

Geotechnical practitioner skills assessments: a case study in evaluation and data use for targeted upskilling

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Abstract

In 2020 a comprehensive capability and skills assessment was undertaken for geotechnical practitioners across Rio Tinto businesses. The assessment included over 20 areas of geotechnical skills including field-based skills, characterisation, data analytics, modelling, and even communication and business aptitudes. Rankings were done by the individual and their leaders on a 1 (basic knowledge) to 4 (mastery) scale. The result was a comprehensive dataset on skills and skills gaps for individuals, entire teams and globally across Rio Tinto. Rio Tinto Iron Ore then utilised this data in 2021, with the support of business leaders, to establish upskilling, learning and development initiatives for its teams. This paper details the foundational work in establishing which competencies are important for which roles. It then demonstrates the process of using the data and results to drive actions in an effort to uplift large groups of practitioners via on-the-job exposure, industry leading learning courses and targeted training.

Keywords: *skills, capability, business strategy*

1 Introduction

In early 2020 the Rio Tinto Surface Mining Centre of Excellence started an initiative that focused on group-wide geotechnical practitioner capability (surface and underground). This was in recognition of geotechnical engineers having critical capabilities in the mining value stream and to holistically assess their strengths and gaps. Technical leaders and management from each business unit responded to state-of-practice polling which looked at what was deemed as important skills for the business unit and an honest evaluation of where current teams stood.

The initial polling was then used to establish a capability development playbook (Figure 1) and a comprehensive set of skills upon which geotechnical practitioners would be evaluated against. The full evaluation list is robust and comprehensive, with 23 skills categories and over 100 total skill elements. Elements range from direct technical skills (e.g. characterisation, modelling, monitoring interpretation) to people and leadership skills including project management, stakeholder engagement, communication and advising. The full table of skills evaluated is found in Appendix A.

Once skills were defined, geotechnical practitioners throughout the business participated in the skills check, along with their direct leaders. Rio Tinto Iron Ore (RTIO) received an evaluation dataset of over 50 participants, with detailed metrics across its teams that showed areas of strong skill development and gaps. RTIO then used this data, in collaboration with its practitioners, to identify key development and upskilling initiatives for its teams. This approach has also been used in other practice areas such as mining engineering, tailings and water storage facilities, and geoscience.

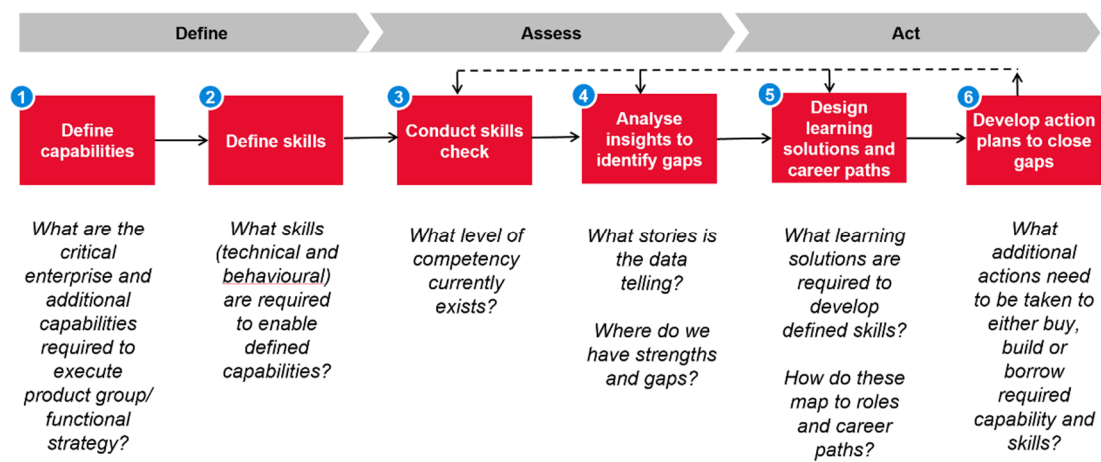


Figure 1 Rio Tinto capability development playbook (Rio Tinto 2020)

2 Defining capabilities and skills

A **capability** is what an organisation needs to be great at to execute its business strategy. It is the collective abilities and expertise of the organisation which come from bringing together skills, knowledge, tools, processes, technology, structure and culture.

Skills relate to an individual: their knowledge, abilities, behaviours and attributes. They are categorised as technical or behavioural.

Capabilities enable business strategy while skills align individual efforts to capabilities (www.rbl.net).

