SCIENCE SET
OPEN ACCESS PUBLISHERS

ISSN: 3067-8366
Research Article

Journal of Environmental Science, Sustainability, and Green Innovation

Advances in Mine Dewatering Design and Monitoring at Tharisa Chrome Mine Rustenburg South Africa

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Submitted: 21 October 2025 **Accepted:** 04 November 2025 **Published:** 10 December 2025

https://doi.org/10.63620/MKJESSGI.2025.1024

Citation: *Roebert, M., Mntungwa, N., Msitsini, M., Holtzhausen, P., Morton, K. L., & van Heerden, W. (2025). Advances in Mine Dewatering Design and Monitoring at Tharisa Chrome Mine Rustenburg South Africa. J of Environ Sci & Sustain & Green Innov, 1(4), 01-04.*

Abstract

Tharisa Minerals is a chrome and platinum group metals (PGM) open-pit mine near Rustenburg, South Africa. The mine dewaters three pits and a planned underground mine. Historic workings under the mine's active East pit also require proactive water management to ensure safe mining operations. Tharisa's dewatering strategy integrates stormwater control, in-pit pumping (boreholes and sumps), and pit perimeter dewatering boreholes. Automated monitoring of water levels records success in meeting drawdown targets. Water re-use enables a phased approach to zero discharge. Tharisa is a good example of pro-active dewatering design. There are valuable insights on dewatering for surface and underground transition mines.

Keywords: Chrome, Dewatering, Pit-Perimeter, Monitoring, In-Pit Pumping, PGMs.

Introduction

South Africa's Tharisa Minerals operates a large chrome and platinum group metals (PGM) open pit mine near Rustenburg, situated in the western limb of the Bushveld Complex (BC). The BC holds over 70% of the world's platinum and chrome resources. Tharisa mine is situated on the south-western limb of the BC and is underlain by the Middle Group (MG) and Upper Group (UG) chromitite layers straddling the boundary between the Marikana and Rustenburg facies (Dildar et al. 2023). Tharisa mines and processes about 4.6 million tonnes/yr (Mt/a) from five MG chromitite seams within the layered mafic and ultramafic intrusions, producing about 1.7 Mt/a of chrome and 120 000 oz PGM/a.

The MG chromitite layers outcrop on the property striking roughly east to west with a gentle change in strike to northwest-southeast in the far west. These layers dip at between 9° and 15° to the north. The stratigraphy typically narrows to the west and the dip steepens to the western edge of the outcrop. The dip shallows out at depth across the whole mine area.

Despite the region's low rainfall of about 600 mm/yr, the mine must continually dewater its three pits and planned underground mine ahead of mining operations. The proximity to old underground mining voids under the eastern area of the East pit requires dewatering in advance of mining to ensure risk-free ore extraction. Figure 1 shows the mine location and main rivers [1].

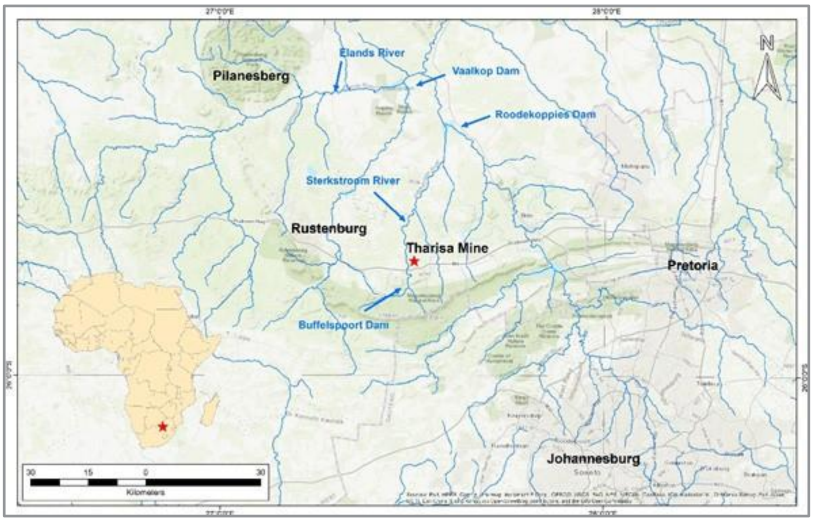

Figure 1: Location of Tharisa Mine in South Africa (Tharisa Minerals 2018)

Figure 2 shows the three pits, local geology, geological structures and the underlying old Samancor chrome workings. There are three pits: East pit, West pit, and Far West pit. The East pit will be mined to an elevation of 980 meters above mean sea level (mamsl), while the West pit will be mined to an elevation of 1 025 mamsl. Tharisa's planned underground mine will be mined to an elevation of 790 mamsl in the first 10 years.

