Report No. 10444

Coiled Tubing Drilling for Definition of Mineral Deposits: MinEx CRC Project 2 – Phase 2

Results of research carried out as MRIWA Project M10444

at the University of South Australia, Curtin University and CSIRO

by

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DOI 10.71342/344764211913

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Acknowledgements

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REFERENCE
The recommended reference for this publication is:
Soe, S., Fox, S., Min, M., Brewis, R., van der Hoek, B., Porumb, I., Li, Y., and Chan, H., 2025, MinEx CRC Project 2, Phase 2: Coiled Tubing Drilling for Definition of Mineral Deposits. *MinEx CRC Report 2025/51.* Report DOI 10.71342/344764211913

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SPONSORING ORGANISATIONS
Anglo American Services (UK) Ltd, Anglo American Technical & Sustainability Services Ltd, BHP Iron Ore Pty Ltd, Department of Regional New South Wales, Epiroc, LKAB Wassara, The Minerals Research Institute of Western Australia, MinEx CRC, South32 Group Operations Pty Ltd

ABOUT THIS PUBLICATION
This publication presents the results of work carried out under Project 2 of the Mineral Exploratioin Cooperative Research Centre (MinEx CRC) in relation to Commonwealth Milestone RP1.2.4: Prototype sampling, positioning, steering and extended reach technologies incorporated in Coiled Tubing drilling platform and trialed in field setting. Recommended modifications and pathway toward V2 prototype technologies.

Report DOI 10.71342/344764211913

KEYWORDS AND TAGS
Mineral exploration, coiled tubing, drilling, CT drilling

Published 2025 by the Minerals Research Institute of Western Australia
This report is published in digital format (PDF) and is available online at
https://www.mriwa.wa.gov.au/research-projects/project-portfolio/

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Table of Contents

1. Introduction

1.1 Mineral Exploration Cooperative Research Centre

The Mineral Exploration Cooperative Research Centre (MinEx CRC) is the world's largest collaborative mineral exploration research venture. The CRC brings together thought leaders from industry, government and research organisations to discover and develop innovative technologies and methods to support the future success of Australia's mineral resources industry.

Over its 10-year lifetime from 2019 to 2029, the CRC's two-fold aims are:

1. To turn successful research outcomes into mining innovation, including integrating technological and business innovation to significantly improve Australia's mining competitiveness and manufacturing capabilities, and;
2. To facilitate commercialisation of intellectual property developed through the work of the CRC in such a manner as to ensure maximum benefit accrues to Australia, including the Australian mining industry, Australian manufacturing, the Australian environment and the Australian economy generally.

The activities of the CRC are organised under 3 primary research programs

1. Drilling Technologies – Developing engineering solutions to improve the productivity and safety, and reduce the cost and environmental impact of exploration drilling.
2. Data from Drilling – Developing and improving technologies for the capture and interpretation of geochemical, petrophysical and geophysical data during drilling to support timely decision-making within the exploration workflow.
3. National Drilling Initiative – Delivering drilling programs – including through the use of novel technologies developed by the MinEx CRC – to map regional geology and architecture to define mineral systems potential in areas of Australia where known prospective geology is concealed beneath cover rocks.

1.2 MRIWA Support of the MinEx CRC

The Minerals Research Institute of Western Australia (MRIWA) supports the work of the MinEx CRC in line with the Institute's priority of addressing the challenges of making significant new mineral discoveries in Western Australia.

MRIWA supports specific research projects under this participation framework identified as offering the potential to systematically advance knowledge and capability to improve mineral exploration productivity through detection, exploration technology and prediction performance.

In doing so, MRIWA aims to stimulate research outcomes that will inform the pre-competitive geological, geochemical and geophysical knowledge base of Western Australia and create exploration capability to:

- Position Western Australia as a global leader in exploration technology, and;
- Facilitate private sector investment in existing and newly identified Western Australian mineral provinces to develop the State's rich natural resources.

2. Research Context: Coiled Tubing Drilling for Definition of Mineral Deposits

Drilling is a vital component of modern mineral exploration, providing physical samples of otherwise inaccessible rock in a precise geospatial context allowing geologists to define and test potentially mineralised features buried beneath the surface. Deploying and operating current drilling technology in remote and sensitive landscapes is both expensive and resource intensive, and as explorers push deeper beneath the surface in search of the next generation of mineral discoveries these costs risk becoming unsustainable.

Coiled Tubing (CT) drilling systems offer a range of efficiencies in comparison to the state-of-the-art drilling technology commonly used in mineral exploration, including faster penetration, reduced operational hazards for drill crew, lower fuel use, and reduced environmental footprint. CT drilling is an established technology used in large-bore deep drilling for the petroleum industry, and this project seeks to scale down this technology to produce a portable, low-footprint drilling system suited for discovery and definition of mineral deposits, including brownfields, resource definition and greenfields drilling.

3. Potential Value to Western Australia

Mineral exploration and discovery represent the foundations of Western Australia's successful mining sector. Maintaining the productivity of this key industry into the future will require the discovery and characterisation of ore bodies deeper below the surface and hidden from traditional methods of discovery, pushing industry to reduce both the cost and the environmental footprint of exploration technology.

Cheaper drilling with a lower environmental footprint will be an important enabling technology for future mineral exploration in Western Australia, where many of the most exciting exploration targets are expected to lie below cover in areas where the State's proven and richly-endowed mineral provinces plunge beneath more recent layers of rock. Development of this next-generation drilling system in WA could also support the growth of innovative local METS providers delivering the new technology to the mining industry.

4. Project Structure

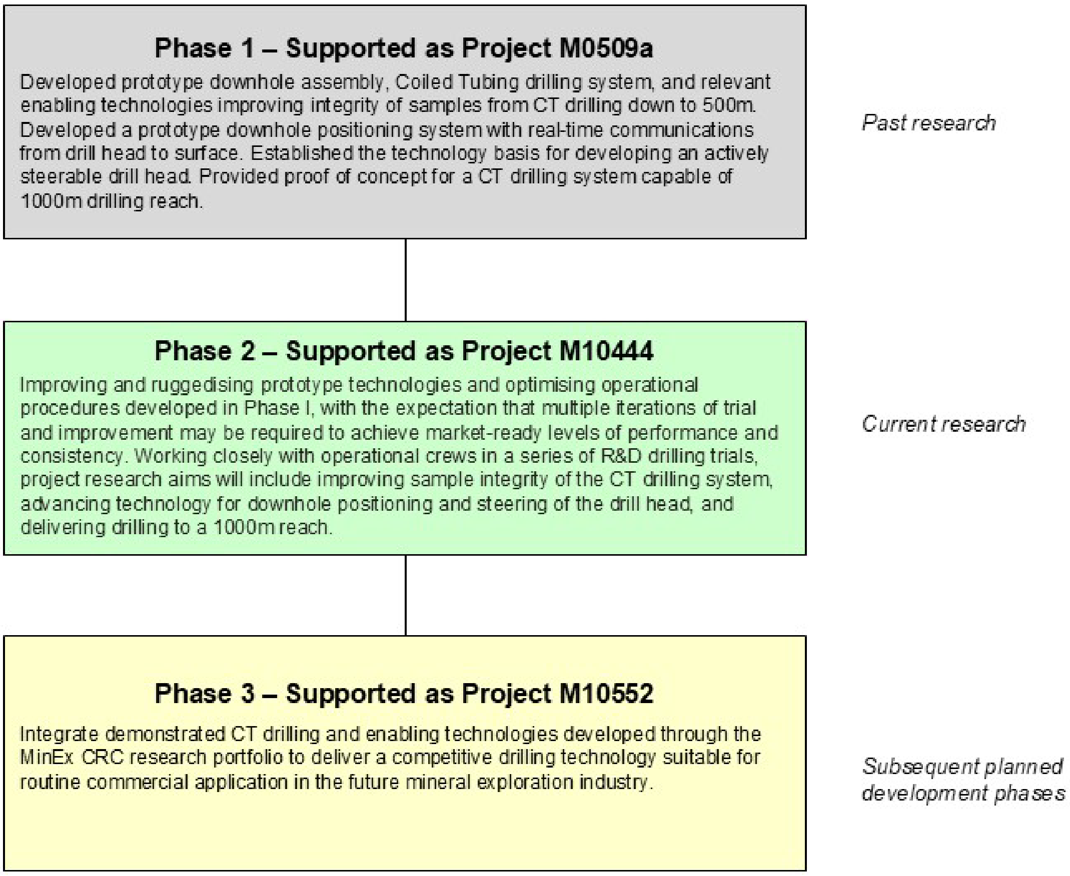
MinEx CRC Project 2: Coiled Tubing Drilling for Definition of Mineral Deposits is intended to deliver a suite of improvements and refinements to CT technology suited to the mineral exploration industry, including:

- Improving the sample integrity of CT drilling to match that of diamond drilling, and;
- Developing the ability to drill multiple deviated holes of up to 1000m reach from a single pad, to within 10m of target and surveyed within 1m, while;
- Maintaining the relative cost, speed, safety and environmental benefits of CT drilling in comparison to existing exploration drilling technologies.

These outcomes are intended to be realised through three staged phases of research over the life of the MinEx CRC (Fig. 1). MRIWA Project M10444 represented Phase 2 of this development program, and focused on delivering improvement across three core areas:

1. Improving sampling technologies and sample quality to deliver accurate, geologically representative sampling throughout the drilling process.
2. Improving precision of positioning, sensing and steering of the Bottom Hole Assembly (BHA), or drill head.
3. Extending reach of the prototype drilling system, with a target depth of 1000m.

Prototype technologies were tested in a range of field trials in collaboration with participating sponsor organisations to inform improvements and optimise operations.



Phase 1 – Supported as Project M0509a

Developed prototype downhole assembly, Coiled Tubing drilling system, and relevant enabling technologies improving integrity of samples from CT drilling down to 500m. Developed a prototype downhole positioning system with real-time communications from drill head to surface. Established the technology basis for developing an actively steerable drill head. Provided proof of concept for a CT drilling system capable of 1000m drilling reach.

Past research

Phase 2 – Supported as Project M10444

Improving and ruggedising prototype technologies and optimising operational procedures developed in Phase I, with the expectation that multiple iterations of trial and improvement may be required to achieve market-ready levels of performance and consistency. Working closely with operational crews in a series of R&D drilling trials, project research aims will include improving sample integrity of the CT drilling system, advancing technology for downhole positioning and steering of the drill head, and delivering drilling to a 1000m reach.

Current research

Phase 3 – Supported as Project M10552

Integrate demonstrated CT drilling and enabling technologies developed through the MinEx CRC research portfolio to deliver a competitive drilling technology suitable for routine commercial application in the future mineral exploration industry.

Subsequent planned development phases

Figure 1: *Phased development plan for MinEx CRC Project 2. The work supported by MRIWA as M10444 comprises Phase 2 of this program.*

5. Overview of Project Outcomes

Pre-commercial drilling trials completed with the CT500 (500m-reach) prototype drilling delivered performance levels competitive with established commercial systems in terms of average penetration rates, speed of hole completion, and consumption of water and fuel.

The system routinely provides high quality chip samples with high depth fidelity and geological representation, and demonstrated significant advantages relative to conventional drilling in terms of workplace health and safety and environmental footprint of drilling.

Application of bespoke drilling fluid additive LiqiCTrol as part of these field trials further contributed to robust improvement performance in relation to sample quality and hole stability. Control of LiqiCTrol application using the prototype iFluid management system demonstrated the capacity to sense departure from optimum drilling conditions and change operating parameters in real time to achieve managed pressure drilling with minimum driller intervention.

Overall productivity measured as metres drilled per dollar was more than double the productivity achieved by conventional drilling techniques in like-for-like drilling under the trial program. This productivity figure is expected to improve further over time as consumable costs are scaled to production and efficiencies are achieved in operations, maintenance and provision of spare parts.

A prototype coiled tubing system configured for drilling to depths of up to 1,000m (the CT1000 rig) was engineered, assembled and completed pre-service trials and initial deployment. The system successfully completed open pressure-managed drilling of holes up to 700m deep in the initial program of field testing completed in this project.

Market-leading technologies for steerable Bottom Hole Assembly (BHA) systems were evaluated for potential adaptation to the scale and operational requirements of the RoXplorer® drilling system. A prototype system was commissioned in collaboration with UK-based specialist energy drilling technology company AnTech, developed through re-engineering of proven AnTech steerable BHA technology to fit the narrower bore of the RoXplorer® system. Due to production delays, this prototype technology will be tested in Phase 3 of this project, supported by MRIWA as Project M10552.

Under the relevant contractual terms governing this research, intellectual property (IP) created through the project is owned legally by MinEx CRC, and owned beneficially by the Project Parties – including MRIWA on behalf of the WA State Government – in accordance with their respective Project Contributions.

Commercialisation opportunities are being assessed on a continuous basis. The CT500 RoXplorer® platform has been licensed to DigCT who have conducted Coiled Tubing drilling on behalf of MinEx CRC in National Drilling Initiative campaigns at the Nifty mine site in Western Australia (in collaboration with GSWA) and in the Northern Gawler region of South Australia (in collaboration with GSSA)

A non-exclusive license covering project IP has also been signed with CoilRig, a newly established spin-out from UniSA. CoilRig will target the shallow geothermal drilling market in North America in the short term, but may expand operations to include mineral exploration, mine production and geotechnical drilling if market opportunities arise.

Any enquiries as to the technical detail of the project outcomes and current disposition of relevant IP should be directed to Professor David Giles, Chief Scientific Officer of the MinEx CRC.

6. Future Research

In line with the staged research plan outlined in Section 4 above (Fig. 1), the outcomes of this project are being further developed by the MinEx CRC research team in a third phase of work.

Supported by MRIWA as Project M10552, this third phase will undertake an extensive program of field testing and further development to further improve and ruggedise the CT drilling system and enabling technologies developed.

7. Project Sponsors

Funding for this project was provided by the following sponsor organisations:

- Anglo American Services (UK) Ltd
- Anglo American Technical & Sustainability Services Ltd
- BHP Iron Ore Pty Ltd
- Epiroc
- LKAB Wassara
- South 32
- The Minerals Research Institute of Western Australia (MRIWA)
- MinEx CRC
- Department of Regional New South Wales

Appendix 1

MinEx CRC Report 2025/51 – Commonwealth Milestone RP1.2.4

Submitted as Commonwealth Milestone Report RP1.2.4 for MinEx CRC Project 2: Coiled Tubing Drilling for Definition of Mineral Deposits

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Commonwealth Milestone Report

Project 2: Coiled Tubing Drilling for Definition of Mineral Deposits

Commonwealth Milestone RP1.2.4

Prototype sampling, positioning, steering and extended reach technologies incorporated in Coiled Tubing drilling platform and trialed in field setting. Recommended modifications and pathway toward V2 prototype technologies.

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Date: June 2025

MinEx CRC Report 2025/51

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Australian Government
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Cooperative Research Centres Program

*Consent for release provided by MinEx CRC CEO 21/05/2026

EXECUTIVE SUMMARY

This document is a compilation of one technical report, three end-of-year Project Review Panel presentations produced by researchers within MinEx CRC Project 02 Phase 02 (Coiled Tubing Drilling for Definition of Mineral Deposits) and one MinEx CRC Project 02 Phase 03 quarterly Project Review Panel presentation from Quarter 1, 2025. Together these reports demonstrate progress towards and completion of Commonwealth Milestone RP1.2.4: Prototype sampling, positioning, steering and extended reach technologies incorporated in Coiled Tubing drilling platform and trialed in field setting. Recommended modifications and pathway toward V2 prototype technologies.

The materials are presented in chronologic order to demonstrate progression of the underlying science and technology. Although MinEx CRC research and development in Coiled Tubing drilling is multifaceted, this report focused on three core areas relating to CM RP1.2.4 namely:

1) Sampling technologies and sample quality (Module 1 of our Project 2 Phase 2 research project)
2) Positioning, sensing and steering (Modules 2 and 3)
3) Extended reach with a target depth of 1000m (Module 4)

Our methodology utilizes field trials in collaboration with MinEx CRC Participants to test our prototype technologies, inform improvements and optimize operations. Sections of the attached report and presentations that are relevant the core components of CM RP1.2.4 are highlighted in the summaries below.

1. 5000m of RoXplorer® Prototype System Drilling trials for mineral exploration in South Australia. MinEx CRC Technical Report 2022/53, 51pp (June 2022)

The report provides a status update of the CT500 RoXplorer® system, with 500m depth reach, as deployed in pre-commercial drilling trials up to May 2022. The CT500 RoXplorer® system consists of the RoXplorer® Coiled Tubing Drilling rig, the Hydraulic Processing System (HPS) for recirculation of the drilling fluid, automated drilling mud monitoring and dosing system, proprietary drilling additives (LiqiCTrol), gamma logging, surveying tool, cement mixing system for hole remediation plus support and transport vehicles. The report evaluates both drilling performance and productivity.

Performance is a multifactor consideration including health, safety and environmental performance, rate of drilling, reliability of technologies and sample quality. Performance of the RoXplorer® system, based on results of the 2021 and 2022 drilling trials, is competitive compared with conventional drilling methods (based on average penetration rates, speed of hole completion, consumption of water and fuel) and has significant WHS and environmental advantages. The performance of the bespoke drilling additive (LiqiCTrol) is robust and contributes to two other important performance measures being sample quality and hole stability. High quality cuttings (chip) samples (with depth fidelity and geological representation) and core are features of the CT500 RoXplorer® system. Prototype chip and core sampling technologies covered in this report have direct relevance to CM RP1.2.4.

Productivity, measured as meters drilled per dollar, was greater than double conventional drilling techniques – compared in the same drilling program. Productivity is predicted to improve with time, as consumable costs are scaled to production and efficiencies are achieved in operations, maintenance and provision of spare parts.

2. MinEx CRC Project 02 Phase 02: Fourth quarterly Project Review Panel meeting Q4 2022 (December 2022)

Summarizes progress on sampling, extended reach and steering and positioning aspects of CM RP1.2.4, including:

- Detailed borehole positioning data collected from 18 CT500 doles drilled during the Delamerian North (collaborating with the Geological Survey of South Australia) and Diamantina (collaborating with Anglo American) drilling trials (slides 15 and 16). The data show 1) improvement in the density of measurements and, 2) improvement in borehole deviation between the Delamerian North and Diamantina campaigns. The improvement in deviation was achieved by greater understanding of the CT drilling process by the drilling crew, combined with regular feedback from the downhole positioning technology.

- Progress on design and fabrication of a 'yard spooler' which will facilitate loading and unloading >1000m of coiled tubing drill pipe onto the 1000m depth reach coiled tubing drill rig (CT1000) (slide 17).

- Introduction to the concept of 'managed pressure drilling' (MPD) and results of preliminary modelling and experiments (slides 18 to 20). By careful monitoring and dynamic management of pressure in the borehole (MPD) drillers should be able to minimize pressure variations due to drilling activities (e.g. running drill string into and out of the borehole). Pressure variations of this kind become more problematic with greater depth with potential to impact hole integrity and sample returns. Our work includes the theory, technology solutions and practice of MPD, which will be critical to successful drilling and collection of high quality samples at depths up to 1000m.

- Preparation of the CT1000 RoXplorer® for field trials planned to take place in 2023 dependent on identifying a suitable drill site (slide 21).
- Rationale, project schedule and budget details of the planned variation of MinEx CRC Project 2 Phase 2 to include development of a steering and sensing bottom hole assembly (steerable BHA) in collaboration with British drilling technology company AnTech Ltd (slides 22 to 26). This plan was developed by the Project 2 Partners during a meeting in September 2022. The Project Variation was drafted in Q1 2023 and executed in June 2023.

3. MinEx CRC Project 02 Phase 02: Eighth quarterly Project Review Panel meeting Q4 2023 (December 2023)

Summarizes progress on extended reach and steering and positioning aspects of CM RP1.2.4, including:

- Preparation of the MinEx CRC 'SmartBHA', incorporating MinEx CRC Partner LKAB Wassara positioning technology and software, for field trials (slide 11). The SmartBHA is a low TRL option for positioning during coiled tubing drilling but does not deliver active steering, which is the ultimate goal of our coiled tubing research.
- First stages of fabrication of the Steerable BHA and visit by key researchers to AnTech Ltd in the UK to discuss integration of the AnTech steerable BHA with the CT1000 RoXplorer® system (slides 12 and 13).
- Summary information of a 700m coiled tubing drilling hole completed at Wentworth NSW with the CT1000 RoXplorer® (slide 14). The Wentworth site was identified in collaboration with Geoscience Australia during planning for the Delamerian Margins National Drilling Initiative campaign. The hole was the last drilled in the Delamerian Margins campaign – providing Project 2 researchers with the opportunity to drill in 'research mode'. Focused on understanding drilling processes rather than achieving productivity goals. The 700m drill hole is the largest yet drilled using the MinEx CRC coiled tubing drilling platform.
- Installation of the 'e-line' communications cable in 1000m of coiled tubing (slide 15). The e-line is a new communications cable compatible with the AnTech Steerable BHA. MinEx CRC Project 2 researchers at UniSA undertook key engineering tasks required for integration of the AnTech Steerable BHA with the CT1000 RoXplorer® system.
- Preparations for laboratory of field-based MPD experiments to be conducted in 2024 (slide 16).

4. MinEx CRC Project 02 Phase 02: Twelfth quarterly Project Review Panel meeting Q4 2024 (December 2024)

Summarizes progress on sampling, extended reach and steering and positioning aspects of CM RP1.2.4, including:

- Results of the first field trial conducted in October 2024 with the iFluid management system upgraded to include managed pressure drilling (MPD) software (slides 16 to 19). The new software provides the ability to receive information from the drill rig and hydraulic processing system, analyse the data to identify optimum drilling conditions and change operating parameters in real-time, automated mode to achieve MPD with minimal driller intervention. The simple trip in / trip out experiment delivered high quality data which will be used to inform future experiments and improve the theoretical understanding of MPD.
- Summary of progress on fabrication of the AnTech Steerable BHA (slides 20 to 23). This work was subject to multiple delays during 2023 and 2024 with final delivery of the AnTech tool not expected until at least Q2 2025 (>15 months after the delivery date planned in discussions with AnTech in 2022).
- Summary of MinEx CRC preparations for the AnTech Steerable BHA drilling trial, which were completed in 2024 (slide 24). The CT1000 RoXplorer® is ready for the planned drilling trials. However, the timing and location of the trials are still unknown. Final plans, including choice of site (in collaboration with MinEx CRC Partner BHP), detailed site access and logistics will be dependent on delivery date of the AnTech tool.
- In response to uncertainty in respect of the AnTech Steerable BHA trials, the MinEx CRC Project 2 team identified an alternate pathway toward real-time steering in partnership with LKAB Wassara (slide 22). LKAB Wassara joined

Project 2 Phase 3 (2025-2027) as an active research partner – contributing their ongoing research on steering during coiled tubing drilling. A summary of the strengths (and weaknesses) of the steerable BHA options – including the MinEx CRC 'SmartBHA' with positioning but not active steering – is provided on slide 15.

5. MinEx CRC Project 02 Phase 03: First quarterly Project Review Panel meeting Q1 2025 (April 2025)

Summarises progress on sampling, extended reach and steering and positioning aspects of CM RP1.2.4, including:

- Progress toward a steerable bottom hole assembly (BHA) for the CT1000 RoXplorer® platform (slides 10 to 19) with active research now on two fronts:
  1) Fabrication of the AnTech Steerable BHA, which is due to be complete in June 2025. The current plan is for laboratory testing at AnTech in the UK in June/July followed by shipping to Australia in August in preparation for field trials in Q4 2025.
  2) Advanced field trials of the LKAB Wassara Steerable BHA conducted at the LKAB Wassara Gallivare test mine in Sweden. MinEx CRC Project 2 researchers visited the LKAB Wassara team in February 2025 during the drilling trials. The diameter of the LKAB Wassara tool is too large for deployment on the current CT1000 RoXplorer® platform. Nonetheless, the successful LKAB Wassara field trials demonstrate that steering and positioning are achievable whilst drilling with coiled tubing in hard rocks. The drilling trials provide valuable insights into the drill/rock interactions during steering and will inform our pathway toward V2 steering and positioning technologies. This is an important milestone for our project.

- Results of managed pressure drilling (MPD) experiments carried out during the MinEx CRC Northern Gawler National Drilling Initiative campaign (in collaboration with the Geological Survey of South Australia) utilizing a bespoke MinEx CRC MPD tool (slides 20 to 22). Pressure variations were carefully measured during tripping in and tripping out. The experimental results were robust and repeatable and demonstrate pressure variations greater than predicted by published theory. These results will be used to improve MPD theory and develop MPD technology and operational protocols to be incorporated in V2 of our coiled tubing drilling platform.

OBJECTIVE(S)	**RESULT(S)**
Demonstrate completion of Commonwealth Milestone RP1.2.4	A compilation of 1 technical report and 4 Project Review Panel Presentations produced by the MinEx CRC Project 2 research team fulfills the requirements of the milestone.
NEXT STEP(S)	**TIMING**
Continuing field trials with MinEx CRC Partners (current plan is with BHP) to test the AnTech Steerable BHA and drilling to depths up to 1000m.	2025-2027 inclusive

MINEX CRC MILESTONES

CM RP1.2.4 Prototype sampling, positioning, steering and extended reach technologies incorporated in Coiled Tubing drilling platform and trialled in field setting. Recommended modifications and pathway toward V2 prototype technologies.

UTILISATION/COMMERCIALISATION OPPORTUNITIES

Commercialisation opportunities are being assessed on a continuous basis within MinEx CRC Project 2. The CT500 RoXplorer® platform has been licensed to DigCT who have conducted Coiled Tubing drilling on behalf of MinEx CRC in the Nifty (in collaboration with GSWA) and Northern Gawler (in collaboration with GSSA) National Drilling Initiative campaigns. CoilRig is a newly established spin-out from UniSA which has signed a non-exclusive license covering MinEx CRC Project 2 IP. CoilRig will target the shallow geothermal drilling market in North America in the short term but may expand to include mineral exploration, mine production and geotechnical drilling if market opportunities arise.

IP

Non-exclusive licenses have been granted to DigCT and CoilRig for access to all MinEx CRC Project 2 IP.

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APPROVED BY

Prof David Giles
Chief Scientific Officer MinEx CRC

Table of Contents

Acknowledgements

The work has been supported by the Mineral Exploration Cooperative Research Centre whose activities are funded by the Australian Government's Cooperative Research Centre Program. This is MinEx CRC Document 2025/51.

Australian Government
Department of Industry, Science, Energy and Resources

Business Cooperative Research Centres Program

5000m of RoXplorer® Prototype System Drilling Trials for Mineral Exploration in South Australia

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David Giles: MinEx CRC, UniSA
Ben van der Hoek: MinEx CRC, UniSA

June 2022
MinEx CRC report number: 2022/53

Table of Contents

EXECUTIVE SUMMARY

This document is intended to provide a current snapshot of the status of the RoXplorer® system that has been deployed in pre-commercial deployments up to May 2022.

The RoXplorer® system is a greenfields mineral exploration technology consisting of several integrated prototypes with various Technology readiness levels, ranging from TRL3 to a low TRL7.

The RoXplorer® system consists of the RoXplorer® Coiled Tubing Drilling rig, the Hydraulic Processing System (HPS) for recirculation of the drilling fluid, automated drilling mud monitoring and dosing system, proprietary drilling additives (LiqiCTrol), gamma logging, surveying tool, cement mixing system for hole remediation plus support and transport vehicles. The RoXplorer® system is designed to provide quality assured chip and core samples from formations down to a maximum of 500 metres depth.

This report evaluates both drilling performance and productivity. Performance is a multifactor consideration including health, safety and the environmental performance, rate, reliability of technologies and sample quality. Productivity is measured as cost per metre.

Performance of the RoXplorer® system, based on results of the 2021 and 2022 drilling trials, is competitive compared with conventional drilling methods (based on average penetration rates, speed of hole completion, consumption of water and fuel) and has significant WHS and environmental advantages. In addition the system has good chip sample integrity and core recovery ability. Client endorsement has also been strong. The performance of the bespoke drilling additive (LiqiCTrol) is also robust and contributes to two other important performance measures being sample quality and hole stability.

Productivity of the RoXplorer® system has been based in part on comparison with equivalent commercial rates on a shift basis and does not reflect the total cost of provision. The cost model does not include costs incurred in preparation for the drilling program including environmental and cultural compliance, contracting, community liaison, site access, preparation and remediation. No allowance for a profit margin, capital costs, management costs or any additional overheads has been accounted for, noting that these may contribute an additional ~50% to the cost model. In addition, productivity is adversely affected by low system availability of ~40% due to ongoing, NDI deployment planning, rain events, vacation, facility closures, remediation obligations, equipment improvements, compliance modifications and maintenance, and the cost of infrastructure and support for periods of non-availability have not been accounted for to date.

Productivity will also improve with time, including for example the cost of drilling fluids (*LiqiCTrol,* being ~18% of total cost in the Delamerian North campaign) and coring. In addition current systems to manage maintenance and provision of spare parts are inefficient, contributing to breakdowns and non-billable downtime.

OBJECTIVE(S)	**RESULT(S)**
To Provide a status report about the RoXplorer® - System for participants and potential commercialisers.	Results are presented in the Report
NEXT STEP(S)	**TIMING**
N/A	No Actions

MINEX CRC MILESTONES

Not Applicable

UTILISATION/COMMERCIALISATION OPPORTUNITIES
Not Applicable
IP
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APPROVED BY
Soren Soe (UniSA), David Giles (UniSA) and Andrew Bailey (MinEx CRC)

1.0 Introduction

This document is intended to provide a current snapshot of the status of the RoXplorer® system that has been deployed in pre-commercial deployments up to May 2022.

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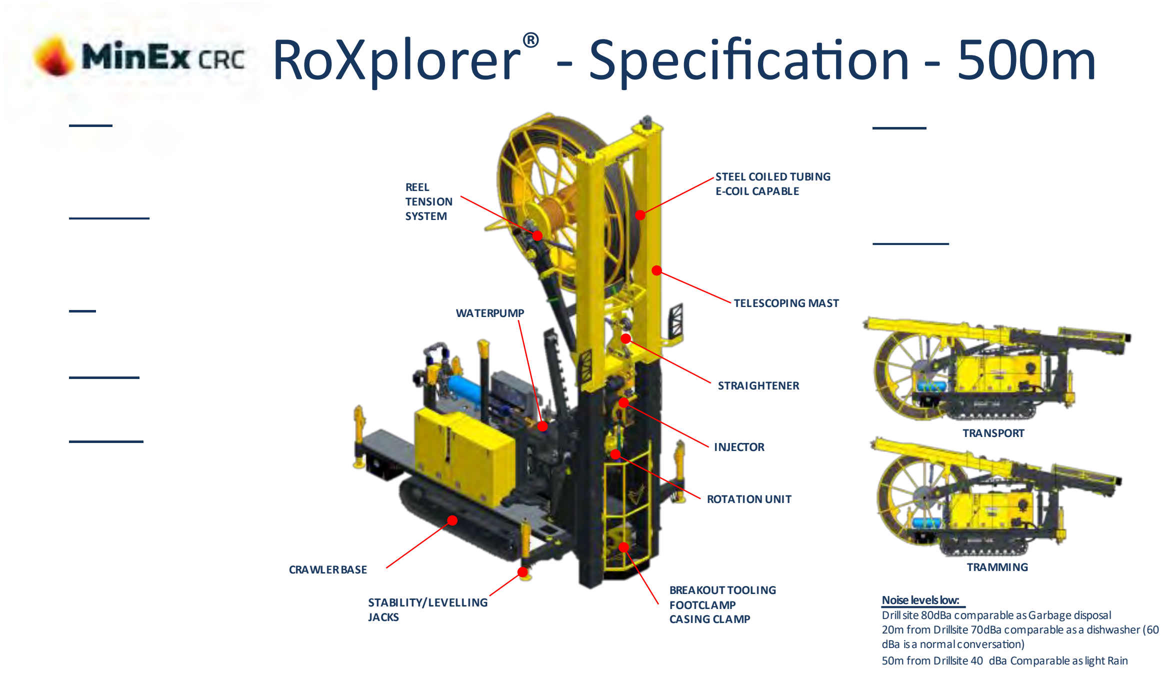
Based on results of the 2021 and 2022 drilling trials, drilling and sampling through several hundred metres of cover/overburden, the RoXplorer® system is competitive with conventional drilling methods (based on average penetration rates, speed of hole completion, consumption of water and fuel) and has significant WHS and environmental advantages.

2.0 Key components of the MinEx CT drilling platform

2.1 RoXplorer® CT drilling rig

The RoXplorer® is a mineral exploration Coiled Tubing (CT) drilling rig build on a mono-constructed, tubular high tensile steel flatbed frame mounted on a hydraulically powered crawler undercarriage (Figure 1). The system is a hybrid, meaning that the rig has conventional top-drive rotary drilling capabilities as well as CT drilling capabilities. The RoXplorer® rig used in all drilling trials to date is equipped with 500 metres of steel coiled tubing wound onto a spool and mounted on a mast directly above the drill hole. The hydraulic system on the RoXplorer® is powered from the liquid-cooled diesel engine, with capacity to run the hydraulic pumps with up to 200 kW of power. The rig functions are computer-controlled electrics over hydraulics with several automated processes. The RoXplorer® operating platform offers wireless tramming and setup functions. For drilling operations, the rig frame is equipped with 4 hydraulic jacks, high pressure fluid pumps, coiled tubing injector, rotary drill head and coiled tubing straightener. The operational weight of the rig is approximately 15.5 ton including 500m of coiled tubing.

A second RoXplorer® system has been built with 1000 metres of coiled tubing installed. The RoXplorer® 1000 rig is an experimental design only appropriate for research purposes at this stage (June 2022).



RoXplorer® - Specification - 500m

Noise levels low:
Drill site 80dBa comparable as Garbage disposal
20m from Drillsite 70dBa comparable as a dishwasher (60 dBa is a normal conversation)
50m from Drillsite 40 dBa Comparable as light Rain

Figure 1. Key design features and specifications of the RoXplorer® CT rig with 500m of coiled tubing (RoXoplorer® 500).

2.2 Hydraulic Processing System (HPS)

The HPS is a self-contained, truck-mounted drilling fluid management and sampling system (Figure 2) designed to clean, prepare and replenish drilling fluid safely, quickly and with minimum manual intervention. In combination with the RoXplorer® CT rig the HPS forms a continuous fluid loop which negates the requirement for drilling sumps and minimizes interaction of drilling fluids with the surface and downhole environment. Monitoring sensors on the HPS measure several drilling fluid parameters every second and adjust the drilling fluid and sampling algorithm accordingly.

The concentration of solids in recycled drilling fluid is a critical parameter when drilling with the Wassara water hammer. Solid concentrations of >250ppm have a detrimental effect on performance and wear-life of the water hammer and if allowed to build up over time will contaminate cuttings samples. All solid particles larger than 50µ must be removed from the drilling fluid and the total solids loading in the recycled fluid should be less than 250ppm. We have not been able to achieve this quality of fluid cleaning with conventional Solid Removal Units. Hence our commitment to design and build an HPS fit-for-purpose for drilling with the RoXplorer®.

The HPS includes a purpose-built coarse-fraction sampling system, inclusive of a fluid splitter and shale shaker equipped with 150µ screens. All drilling fluids are passed through the shale shaker to remove coarse particles, however the sampled volume can be controlled by the user at ½, 1/3 or 1/6 of the total fluid volume.

The HPS can be moved and set-up safely and efficiently in the field as well as over longer distances by one person. After arrival to a new site the HPS is unpacked, prechecked, setup, filled with freshwater, drill mud prepared and ready to sample in less than three hours.

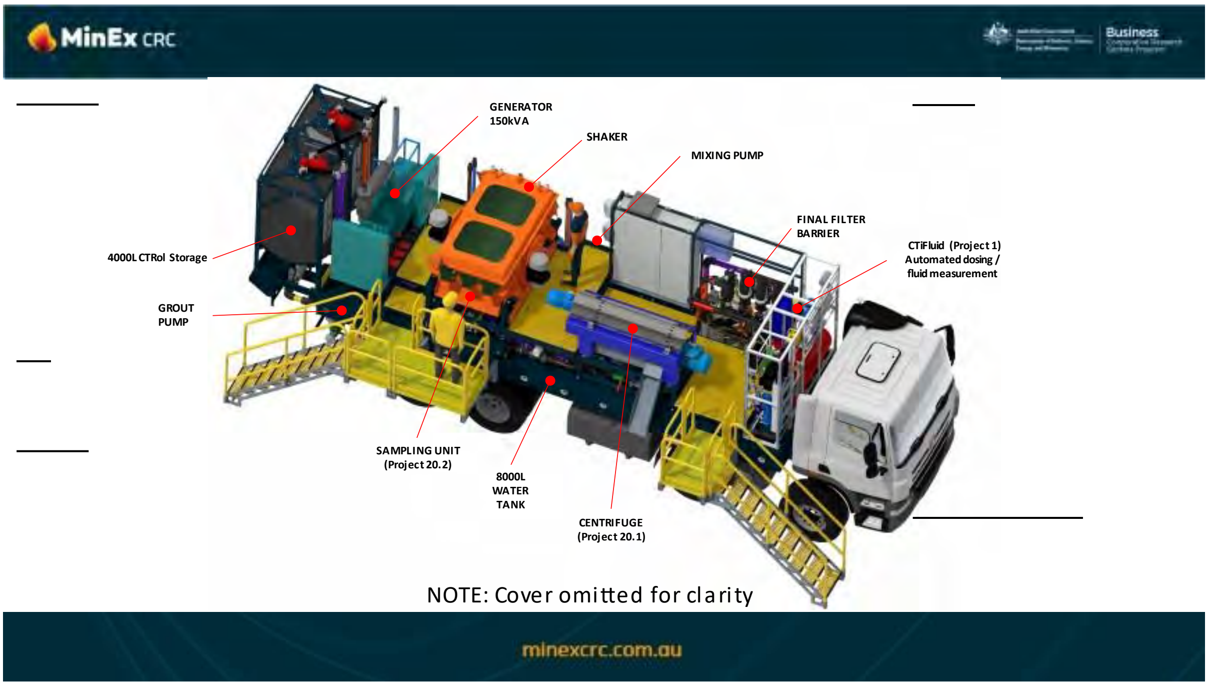


Figure 2. Key design features and specifications of the MinEx CRC Hydraulic Processing System (HPS).