The initial challenge in this endeavour was in enabling practice leads and subject matter experts (SMEs) across many commodities, operating environments and business units to align on what capabilities and skills were to be included. Of course each business unit and technical team had versions of geotechnical skill lists, role descriptions and qualifications to govern geotechnical roles. However, the capability development initiative was the first earnest attempt by Rio Tinto to really define what a well-rounded mining geotechnical practitioner looked like and also to define the capabilities required and the business needs. This was looked at under five major skill areas: technical, leadership, data/digital, partnership and commercial. Many hours were dedicated to SME meetings and definition documentation that would ultimately underpin the skill elements and the overall capability strategy.

From these efforts, capability matrices, skill cards and associated development cards were established, which set the foundation for the skills check and evaluations steps. Examples for the capability matrix and skills are shown in Figures 2 and 3, respectively. An example skill card is shown in Figure 4. These are associated with the full skills evaluation table in Appendix A.

		Skills	Capability
		Individual	Organisational
Technical	Technical	An individual's technical and functional skills	An organisations distinctive work process capabilities
	Behavioural	An individual's behavioural skills (leadership and core)	An organisations distinctive social capabilities

Figure 2 Skills and capability matrix

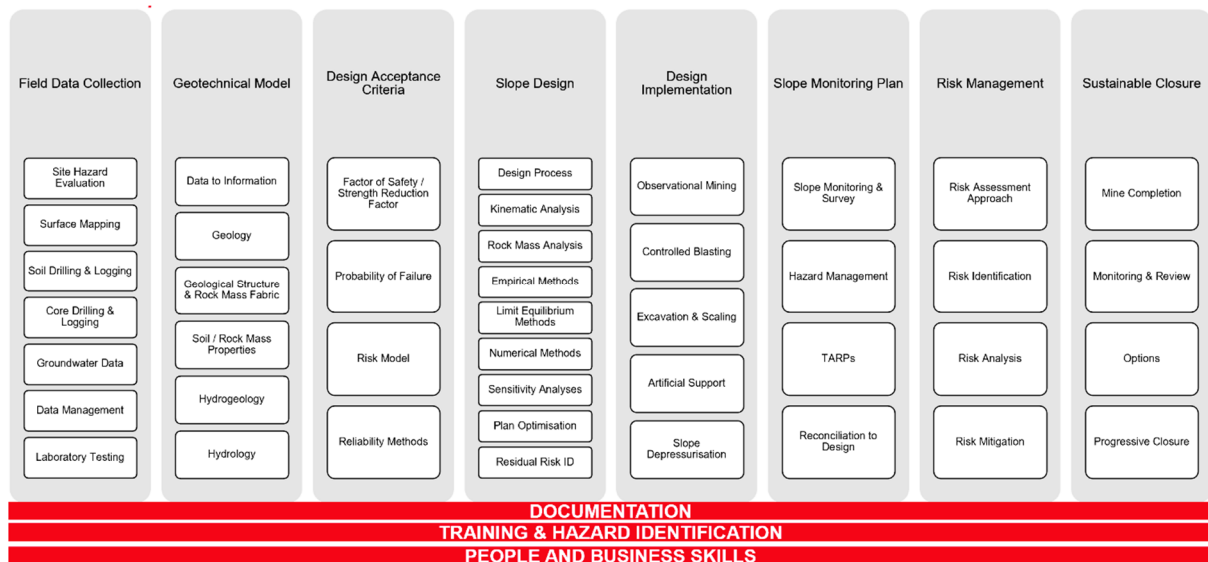


Figure 3 Example of a capability matrix developed during the definition phase of the initiative

Type	Technical	Skill Name	Geotechnical Field Data Collection
Definition		Has knowledge and experience in the field collection of all input data to compile and understand a geotechnical model	
Descriptors		<ul style="list-style-type: none"> Understands the principles of geotechnical drilling operations and is able to undertake soil and core logging, and hydrogeological testing Has knowledge and experience in geotechnical mapping and is able to focus on important aspects of geotechnical performance Has knowledge and experience of structural geology mapping, analysis, interpretation and integration Understands the principles of soil and rock laboratory testing, and selection of applicable samples and testing methods 	

Figure 4 Example of a skill card developed during the definition phase of the initiative

2.1 Skills check and data analytics

Once the capability framework was in place and detailed skills areas were identified, the subsequent work was to poll the geotechnical engineer teams throughout the business. For RTIO this meant polling a relatively large geotechnical team which is split between different focus areas: 1) Perth-based design, data acquisition and other central functions, and (2) site-based and operational-focused geotechnical teams (Figure 5). The total population polled was 55 individuals. They first completed a self-evaluation step against the elements in Appendix A, and then their direct line leader or selected reviewer completed a secondary evaluation. This step achieved one of the primary goals of the capability playbook as individuals and their leaders used these evaluations and conversations to build individual development plans (steps 5 and 6 of the playbook).