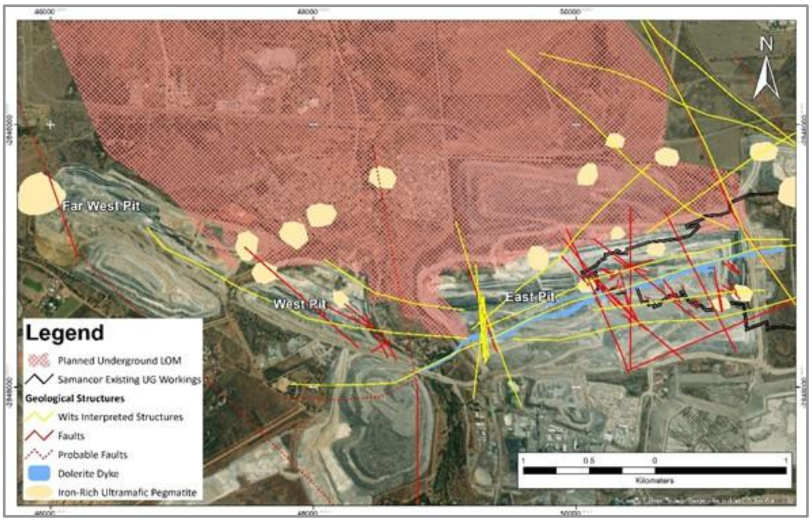

Figure 2: Tharisa Mine geology and pits

The main aquifers at Tharisa are the weathered zones of the upper BC, faults and dyke contacts, and the ore body contacts. The eastern side of the East pit is underlain by flooded, mined-out workings (known as the Samancor workings). Groundwater flow is from south to north. Recharge is from rainfall, stored water in waste rock dumps and from the Sterkstroom river which separates the East and West pits. The Sterkstroom is fed by the Buffelspoort dam so it has a constant head. Rainfall is between 240 to 850 mm/a with most of the rain falling in November to April. During Summer rainfall months, the pits can become flooded. Water pumped out of the pit is classified as calcium sulphate dominant, as the major cation and anions are calcium (Ca^{2+}) and sulphate (SO_4^{2-}). Traces of nitrate are common. The water is used in the process plant and dust suppression.

The design of the dewatering strategy addresses four objectives:

1. Cutting off recharge through detailed stormwater diversion and shallow borehole pumping.
2. Exploitation of permeability by pumping from deeper water-bearing zones
3. Monitoring groundwater levels within and along the pit perimeter to evaluate dewatering success and maintain targets for monthly drawdowns
4. Starting early – dewatering in advance of mining, with accurate management of the flooded Samancor workings, seasonal rainfall and elevated groundwater levels

A phased approach to achieve a cost-effective dewatering design has been used (Morton 2024) to develop the detailed strategy for the Tharisa surface mine which comprises:

- Diversion of surface runoff using accurate stormwater drainage and grading of roads
- Pumping from sumps and in-pit dewatering boreholes to collect pit water and intercept the Samancor workings' water
- Pumping from pit-perimeter dewatering boreholes (shallow and deep)
- Monitoring of groundwater levels using dedicated monitor-

ing boreholes

- Target setting for maintaining groundwater levels below planned mining blocks, in monitoring boreholes within the pits and around the perimeter
- Regular review and upgrade of the pumping network to intercept water in advance of mining

Figure 3 shows the layout of the 2024 dewatering boreholes. Detailed structural geological mapping was done to identify the main conduits carrying the groundwater into the mine. The structural mapping followed the guidelines outline in Morton et al. (2023). The main conduits are NE-SW fault zones, dyke contacts, bedding planes and orebody contact zones [2].