2.3 Drill site set-up

The main components of the RoXplorer® drill site are:

1. RoXplorer® 500 CT drilling rig
2. Hydraulic Processing System (HPS 8x8 truck)
3. Water Truck
4. Medium sized personnel carrier/crane truck
5. Tool/office/spares/document trailer – *HUMPY*
6. Drilling tool stillage and driller's platform
7. Portaloo
8. Potential waste skip(s) for site Layout 1 or backhoe to drill and remediate a sump for site layout 2

Two versions of the drill site exist with almost the same layout (Figure 3 and Figure 4):

The main difference is that drill site layout 1 uses a waste skip (or two waste skips) for collection of waste drill cuttings, whereas layout 2 uses a sump to collect waste drill cuttings. Both layouts fit easily within a 20x20m footprint with additional space required for visitor parking.

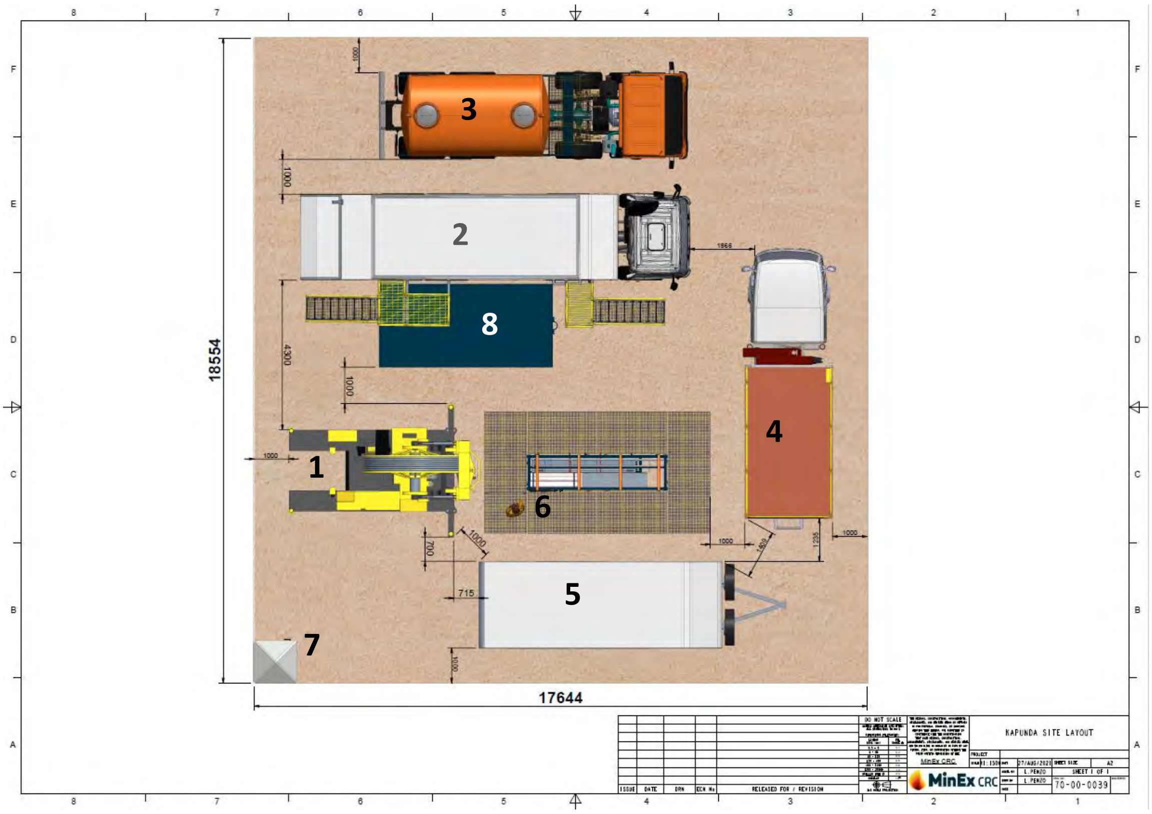


Figure 3. Drill site layout 1, using waste skip for disposal of solids waste from shale shaker and centrifuge. Length and width dimensions are shown in millimetres. Items are numbered as per the list in the text.

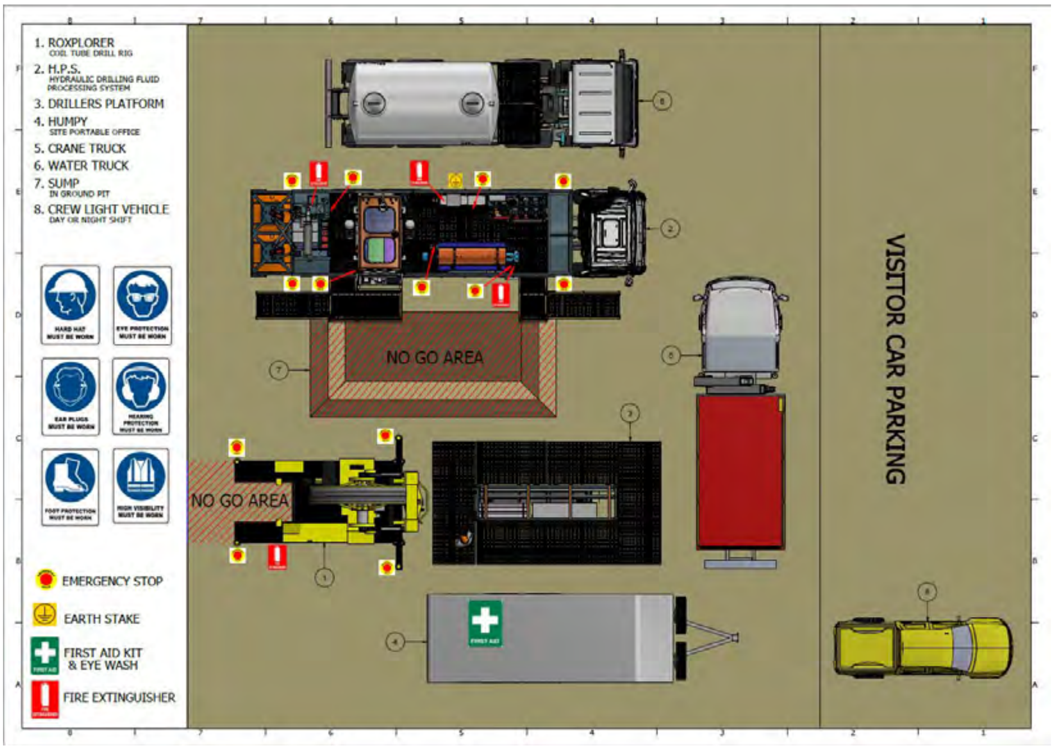


Figure 4. Drill site layout 2, using dry sump (no go area adjacent to HPS) for on-site disposal of solids waste from shale shaker and centrifuge.

2.3.1 Laydown area for additional equipment and transport

The track-mounted RoXplorer® 500 CT drilling rig is transported to site using a prime mover and three-axle trailer (Figure 5) which also carries a shipping container for storage of drilling equipment (e.g. casing, drilling additives, fuel, tools and spare parts). A laydown area of approximately 30 x 30 meters within short driving distance of the drill site is required to park the prime mover and trailer and layout additional equipment.

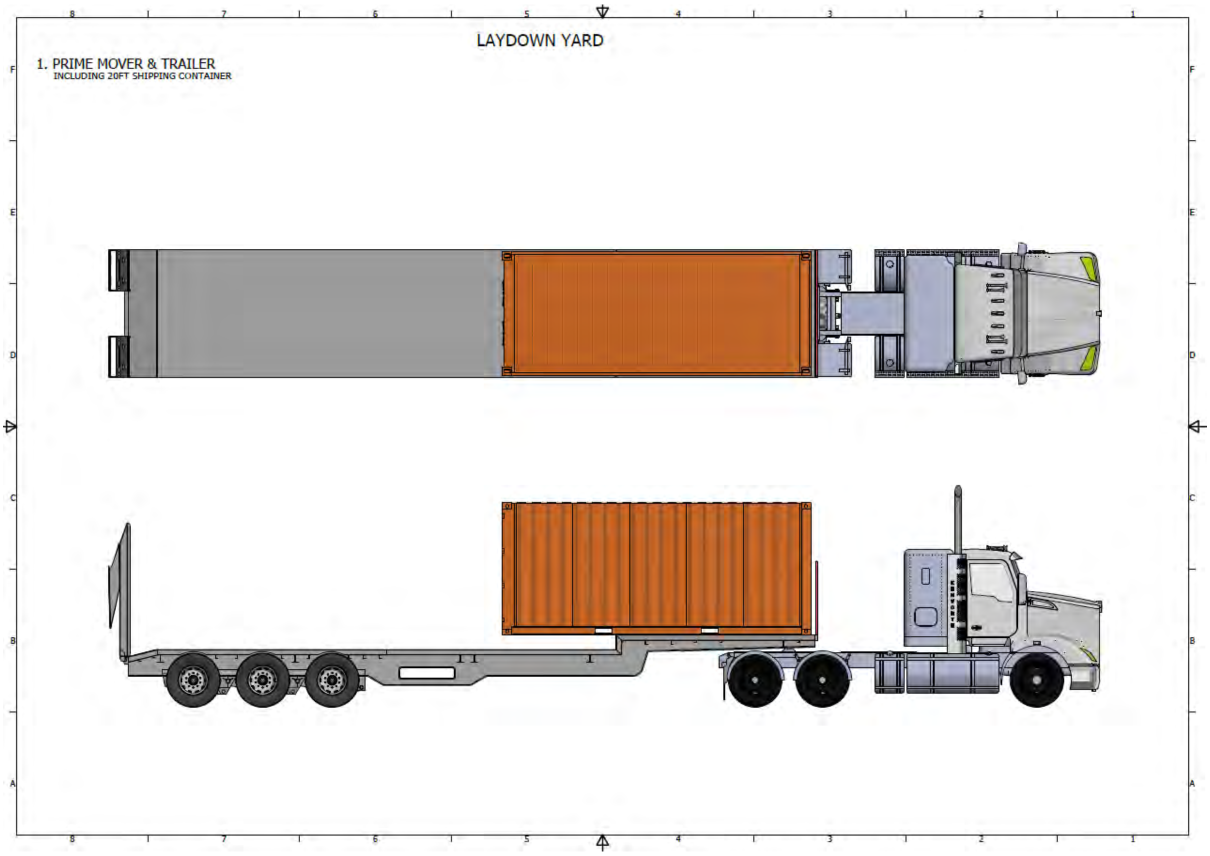


Figure 5. Equipment for transportation of the RoXplorer® 500 CT rig and tooling container.

2.3.2 Mobilisation

Mobilisation and movement between drill sites is accommodated by four vehicles (Figure 6):

1. Prime mover and trailer (carrying RoXplorer® and tooling container, as above)
2. Hydraulic Processing System
3. Water truck
4. Medium sized crane truck towing drillers humpy.

All vehicles are within size and weight limits for operation on public roads throughout Australia. Under the Australian Heavy Vehicle National Law (the HVNL commenced on 10 February 2014) for heavy vehicles over 4.5 tonnes gross vehicle mass. Time to setup the drill site is less than three hours (as done for the drilling trial at Kapunda), in daylight, if the drill site is well-prepared with a waste skip and marking.

Figure 6. MinEx CRC CT drilling platform ready for mobilisation.

2.3.3 Accommodation

In double-shift 24-hour operations accommodation and messing is required for two drilling crews of three to four (see Section 2.5) plus visitors (seven to twelve people).

2.4 Drill site communications

Communication *onsite* between the computers and control systems which operate the RoXplorer® and HPS is managed by an onsite local area wireless network.

Additional *offsite* communication with adequate bandwidth is required to remotely manage the fluid monitoring and management system (*iFluid*). During the Delamerian NDI drilling campaign *iFluid* was managed by Curtin University researchers from their offices in Perth. If the telephone network (Telstra or Optus) cannot be accessed with onsite modems, as is the case for much of regional and remote Australia, offsite communications via satellite are required. MinEx CRC have entered a one-year lease arrangement with Sydney-based company Field Solutions to provide and support satellite internet with sufficient bandwidth at our remote drill sites.

Breakdown of the *onsite* or *offsite* communications systems has the potential to close operations on the drill site.

2.5 Drilling Personnel

The MinEx CRC CT drill platform is operated by a crew of four (or three*):

1. Driller
2. HPS Operator
3. Sampler / Drilling assistant
4. *Water truck driver

*If water storage or water piping is available at the drill site a water truck driver is not required, reducing the site personnel to three. When operating double shifts in the Delamerian NDI campaign MinEx CRC also deployed a drill program co-ordinator to site, for a total of nine (9) personnel in camp.

3.0 Drilling Operations

3.1 Safety features of the RoXplorer®

Key safety features of the RoXplorer® CT drilling platform include:

1) There is minimal rod handling. While drilling in CT mode the coiled tubing spools off the reel and into the drill collar with no manual intervention. Rod handling is restricted to drilling the pre-collar, where we typically use 3m long conventional drill rods with a 121mm rotary bit and inserting (and removing) PQ casing. Casing depths vary depending on ground conditions but are typically ~30m.
2) Most drilling is conducted without any rotation of the drill string. While drilling in CT mode the coiled tubing spools off the reel and into the drill collar with no rotating parts above surface. The interlocked rotation barrier slows rotation when the barrier is open, providing compliant operator safety during conventional drilling operations through near-surface materials.
3) The RoXplorer® CT system uses water-based drilling mud all the times so that there is no dust generated by drilling. The universal drilling additive LiqiCTrol is a non-hazardous starch-based product which naturally biodegrades over a period of days leaving no residual environmental contamination.
4) The RoXplorer® CT system uses two power generators while drilling. A 200KW Diesel engine on the RoXplorer® drill rig and a 150kVA generator on the HPS. Noise pollution is lower than conventional diamond drilling and considerably lower than RC drilling operations with air compressors and boosters.

3.2 Borehole orientation

The RoXplorer® can be set up to drill at angles between vertical (90°) and 60° and in practice it has drilled at starting angles of 90° and 80°. Borehole deviation can be minimised by drilling with modest rate of penetration (ROP) and with the use of rigid weight rods within the BHA. The MinEx CRC drill crew have not used weight rods in the 2021 and 2022 drilling operations due to the added manual handling of heavy components when loading and unloading the BHA.

Although technologies are under development by the Project 2 research team, at present the RoXplorer® does not have real-time positioning or active steering of the BHA. Measurement of hole orientation is achieved after drilling by deployment of the Imdex EZY GYRO which has been modified to fit on the RoXplorer® drill string. Drilling and sampling are most efficient when executed in continuous 24 hour, seven days-a-week operation and the system only needs to be shut down once every 24 hours if local Health and safety protocols allows for that.

3.3 Pre-collar and casing

Surface casing is an essential component of the drillhole plan, mitigating wash-out and ensuring fluids return through unconsolidated near-surface materials. A typical RoXplorer® drilling operation utilises conventional top-drive rotary drilling to start the hole and install casing from surface to the depth required to ensure hole integrity. Maximum bit diameter for conventional drilling is 4 ¾" (121mm) (Table 1A). Our drillers aim to install a minimum of 15m of PQ casing, however the final hole design is highly dependent on ground conditions. Casing is installed until fluid loss and borehole stability can be maintained without casing using the proprietary drilling additives (*LiqiCTrol*).

3.4 CT drilling

Once borehole stability and consistent fluid returns are achieved coiled tubing drilling is used to progress the hole. When drilling in CT mode, the RoXplorer® system can deploy a range of bottom hole assemblies (BHAs) depending on ground conditions and sample specifications (Table 1B). The RoXplorer® system will drill and sample through most formations where sufficient returns can be maintained and is one of few drilling systems that with a small footprint can drill efficiently through both soft and hard water-filled formations at depths deeper than 300metres. Blade or drag bits coupled with a downhole motor are most efficient in unconsolidated formations, whereas percussion bits coupled with a hammer and downhole motor are most efficient in consolidated formations.

The RoXplorer® system can also provide a core sample from the bottom of the borehole if the formation permits. Core is drilled with the proprietary RoXplorer® Coring BHA, with the option of a 1.5m or 3m core barrel, delivering 43.9mm diameter core from within a 60mm hole (Table 1C). For comparison NQ drill core has a diameter of 47.6mm. The core is retrieved by retracting the coil from the hole and removing the core barrel assembly.

A.

RoXplorer® COILED TUBING SYSTEM INFORMATION - CASING INSTALLATION		
	Metric system (mm/m)	Imperial System (in/Feet)
Maximum Rotary drilling bit diameter	121.0 mm	4¾”
Maximum PQ Casing installation depth	60 m	200 Feet
Maximum HQ Casing installation depth	250 m	800 Feet

B.

RoXplorer® COILED TUBING SYSTEM INFORMATION		
	Metric system (mm)	Imperial System (in)
Maximum Coiled Tubing drilling bit diameter	95.0	3.740
Minimum Coiled tubing drilling bit diameter	60.0	2.362

C.

SELECTIVE CORING SYSTEM INFORMATION - Version 1		
	Metric system (mm)	Imperial System (in)
Hole Diameter	60.0	2.362
Core Diameter	43.9	1.728
Core Length	1500 or 3000	59 / 118

Table 1. Drill bit and casing sizes for RoXplorer® CT rig. A. casing, B. drilling below casing with blade, drag or percussion bits, C. coring.

3.5 Drilling additive

The MinEx CRC CT drilling platform utilises a universal drilling additive LiqiCTrol, developed in MinEx CRC Project 1. LiqiCTrol is a multi-purpose drilling fluid which replaces multiple fluid additives used in conventional drilling. It is intended that LiqiCTrol can be used in most drilling scenarios without the need for customisation of the fluid and removing the need for an onsite fluid engineer. LiqiCTrol is easy to mix (with few solid remnants or "fish-eyes") which enables automation of mixing and dosing thereby reducing current manual process. The applicability of LiqiCTrol to many drilling scenarios will simplify inventory management.

LiqiCTrol is mixed on-site with concentration carefully controlled as-needs to manage hole stability, fluid loss and cuttings transport. Constant monitoring of the fluid parameters is provided via iFluid, also developed within MinEx CRC Project 1. In broken or permeable ground *LiqiCTrol* invades the hole wall and rapidly increases viscosity, blocking pore spaces and fractures, mitigating fluid loss and ensuring integrity of the hole. These properties reduce the potential for hole collapse, stuck pipe and loss of down hole tooling. In combination with *iFluid*, *LiqiCTrol* provides a pathway toward automated dosing and near real-time optimisation of drilling fluid performance.

LiqiCTrol is an essential component of the RoXplorer® system. Due to the research nature of the formulation and small batch production in a non-commercial setting the current production cost of LiqiCTrol is high compared to commercial products. However, there is significant value gained through improved productivity, increased hole completion rates, replacement of multiple fluid additives, reduced labour costs and enhanced safety performance through automation.

4.0 Sampling

The RoXplorer® System provides two types of samples from the formation drilled:

- Continuous cuttings samples through cover and basement when drilling with conventional top drive or CT mode using blade, drag or percussion bits.
- Selected intervals of core from competent rock taken from the bottom of the hole when drilling with the Selective Coring Interval BHA.

4.1 Cuttings sample

The system provides a continuous stream of drill cuttings carried from the bit face to the surface by the drilling fluid through the open hole. Drilling fluids that return to surface are captured at the drill collar in their entirety.

While drilling the top sections of the hole, prior to the installation of casing, porous unconsolidated sediments can result in low fluid return, with variable cuttings content and unpredictable sample volumes. Significant washout can increase expected sample volume and mixing of cuttings in the "nest" surrounding the drill string at the top of the open hole. Casing is installed (typically 20-30m but with the capacity for 250m) to control unconsolidated formations at the top of the hole and fitted with a collar capture device to provide a clean conduit between the drill collar and the sampling system incorporated in the HPS.

The sampling system has three components; i) a patented drilling fluid splitter, ii) a dual deck shale shaker fitted <150µ screens, and iii) a sample bagging station. The fluid splitter allows for multiple, user defined splits at 3/6, 2/6 or 1/6 of the total fluid volume (see van der Hoek *et al* 2022). A variable option is being developed that can deliver between 16-27% but was not available for the 2021/2022 drilling trials. The fluid splitter is mounted directly above the shale shaker.

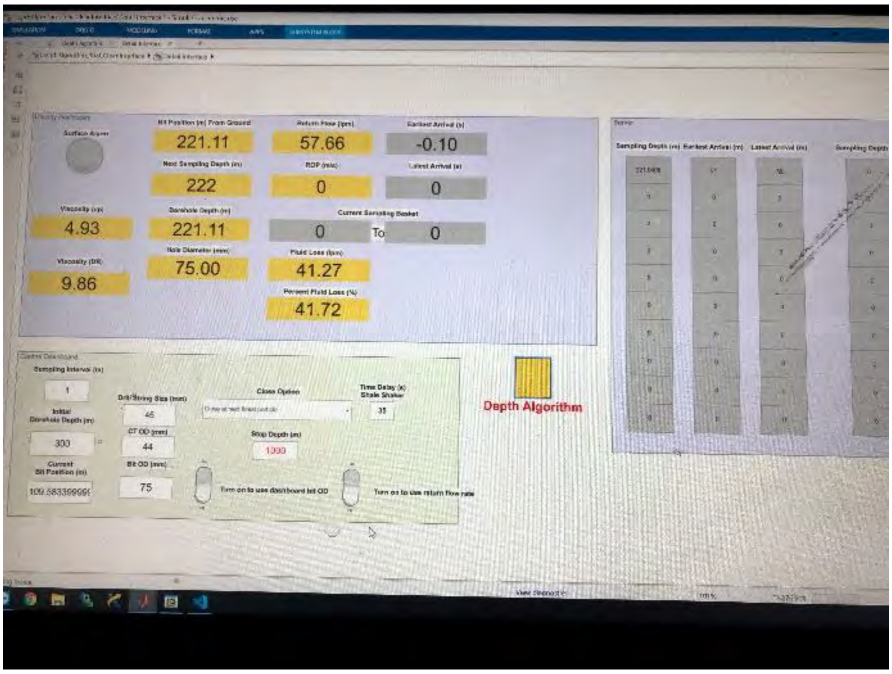
During the 2021/2022 drilling trials a 3/6 split was delivered to the upper deck of the shale shaker for sampling with the remaining waste stream delivered to the lower deck.

The >150µ material from the upper deck is carried across the shaker screen and discharged for sampling. The samples are collected in calico bags fitted to a movable frame which can be placed below the sample discharge point for the desired sampling interval. The sample interval is informed by a drilling depth algorithm, using fluid flow and fluid property data from *iFluid*. The same data can then be used to assess the depth accuracy and smearing of the sample.

4.1.1 Sample properties

The length of the sample interval (typically 1 metre) is user-defined at the surface based on the sample depth algorithm (Figure 7). The interval is delimited at the point where the sample enters the sample bag from the shale shaker (Figure 8). The predicted maximum sample volume is a function of the drill bit diameter and interval length. However, the actual sample volume is also a function of the efficiency (and consistency) of cuttings returns, the cuttings particle size distribution (i.e. the proportion of cuttings >150µ) and the user-defined sample split volume (see Section 4.1 above).

The particle size distribution (PSD) of RoXplorer® cuttings is strongly dependent on the drilled formation but has a typical range between <10µ and 4mm. PSD measurements from laboratory experiments and previous drilling trials indicate that in most formations the majority of drill cuttings are larger than 150µ and that there is little mineralogical or chemical segregation between the coarse and fine fractions. Some <150µ particles are agglomerated into larger particles due to particle-particle interactions (enhanced by LiqiCTrol) in transit from the bit face to the HPS and thus included in the +150µ sample. Samples have initial moisture content between 20 and 50% depending on the formation being drilled (hydrophyllic mineralogy leads to higher water content) and concentration of LiqiCTol being used.



Bit Position (m) From Ground: 221.11
Return Flow (lpm): 57.66
Earliest Arrival (s): -0.10
Next Sampling Depth (m): 222
ROP (m/s): 0
Latest Arrival (s): 0
Viscosity (cp): 4.93
Borehole Depth (m): 221.11
Current Sampling Basket: 0 To 0
Viscosity (DR): 9.86
Hole Diameter (mm): 75.00
Fluid Loss (lpm): 41.27
Percent Fluid Loss (%): 41.72

Control Dashboard
Sampling Interval (m): 1
Initial Borehole Depth (m): 300
Current Bit Position (m): 109.58339999
Drill String Size (mm): 45
CT OD (mm): 44
Bit OD (mm): 75
Time Delay (s) Shale Shaker: 35
Stop Depth (m): 1000

Figure 7. Depth algorithm graphic interface as presented at the HPS coarse fraction sampling station.

Figure 8. Coarse fraction cuttings discharging from the shale shaker into calico bag at the coarse fraction sampling station.

4.1.2 Cuttings sample depth validation

There are currently two methods of validating the depth of the samples after the hole is drilled:

1. Driller-deployed cartridge that contains coloured tracer particles (Figure 9). The cartridge is dropped into the open hole, travels to the bottom-of-hole and broken by the action of the drill bit when drilling resumes. Travel time of the tracer particles to surface can be used to validate and calibrate the depth algorithm.
2. Natural gamma log that can be used to depth match in-situ gamma response to cuttings samples by visual inspection and manual logging (e.g. chip trays) or in-field analyses (e.g. portable XRF).

Figure 9. Driller-deployed cartridge containing tracer particles being deployed at the Kapunda drill site.

4.2 Waste

The >150µ material from the waste stream collected from the lower deck of the shaker screen is delivered to a skip bin or into a solids waste pit (a sump minus fluid storage). Fluid that passes through the upper and lower shaker screens is delivered to a decanter centrifuge for cleaning of the fine-fraction (<150 µ) cuttings. Solids removed at this stage are discharged to waste collection and cleaned fluids are returned to manage drilling.

The solid waste from 500 metre deep borehole has a maximum volume of approximately 4 cubic metres and a mass of approximately 8 tons. Solid waste can be disposed on site in a dry sump if environmental requirements and ground conditions allow and a backhoe is available. The sump should be constructed prior to arrival of the drilling platform, with sufficient volume to accommodate the anticipated solids volume and with at least one shallow-angled wall for egress (Figure 10). Sumps can only be constructed in relatively competent surface materials where the walls can support the weight of the HPS, parked adjacent to and within 1m of the sump (Figure 4).

Figure 10. Dry sump constructed in preparation for drilling at the Delamerian NDI campaign.

The most environmentally friendly and safest solution is that the solid waste is collected in skips above the ground and removed from site for disposal (Figure 11). Skips can safely be placed on the drill site days before the drilling crew arrives and removed days after drilling to avoid personnel in the area during set-up. If skips are of adequate size to contain the total anticipated waste volume and placed properly there should be no manual handling of waste during drilling process. Skips can be easily covered by tarps to avoid filling with excess water during rain events. Excess water can be allowed to evaporate to reduce volume and mass in the skip prior to collection and disposal Several skips are required in a drilling program to roster between sites, allowing time for removal, waste disposal and placement at the next drill site.

Figure 11. (Left) Solid waste collection in a single skip during drilling at Kapunda. (Right) Double skip waste collection from shale shaker (top of image) and centrifuge (bottom of image) during drilling at Delamerian South (Alawoona).

5.0 Post drilling activities

5.1 Borehole survey and gamma logging

The RoXplorer® System is configured to deploy the two Imdex tools EZ-GYRO and EZ-GAMMA to provide a survey and natural gamma log respectively. The tools have been integrated into the RoXplorer® system and are deployed in a protective shell at the tip of the coiled tubing after drilling is completed. Use of the coiled tubing to deploy the tools immediately after drilling (rather than a separate wireline deployment) reduces the potential for borehole collapse prior to logging and allows the drill hole to be closed and the site remediated soon after drilling. The tools are lowered at a constant rate (dictated by count times on the EZ-GAMMA tool) and measurements are recorded digitally on an Imdex tablet.

The survey data have been useful for monitoring the borehole deviation on the RoXplorer® System which does not currently have active steering capability. Gamma data are useful for borehole logging, particularly the identification and accurate depth measurement of stratigraphic boundaries which can be compared with the chip samples to validate and calibrate the sample depth algorithm.

5.2 Cementing (or Grouting)

The HPS is equipped with a grout mixing pump in addition to a grout injection pump. Grout is mixed in external tanks before being injected into the borehole through a 32mm diameter polyethylene (PE) pipe that is manually installed from the top to the bottom of the borehole.

6.0 2021 and 2022 drilling trials

The RoXplorer® prototype system developed in the Deep Exploration Technologies CRC was deployed in four (4) locations between 2016 and 2018; the Brukunga test site in the Adelaide Hills, the Port Augusta mineral systems drilling program in South Australia, Stavely drilling program near Horsham in Victoria and the Nevada drilling program in the US hosted by Barrick Gold. Twelve holes for approximately 2300 metres of drilling were completed in those deployments.

After the return of RoXplorer® from Nevada in 2019 the drill rig was refitted and the HPS designed and built, in preparation for additional drilling trials at Mawson Lakes (July-August 2021) and Kapunda (September 2021) and deployment to the Delamerian NDI campaign (October 2021 to April 2022). Since August 2021 the MinEx CRC CT platform has completed 19 drillholes for a total of 5211m

The Project 2 and Project 1 research teams were responsible for conducting drilling trials at the UniSA Mawson Lakes campus and at Kapunda. During the Delamerian NDI campaign responsibility for logistics, site management and drilling transferred to MinEx CRC and the Project 2 and Project 1 research teams were responsible for technical support.

6.1 Mawson Lakes drill hole

The Mawson Lakes hole was drilled on the UniSA campus with permissions granted as a water bore. There was no true mobilisation phase. The CT platform was set-up and fit within a 12 x 15m footprint immediately behind the MinEx CRC workshop (Figure 12). Drilling hours were limited to 8am to 4pm. The 241.5m hole, including installation of 21m of HWT casing, was drilled through clay and shelly sands in ten eight-hour shifts. The drill plan was to proceed to >400m however we encountered a 3.5 bar over-pressured aquifer, ceased drilling, balanced the hole and cemented the hole from bottom up using the HPS and CT rig. This procedure was completed without escape of fluid from the aquifer.

Figure 12. RoXplorer® 500 and HPS set up to drill at the UniSA Mawson Lakes campus.

6.2 Kapunda drilling

Two drillholes were completed in collaboration with MinEx CRC Affiliate EnviroCopper at their Kapunda in-situ recovery (ISR) site approximately one hour north of Mawson Lakes. The CT drilling platform was mobilised to Kapunda and set-up on an 18 x 18m drill site (Figure 13) ready to drill in 2 hours and 25 minutes. A hay bale barrier was erected on the northeast side of the drill site to mitigate noise pollution at a residence approximately 100m away. Noise meter measurements 50m from the drill site were consistently in the range 51 to 59 dB while drilling. Drilling was conducted in single shifts of 12-hour duration.

We completed a 290.1m hole in ten 12-hour shifts, including 12m of HWT casing. The formation included a thin (1m) veneer of colluvium, overlying sulphide-bearing, metamorphosed sandstones and siltstones with local silicification and partial weathering in the upper 30m. The formation was competent from surface and locally very hard with intervals of broken ground – consistent with brittle fracture zones. Three episodes of significant fluid loss were mitigated using LiqiCTrol, with 105 cubic metres of water used to drill the hole.

We drilled a second hole on the same drill site at Kapunda for the purpose of trialling our selective coring tool. The 31.7m hole was drilled in two ten-hour shifts, including 12m of HWT casing. We were able to collect approximately 0.3m of broken rock and short sections of core with the selective coring tool in its first field deployment. Drilling was conducted with minimal disturbance to the drill site (Figure 14). Solid waste collected in a single skip was removed from site.

Figure 13. Aerial view of the Kapunda drill site.

Figure 14. Kapunda drill site minutes after the drilling crew demobilised with the waste skip waiting for collection.

6.3 Delamerian South (Alawoona) NDI campaign

We drilled five holes for 1778.9m in the Delamerian South (Alawoona) NDI campaign area (Figure 15). Two of these holes were drilled at the same site as conventional drillholes to provide comparison of drill performance through the same formation (see Section 8.1). The geology in the Alawoona area includes Quaternary aeolian sands overlying lagoonal and marginal marine sedimentary rocks of the Loxton Sands (dune sands), Murray Group (limey sands and marls) and Renmark Group (organic-rich fine sands) to depths of 250 to 300m. These overly diverse Cambro-Ordovician basement rocks including granite, mafic magmatic and metasedimentary rocks.

The first hole (NDIAW_D06_CT) was drilled to 337.2m in thirteen 12-hour shifts. The first attempt to collar and case through unconsolidated near-surface materials (to a depth of 33m) was abandoned when circulation could not be established. The collar was re-drilled and a modified workflow used to install 30m of casing. This workflow was used successfully for casing all subsequent holes. Drilling proceeded rapidly to basement, including 166m in one 12-hour shift, but was halted by a significant fluid loss episode at the basement/cover interface. Fluid loss could not be mitigated by *LiqiCTrol* but required HQ casing to be installed from surface to a depth of 235m. This is the maximum length of HQ casing installed to date by the RoXplorer®. Once fluid circulation was re-established drilling continued into the basement and we were able to collect a short 0.3 m of core. All 235m of HQ casing were recovered at the end of drilling.

At the second Alawoona hole (NDIAW_D01_CT) we mobilised and set up ready to drill in one shift then drilled 310m in five 12-hour shifts. Best productivity was 150m in one shift. The hole was surveyed and cemented in another shift and the drill crew demobilised to Adelaide as the roster finished.

Figure 15. Delamerian South (Alawoona) drill site in corner of wheat paddock. This drill site layout utilising two skips to collect solid waste.

After a three week break the drill crew mobilised to third Alawoona hole (NDIAW_D04_CT), set-up and commenced drilling the pre-collar in two shifts. The 481.7m hole, including 51m of PQ casing, was completed in eight more 12-hour shifts. Best productivity was achieved in two consecutive shifts in which 244m were drilled. The final two shifts were spent collecting 5m of core in 2 runs, surveying, collecting a gamma log and cementing the hole. The 482m drilled in NDIAW_D04_CT is maximum depth achieved to date using the RoXplorer®. Water consumption for the entire hole was ~28 cubic metres and total fuel consumption for all vehicles and equipment was 1750 litres of diesel.

NDIAW_D04_CT80 was drilled at the same site as NDIAW_D04CT, but with 80^{o} starting inclination. The hole was drilled to 337.3m, including 51m of PQ casing, in seven 12-hour shifts.

At the fifth Alawoona hole (NDIAW_D02_CT) we mobilised and set up ready to drill in one shift then drilled to 312.7m, including casing, in four 12-hour shifts. Best productivity was achieved in two consecutive shifts in which 300m were drilled. One of the four shifts was dedicated to collecting drill core with a continuous length of granite collected in one core run. Following NDIAW_D02_CT the crew demobilised to Adelaide in order to prepare for the Delamerian North component of the drilling campaign.

6.4 Delamerian North (Quondong Vale) NDI campaign

We have drilled twelve holes for 2873.2m in the Delamerian North (Quondong Vale) NDI campaign area. The geology in the Quondong Vale area is comparable to Alawoona but with slightly shallower cover depths of 150 to 250m. This was the most remote campaign yet undertaken with the MinEx CRC CT drilling platform. Accommodation for the first holes was at Quondong Vale Station, an approximately two-hour drive from Burra on dirt roads, and at Oak Vale Station, three hours from Burra, for the last holes. Offsite communication was by satellite phone (for person-to-person communication) and via satellite internet link for data transfer and remote control of the *iFluid* system by Project 1 researchers in Perth. The Quondong Vale drilling was conducted with Covid-19 protocols in place which restricted access by the client (the Geological Survey of South Australia) and third-party contractors. As a result, the drilling crew were responsible for a range of non-drilling activities including setting up satellite communications at the camp and drill site, organising accommodation and messing, site preparation and site access.

The first four holes (NDIQV_D08_CT, NDIQV_D10_CT, NDIQV_D09_CT and NDIQV_D18_CT) were drilled in 31 successive 12-hour shifts, including 985.8m of total drilling, and six shifts dedicated to mobilising between holes. Three shifts were required to mobilise between hole 9 and 18 due to bogging of the rig transport vehicle on the access track. Rig access was achieved by tramming the RoXplorer® the final six kilometres between the bog site and drill site. Bottom-of-hole core was collected from all four drill holes. NDIQV_D08_CT was not surveyed or logged with the gamma tool due to a fault in the tool hardware which had to be replaced. All other holes were surveyed and logged after drilling and cemented. After completing NDIQV_D18_CT the drill crews demobilised to Adelaide for time off.

During the following drilling stint we completed two drill holes (NDIQV_D20_CT and NDIQV_D17_CT) and reached a depth of 170m in NDI_QV_D16_CT before we were forced to halt drilling due to thunderstorms and demobilise to avoid stranding the drill crew. After a two-week break which allowed roads to dry out we re-entered NDI_QV_D16_CT, which had remained open, cleaned out the bottom of the hole and continued drilling to a total depth of 231m. The remaining four holes in the campaign (NDI_QV_D15_CT, NDI_QV_D19_CT, NDI_QV_D13_CT and NDI_QV_D14_CT) were completed in successive shifts. Excluding rain delays these seven holes for 1659.4m of total drilling, including casing and core were drilled in 47 12-hour shifts. This included seven shifts largely devoted to mobilisation between holes and two shifts during the drilling of NDI_QV_D14_CT where there was no drilling progress due to a split which developed in the coiled tubing 120m from the bottom of the coil. After a failed attempt to mend the coil by welding, the lower 120m was removed from the coil and the BHA re-attached before proceeding to the final hole NDIQV_D12_CT.