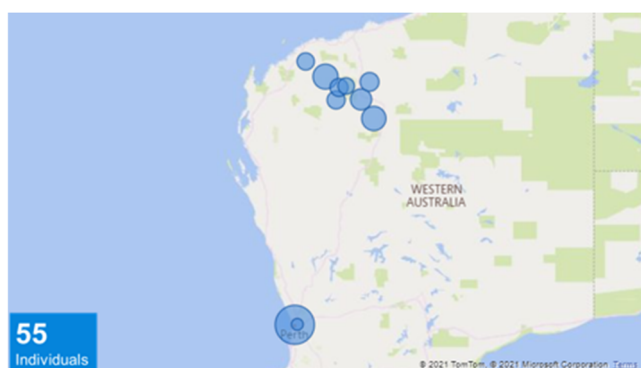


Figure 5 Location of skills check surveys

This was accomplished more effectively as there were specific focus areas to draw on from a framework that also aligned with the needs of the business... a true win-win!

2.2 Data analytics and findings

Once the skills check results were completed RTIO had a powerful dataset that could be analysed for many uses and in multiple subsets including:

- RTIO group-wide.
- Perth-based central teams.
- Site-based teams.
- Site by site.
- Leader versus individual.

Upon holistic review, these outcomes were now able to be used in ways that connected to business strategy goals. As with all datasets, some outcomes were very revealing and useful while others were skewed. Some results, such as low scores in underground geotechnical fields, were not surprising at all for a group that has only surface mines. Also, seeing outcomes such as site teams being scored lower in design areas (e.g. modelling and characterisation) and central teams scoring lower in operational areas (e.g. monitoring systems) was somewhat expected.

Data populations were broken down as noted using dashboard-style visualisation (i.e. PowerBI). This helped to compress the information in ways that enabled analytical views for full teams. Examples are shown in Figures 6 and 7.

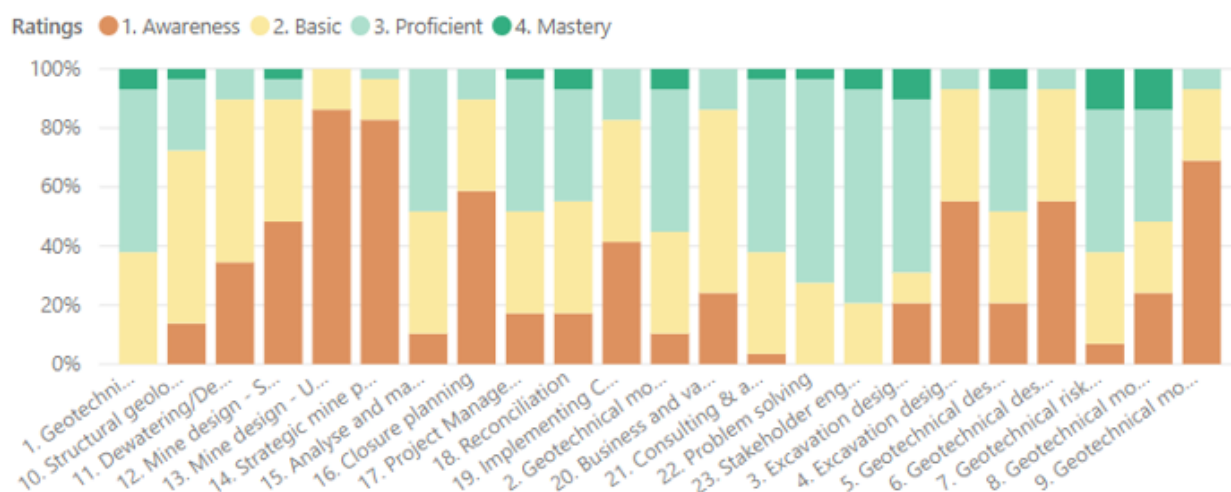


Figure 6 Proficiencies by group showing the relative ratings of 29 central participants