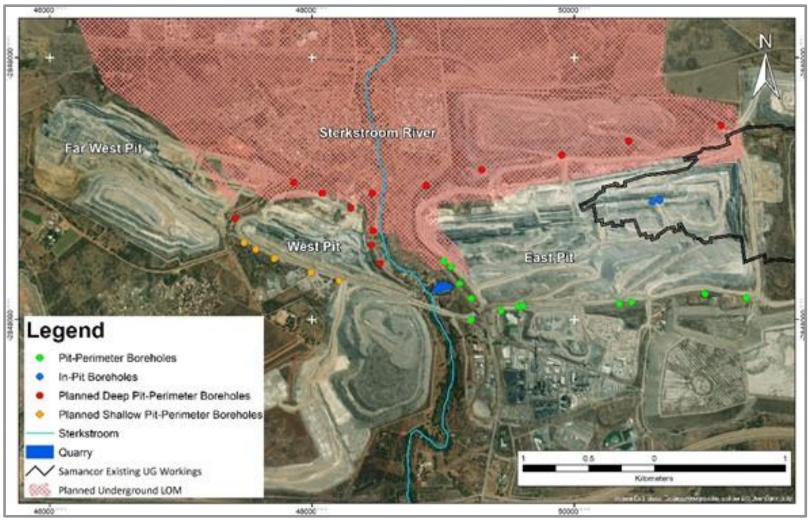

Figure 3: Tharisa Mine Dewatering boreholes 2024

Conceptual Model

Geological, structural and hydrogeological information was used to create a conceptual hydrogeological model. This model provides a comprehensive understanding of the groundwater system in and around the mining area and provides a framework for interpreting hydrogeological data detailing: where the water comes from, what it moves along and where it is stored. Sources of water include near-surface groundwater seepage, the Sterkstroom river, waste rock dumps, recycling from an old quarry, deeper fractured rock aquifer contribution and direct precipitation. Conduits for water flow include open faults and chromitite and dyke contacts, and water storage areas include high porosity rocks, old mining voids such as the old Samancor workings, tailings storage facilities and waste rock dumps. Tailings and waste rock dumps release water into the workings over time through structural connection, even during the drier periods [3].

Site specific transmissivity was estimated between 15 to 30 m²/d in the shallow weathered zone (about 0 to 33 m thick), and between 2 to 4 m²/d in the deeper fractured zone matrix. This value can be as high as 250 m²/d along open faults and fracture zones. The hydraulic head ranges between 1 171 to 1 208 mamsl. A conceptual illustration of the hydrogeology of a North-South (N-S) cross section through the East pit is shown in figure 4.

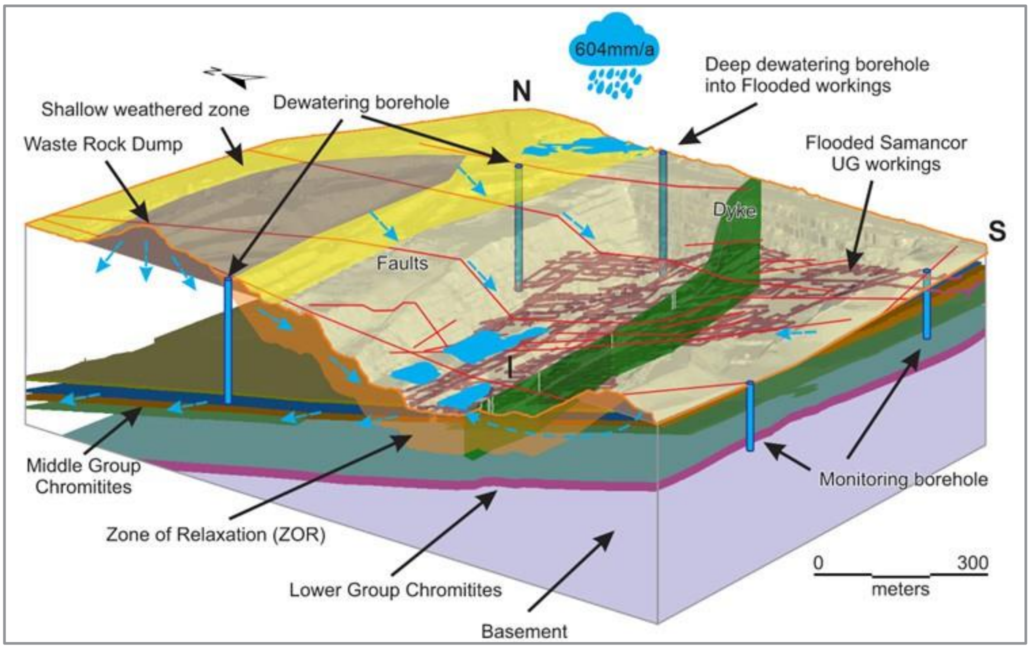

Figure 4: Conceptual illustration of groundwater flow regime (N-S)

Numerical Model

A numerical model was built, based on the conceptual model, using FEFLOW® to simulate the probable inflow to the pits up to the year 2041 and inform the design of the required pumping capacity. Three different dewatering scenarios (base case and 1 and 2) were modelled to simulate reducing the predicted passive inflow into the pits, as shown in figure 5 for the East pit.

