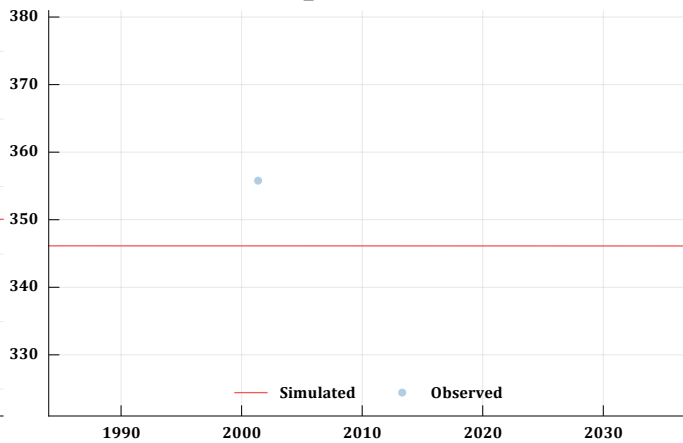
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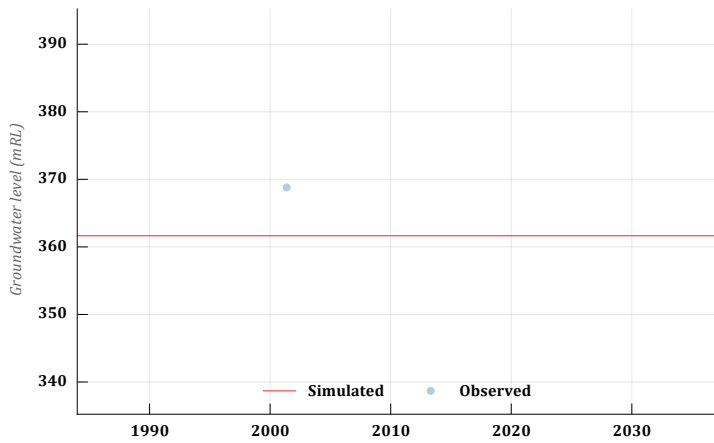
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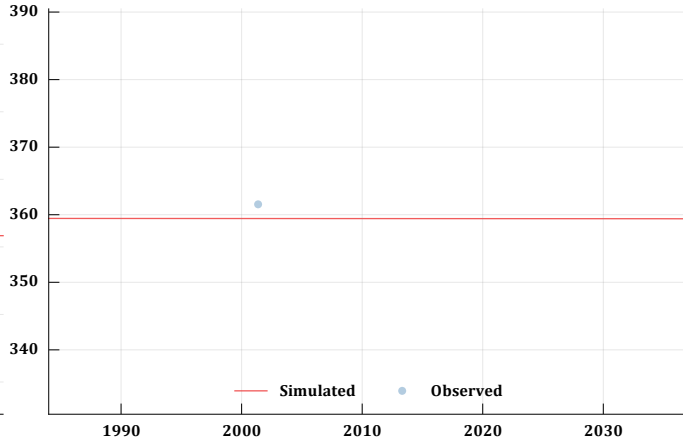
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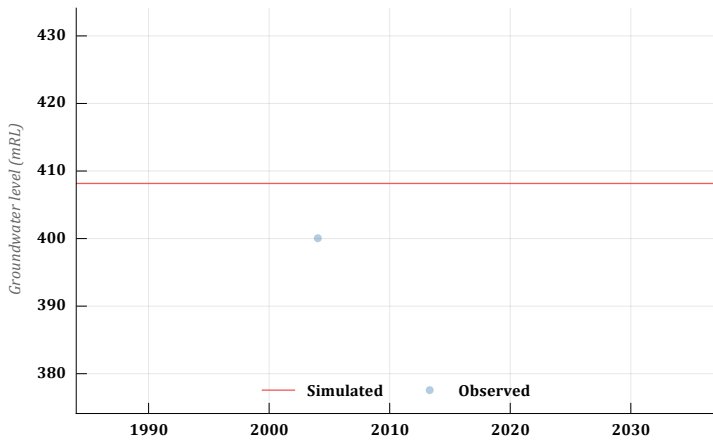
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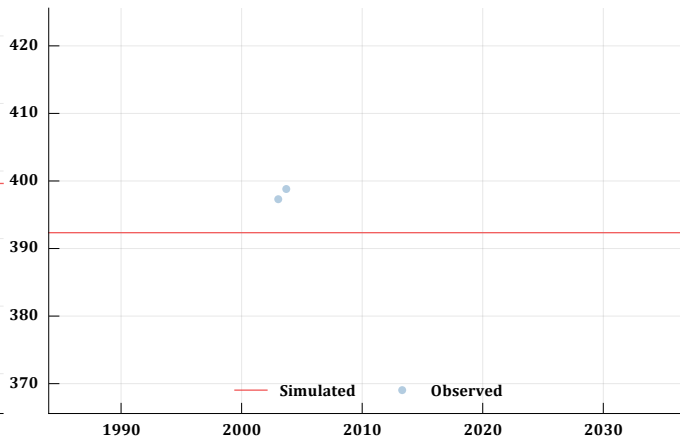
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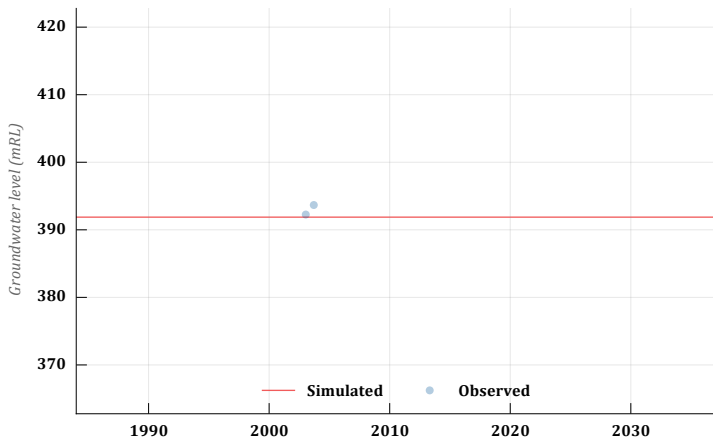
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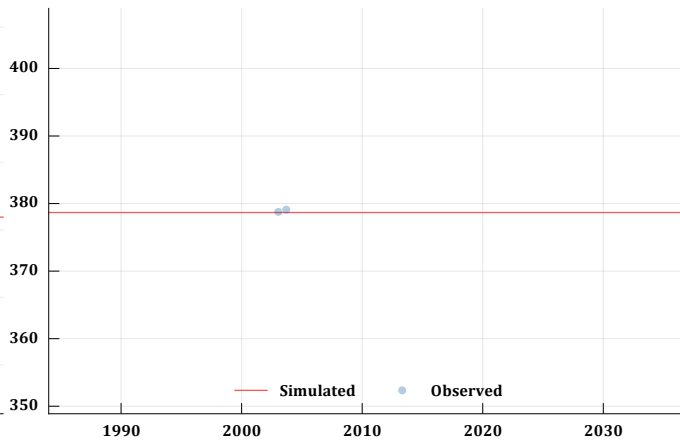
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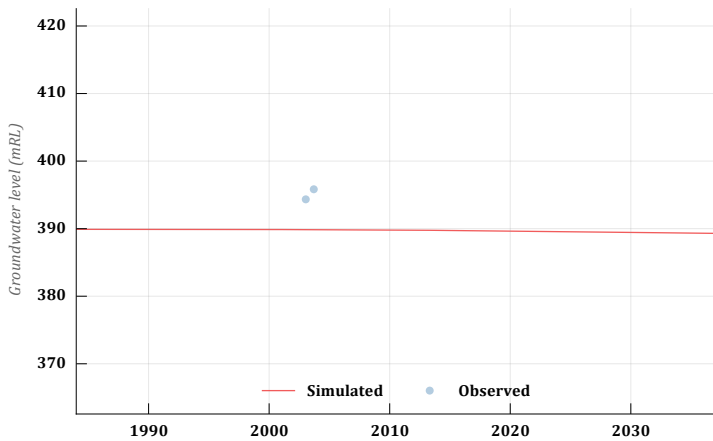
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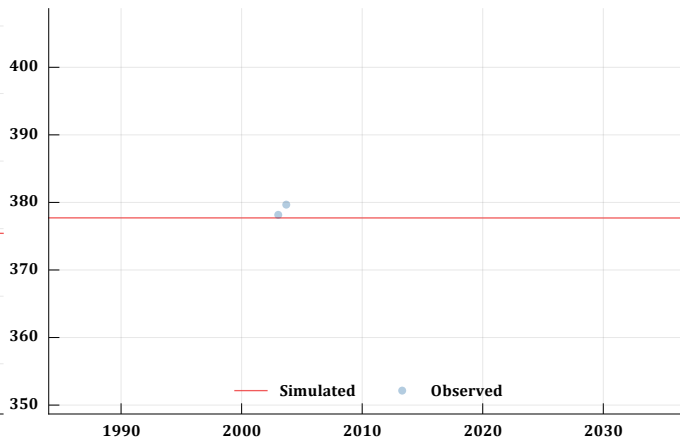
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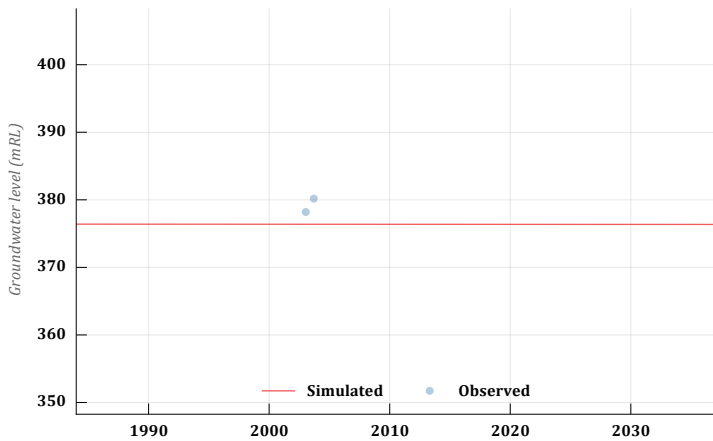
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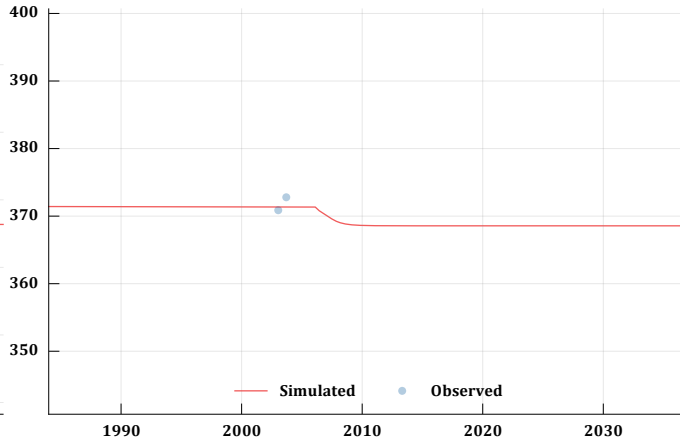
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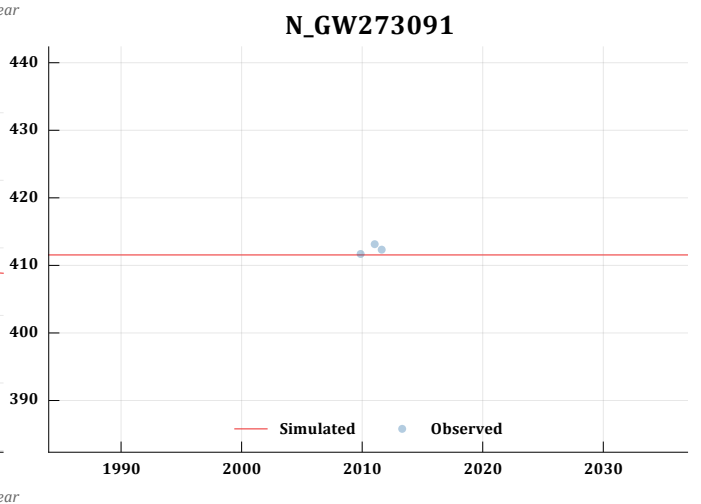
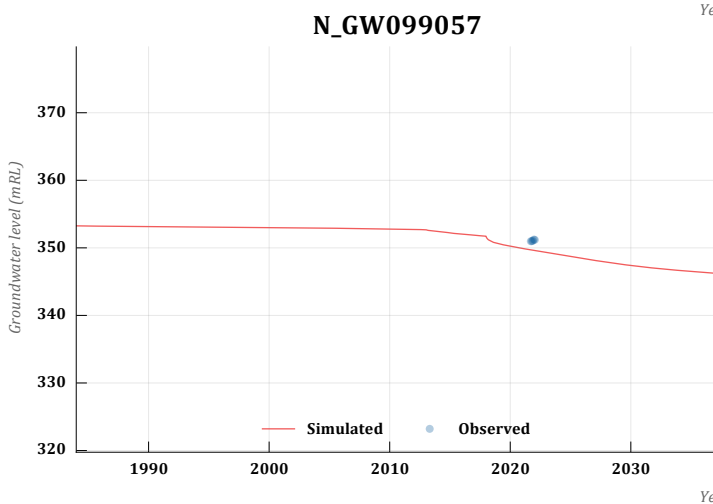
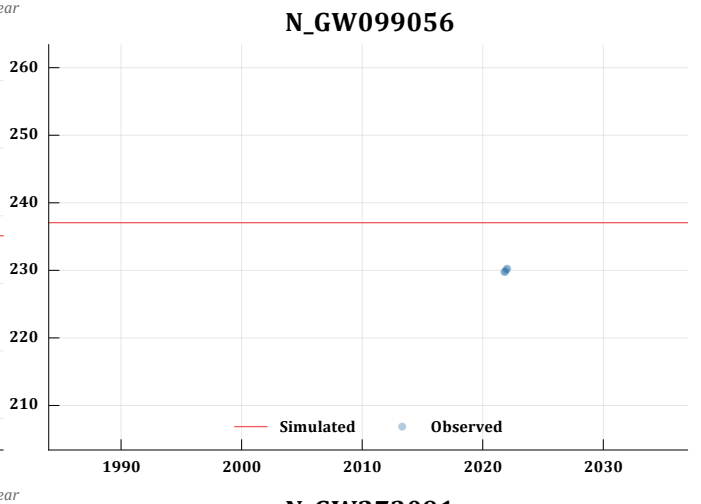
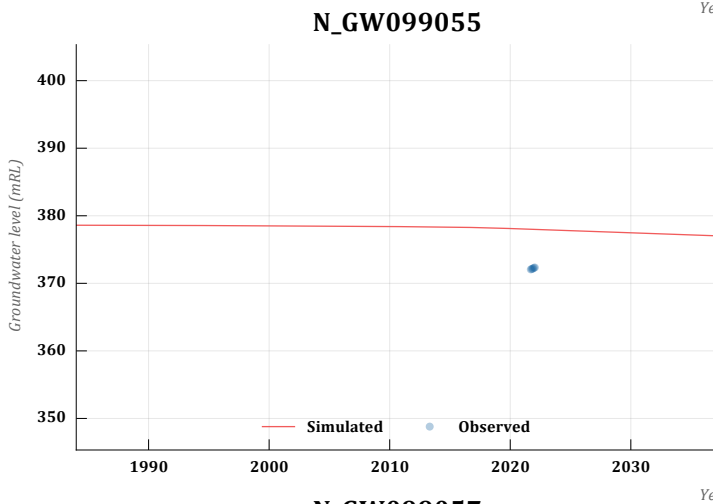
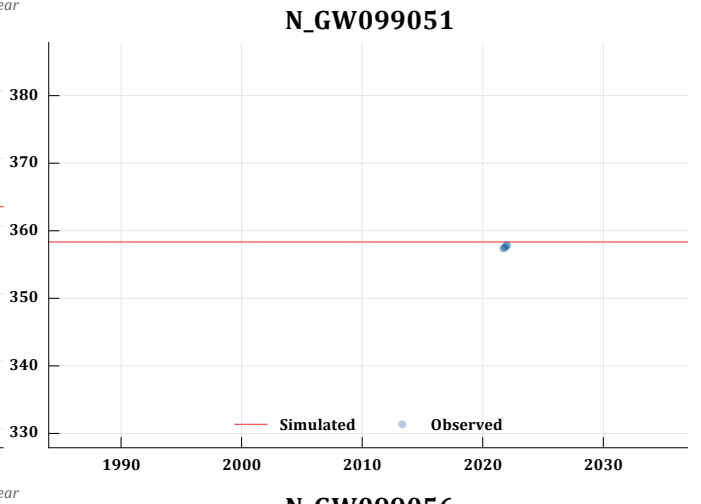
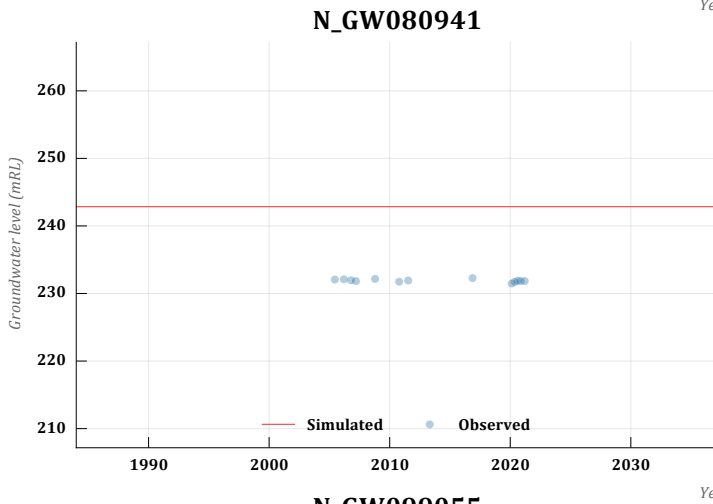
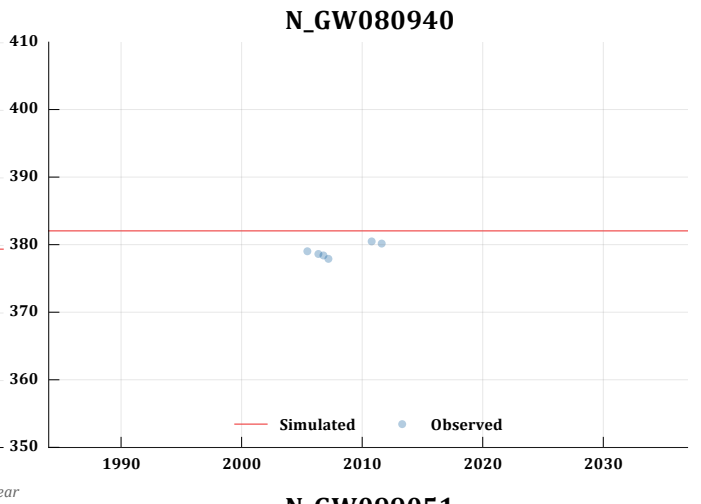
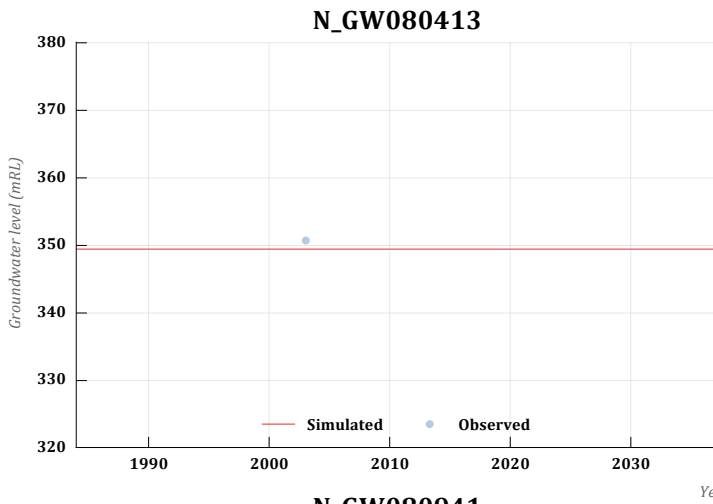


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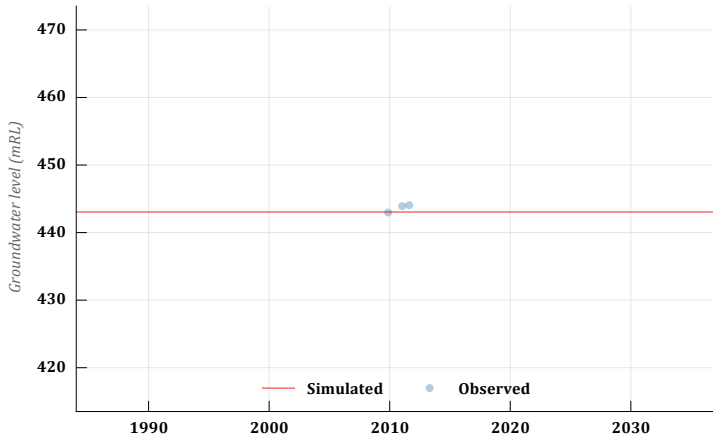


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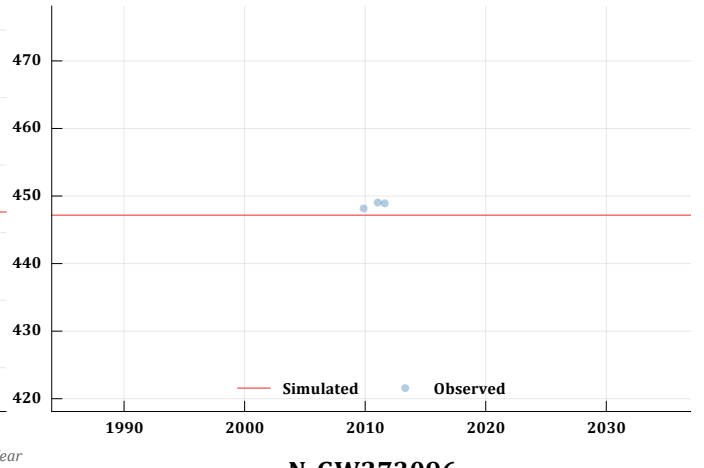