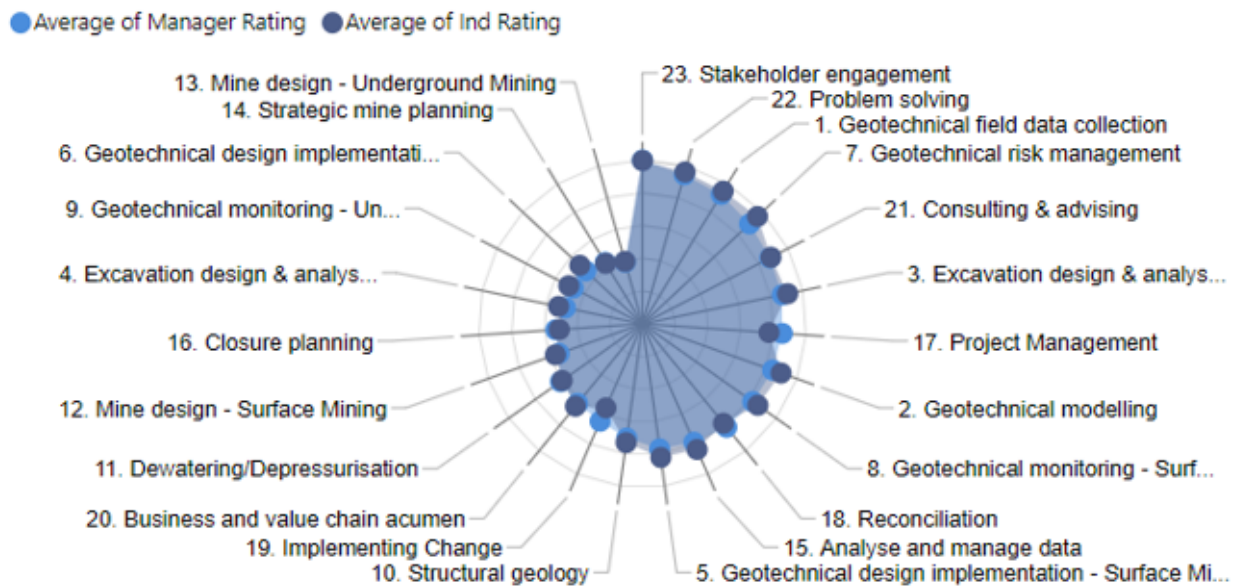


Figure 7 Spider plot showing proficiencies rated by individual self-assessment and the leader score of individuals, 29 central participants

These examples are results from the largest dataset and included central design and characterisation support functions. It is notable that ratings by leaders and individuals are generally aligned and that higher proficiencies are lining up with the core work of this team. However, the data also highlighted some areas that senior leaders use at the business level to identify strategic proficiency gaps, such as understanding of water in slopes and dewatering processes. In this case, the dataset was used to justify group attendance in formal training courses (e.g. University of Arizona ca. 2021) and make changes to the design workflow as to the treatment of hydrogeological inputs.

Similar analytics were produced for site-based, operational-focused teams, with some notable differences from the central teams. For instance, Figure 8 shows variations between the leaders as they scored the individual and the individuals' self-assessments. This was somewhat expected as site leadership is typically not comprised of geotechnical professionals. Regardless, this finding was relevant in subsequent education campaigns that provided site leadership with more in-depth information on core geotechnical work.

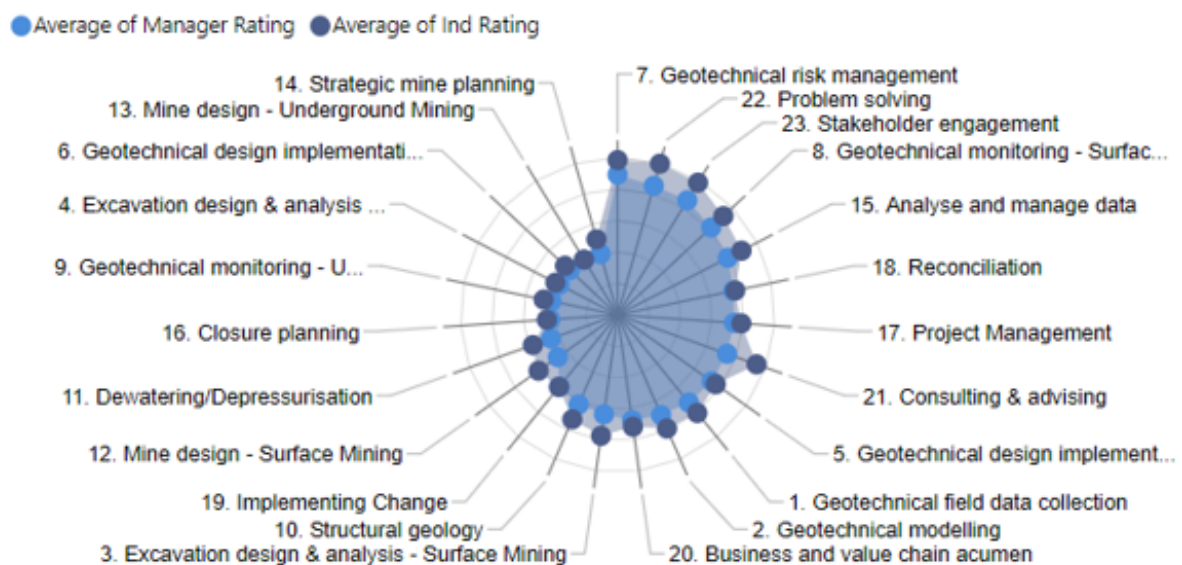


Figure 8 Spider plot showing proficiencies rated by individual self-assessment and the leader score of individuals, 13 site-based participants