7.0 Drilling Performance and Productivity

We consider drilling performance and productivity as separate but related measures. *Drilling productivity* is measured by drilling cost per metre ($/m). *Drilling performance* is a multifactor consideration including; work health, safety and the environment (with environmental performance linked to water and fuel use); rate of drilling; reliability of drilling technologies; hole trajectory and sample quality. Some aspects of drilling performance have direct positive correlation with drilling productivity (e.g. safety, reliability). Other aspects of drilling performance have complex, and potentially negative, correlation to productivity. For example, high rates of penetration will drive down cost per metre (increase productivity) but tend to increase hole deviation and reduce sample quality (decrease performance). Due to these differences we have divided performance measures from productivity measures in the following analysis.

7.1 Delamerian NDI campaign drilling performance

The Delamerian NDI campaign was the first multi-hole operational field trial of the integrated MinEx CRC CT drilling platform including RoXplorer® and HPS. Highlights of the campaign are summarised in Table 2, with details provided below.

7.1.1 Safety and environment

There were no lost time injuries during the Delamerian NDI campaign and there have been no lost time injuries on all RoXplorer® drilling trials 2016 to 2022 inclusive. On one occasion there was a minor leak around the drill collar detected during drilling. The spill was reported and remediated.

7.1.2 Water consumption

Water consumption varied with ground conditions from 20 to 363 litres per metre (l/m) drilled. Spikes in water consumption of >200 l/m occurred during significant water loss episodes when intersecting cavities or broken ground. Average water consumption in the Delamerian campaign (17 holes for 4652.1m) was 86 l/m. Conventional drilling (mud rotary with diamond tail) conducted in the Delamerian South NDI campaign by a commercial operator, including two holes twinned by the MinEx CRC CT platform RoXplorer®, consumed an average of 1044 l/m.

7.1.3 Fuel consumption

Fuel consumption is defined here as the diesel used by the MinEx CRC CT platform during drilling operations. Fuel used for light vehicles, water cartage, dust suppression and mobilisation is not included. Fuel consumption during the Delamerian NDI campaign varied with ground conditions from 4.2 to 6.3 litres of diesel per metre drilled (l/m). There was a fault in the fuel injectors on the RoXplorer® leading to higher-than-normal fuel consumption of 6.3 l/m for a portion of the drilling campaign. Excluding those higher values, the average consumption of diesel during the Delamerian NDI campaign was 4.5 l/m equating to 12 kilograms of CO_2 emitted per metre drilled*.

Fuel consumption for the conventional drill rig over the first 19 days of operation in the Delamerian South campaign, determined from fuel costs divided by average diesel price over the period ($1.65/litre) divided by meters drilled (888.2m) was approximately 8 l/m, equating to 21 kilograms of CO_2 emitted per metre drilled*.

**1 litre of diesel weighs 835 grammes. Diesel consist for 86.2% of carbon, or 720 grammes of carbon per litre diesel. In order to combust this carbon to CO_2, 1920 grammes of oxygen is needed. The sum is then 720 + 1920 = 2640 grammes of CO_2/litre diesel.*

7.1.4 Drilling additives

During the Delamerian NDI campaign the MinEx CRC CT platform used between 0.2 and 1.5kg of LiqiCTrol per metre drilled (kg/m) at an average of 1.14 kg/m over 4652 metres of drilling. Use of LiqiCTrol was slightly higher in the northern Delamerian the average was 1.46 kg/m and we consider this to be a relatively high consumption of LiqiCTrol, required by challenging drilling conditions – including running sands, gravels and unstable ground. In more competent ground less additive will be required. For comparison, average drilling additive consumption for the conventional mud rotary and diamond drilling conducted in the two holes twinned by CT drill holes in the Delamerian South NDI campaign was 2.6 kg/m.

The performance of LiqiCTrol is difficult to quantify but contributes to two other important performance measures; i) sample quality, which is dependent on the efficiency of cuttings transport in the drilling fluid and ii) hole stability. The time and cost of retrieving stuck drill rods due to hole collapse can have significant impact on drilling performance and productivity. During the

Delamerian NDI campaign, over 17 holes and 4652m of drilling with the MinEx CRC CT platform, using LiqiCTrol and iFluid for fluid management, there was no time spent retrieving stuck pipe. In contrast, over six holes drilled with the conventional rig there were multiple shifts spent retrieving stuck pipe.

CATEGORY	MEASURE	HIGHLIGHTS/COMMENTS
Safety	0	• There were no safety incidents during the Delamerian NDI campaign
Environment	1 spill	• One minor leak of drilling fluid at the drill collar
Number of holes	17	• 17 holes drilled in 130 shifts (excluding mob/demob)
Water consumption	86 litres/m	• <1/10th of rotary mud + diamond drilling in same formation
Fuel consumption	4.5 litres/m	• <60% of rotary mud + diamond drilling in same formation
Meters drilled	4652.1m	• 481.7m hole (NDIAW_D04_CT) is the deepest hole yet drilled with the RoXplorer® CT rig
Pre-collar and casing	477m	• Average ROP drilling pre-collar 8m/hr • Max PQ casing was 51m (in three holes) • 21m of PQ casing could not be retrieved from one hole
HQ casing	235m	• 235m is the deepest casing inserted and retrieved with the RoXplorer® CT rig
CT rotary mud and percussion drilling	4132.5m	• Average ROP while drilling 13m/hr • Best 12h shift 192m • 98% of cuttings samples recovered
Diamond coring	42.7m	• Core recovered from 16 of 17 holes drilled • Average ROP while coring 1m/hr • Max coring interval 4.2m • Core recovery 58% to 100% depending on ground conditions
Hole integrity		• No stuck drill pipe • Near-surface casing + fluid management with LiqiCTrol ensured hole integrity in 16 of 17 drill holes. • The pre-collar in the first hole (NDIAW_D06_CT) was abandoned at 33m and re-drilled. Fluid loss at the basement/cover interface (~230m) in the same hole at could not be mitigated by drilling additives. Circulation was recovered after inserting 235m HQ casing.
Hole deviation	<10%	• Max deviation was ~10% measured as (lateral deviation*100/depth) for vertically collared hole

7.1.5 Borehole survey and deviation

Except for NDIAW_D04_CT80, our intention was to drill vertical holes during the Delamerian NDI campaign. Real-time positioning or downhole steering technology was not available during the Delamerian NDI campaign and we did not use weight rods to mitigate hole deviation. The holes were surveyed at completion to reconstruct the hole trajectory. The measured deviations ranged from less than 2% to slightly greater than 10% measured as lateral deviation*100/depth (Figure 16). As a general rule, holes that were drilled at higher ROP (e.g. NDIAW_D04_CT) had greater deviations that holes drilled at lower ROP (e.g. NDIQV_D18_CT).

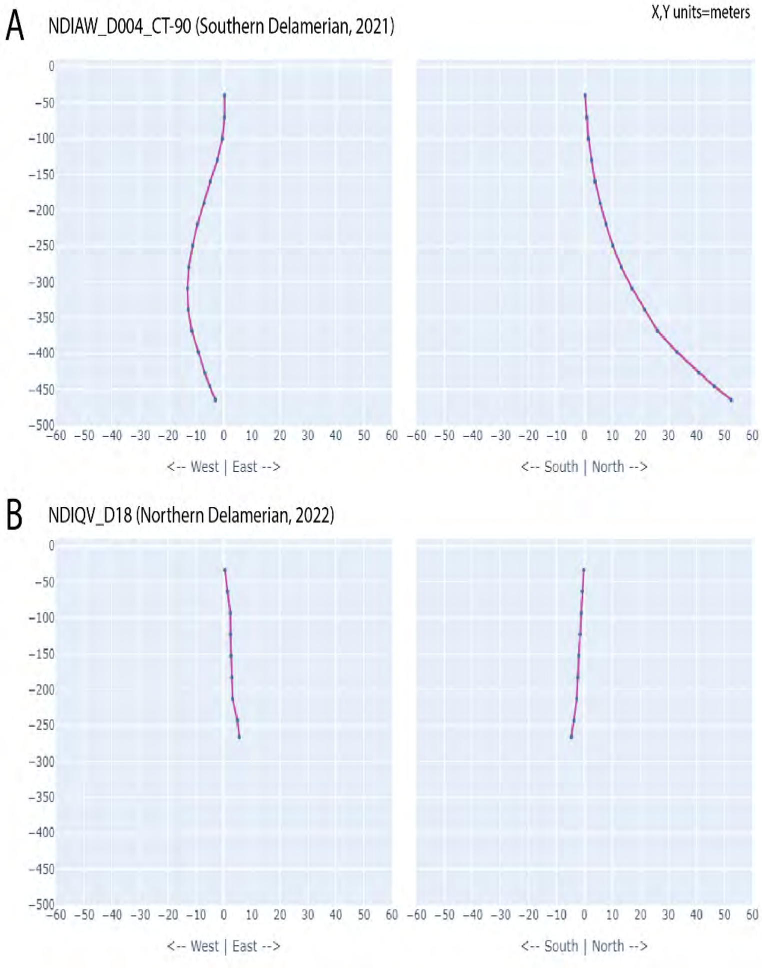


Figure 16. Borehole deviation examples from the NDI program in South Australia. Note there is approximately x5 horizontal exaggeration which exaggerates the apparent deviation.

7.1.6 CT rotary mud and percussion drilling

During the Delamerian NDI campaign the majority of drilling was conducted in CT mode using either drag bits combined with a downhole motor (CT rotary mud) or percussion bits combined with a downhole motor and hammer (CT percussion drilling). Average penetration rates whilst drilling in these modes was 13 meters per hour.

7.1.7 Cuttings sample quality and depth validation

In the Delamerian NDI campaign the depth accuracy of the cuttings from the RoXplorer® system was determined by comparing the chemistry of the cuttings with a borehole gamma survey.

After completion of drilling an Imdex EZ-GAMMA^{TM} tool was deployed on the end of the coil by the drill crew. The natural gamma instrument records naturally occurring radiation from radioactive isotopes of potassium (K), thorium (Th) and uranium (U). The EZ-GAMMA^{TM} measures these properties *in-situ* within the borehole with a depth assigned by an encoder on the drill rig. Geological Survey of South Australia (GSSA) have made the EZ-GAMMA^{TM} datasets available via the Delamerian Drilling Atlas[1].

The GSSA collected portable X-ray fluorescence (pXRF) chemical data for cuttings that were sampled at 1 m intervals. The depth of the samples was assigned based on their arrival time at the sample bag as calculated by the depth algorithm. The cuttings were analysed off-site by handheld pXRF for a suite of elements including K, Th, and U. Potassium concentrations in most rock types are well-above pXRF detection limits and measurements relatively reliable. In contrast Th and U concentrations are typically close to or below pXRF detection limits so measurements should be considered semi-quantitative.

The pXRF chemistry of the chips and the gamma log from four drill holes in the Delamerian NDI campaign are presented side by side in figures 17 to 20 and allow for visual comparison and semi-quantitative measures of depth accuracy for boundaries between units with contrasting concentrations of K, U and Th (e.g. shale vs sandstone). Some major boundaries and small-scale features can be correlated across the datasets with good depth accuracy. For example:

- A narrow U-rich unit at 70m in NDIQV_09_CT (Figure 17)
- A sharp boundary in K concentration at 190m in NDIQV_09_CT (Figure 17)
- A narrow U-rich unit at 42m in NDIQV_18_CT (Figure 18)
- A sharply defined peak in Th concentration between 175 and 185m in NDIQV_20_CT (Figure 19).

Closer examination of these data allow a semi-quantitative analysis of the degree of sample smearing in the CT cuttings. Smearing is the carryover of material from one sample interval into subsequent intervals due to mixing of cuttings during transport and/or interaction with drilling and sampling equipment. The effect of smearing is to increase the apparent depth and reduce the sharpness of geological boundaries, for example a gradational boundary in the chemistry when there is a sharp boundary on the gamma log.

In NDIQV_09_CT, a sharp boundary in the gamma log between 23 and 24m depth is represented by a slightly more gradual change between 25 and 28m in the pXRF data (Figure 20) – indicating an ~2m depth offset combined with smoothing of the true boundary as might be expected from smearing. In contrast, the sharp boundary in the gamma log between 189 and 190m is represented by a sharp boundary in the pXRF data between the 190 and 191m depth intervals (Figure 20) – indicating an ~1m depth offset with little to no apparent smoothing. (Noting that any smoothing effect will be masked in a transition from low to high concentrations). These data provide preliminary evidence that smearing may have greater impact on sample quality within shallow, unconsolidated materials in the near-surface and that, once casing has been installed, CT cuttings samples provide a faithful record of downhole geology. Further interrogation of the raw data is required to quantify smearing and correlate with sample properties, drilling rates, PSD and how the material is transported in borehole, hoses and on the sample shaker.

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[1] https://geoscience.sarig.sa.gov.au/spotfire/wp/analysis?file=/Anonymous/Delamerian_Drilling_Atlas_v2

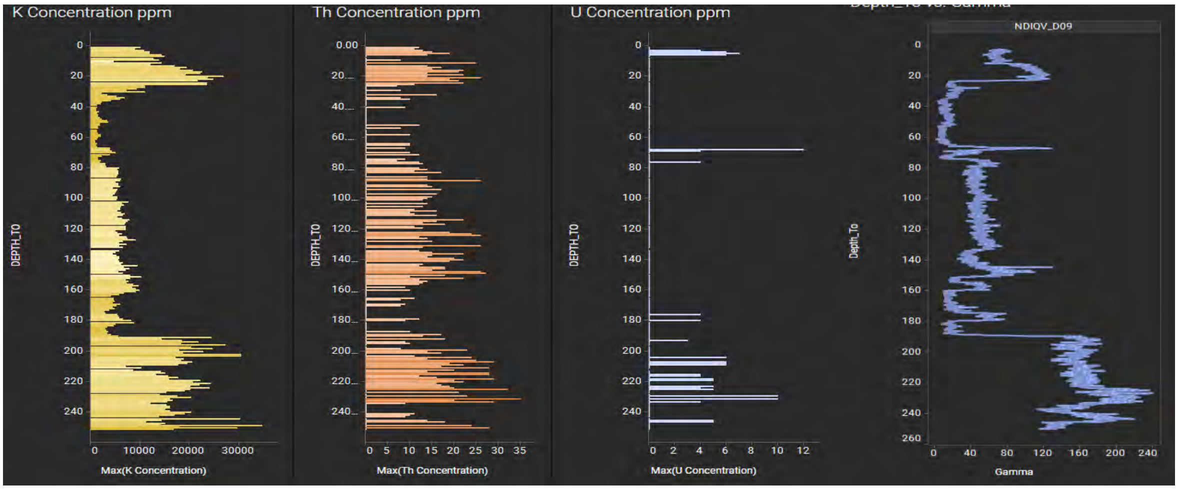


Figure 17. Downhole plots of K, Th, U form pXRF chemistry and natural gamma from NDIQV_D09

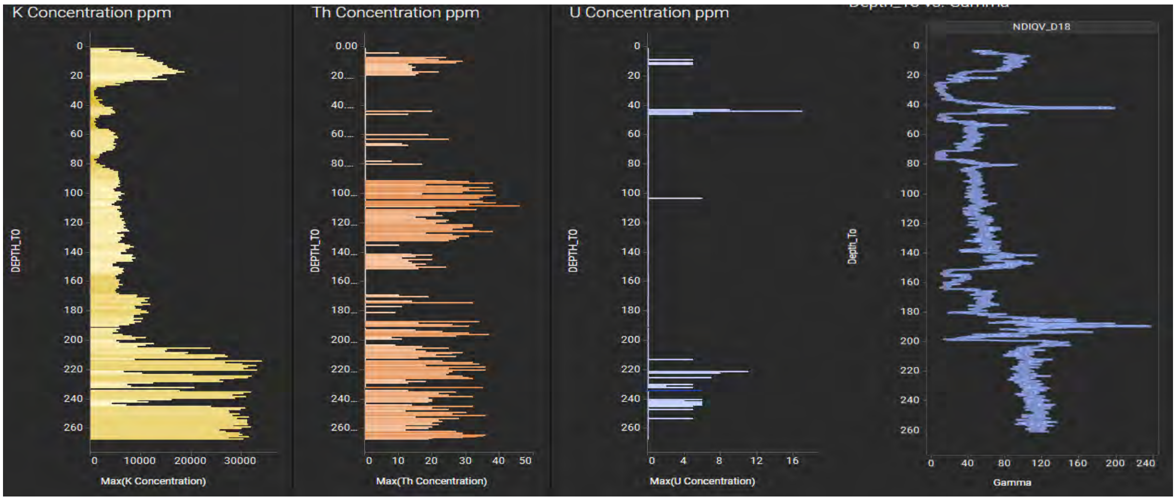


Figure 18. Downhole plots of K, Th, U form pXRF chemistry and natural gamma from NDIQV_D18

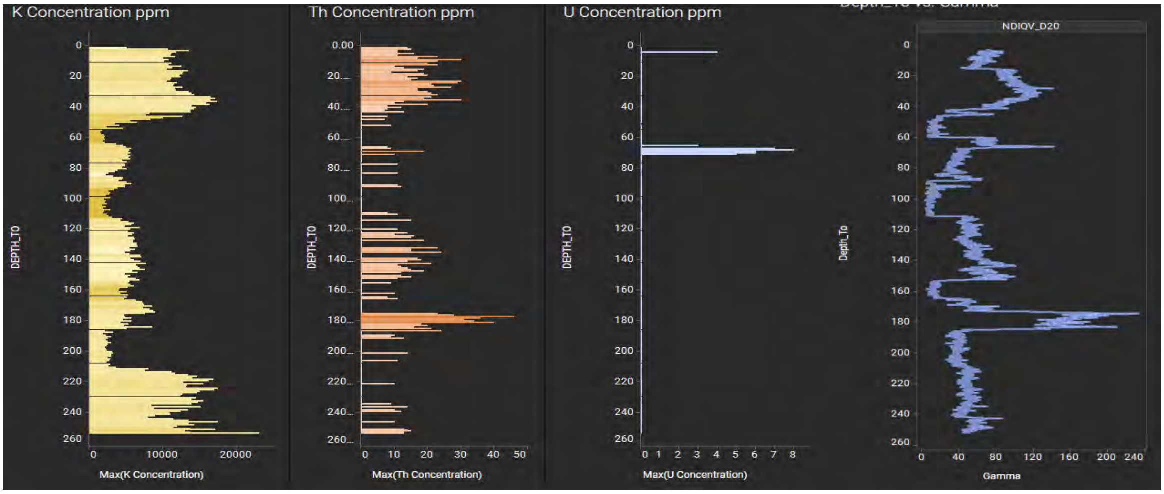


Figure 19. Downhole plots of K, Th, U form pXRF chemistry and natural gamma from NDIQV_D20

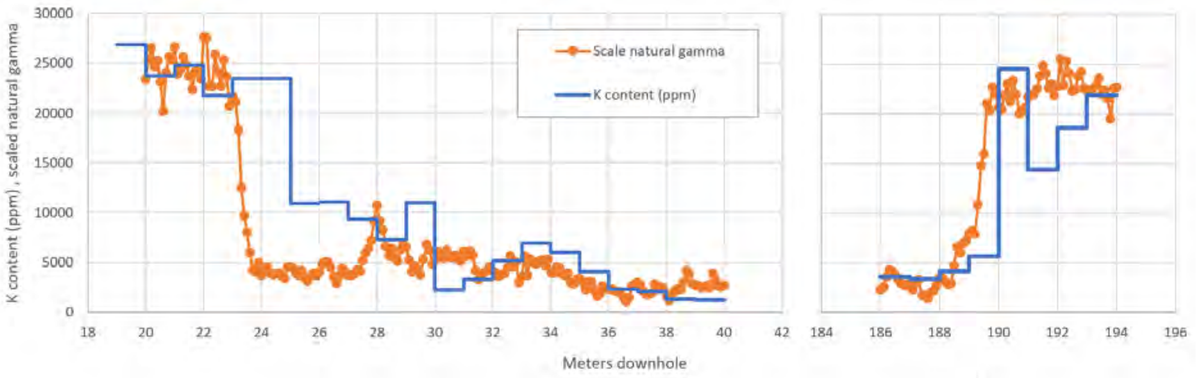


Figure 20. Downhole plots of K content form pXRF chemistry and natural gamma from NDIQV_D09. The gamma data are scaled to have similar amplitude to K-content to highlight the location of boundaries in the two datasets. In the shallower interval scaling is natural gamma * 220, in the deeper interval scaling is natural gamma *140. Different scaling is not surprising given that the gamma response also depends on Th and U content.

7.1.8 Core sampling

The Selective Interval Coring BHA was used in 16 of the 17 drill holes in the Delamerian NDI campaign for a total of 42.7m of drilling. All drill core was collected from the bottom of hole, with the deepest cored interval recovered from a depth of 480m in NDIAW_D04_CT90. Cored materials include competent felsic intrusive rocks, metasedimentary rocks and volcanics with variable degrees of alteration, shearing and fracturing (Figure 21). Core recovery, measured as length of retrieved core * 100 / measured drilling interval, ranges between 58% and 100% and is strongly dependent on the formation drilled.

Figure 21. Collated core photographs from the Delamerian NDI campaign. (Made available by GSSA).

7.1.9 Client Endorsement

The quality of sample delivered by the RoXplorer® CT platform, both drill core and cuttings, has been endorsed by GSSA geologists, with visual logs of cuttings, pXRF data and downhole gamma logs made available to the public via the GSSA-hosted South Australian Drilling Atlas. Tom Wise, Senior Geologist at the GSSA, provided the following commentary on the samples delivered by RoXplorer® during the Delamerian NDI campaign.

> *"Based on the samples we have received and worked on to date, the GSSA has found chips and core produced by the RoXplorer® systems acceptable and comparable to other drilling methods. Please note however, that we are still working through processing/analysing/logging samples, and it is only at the completion of this process that we can give a conclusive appraisal.*
>
> *The RoXplorer® has provided the GSSA with a valuable tool to efficiently reach basement in a greenfields terrane, provide acceptable sample through cover and basement lithologies (including in unconsolidated material), and provide a contextual core sample at EOH.* ***Sample produced by the RoXplorer® of unconsolidated cover materials was in fact superior to those produced by the conventional rotary mud method.***
>
> *We have qualitatively compared our interpretations of lithological boundaries with both downhole gamma logs on the same hole, as well as with samples from twinned or nearby holes drilled with conventional methods, and have found the RoXplorer sample is generally representative with reasonable depth fidelity. We look forward to more formal benchmarking of samples produced by the RoXplorer® against those produced by conventional rotary mud and diamond drilling, when time permits.*
>
> *We have had instances where sample contamination has been noted, and it would be worthwhile debriefing with MinEx on how/why this has occurred, and possible strategies for future mitigation.*
>
> *For your interest, we had a lot of positive feedback from the Uncover Curnamona conference in Broken Hill last week, where we displayed core and chips from the NDI. Industry and government geos were impressed to see the quality of samples first-hand."*

7.2 Drilling productivity

Here we define drilling productivity as cost per meter drilled ($/m) at two levels:

1. The cost of preparing for the drilling program inclusive of environmental and cultural compliance, contracting, community liaison, site access, site preparation and remediation. Although these costs can be impacted by the drilling technology (e.g. smaller footprint drill site and no sumps aids environmental compliance and reduces site preparation costs) they are not directly controlled by performance of the drilling crew and drilling technology.
2. The cost of drilling, restricted to those activities which contribute to executing the drill hole plan, collecting samples and logging the drill hole which are directly controlled by performance of the drilling crew and drilling technology. Important components of the cost of drilling include accommodation and messing, rental of vehicles and equipment, salaries of the crew, mobilisation and set-up and consumables (e.g. water, fuel, drilling additives, cement). All drilling costs are impacted by the rate-of-drilling and the efficiency of completing drilling related tasks (e.g. survey and grouting) which are directly related to the drilling technology and competence of the drilling crew.

For the purposes of this report (to assess the performance and productivity of the RoXplorer® CT platform) we will focus on the cost of drilling which we divide into two categories:

a) Billable costs; covering costs incurred to execute the drill hole plan at the location specified by the client and dealing with variable ground conditions as required to execute the drill hole plan. Billable costs include fixed per diem costs (accommodation and messing, equipment rental), drilling preparation time costs (mobilisation and demobilisation, unpacking, setup, pack and move), drilling time costs (unpacking, set-up, packing and hole move, casing installation and retrieval, drilling and sampling, survey and logging, cementing) and drilling consumable costs (water, fuel, drilling additives and cement). Also included are costs incurred in compliance with safety and environmental requirements whilst drilling including safety and prestart meetings, site inductions and weed and seed inspections. Inactive time caused by the client or third parties can also be billable.

b) Non-billable costs; covering costs incurred to deploy experimental or prototype tools (research time), downtime due to faulty or poorly maintained equipment, inadequate processes or operator error. In the context of the prototype technologies being developed by MinEx CRC, research time is considered an essential investment in R&D to be covered by research project funding. Whilst not passed on to the client, time and costs due to unreliable equipment or processes have implications for the viability of the technology in a commercial setting. Part of the purpose of deploying the RoXplorer® CT platform to the Delamerian NDI campaign was to identify and mitigate the causes of such downtime. Other non-billable activities that were executed by the drilling crew during the Delamerian NDI campaign included food shopping and preparation, camp cleaning, maintenance and waste management.

7.3 Delamerian North NDI cost model

The cost model presented in Table 3 is based on cost recovery of billable drilling costs using a complete dataset extracted from drill plods from the Delamerian North NDI campaign. The total calculated cost of twelve holes and 2873.2m of drilling is $692K, at an average of $241/m. This cost model does not include costs incurred in preparation for the drilling program including environmental and cultural compliance, contracting, community liaison, site access, site preparation and remediation. No allowance for a profit margin, capital costs, management costs or any additional overheads has been accounted for, noting that these may contribute an additional ~50% to the cost model.

The following sections explain the cost model and break down costs in terms of time and money for the various components of the drilling program.

7.3.1 Contributions to per hour rates

Drilling preparation time is charged at $450 /h – calculated to cover salary costs of four crew plus drilling supervisor as well as provision, support, maintenance, and depreciation of drilling assets (RoXplorer® CT rig, HPS, support vehicles) even if no drilling is taking place. Drilling crew costs can vary depending on market conditions. Salary costs for the four-person drilling crew plus drilling supervisor during late 2021 and early 2022 were approximately $3,500 per 12-hour shift (or $292 /h). Provision of essential drilling infrastructure (including the RoXplorer® CT rig, HPS, drillers humpy, Hino support truck, prime mover, trailer and shipping container) are charged at a modest rate of $158 /h.

Drilling time is charged at $540 /h – calculated to cover salaries and drilling equipment costs (as above) plus additional costs incurred through wear and tear of equipment during drilling (coiled tubing, tooling). The additional \$90 /h cost of active drilling time covers wear and tear, maintenance and eventual replacement of essential drilling equipment including the drill coil (with estimated coil life of ~1000 trips), downhole motors, hammers and drill bits. These charges are modest given that the RoXplorer® CT platform is a complex prototype system with well over 3000 newly engineered parts integrated with standard parts in a unique, proprietary design. Some components of the original prototype build in 2016 are now obsolete and re-engineering is needed for safe replacements. Sourcing of spare parts can be time-consuming and costly and there are few qualified personnel for maintenance. These per hour costs are comparable to conventional drilling charges for in-active and active billable hours (Table 3).

In addition, our cost model includes a charge of \$225 /h (in-active costs shared by the driller and client) for drilling downtime caused by sampling system overload (see Section 7.4.8), which is a function of challenging ground conditions and immature technology.

7.3.2 Fixed per diem costs

Fixed per diem costs are passed directly to the client with no mark up. Fixed equipment costs include water truck rental, light vehicle rentals, lease and support of satellite communications, rental of survey and logging tools. Survey and logging tools were provided in-kind to the Delamerian NDI campaign by MinEx CRC Participant Imdex Limited. We have included them in the cost model because logging tools are typically rented by the drilling service provider with charges passed on to the client. Fixed equipment costs of \$600 /shift used in our model are comparable to charge rates from providers of conventional drilling services.

7.3.3 Consumables

Cost of consumables are passed directly to the client with no mark up. These include a market-rate for trucked water, retail costs of diesel and cement and production and transport costs for *LiqiCTrol*.

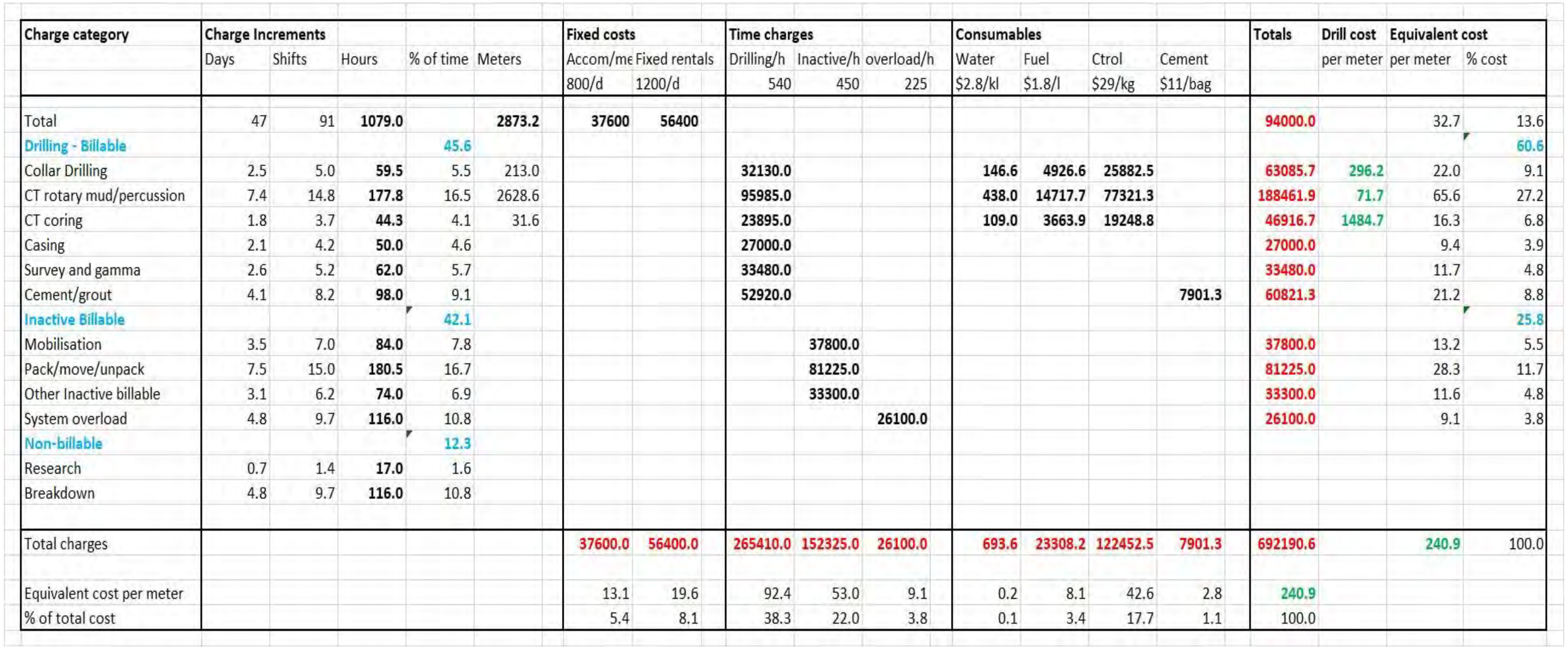
During the Delamerian North NDI campaign we consumed 4195kg of *LiqiCTrol* at an average of 14.9 kg/h (1.46 kg/m). At \$29/kg the total cost of *LiqiCTrol* during the Delamerian North NDI campaign was ~\$122,500 or 17.6% of the total cost. These relatively high costs reflect the research nature of the formulation and small-batch production in a laboratory setting. We expect the cost to come down when (and if) *LiqiCTrol* can be produced at scale in a commercial setting.

At current costs the use of *LiqiCTrol* during CT drilling is more expensive than drilling additives used in conventional drilling operations. However, the value of *LiqiCTrol* to the drilling operation should be considered in light of its many functions, including cuttings return, lubrication and bore hole integrity. During the Delamerian NDI campaign, over 17 holes and 4652.1m of drilling in challenging cover materials and in contrast to conventional rotary mud and diamond drilling in the same formations, there were no costs incurred by retrieving stuck drill rods due to hole collapse.

7.4 Billable time

7.4.1 Mobilisation

There were seven shifts dedicated to mobilisation from Adelaide to the Delamerian North NDI campaign area. The initial mobilisation on January 27th and 28th involved transport of all drilling and support infrastructure to the campaign area and set up of camp at Quondong Vale station. Both drilling crews demobilised on February 15th for rest and recreation, leaving drilling infrastructure onsite and remobilised on March 6th. The second period of drilling finished early when thunderstorms and rain forced evacuation of the drill-site and camp on March 14th. Remobilisation was delayed until March 28th to allow the drill site and access roads to dry out. The campaign was wrapped up on April 14th with both crews demobilising to Adelaide on April 15th. The April 15th demobilisation was conducted quickly to avoid incoming rain, with some drilling infrastructure left on site and recovered in the following weeks as access roads dried out.



Charge category	Charge Increments					Fixed costs		Time charges			Consumables				Totals	Drill cost	Equivalent cost	
	Days	Shifts	Hours	% of time	Meters	Accom/me	Fixed rentals	Drilling/h	Inactive/h	overload/h	Water	Fuel	Ctrol	Cement		per meter	per meter	% cost
						800/d	1200/d	540	450	225	$2.8/kl	$1.8/l	$29/kg	$11/bag				
Total	47	91	**1079.0**		**2873.2**	**37600**	**56400**								**94000.0**		32.7	13.6
Drilling - Billable				**45.6**														**60.6**
Collar Drilling	2.5	5.0	**59.5**	5.5	213.0			**32130.0**			**146.6**	**4926.6**	**25882.5**		**63085.7**	**296.2**	22.0	9.1
CT rotary mud/percussion	7.4	14.8	**177.8**	16.5	2628.6			**95985.0**			**438.0**	**14717.7**	**77321.3**		**188461.9**	**71.7**	65.6	27.2
CT coring	1.8	3.7	**44.3**	4.1	31.6			**23895.0**			**109.0**	**3663.9**	**19248.8**		**46916.7**	**1484.7**	16.3	6.8
Casing	2.1	4.2	**50.0**	4.6				**27000.0**							**27000.0**		9.4	3.9
Survey and gamma	2.6	5.2	**62.0**	5.7				**33480.0**							**33480.0**		11.7	4.8
Cement/grout	4.1	8.2	**98.0**	9.1				**52920.0**						**7901.3**	**60821.3**		21.2	8.8
Inactive Billable				**42.1**														**25.8**
Mobilisation	3.5	7.0	**84.0**	7.8					**37800.0**						**37800.0**		13.2	5.5
Pack/move/unpack	7.5	15.0	**180.5**	16.7					**81225.0**						**81225.0**		28.3	11.7
Other Inactive billable	3.1	6.2	**74.0**	6.9					**33300.0**						**33300.0**		11.6	4.8
System overload	4.8	9.7	**116.0**	10.8						**26100.0**					**26100.0**		9.1	3.8
Non-billable				**12.3**														
Research	0.7	1.4	**17.0**	1.6														
Breakdown	4.8	9.7	**116.0**	10.8														
Total charges						**37600.0**	**56400.0**	**265410.0**	**152325.0**	**26100.0**	**693.6**	**23308.2**	**122452.5**	**7901.3**	**692190.6**		**240.9**	100.0
Equivalent cost per meter						13.1	19.6	92.4	53.0	9.1	0.2	8.1	42.6	2.8	**240.9**			
% of total cost						5.4	8.1	38.3	22.0	3.8	0.1	3.4	17.7	1.1	100.0			

Table 3. RoXplorer® CT platform drilling cost model based on the Delamerian North NDI campaign.

7.4.2 Pack-up, move, unpack and hole setup

The total time for pack-up, move, unpack and hole set-up in the Delamerian North NDI campaign was 180.5 hours, approximately 15 hours per hole, accounting for 16.7% of total time and 11.7% of total cost. This time includes three shifts that were dedicated to the move between NDIQV_D09_CT and NDIQV_D18_CT during which the rig transport vehicle became bogged on a poorly prepared access track. The RoXplorer® rig had to be trammed six kilometres to the drill site. Recovery of the bogged vehicle was time consuming and resulted in mechanical damage to the recovery vehicle. Excluding the bogging incident, the average time for pack-up, move, unpack and hole set-up in the Delamerian North NDI campaign was 12 hours per hole.

We consider this a key area in which to make productivity improvements on the drill site. An achievable short-term aim is to reduce pack-up, move and set-up time to 8 hours, through streamlining drill site operations, effective delegation of tasks and familiarisation of the drill crew with procedures. Pack-up, move and hole setup costs as a proportion of total costs should be lower in drilling campaigns with fewer, longer holes with less intervening travel time (for example in the Alawoona area, compared to the Quondong Vale area).

7.4.3 Pre-collars and casing installation

During the Delamerian North NDI campaign we drilled 121mm pre-collars and installed near-surface casing over 213m at any average of ~18m per drill hole. The average penetration rate whilst drilling the pre-collars was 3.6m/h. The entire process took approximately 9 hours per hole for a total of 109.5 hours (10.1% of total time and 13.0% of total cost).

In more competent ground shallower casing may be possible thus reducing costs. Surface casing costs as a proportion of total costs will be lower in drilling campaigns with fewer, longer holes if ground conditions are comparable.

7.4.4 CT rotary mud and percussion drilling

During the Delamerian North NDI campaign we drilled 2628.6m in 178 hours (16.5% of total time and 27.2% of total cost) using CT rotary mud and percussion techniques. The average penetration rate whilst drilling in these modes was 14.8m/h at a drill cost per meter whilst drilling of $71.7.