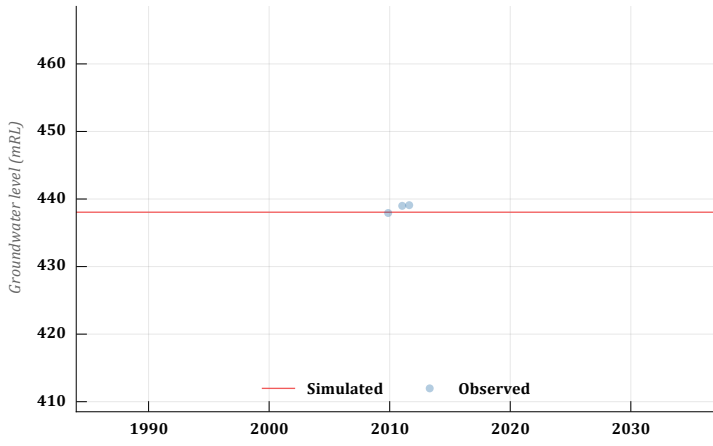
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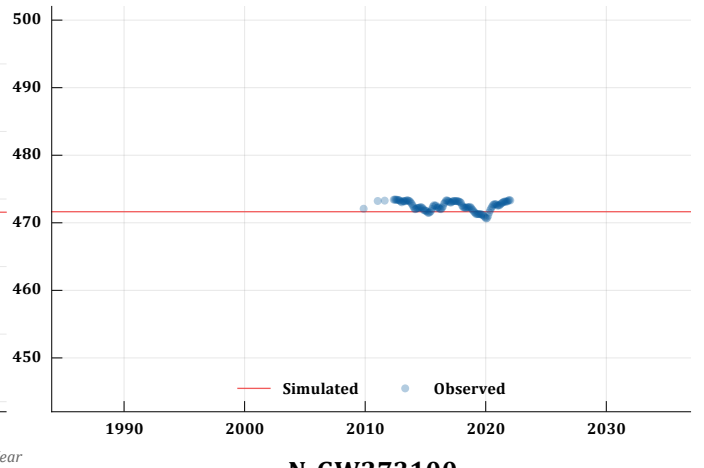
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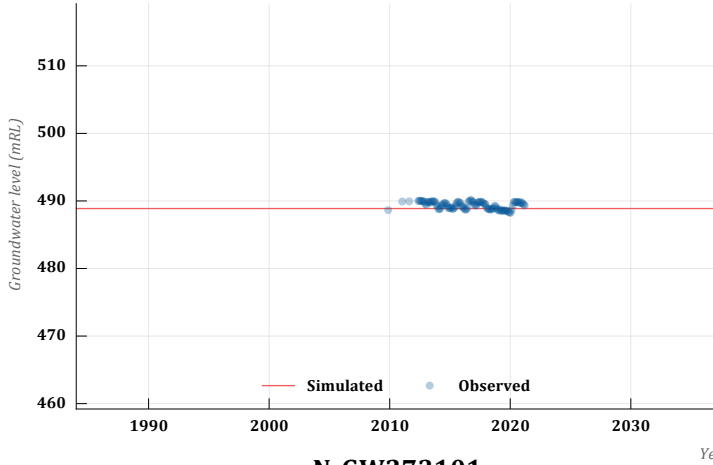
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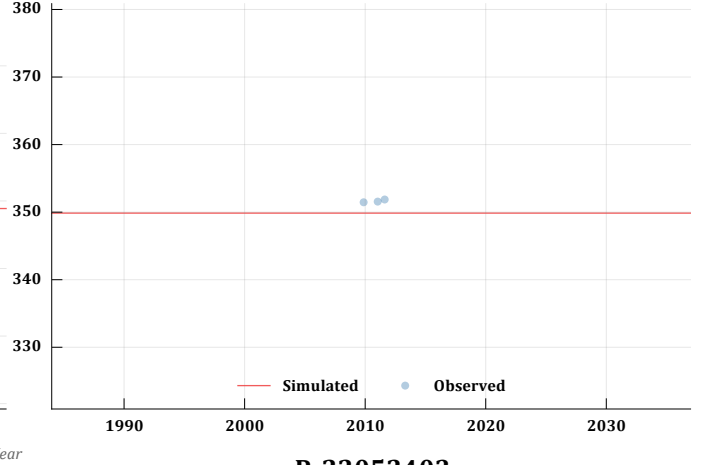
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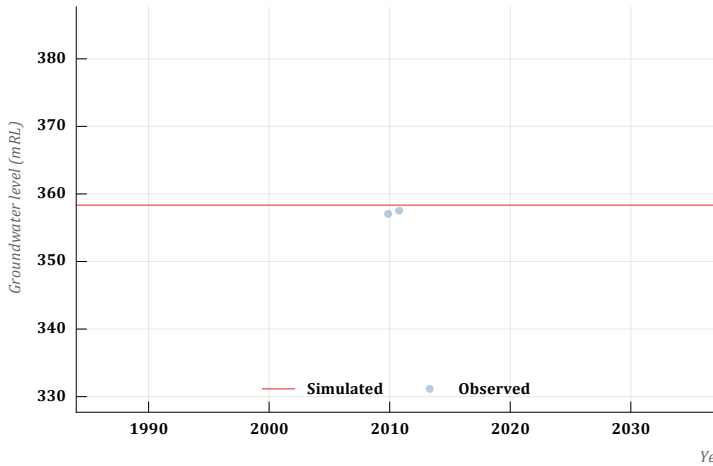
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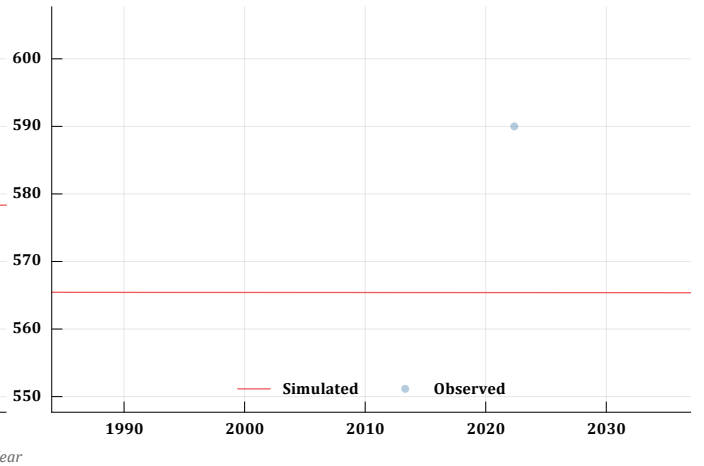
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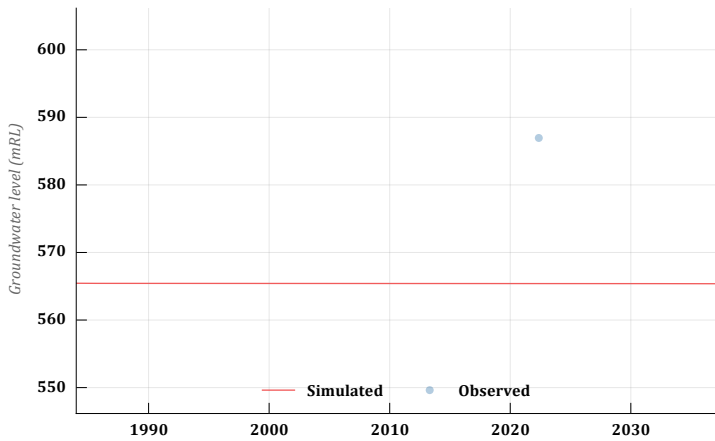
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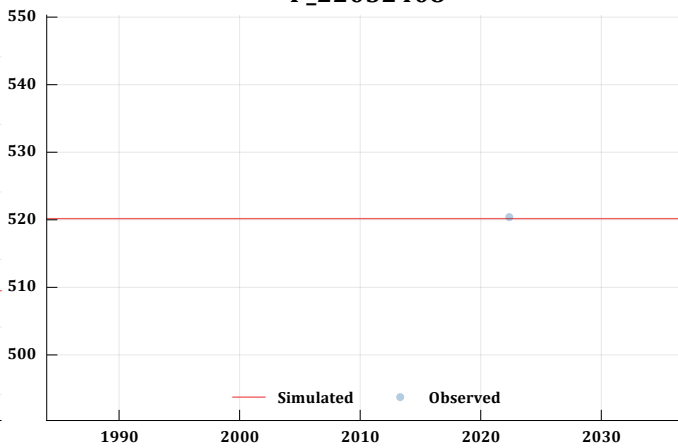
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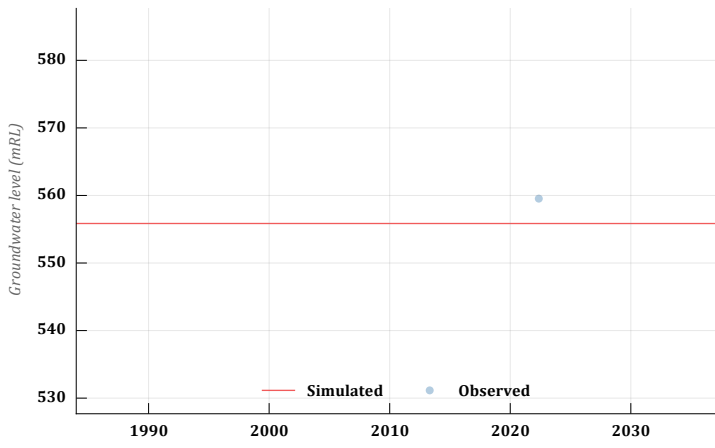
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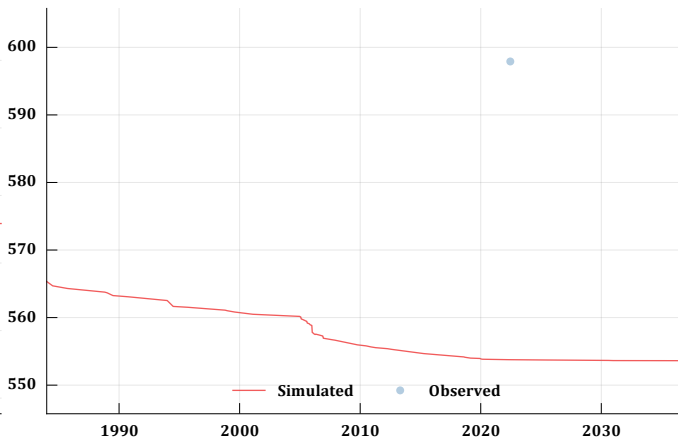
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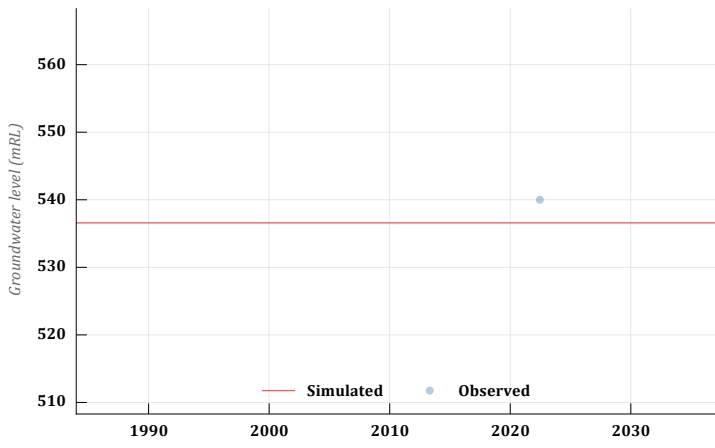
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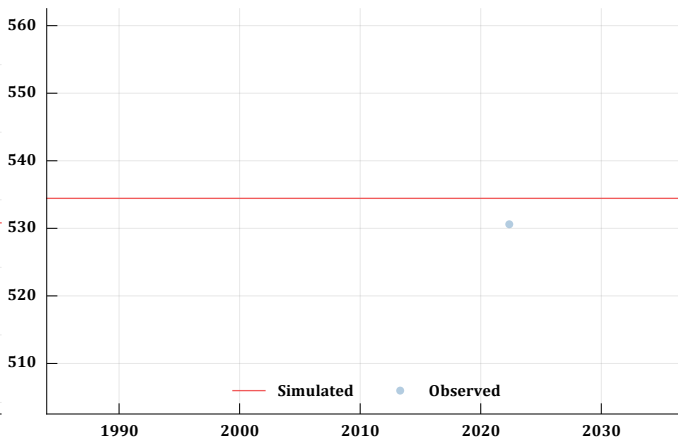
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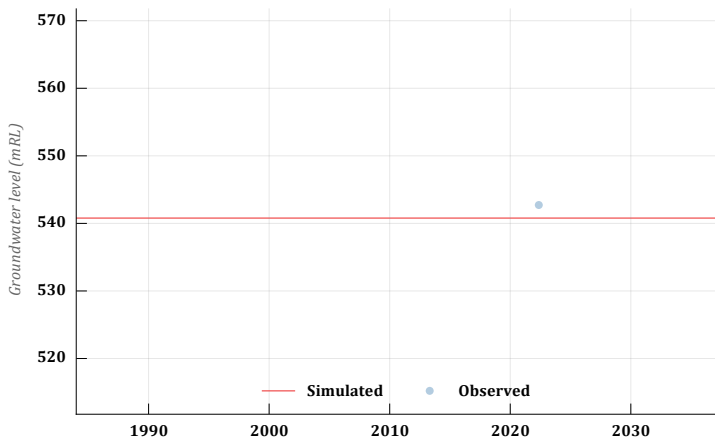
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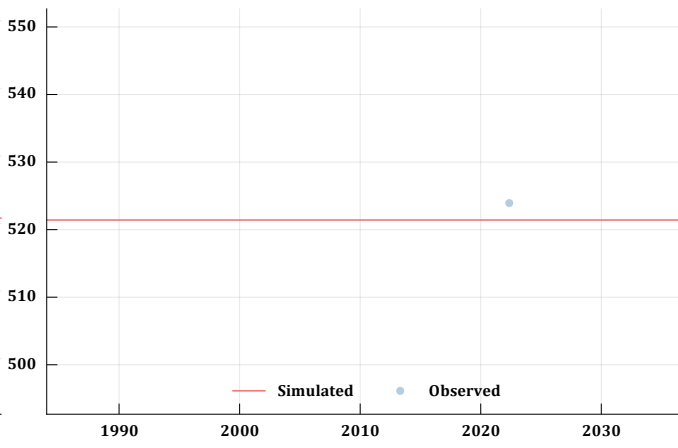
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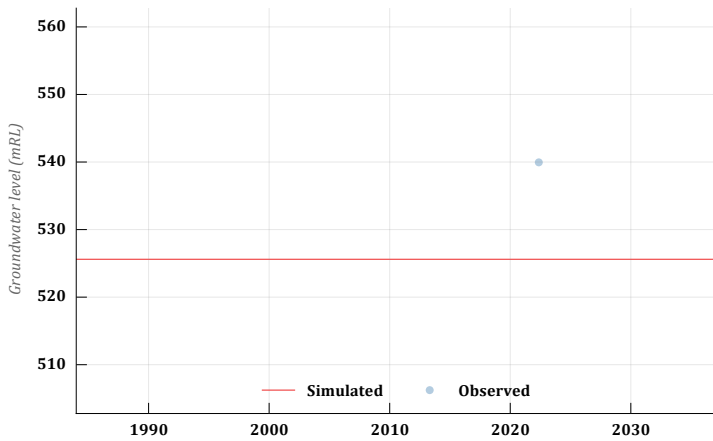
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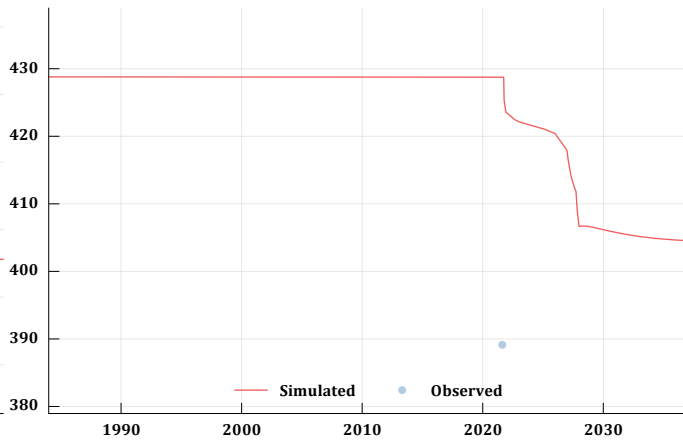
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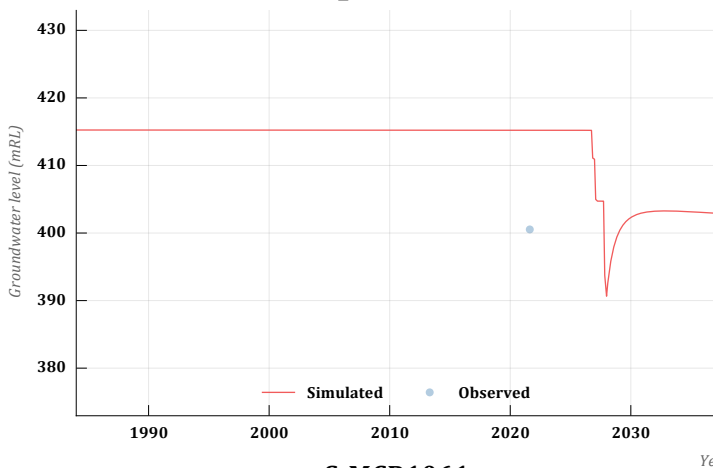
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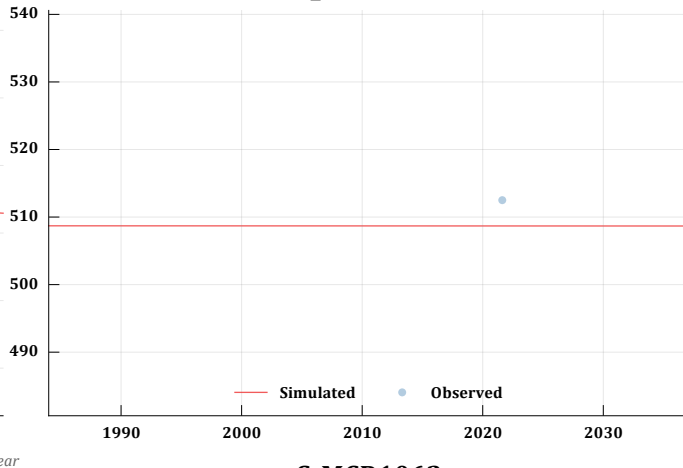
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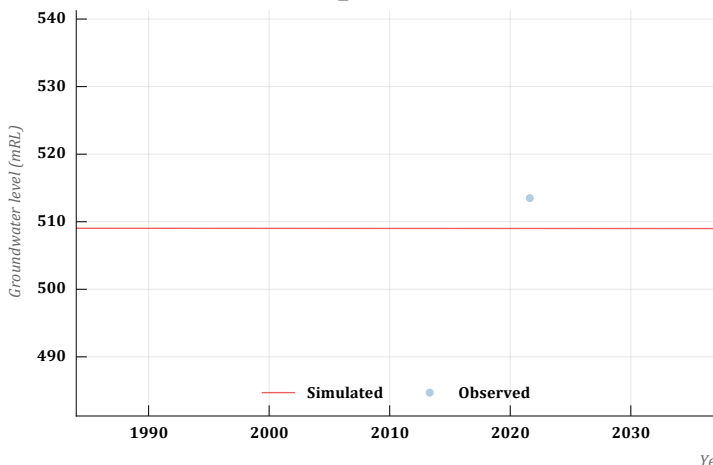
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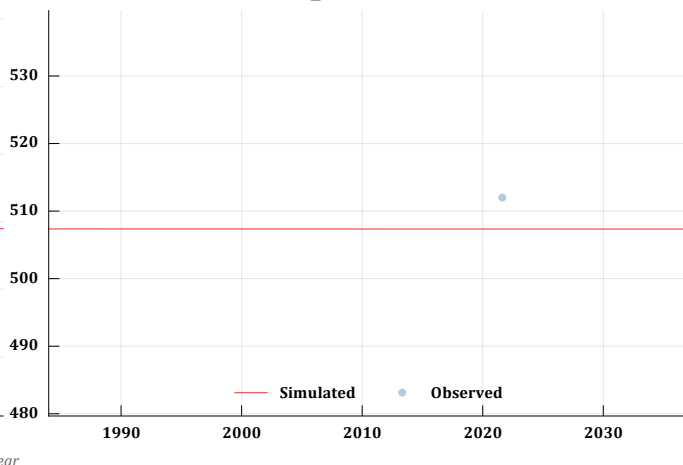
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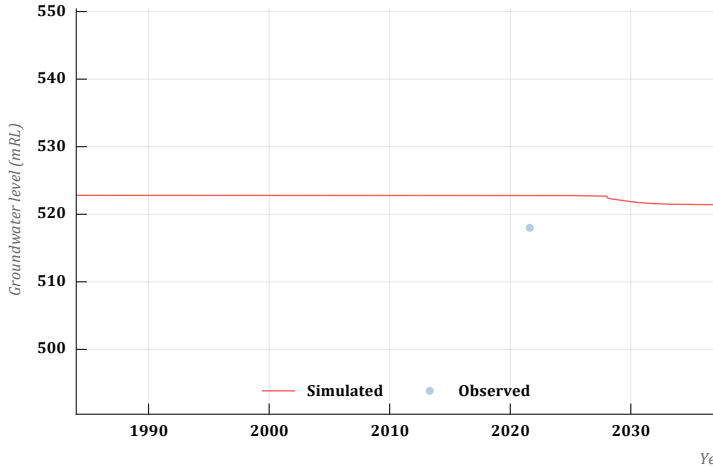
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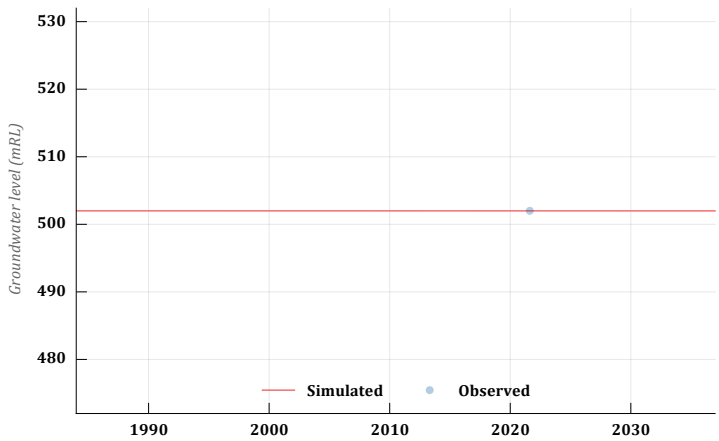
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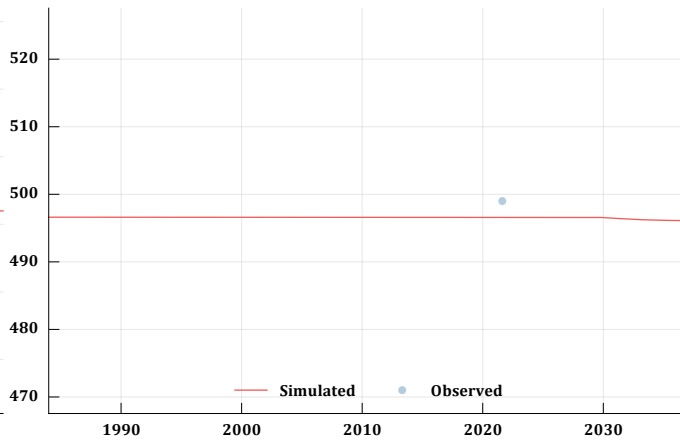
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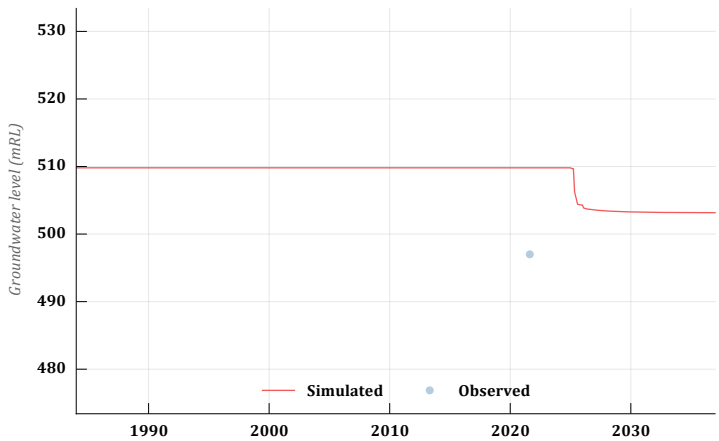
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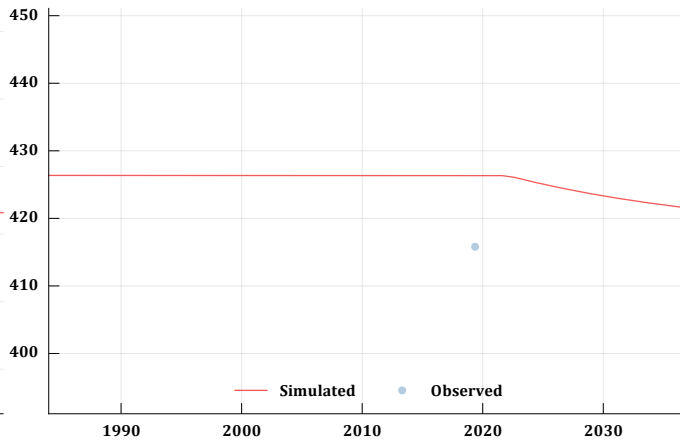
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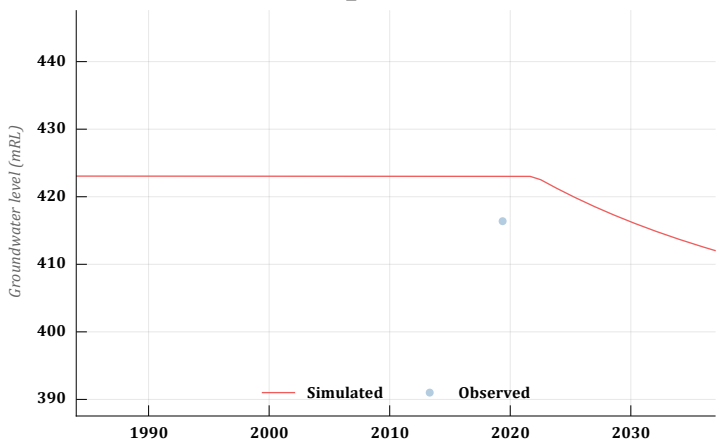
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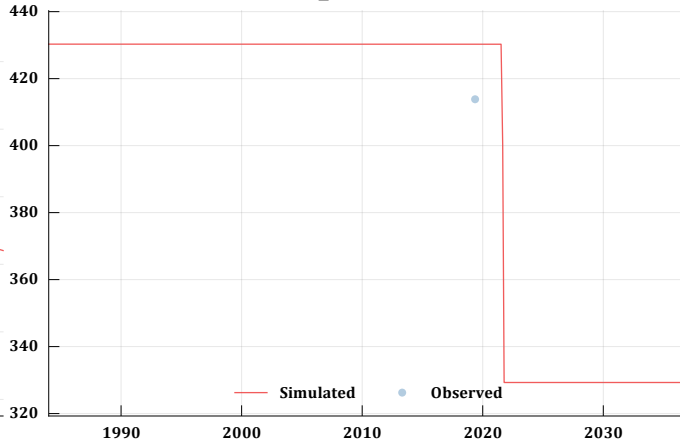
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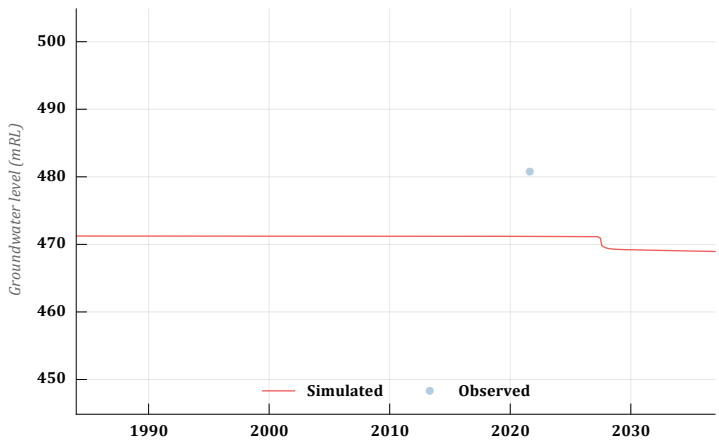
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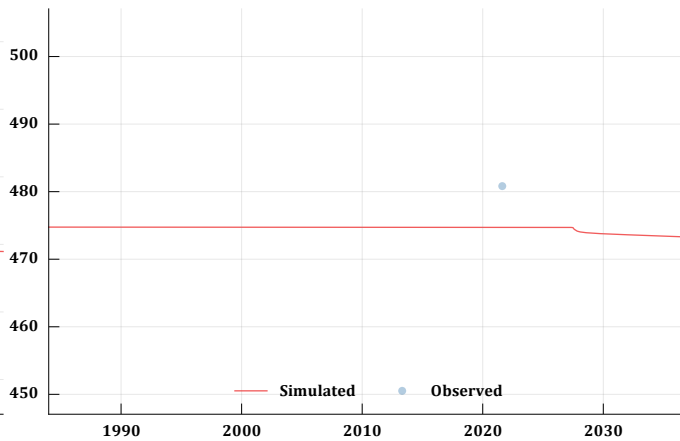
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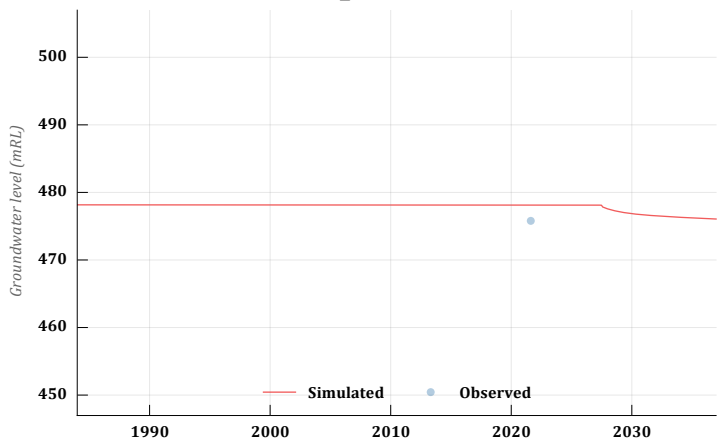
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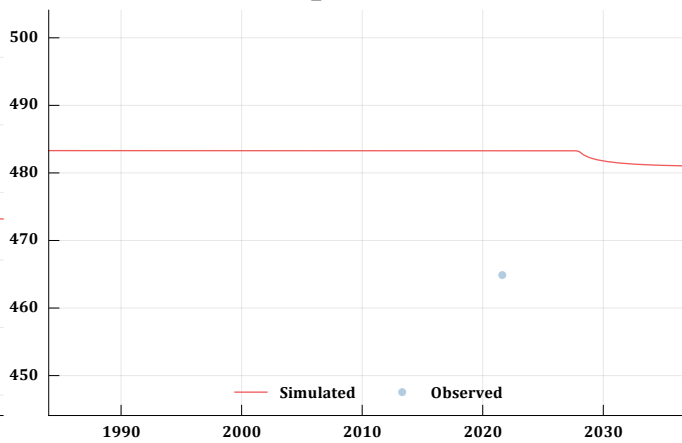
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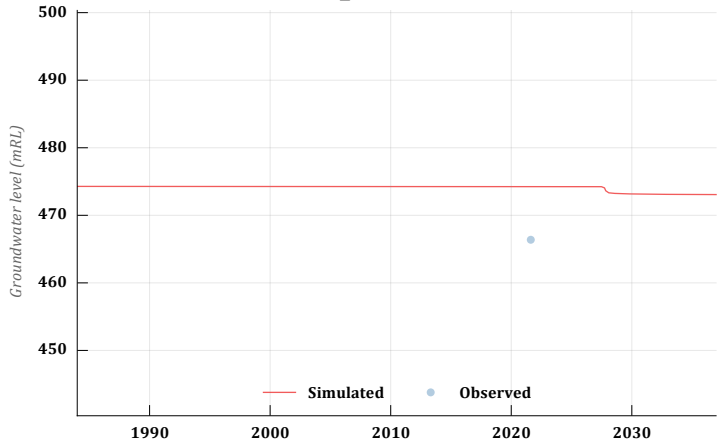
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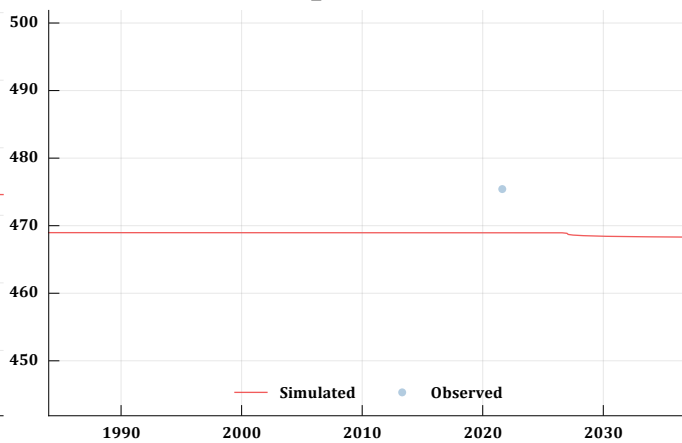
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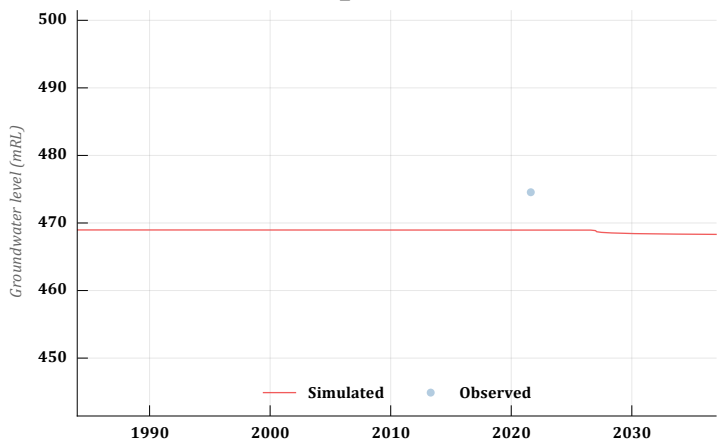
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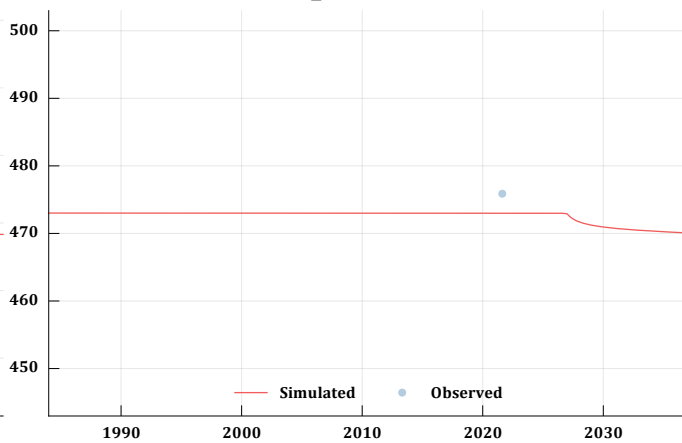
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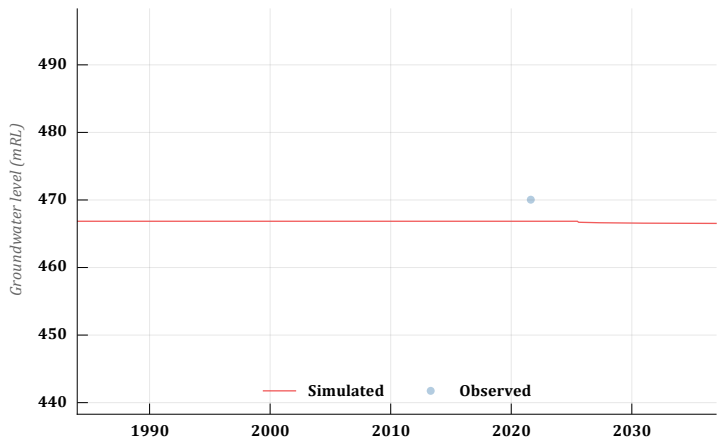
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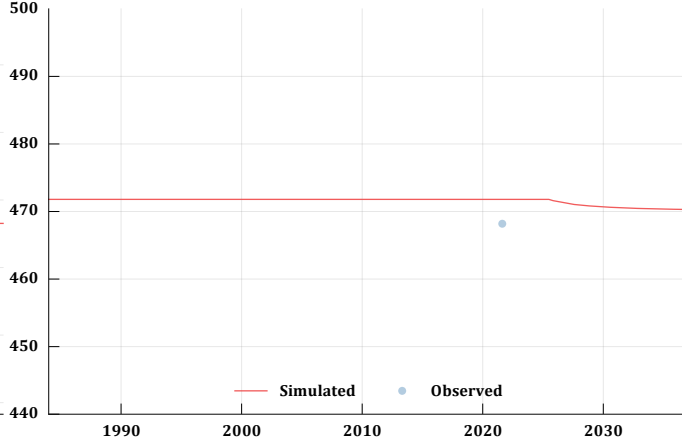
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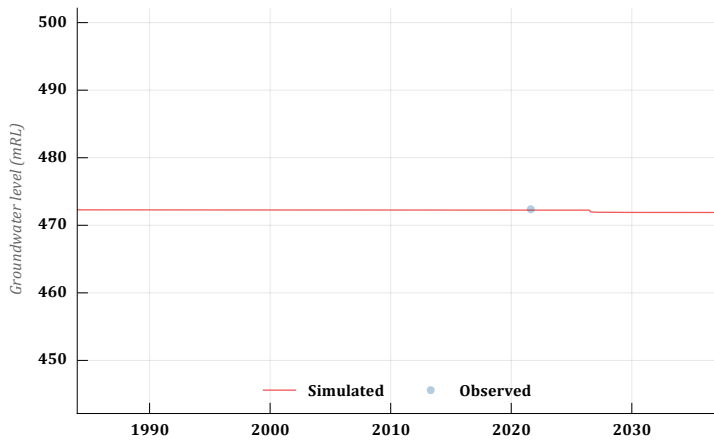
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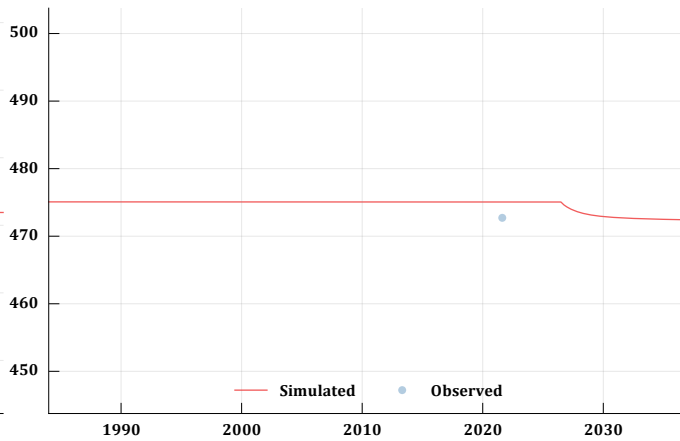
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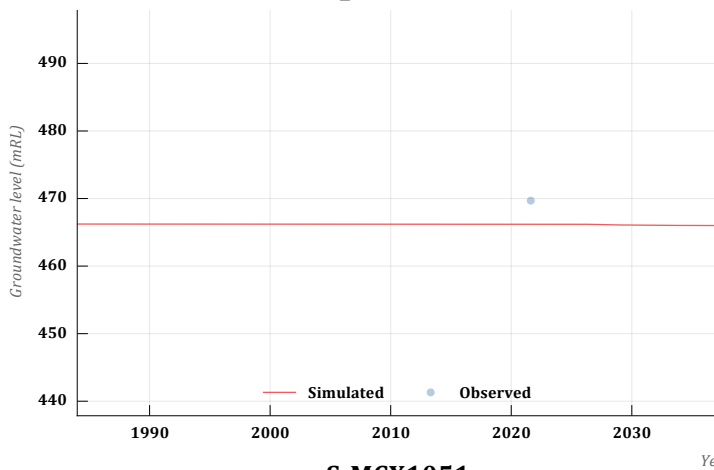
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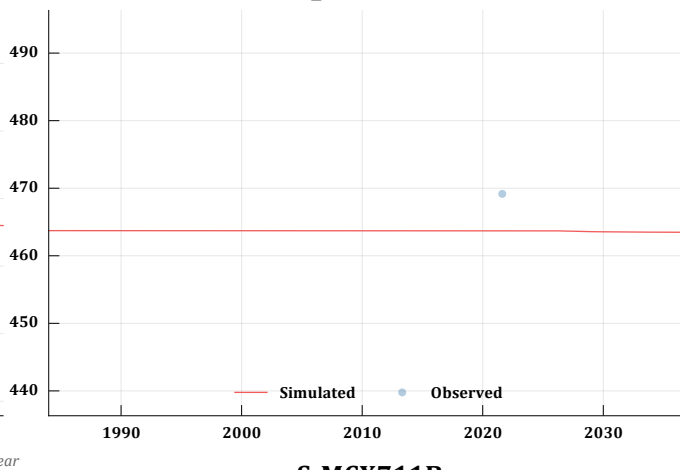
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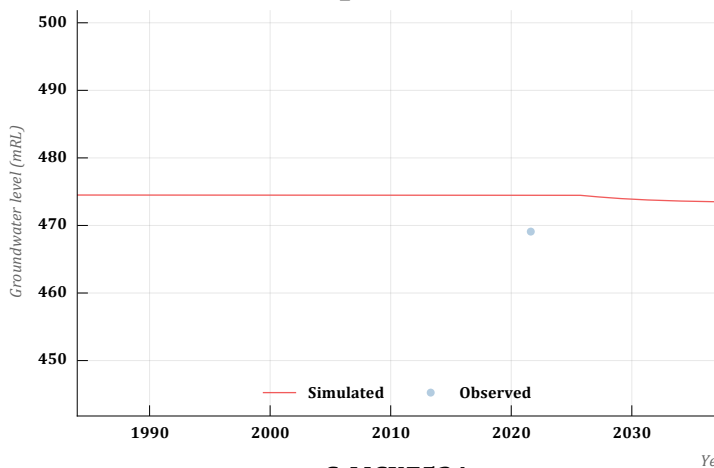
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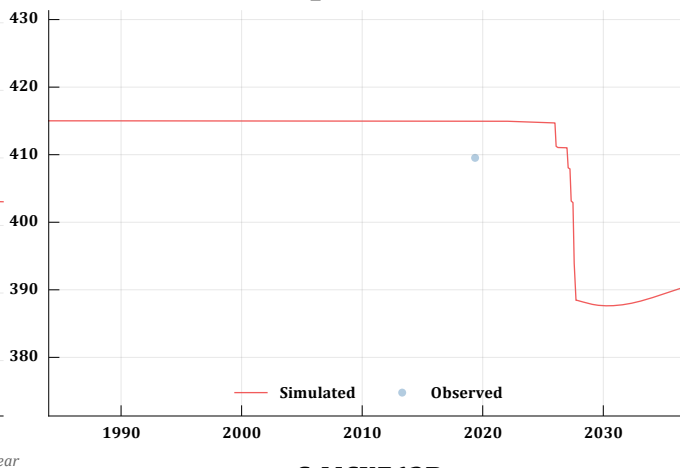
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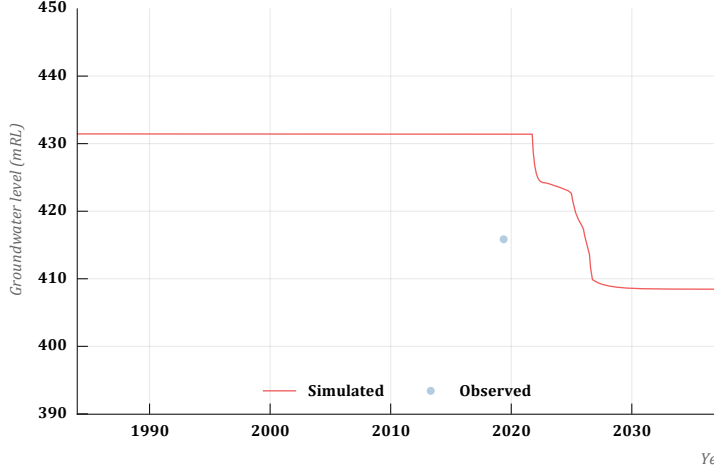
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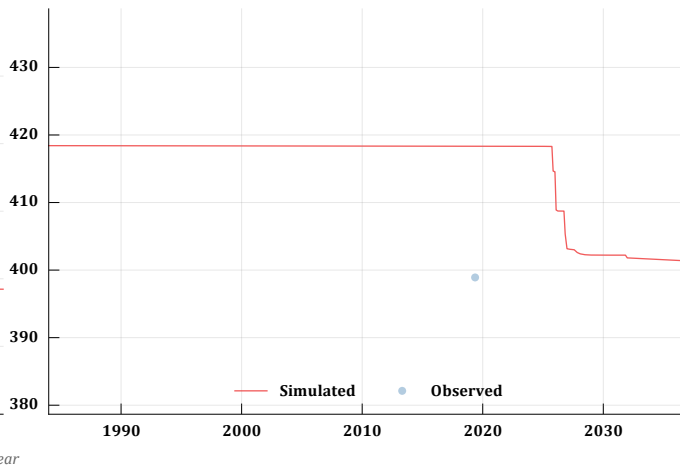
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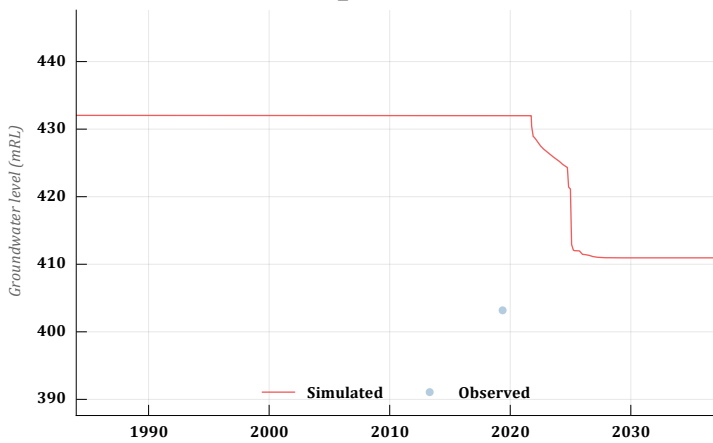
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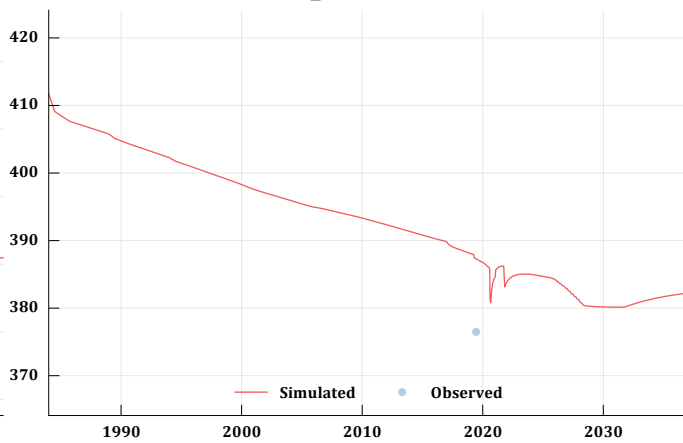
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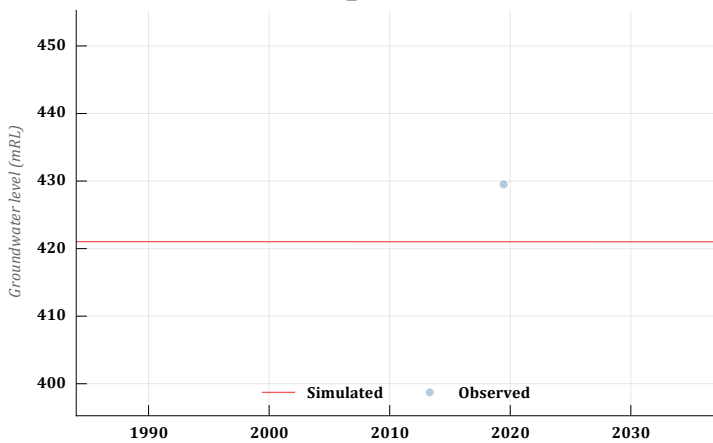
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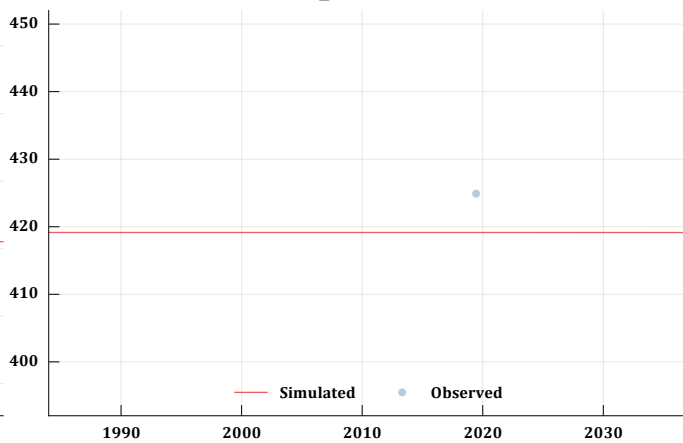
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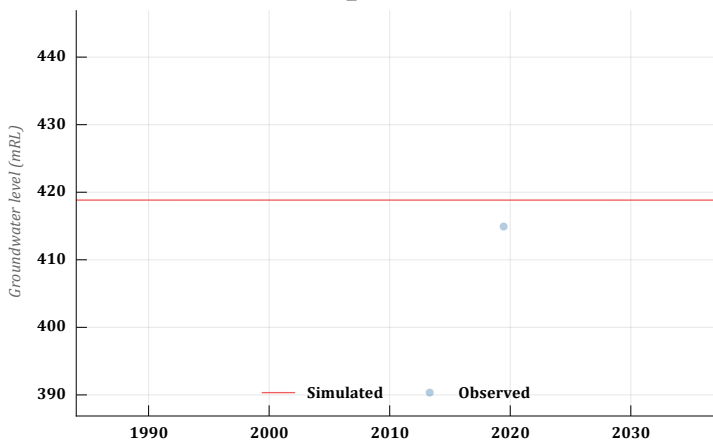
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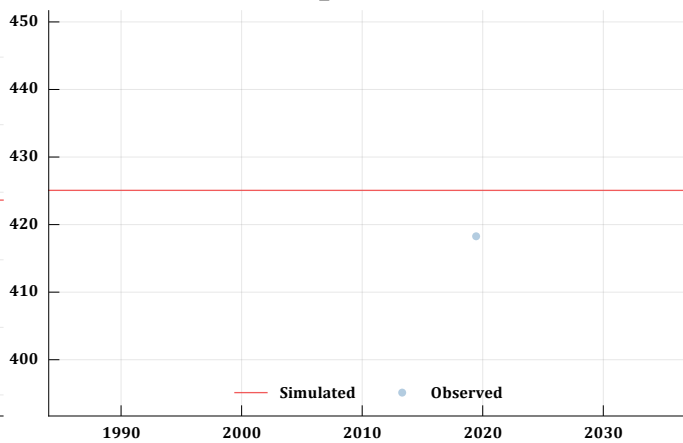
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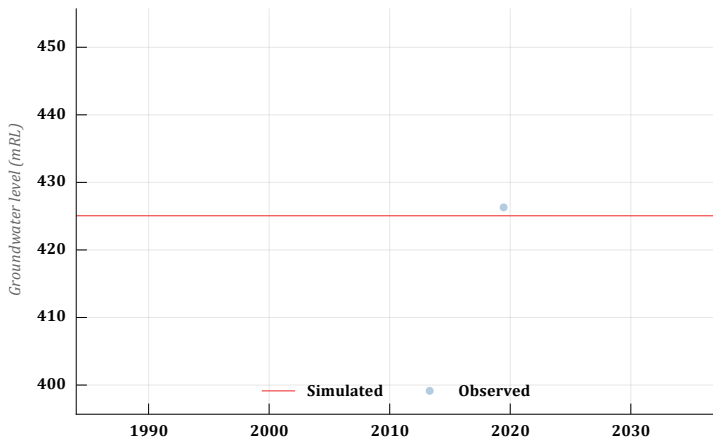
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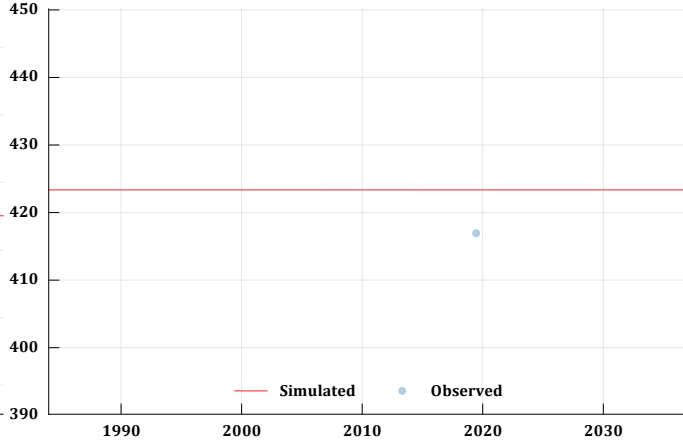
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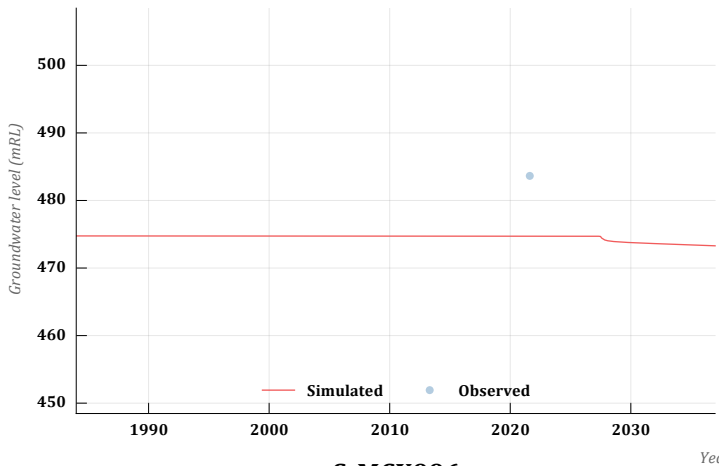
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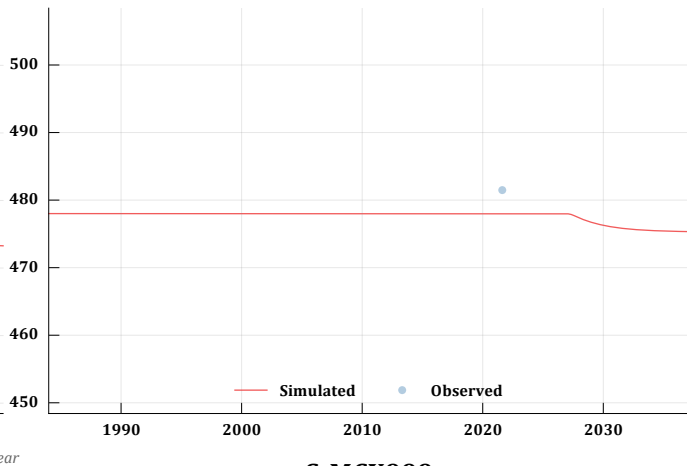
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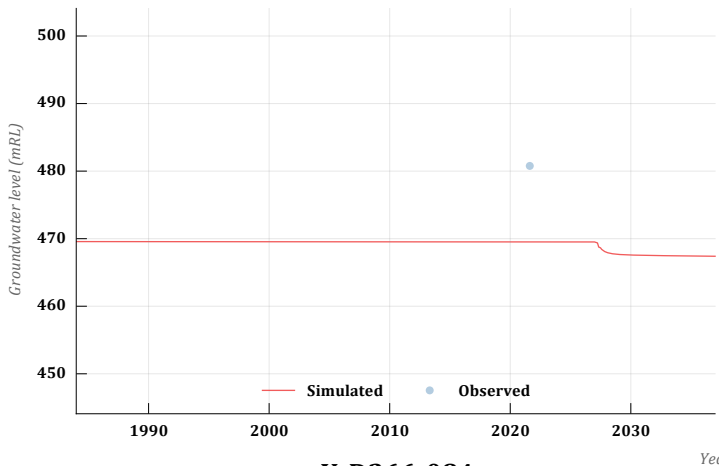
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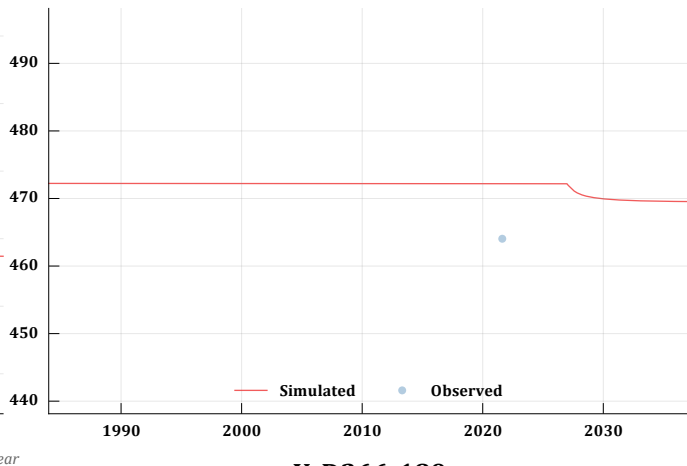
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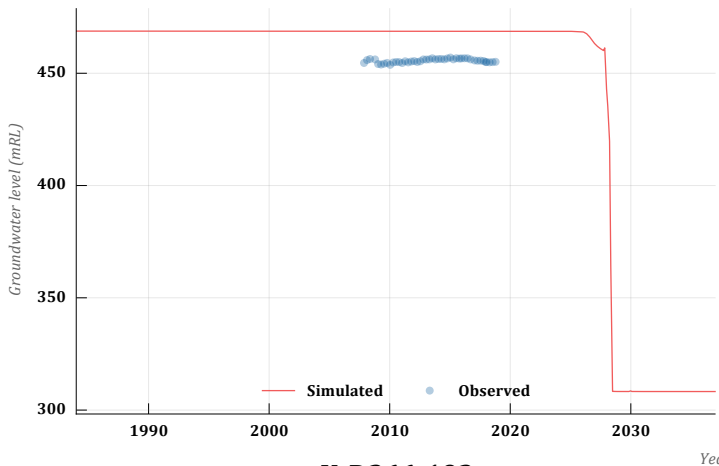
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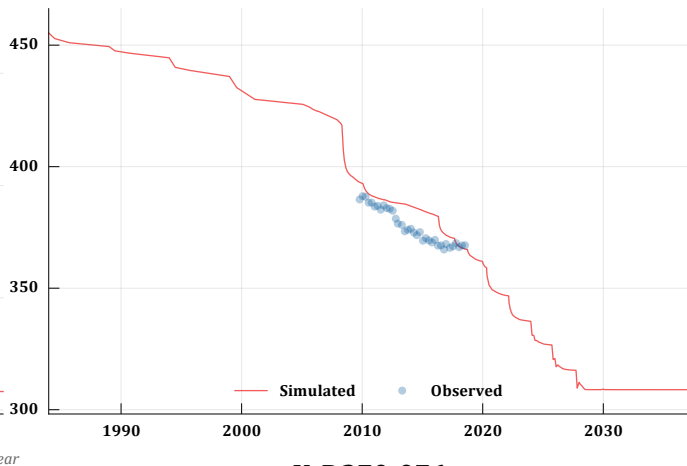
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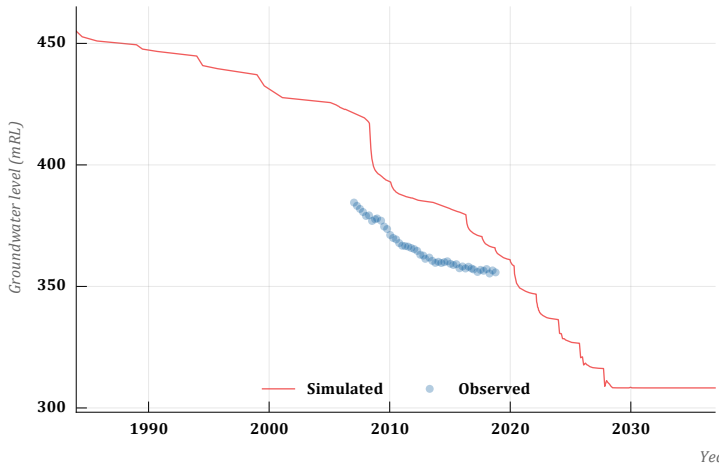
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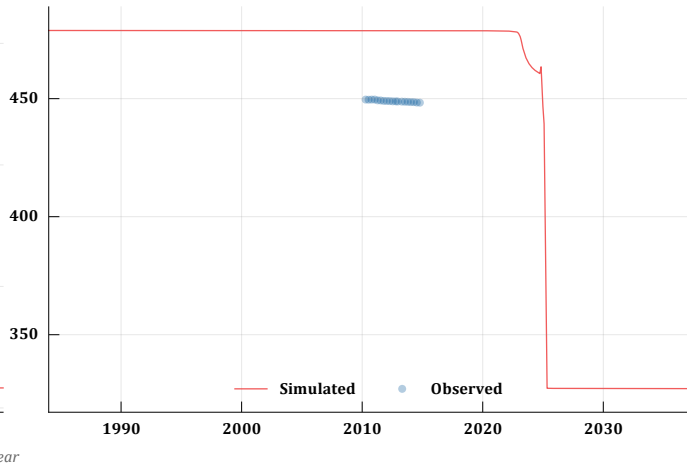
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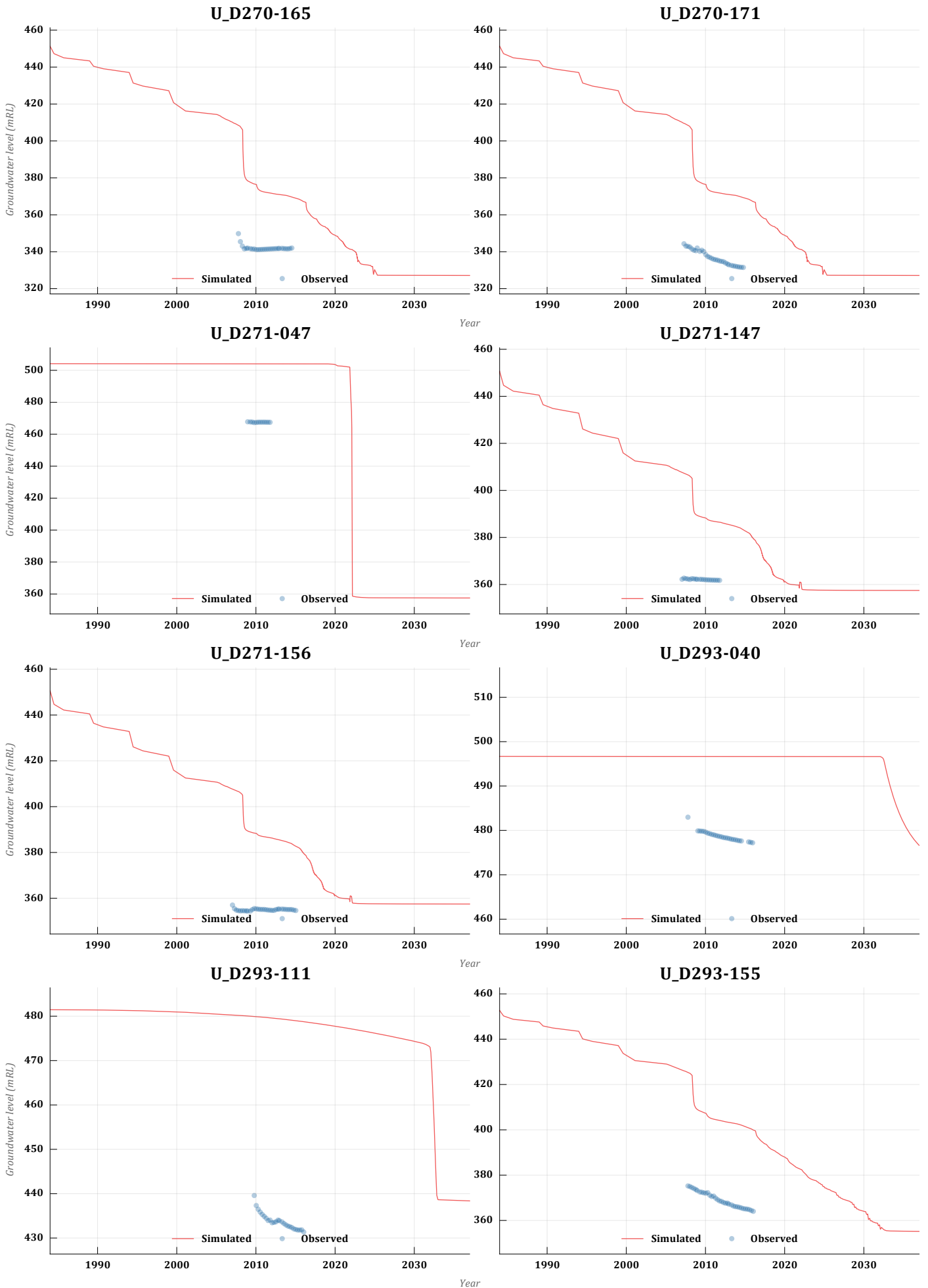