Overall, larger patterns began to stand out, which enabled the geotechnical leadership team to discuss initiatives that would benefit the site-based and central groups as a whole in addition to enabling more targeted individual-leader development discussions. For 2021, a ‘critical few’ items were selected using this dataset for a targeted effort to upskill and develop the larger team. These included:

- Education and application upskilling for pore pressure interpretation (e.g. the University of Arizona Water in Slopes course).
- Having central teams increase site visits and actively participate in reconciliation mapping to increase awareness of site geotechnical practice and structural geology.
- Refresher courses on radar and prism monitoring systems.

Other areas were identified (Figure 9) but it was important to keep the focus limited to a few areas at a time to ensure achievability, thus the concept of a ‘critical few’. This did not, however, limit individuals in beginning development in other areas. For the RTIO business it established a good framework to carry forward further initiatives into 2022 and beyond and align to the overall Rio Tinto capability matrix (Figure 10).

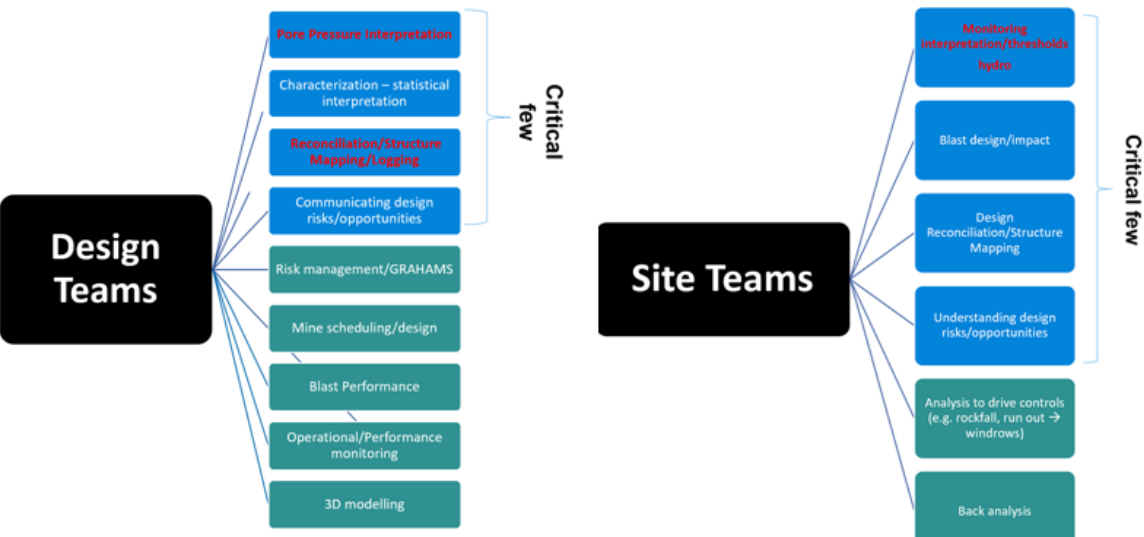


Figure 9 Breakdown of targeted development areas post-data analysis

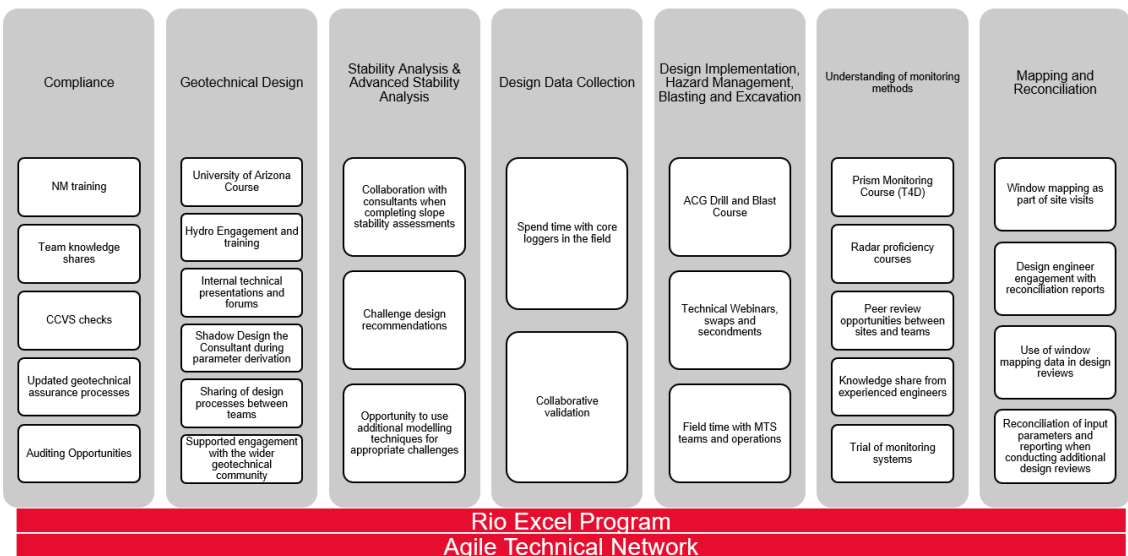


Figure 10 Detailed development opportunities against the capability matrix

3 Conclusion

The capability framework and subsequent skills check steps have now become an embedded process for Rio Tinto, leading to several formal training programs, informal on-the-job learning, and detailed development pathways that both individuals and their leaders can measure and track. This framework has also given the business justification to support employees in partnerships with academia for targeted development (e.g. University of Arizona ca. 2021).

In 2022 the skills check survey was run again and compared against 2020 date, which demonstrated skills uplift across RTIO geotechnical teams (Figure 11), with participation greater than 95%. This is a phenomenal result which demonstrates the value of: the playbook and conducting detailed skills assessments, defining centralised skills criteria, and using data for targeted skills uplift initiatives worked to develop individuals and teams. The strong collaboration and participation in RTIO staff also showed that teams and individuals saw value and development opportunity in the survey and the use of outcomes. These processes are also highly valuable to managers and senior geotechnical leaders for input into the business strategy and providing focus on where to strengthen critical geotechnical skills. These evaluations and resulting data will be used for continuous improvement and to strengthen geotechnical teams across the business.



Figure 11 2020 versus 2022 skills assessment results showing an increase in most categories

Acknowledgement

The authors acknowledge the RTIO geotechnical and management teams, who helped utilise the skills check framework to full effect.