Of course, the integrated cost per meter for each drill hole and the entire program is significantly higher due to the multiple other costs involved. However, the low cost of drilling in these modes helps demonstrate the potential of the CT technique if other processes can be optimised, downtime minimised and drilling up-time maximised. If penetration rates of >10m/h can be sustained for continuous periods of time, average penetration rates of 125m/shift are achievable when drilling in these modes.

7.4.5 Diamond coring with the CT rig

Drilling with the prototype diamond coring BHA is time consuming. The rate of penetration is slow and the driller receives minimal feedback from the BHA to inform drilling decisions – notably the prototype tool does not have a mechanism to indicate the volume of material in the core barrel and deliver that information to surface. During the Delamerian NDI campaign it often required several trips in and out of the hole with the coring BHA to collect our target 3m of drill core. The 31.6m of core collected during the Delamerian North NDI campaign required 44.3 hours of drilling time at an average sampling rate of 0.7m/h. The modelled cost of coring, including consumables was $49,917 (6.8% of total cost) at an average rate of $1485/m. A hidden cost of coring is that it has a disproportionate impact on the life of the coiled tubing drill string due to the multiple hole entries for every sample collected. In commercial operations the drilling service provider would be required to price this extra wear into the cost of coring.

We expect that the cost of coring with the MinEx CRC CT platform will improve as the coring and BHA communications technology matures and drillers become familiar with the technique. We consider an achievable, short-term target for improvement to be average sample collection rates of 1m/h.

7.4.6 Survey and Logging

During the Delamerian NDI campaign we deployed the Imdex EZ-GYRO and EZ-GAMMA in 16 out of 17 holes. The standard survey and logging process involved:

- Unpacking, setting up and attaching the survey tools to the BHA (approximately 90 minutes).
- Surveying while entering the hole at 8 metres per minute and stopping every 30 metres for 2-4 minutes (approximately 90 minutes for a 400m drill hole).
- Pulling out of the hole, with drilling mud circulating, at 16-18 metres per minute (approximately 25 minutes for a 400m drill hole).
- Download the survey and logging data and pack equipment away (approximately 90 minutes).

Average time to survey and log holes in the Delamerian North NDI campaign was approximately 5 hours per hole, for a total of 62 hours (5.7% of total time). Survey cost, crew time only, was $32,400 (~$2700 per hole) and 4.8% of total cost.

7.4.7 Cementing (or grouting)

During the Delamerian North (Quondong Vale) NDI campaign all twelve drill holes were cemented at the completion of the survey and logging procedure. The standard grouting process involved:

- Mixing 3 to 5m^3 of cement depending on hole depth (approximately 2 hours).
- Installing polyethylene pile (2 to 3 hours).
- Pumping (60 to 90 minutes).
- Clean up (approximately 2 hours).

Average time to cement holes in the Delamerian North NDI campaign was approximately 8 hours per hole, for a total of 98 hours (9.1% of total time). With crew time and the cost of cement the total cost of cementing was $59,741 (~$5000 per hole) and 8.8% of total cost.

7.4.8 Billable downtime: Sample system overload

During the Delamerian North (Quondong Vale) NDI campaign there was 116 hours of billable downtime (10.8% of total time and 3.8% of total cost) spent unblocking and cleaning the fluid splitter and sample shaker due to overload of the sampling system – when the delivery rate of drilling fluid and cuttings was greater than the processing rate of the fluid splitter and/or sample shaker. Contributing factors to sample system overload were:

- Rate of penetration; with higher ROP resulting in higher concentrations of cuttings in the drilling fluid)

- The nature of cuttings; particularly “sticky” clay-rich material which agglomerates into large particles with potential to foul the shaker screens and cause blockages in the fluid splitter and feed pipes (Figure 22)). The drill crew used a fluid additive to help mitigate, but not entirely resolve, this problem.
- Inefficient operation of the sample shaker; the main steel frame of sample shaker was bent due to faulty operation before deployment to the Delamerian North NDI campaign. Transport of cuttings across the shaker screens and separation of fluid and fine particles could have been impaired if the sample shaker was not level or balanced during operation.

Figure 22. Sticky clays attached to the coil tubing and closing the entire anulus at the drill collar. This material contributed to sample system overload, causing blockages in the fluid splitter and sample shaker.

7.5 Non-billable time

7.5.1 Research time

During the Delamerian NDI campaign there was a total of 49 hours of research time (3% of total program time) including time spent to test the “smart BHA”, conduct a particle tracking test, optimise iFluid and conduct a downhole optic fibre distributed acoustic sensing (DAS) seismic test. The component of research time in the Delamerian North NDI campaign was 17 hours (1.6% of total time).

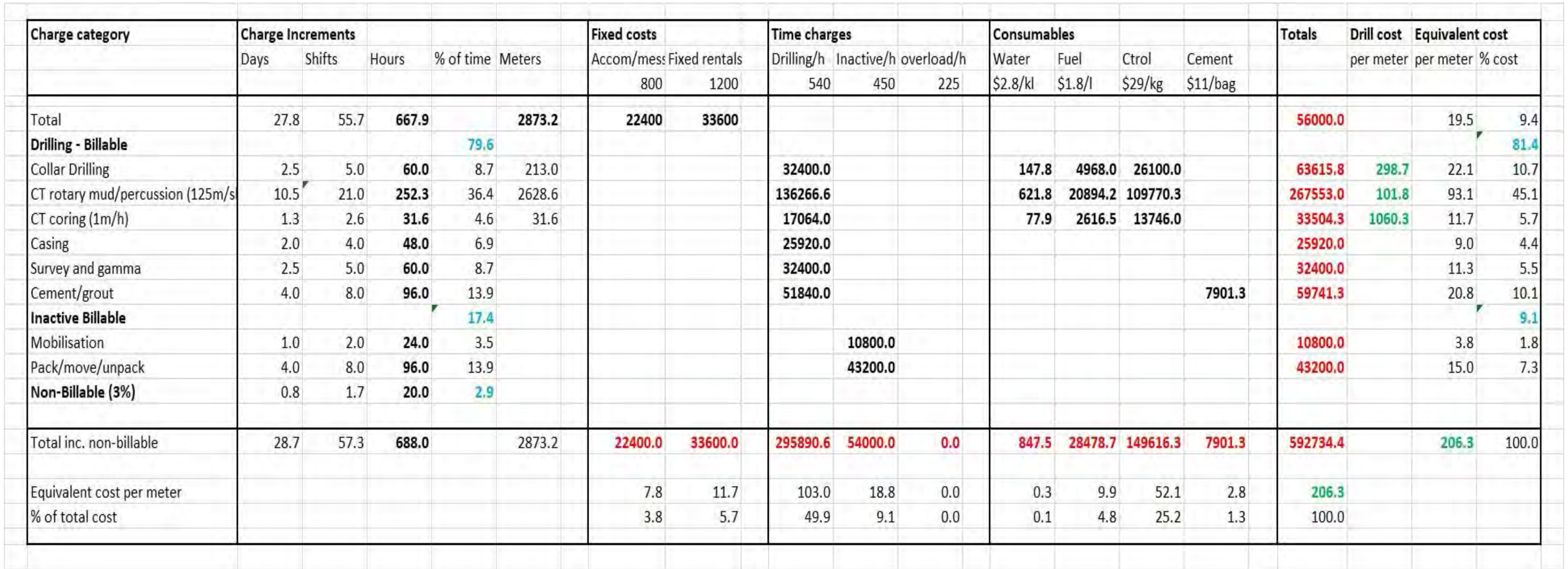
7.5.2 Non-billable downtime: Equipment breakdown and maintenance

During the Delamerian North (Quondong Vale) NDI campaign there was 116 hours of non-billable downtime (11% of total time) due equipment breakdown, including repairs and maintenance of trucks, RoXplorer® CT rig, HPS and tooling (Table 3).

The causes of downtime reported in drilling logs include:

1. Loss of, or inability to connect to, drill site communications.
2. Mechanical breakdown/maintenance of support vehicles (e.g. flat tyres, gearbox failure, dashboard fault readings, damages caused during recovery from bog).
3. Mechanical breakdown/maintenance of RoXplorer® CT drill rig (e.g. inefficient charge pumps, maintenance of the coiled tubing feed mechanism and injector).

4. Maintenance of the BHA (e.g. on-site rebuilds of the down hole motor and hammer)
5. Formation of cracks in the shale shaker sampling system.
6. Sub-optimal fluid management (e.g. blockages of the *iFluid* system, failure of the depth algorithm).



Charge category	Charge Increments					Fixed costs		Time charges			Consumables				Totals	Drill cost	Equivalent cost	
	Days	Shifts	Hours	% of time	Meters	Accom/mess	Fixed rentals	Drilling/h	Inactive/h	overload/h	Water	Fuel	Ctrol	Cement		per meter	per meter	% cost
						800	1200	540	450	225	$2.8/kl	$1.8/l	$29/kg	$11/bag				
Total	27.8	55.7	667.9		2873.2	22400	33600								56000.0		19.5	9.4
Drilling - Billable				79.6														81.4
Collar Drilling	2.5	5.0	60.0	8.7	213.0			32400.0			147.8	4968.0	26100.0		63615.8	298.7	22.1	10.7
CT rotary mud/percussion (125m/s	10.5	21.0	252.3	36.4	2628.6			136266.6			621.8	20894.2	109770.3		267553.0	101.8	93.1	45.1
CT coring (1m/h)	1.3	2.6	31.6	4.6	31.6			17064.0			77.9	2616.5	13746.0		33504.3	1060.3	11.7	5.7
Casing	2.0	4.0	48.0	6.9				25920.0							25920.0		9.0	4.4
Survey and gamma	2.5	5.0	60.0	8.7				32400.0							32400.0		11.3	5.5
Cement/grout	4.0	8.0	96.0	13.9				51840.0						7901.3	59741.3		20.8	10.1
Inactive Billable				17.4														9.1
Mobilisation	1.0	2.0	24.0	3.5					10800.0						10800.0		3.8	1.8
Pack/move/unpack	4.0	8.0	96.0	13.9					43200.0						43200.0		15.0	7.3
Non-Billable (3%)	0.8	1.7	20.0	2.9														
Total inc. non-billable	28.7	57.3	688.0		2873.2	22400.0	33600.0	295890.6	54000.0	0.0	847.5	28478.7	149616.3	7901.3	592734.4		206.3	100.0
Equivalent cost per meter						7.8	11.7	103.0	18.8	0.0	0.3	9.9	52.1	2.8	206.3			
% of total cost						3.8	5.7	49.9	9.1	0.0	0.1	4.8	25.2	1.3	100.0			

Table 4. Hypothetical cost model for the RoXplorer® CT platform, informed by the Delamerian North NDI campaign but minimising downtime and achieving consistent penetration rates of 125m/shift during CT mud rotary and percussion drilling and 1m/h during CT coring.

Causes 1 and 2 are related to drill site equipment and technology not developed by MinEx CRC but required to complete the drill program. A significant cause of downtime at the outset of the Delamerian North NDI campaign was excess time taken to establish a third party-provided satellite internet connection at the drill site. The satellite system was required to establish remote connection of the *iFluid* system to Perth-based researchers for the essential purpose of fluid management. This resulted in five shifts of low drilling productivity (with drilling advanced by only 30m) after initial mobilisation to NDIQV_D08_CT.

Causes 3 through 6 are related to deployment of prototype MinEx CRC technology. Data collected during the drilling campaign can be used to identify the root causes of this downtime, estimate equipment life, calculate mean-time between failure and develop mitigation strategies. We anticipate that downtime will be reduced by a combination of; i) redesign and ruggedisation of the RoXplorer®, HPS and ancillary equipment; ii) software updates informed by real drilling conditions; iii) optimised work practices informed by the drilling campaign; iv) familiarisation, experience and training of drill crews and; v) improved systems management (e.g. establishing a spare parts inventory and maintenance schedule).

The RoXplorer® system is a prototype system and has well over 3000 UniSA engineered parts in addition to all standard parts used is in the system. Maintenance, spare-parts warehousing, manufacturing, supply chain and logistics requires significant human resources and comprehensive planning many months ahead. MinEx CRC is not a drilling company and current systems to manage maintenance and provision of spare parts are inefficient, contributing to breakdowns and non-billable downtime. In a commercial drilling operation maintenance, warehousing, inventory management and sourcing of spare parts would be integrated into a Computer Maintenance Management System (CMMS) as part of a centralised ERP Enterprise Resource Planning (ERP) system. Establishing similar systems management practices for the RoXplorer® CT platform has the potential to deliver significant productivity improvements.

Our long-term aim, in combination with commercial partners as the RoXplorer® platform enters the market, is to reduce non-billable downtime to less than 3% of total campaign time, in line with expectations of mature commercial technologies.

8.0 Productivity potential informed by Delamerian North NDI campaign

The preceding performance and productivity analysis can be used to identify key areas of improvement and assess the potential productivity of the RoXplorer® CT platform. The key areas of improvement include:

- Minimising non-billable time and billable downtime - thus maximising time spent on billable activities.
- Optimising non-drilling billable activities (survey and logging, cementing, pack, move, unpack and set-up) – thus increasing the drilling "up-time"
- Increasing average ROP during drilling up-time.

Table 4, informed by discussion with MinEx CRC driller Alan Broad, presents a potential cost model for the Delamerian North NDI campaign, based on eliminating billable downtime (solving the sample system overload challenge) and reducing non-billable downtime to 3% of total time, streamlining mobilisation and hole moves whilst maintaining casing, survey and logging, cementing and drilling rates at documented levels – pre-collar drilling at 3.6m/h, CT rotary mud and percussion drilling at 10.4m/h (125m/shift) and CT coring at 1m/h – and using the same charge rates as presented in Table 3. These simple and achievable adjustments would reduce inactive billable time from 42.1% to 17.4% of total time, increase drilling up-time from 26.1% to 34.6% of total time and deliver the same drilling program in 56 shifts (64% of the actual program) at a cost of $593K and $206/m (86% of the actual program).

We used this model as a starting point to provide a semi-quantitative assessment of the impact of three important parameters on drilling productivity; average hole depth in the drilling program (Figure 23), variable penetration rates during drilling (Figure 24) and cost of the LiqiCTrol drilling additive (Figure 25). Figure 23 demonstrates that the per meter cost of drilling with RoXplorer® CT platform *decreases* with average hole depth, in contrast to conventional drilling techniques where per meter costs increase with hole depth. The modelling suggests that per meter drilling costs of approximately $150 are achievable with the RoXplorer® CT platform using the presented cost model. For example, a twelve-hole program with average depths of 360m, downtime minimised to 3% of total time, at currently demonstrated drilling rates and with LiqiCTrol costing $10kg would cost $144/m*.

*Noting that this modelling only accounts for billable drilling costs and does not include costs incurred in preparation for the drilling program including environmental and cultural compliance, contracting, community liaison, site access, site preparation and remediation. In addition, profit margin, capital, management costs or additional overheads have also not been accounted for.

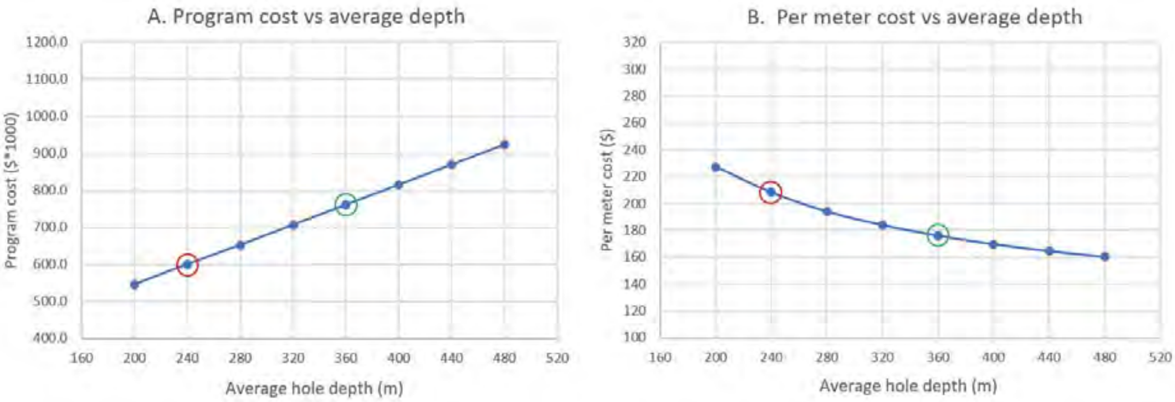


Figure 23. Impact of average hole depth on A. program and B. per meter costs using the various assumptions and costing model presented in Table 4. Red circles indicate average depths in the Delamerian North NDI campaign. Green circles indicate equivalent assumptions as green circles on Figure 24 and 25.

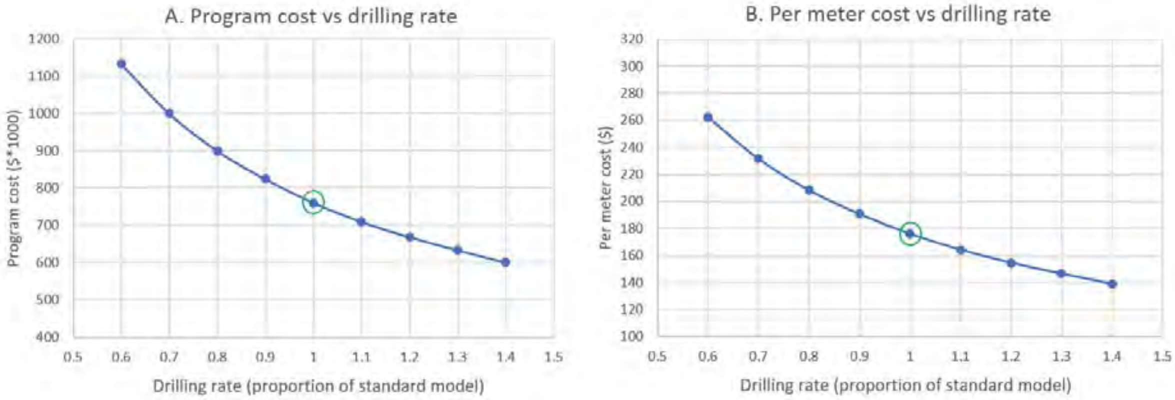


Figure 24. Impact of drilling rates (expressed as a proportion of the rates assumed in Table 4) on A. program and B. per meter costs for a drilling program with average hole depths of 360m and otherwise using the various assumptions and costing model presented in Table 4. Green circles indicate equivalent assumptions as green circles on Figure 23 and 25.

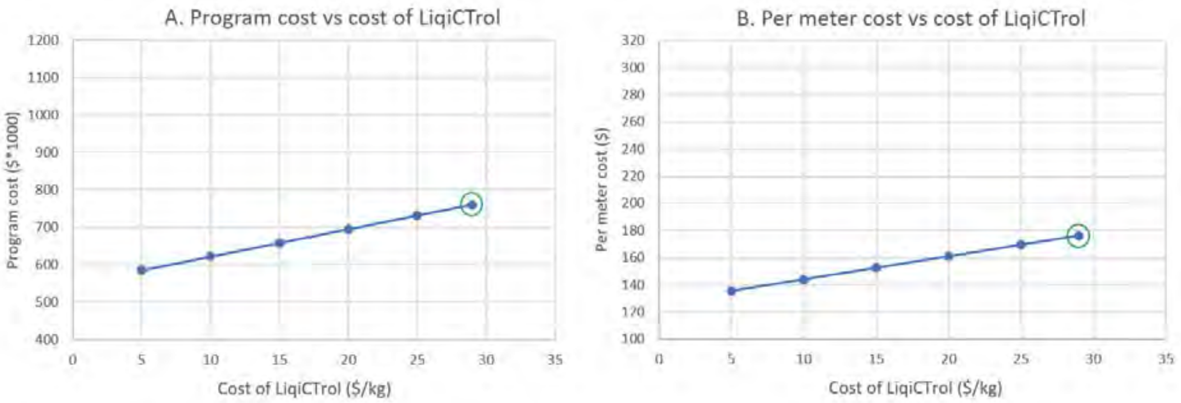


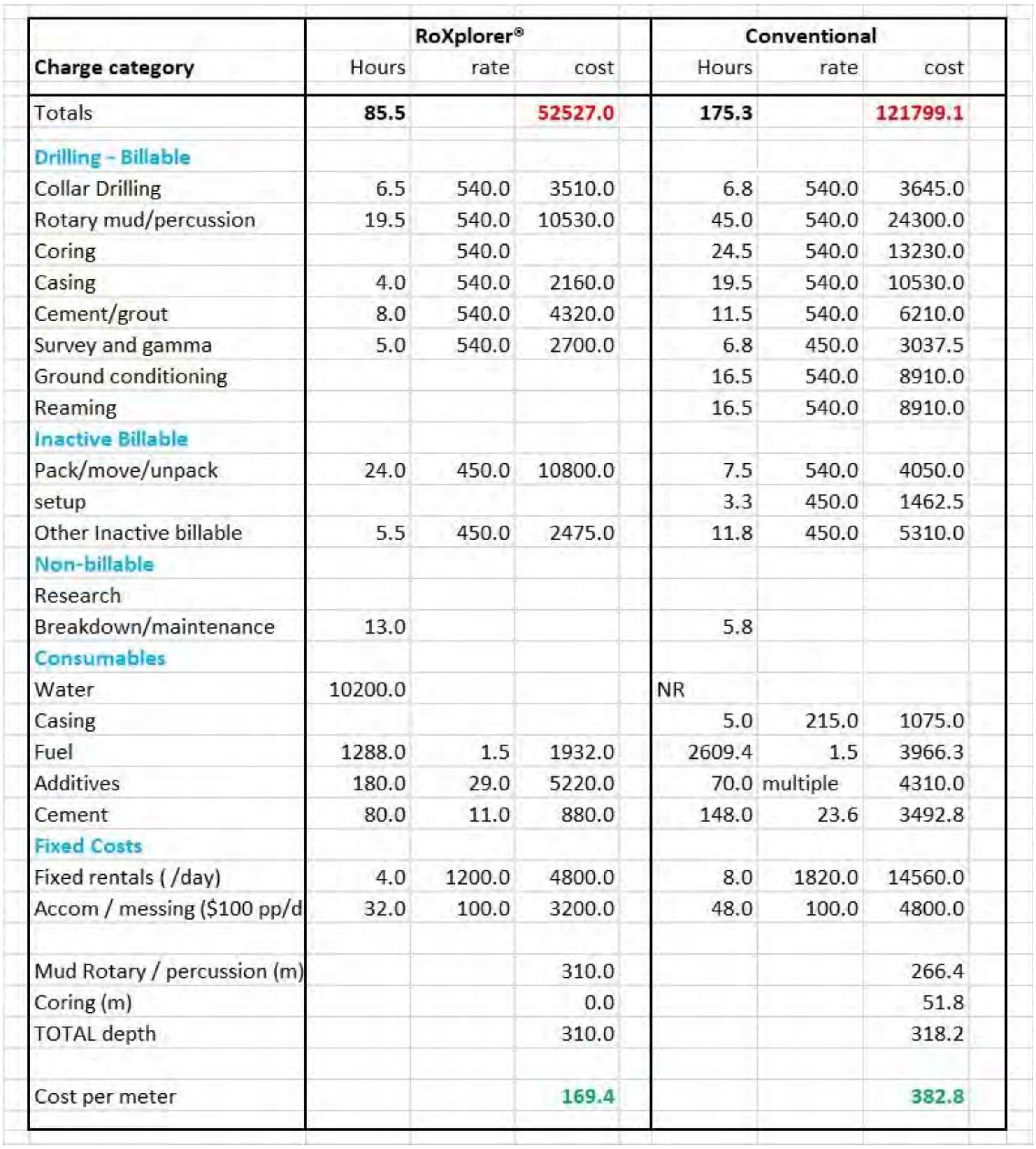
Figure 25. Impact of cost of LiqiCTrol on A. program and B. per meter costs for a drilling program with average hole depths of 360m and otherwise using the various assumptions and costing model presented in Table 4. Green circles indicate equivalent assumptions as green circles on Figure 23 and 24.

8.1 Comparison with conventional rotary mud and diamond drilling

The five drillholes completed by the RoXplorer® CT platform in the Delamerian South (Alawoona) NDI campaign were drilled into the same formations, as six drillholes completed by a conventional multipurpose rig, drilling mud rotary through the cover rocks and diamond through the basement. Two of the CT holes were drilled at the same site as conventional drillholes. Although the CT and conventional drilling rigs had different objectives (the conventional program was focussed on delivering ~50m runs of drill core from the basement, for detailed geological observations) the paired drilling programs provide a means to compare drilling performance and productivity through the same formation. Key aspects of drilling performance are compared in Table 5 and a comparison of charges for the twinned holes NDIAW_D01 and NDIAW_D01_CT is shown in Table 6.

Category	RoXplorer®	Conventional
Number of holes	5	6
Total meters	1778.9	1976.1
Mud rotary / percussion	1770.8	1654.3
Coring	8.1	321.8
Water consumption	86 l/m	1044 l/m
Fuel consumption	4.5 l/m	8 l/m
Additive consumption	1.14 kg/m	2.6 kg/m
Time retrieving stuck pipe	3 Hours	Several Days

Table 5. Comparison of key performance criteria for RoXplorer® CT and conventional mud rotary/diamond drilling conducted in the Delamerian South (Alawoona) NDI campaign.



	RoXplorer®			Conventional		
Charge category	Hours	rate	cost	Hours	rate	cost
Totals	**85.5**		**52527.0**	**175.3**		**121799.1**
Drilling - Billable						
Collar Drilling	6.5	540.0	3510.0	6.8	540.0	3645.0
Rotary mud/percussion	19.5	540.0	10530.0	45.0	540.0	24300.0
Coring		540.0		24.5	540.0	13230.0
Casing	4.0	540.0	2160.0	19.5	540.0	10530.0
Cement/grout	8.0	540.0	4320.0	11.5	540.0	6210.0
Survey and gamma	5.0	540.0	2700.0	6.8	450.0	3037.5
Ground conditioning				16.5	540.0	8910.0
Reaming				16.5	540.0	8910.0
Inactive Billable						
Pack/move/unpack	24.0	450.0	10800.0	7.5	540.0	4050.0
setup				3.3	450.0	1462.5
Other Inactive billable	5.5	450.0	2475.0	11.8	450.0	5310.0
Non-billable						
Research						
Breakdown/maintenance	13.0			5.8		
Consumables						
Water	10200.0			NR		
Casing				5.0	215.0	1075.0
Fuel	1288.0	1.5	1932.0	2609.4	1.5	3966.3
Additives	180.0	29.0	5220.0	70.0	multiple	4310.0
Cement	80.0	11.0	880.0	148.0	23.6	3492.8
Fixed Costs						
Fixed rentals (/day)	4.0	1200.0	4800.0	8.0	1820.0	14560.0
Accom / messing ($100 pp/d	32.0	100.0	3200.0	48.0	100.0	4800.0
Mud Rotary / percussion (m)			310.0			266.4
Coring (m)			0.0			51.8
TOTAL depth			310.0			318.2
Cost per meter			**169.4**			**382.8**

Table 6. Comparison of charge model for RoXplorer® CT and conventional mud rotary/diamond drilling conducted on the twinned holes NDIAW_D01_CT and NDIAW_D01 in the Delamerian South (Alawoona) NDI campaign.

Data delivered from the Delamerian NDI campaign has allowed us to update our multifactor performance comparison of the RoXplorer® CT platform with other drilling techniques, demonstrating the safety and environmental advantages of CT drilling (Table 7).

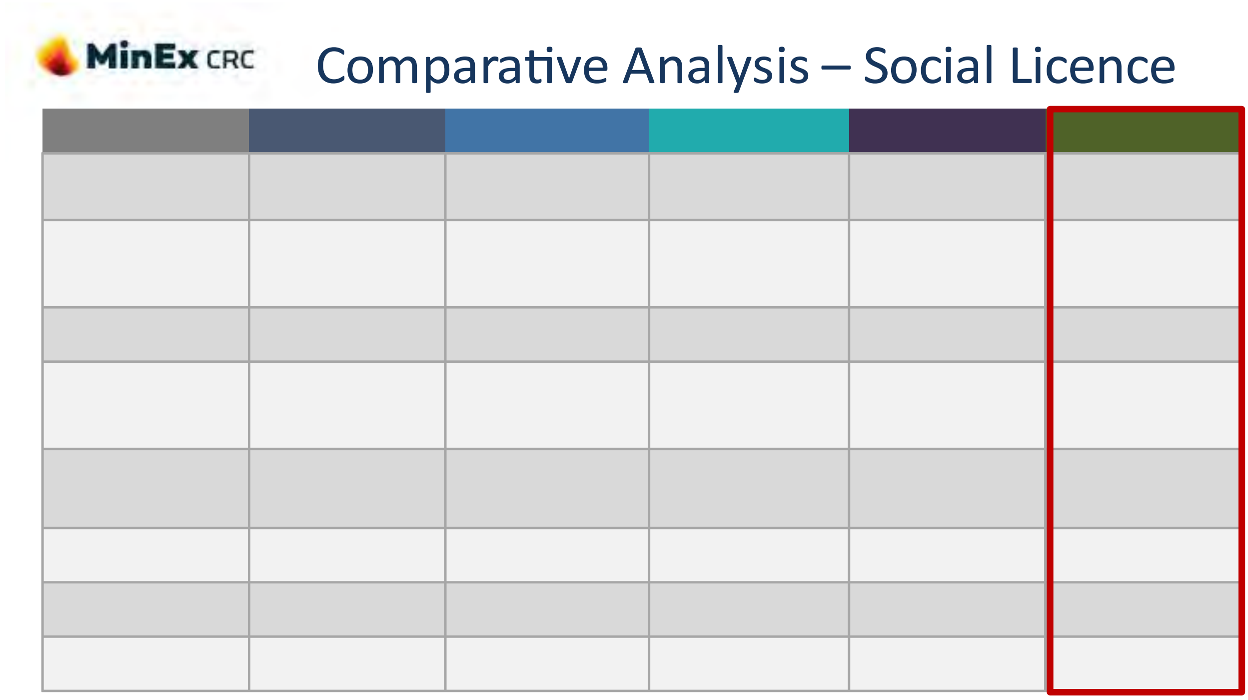

Comparative Analysis – Social Licence

Table 7. Comparison of safety and environmental performance of RoXplorer® with other drilling techniques.

9.0 Conclusions and Recommendations

9.1 Conclusions

The RoXplorer® - System has over been tested in over 5000 metres of drilling between August 2021 and April 2022 in four different locations. Based on results of the trials, drilling, and sampling through several hundred metres of cover, the RoXplorer® - system is competitive with conventional drilling methods based on average penetration rates, speed of hole completion, consumption of water, drilling additives and fuel plus has significant WHS and environmental advantages.

The RoXplorer® - System has been demonstrated to operate in remote, off-grid, conventional Greenfields's exploration environments as well as urban settings providing chips, core samples, borehole logs and surveys consistently.

The RoXplorer® - System is several integrated prototypes with various technology readiness levels, ranging from TRL5 (Large scale Prototype tested in intended environment) to a low TRL7 (Demonstration system in operational environment) and **has clearly demonstrated, without any doubt, that the Coiled Tubing drilling technologies for Greenfields mineral exploration, performs as designed, to 500 metres depth, in the formations drilled – when being operational.**

All cost comparisons between the RoXplorer® - System and conventional drilling operations suggest that the technology can ultimately be used either to significantly reduce exploration drilling costs per metre drilled or to increase profits per metre drilled.

Productivity of the RoXplorer® system has been based in part on comparison with equivalent commercial rates on a shift basis and does not reflect the total cost of provision. The cost model does not include costs incurred in preparation for the drilling program including environmental and cultural compliance, contracting, community liaison, site access, preparation and remediation. No allowance for a profit margin, capital costs, management costs or any additional overheads has been accounted for, noting that these may contribute an additional ~50% to the cost model. In addition, productivity is adversely affected by low system availability of ~40% due to ongoing improvements , NDI deployment planning, rain events, vacation, facility closures, remediation obligations, equipment improvements, compliance modifications and maintenance, and the cost of infrastructure and support for periods of non-availability have not been accounted for to date. The value products produced from the RoXplorer® - system comes from sampling of Chips & Core plus survey & logging, which are now used by the South Australian Government (GSSA) and integrated into the workflow as other established sampling method with results made available to the public.

GSSA's official endorsement on the RoXplorer sampling is:

> *"Based on the samples we have received and worked on to date, the GSSA has found chips and core produced by the RoXplorer® systems acceptable and comparable to other drilling methods. Please note however, that we are still working through processing/analysing/logging samples, and it is only at the completion of this process that we can give a conclusive appraisal.*
>
> *The RoXplorer® has provided the GSSA with a valuable tool to efficiently reach basement in a greenfields terrane, provide acceptable sample through cover and basement lithologies (including in unconsolidated material), and provide a contextual core sample at EOH.* ***Sample produced by the RoXplorer® of unconsolidated cover materials was in fact superior to those produced by the conventional rotary mud method.***
>
> *We have qualitatively compared our interpretations of lithological boundaries with both downhole gamma logs on the same hole, as well as with samples from twinned or nearby holes drilled with conventional methods and have found the RoXplorer sample is generally representative with reasonable depth fidelity. We look forward to more formal benchmarking of samples produced by the RoXplorer® against those produced by conventional rotary mud and diamond drilling, when time permits.*
>
> *We have had instances where sample contamination has been noted, and it would be worthwhile debriefing with MinEx on how/why this has occurred, and possible strategies for future mitigation.*
>
> *For your interest, we had a lot of positive feedback from the Uncover Curnamona conference in Broken Hill last week, where we displayed core and chips from the NDI. Industry and government geos were impressed to see the quality of samples first-hand."*

Kind Regards,
Tom Wise
Senior Geologist
Department for Energy and Mining"

The recorded performance of the Prototype RoXplorer® - System, tested in the intended environment, still holds a potential to "double" the average productivity (185%) by improving reliability of existing designs, as to be expected from a prototype. Industrialising a prototype to improve reliability requires in broad terms "engineering and testing" resources along with the right facility to apply improvements and prolonged testing efficiently.

In addition to the potential of doubling the productivity, by improving reliability of existing designs, potential for productivity improvements exists from:

- improving the performance of the drilling system, the HPS and associated support equipment

- automation
- more productive designs for any of the applied technologies
- operating a fleet of RoXplorer® - Systems compared to one unit
- having a commercial supplier providing experienced field support
- spare parts availability
- Drilling campaign logistics
- planning for drill crew to serve the functions related to the drill site only.
- Improved procedures

The RoXplorer® system is a prototype system and has well over 3000 UniSA engineered parts in addition to all standard parts used is in the system. Per definition a Prototype system (TRL less than TRL8) will require extensive maintenance, engineering, and modification over and above what is required by a commercial system to operate. Commercial equipment needed to execute the drilling as support vehicles like trucks and trailers, also need management and service plus, physical modifications to be compliant for specific deployments.

Maintenance, spare-parts warehousing, manufacturing, supply chain and logistics requires significant human resources and comprehensive planning many months ahead of deployment. MinEx CRC is not an established drilling company nor a commercial drilling equipment manufacturing organisation, so current systems and facilities to manage maintenance and provision of spare parts are inefficient, contributing to longer breakdowns non-billable downtime and the need for longer periods in the workshop between deployments (low availability). In MinEx CRC manufacturing of spares, maintenance, warehousing, inventory management and sourcing of spare parts are manual operations, being very resource demanding from the research team and MinEx. The professional roles to service and repair equipment such as hydraulic fitters, diesel mechanics, electricians, programmers, planners, warehousing, manufacturing, admin are not in MinEx CRC, nor facilities to operate a drilling service & repair facility including of warehousing for spares and equipment. All workshop service roles are currently filled by the drilling crew between rosters plus project researchers. During the drilling rosters and roster-off periods (or annual leave) for the drill crew there are limited mentionable MinEx CRC workshop services available.

Establishing practices and professional infrastructure for the above for the RoXplorer® CT platform has the potential to deliver improvements for availability of the equipment. Infrastructure and organisation are estimated to involve significant costs if not integrated into an established operator with similar organisation and facilities. A Coiled Tubing spooling facility will need to be added to known existing Australian operators.

Practically the planning and execution of the RoXplorer® – System drilling campaigns has been internally Project managed by the MinEx CEO with weekly meetings involving CEO, CFO, CSO, drilling manager operations, P1 Program Leader and Project resources involved.

In the remote Delamerian North campaign from January to April 2022, only 17 hours of research time (1.6% of total time), was recorded. To progress technologies in Project 1 (Ifluid) and Project 2 (Sampling, drilling to 1000m, steering and positioning) beyond lab- testing it is expected that several months of testing while drilling will be needed in the years to come.

9.2 Recommendations

The recommendations in this section are based on the conclusions in this report plus interactions with the Project 2 participants – having in mind that there can be several pathways forward.

The recommendations in this section do not address where any monetary funding would arise from but based on and not limited to:

1. 5000 metres of drilling between August 2021 and April 2022 has clearly demonstrated, that the RoXplorer® - System technologies for Greenfields mineral exploration, performs as designed in the formations drilled
2. Cost comparisons between the RoXplorer® - System and conventional drilling operations suggest that the technology could ultimately be used either to significantly reduce exploration drilling costs or to increase profits per metre drilled.
3. Industrialising or ruggedising a prototype to improve reliability requires in broad terms “engineering and testing” resources along with the right facilities to apply improvements and prolonged testing efficiently and effectively
4. Addressing the positive pull from the mining companies Anglo American, South32 and BHP to commence the process of commercialising the RoXplorer® - system
5. Drilling with a prototype with low availability is compared to commercial operation expensive.

Additional learnings about the current system are guaranteed to come from future drilling trials, however, it could be important to discuss when learnings about the current technology are sufficient to progress the technologies for commercialisation. What risks are a commercialiser ready to take? An unjustified conservative guesstimate applying the 80/20 rule after +5000m of drilling for the system (and +7.500m for the RoXplorer rig), would be that we have learned 80% of what can be learned by additional drilling with the existing prototype, without any modifications, such as ruggedizing.