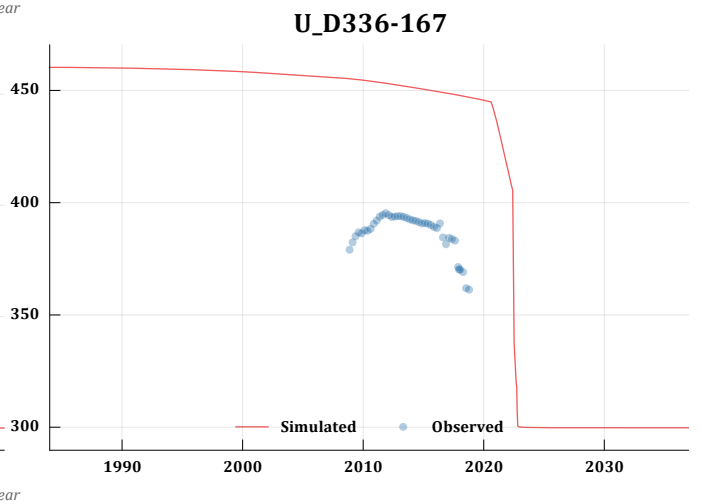
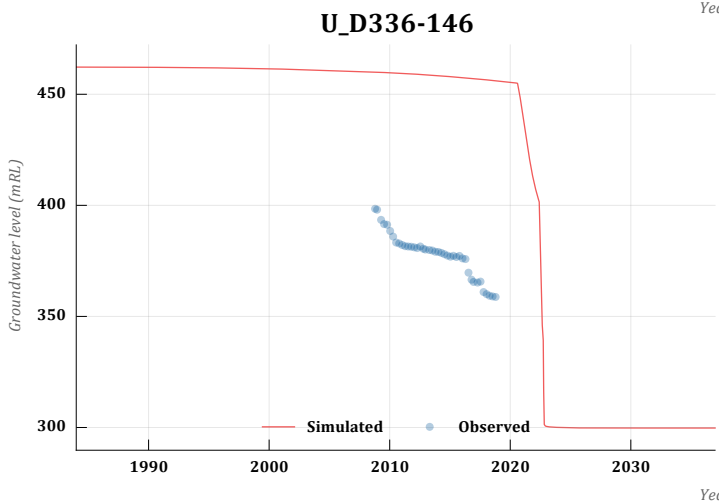
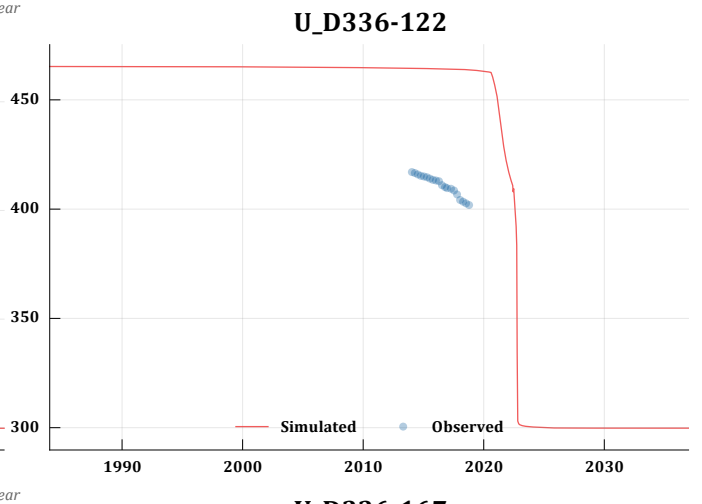
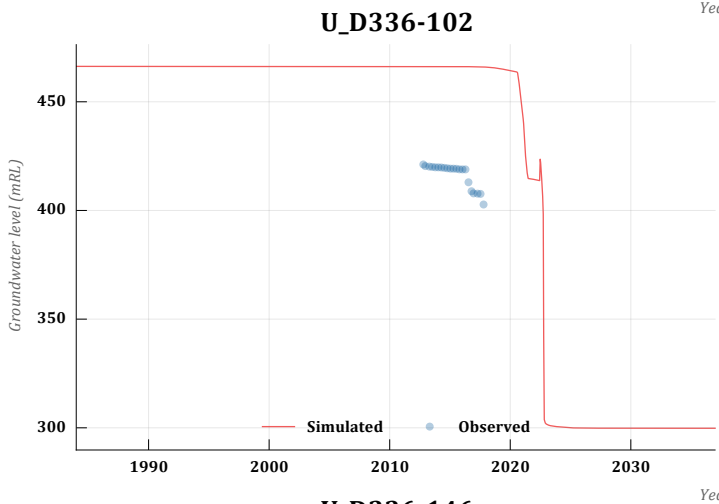
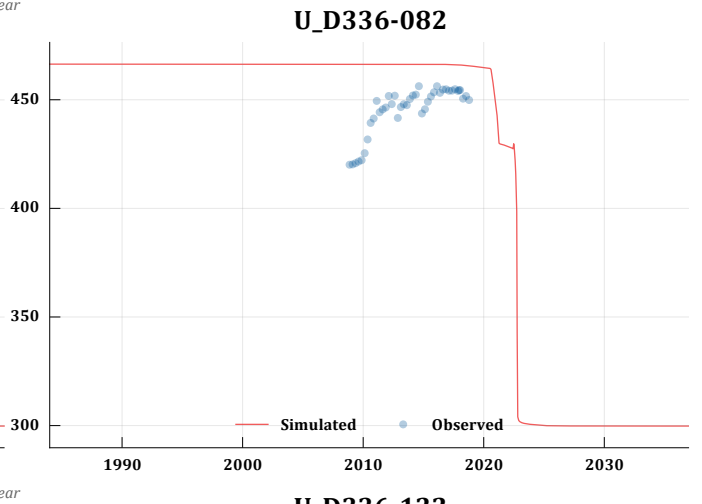
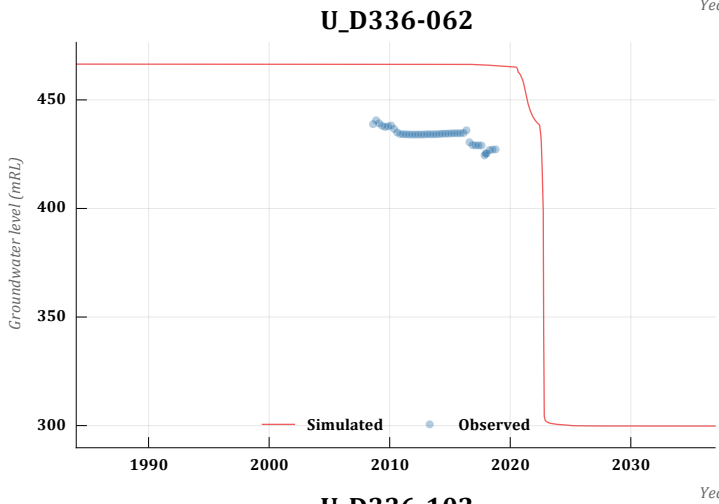
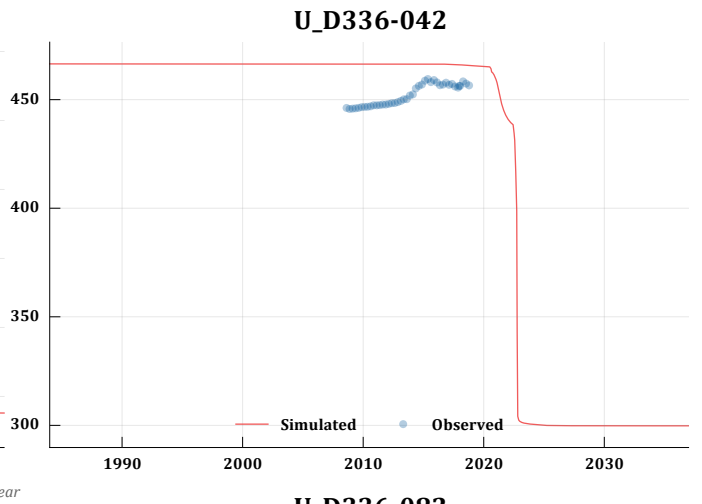
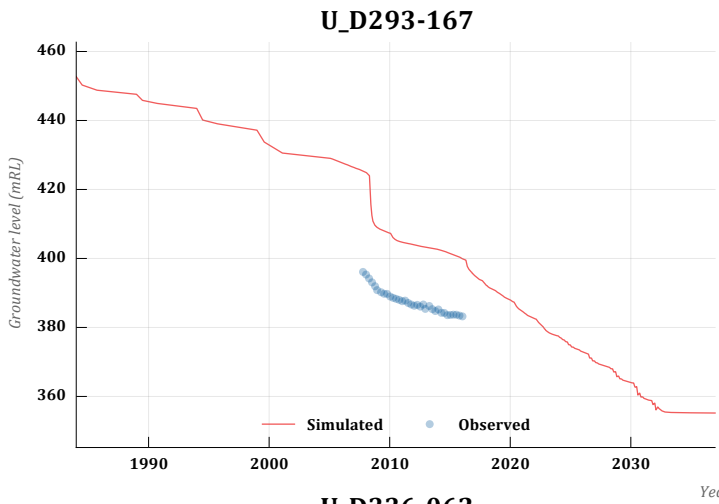
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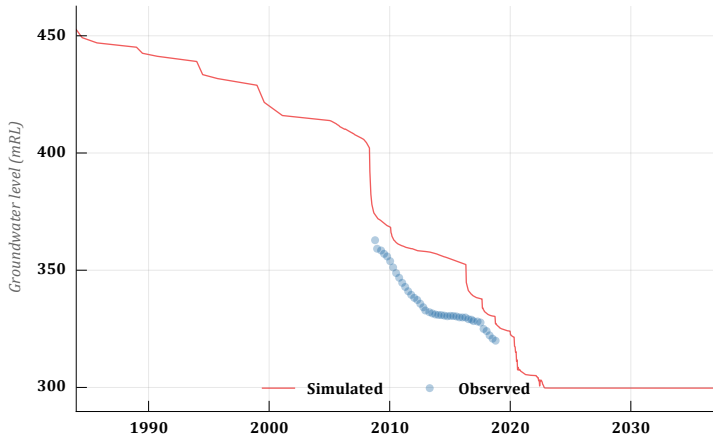
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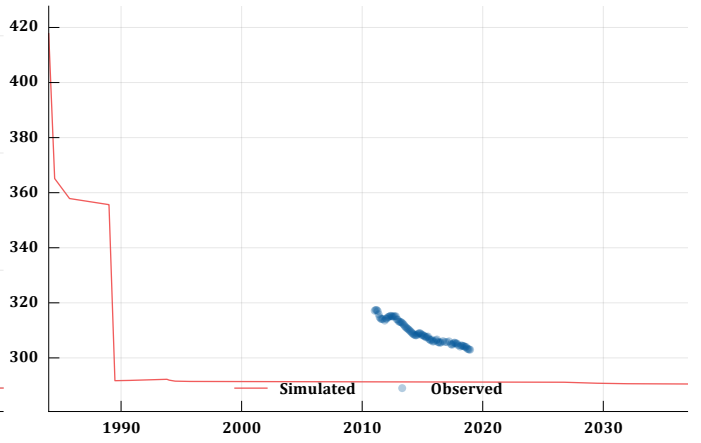