Appendix A Detailed geotechnical skills assessment items from 2020

Factor	Skill	Definition	Descriptors/ Subskill
Geotechnical	1. Geotechnical field data collection	Has knowledge and experience in the field collection of all input data to compile and understand a geotechnical model.	1.1 Understands the principles of geotechnical drilling operations and is able to undertake soil and core logging, and hydrogeological testing 1.2 Has knowledge and experience in geotechnical mapping and is able to focus on important aspects of geotechnical performance 1.3 Has knowledge and experience of structural geology mapping, analysis, interpretation and integration 1.4 Understands the principles of soil and rock laboratory testing, and selection of applicable samples and testing methods
Geotechnical	2. Geotechnical modelling	Has knowledge and experience in the application of rockmass characterisation and classification schemes, and the development of geotechnical models.	2.1 Is able to apply rock mass classification schemes 2.2 Is able to select and apply appropriate values for rockmass strength and strength of structures 2.3 Is able to develop geological and geotechnical models and integrate hydrogeological and hydrology inputs 2.4 Understands the significance of geological features on rock mass quality 2.5 Is able to undertake data summary tasks for in situ stress and seismic loading
Geotechnical	3. Excavation design & analysis - Surface Mining	Possesses knowledge and experience in the geotechnical design of excavations.	3.1 Has knowledge and experience in the selection of excavation design sections 3.2 Possesses knowledge and experience in the development of geotechnical design parameters 3.3 Is able to select the appropriate stability assessment method, and complete stability analyses 3.4 Is able to develop geotechnical excavation design recommendations 3.5 Understands and communicates excavation limitations and risks
Geotechnical	4. Excavation design & analysis - Underground Mining	Possesses knowledge and experience in the geotechnical design of excavations in an underground work environment.	4.1 Has knowledge and experience in the selection of excavation design sections 4.2 Possesses knowledge and experience in the development of geotechnical design parameters 4.3 Is able to select the appropriate stability assessment method, and complete stability analyses 4.4 Is able to develop geotechnical excavation design and sequencing recommendations 4.5 Understands and communicates excavation limitations and risks
Geotechnical	5. Geotechnical design implementation - Surface Mining	Has knowledge and experience in the management of operational geotechnical aspects.	5.1 Understands the concepts of control blasting 5.2 Has knowledge and experience in the assessment of blasting results 5.3 Has knowledge and experience in the design and quality assurance / quality control of ground support 5.4 Understands the geotechnical design parameters and is able to communicate factors affecting design, e.g., depressurisation, hydrology 5.5 Knows how to develop and implement operational documentation including excavation management plans, ground control management plans.
Geotechnical	6. Geotechnical design implementation - Underground Mining	Has knowledge and experience in the management of operational geotechnical aspects in an underground mine.	6.1 Understands the concepts of control and perimeter blasting 6.2 Has knowledge and experience in the assessment of blasting results 6.3 Has knowledge and experience in the design and quality assurance / quality control of ground support 6.4 Understands the geotechnical design parameters and is able to communicate factors affecting design, e.g., depressurisation, hydrology 6.5 Knows how to develop and implement operational documentation including ground control management plans
Geotechnical	7. Geotechnical risk management	Has knowledge and experience in the identification, mitigation and control of geotechnical hazards and risks.	7.1 Is able to identify geotechnical hazards and risks 7.2 Understands the Risk Assessment process 7.3 Has knowledge and experience in geotechnical hazard mitigation and controls, including the development of Trigger-Action-Response Plans 7.4 Is aware and able to communicate design limitations, assumptions and risks