In the discussion it is important that the terminology of commercialising the system does not get mixed up between:

i) the commercialiser that is building the “Product” (RoXplorer® - system) and secondly the
ii) commercialiser that is offering the “drilling and sampling contractor” service to the “tenement holder” (explorer or mining company).

The two commercialisers, are two very different organisations where the organisation that builds the “product” in simple terms is a large “factory setting” and the organisation that provides the drilling service in simple terms is a “service provider” or “contractor” that holds large amount of capital equipment plus the facilities and personnel to maintain the heavy equipment.

It is also important to state that the individual system components could find productive use for other types of drilling (e.g. Geothermal, In-situ mining, construction, dewatering) however, for a commercialiser to offer to a drilling contractor the “RoXplorer® - System product” all the subsystems must be offered as “One System” or “One Package”.

Any journey to a successful commercialised offering begins with locking in what “Product” is being commercialised and, in this context, meaning the RoXplorer® - System as tested in the Delamerian, meaning the RoXplorer being the 500 metre rig, HPS and BHA, and for clarification *none* of the future developments planned for the equipment.

The pathway developing a RoXplorer® - System to TRL8 (First of a Kind Commercial system) will have to follow the path of first getting all the sub-systems to TRL7 and then optimising the technologies (Ruggedising) until an agreed service life or MBF (Meantime between failures) are achieved for the combined system. Part of this process is also making the Ifluid independent from daily operation by researchers in Perth.

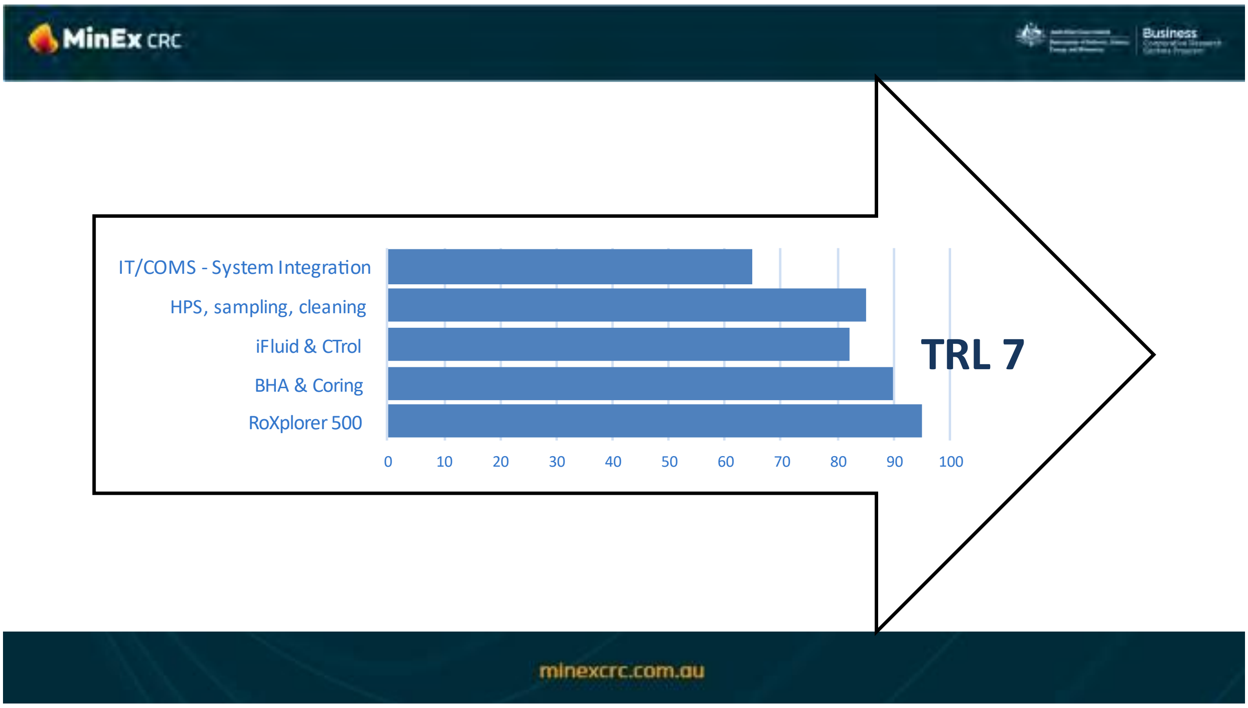


Figure 26. Subsystems TRL levels in the RoXplorer® - System.

Figure 26 is a subjective assessment of the TRL's in the RoXplorer® - System and a documented TRA (Technology Readiness Assessment) has not been conducted for hard or software.

There could be several pathways going forward.

It is important to state that the 5000 metres of drilling has provided very important learnings about the RoXplorer® - system including establishing a comprehensive reference for performance, however, the current operating model is a compromise when it comes to progressing the reliability of the technology efficiently.

The process of ruggedising the RoXplorer® - system, while it is at the same time used for drilling remotely for contract drilling, could take a decade at the current pace with the current resources and facilities.

> An example of this is the Charge pump on the HPS which had intermediate challenges to pump the new versions of CTrol as identified in September 2021. The actual process of identifying the problem, changing designs to a different pump took in our current operating environment, 8 months, and a new type of pump is now workshop commissioned on the HPS - awaiting field testing in the intended environment. After identifying the problem, this process could have taken; the engineering time to identify the problem, the lead time of the pump plus a few weeks to assemble and commission, leading to a total of 8 weeks instead of 8 Months.
>
> This is not an atypical pace of a critical systems-improvement in the current setting where the drilling crew also are the workshop fitters plus equipment is in the field for months at the time.
>
> Less complex new designs can be implemented much faster, for example the three different versions of the sample station as required by the clients in different campaigns.

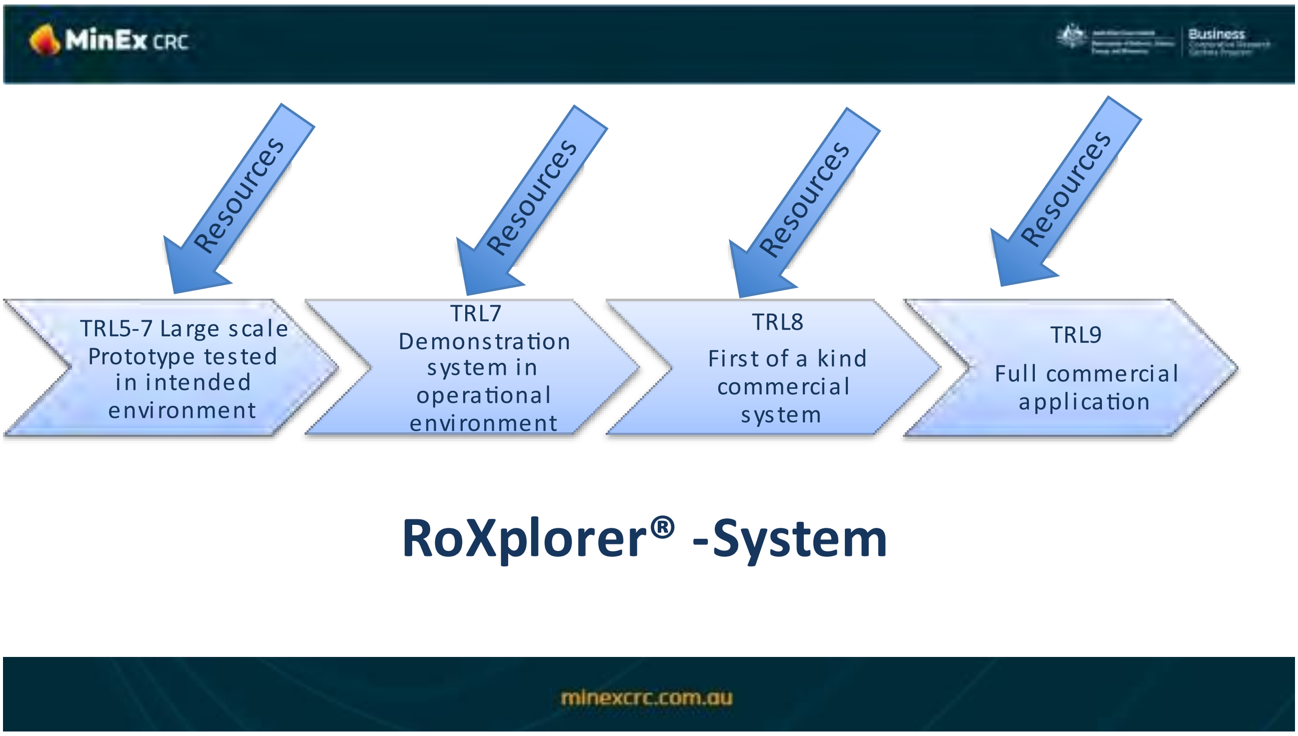
Project 2 Engineers has in 2022 spend +90% of their time supporting the field trials similar to Project 2 resources spend in Q3/Q4 2021.

When it comes to allocating the scarce resources in projects, the current priority of MinEx CRC is to honour the contractual obligations and commitments in the NDI, also to make revenue to keep the CT-drilling services funded. This current priority of MinEx CRC was necessary to execute the 2021/22 drilling trials, however, is not sustainable while maintaining current Project 2 Technology development activities by the same engineering team.

It is expected that to accelerate the process of ruggedising the RoXplorer® - System a larger group of skilled Mechanical Engineers, control systems Engineers, electricians, and fitters in a designated test facility with an abundance of manufacturing resources would be ideal *(Without any context - Huisman's wording was that 30 engineers would be applied).* This would mean that the effect of improvement could be tested and actual performance documented without any delays. Large industrial manufacturing companies and many major drilling companies have facilities for exactly that purpose.
The type, or scope of work, gradually changes from research to Engineering & industrialising and MinEx CRC do not currently have the facilities, organisation, and budget to efficiently ruggedise all of the RoXplorer – System.

After a product reaches TRL7 it is then required to be tested comprehensively in the field to validate the MBF and, at the same time, the final designs for the TRL8 version of the Product are normally being completed.

Suggested and common in the industry, is that 5 to 7 Systems are produced as the first TRL8 series where 5 are assembled with two system as spares. Broadly named the 0 (Zero) -Serie.


MinEx CRC

Resources

TRL5-7 Large scale Prototype tested in intended environment

Resources

TRL7 Demonstration system in operational environment

Resources

TRL8 First of a kind commercial system

Resources

TRL9 Full commercial application

RoXplorer® -System

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Figure 27.

Suggested recommendations:

1. Come to agreement what the priority in 2023 is between Ruggedising the Prototypes versus satisfying drilling requirements in the NDI, and if these are mutually exclusive choices?
2. Aim to identify potential commercialiser/s and manufacture/s of the RoXplorer® - System "product" and work with them to get all sub systems to TRL7.

3. Help the process by establishing an industry “pull” (demand) for a minimum of say 5 identical RoXplorer® - Systems in the next 24-36 Months
4. Prioritise the MinEx CRC effort to assist the commercialiser, which could mean that the current prototypes would not be available for the NDI as they could be needed in the ruggedising process.

10.0 Acknowledgements

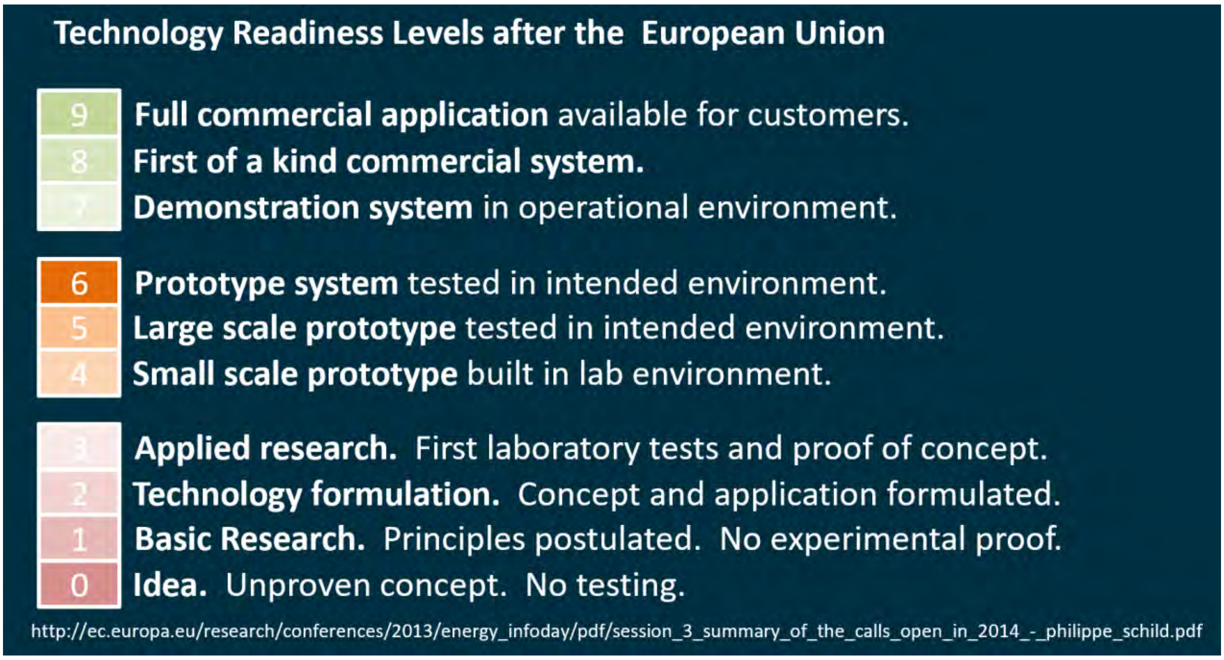
Thanks to GSSA, Enviro Copper and UniSA for supporting the trial of new drilling technologies.

“The work has been supported by the Mineral Exploration Cooperative Research Centre whose activities are funded by the Australian Government's Cooperative Research Centre Program. This is MinEx CRC Document 2022/53.

11. Definitions

Definitions		**DRILLING AND DRILLING RELATED TIME**		**SITE ACTIVITIES**			
		Drilling Time	**Active Time**	**Inactive Time**	***Inactive Time***	**Research Time**	**Down Time**
		Hours	**Hours**	**Hours**	***Hours***	**Hours**	**Hours**
		Billable	**Billable**	**Billable**	***Not Billable***	**Not Billable**	**Not Billable**
		Drilling for Casing	Rigging up and down	Rig moves between holes and project areas	Food shopping, Crew Cooking,	Research	Mechanical, electrical, Com's or software Breakdown of RoXplorer System (HPS, Rig, Satelite, Wifi, Computers)
		Collaring hole and setting collar pipe Top Casing	Weed & Seed inspections	Unpacking and repacking, including camp	Camp Power - Gensets		
		CT Drilling	Client site inductions	Delays caused by Third Party	Camp Comms - Satelite		
		Coring	Mixing mud and conditioning hole	Weather delays	Camp Cleaning		
			Establishing water supply	Water source for drilling operations, delivery of water to the drillsite to be charged as per Schedule of Rates	Camp Waste Management,		
			Collaring hole and setting collar pipe Top Casing	Initial inductions			
			Changing drilling method Rotary/CT/core (charged at Core hourly rate)	Cleared drill sites including sumps			
			Running reaming and pulling casing	Core trays, sample bags and daily collection			
			Bit's and barrel changes	Reasonable access to and around project area			
			Stuck rods due to ground conditions	Irreparably damaged tyres due to poor access charged at cost			
			Cementing/Grouting				
			Running PVC geophysical casing	Client delays and site meetings			
			Surveying/Gyro/Geophysical where contractor using own winch and rig shut down				
			Prestart Meetings				
			Safety Meetings				

TRL:



Technology Readiness Levels after the European Union

9 **Full commercial application** available for customers.
8 **First of a kind commercial system.**
7 **Demonstration system** in operational environment.

6 **Prototype system** tested in intended environment.
5 **Large scale prototype** tested in intended environment.
4 **Small scale prototype** built in lab environment.

3 **Applied research.** First laboratory tests and proof of concept.
2 **Technology formulation.** Concept and application formulated.
1 **Basic Research.** Principles postulated. No experimental proof.
0 **Idea.** Unproven concept. No testing.

http://ec.europa.eu/research/conferences/2013/energy_infoday/pdf/session_3_summary_of_the_calls_open_in_2014_-_philippe_schild.pdf

Technology Readiness Assessment (TRA) Definition
A TRA is a formal, systematic, metrics-based process and accompanying report that assesses the maturity of technologies called Critical Technology Elements (CTEs) to be used in systems. CTEs can be hardware or software. The definition of a CTE is as follows:
A technology element is "critical" if the system being acquired depends on this technology element to meet operational requirements (within acceptable cost and schedule limits) and if the technology element or its application is either new or novel or in an area that poses major technological risk during detailed design or demonstration.

The definition of a CTE is as follows:
A technology element is "critical" if the system being acquired depends on this technology element to meet operational requirements (within acceptable cost and schedule limits) and if the technology element or its application is either new or novel or in an area that poses major technological risk during detailed design or demonstration.

Coiled Tubing Drilling For Mineral Exploration – Project 2

MinEx CRC

Agenda:
Welcome and “roll call” by Project Leader.

Progress Reporting

1. Update by Project Leader
    a. Project Overview
    b. New Quarterly milestones
    c. General project progress
        i. Research
            1. Sample quality
            2. Positioning and sensing – AnTech discussion
            3. Steering - AnTech funding discussion
            4. Drilling to 1000 metres
            5. Drilling Support
        ii. Project Interactions
    d. Project budget
    e. Project risks & impediments
    f. Commercialisation
    g. Discussion

Project 2 PRP Meeting

4. Project Review members reflection on the quarter - PRP-Chair
5. Advise if the Chair of a PRP will sign off project milestones within the MinEx CRC quarterly reporting structure.
6. General Business – New Participants

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Majors, METS and Survey Participants

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SOUTH32

RioTinto

Geotec
Boyles Bros S.A.

IMDEX
REAL-TIME SUBSURFACE SOLUTIONS

AMC

REFLEX

McKAY
DRILLING
Setting the Standard

Epiroc

SANDVIK

wassara
STRAIGHT
FORWARD
DRILLING

Geological Survey of
Western Australia

SOUTH
AUSTRALIA

Government
of South Australia
Department for
Energy and Mining

NSW
GOVERNMENT

Australian Government
Geoscience Australia

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Australian National University

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THE UNIVERSITY OF NEWCASTLE AUSTRALIA

University of South Australia

THE UNIVERSITY OF WESTERN AUSTRALIA

UNSW SYDNEY

ALFA LAVAL

AuScope

CORESAFE

DATACODE Global Solutions for Local Needs

demetallica

encounter RESOURCES LIMITED

EVIDENT

ENVIRO COPPER

HiSeis

ifm

INCA MINERALS LTD

Fe Lodestone Mines

MATSA RESOURCES

Middle Island RESOURCES LIMITED

MINALYZE

mriwa Minerals Research Institute of Western Australia

Santos

Sercel

SER Strategic Energy Resources

NORTHERN TERRITORY GOVERNMENT

GEOLOGICAL SURVEY OF VICTORIA

GEOLOGICAL SURVEY OF QUEENSLAND

Tasmanian Government

Health & Safety

No Incidents reported by Drilling Team or Project 2 in Q4

LIFE-OF-PROJECT PERFORMANCE TARGET

Develop sample integrity of CT drilling to that of Diamond drilling, then develop ability to drill multiple deviated holes, each up to 1000 m reach, from a single pad, landing within 10 m of target at end-of-hole and surveyed within 1 m, whilst maintaining the cost, rapidity, safety and environmental benefits of greenfields CT rig.

PROJECT 2: COILED TUBING DRILLING FOR DEFINITION OF MINERAL DEPOSITS

LEADER:	Soren Soe
PARTICIPANTS:	Anglo American, BHP, Epiroc, LKAB Wassara, MRIWA, South 32, Curtin University, CSIRO, UniSA
RESOURCES:	$2.369M (cash) Phase ll (including $262k from Phase lll)

PERFORMANCE TARGET (Life-of-MinEx CRC):

To improve the sample integrity of CT drilling to that of diamond drilling, then develop the ability to drill multiple deviated holes, up to 1000 m reach, from a single pad, to within 10 m of target and surveyed within 1 m, whilst maintaining the cost, rapidity, safety and environmental benefits of a greenfield CT rig.

PROJECT 2 - PARTICIPANTS

MINER	METS	SURVEY	RESEARCH
Anglo American	Epiroc		UniSA
BHP	LKAB Wassara		CSIRO
South 32			Curtin
MRIWA			

PROJECT 2 – RESEARCH

MODULE 1 - IMPROVE SAMPLE INTEGRITY OF CT DRILLING

MODULE 2 - DOWNHOLE POSITIONING SYSTEM & SENSING

MODULE 3 - DOWNHOLE STEERING SYSTEM

MODULE 4 - DRILLING TO A 1000 M REACH

3.85 FTE

MODULE 5 - DRILLING SUPPORT

1.6 FTE

PROJECT 2: Milestones

2022Q4

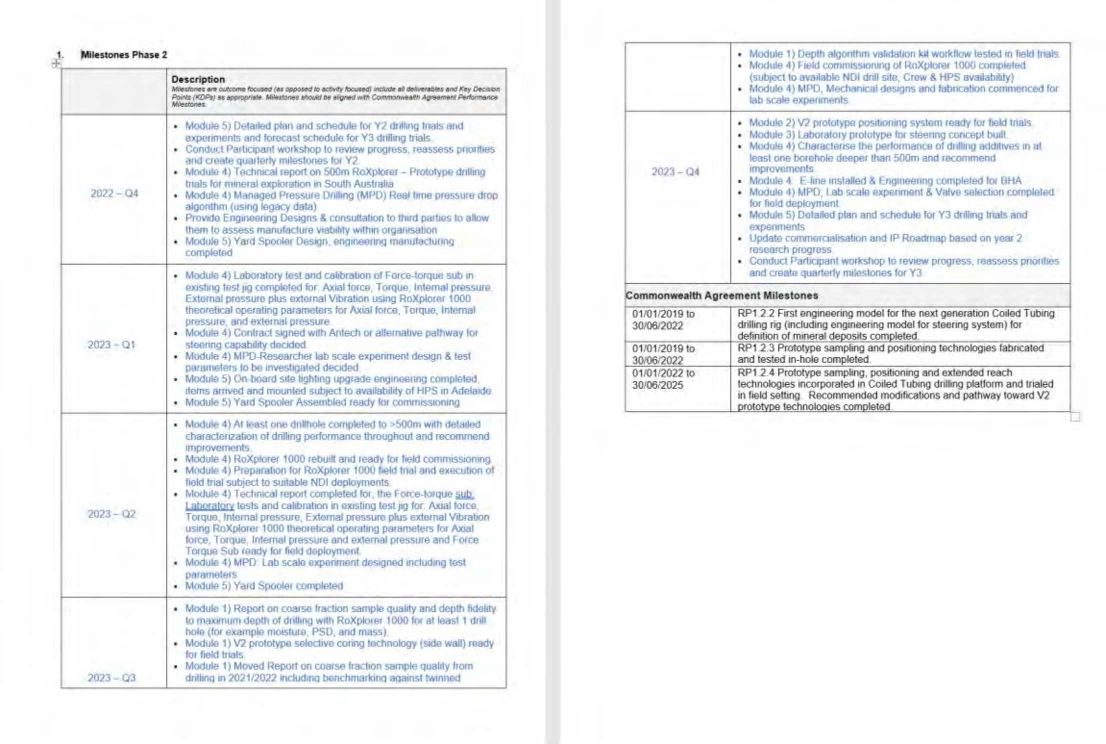
2023Q1
NDI Projects + RoXplorer 1000 KDP-Steering

2023 Q2
Drilling Trial RoXplorer 1000 and SMART BHA logging

2023Q3-Q4
RoXplorer 1000 & Systems Preparation for steering

2024Q1+Q2
Drilling Trial steering and logging

PROJECT 2: Milestones



1. **Milestones Phase 2**

	Description *Milestones are outcome focused (as opposed to activity focused) include all deliverables and Key Decision Points (KDPs) as appropriate. Milestones should be aligned with Commonwealth Agreement Performance Milestones.*
2022 – Q4	• Module 5) Detailed plan and schedule for Y2 drilling trials and experiments and forecast schedule for Y3 drilling trials. • Conduct Participant workshop to review progress, reassess priorities and create quarterly milestones for Y2. • Module 4) Technical report on 500m RoXplorer – Prototype drilling trials for mineral exploration in South Australia • Module 4) Managed Pressure Drilling (MPD) Real time pressure drop algorithm (using legacy data) • Provide Engineering Designs & consultation to third parties to allow them to assess manufacture viability within organisation • Module 5) Yard Spooler Design, engineering manufacturing completed
2023 – Q1	• Module 4) Laboratory test and calibration of Force-torque sub in existing test jig completed for: Axial force, Torque, Internal pressure, External pressure plus external Vibration using RoXplorer 1000 theoretical operating parameters for Axial force, Torque, Internal pressure, and external pressure. • Module 4) Contract signed with Antech or alternative pathway for steering capability decided. • Module 4) MPD-Researcher lab scale experiment design & test parameters to be investigated decided. • Module 5) On-board site lighting upgrade engineering completed, items arrived and mounted subject to availability of HPS in Adelaide. • Module 5) Yard Spooler Assembled ready for commissioning
2023 – Q2	• Module 4) At least one drillhole completed to >500m with detailed characterization of drilling performance throughout and recommend improvements. • Module 4) RoXplorer 1000 rebuilt and ready for field commissioning. • Module 4) Preparation for RoXplorer 1000 field trial and execution of field trial subject to suitable NDI deployments. • Module 4) Technical report completed for, the Force-torque sub. Laboratory tests and calibration in existing test jig for: Axial force, Torque, Internal pressure, External pressure plus external Vibration using RoXplorer 1000 theoretical operating parameters for Axial force, Torque, Internal pressure and external pressure and Force Torque Sub ready for field deployment. • Module 4) MPD: Lab scale experiment designed including test parameters. • Module 5) Yard Spooler completed
2023 – Q3	• Module 1) Report on coarse fraction sample quality and depth fidelity to maximum depth of drilling with RoXplorer 1000 for at least 1 drill hole (for example moisture, PSD, and mass). • Module 1) V2 prototype selective coring technology (side wall) ready for field trials. • Module 1) Moved Report on coarse fraction sample quality from drilling in 2021/2022 including benchmarking against twinned • Module 1) Depth algorithm validation ~~kit~~ workflow tested in field trials. • Module 4) Field commissioning of RoXplorer 1000 completed (subject to available NDI drill site, Crew & HPS availability) • Module 4) MPD, Mechanical designs and fabrication commenced for lab scale experiments.
2023 – Q4	• Module 2) V2 prototype positioning system ready for field trials • Module 3) Laboratory prototype for steering concept built. • Module 4) Characterise the performance of drilling additives in at least one borehole deeper than 500m and recommend improvements. • Module 4: E-line installed & Engineering completed for BHA • Module 4) MPD, Lab scale experiment & Valve selection completed for field deployment. • Module 5) Detailed plan and schedule for Y3 drilling trials and experiments • Update commercialisation and IP Roadmap based on year 2 research progress. • Conduct Participant workshop to review progress, reassess priorities and create quarterly milestones for Y3.
Commonwealth Agreement Milestones	
01/01/2019 to 30/06/2022	RP1.2.2 First engineering model for the next generation Coiled Tubing drilling rig (including engineering model for steering system) for definition of mineral deposits completed.
01/01/2019 to 30/06/2022	RP1.2.3 Prototype sampling and positioning technologies fabricated and tested in-hole completed.
01/01/2022 to 30/06/2025	RP1.2.4 Prototype sampling, positioning and extended reach technologies incorporated in Coiled Tubing drilling platform and trialed in field setting. Recommended modifications and pathway toward V2 prototype technologies completed.

Module 1) Improve the sample integrity of CT drilling

Module 2) Downhole positioning system

Module 3) Down hole steering system

Module 4) Drilling to a 1000m reach

Module 5) RoXplorer Systems Drilling support

PROJECT 2: Milestones 2022 Q4

Module 5) Detailed plan and schedule for Y2 drilling trials and experiments and forecast schedule for Y3 drilling trials.

Conduct Participant workshop to review progress, reassess priorities and create quarterly milestones for Y2.

Module 4) Technical report on 500m RoXplorer – Prototype drilling trials for mineral exploration in South Australia

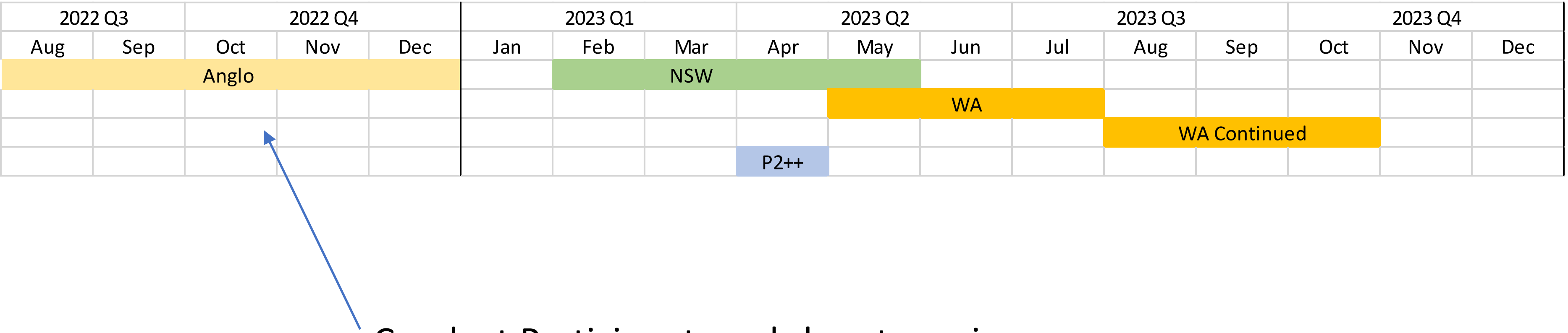
Module 4) Managed Pressure Drilling (MPD) Real time pressure drop algorithm (using legacy data)

Provide Engineering Designs & consultation to third parties to allow them to assess manufacture viability within organisation

Module 5) Yard Spooler Design, engineering manufacturing completed

PROJECT 2: Milestones 2022 Q4

Module 5) Detailed plan and schedule for Y2 drilling trials and experiments and forecast schedule for Y3 drilling trials.



2022 Q3		2022 Q4			2023 Q1			2023 Q2			2023 Q3			2023 Q4		
Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anglo						NSW										
									WA							
												WA Continued				
								P2++								

Conduct Participant workshop to review progress, reassess priorities and create quarterly milestones for Y2.

Module 4) Technical report on 500m RoXplorer – Prototype drilling trials for mineral exploration in South Australia

MinEx CRC

Australian Government
Department of Industry, Science, Energy and Resources

Business Cooperative Research Centres Program

5000m of RoXplorer® Prototype System Drilling Trials for Mineral Exploration in South Australia

Authors:
Soren Soe: MinEx CRC, UniSA
David Giles: MinEx CRC, UniSA
Ben van der Hoek: MinEx CRC UniSA

June 2022
MinEx CRC report number: 2022/53

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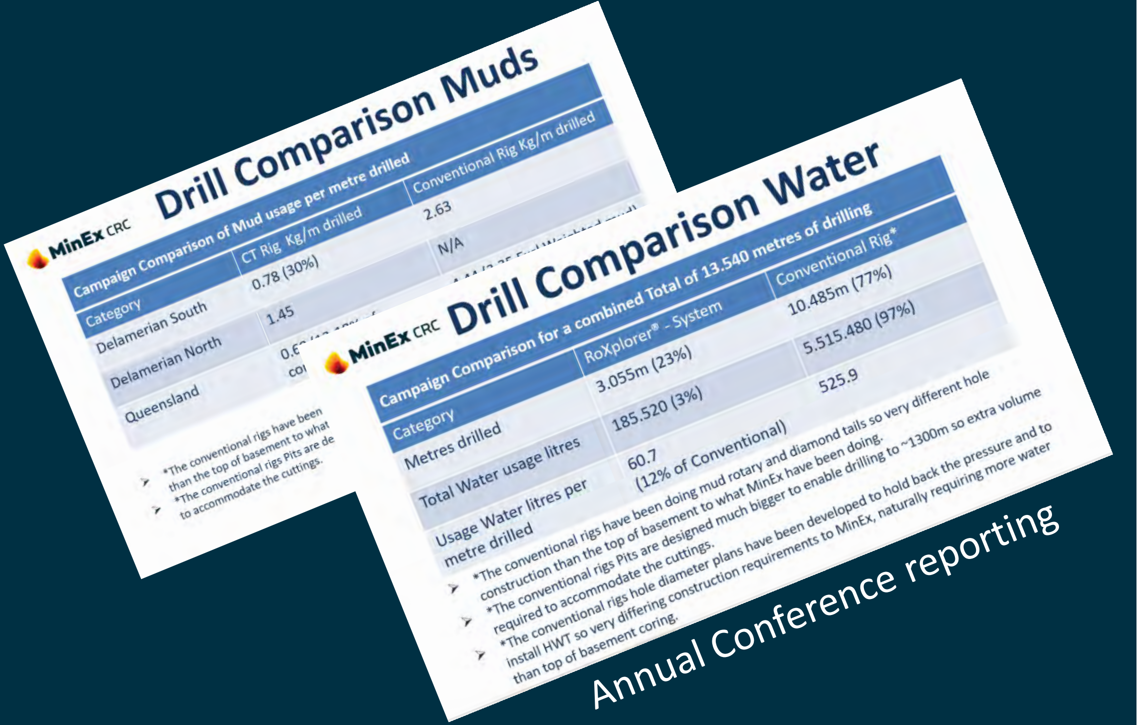
RoXplorer® Performance report



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Drill Comparison Muds

Campaign Comparison of Mud usage per metre drilled		
Category	CT Rig Kg/m drilled	Conventional Rig Kg/m drilled
Delamerian South	0.78 (30%)	2.63
Delamerian North	1.45	N/A
Queensland	0.6	

- *The conventional rigs have been … than the top of basement to what …
- *The conventional rigs Pits are de… to accommodate the cuttings.

MinEx CRC

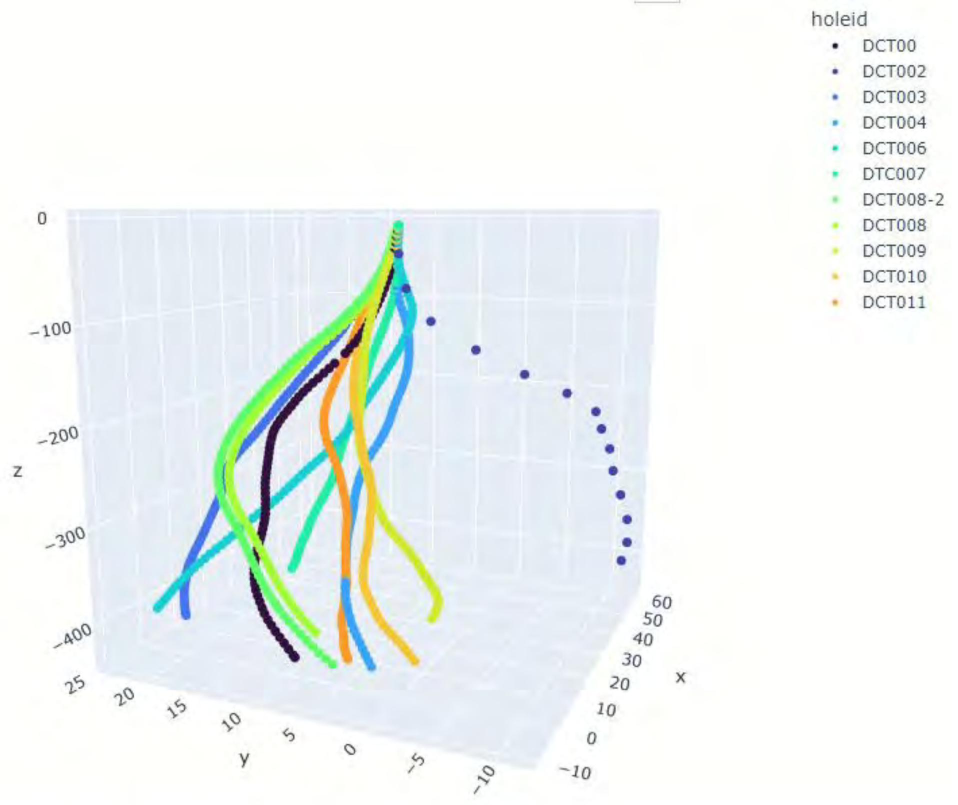
Drill Comparison Water

Campaign Comparison for a combined Total of 13.540 metres of drilling		
Category	RoXplorer® - System	Conventional Rig*
Metres drilled	3.055m (23%)	10.485m (77%)
Total Water usage litres	185.520 (3%)	5.515.480 (97%)
Usage Water litres per metre drilled	60.7 (12% of Conventional)	525.9

- *The conventional rigs have been doing mud rotary and diamond tails so very different hole construction than the top of basement to what MinEx have been doing.
- *The conventional rigs Pits are designed much bigger to enable drilling to ~1300m so extra volume required to accommodate the cuttings.
- *The conventional rigs hole diameter plans have been developed to hold back the pressure and to install HWT so very differing construction requirements to MinEx, naturally requiring more water than top of basement coring.