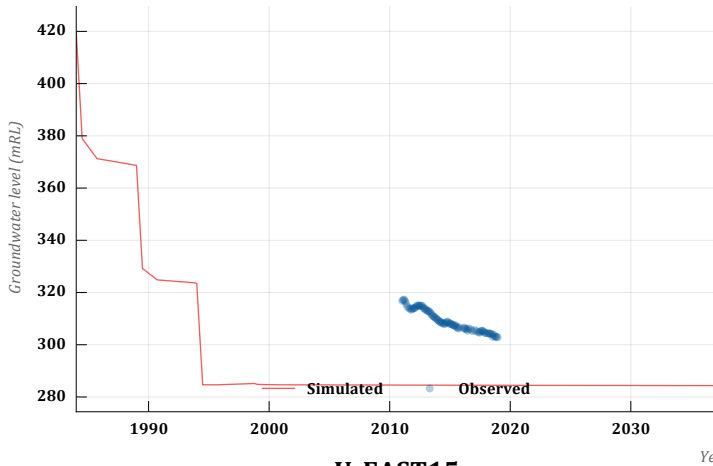
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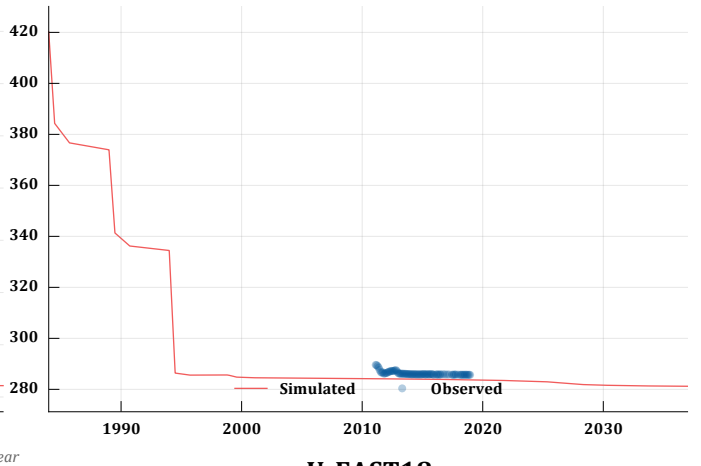
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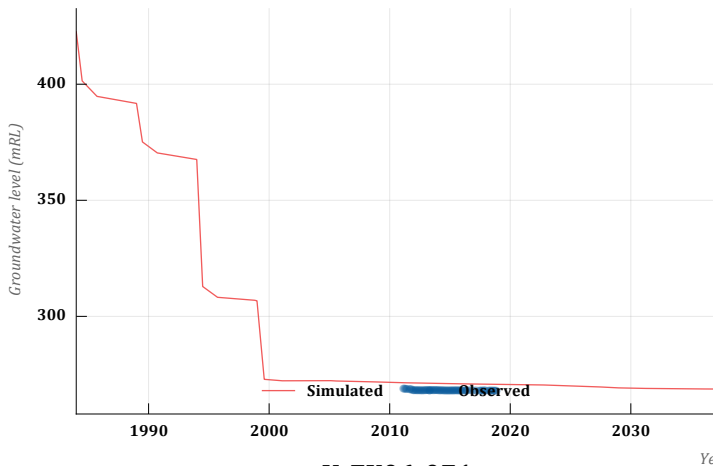
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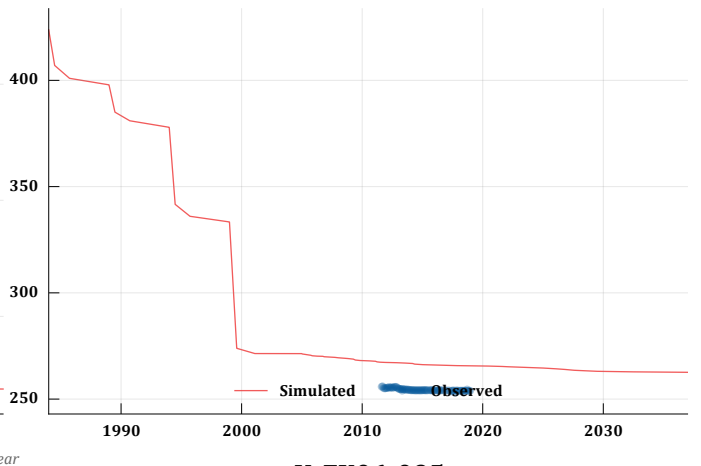
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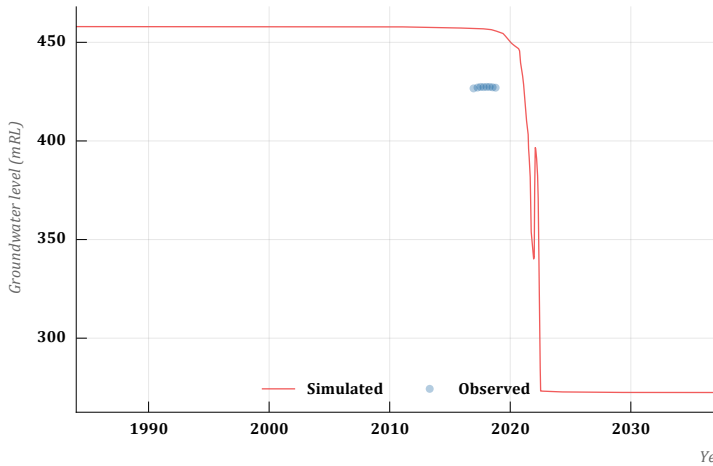
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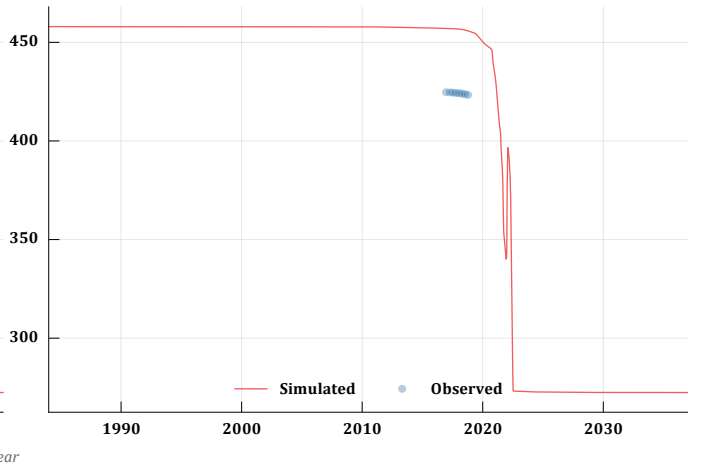
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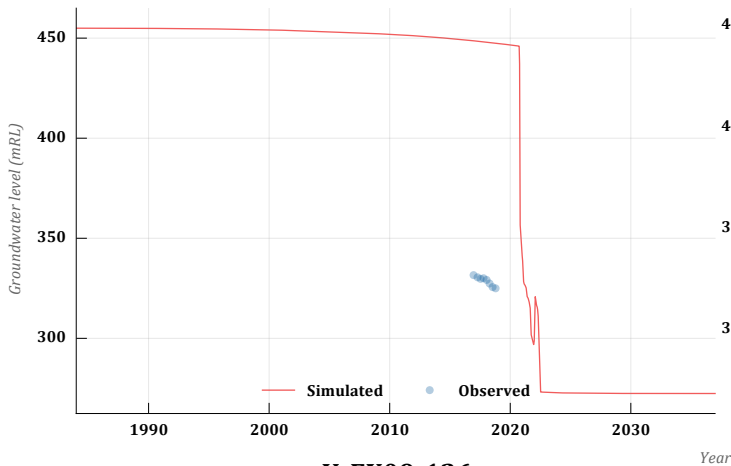
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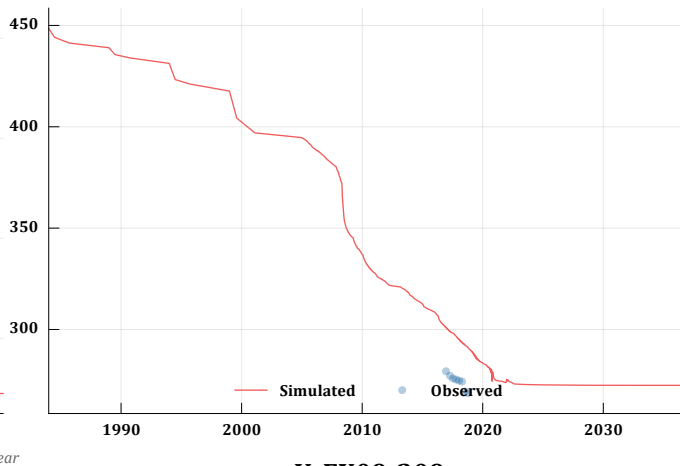
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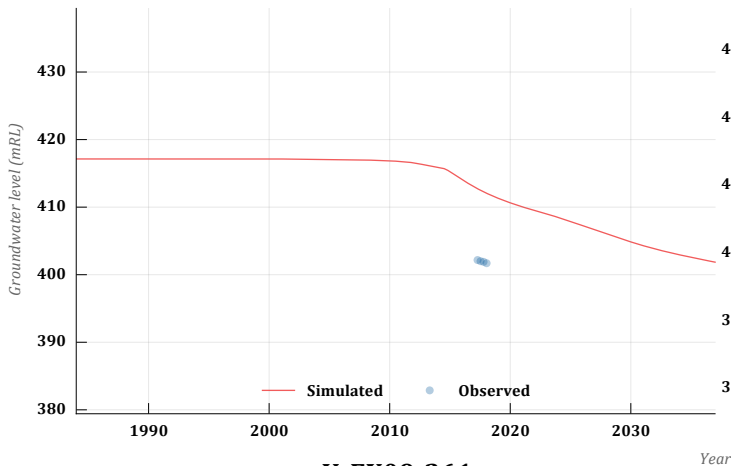
U_EX06-185



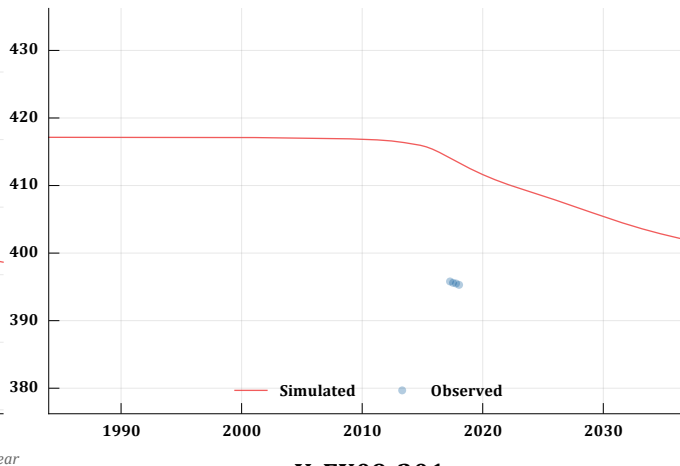
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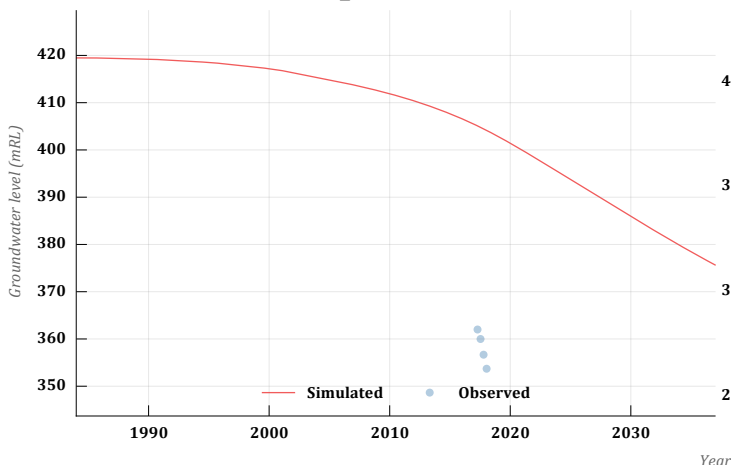
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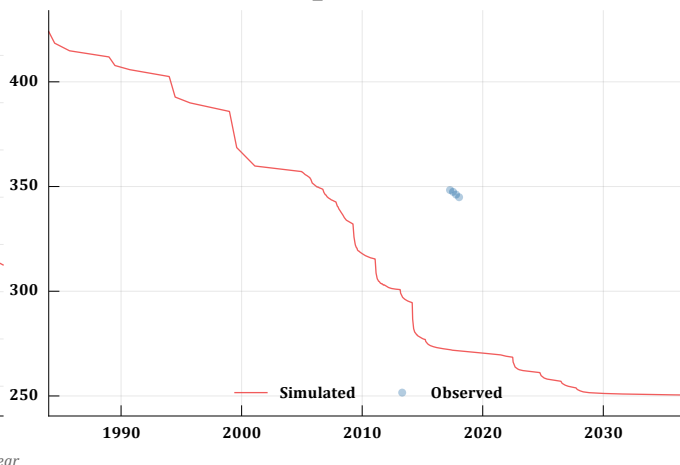
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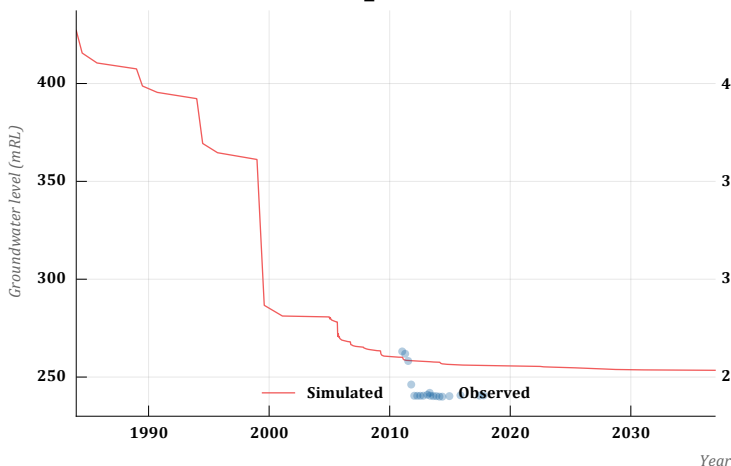
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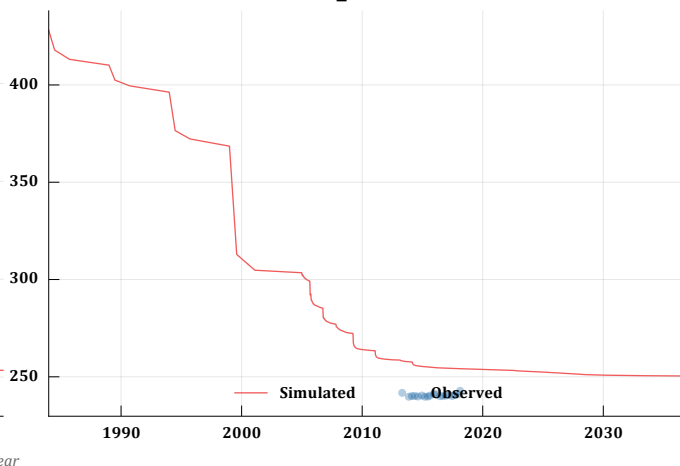
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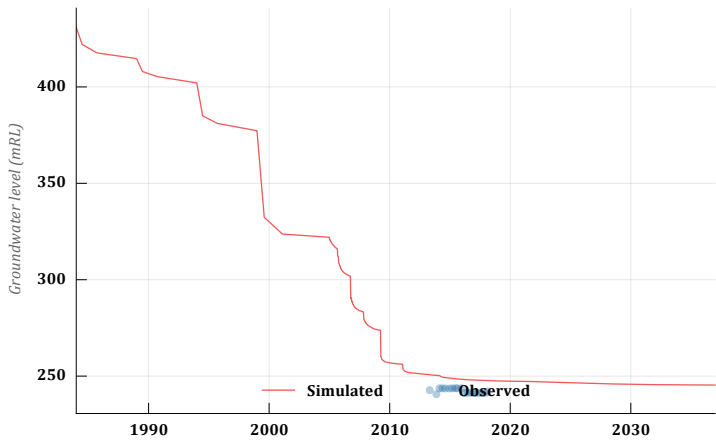
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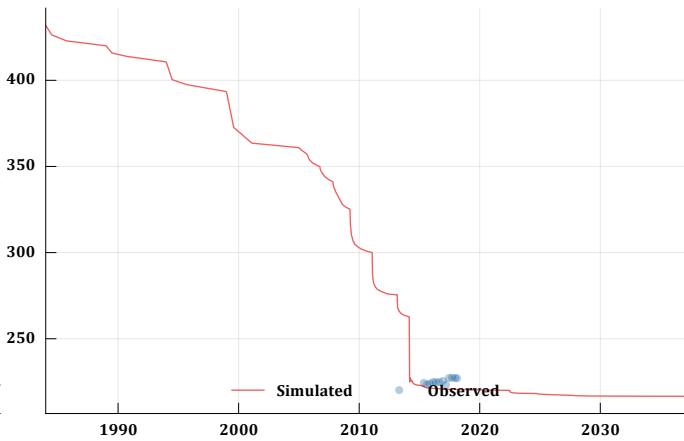
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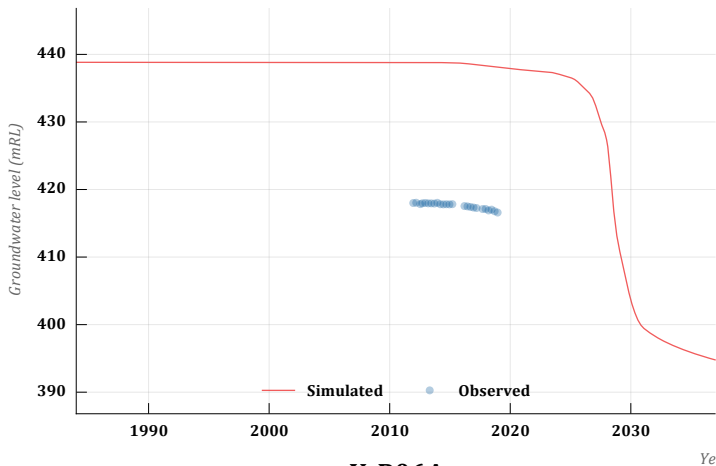
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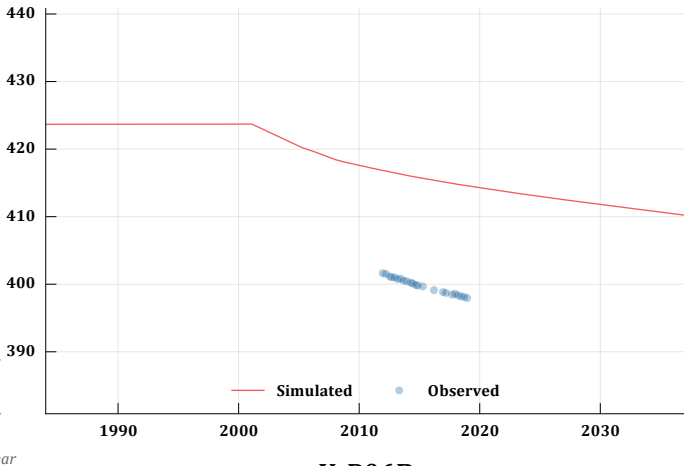
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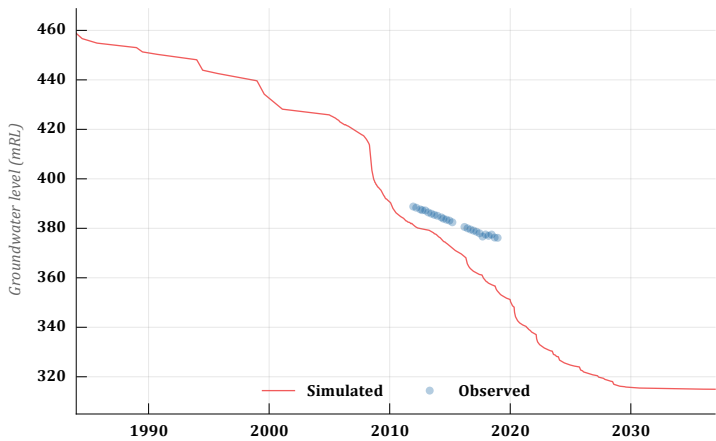
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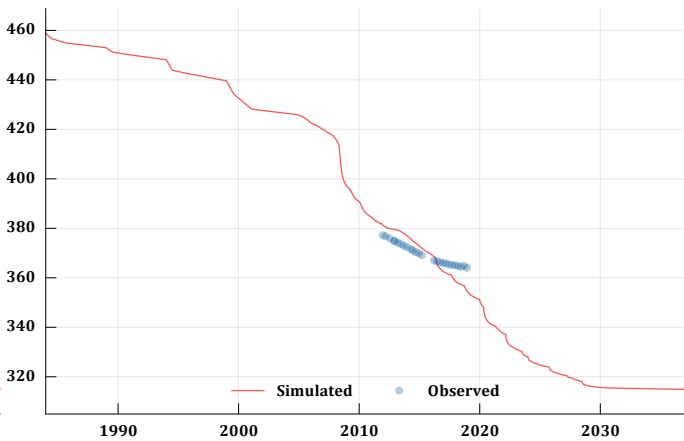
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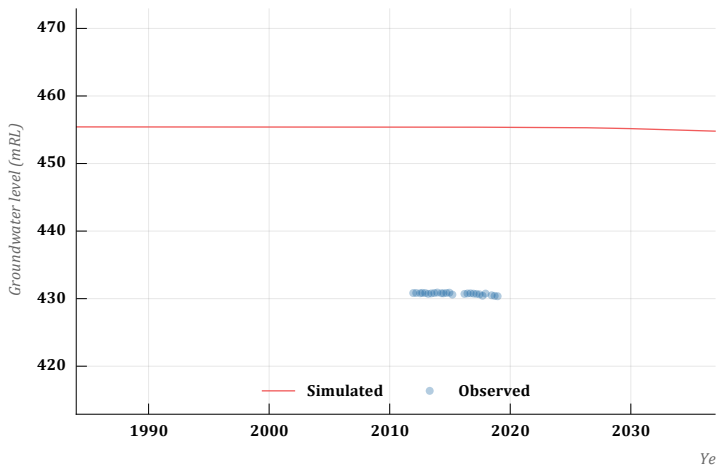
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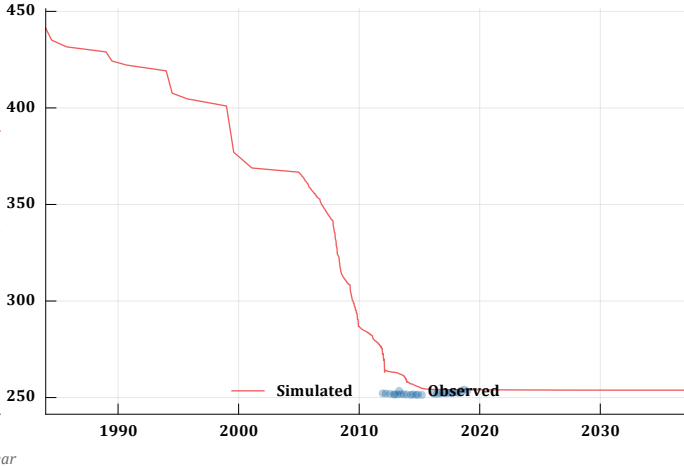
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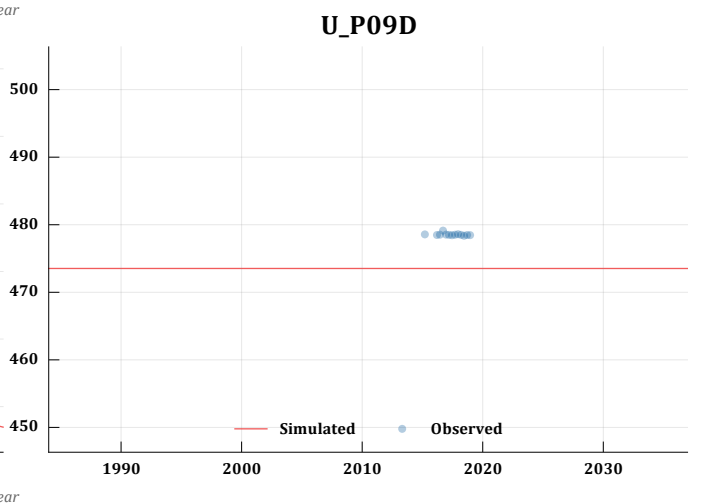
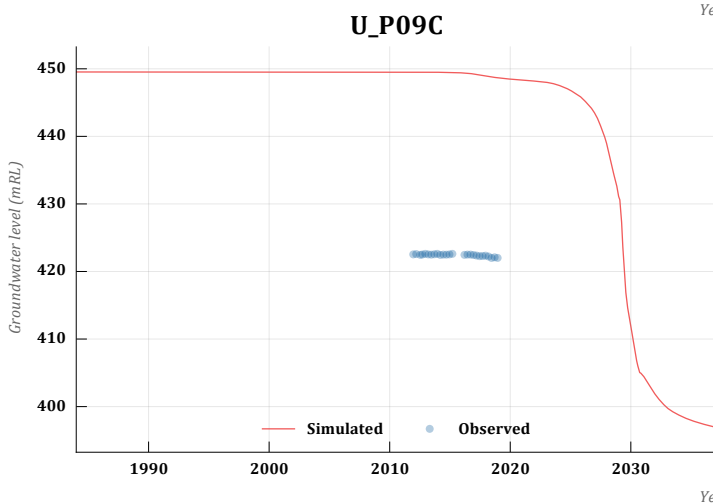
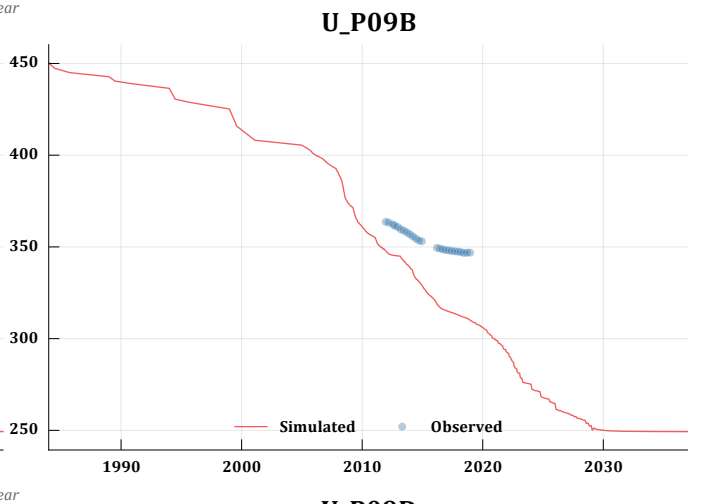
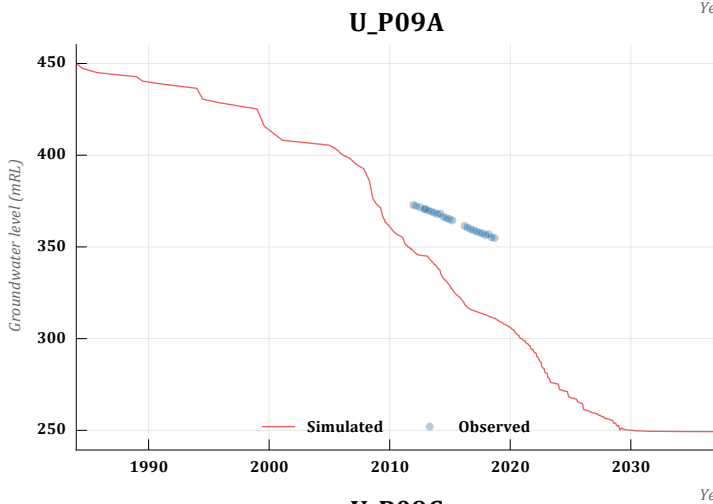
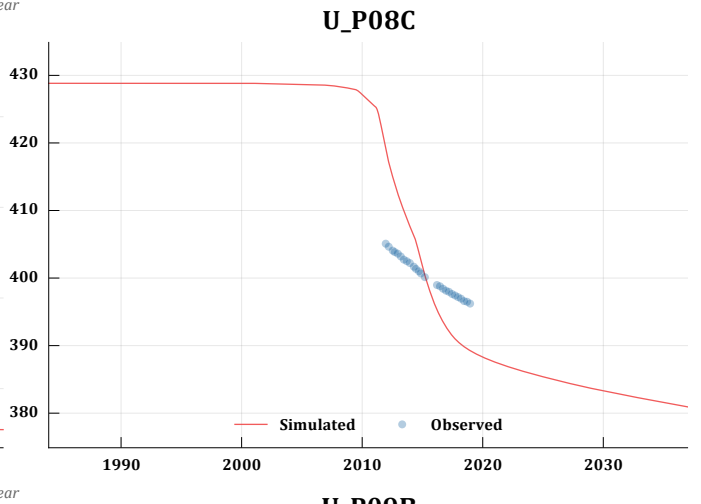
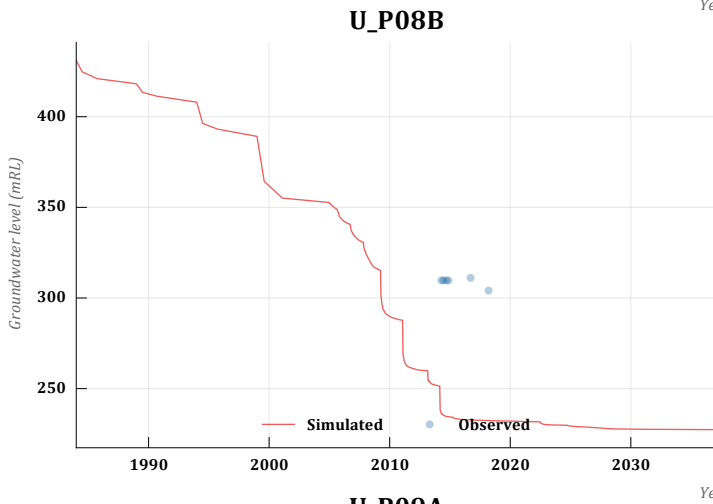
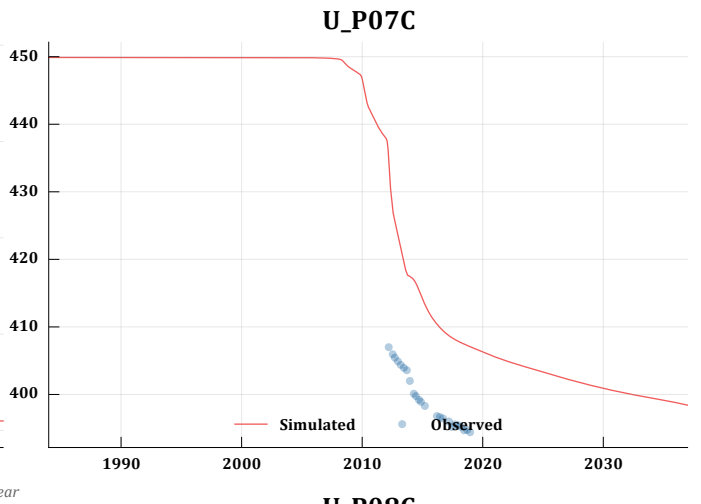
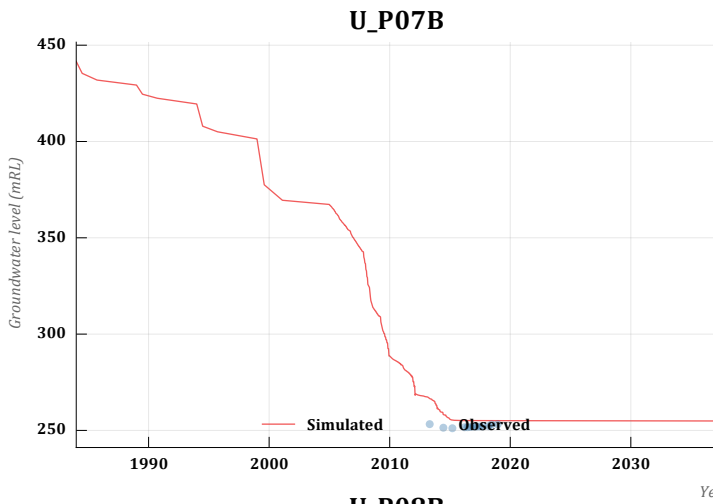