Factor	Skill	Definition	Descriptors/ Subskill
Geotechnical	8. Geotechnical monitoring - Surface Mining	Understands geotechnical monitoring programs and methods and is able to analyse and interpret monitoring data.	8.1 Is able to specify an appropriate monitoring program 8.2 Understands the installation requirements of monitoring systems 8.3 Understands the various methods in use to monitor and assess ground performance 8.4 Is able to collect, analyse and interpret monitoring data 8.5 Understands and can report implications of deviation from expected movements
Geotechnical	9. Geotechnical monitoring - Underground Mining	Understands geotechnical monitoring programs and methods and is able to analyse and interpret monitoring data in an underground work environment.	9.1 Is able to specify an appropriate monitoring program 9.2 Understands the installation requirements of monitoring systems 9.3 Understands the various methods in use to monitor and assess ground performance and stability 9.4 Is able to collect, analyse and interpret monitoring data 9.5 Understands and can report implications of deviation from expected movements
Orebody Knowledge	10. Structural geology	Has knowledge and experience of structural geology analysis, interpretation and integration.	10.1 Has knowledge and experience of structural controls of ore deposits 10.2 Knows how to apply structural geology analysis and interpretation 10.3 Is able to produce a comprehensive synthesis of structural geology based on relevant data
Water	11. Dewatering/Depressurisation	Possesses knowledge and experience in the design and implementation of a dewatering or depressurisation system.	11.1 Understands hydrogeological drilling methods and their suitability to various environments and technical requirements 11.2 Is able to understand and incorporate geological conceptualisation, geotechnical criteria and mine planning requirements into dewatering/depressurisation program design 11.3 Knows how to design and implement test-pumping programs, determine well hydraulics and select/optimize pumping systems to achieve the dewatering/depressurisation program 11.4 Is able to collect and analyse dewatering/depressurisation data to track performance against design and make adjustments to the program as required
Surface Mining	12. Mine design	Possesses knowledge and experience in the design of mine excavations, dumps, stockpiles and mine haul roads.	12.1 Has knowledge and experience in the design of mine excavation, including mine haulage roads, stockpiles, and waste dumps 12.2 Has knowledge and experience in mining method selection 12.3 Is able to complete sensitivity and optimisation of mine designs 12.4 Is able to understand and explain the integration of all design inputs
Underground Mining	13. Mine design	Possesses knowledge and experience in the design of mine excavations, stockpiles and mine haul roads to ensure safe and efficient removal of waste and ore from an underground mine.	13.1 Has knowledge and experience in the design of mine excavation, including mine haulage roads, stockpiles, and ore/waste removal from work headings 13.2 Has knowledge and experience in mining method selection 13.3 Is able to complete sensitivity and optimisation of mine designs 13.4 Is able to generate mine infrastructure plans 13.5 Is able to understand and explain the integration of all design inputs
Multi-domain	14. Strategic mine planning	Is able to conduct value driven scenario analysis across the full value chain utilising production planning tools and methodologies.	14.1 Has knowledge and experience in generating life of mine plans 14.2 Has a complete understanding of the value chain and the linkages between the different parts 14.3 Is able to develop a case matrix of options that span the value chain 14.4 Is able to generate multiple schedules and cashflow analysis to determine the value landscape