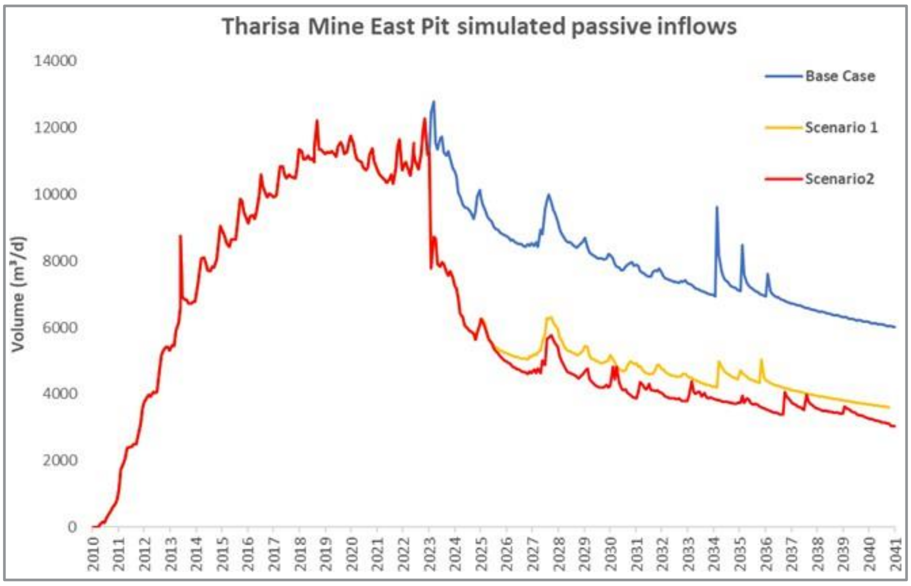

Figure 5: Output from 2024 numerical model showing the East pit simulated passive inflows

These scenarios simulated the effect of twelve shallow dewatering boreholes south of the East pit, five additional deep dewatering boreholes north of the East pit, and two in-pit dewatering boreholes targeting the old underground Samancor workings.

The deep boreholes are designed to cut off recharge from geological structures. In-pit boreholes were drilled to lower water levels in the flooded Samancor workings and intercept the dyke contacts. Shallow boreholes were drilled into geological structures, identified through geophysical surveys and mapping, to cut off recharge from the river and capture groundwater seepage [4].

Output from the 2024 numerical model for the East pit includes:

- Base case: Pit sump pumping and dewatering from two boreholes drilled into the Samancor workings
- Scenario 1: When the 12 shallow dewatering boreholes are operational, passive inflow decreases by 3 500 m³/day
- Scenario 2: An additional decrease of approximately 1 000 m³/day in simulated passive inflows is observed when the five additional deep dewatering boreholes are implemented.

Dewatering Implementation

Following the site investigation and the development of the conceptual model, numerical modelling was used to calculate the number of boreholes required to keep the groundwater level below the pit bottom in advance of mining. Because the ore body dips to the north, the northern dewatering boreholes are deep enough to intercept water on structures and bedding planes targeted below the planned mine level.

In 2025 two dewatering boreholes were drilled into the Samancor workings and equipped in the East pit to extract 6 720 m³/d. Twelve shallow boreholes were sited using Electrical Resistivity Tomography (ERT) to intercept the shallow weathered aquifer on the southern and western sides of the East pit. Five deep boreholes are in progress to intercept the deep groundwater on the northern side of the East pit. On the West pit perimeter, thirteen boreholes are planned. These boreholes were also sited using ERT.

The twelve boreholes on the East pit perimeter and the two in-pit boreholes were drilled using rotary percussion, cased, developed and aquifer tested. Water is pumped to the plant and an old nearby quarry. The 2025 pumping strategy is a combination of:

1. East pit: a central sump, two in-pit boreholes, and seventeen pit-perimeter boreholes
2. West pit: a central sump and thirteen planned pit perimeter boreholes
3. Far West pit: a central sump

Conclusion

Tharisa mine needs to pump between 7 000 – 10 000 m3/d to keep the groundwater level below pit bottom in advance of mining. The dewatering strategy incorporates a phased installation of pit perimeter boreholes, in-pit boreholes, and sumps to intercept water effectively. By cutting off recharge through detailed stormwater diversion, utilizing accurate water level monitoring networks, and starting dewatering operations well in advance of mining, the strategy ensures efficient water management. A conceptual and numerical model (developed using FEFLOW®) included groundwater flow mapping, recharge sources, and identification of storage areas, enabling the optimization of borehole placement and design of pumping capacities. This phased approach has proven to be a cost-effective method for managing groundwater inflows, reducing environmental discharge, and supporting Tharisa's mining operations across multiple pits and the planned underground mine. Successful implementation of this dewatering design highlights its applicability to other surface and surface-to-underground transition mines.

Acknowledgements

The authors thank Tharisa management for the permission to publish the information from Tharisa.

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