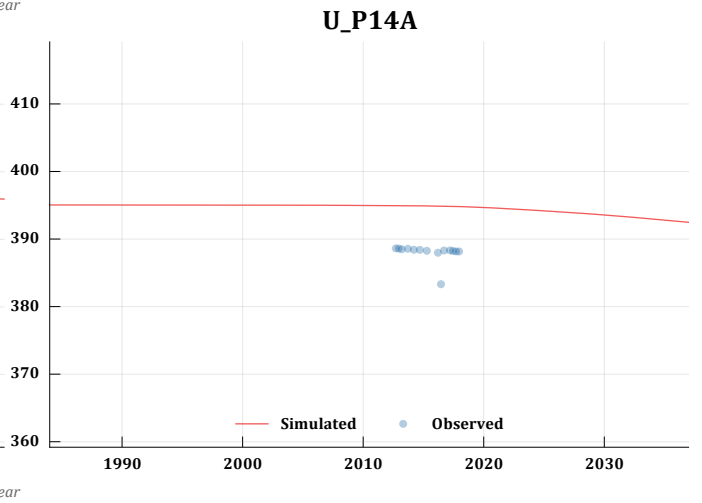
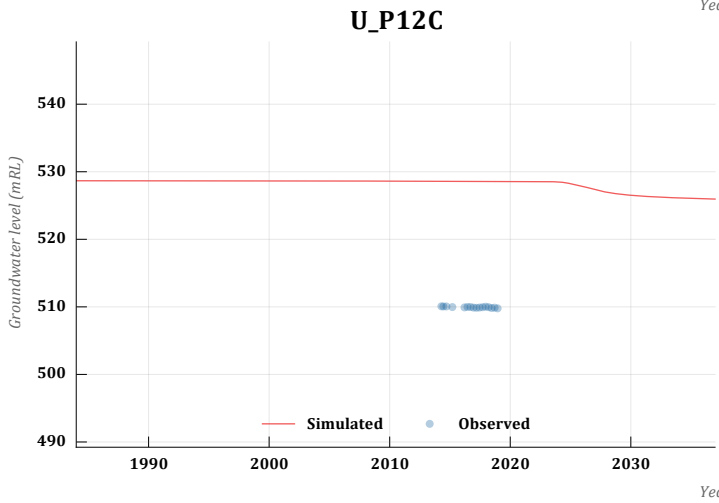
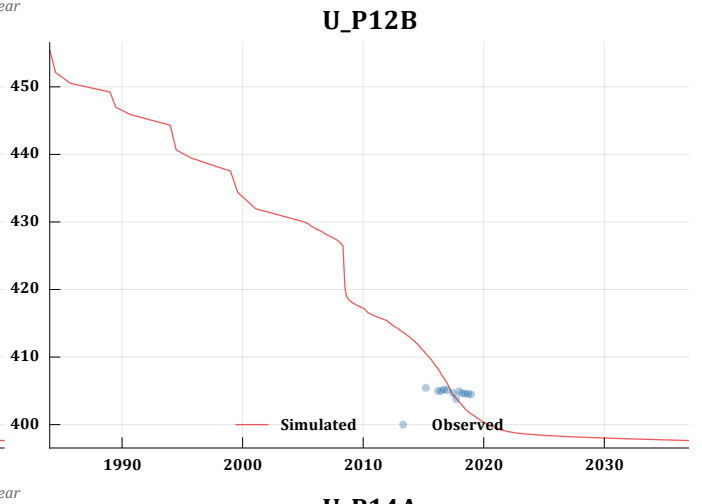
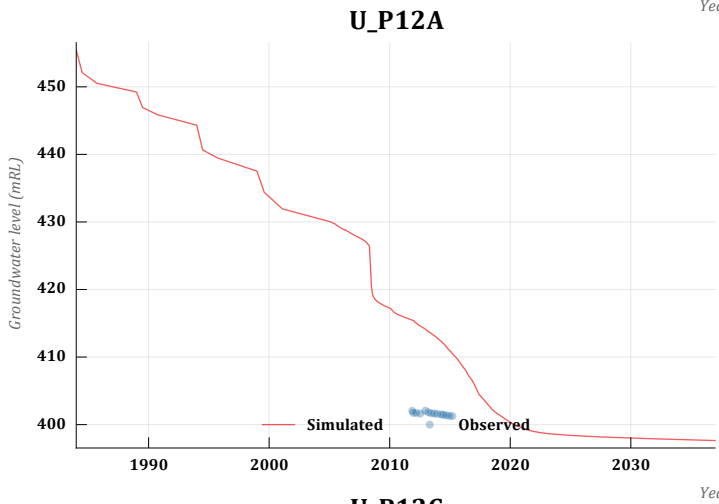
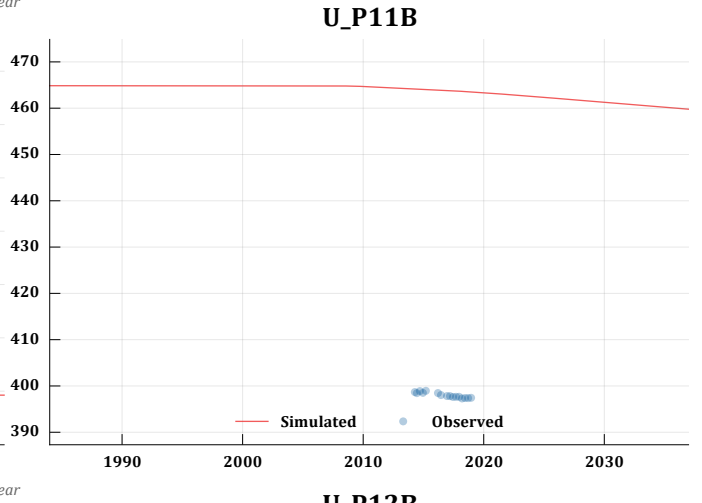
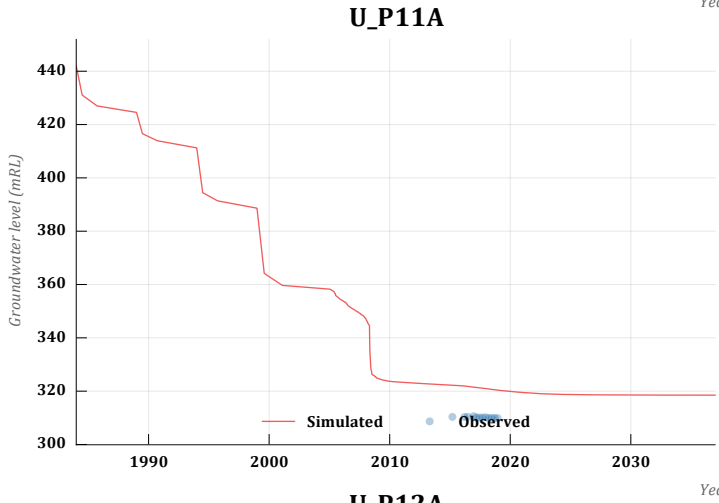
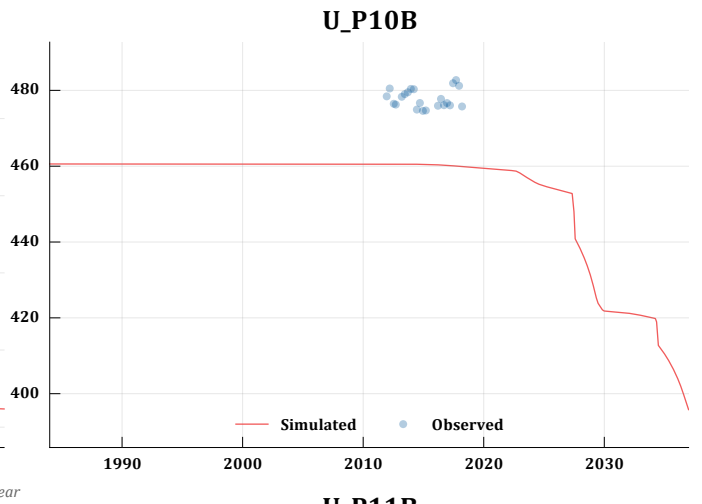
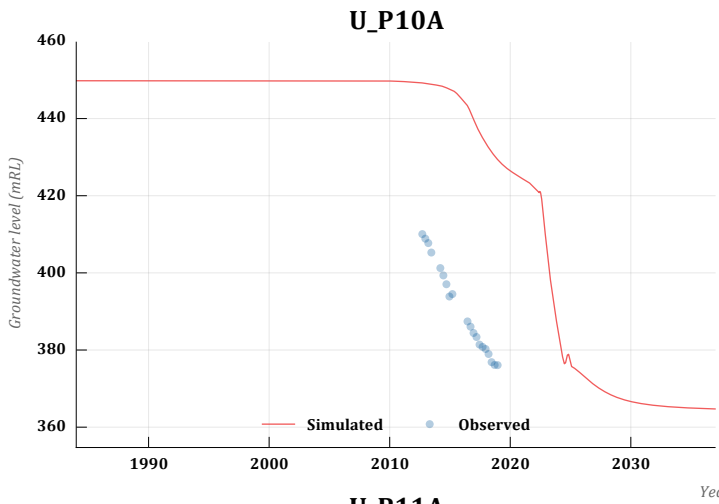
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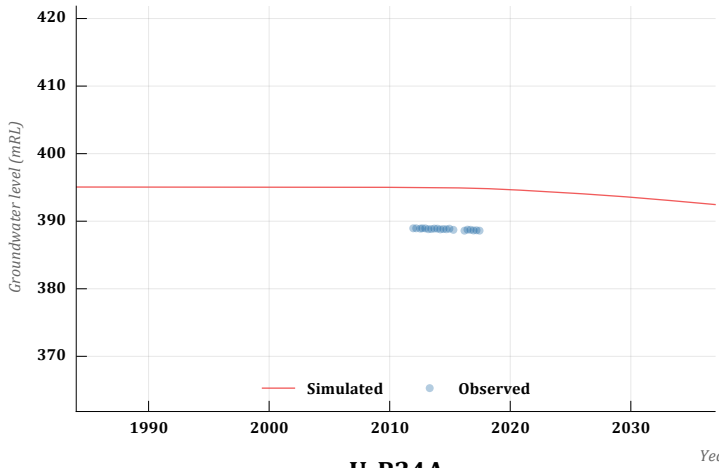
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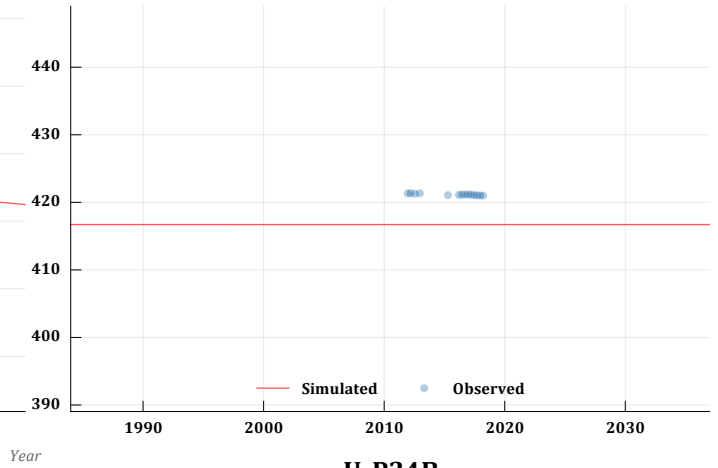




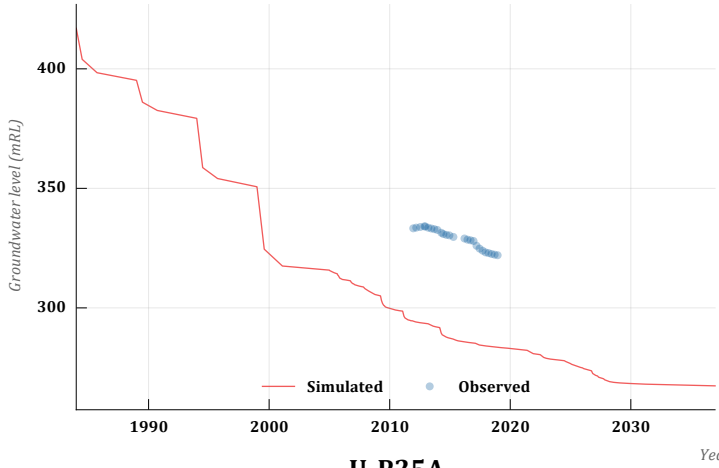
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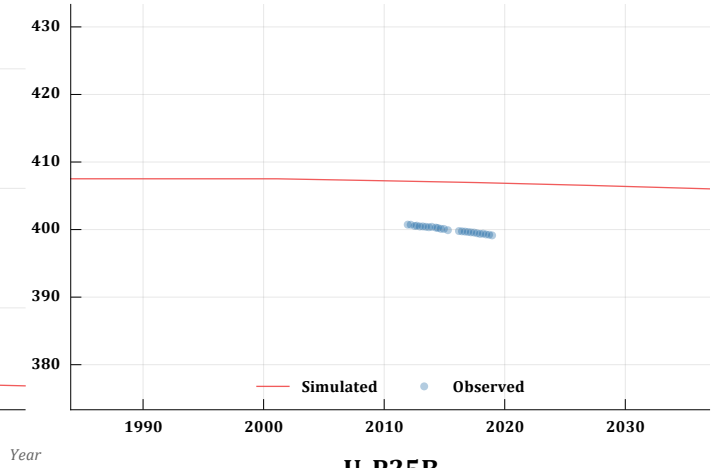
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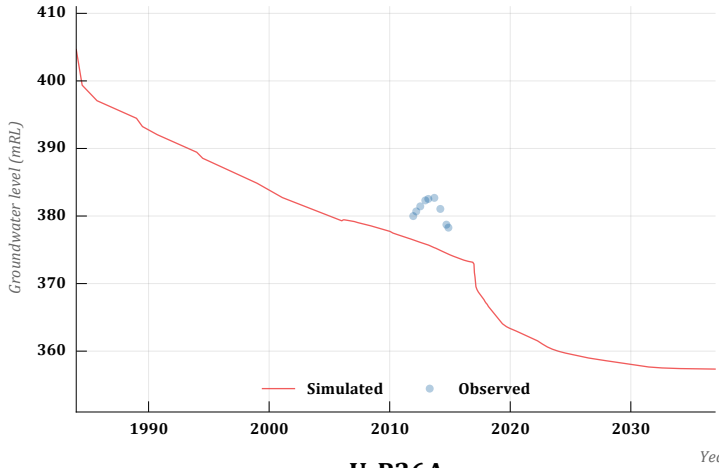
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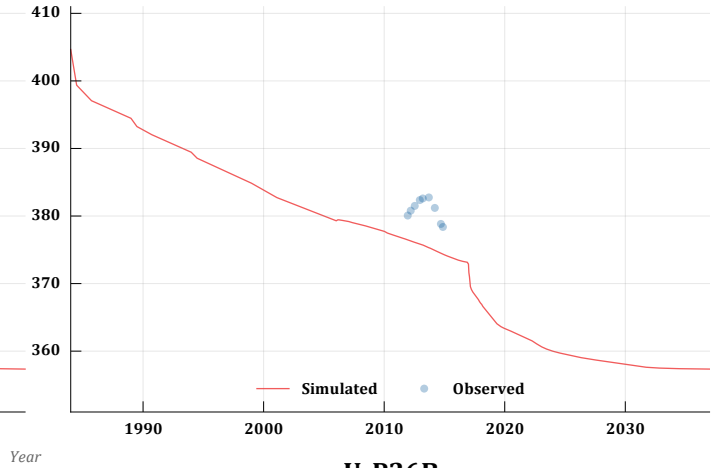
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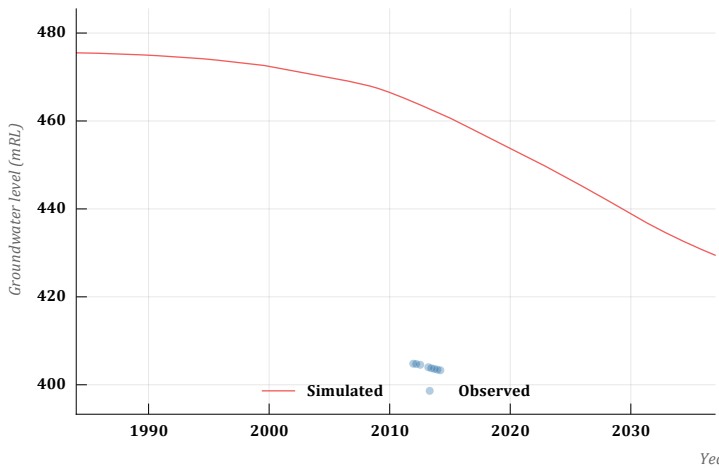
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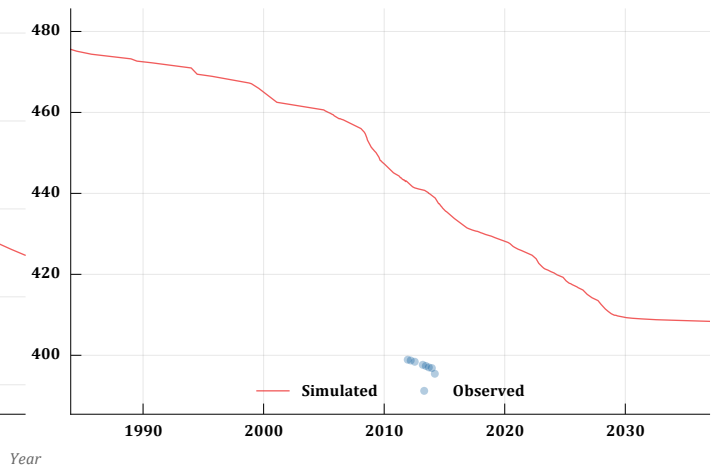
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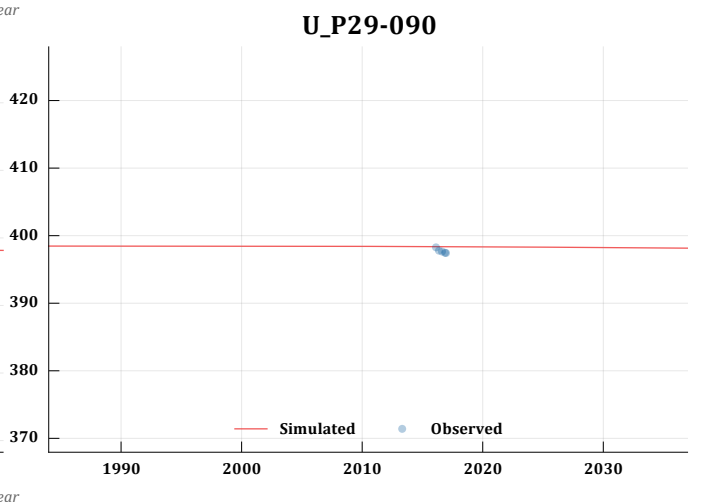
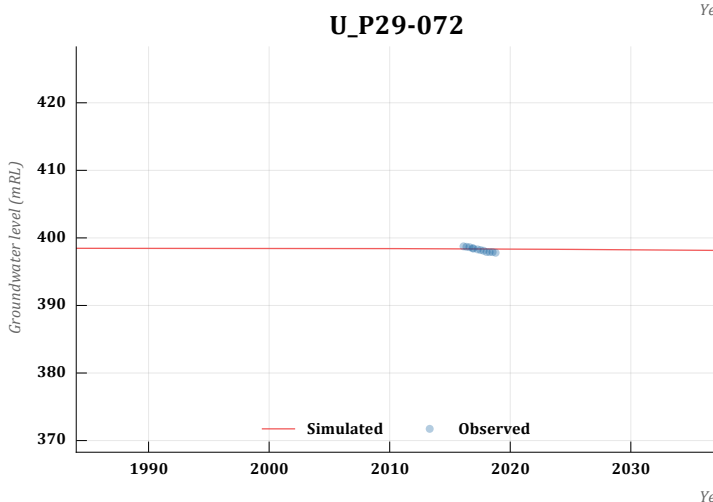
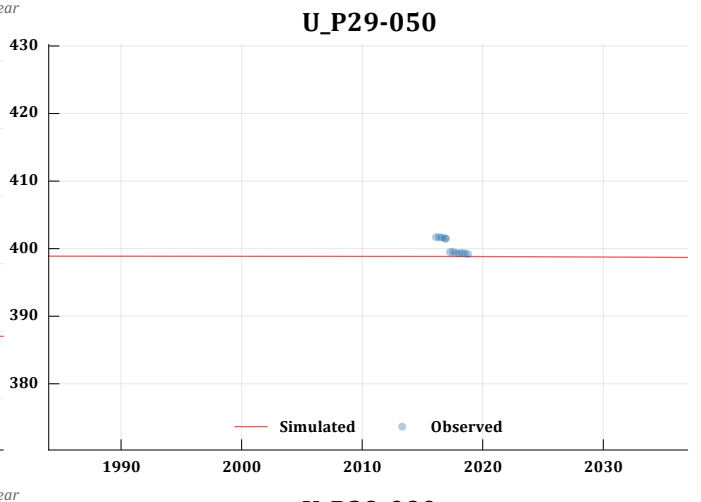
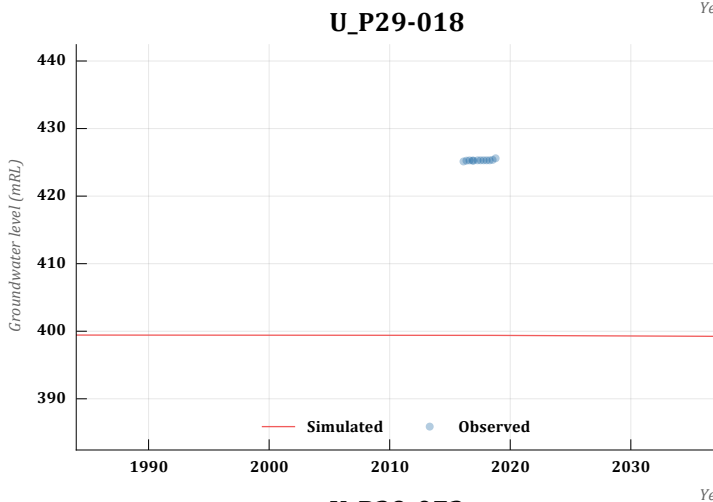
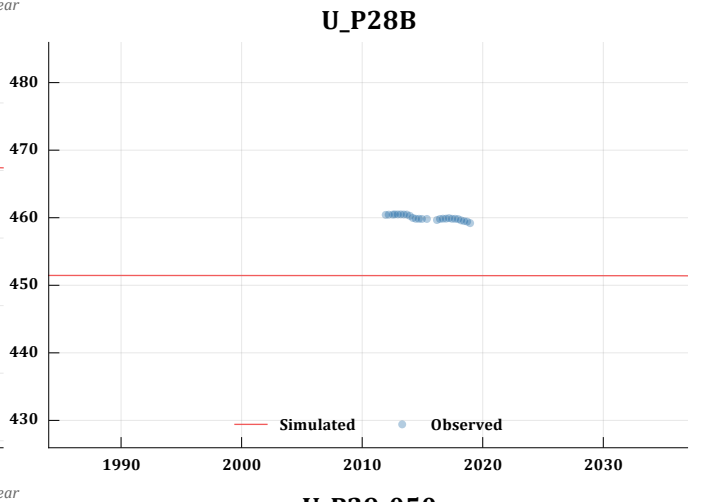
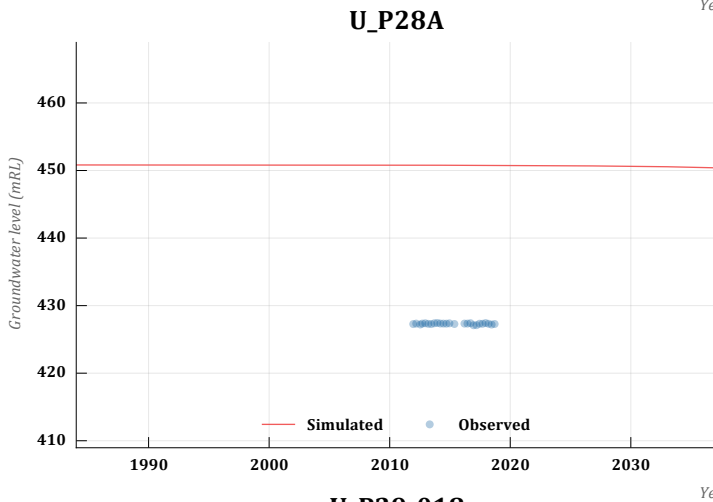
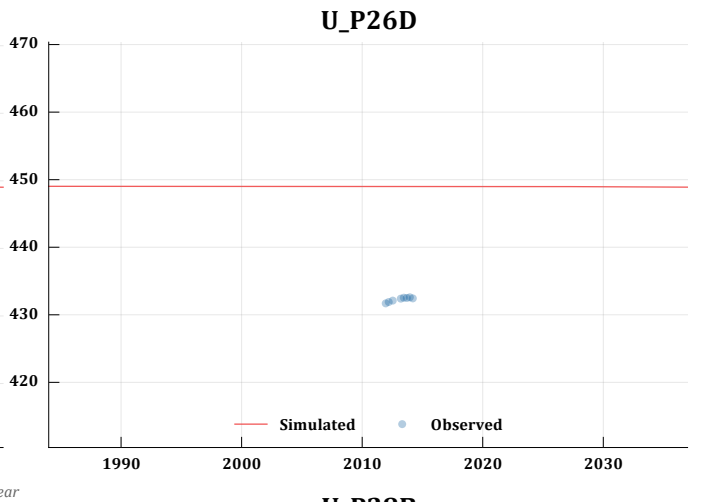
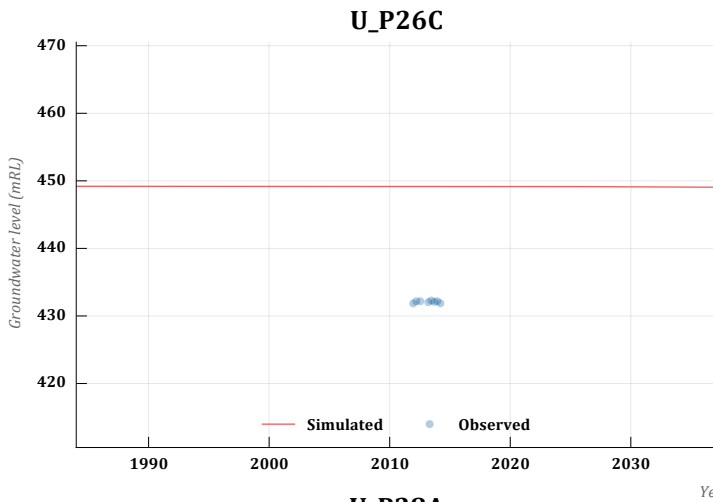


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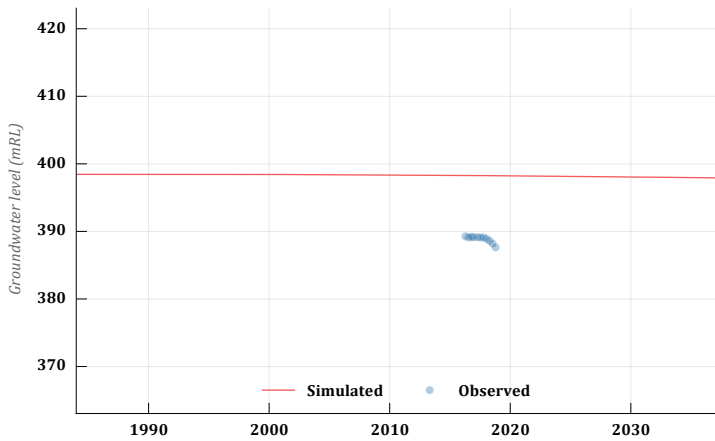


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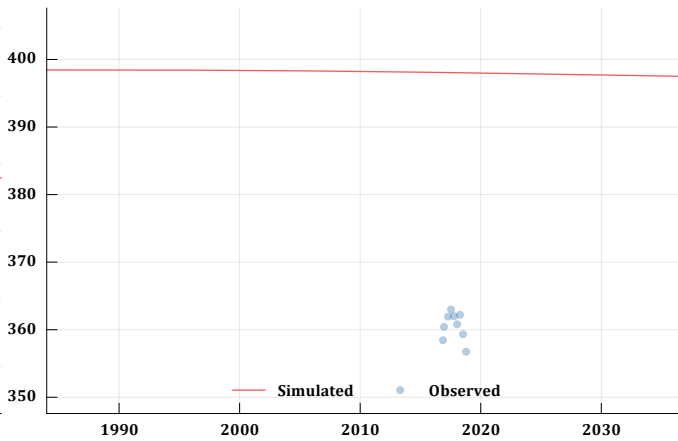