Annual Conference reporting

Deviation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DCT002
DCT003
DCT004
DCT006
DTC007
DCT008-2
DCT008
DCT009
DCT010
DCT011
z
0
−100
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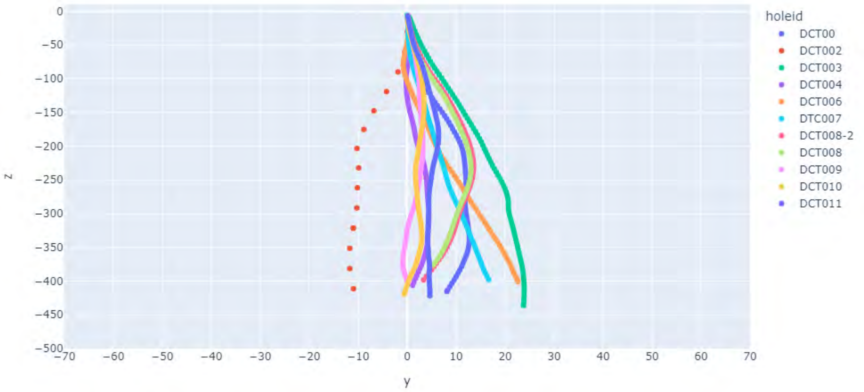
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z
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−100
−150
−200
−250
−300
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−450
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y
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60
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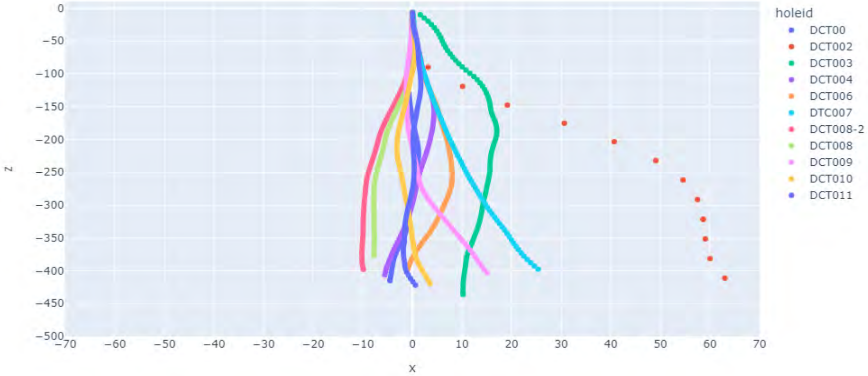
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z
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−200
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−400
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−500
x
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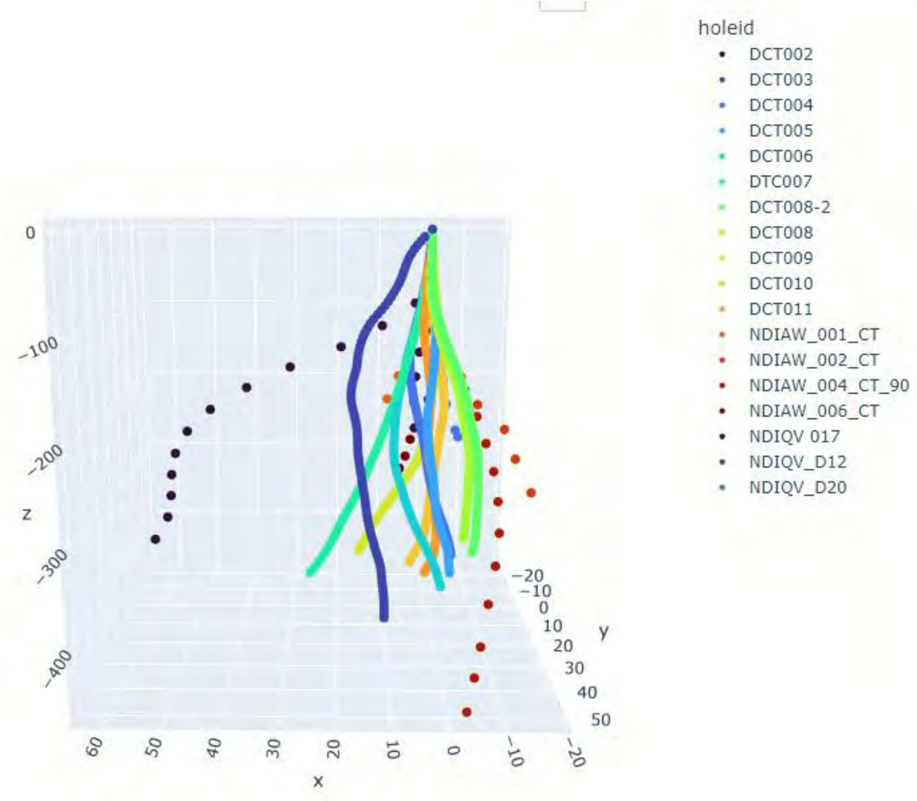
70

Deviation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DCT003
DCT004
DCT005
DCT006
DTC007
DCT008-2
DCT008
DCT009
DCT010
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NDIAW_001_CT
NDIAW_002_CT
NDIAW_004_CT_90
NDIAW_006_CT
NDIQV 017
NDIQV_D12
NDIQV_D20
z
0
−100
−200
−300
−400
x
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−10
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y
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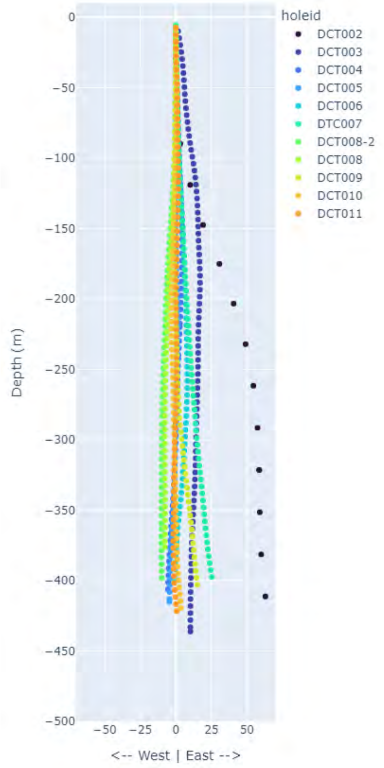
40
50


holeid
DCT002
DCT003
DCT004
DCT005
DCT006
DTC007
DCT008-2
DCT008
DCT009
DCT010
DCT011
Depth (m)
0
−50
−100
−150
−200
−250
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−350
−400
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−500
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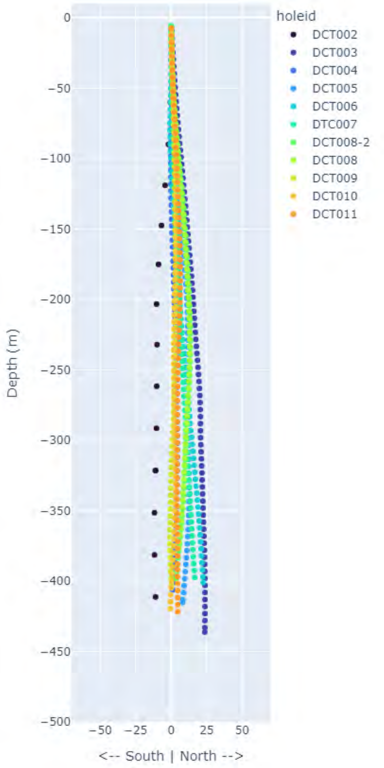
0
25
50
<-- West | East -->


holeid
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DCT003
DCT004
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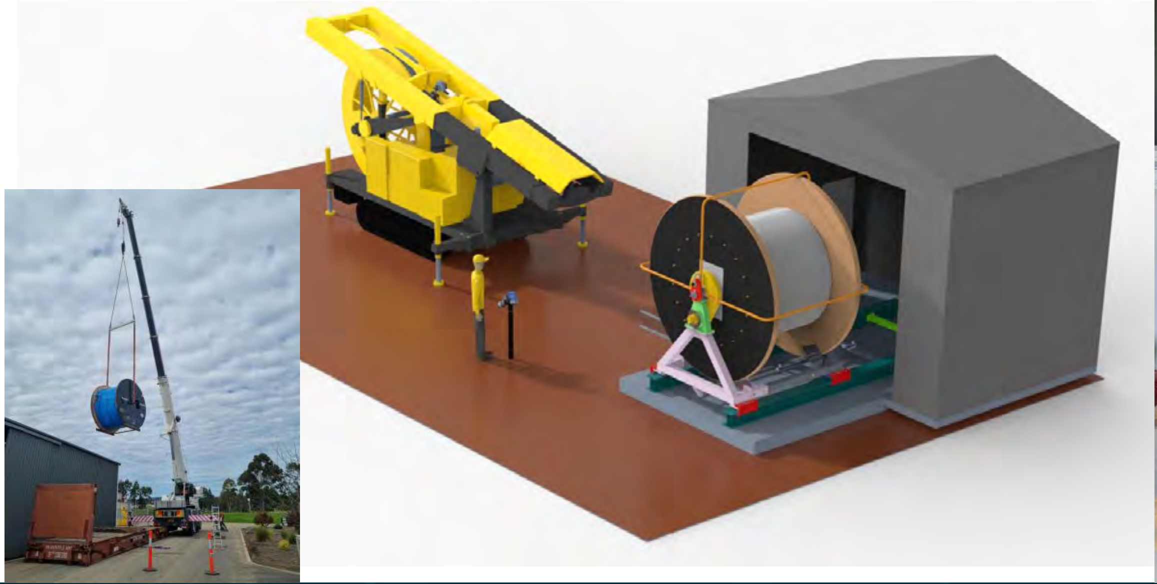
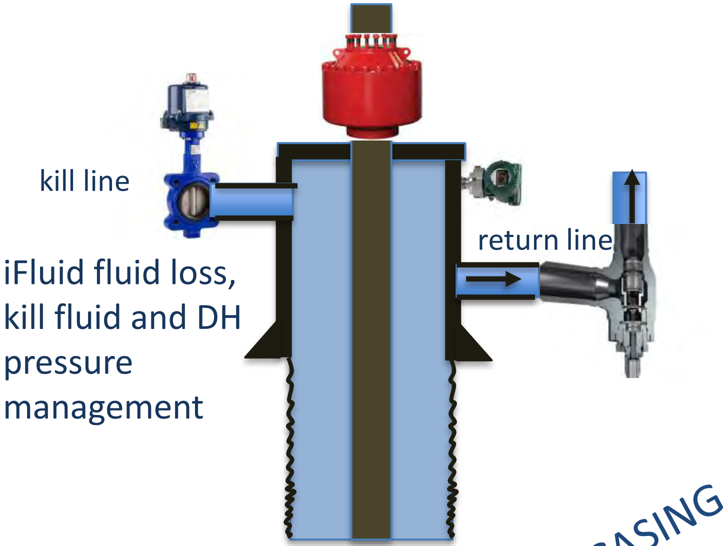
DCT006
DTC007
DCT008-2
DCT008
DCT009
DCT010
DCT011
Depth (m)
0
−50
−100
−150
−200
−250
−300
−350
−400
−450
−500
−50
−25
0
25
50
<-- South | North -->

Yard Spooler – Progress

Module 5) Yard Spooler Design, engineering manufacturing completed



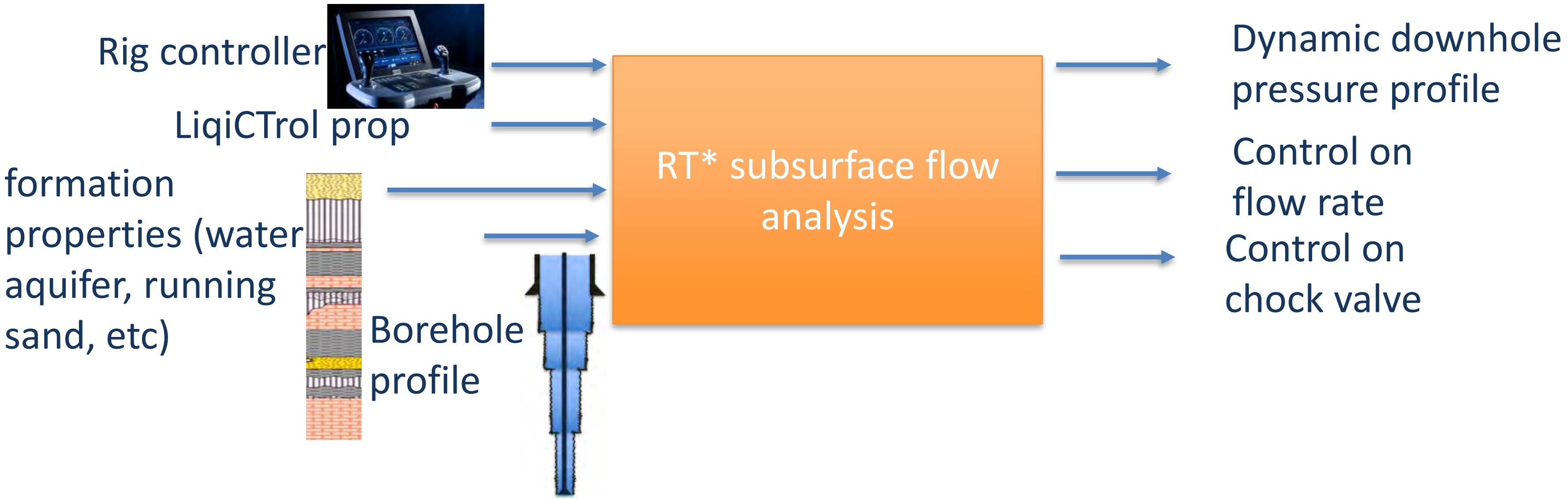
Manage Pressure Drilling – 1000 metres



Objective 1 : AVOID CASING DRILLING TO 1000m

- Automated system to provide dynamic control of borehole pressure while drilling and when not drilling
- Application:
  - Provide borehole stability
  - High pressure aquifers (e.g. artesian)
  - Keep borehole full and under given pressure

Manage Pressure Drilling



Rig controller

LiqiCTrol prop

formation properties (water aquifer, running sand, etc)

Borehole profile

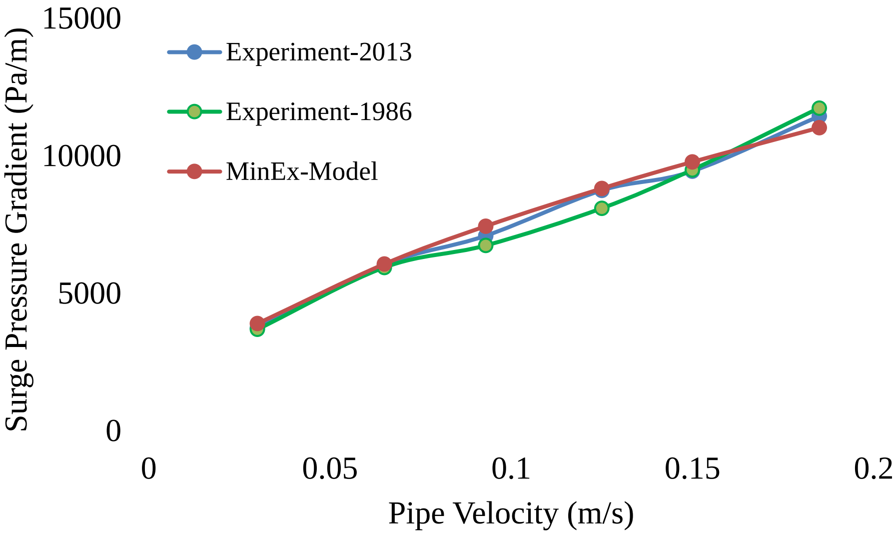
RT* subsurface flow analysis

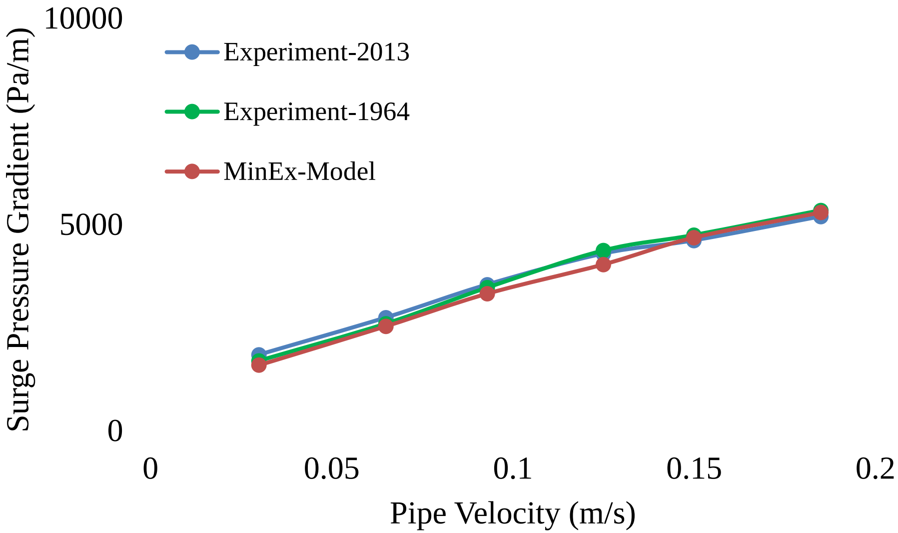
Dynamic downhole pressure profile

Control on flow rate

Control on chock valve

Manage Pressure Drilling – 1000 metres





PROJECT 2: PROGRESS

Module 4) The RoXplorer 1000m Rig being reassembled

Why AnTech BHA “2023”

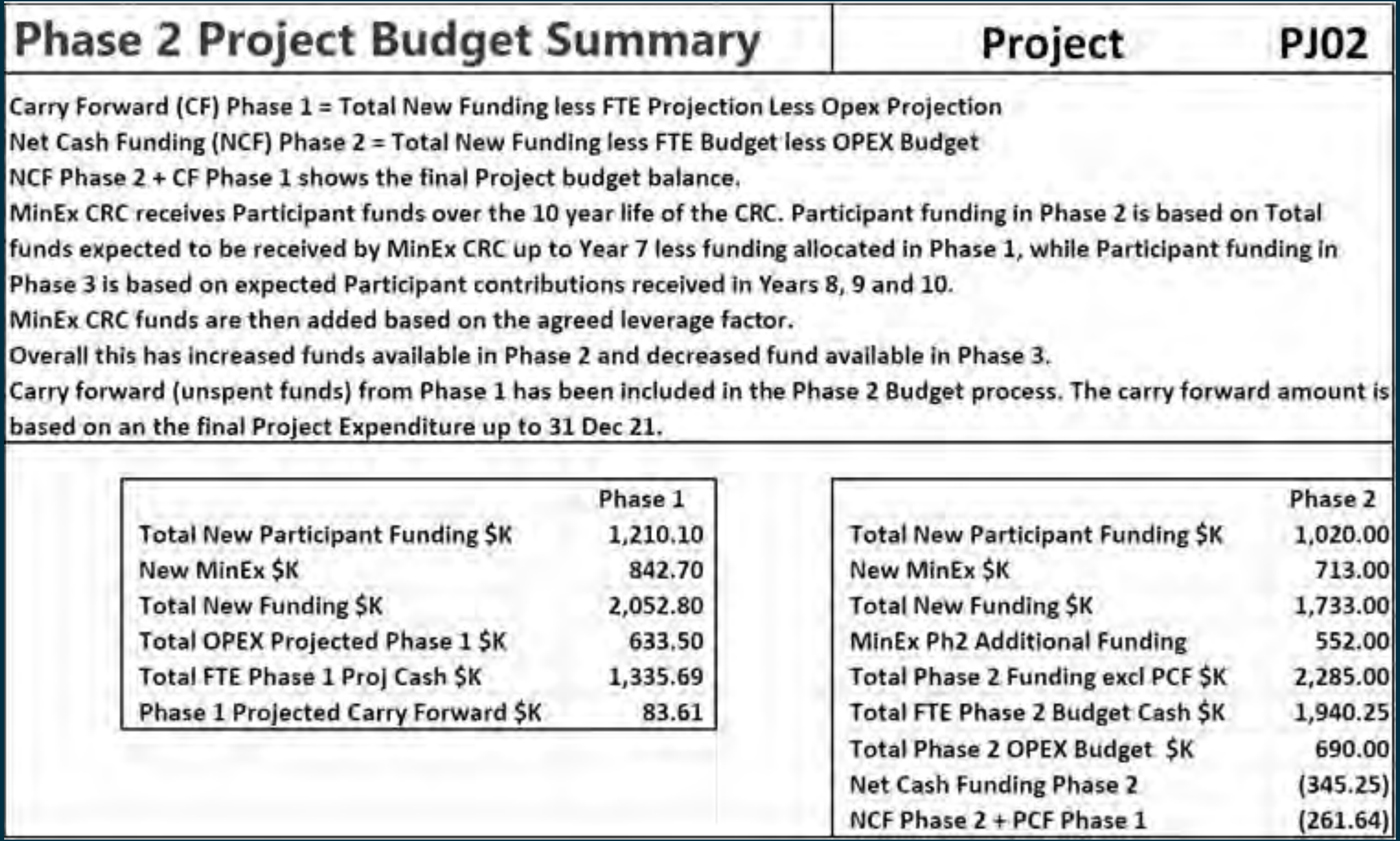
Image redacted for reasons of commercial sensitivity

The illustration provides an overview of the main components of a directional drilling system for CTD. For this project, the only component that will be used for the first time is the AnTech COBALT BHA (2 3/8”) or as we Prefer to call it the new *V2 MinEx SMART BHA*.

Image redacted for reasons of commercial sensitivity

Image redacted for reasons of commercial sensitivity

PROJECT 2 BUDGET



Phase 2 Project Budget Summary

Project **PJ02**

Carry Forward (CF) Phase 1 = Total New Funding less FTE Projection Less Opex Projection

Net Cash Funding (NCF) Phase 2 = Total New Funding less FTE Budget less OPEX Budget

NCF Phase 2 + CF Phase 1 shows the final Project budget balance.

MinEx CRC receives Participant funds over the 10 year life of the CRC. Participant funding in Phase 2 is based on Total funds expected to be received by MinEx CRC up to Year 7 less funding allocated in Phase 1, while Participant funding in Phase 3 is based on expected Participant contributions received in Years 8, 9 and 10.

MinEx CRC funds are then added based on the agreed leverage factor.

Overall this has increased funds available in Phase 2 and decreased fund available in Phase 3.

Carry forward (unspent funds) from Phase 1 has been included in the Phase 2 Budget process. The carry forward amount is based on an the final Project Expenditure up to 31 Dec 21.

	Phase 1
Total New Participant Funding $K	1,210.10
New MinEx $K	842.70
Total New Funding $K	2,052.80
Total OPEX Projected Phase 1 $K	633.50
Total FTE Phase 1 Proj Cash $K	1,335.69
Phase 1 Projected Carry Forward $K	83.61

	Phase 2
Total New Participant Funding $K	1,020.00
New MinEx $K	713.00
Total New Funding $K	1,733.00
MinEx Ph2 Additional Funding	552.00
Total Phase 2 Funding excl PCF $K	2,285.00
Total FTE Phase 2 Budget Cash $K	1,940.25
Total Phase 2 OPEX Budget $K	690.00
Net Cash Funding Phase 2	(345.25)
NCF Phase 2 + PCF Phase 1	(261.64)

Image redacted for reasons of commercial sensitivity

PROJECT 2 - RISKS & IMPEDIMENTS

Not securing additional funding for the AnTech activities.

Collaboration with Project OP4 after changes in Curtin University.

Availability of CT equipment for several months of project critical experiments due to NDI agenda and competing projects. Conflicting operational agendas, schedules and budgets between CT in the NDI and the CT research agenda.

Image redacted for reasons of commercial sensitivity

Questions ?

MinEx CRC

Australian Government
Department of Industry, Science, Energy and Resources

Business
Cooperative Research Centres Program

Coiled Tubing Drilling For Mineral Exploration – Project 2

MinEx CRC

MINEX CRC PROJECT 2 PRP MEETING - Q4, 2023

Agenda:
Welcome and “roll call” by Project Leader.

Progress Reporting

1. Update by Project Leader
    a. Project Overview
    b. General project progress
        i. Research
            1. Sample quality
            2. Positioning and sensing – AnTech discussion
            3. Steering - AnTech funding discussion
            4. Drilling to 1000 metres
            5. Drilling Support
        ii. New 2024 Project Milestones
    c. Project budget
    d. Project risks & impediments
    e. Commercialisation
    f. Discussion – Phase lll transition

Project 2 PRP Meeting

4. Project Review members reflection on the quarter - PRP-Chair
5. Advise if the Chair of a PRP will sign off project milestones within the MinEx CRC quarterly reporting structure.
6. General Business

MINEX CRC PROJECT 2 PRP MEETING - Q4, 2023

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Majors, METS and Survey Participants

AngloAmerican

BHP

SOUTH32

RioTinto

Geotec
Boyles Bros S.A.

IMDEX
REAL-TIME SUBSURFACE SOLUTIONS

AMC

REFLEX

McKAY
DRILLING
Setting the Standard

Epiroc

SANDVIK

wassara
STRAIGHT
FORWARD
DRILLING

Geological Survey of
Western Australia

SOUTH
AUSTRALIA

Government
of South Australia
Department for
Energy and Mining

NSW
GOVERNMENT

Australian Government
Geoscience Australia

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THE UNIVERSITY of ADELAIDE

Australian National University

CSIRO

Curtin University

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

University of South Australia

THE UNIVERSITY OF WESTERN AUSTRALIA

UNSW SYDNEY

AIC Mines Limited

AuScope

DATACODE

encounter RESOURCES LIMITED

EVIDENT

ENVIRO COPPER

HiSeis

Fe Lodestone Mines

MATSA RESOURCES

Middle Island RESOURCES LIMITED

MINALYZE

MONASH University

mriwa

Santos

SER Strategic Energy Resources

UNIVERSITY of TASMANIA

NORTHERN TERRITORY GOVERNMENT

GEOLOGICAL SURVEY OF VICTORIA

GEOLOGICAL SURVEY OF QUEENSLAND

Tasmanian Government

Health & Safety

No Incidents reported by Drilling Team or Project 2 in Q4

LIFE-OF-PROJECT PERFORMANCE TARGET

Develop sample integrity of CT drilling to that of Diamond drilling, then develop ability to drill multiple deviated holes, each up to 1000 m reach, from a single pad, landing within 10 m of target at end-of-hole and surveyed within 1 m, whilst maintaining the cost, rapidity, safety and environmental benefits of greenfields CT rig.

PROJECT 2: COILED TUBING DRILLING FOR DEFINITION OF MINERAL DEPOSITS

LEADER: Soren Soe

PARTICIPANTS: Anglo American, BHP, Epiroc, LKAB Wassara, MRIWA, South 32, Curtin University, CSIRO, UniSA

RESOURCES: $2.369M (cash) Phase ll (including $262k from Phase lll)
$933k (additional cash) Variation for AnTech Integration

PERFORMANCE TARGET (Life-of-MinEx CRC):

To improve the sample integrity of CT drilling to that of diamond drilling, then develop the ability to drill multiple deviated holes, up to 1000 m reach, from a single pad, to within 10 m of target and surveyed within 1 m, whilst maintaining the cost, rapidity, safety and environmental benefits of a greenfield CT rig.

PROJECT 2 - PARTICIPANTS

MINER	METS	SURVEY	RESEARCH
Anglo American	Epiroc		UniSA
BHP	LKAB Wassara		CSIRO
South 32			Curtin
MRIWA			

PROJECT 2 – RESEARCH

MODULE 1 - IMPROVE SAMPLE INTEGRITY OF CT DRILLING

MODULE 2 - DOWNHOLE POSITIONING SYSTEM & SENSING

MODULE 3 - DOWNHOLE STEERING SYSTEM

MODULE 4 - DRILLING TO A 1000 M REACH

3.85 FTE

MODULE 5 - DRILLING SUPPORT

1.6 FTE

PROJECT 2: Milestones 2022 Q4

Module 2) V2 prototype positioning system ready for field trials.

Module 3) Laboratory prototype for steering concept built.

Module 4) Characterise the performance of drilling additives in at least one borehole deeper than 500m and recommend improvements.

Module 4: E-line installed & Engineering completed for BHA

Module 4) MPD; Lab scale experiment & Valve selection completed for field deployment.

Module 5) Detailed plan and schedule for Y3 drilling trials and experiments

Update commercialisation and IP Roadmap based on year 2 research progress.

Conduct Participant workshop to review progress, reassess priorities and create quarterly milestones for Y3.

Image redacted for reasons of commercial sensitivity

Image redacted for reasons of commercial sensitivity

Image redacted for reasons of commercial sensitivity

Module 4) Characterise the performance of drilling additives in at least one borehole deeper than 500m and recommend improvements.

Key results

- 700m Borehole drilled at Wentworth.
- Only 30m of top casing
- 4 l/m fluid loss at Total depth = 100% returns
- Characterise performance of deep open hole drilling, LiqiCTrol performance and borehole integrity.
- Challenge to operate 24/7 due to crew shortage
- Continued Heavy rain impacted continues operation

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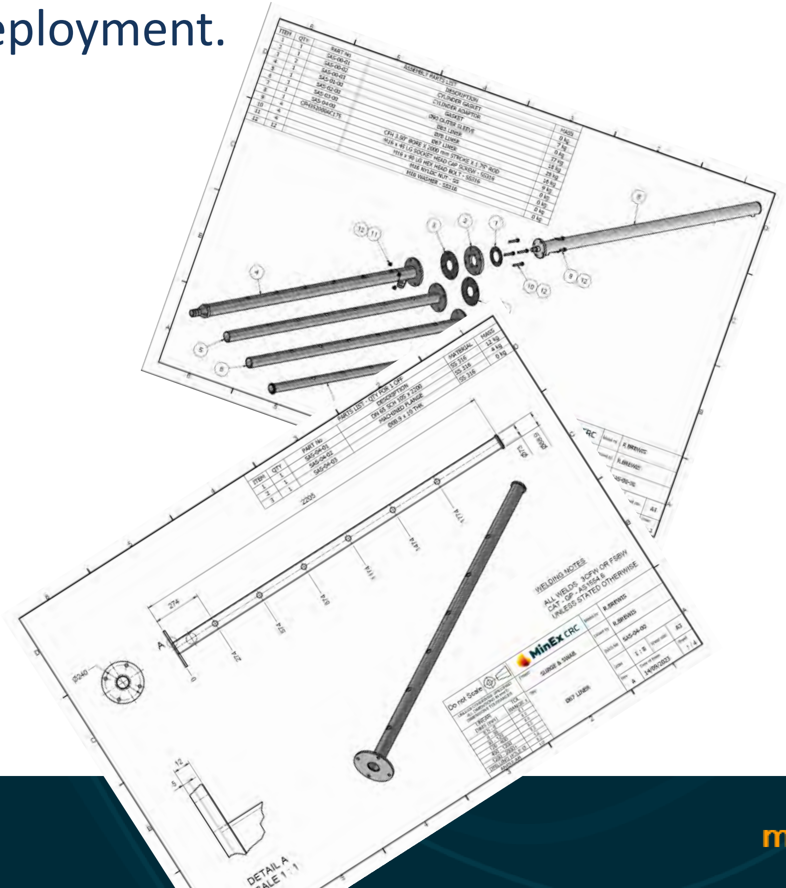
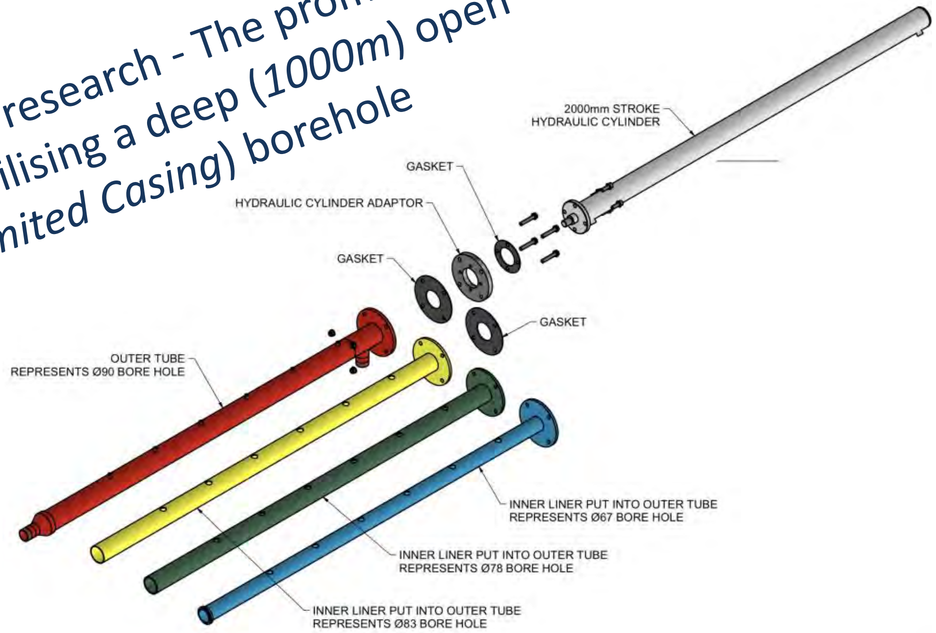
Module 4) MPD; Lab scale experiment & Valve selection completed for field deployment.

MPD research - The promise of stabilising a deep *(1000m)* open *(Limited Casing)* borehole





Update commercialisation and IP Roadmap based on year 2 research progress & Conduct Participant workshop to review progress, reassess priorities and create quarterly milestones for Y3.