Factor	Skill	Definition	Descriptors/ Subskill
Multi-domain	15. Analyse and manage data	Possesses and applies skills in collecting, interpreting and managing relevant data to support effective decision making.	15.1 Uses relevant technical models, systems and tools as part of the analytical process 15.2 Utilises systems and processes to effectively collect, store, and manage data 15.3 Applies Quality Assurance/Quality Control procedures to ensure the accuracy and completeness of data obtained
Multi-domain	16. Closure planning	Has knowledge and experience in the development of discipline specific closure options.	16.1 Understands the closure value chain and the linkages between different parts 16.2 Has knowledge and experience in the development of closure options 16.3 Has knowledge and experience in the development of discipline specific closure aspects 16.4 Understands how to develop cost schedules 16.5 Is able to understand environmental and regulatory requirements with respect to closure.
Multi-domain	17. Project Management	Has knowledge and experience in managing projects in line with time, budget and return-on-investment expectations.	17.1 Understands how to effectively manage the deployment of resources needed to deliver project 17.2 Has knowledge and experience in managing project timelines and critical paths 17.3 Is able to undertake financial monitoring of the project and manage the budget 17.4 Understands how to apply project management tools and techniques for the delivery of project
Multi-domain	18. Reconciliation	Knows how to undertake a reconciliation process and identify discrepancies, trends and improvement opportunities.	18.1 Is able to complete and utilise reconciliations to identify problems, discrepancies and trends 18.2 Understands how to use reconciliation data to identify improvements to modelling or operational practices 18.3 Is able to utilise reconciliation and root cause analysis techniques to identify value opportunities 18.4 Is able to apply lessons learned from reconciliation data to drive continuous improvement 18.5 Knows how to disseminate reconciliation data to inform operational practice and decision making
Multi-domain	19. Implementing Change	Has knowledge and experience in building readiness to change and supporting adoption and embedding.	19.1 Understands and has experience in applying Rio Tinto's management of change process 19.2 Is able to define the change management scope and strategy to guide the change management end-to-end 19.3 Understands how to identify the impacts of the proposed change across all organisational dimensions 19.4 Is able to develop a plan to support adoption (including communication, training & capability development, and measuring & reinforcing the change) 19.5 Is able to identify and prepare the project sponsor and change champions to support the implementation of changes with the business
People	20. Business and value chain acumen	Incorporates financial information, understanding of the core value of the business and upstream and downstream factors to support decision making and drive value chain improvements.	20.1 Understands and uses financial information to monitor performance and guide decisions 20.2 Understands the core value of the business and the key factors that drive value improvement 20.3 Understands and aligns work to the commercial drivers and priorities of the business 20.4 Is able to identify and take into account the impact of variables on the bottom line, customers and across the value chain 20.5 Understands and takes into account upstream and downstream constraints and impacts when making decisions
People	21. Consulting & advising	Provides tailored guidance, advice or information to support others in making effective decisions or improving performance.	21.1 Provides expert advice on technical or systems-related work to improve performance or achieve goals 21.2 Effectively communicates technical knowledge and information to inform others' decision making 21.3 Is able to contextualise technical advice to relevant business strategy 21.4 Shares information widely with others; making others aware of information that may be useful to them 21.5 Navigates connecting different groups, by facilitating introductions across personal network and contacts
People	22. Problem solving	Builds a comprehensive understanding of a problem and identifies, evaluates and selects the best solution that mitigates risk	22.1 Builds a comprehensive understanding of the true nature and impact of a problem 22.2 Effectively identifies, investigates and evaluates alternative solutions including associated risks 22.3 Applies logic and well-reasoned judgement to select and implement best solution that manages risk to appropriate level 22.4 Approaches problems with solutions aimed at causes not just symptoms
People	23. Stakeholder engagement	Identifies relevant stakeholders and builds effective, long term partnerships to deliver business value.	23.1 Is able to build trust with stakeholders 23.2 Understands and conveys how own work links to stakeholder needs/wants/expectations 23.3 Is able to engage effectively with stakeholders to deliver business value 23.4 Identifies relevant stakeholders and plans most appropriate way to engage with each

Proficiency Level	Category	Description
4	Mastery	Highly developed knowledge, applies in complex and diverse situations for significant impact, coaches and teaches others, is widely recognised as an authority within and outside of work team
3	Proficient	Detailed knowledge, applies in non-routine situations for positive impact, provides guidance and advice to others, is recognised as an authority within work team
2	Basic	Basic knowledge, applies in less complex situations, requires some guidance to apply on-the-job
1	Awareness	Limited knowledge, minimal application, requires supervision to apply on-the-job

Proficiency descriptors used for each skill as rated by individual and leader.

References

Rio Tinto 2020, *Capability Playbook and Skills Cards 2020*, Rio Tinto, internal memo.
University of Arizona ca. 2021, *Water in Slopes Course*, University of Arizona, Geotechnical Centre of Excellence, Tucson.