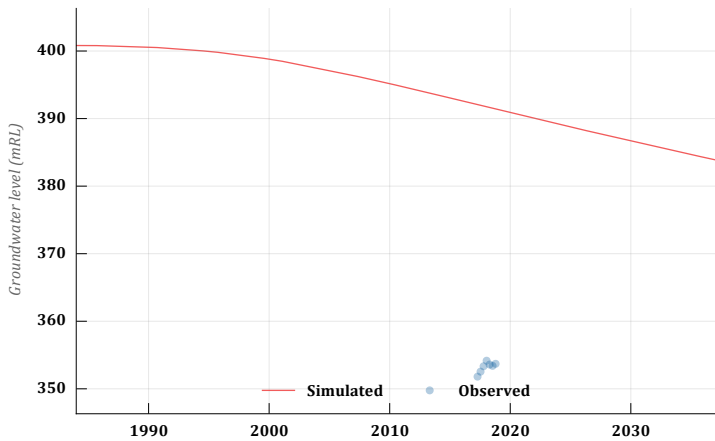
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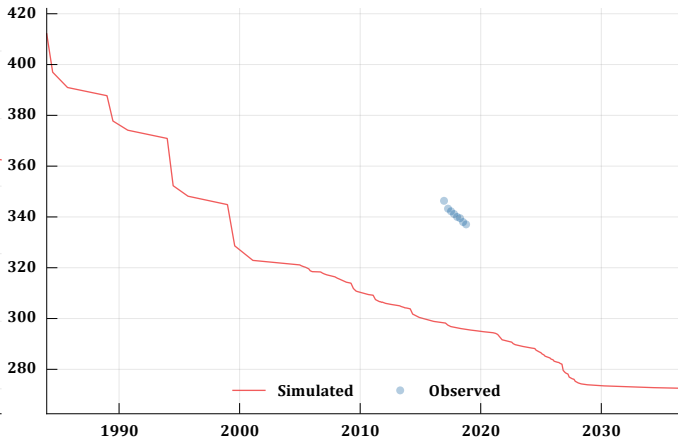
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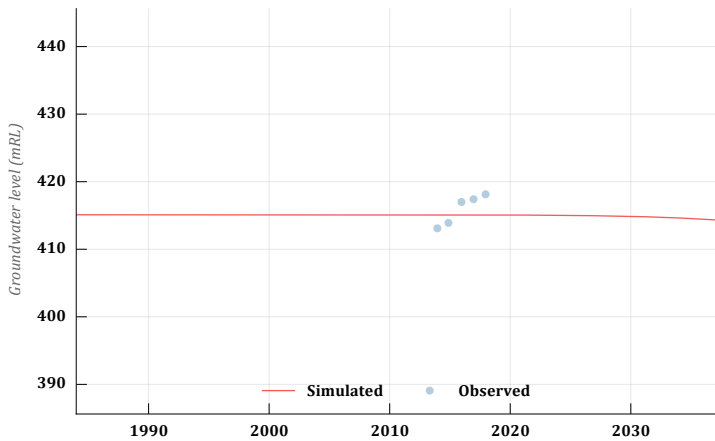
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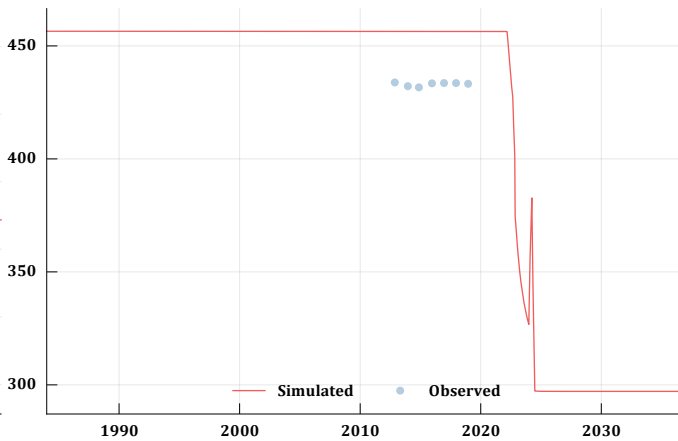
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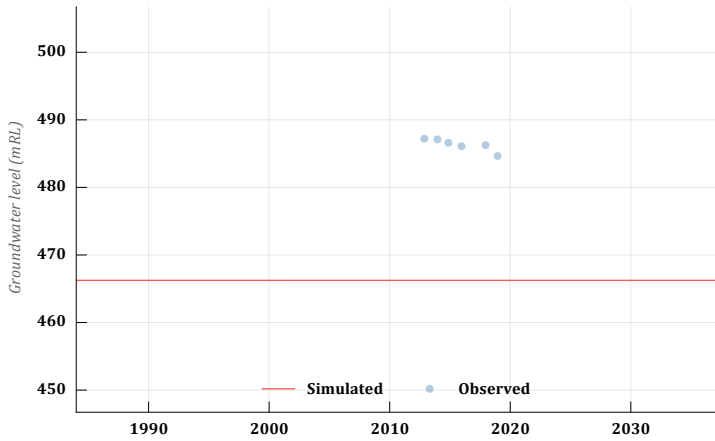
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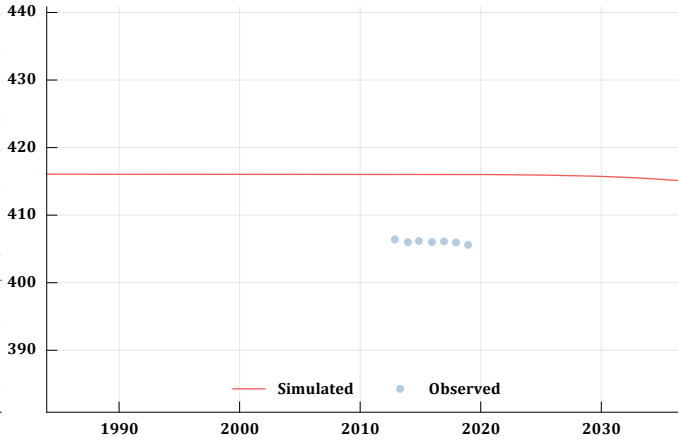
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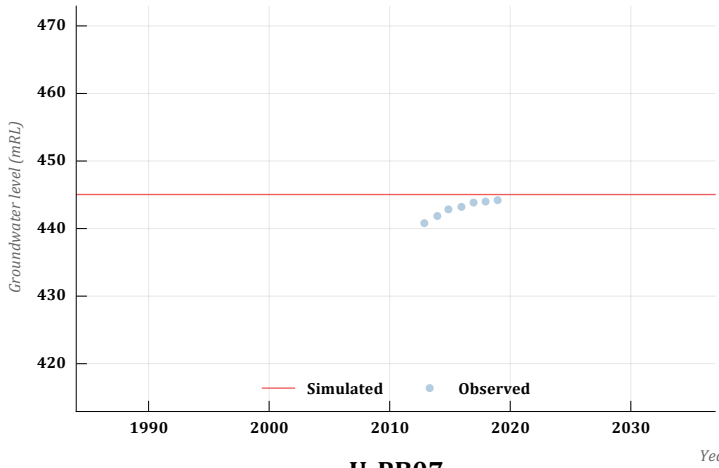
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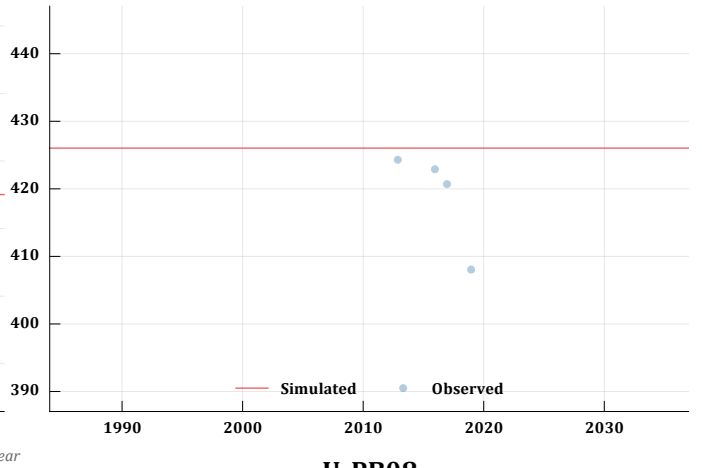
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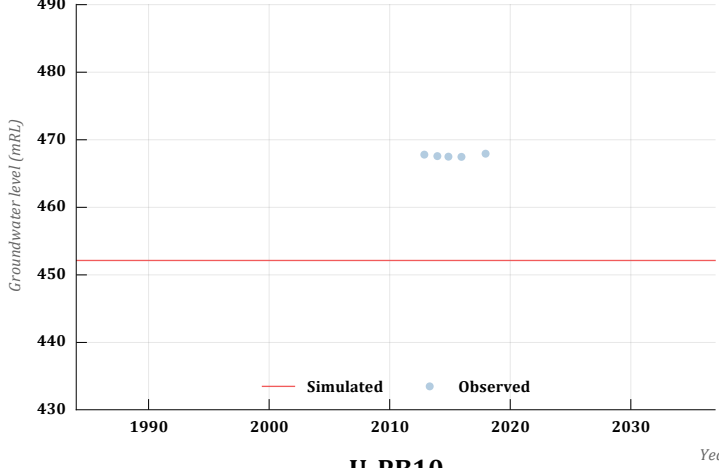
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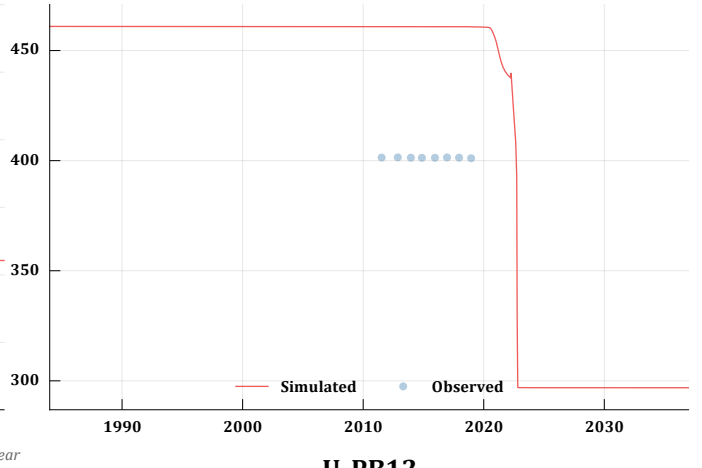
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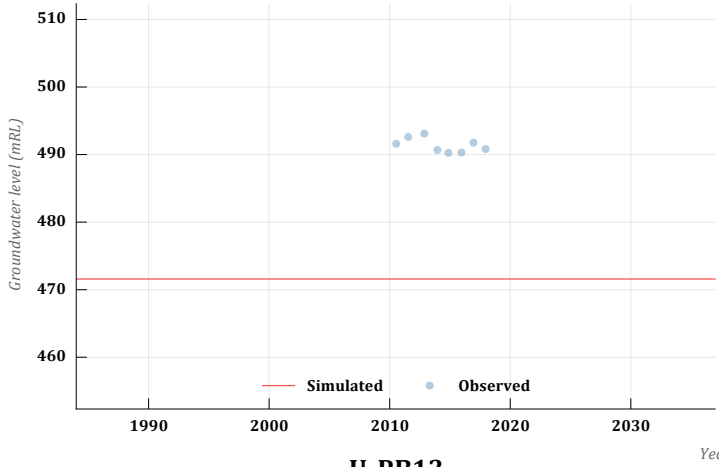
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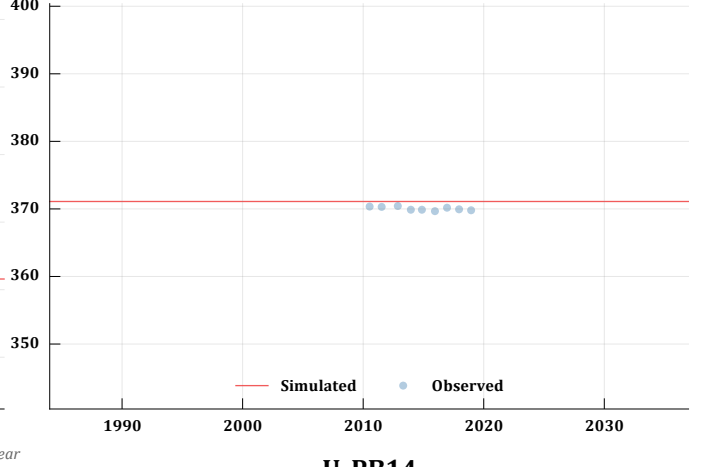
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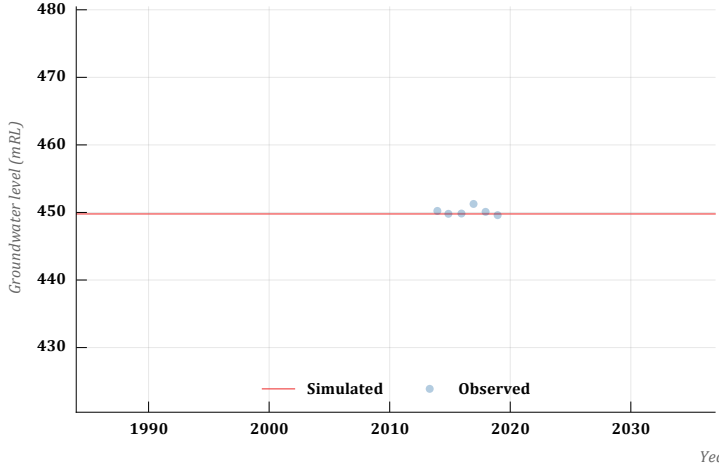
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U_PB12



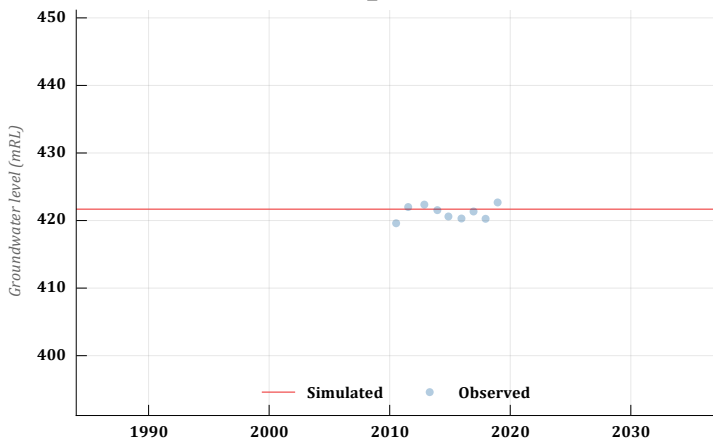
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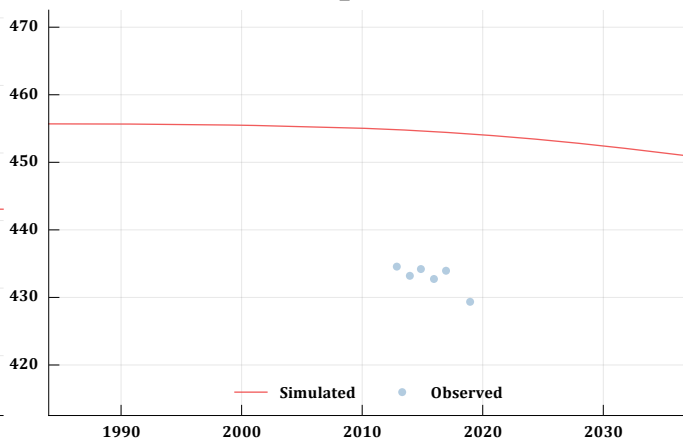
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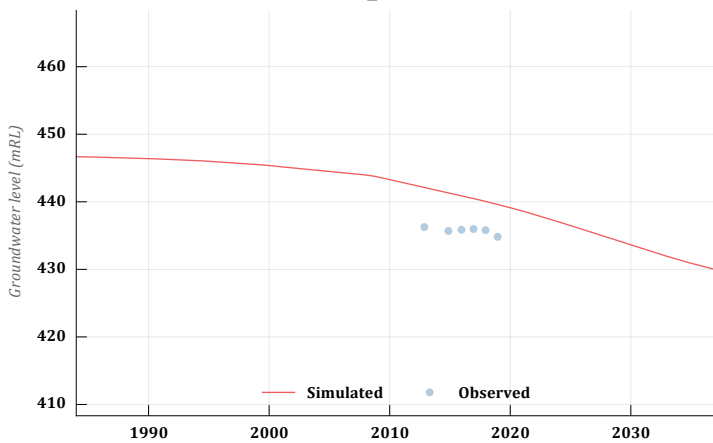
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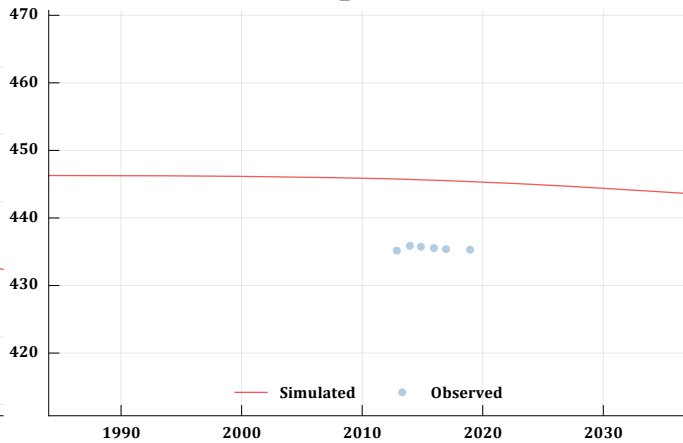
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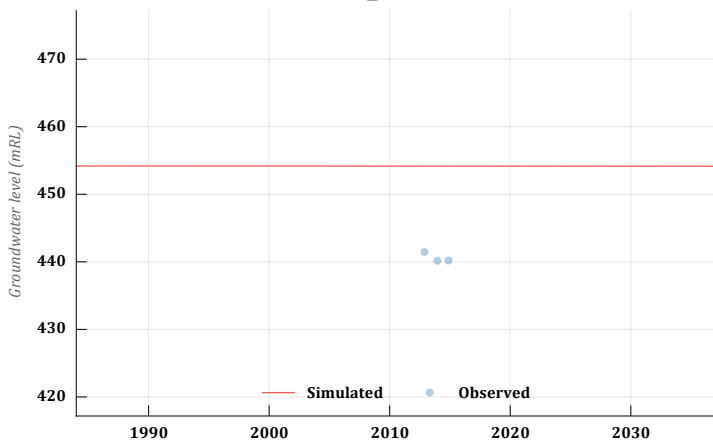
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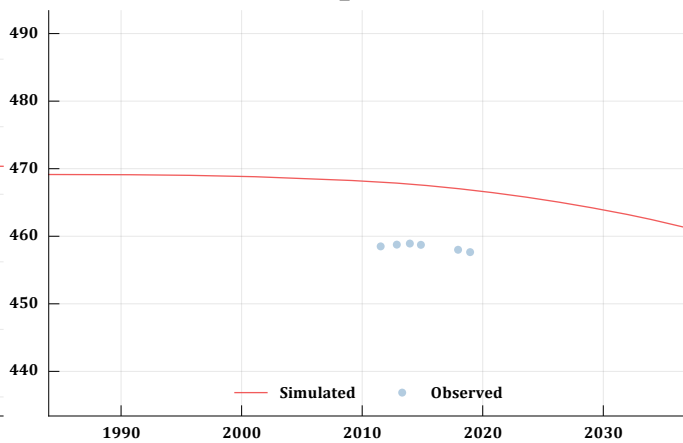
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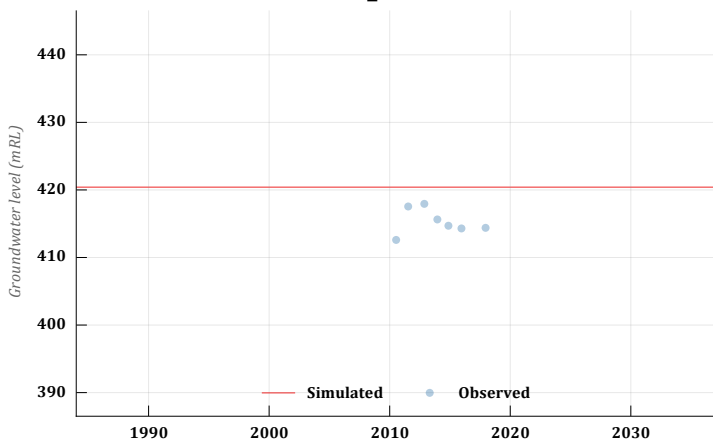
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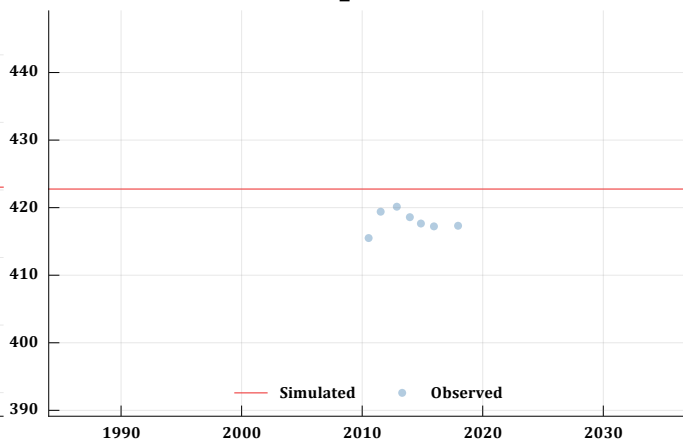
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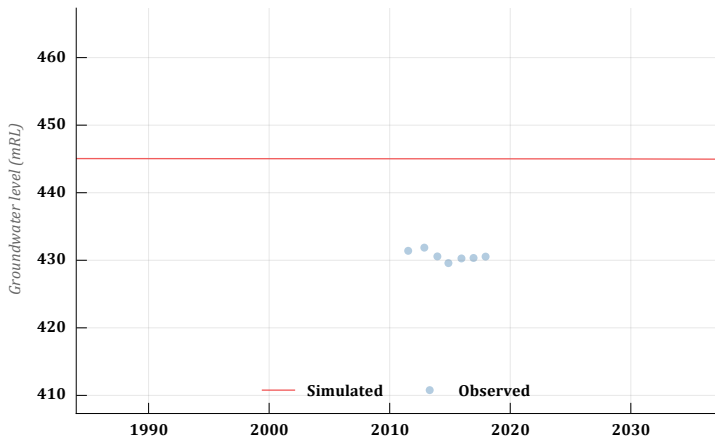
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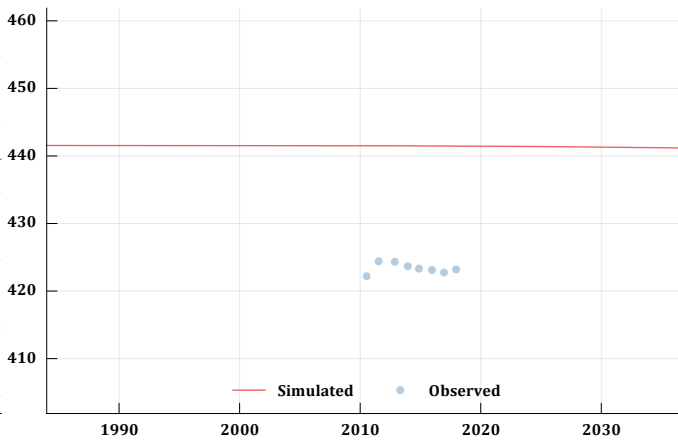
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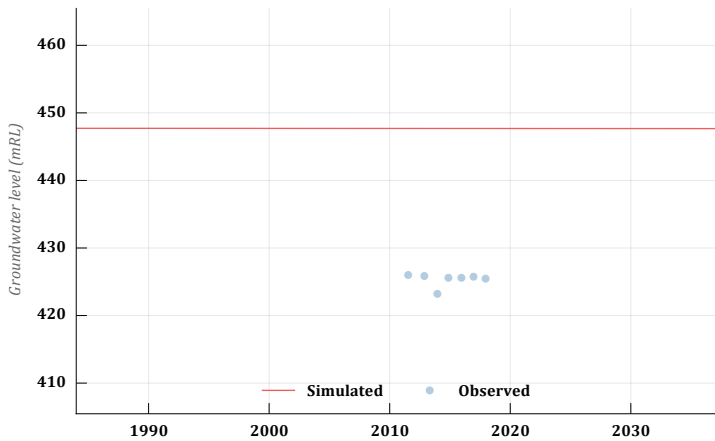
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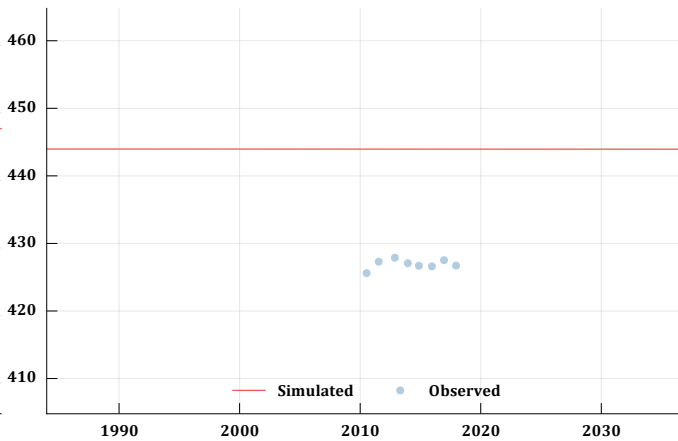
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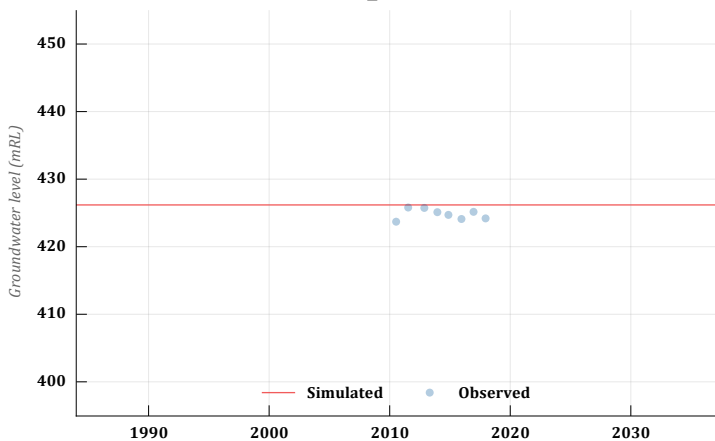
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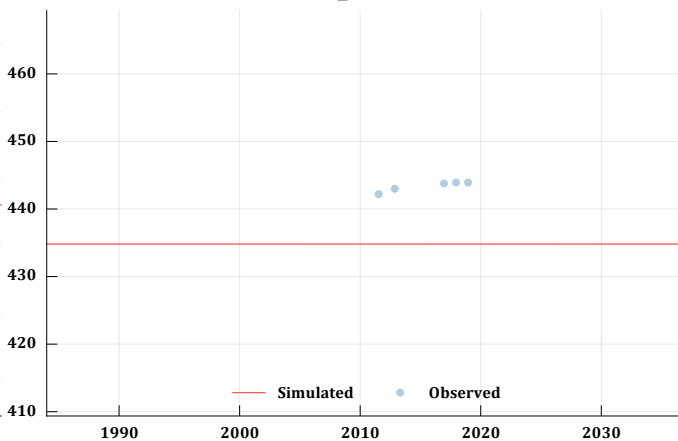
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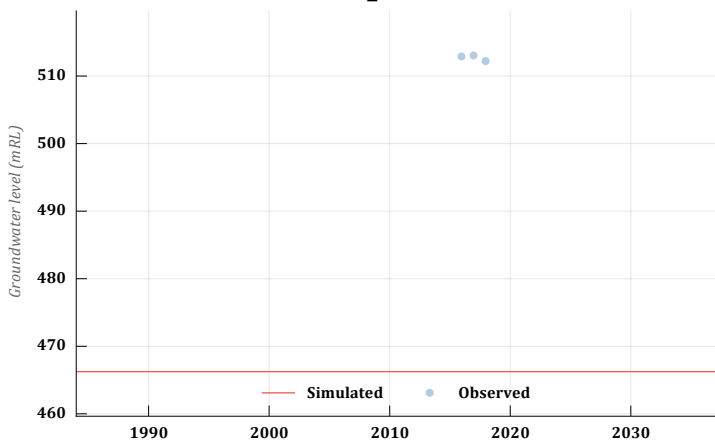
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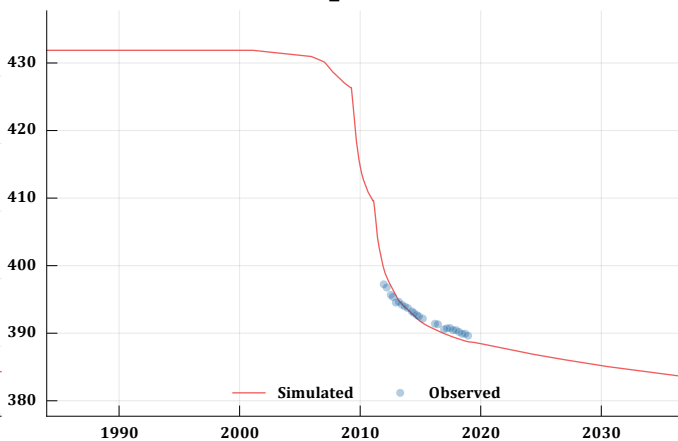
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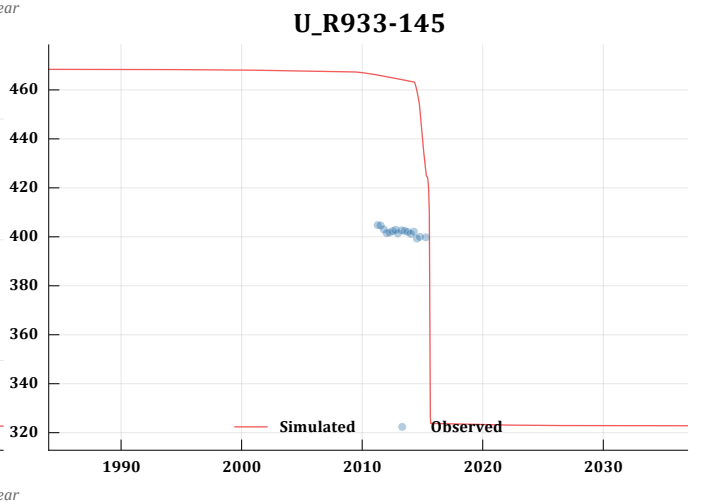
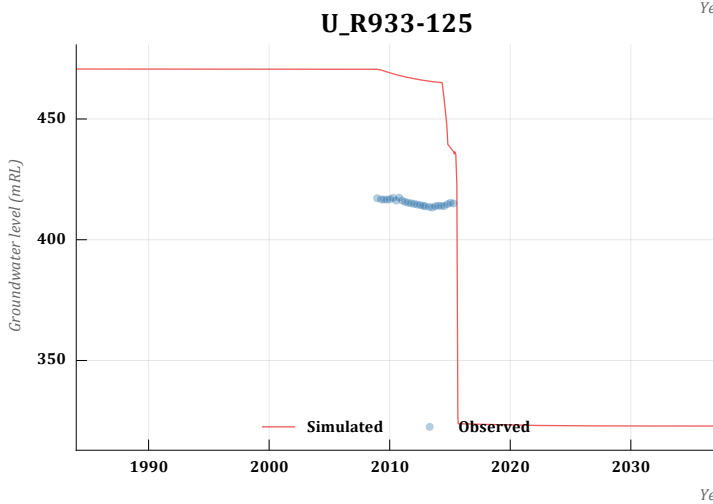
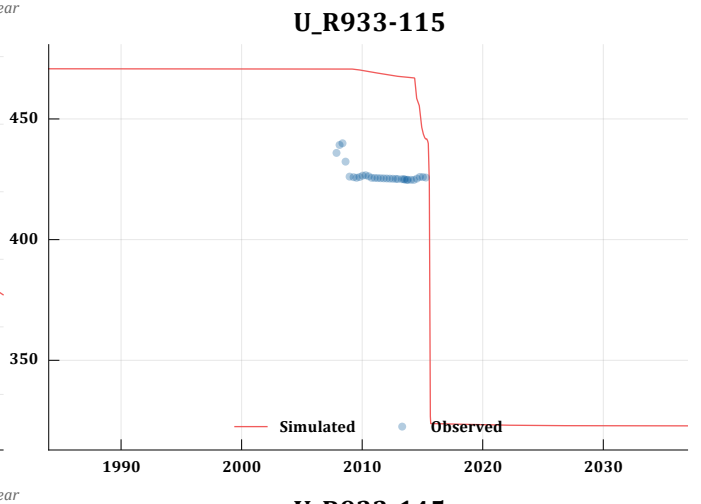
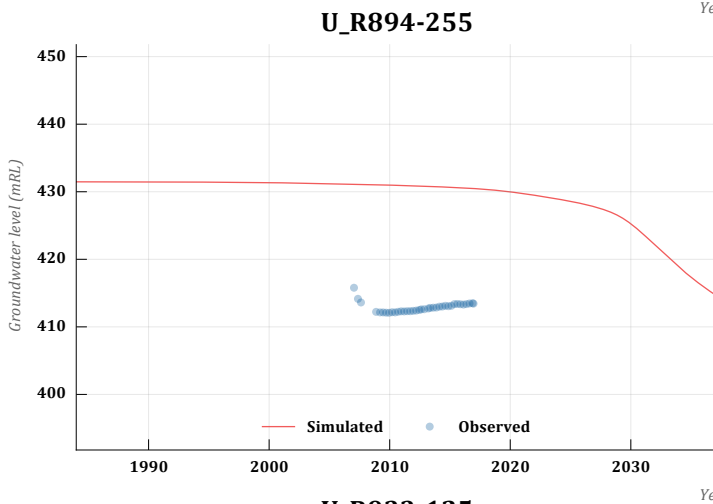
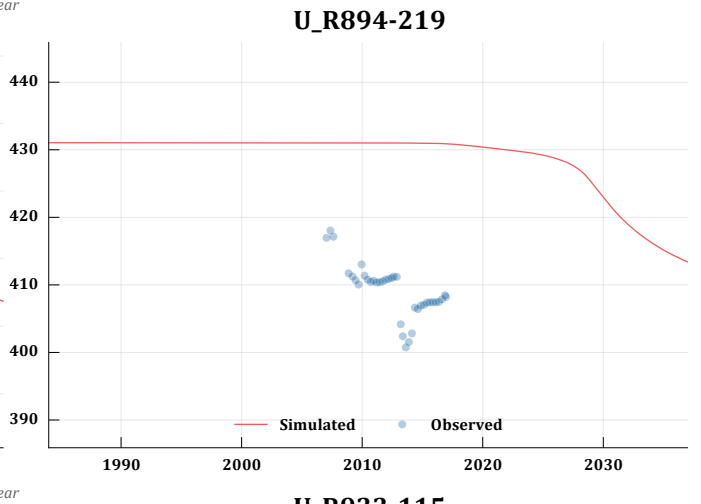
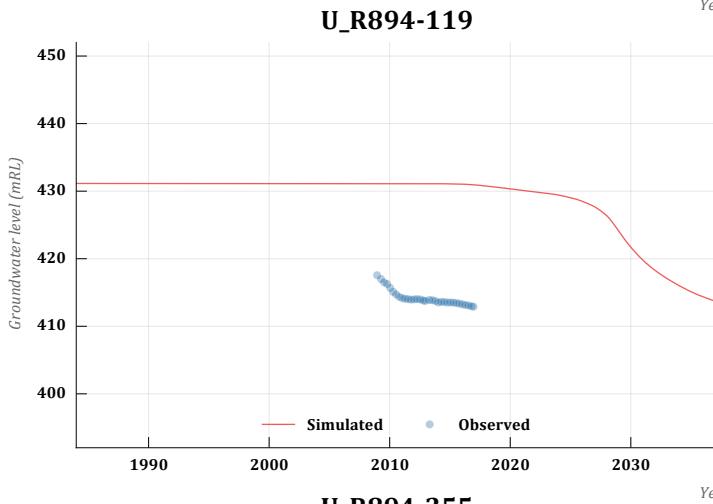
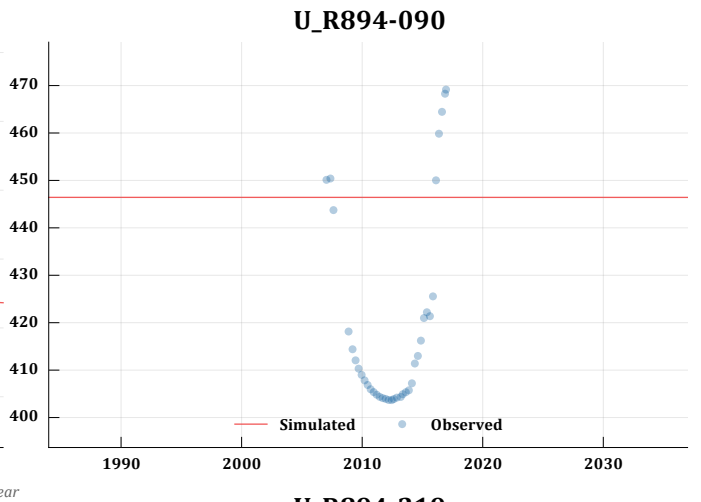
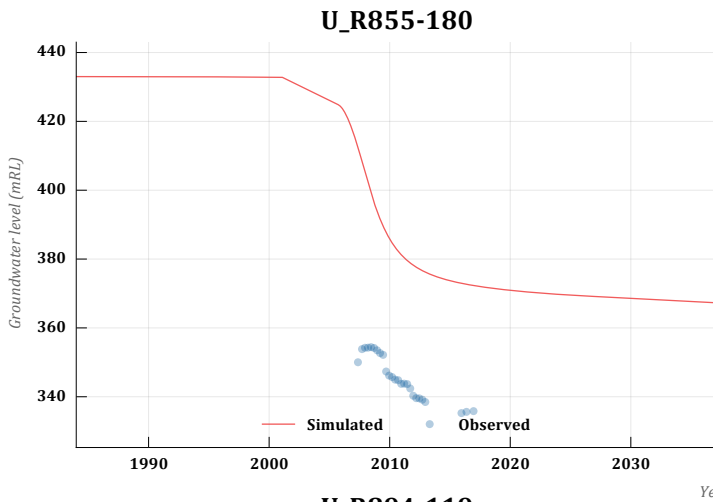