TECHNOLOGY READINESS LEVEL (TRL)

DEPLOYMENT	9	ACTUAL SYSTEM PROVEN IN OPERATIONAL ENVIRONMENT
	8	SYSTEM COMPLETE AND QUALIFIED
	7	SYSTEM PROTOTYPE DEMONSTRATION IN OPERATIONAL ENVIRONMENT
DEVELOPMENT	6	TECHNOLOGY DEMONSTRATED IN RELEVANT ENVIRONMENT
	5	TECHNOLOGY VALIDATED IN RELEVANT ENVIRONMENT
	4	TECHNOLOGY VALIDATED IN LAB
RESEARCH	3	EXPERIMENTAL PROOF OF CONCEPT
	2	TECHNOLOGY CONCEPT FORMULATED
	1	BASIC PRINCIPLES OBSERVED

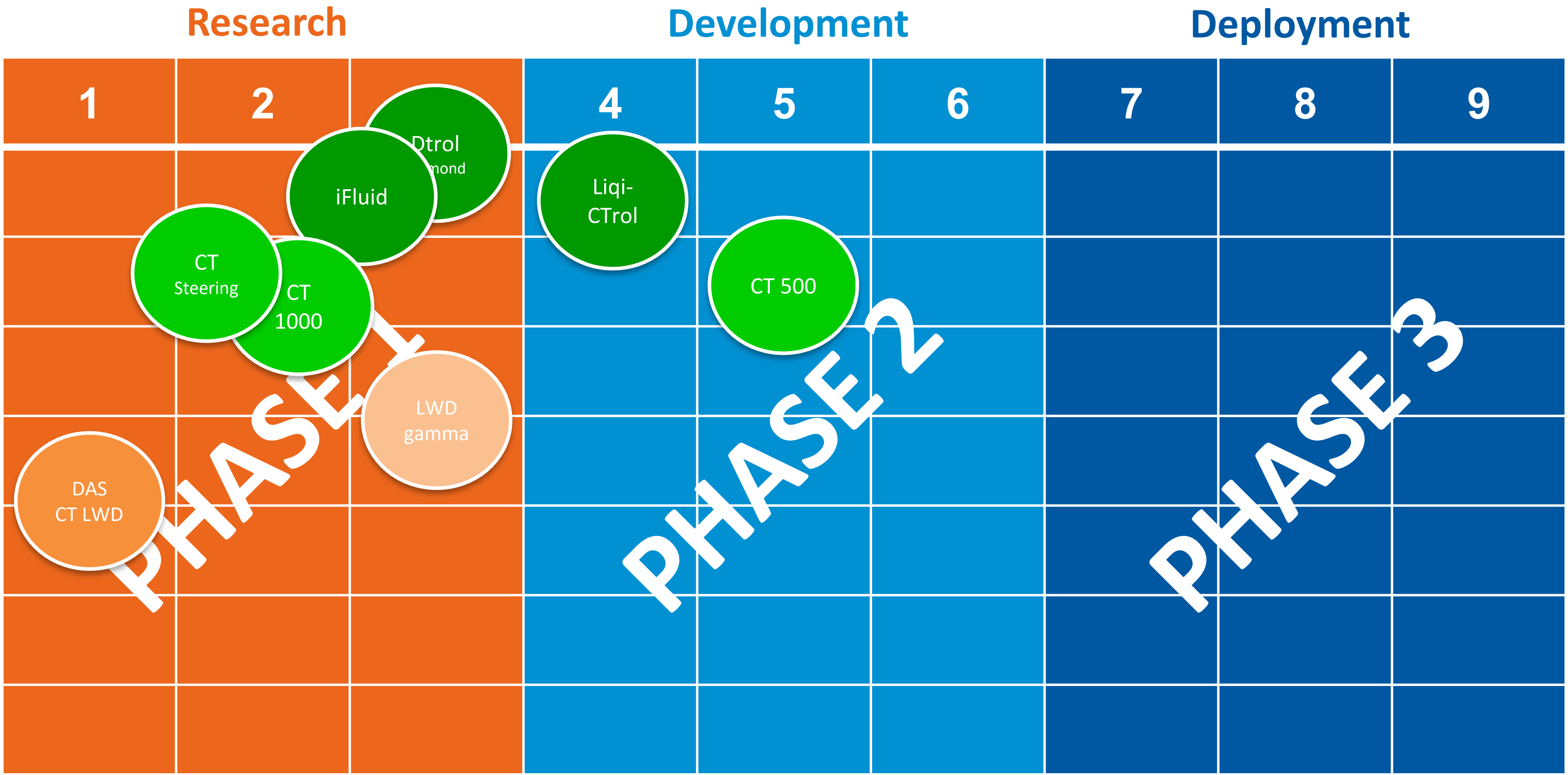
https://www.twi-global.com/technical-knowledge/faqs/technology-readiness-levels

MinEx CRC

CT Technology Readiness Levels 2019

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program

Department of Industry, Science, Energy and Resources
Cooperative Research Centres Program



MinEx CRC

CT Technology Readiness Levels 2023

Australian Government
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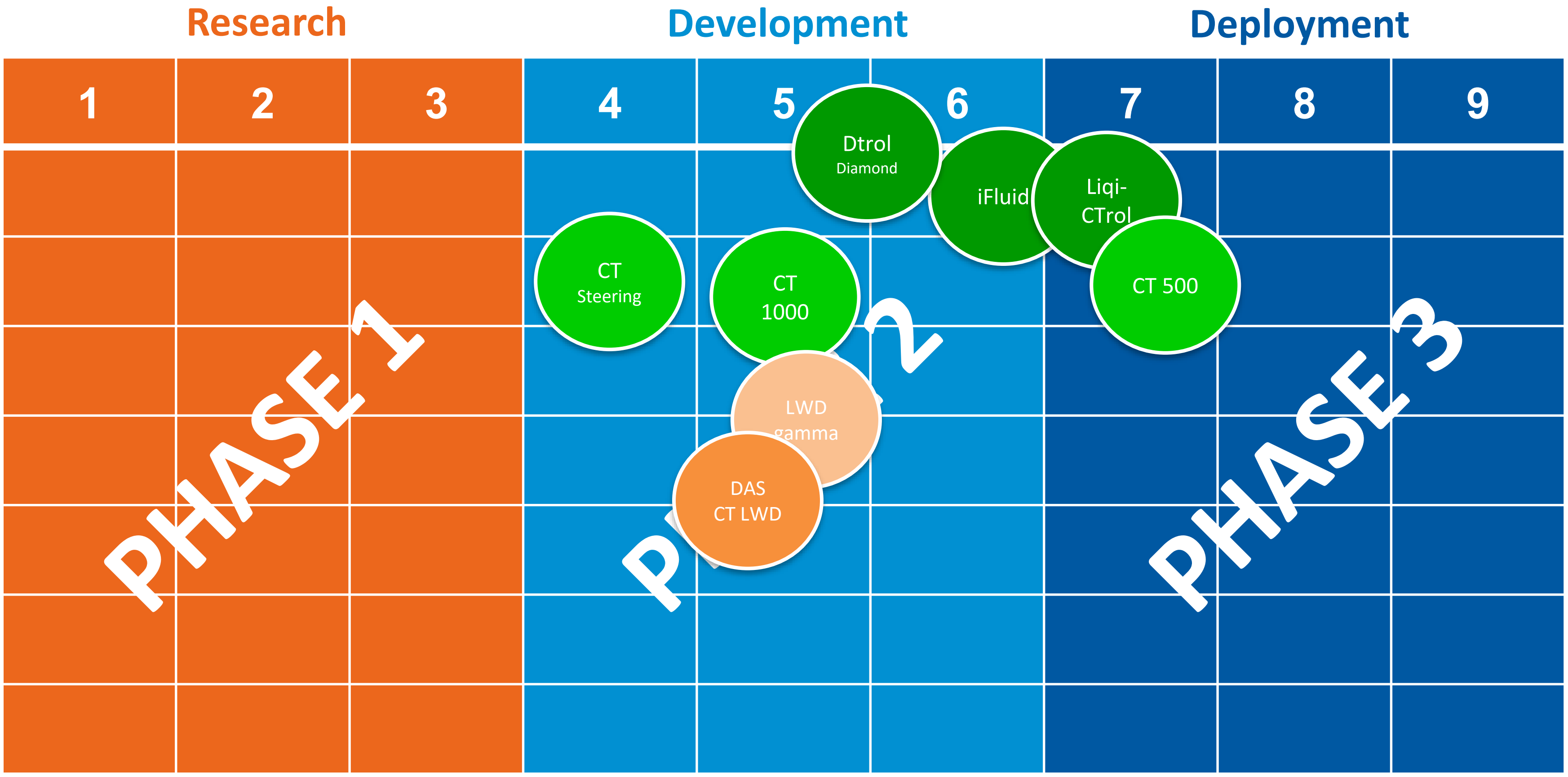

MinEx CRC

MinEx CRC Technology Readiness Levels 2023

Australian Government
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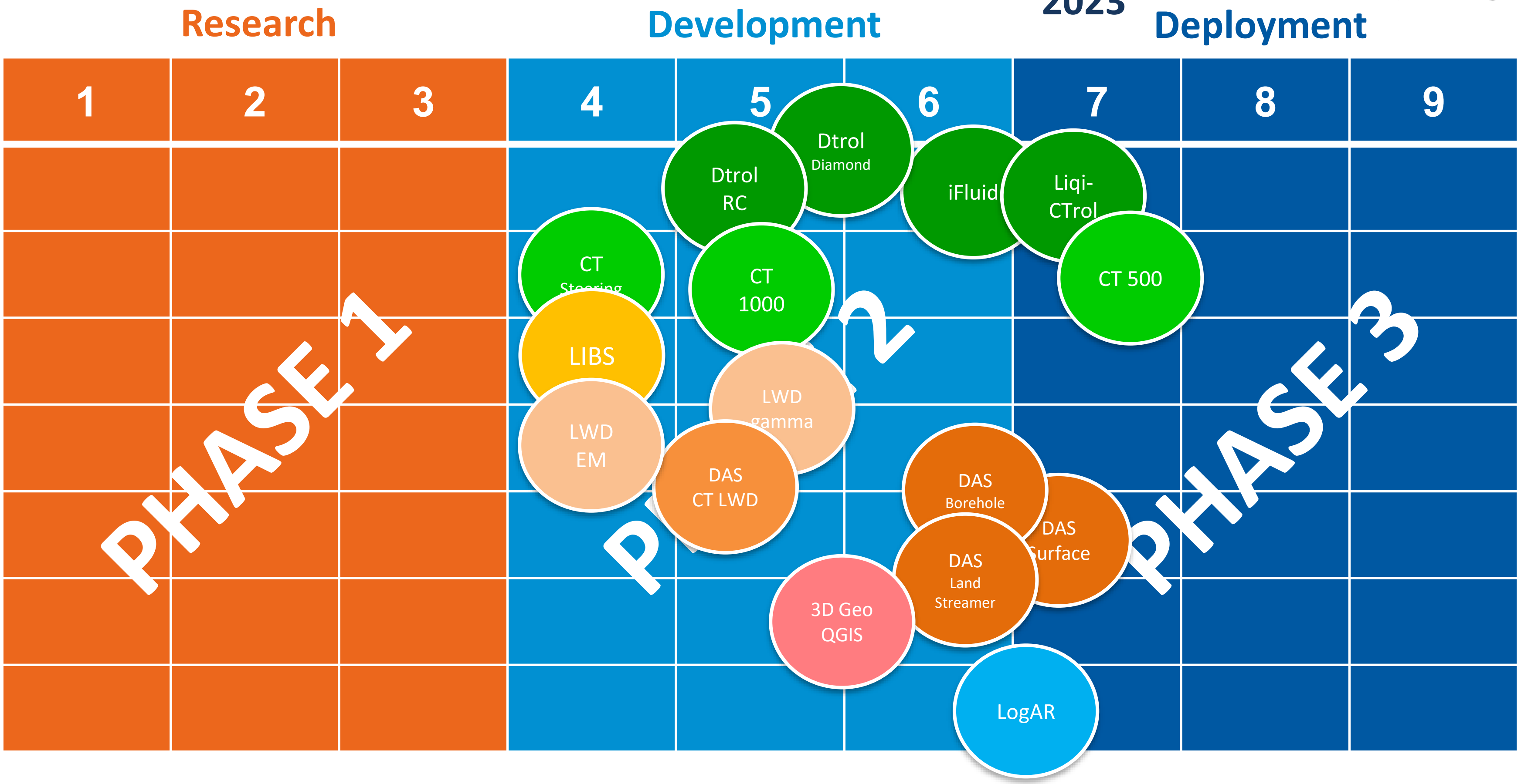
Cooperative Research Centres Program



Research

Development

Deployment

1
2
3
4
5
6
7
8
9

PHASE 1

PHASE 2

PHASE 3

Dtrol RC

Dtrol Diamond

iFluid

Liqi-CTrol

CT Steering

CT 1000

CT 500

LIBS

LWD gamma

LWD EM

DAS CT LWD

DAS Borehole

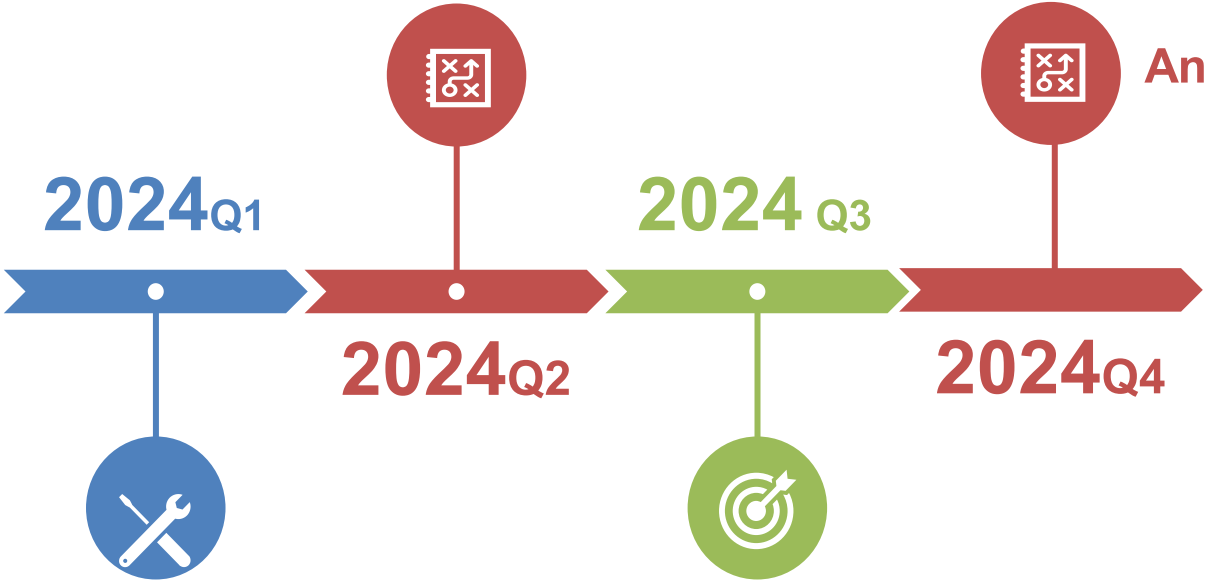
DAS Surface

DAS Land Streamer

3D Geo QGIS

LogAR

Module 5) Detailed plan and schedule for Y3 drilling trials and experiments.



2024Q1

Sidewall Coring + SMART BHA Trial & Order AnTech

2024Q2

RoXplorer 1000 prep for AnTech

2024 Q3

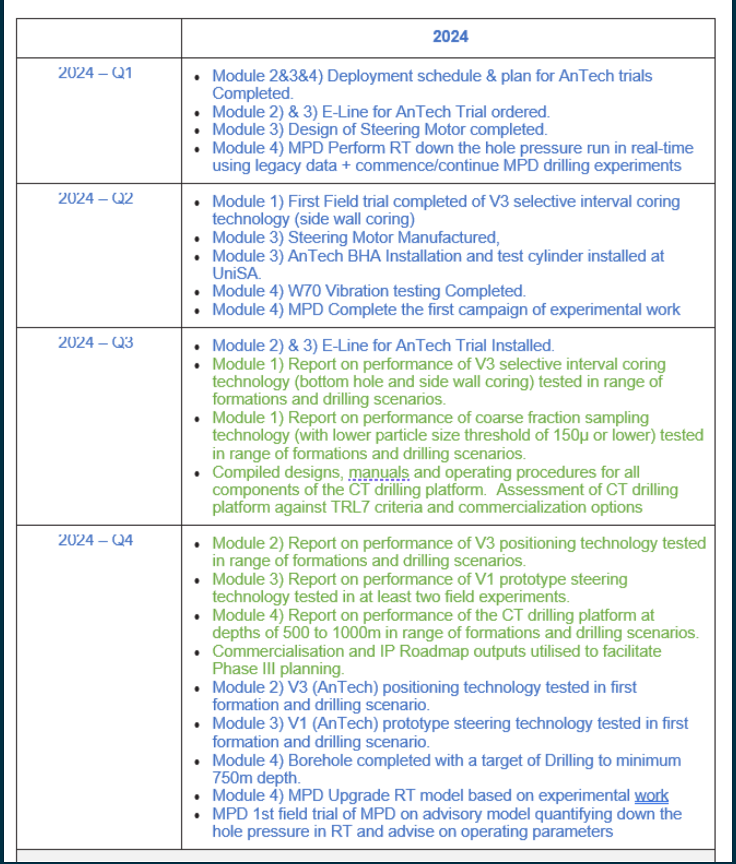
AnTech Drilling Trial 1 September

2024Q4

AnTech Drilling Trial 2 November


KDP for Phase III

PROJECT 2: Milestones 2024



	2024
2024 – Q1	• Module 2&3&4) Deployment schedule & plan for AnTech trials Completed. • Module 2) & 3) E-Line for AnTech Trial ordered. • Module 3) Design of Steering Motor completed. • Module 4) MPD Perform RT down the hole pressure run in real-time using legacy data + commence/continue MPD drilling experiments
2024 – Q2	• Module 1) First Field trial completed of V3 selective interval coring technology (side wall coring) • Module 3) Steering Motor Manufactured, • Module 3) AnTech BHA Installation and test cylinder installed at UniSA. • Module 4) W70 Vibration testing Completed. • Module 4) MPD Complete the first campaign of experimental work
2024 – Q3	• Module 2) & 3) E-Line for AnTech Trial Installed. • Module 1) Report on performance of V3 selective interval coring technology (bottom hole and side wall coring) tested in range of formations and drilling scenarios. • Module 1) Report on performance of coarse fraction sampling technology (with lower particle size threshold of 150μ or lower) tested in range of formations and drilling scenarios. • Compiled designs, manuals and operating procedures for all components of the CT drilling platform. Assessment of CT drilling platform against TRL7 criteria and commercialization options
2024 – Q4	• Module 2) Report on performance of V3 positioning technology tested in range of formations and drilling scenarios. • Module 3) Report on performance of V1 prototype steering technology tested in at least two field experiments. • Module 4) Report on performance of the CT drilling platform at depths of 500 to 1000m in range of formations and drilling scenarios. • Commercialisation and IP Roadmap outputs utilised to facilitate Phase III planning. • Module 2) V3 (AnTech) positioning technology tested in first formation and drilling scenario. • Module 3) V1 (AnTech) prototype steering technology tested in first formation and drilling scenario. • Module 4) Borehole completed with a target of Drilling to minimum 750m depth. • Module 4) MPD Upgrade RT model based on experimental work • MPD 1st field trial of MPD on advisory model quantifying down the hole pressure in RT and advise on operating parameters

Module 1) Improve the sample integrity of CT drilling

Module 2) Downhole positioning system

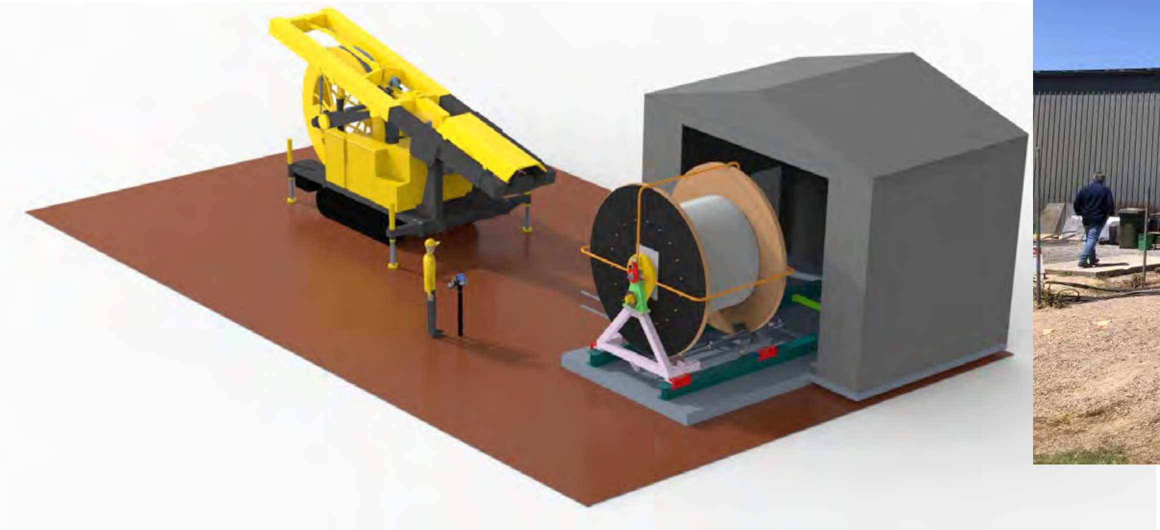
Module 3) Down hole steering system

Module 4) Drilling to a 1000m reach

Module 5) RoXplorer Systems Drilling support

Yard Spooler – Progress

Yard Spooler Design, engineering, manufacturing, commissioning and installation completed at UniSA.



PROJECT 2 BUDGET

YTD Opex and FTE spending is currently under budget, however, will be ramped up in 2024

PROJECT 2 - RISKS & IMPEDIMENTS

The risks involved in the transition for Project 2 going into Phase lll are highlighted in the notes from the Project Participants workshop and the final schedule for the AnTech drilling trials make the completion very close to the end of Phase ll.

Availability of CT equipment for several months of project critical experiments due to NDI agenda and competing projects. Conflicting operational agendas, schedules and budgets between CT in the NDI and the CT research agenda.

Commercialisation

Epiroc

A possible contract is being discussed with a private entity to take over the MinEx CRC drilling crew and RoXplorer® 500 system in 2024.

SCHRAMM®

Project 2 Phase III

2024 Q4

AnTech Drilling Trial 2 November & KDP December

2025

Scoping Study

2026

TBA

2027

TBA

PROJECT 2 Phase lll

Phase lll - Suggestion

2025 Scoping study:

A. BHA Steering Technology readiness for Mineral Exploration for CT Drilling
B. Business Viability for steering system.
  a) Market
  b) Cost reductions
C. Defining Milestones for 2026 and 2027
  a) Managed pressure drilling
  b) Drilling to 1000m
  c) Steering (a) AnTech, b) Wassara, c) SMART BHA with passive steering)

Additional Funding for Phase lll

- Additional participants

Questions ?

Australian Government
Department of Industry, Science, Energy and Resources

Business
Cooperative Research Centres Program

Coiled Tubing Drilling For Mineral Exploration – Project 2

MinEx CRC

MINEX CRC PROJECT 2 PRP MEETING - Q4, 2024

Agenda:
Welcome by Project Chair.

Progress Reporting

1. Update by Project Leader
   a. Project Overview
   b. General project progress
      i. Research
         1. Sample quality
         2. Positioning and sensing – AnTech discussion
         3. Steering - AnTech funding discussion
         4. Drilling to 1000 metres
         5. Drilling Support
      ii. 2024 & 2025 AnTech Project Milestone consolidation.
   c. Project budget end Phase ll
   d. Project risks & impediments
   e. Commercialisation
   f. Discussion – Phase lll transition

Project 2 PRP Meeting

4. Project Review members reflection on the quarter - PRP-Chair
5. Advise if the Chair of a PRP will sign off project milestone consolidation within the MinEx CRC quarterly reporting structure.
6. General Business

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BHP

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Geotec Boyles Bros S.A.

IMDEX REAL-TIME SUBSURFACE SOLUTIONS

AMC

REFLEX

McKAY DRILLING Setting the Standard

Epiroc

SANDVIK

wassara STRAIGHT FORWARD DRILLING

Geological Survey of Western Australia

SOUTH AUSTRALIA

Government of South Australia
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THE UNIVERSITY of ADELAIDE

Australian National University

CSIRO

Curtin University

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

University of South Australia

THE UNIVERSITY OF WESTERN AUSTRALIA

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MinEx CRC

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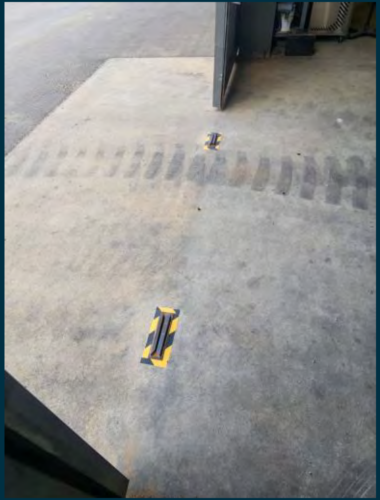
Health & Safety

Incidents reported by MinEx CRC Employee working at UniSA in Q4



LIFE-OF-PROJECT PERFORMANCE TARGET

Develop sample integrity of CT drilling to that of Diamond drilling, then develop ability to drill multiple deviated holes, each up to 1000 m reach, from a single pad, landing within 10 m of target at end-of-hole and surveyed within 1 m, whilst maintaining the cost, rapidity, safety and environmental benefits of greenfields CT rig.

PROJECT 2: COILED TUBING DRILLING FOR DEFINITION OF MINERAL DEPOSITS

LEADER:	Soren Soe
PARTICIPANTS:	Anglo American, BHP, Epiroc, LKAB Wassara, MRIWA, South 32, Curtin University, CSIRO, UniSA
RESOURCES:	$2.369M (cash) Phase ll (including $262k from Phase lll) $933k (additional cash) Variation for AnTech Integration

PERFORMANCE TARGET (Life-of-MinEx CRC):

To improve the sample integrity of CT drilling to that of diamond drilling, then develop the ability to drill multiple deviated holes, up to 1000 m reach, from a single pad, to within 10 m of target and surveyed within 1 m, whilst maintaining the cost, rapidity, safety and environmental benefits of a greenfield CT rig.

PROJECT 2 - PARTICIPANTS

MINER	METS	SURVEY	RESEARCH
Anglo American	Epiroc		UniSA
BHP	LKAB Wassara		CSIRO
South 32			Curtin
MRIWA			

PROJECT 2 – RESEARCH

MODULE 1 - IMPROVE SAMPLE INTEGRITY OF CT DRILLING

MODULE 2 - DOWNHOLE POSITIONING SYSTEM & SENSING

MODULE 3 - DOWNHOLE STEERING SYSTEM

MODULE 4 - DRILLING TO A 1000 M REACH

MODULE 5 - DRILLING SUPPORT

PROJECT 2: Milestones 2024 Q4
Not related to AnTech Trials

- Commercialisation and IP Roadmap outputs utilised to facilitate Phase III planning.

- Module 4) MPD Upgrade RT model based on experimental work.

- Module 4) MPD 1st field trial of MPD on advisory model quantifying down the hole pressure in RT and advise on operating parameters

Commercialisation and IP Roadmap

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program

Research

Coil Tube research

RoXplorer drilled 407m

Kapunda

Selective Coring &
Sidewall coring

2010
2013
2017
2018
Phase 1
2021
2022
Phase 2
Phase 3
2028

DEEP EXPLORATION TECHNOLOGIES CRC
Uncovering the future

Commenced

Nevada

MinEx CRC

Commenced

Commercial operations DIGCT
Commercial operations: 1x complete RoXplorer.

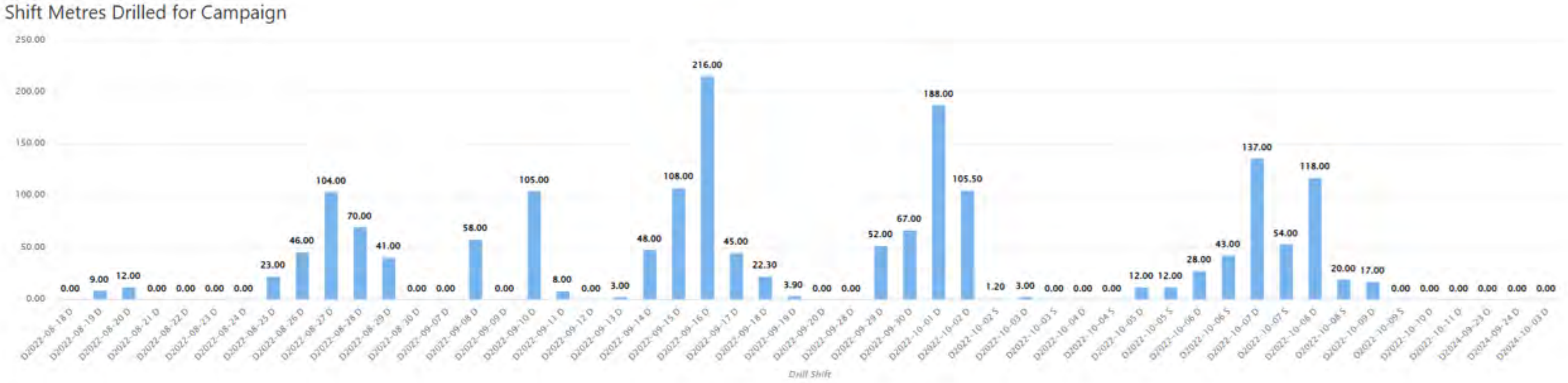
NDI – GSSA
RoXplorer drilled 700m

Anglo American

Anglo American Shift Metres

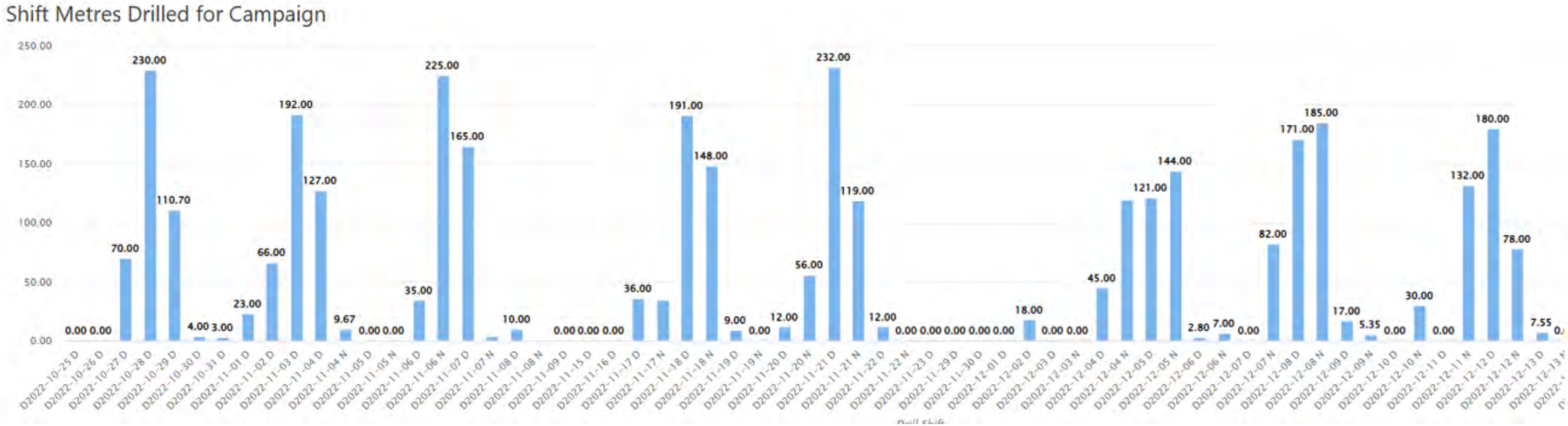
First Swing

AA01



Second Swing

AA02



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MinEx CRC

MinEx CRC Technology Readiness Levels 2024

Australian Government
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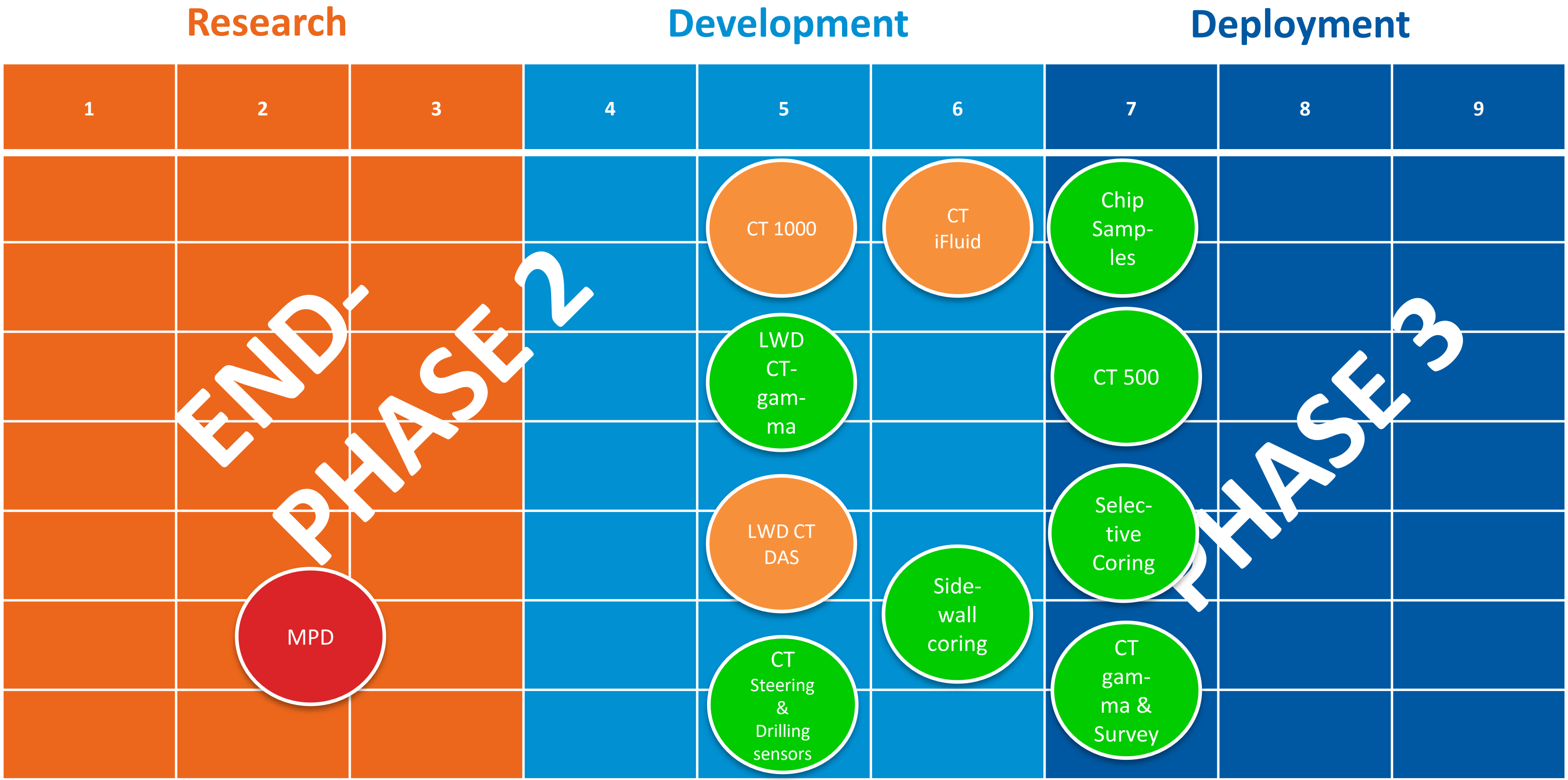
Business
Cooperative Research
Centres Program

Department of Industry, Science, Energy and Resources
Cooperative Research
Centres Program



Research

Development

Deployment

1

2

MPD

3

END-PHASE 2

4

5

CT 1000

LWD CT-gamma

LWD CT DAS

CT Steering & Drilling sensors

6

CT iFluid

Side-wall coring

7

Chip Samples

CT 500

Selective Coring

CT gamma & Survey

8

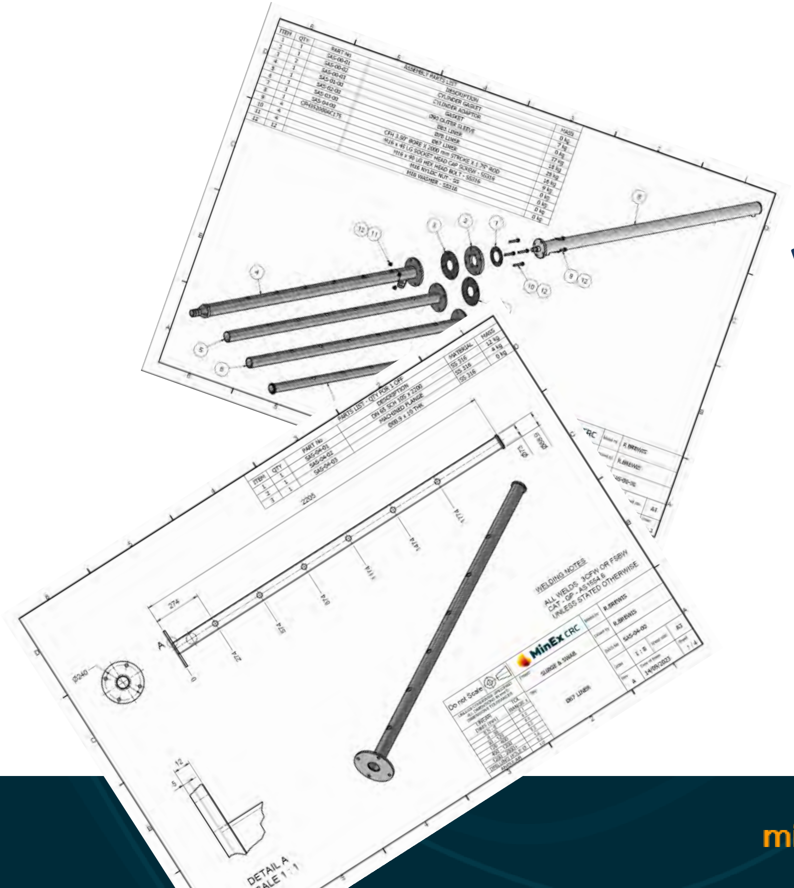
9

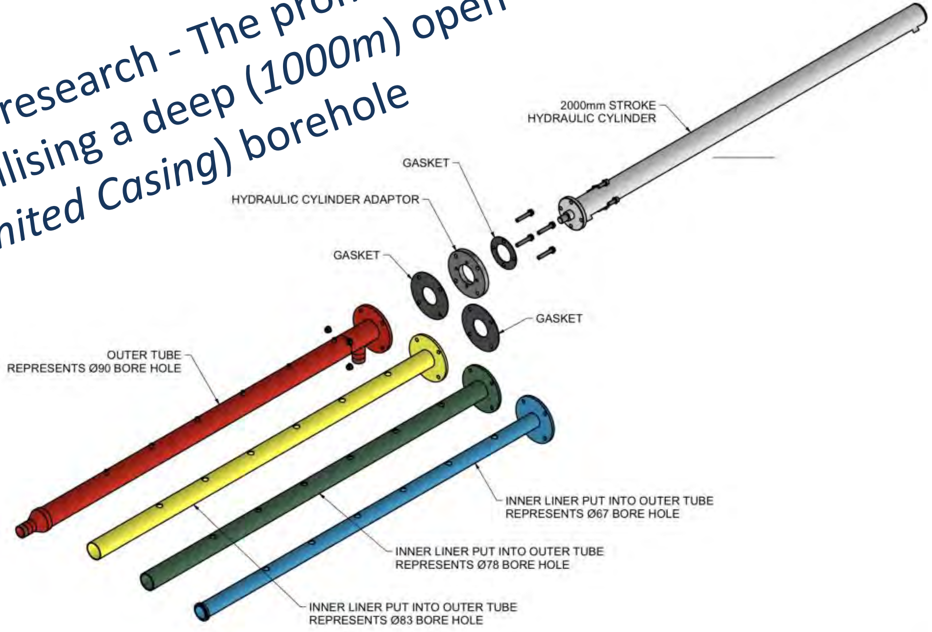
PHASE 3

Image redacted for reasons of commercial sensitivity

Module 4) MPD Upgrade RT model based on experimental work.

MPD research - The promise of stabilising a deep (*1000m*) open (*Limited Casing*) borehole





Field Deployment on Advisory Mode

- Software upgrade on iFluid to manage deployment of Depth algorithm along with MPD.
- Ability to receive and change operating parameters by multiple computer in the loop
- Ability to run multiple algorithms in true real-time at the same time.
- Ability to test remotely.

Return Flow (lpm) 0

Viscosity (cp) 14.20

Viscosity (OR) 28.40

Fluid Loss (lpm) 149.46

Percent Fluid Loss (%) 100.00

Bit Position (m) From Ground 130.94

Next Sampling Depth (m) 249.2...