U_PB31

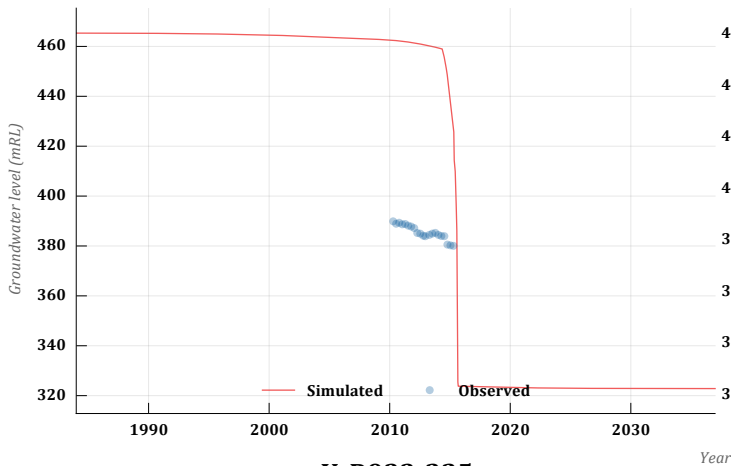


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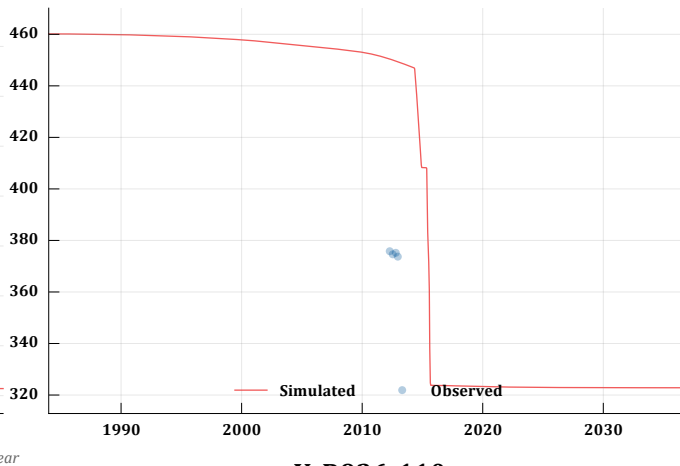




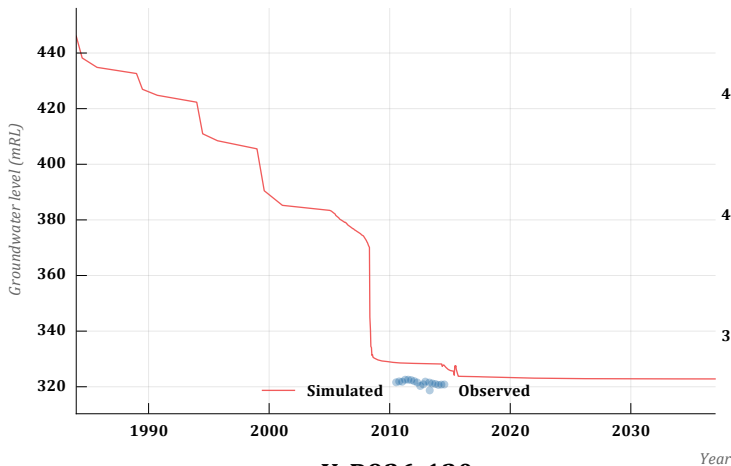
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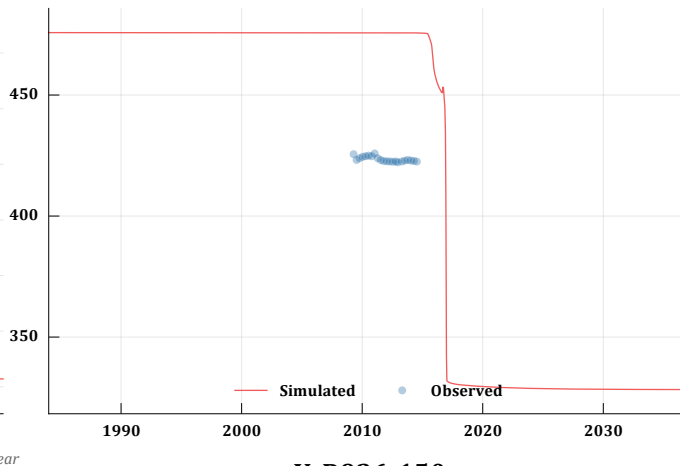
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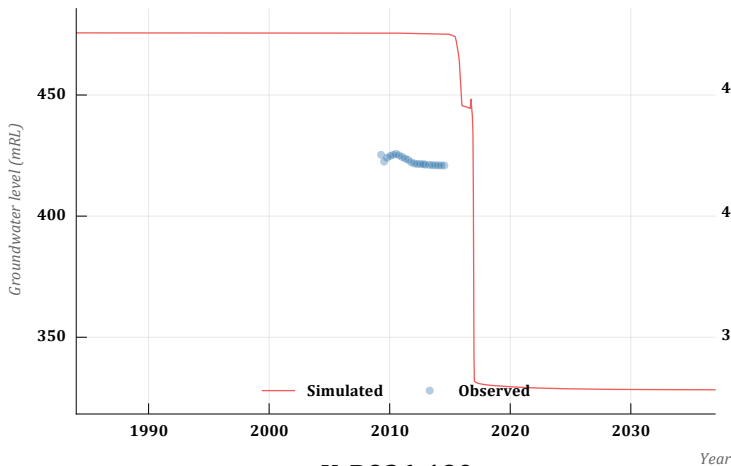
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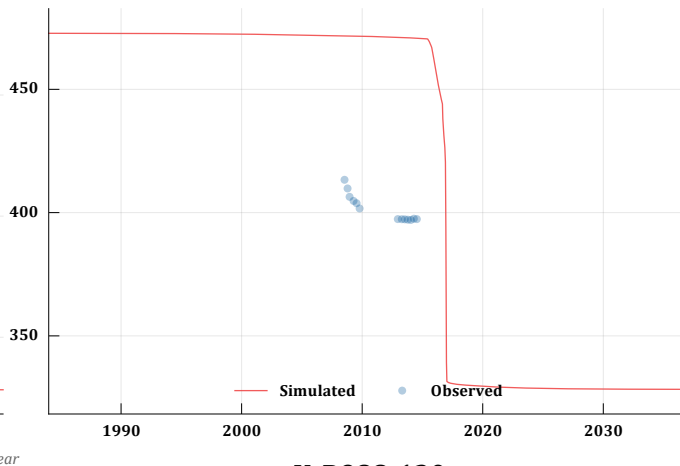
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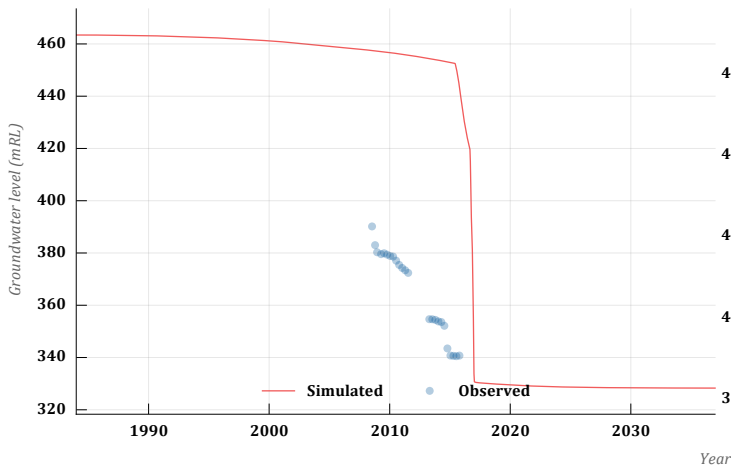
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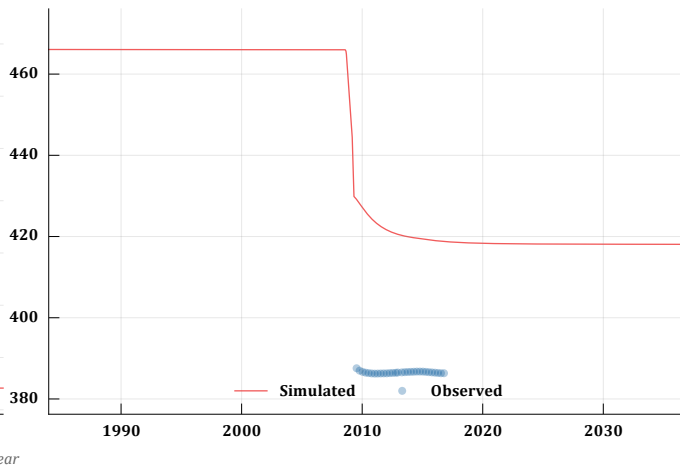
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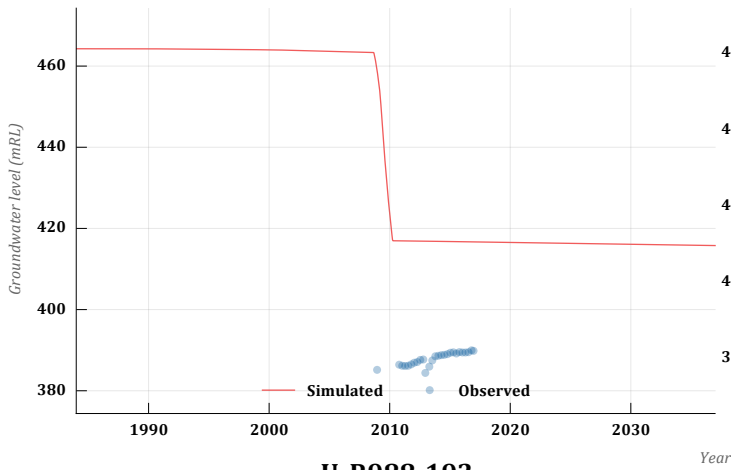
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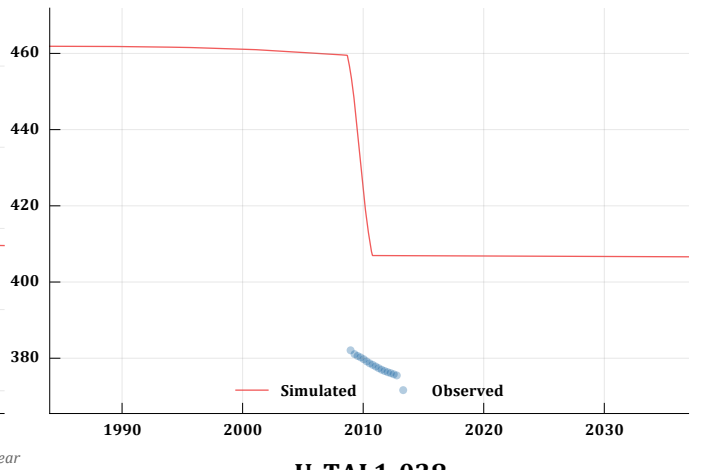
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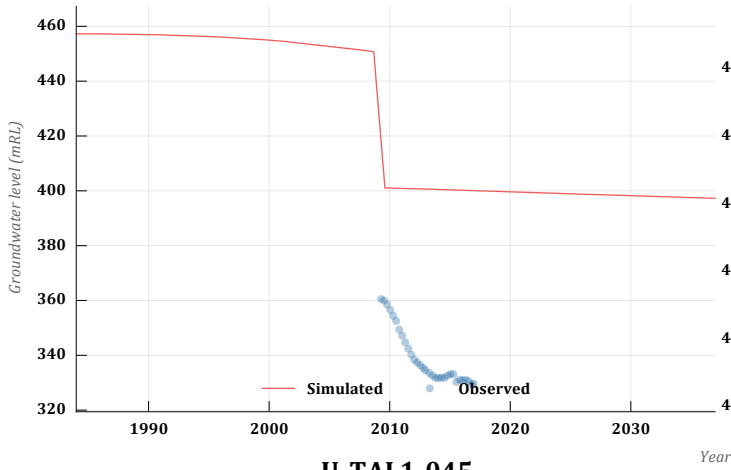
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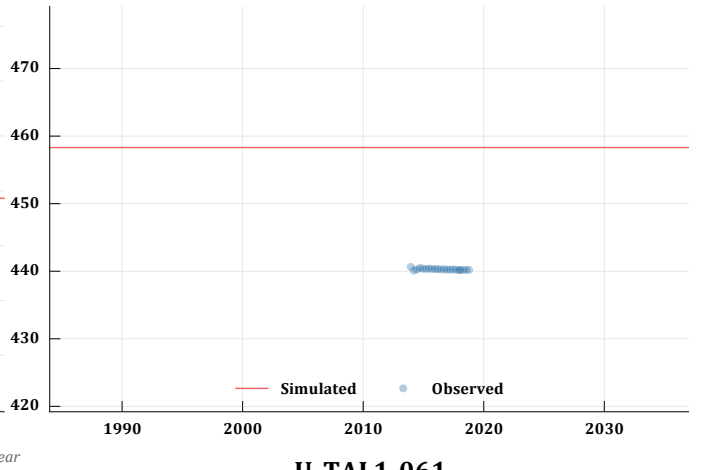
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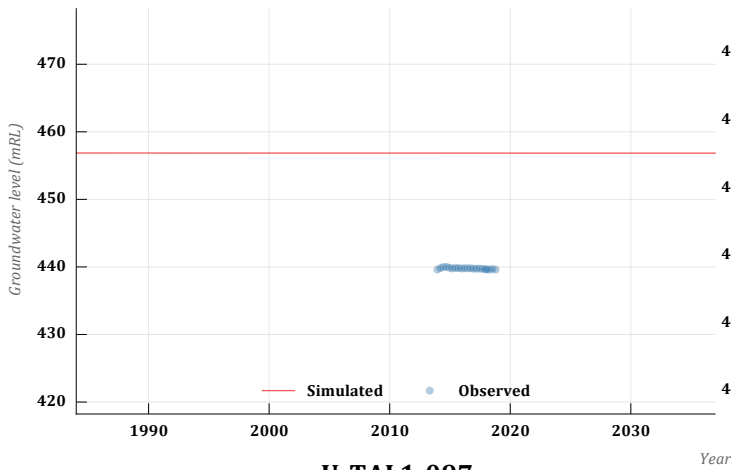
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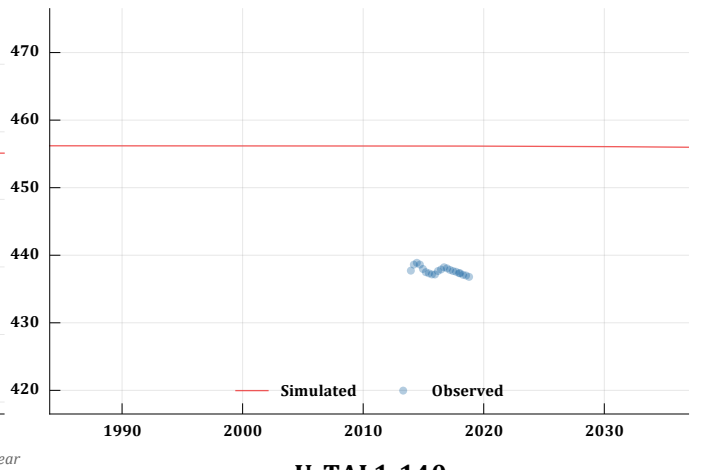
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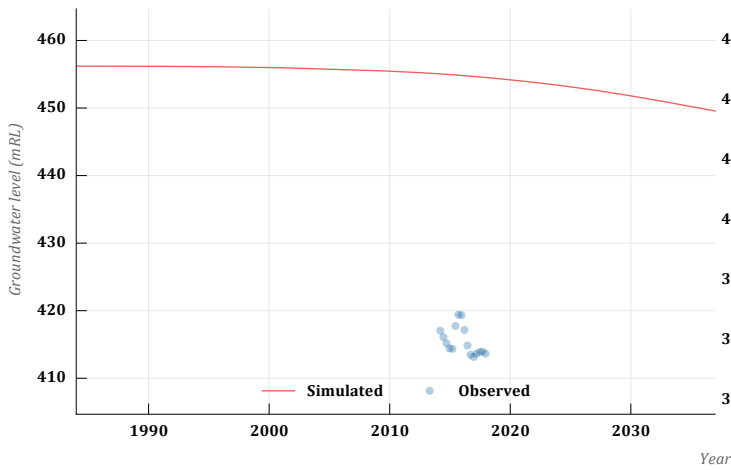
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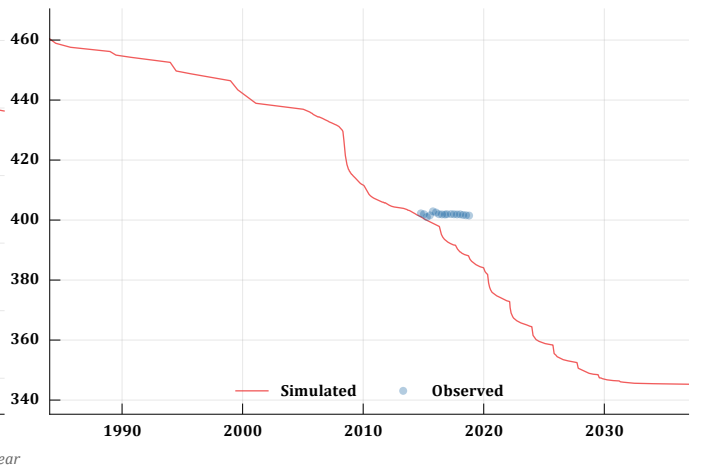
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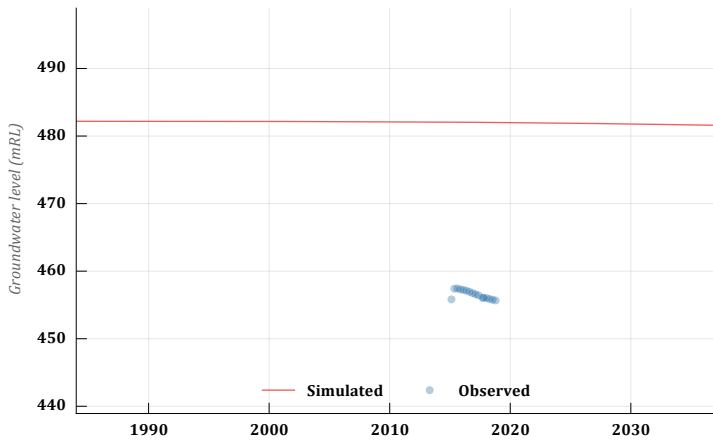
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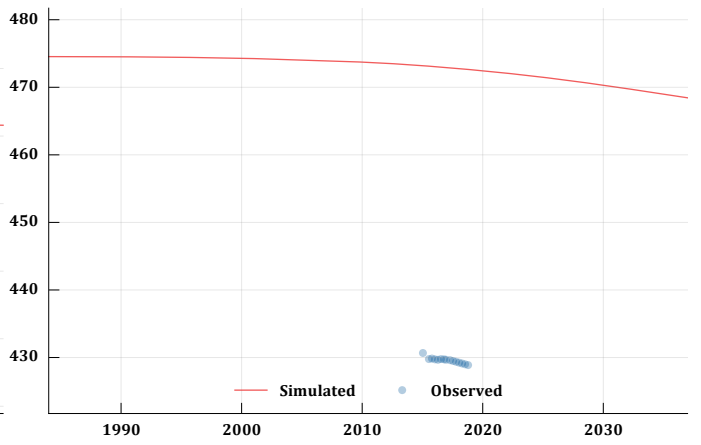
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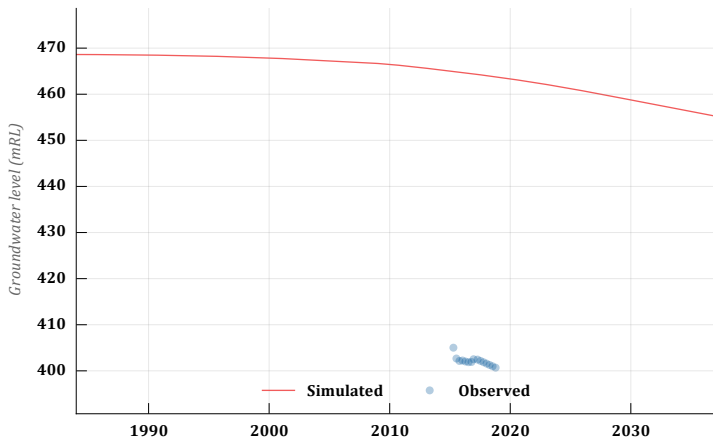
U_TAL2-050



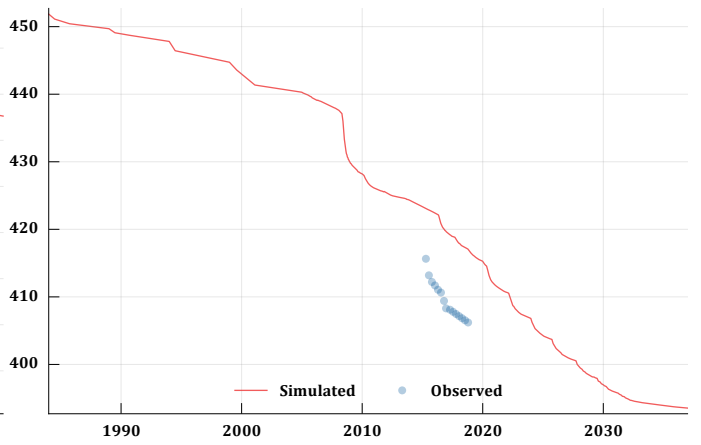
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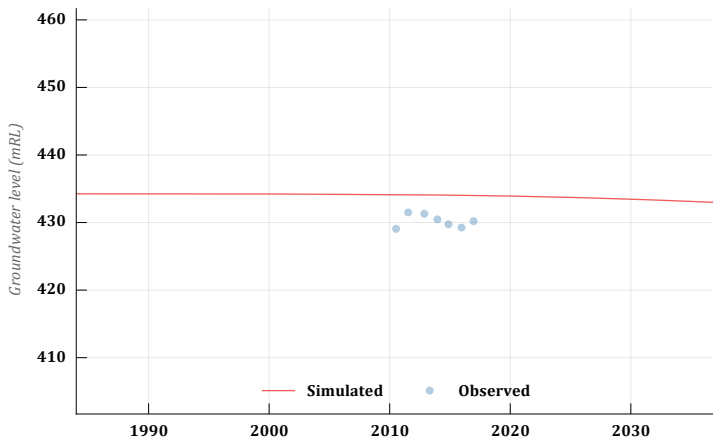
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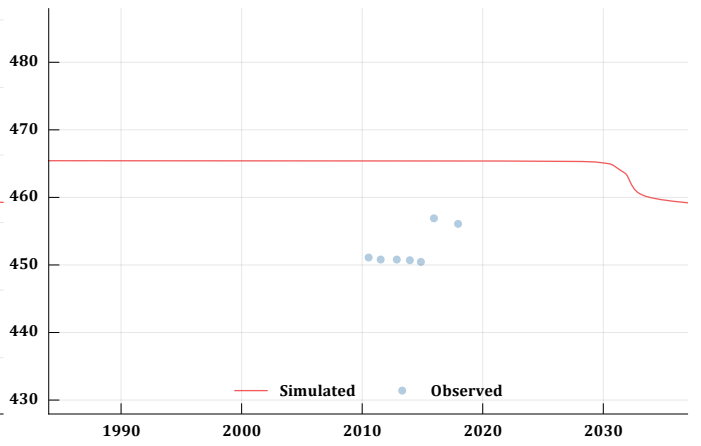
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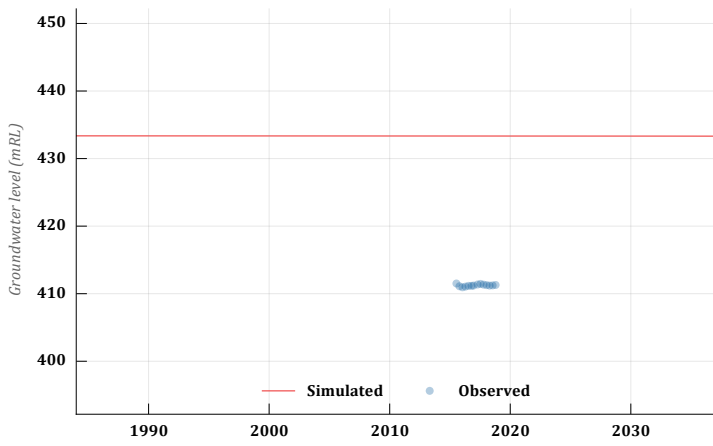
U_UB1



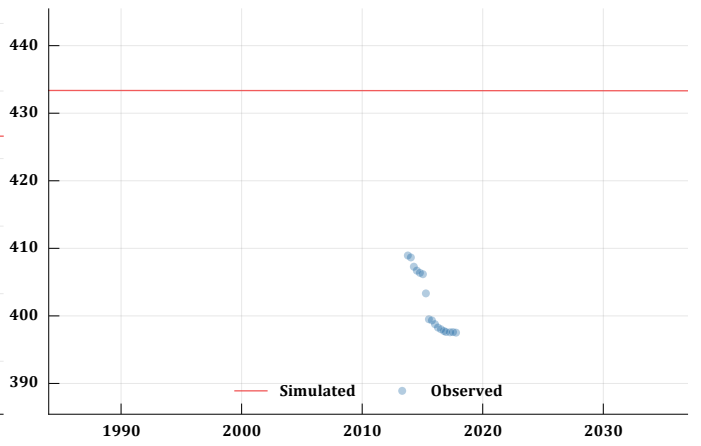
U_UB3



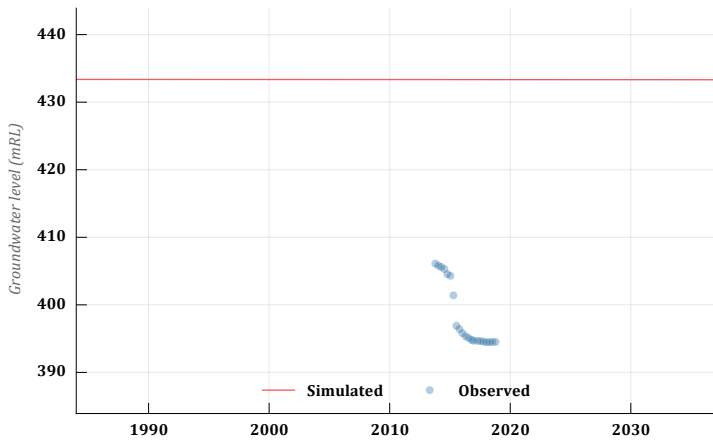
U_UW1-022



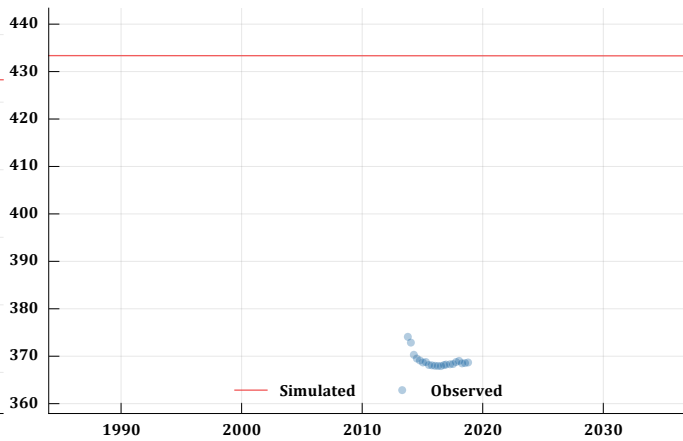
U_UW1-035



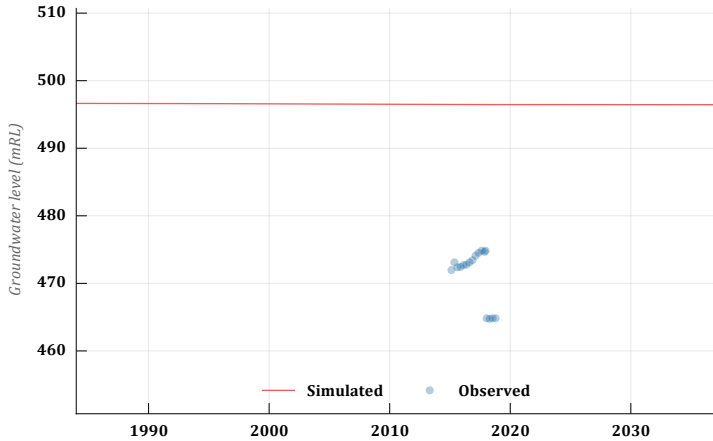
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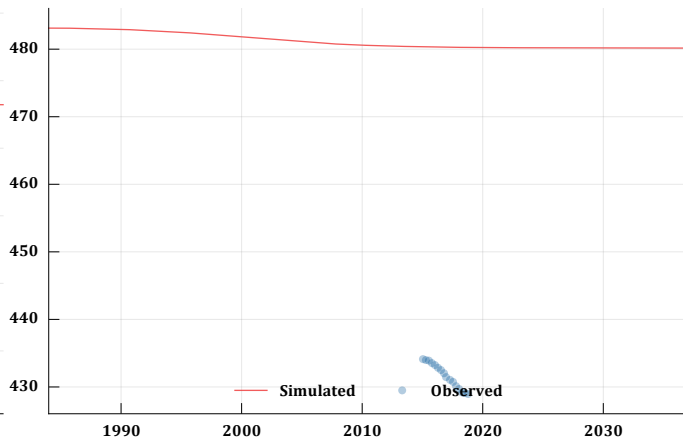
U_UW1-067



U_UW2-050



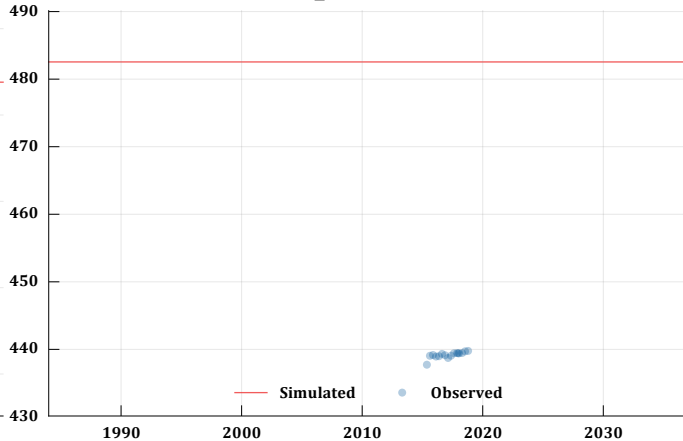
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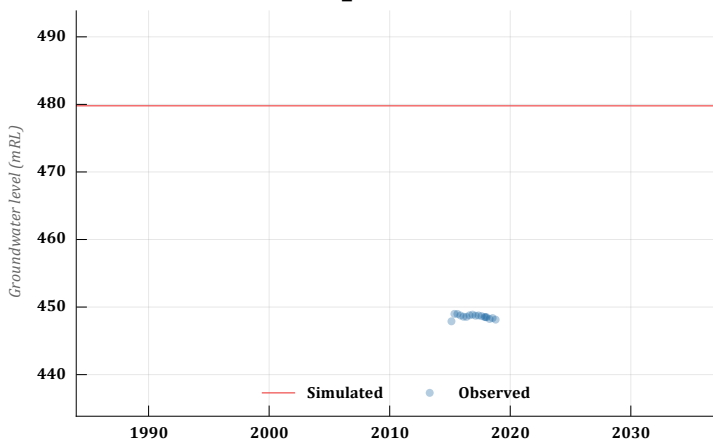
U_UW2-110



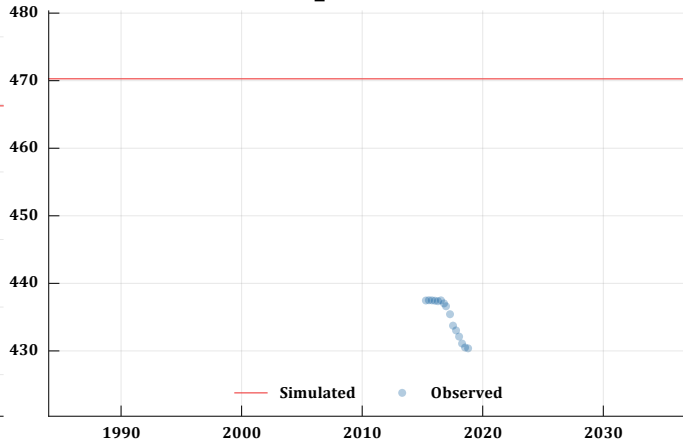
U_UW3-040



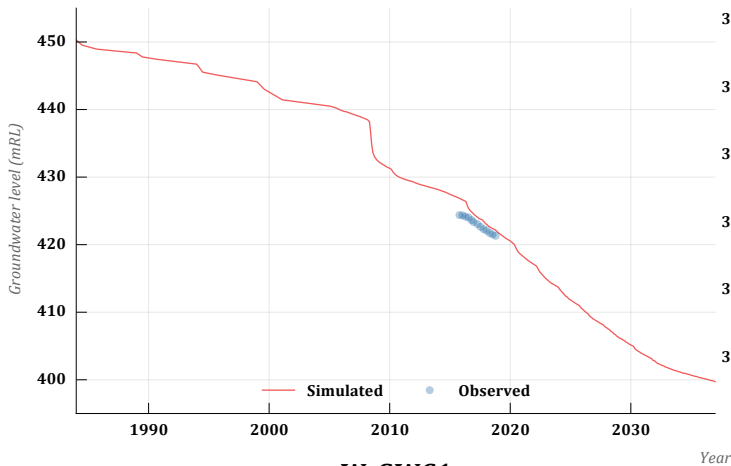
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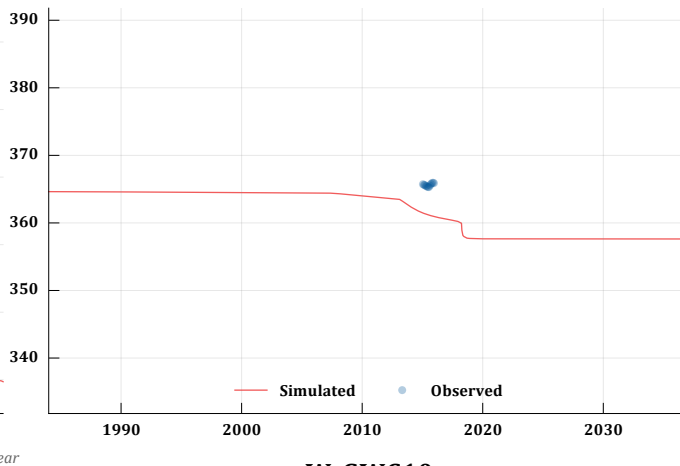
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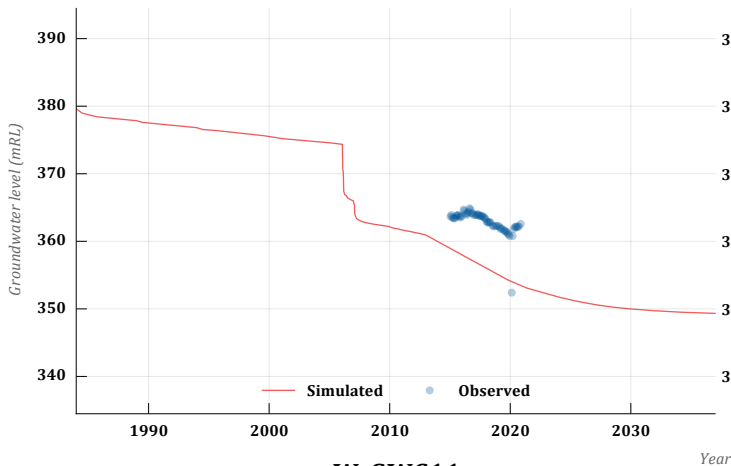
U_UW3-098



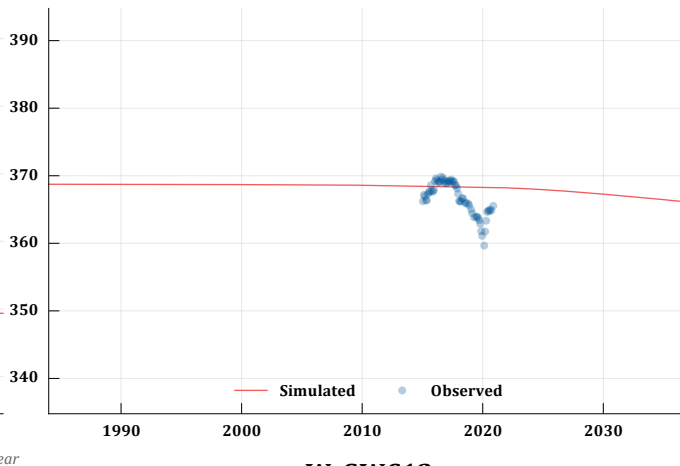
W_GWA22



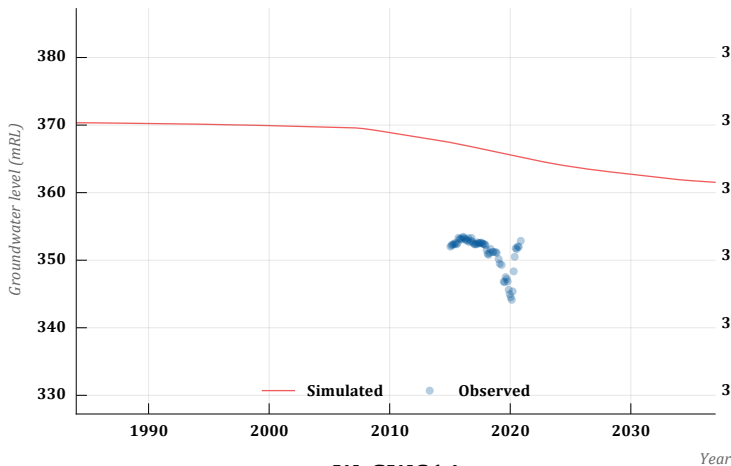
W_GWC1



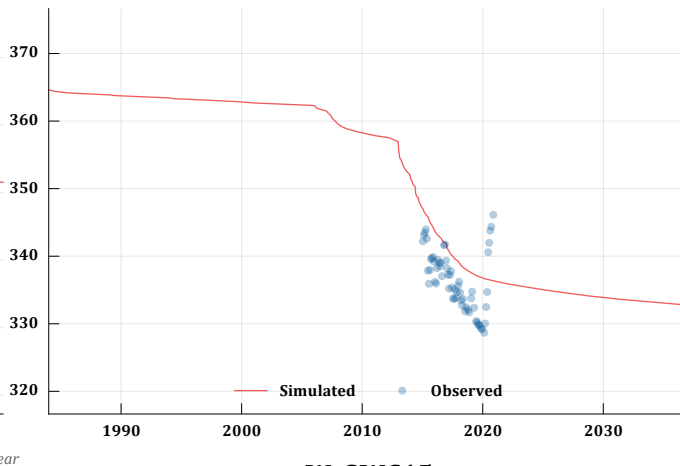
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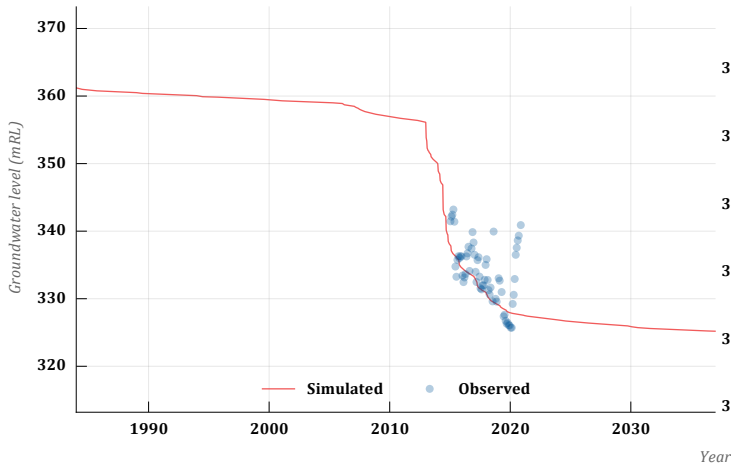
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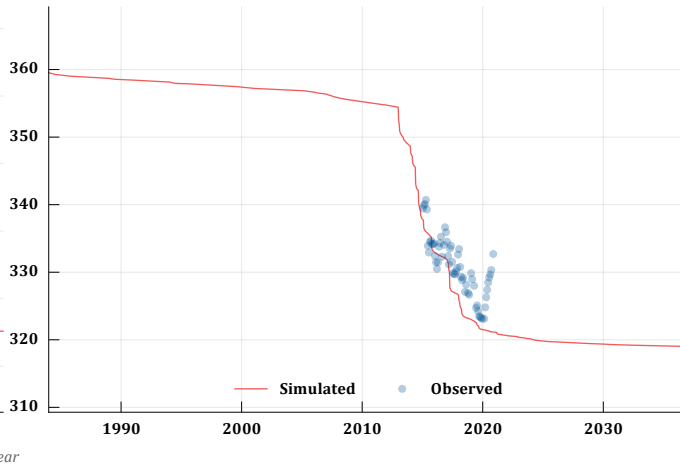
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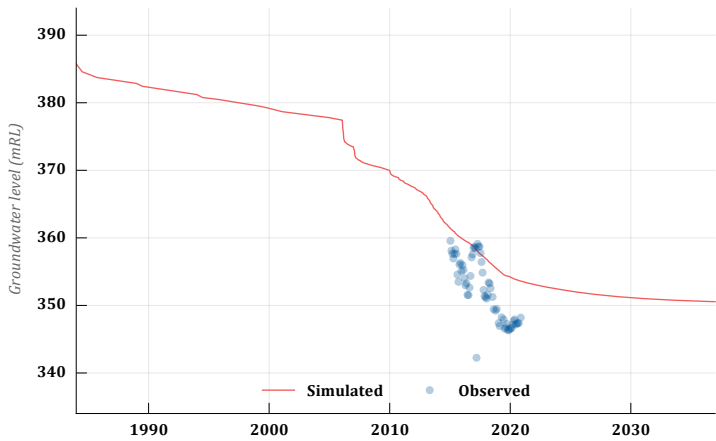
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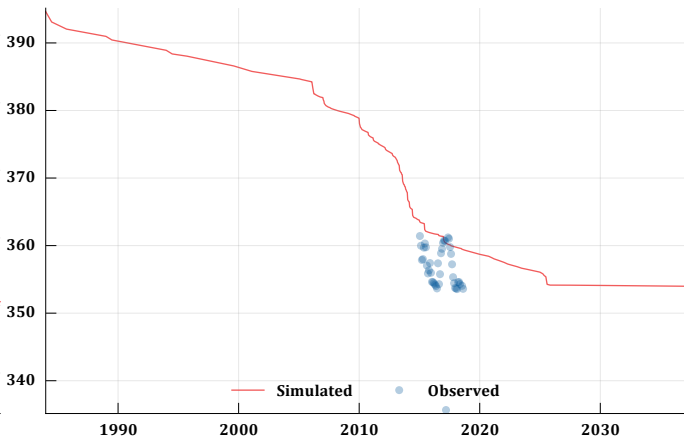
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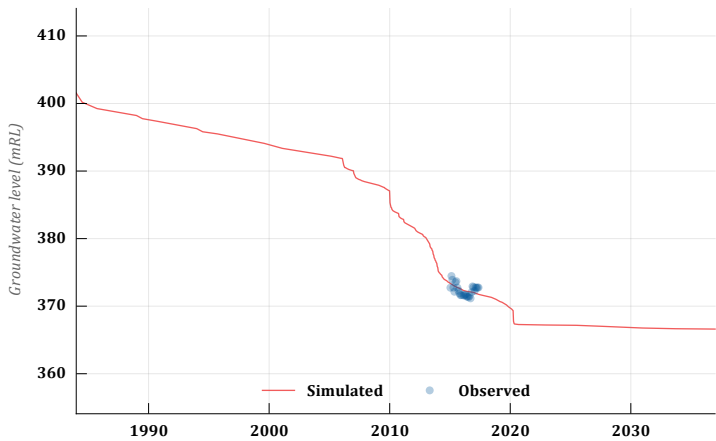
W_GWC16



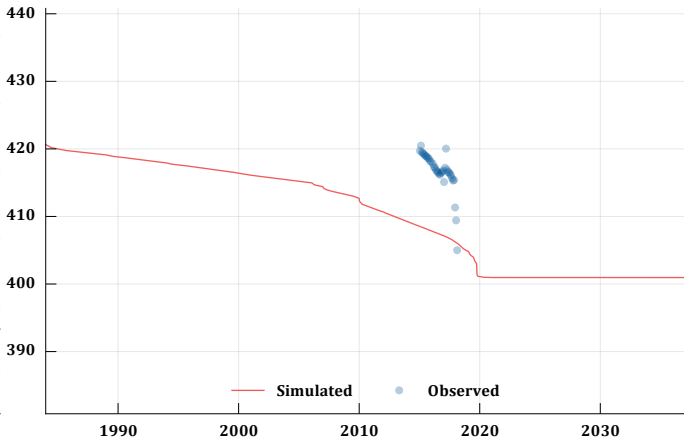
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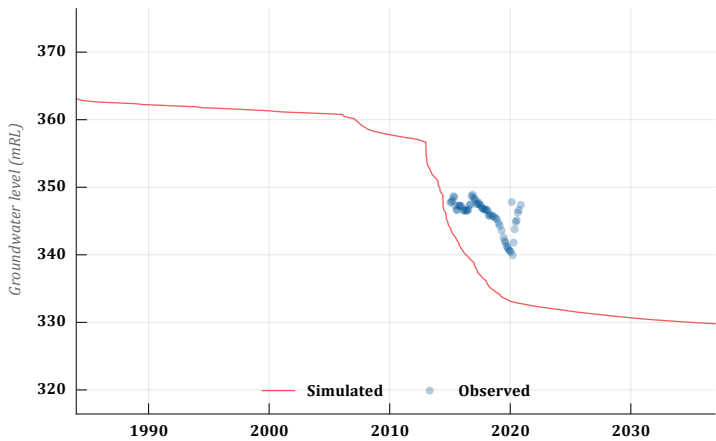
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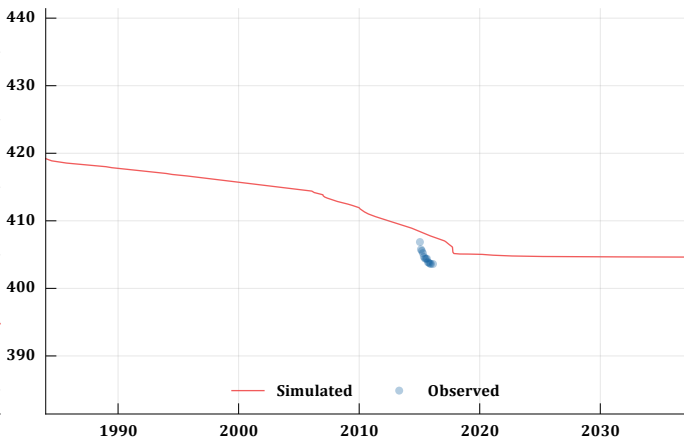
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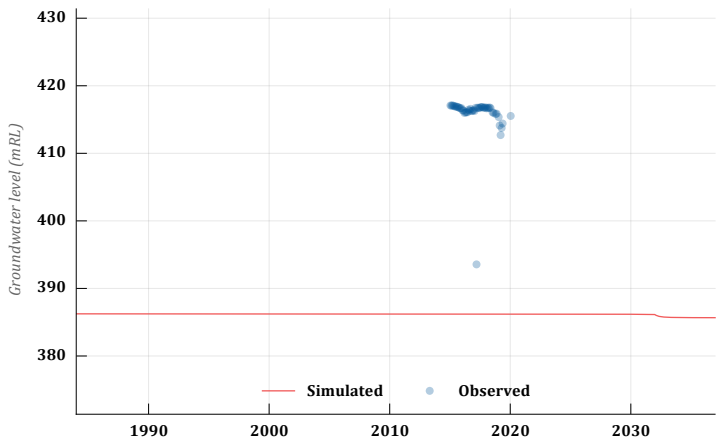
W_GWC2



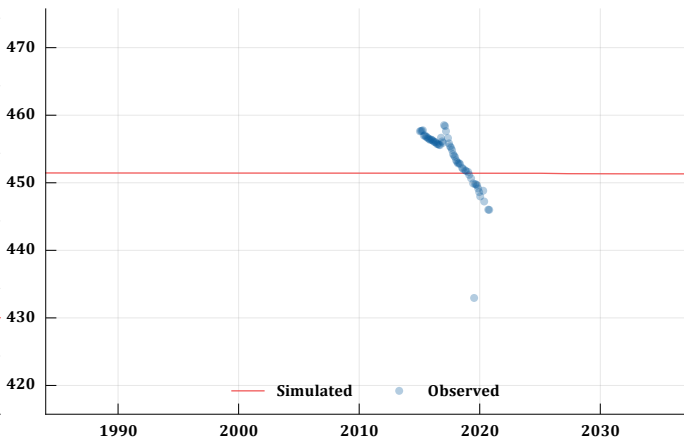
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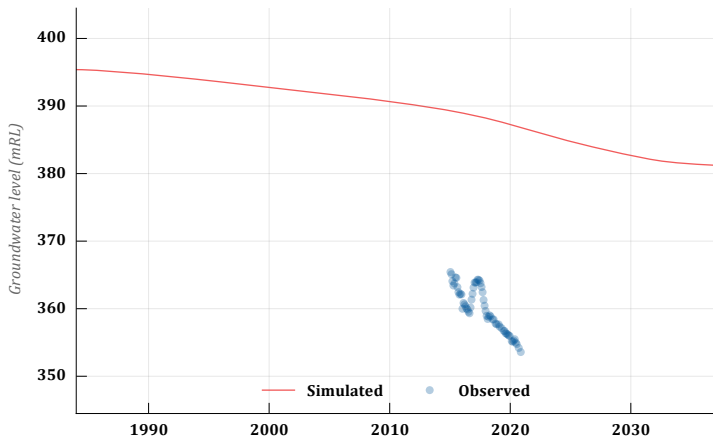
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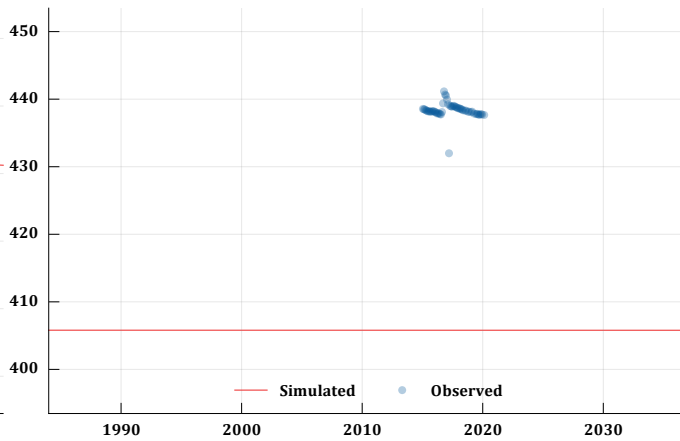
W_GWC25



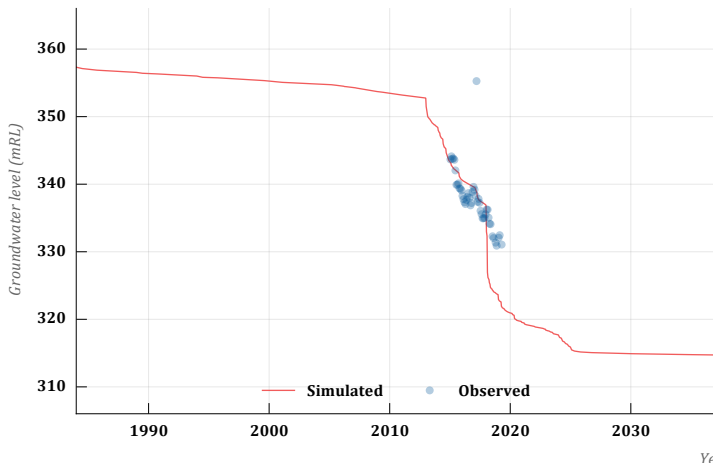
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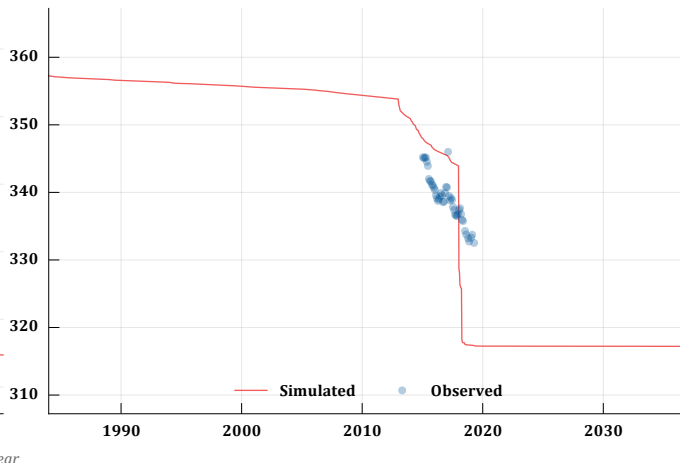
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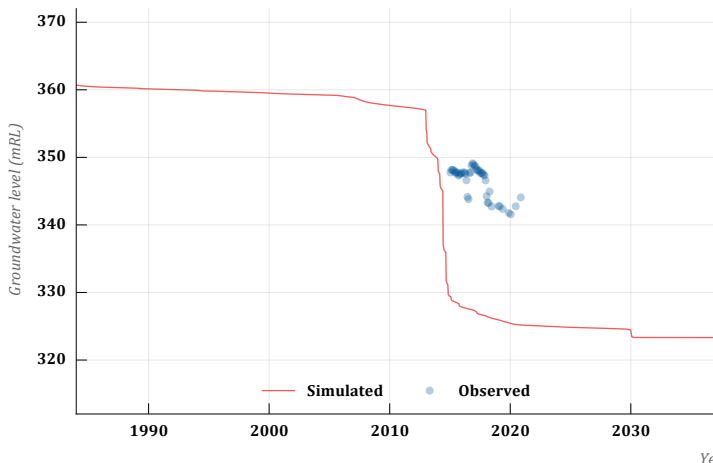
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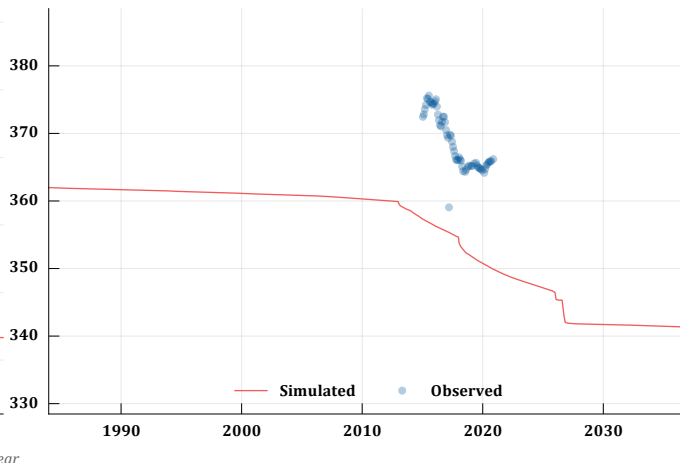
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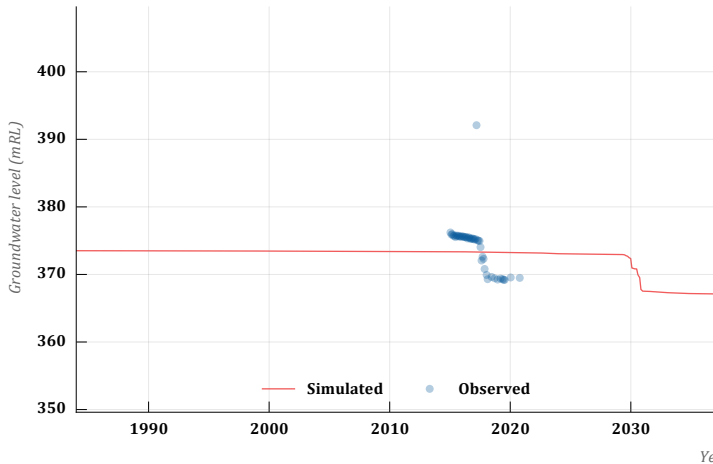
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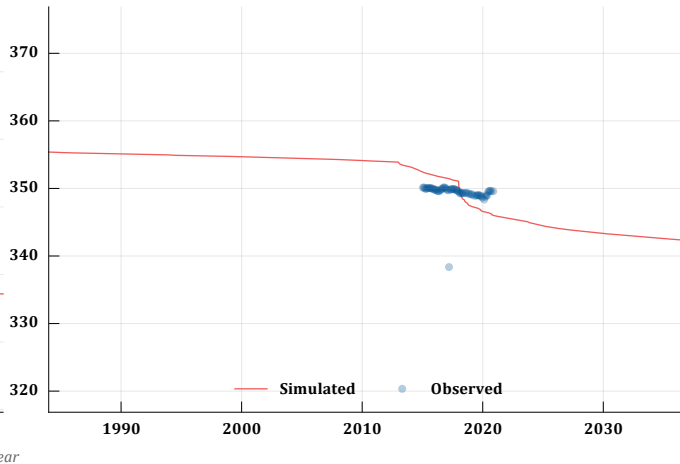
W_GWC30



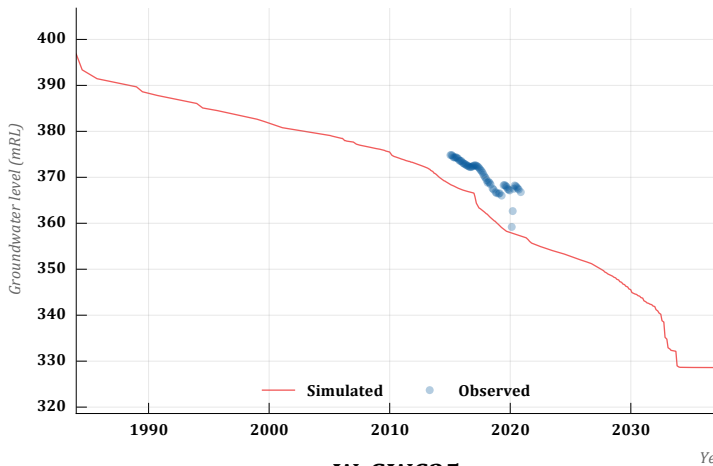
W_GWC31



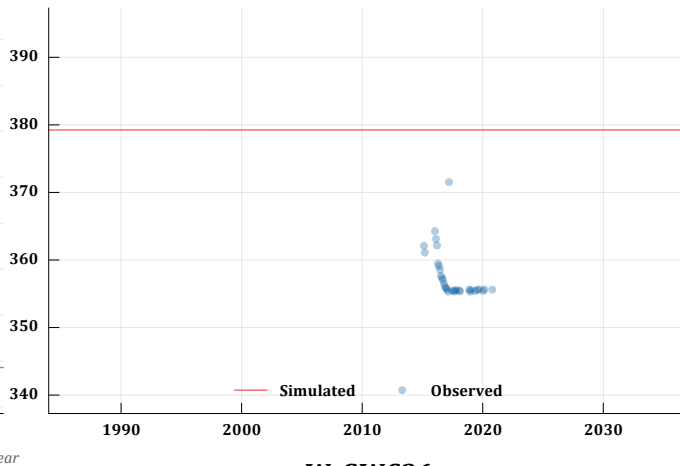
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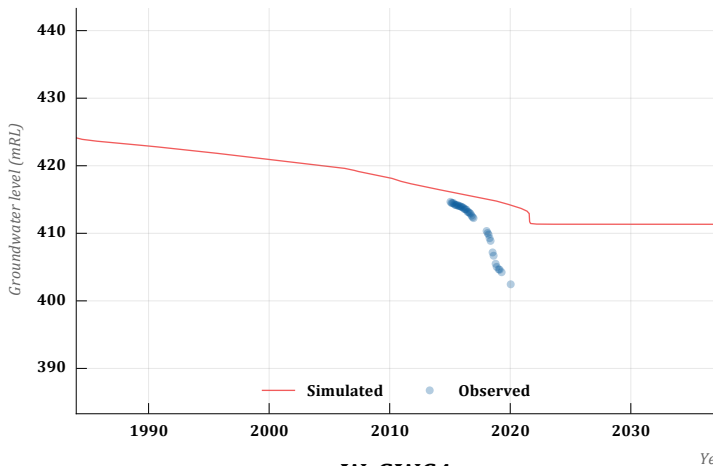
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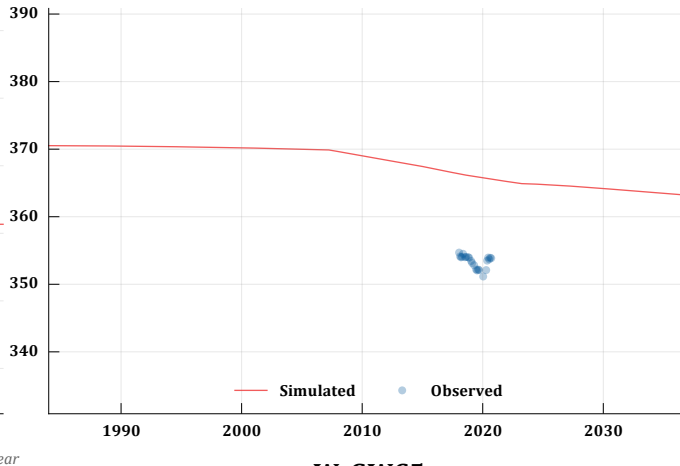
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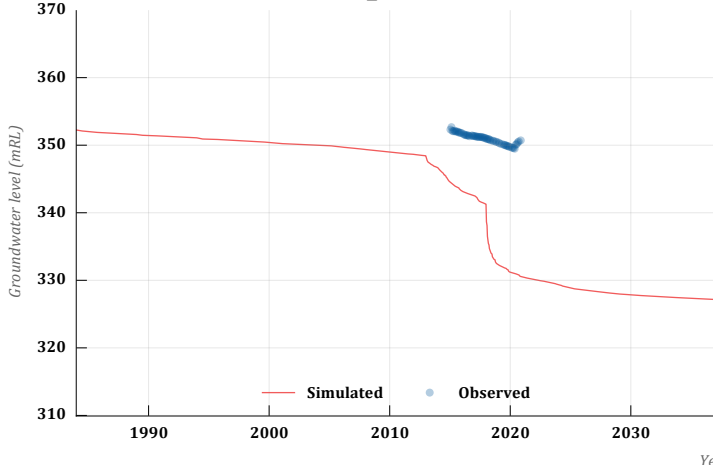
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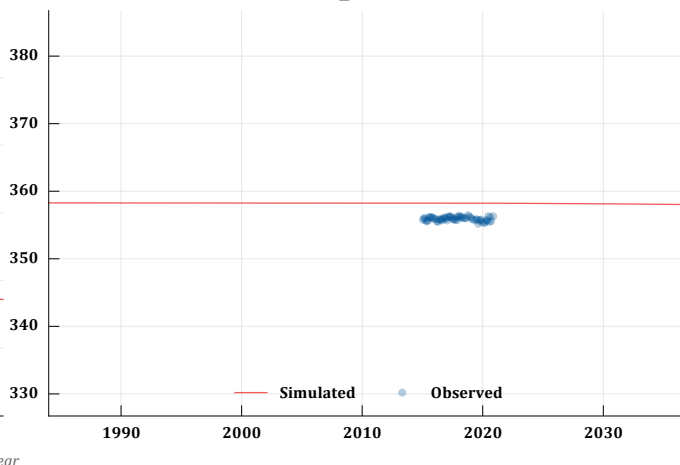
W_GWC36



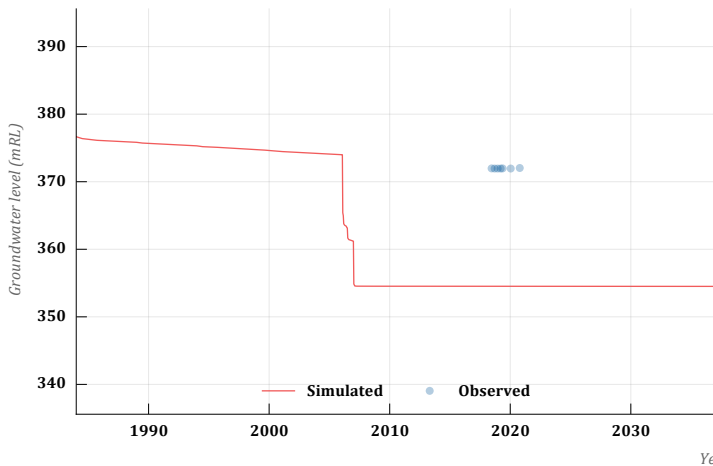
W_GWC4



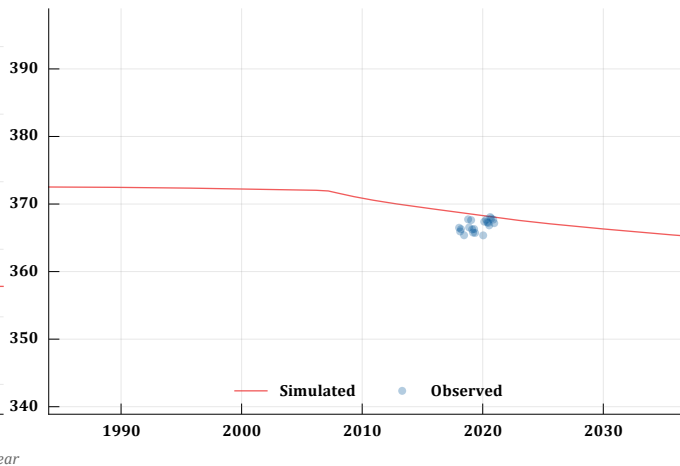
W_GWC5



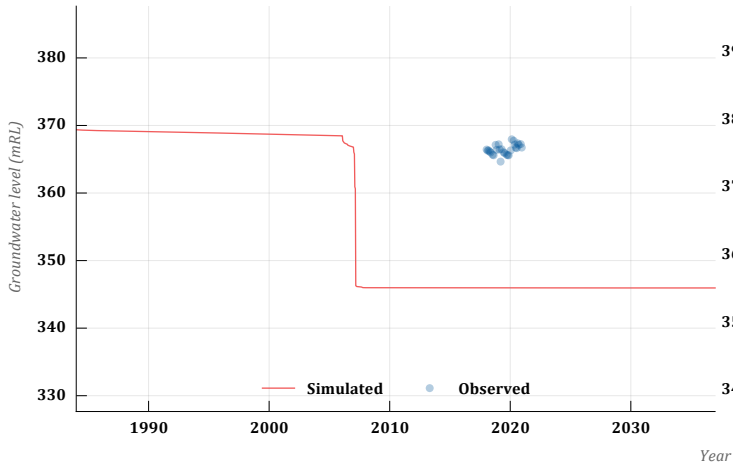
W_P13



W_P20



W_P21



W_P26