Borehole Depth (m) 249.21

Hole Diameter (mm) 95.00

ROP (m/s) 0

BAG ID 249

Sampling Interval -- To 0

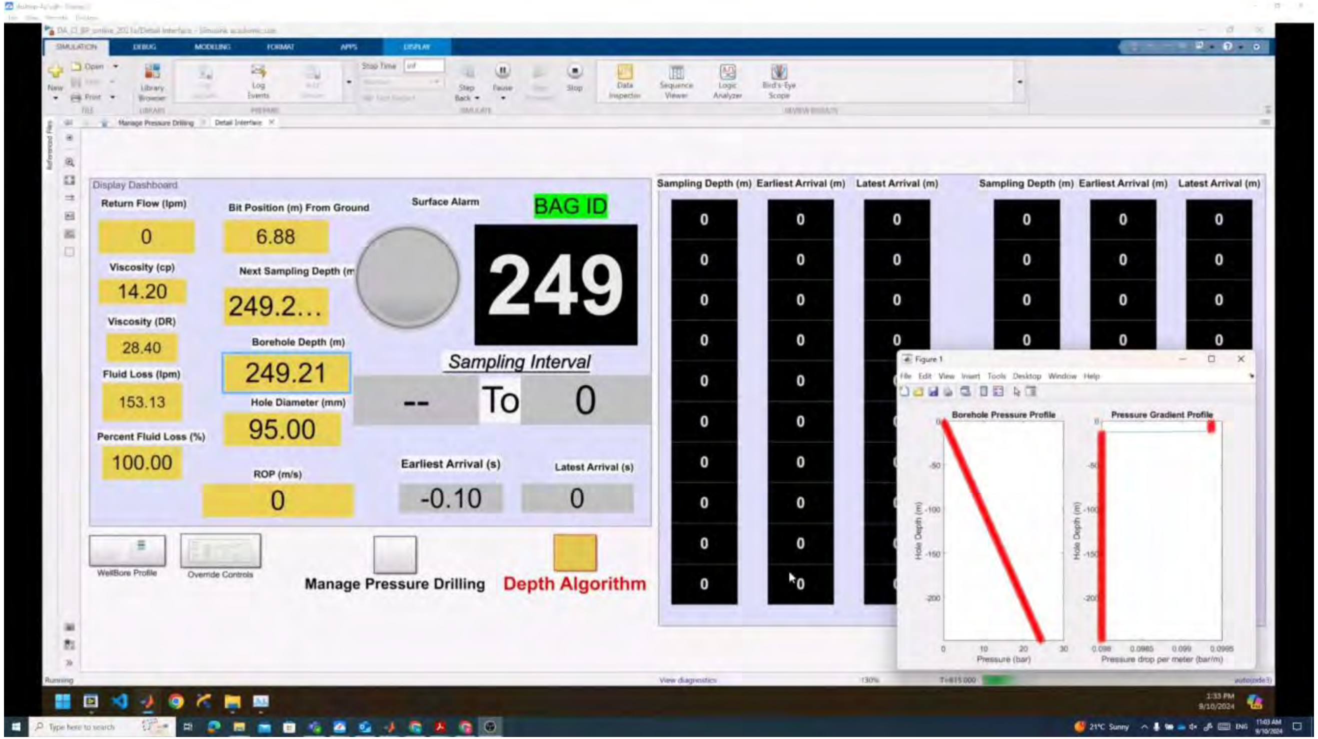
Earliest Arrival (s) -0.10

Latest Arrival (s) 0

Field Deployment on Advisory Mode

Trip In:

- Real-time measurement of downhole pressure profile.
- SA deployment 9th Oct 2024
- Trip in and trip out conducted.
- Experimental setup will be used to make the model more accurate in next quarters



Return Flow (lpm): 0

Bit Position (m) From Ground: 6.88

Viscosity (cp): 14.20

Next Sampling Depth (m: 249.2...

Viscosity (DR): 28.40

Borehole Depth (m): 249.21

Fluid Loss (lpm): 153.13

Hole Diameter (mm): 95.00

Percent Fluid Loss (%): 100.00

ROP (m/s): 0

BAG ID: 249

Sampling Interval: -- To 0

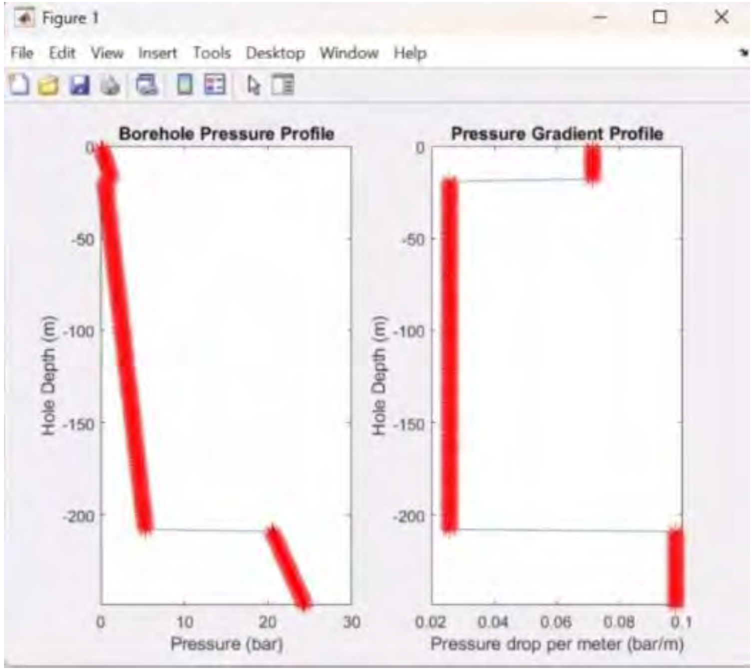
Earliest Arrival (s): -0.10

Latest Arrival (s): 0

Sampling Depth (m)	Earliest Arrival (m)	Latest Arrival (m)	Sampling Depth (m)	Earliest Arrival (m)	Latest Arrival (m)
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0				
0	0				
0	0				
0	0				
0	0				
0	0				

Field Deployment on Advisory Mode

Trip out



Trip In

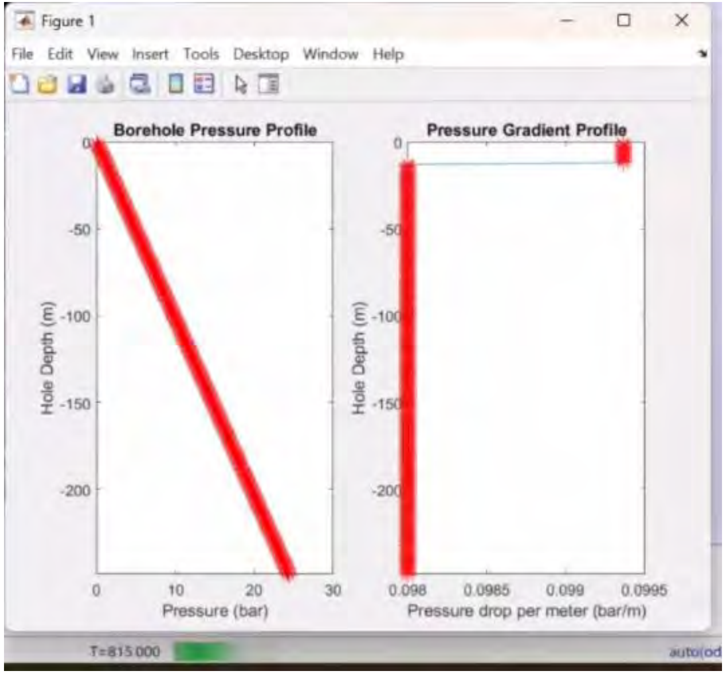


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Image redacted for reasons of commercial sensitivity

Image redacted for reasons of commercial sensitivity

Commonwealth milestones:

RP1.2.4 Prototype **sampling, positioning, steering and extended reach technologies** incorporated in Coiled Tubing drilling platform and trailed in field setting completed. Recommended modifications and pathway toward V2 prototype technologies completed.

Start	Finish
01/01/22	30/06/25

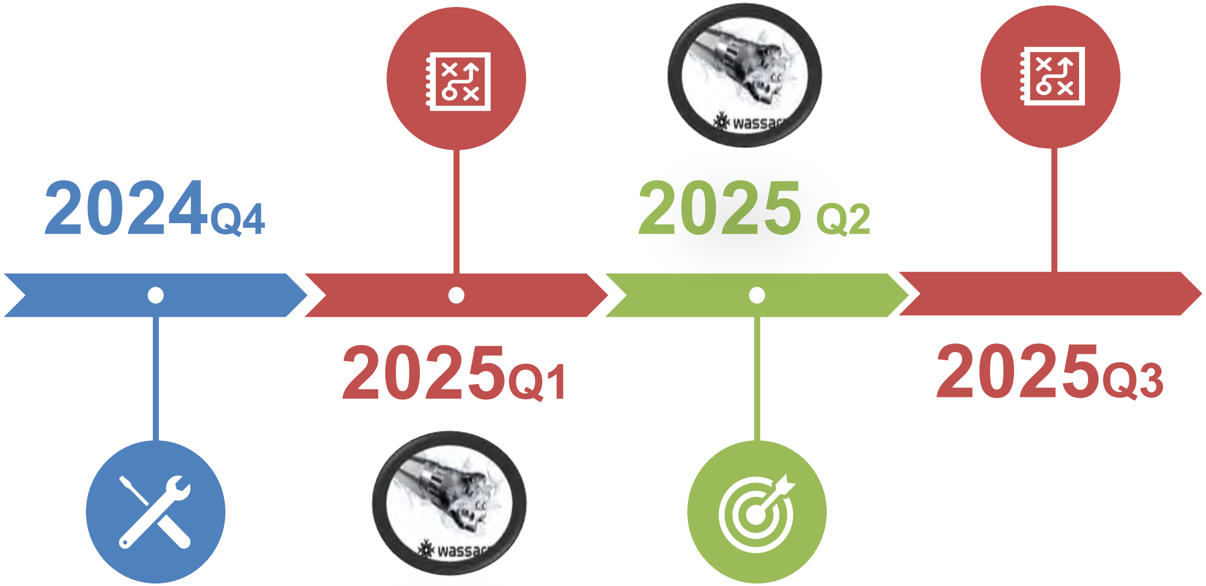
RP1.2.5 V2 prototype technologies incorporated in Coiled Tubing drilling platform and trailed in field setting completed.

Start	Finish
01/01/25	30/06/28

RP1.2.6 Utilisation / Commercialisation agreements for next generation Coiled Tubing drilling platform completed and in place.

Start	Finish
01/01/25	30/06/28

Prep for AnTech & Potential BHP trial



AnTech Drilling Tool Integration at UniSA


AnTech Drilling Trial
July 2025

PROJECT 2 BUDGET

YTD Opex and FTE spending is currently on budget and OPEX almost spend.

	Phase 2	Phase 2 Estimate for 2024 Q4
New Participant Funding Phase 2 $K	**$ 1,020.00**	**$ 1,003.00**
New MinEx Project Funding Phase 2 $K	**$ 713.00**	**$ 713.00**
Total Project Funding Phase 2 $K	**$ 1,733.00**	**$ 1,716.00**
Total MinEx Ph2 Additional Funding ($K)	**$ 552.00**	**$ 552.00**
Total Phase 2 Funding ($K)	**$ 2,285.00**	**$ 2,268.00**
FTE Budget Cash Phase 2 $K	**$ 1,940.25**	**$ 1,857.10**
Total Phase 2 Opex Budget $K	**$ 690.00**	**$ 690.00**
Net Cash Funding Phase 2	**-$ 345.25**	**-$ 279.10**
PCF (Project carry forward) Phase 1	**$ 83.55**	**$ 83.55**
NCF Phase 2 + PCF Phase 2	**-$ 261.70**	**-$ 195.55**

EY-ESTIMATE

OPEX:
$182.000 Spend towards AnTech Tooling

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PROJECT 2 - RISKS & IMPEDIMENTS

The risks involved in the transition for Project 2 going into Phase lll are highlighted in the notes from the Project Participants workshop and the final schedule for the AnTech drilling trials make the completion very close to the end of Phase ll.

Availability of CT equipment for several months of project critical experiments due to NDI agenda and competing projects. Conflicting operational agendas, schedules and budgets between CT in the NDI and the CT research agenda.

A workable model to transfer reliable CT drilling Productivity and knowledge to operators.

MinEx CRC

Australian Government
Department of Industry, Science, Energy and Resources
Business Cooperative Research Centres Program

Commercialisation

Contract executed with SCHRAMM/Epiroc to take over the MinEx CRC drilling equipment manufacturing.

Contract Implemented mid-February with DIGCT taking over the MinEx CRC drilling operation inclusive most of the crew and RoXplorer® 500 – System’s equipment.

Epiroc

SCHRAMM

DIG CT

Questions ?

Coiled Tubing Drilling For Mineral Exploration – Project 2

MinEx CRC

Agenda:
Welcome by Project Chair.

Progress Reporting

1. Update by Project Leader
    a. Project Overview
    b. General project progress
        i. Research
            1. DOWNHOLE POSITIONING,LOGGING AND STEERING
            2. 1000M DEPTH CAPACITY
            3. SAMPLE QUALITY OF CT DRILLING
    c. Project budget
    d. Project risks & impediments
    e. Commercialisation

Project 2 PRP Meeting

4. Project Review members reflection on the quarter - PRP-Chair
5. Advise if the Chair of a PRP will sign off project milestone consolidation within the MinEx CRC quarterly reporting structure.
6. General Business

MINEX CRC PROJECT 2 PRP MEETING - Q1, 2025

OUR SPONSORS

Majors, METS and Survey Participants

AngloAmerican

BHP

RioTinto

Geotec Boyles Bros S.A.

Fortescue

IMDEX™

McKAY DRILLING
Setting the Standard

Epiroc

SANDVIK

wassara

Geological Survey of Western Australia

SOUTH AUSTRALIA

Government of South Australia
Department for Energy and Mining

NSW GOVERNMENT

Australian Government
Geoscience Australia

OUR SPONSORS

Research Participants and Affiliates

THE UNIVERSITY of ADELAIDE

Australian National University

CSIRO

Curtin University

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

University of South Australia

THE UNIVERSITY OF WESTERN AUSTRALIA

UNSW SYDNEY

ANGLOGOLD ASHANTI

AIC Mines Limited

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mriwa Minerals Research Institute of Western Australia

SER Strategic Energy Resources

MONASH University

SOUTH32

VERACIO

GEOLOGICAL SURVEY OF VICTORIA

GEOLOGICAL SURVEY OF QUEENSLAND

Tasmanian Government

NORTHERN TERRITORY GOVERNMENT

Health & Safety

Nothing to report

LIFE-OF-PROJECT PERFORMANCE TARGET

Develop sample integrity of CT drilling to that of Diamond drilling, then develop ability to drill multiple deviated holes, each up to 1000 m reach, from a single pad, landing within 10 m of target at end-of-hole and surveyed within 1 m, whilst maintaining the cost, rapidity, safety and environmental benefits of greenfields CT rig.

PROJECT 2: COILED TUBING DRILLING FOR DEFINITION OF MINERAL DEPOSITS

LEADER: Soren Soe

PARTICIPANTS: Anglo American, BHP, Epiroc, LKAB Wassara, MRIWA, Curtin University, UniSA

RESOURCES: $1.175M (cash) Phase lll with OPEX of $194.000

PERFORMANCE TARGET (Life-of-MinEx CRC):

To improve the sample integrity of CT drilling to that of diamond drilling, then develop the ability to drill multiple deviated holes, up to 1000 m reach, from a single pad, to within 10 m of target and surveyed within 1 m, whilst maintaining the cost, rapidity, safety and environmental benefits of a greenfield CT rig.

PROJECT 2 - PARTICIPANTS

MINER	METS	SURVEY	RESEARCH
Anglo American	Epiroc		UniSA
BHP	LKAB Wassara		Curtin
(VALE)			
MRIWA			

PROJECT 2 – RESEARCH

MODULE 1 – DOWNHOLE POSITIONING,LOGGING AND STEERING

MODULE 2 – 1000M DEPTH CAPACITY

MODULE 3 – SAMPLE QUALITY OF CT DRILLING

New Module names and order

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Image redacted for reasons of commercial sensitivity

Image redacted for reasons of commercial sensitivity

PROJECT 2: Milestones 2025 Q1

Module 1: Establish KPIs for each potential avenue toward positioning, logging and steering function on the MinEx CRC CT drilling platform.

Module 2&3: Wassara to host an onsite visit from representatives of the MinEx Project 2 team to the Wassara drill site to see the technology in deployment.

Module 1.2&3: BHP to confirm schedule, budget and scope for RoXplorer Trials.

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KPI's toward positioning, logging and steering

In Logging While Drilling (LWD) and Steering technology development, transitioning from **Technology Readiness Level (TRL) 3 to TRL 5** involves refining prototypes and validating performance in relevant environments. Below are five **key indicators** to track during this phase. It is too early to define values.

1. **Prototype Performance & Reliability** – Measures how consistently the technology operates under simulated field conditions, ensuring it meets design expectations.
2. **Data Accuracy & Interpretation** – Evaluates the precision of logging data and its usability for decision-making, crucial for steering optimization.
3. **Telemetry & Communication Efficiency** – Assesses the speed and reliability of data transmission from downhole tools to surface systems.
4. **Operational Integration & Compatibility** – Tracks how well the technology integrates with existing drilling systems, minimizing disruptions.
5. **Field Testing Success Rate** – Monitors the percentage of successful trials in real-world drilling environments, confirming readiness for further development.

Wassara

Feb 2025

Wassara – Gallivare Mine Visit

Future Drilling System

- Large ‘hammer cuttings’
- High ROP 1.1m/min

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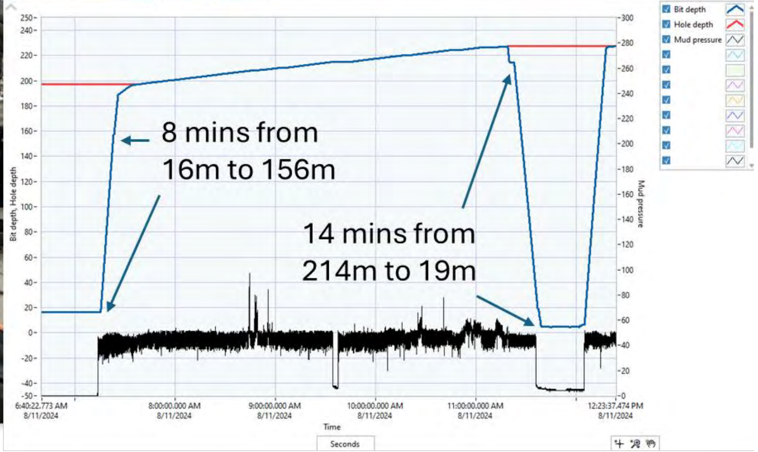
Project 2 overview Module 2
1000 metres depth capacity

Managed Pressure Drilling Experiment

Coober Pedy 03 - 08/11/2024

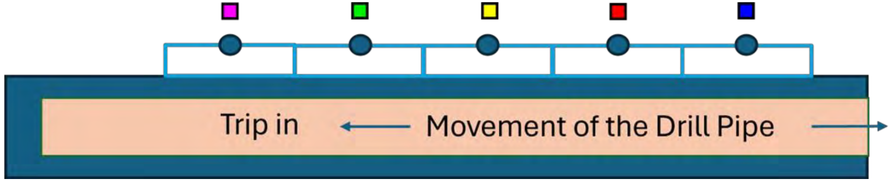


8 mins from 16m to 156m

14 mins from 214m to 19m

140 m / 480 s = 0.25 m/s tripping in

195 m / 840 s = 0.23 m/s tripping out

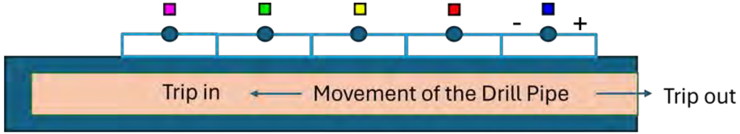


Trip in ← Movement of the Drill Pipe → Trip out

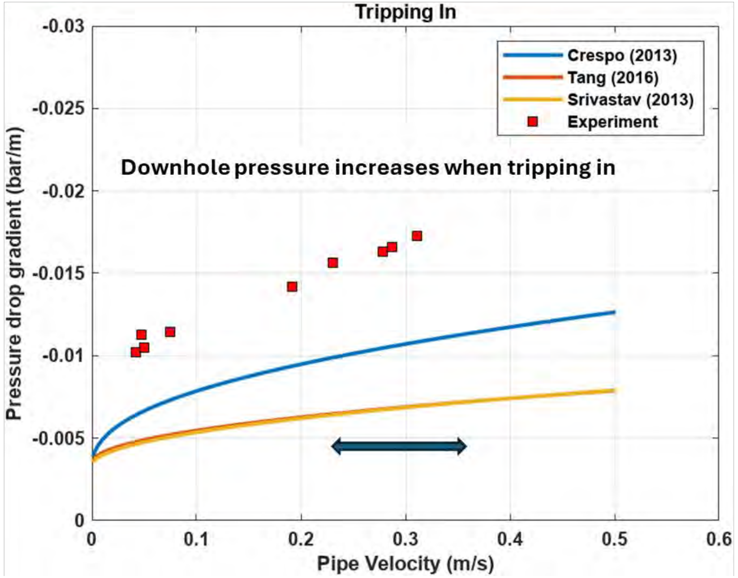
Project 2 overview Module 2
1000 metres depth capacity

Managed Pressure Drilling Experiment

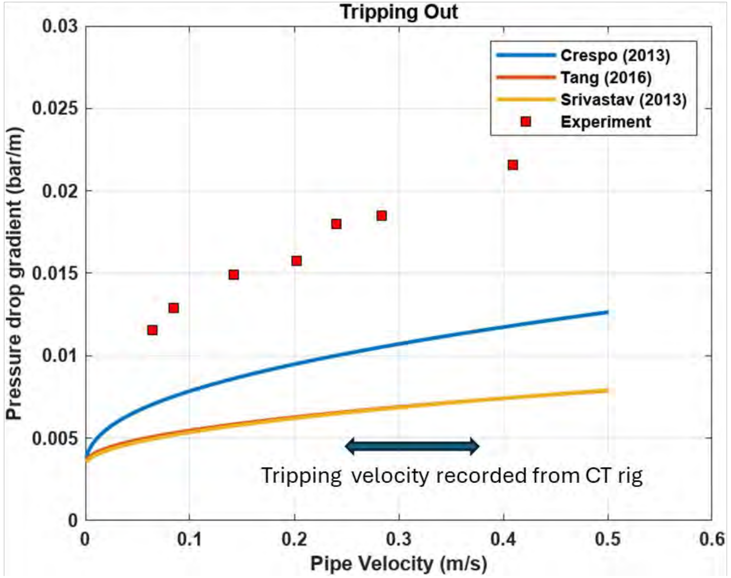
Drilling Mud	: UDF
Marsh Funnel	: 198 seconds
Viscosity @ 1000 1/s	: 28.1 cp



Downhole pressure decreases when tripping out

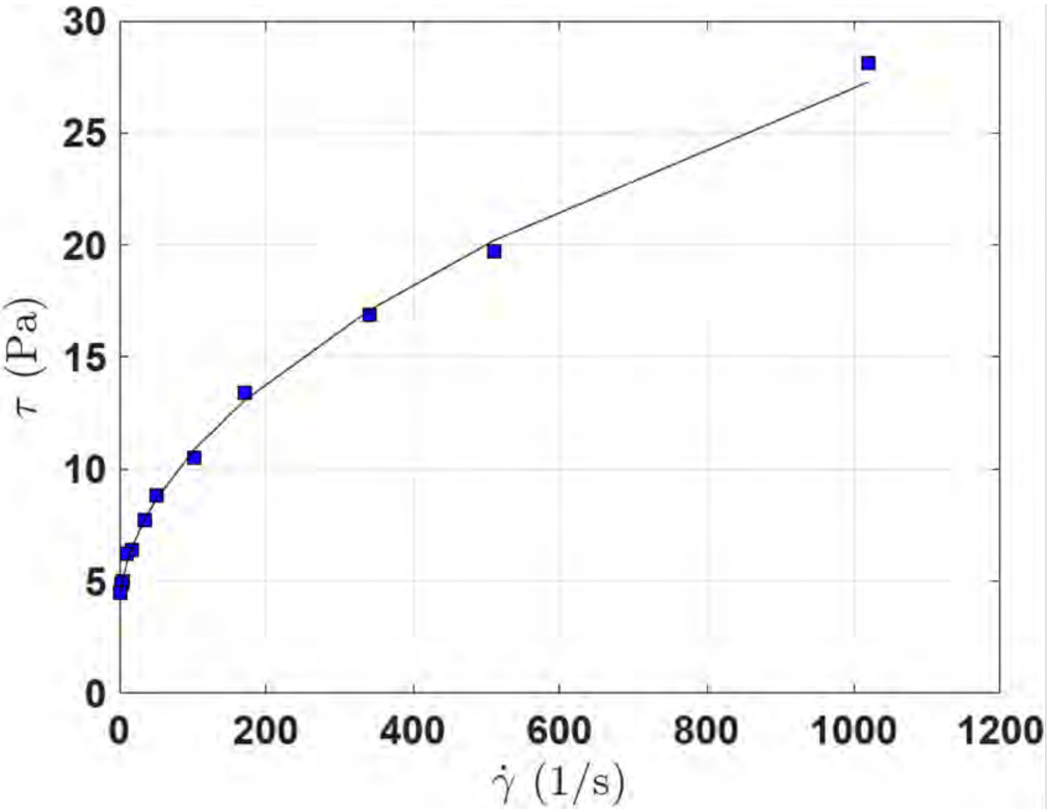


Downhole pressure increases when tripping in



Tripping velocity recorded from CT rig

Project overview Module 1
downhole positioning, logging and steering

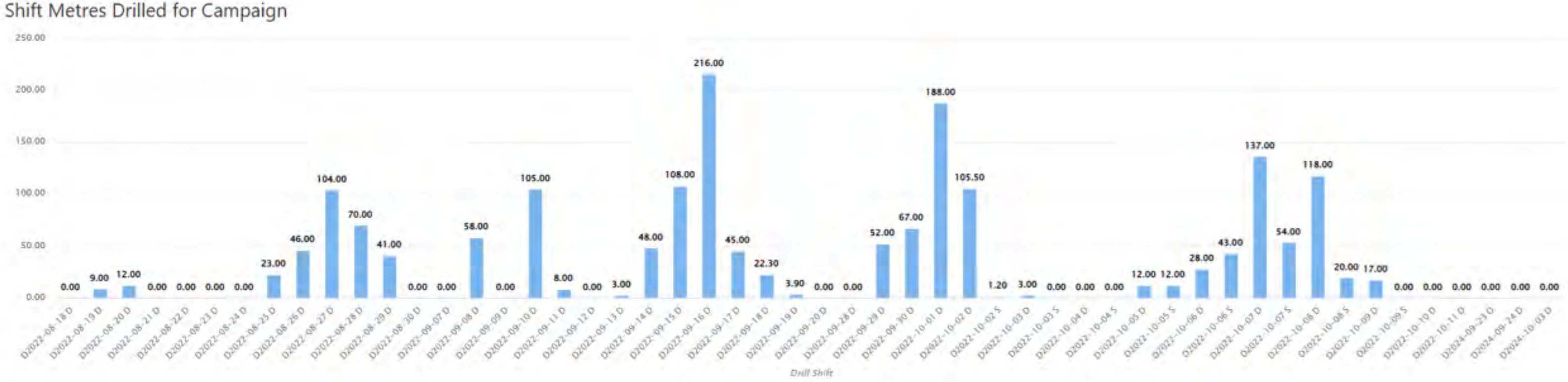


Yield stress : 3.6 Pa
Consistency, K : 0.6808
Behaviour : 0.5123

Anglo American Shift Metres

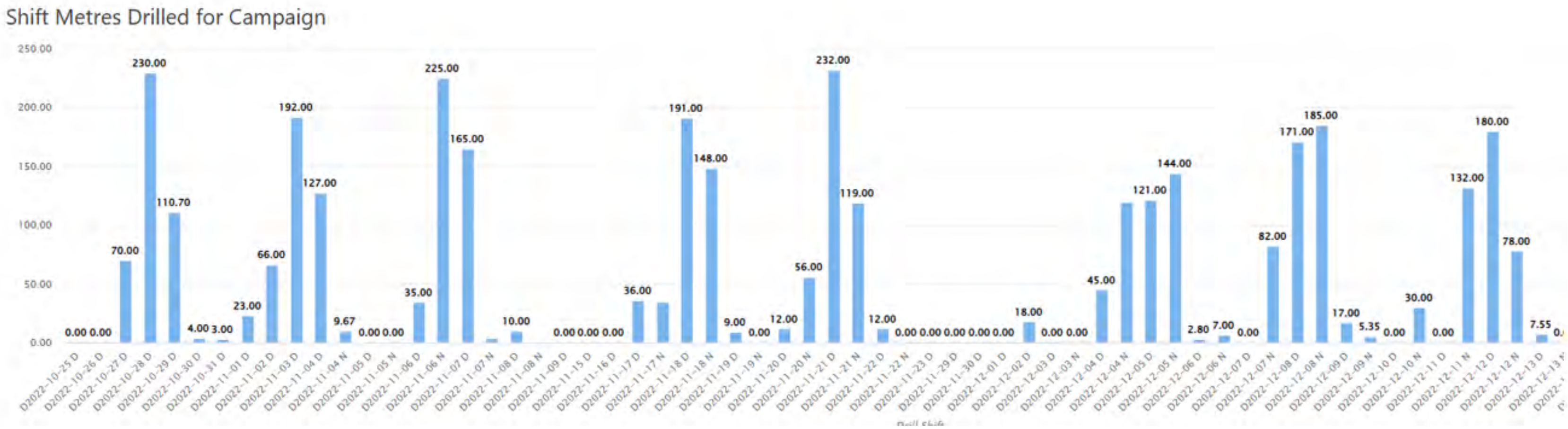
First Swing

AA01

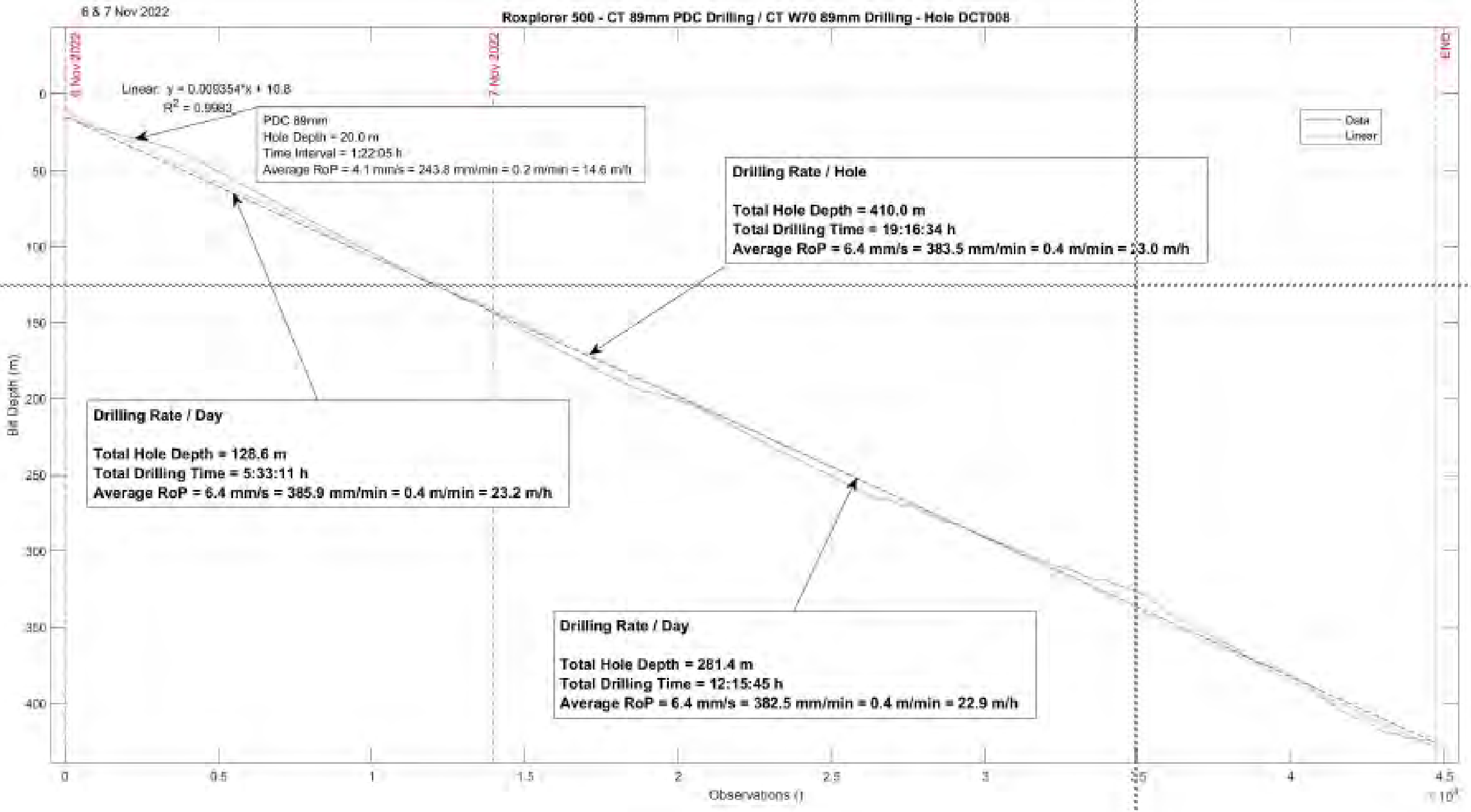


Second Swing

AA02



Project overview CT Drilling



6 & 7 Nov 2022

Roxplorer 500 - CT 89mm PDC Drilling / CT W70 89mm Drilling - Hole DCT008

Linear: $y = 0.009354*x + 10.8$
$R^2 = 0.9983$

PDC 89mm
Hole Depth = 20.0 m
Time Interval = 1:22:05 h
Average RoP = 4.1 mm/s = 243.8 mm/min = 0.2 m/min = 14.6 m/h

Drilling Rate / Hole

Total Hole Depth = 410.0 m
Total Drilling Time = 19:16:34 h
Average RoP = 6.4 mm/s = 383.5 mm/min = 0.4 m/min = 23.0 m/h

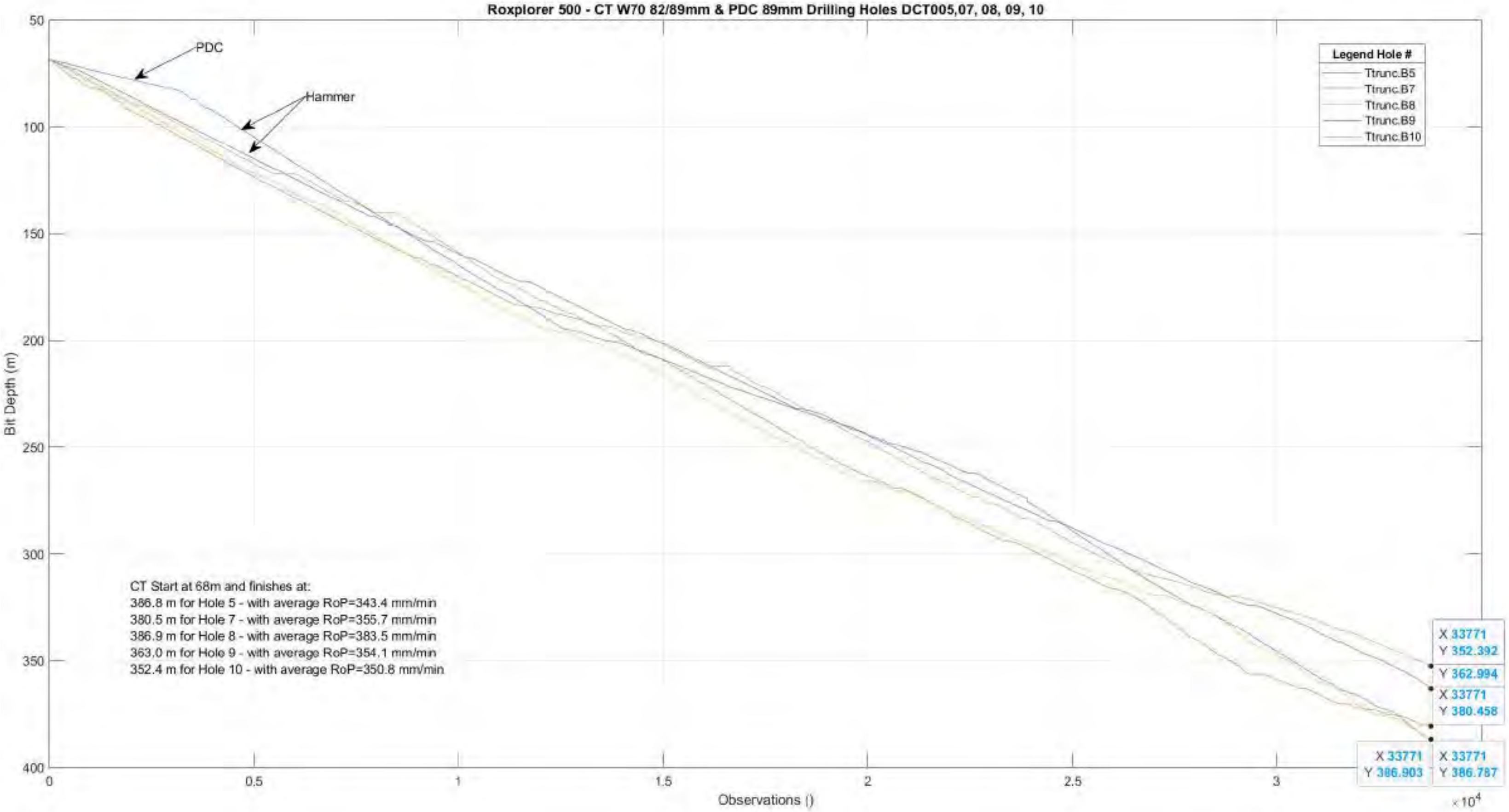
Drilling Rate / Day

Total Hole Depth = 128.6 m
Total Drilling Time = 5:33:11 h
Average RoP = 6.4 mm/s = 385.9 mm/min = 0.4 m/min = 23.2 m/h

Drilling Rate / Day

Total Hole Depth = 281.4 m
Total Drilling Time = 12:15:45 h
Average RoP = 6.4 mm/s = 382.5 mm/min = 0.4 m/min = 22.9 m/h

Project overview CT Drilling



CT Start at 68m and finishes at:
386.8 m for Hole 5 - with average RoP=343.4 mm/min
380.5 m for Hole 7 - with average RoP=355.7 mm/min
386.9 m for Hole 8 - with average RoP=383.5 mm/min
363.0 m for Hole 9 - with average RoP=354.1 mm/min
352.4 m for Hole 10 - with average RoP=350.8 mm/min

PROJECT 2 BUDGET

The operational budget for Phase III is $194.000.

Successful change in Scope for the $500.000 NSW funding.

PROJECT 2 - RISKS & IMPEDIMENTS

The final schedule for the AnTech drilling trials makes challenges to planning and uncertainty about final location and the DIG CT drilling equipment availability are still real.

Commercialisation

Epiroc

SCHRAMM

MinEx CRC and CoilRig™ has executed the licensing agreement of the Coiled Tubing Technologies.

DIG CT

Questions ?