MINING QUALIFICATIONS AUTHORITY

RESEARCH STUDY PROBING THE GREEN SKILLS THAT CAN BE PRIORITISED IN THE MINING AND MINERALS SECTOR (MMS)

FINAL INTEGRATED REPORT

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Exigo³

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ACRONYMS AND ABBREVIATIONS

AGRISETA	Agriculture Sector Education & Training Authority
ASEAN	Association of South East Asian Nations
AMD	Acid Mine Drainage
AsgiSA	Accelerated and Shared Growth Initiative of South Africa
BCM	Botswana Chamber of Mines
CAEM	Argentinean Chamber of Mining Entrepreneurs
CEO	Chief Executive Officer
CEDEFOP	European Centre for the Development of Vocational Training
CHE	Council on Higher Education
CLAS	Cement, Limestone, Aggregates and Sand
Cmsn	Commission
COI	Communities of Interest
CoC	Code of Conduct
COO	Chief Operating Officer
CSIR	Council for Scientific & Industrial Research
CSR	Corporate Social Responsibility
DEA	Department of Environmental Affairs
DHET	Department of Higher Education and Training
DoL	Department of Labour
EIA	Environmental Impact Assessment
ELRC	Environmental Learning Research Centre
ETDP	Education Training and Development Practices
FIMI	Federation of Indian Mineral Industries
FinnMin	Finnish Mining Association
GIS	Geographical Information Systems
GFETQS	General and Further Education and Training Qualifications Sub-framework
HEQSF	Higher Education Qualifications Sub-framework
IBM	International Business Machines
IFC	International Finance Corporation
ILO	International Labour Organisation
IT	Information Technology
GHG	Greenhouse gas emissions
GIS	Geographic Information Systems
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
ICMM	International Council on Mining and Metals
JIPSA	Joint Initiative on Priority Skills Acquisition

LGSETA	Local Government Sector Education and Training Authority
LPSDP	Leading Practice Sustainable Development Program
MABC	Mining Association of British Columbia
MCA	Minerals Council of Australia
MMS	Mining and Minerals Sector
MPRDA	Mineral and Petroleum Resources Development Act
MQA	Mining Qualification Authority
NBF	National Biodiversity Framework
NFA	National Forest Act
NEMA	National Environmental Management Act
NEMAQA	National Environmental Management Act: Air Quality Act
NEMBA	National Environmental Biodiversity Act
NEMPAA	National Environmental Management Protected Areas Act
NEMWA	National Environmental Management Waste Act
NLRD	National Learners' Record Database
NQF	National Qualification Framework
NWA	National Water Act
OBE	Outcome-based Education
OECD	Organisation for Economic Co-operation and Development
OFO	Organising Framework for Occupations
OQSF	Occupational Qualifications Sub-Framework
PGM	Platinum Group Metals
PWC	PricewaterhouseCoopers
QC	Quality Council
QCTO	Quality Council for Trades and Occupations
QMA	Quebec Mining Association
R&D	Research & Development
SCANS	Secretary's Commission on Achieving Necessary Skills
SETA	Sector Education and Training Authority
SMI	Sustainable Mining Initiative
SSP	Sector Skills Plan
StatsSA	Statistics South Africa
THETA	Tourism, Hospitality and Sport Education and Training Authority
TSM	Towards Sustainable Mining
UNEP	United Nations Environmental Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States

EXECUTIVE SUMMARY

This report was developed by **Urban-Econ Development Economists** supported by **Exigo Sustainability (Exigo3)** at the request of the Mining Qualification Authority (MQA). The study that culminated in the report in question aimed at **investigating the status of essential "green skills" in the entire mining and minerals sector (MMS) across eight sub-sectoral value chains** (excluding for the coal sector of which similar study was already conducted). These sub-sectors include Gold mining, Diamond mining, Diamond processing, Platinum Group Metals (PGM), Cement, limestone, aggregates and sand (CLAS), Jewellery manufacturing, Services incidental to mining (SITM), Other mining. As per the Terms of Reference, the study also focused only on the green skills required to address specific aspects of the environment such as air quality, water quality and quantity, waste management, and biodiversity. The specific **research questions** aimed to be investigated during the study included:

1. What are the essential green skills?
2. Which of these green skills are considered to be scarce in the country?
3. What factors affect the supply and demand for the green skills?
4. Which of the green skills are integral to the new QCTO and where gaps exist?
5. What are the career-pathing implications of the green skills?

The study provides practical recommendations for the MQA and other industry stakeholders to consider in order to address the current or future expected skills shortages and gaps in the MMS related to the four environmental fields mentioned above.

Methodology, assumptions, and limitations

Due to the key research questions posed for the study, the investigation into green skills in the MMS required a description of the situation with respect to the supply and demand for green skills within the eight MMS sub-sectors and identification of the commonalities among them to determine essential and scarce green skills. This in turn implied that a **qualitative approach** was most suitable for the study. In order to ensure the validity of findings, though, the research largely relied on primary data gathered through interviews with representatives of the MMS sub-sectors.

While the primary data provided an insight into the demand and shortages of various green skills among the MMS sub-sectors, secondary data was used to undertake policy and literature review. The former assisted in identifying the needs for green skills that arise from the policies and legislative environment; while the latter allowed the team to develop working definitions for key terms, gather necessary insight into the composition of each MMS sub-sector, develop sectoral value chains, and discuss environmental impacts during different stages of the mining life cycle. Thereafter, the research team embarked on the selection of the representatives to be interviewed and primary data gathering involved the following:

- A quota sampling technique was employed to select two to three companies representing each sub-sector to be engaged with. A total of 24 mining companies were interviewed and 50 managers and professionals were engaged with. The engagement was conducted using telephonic or face-to-face interviews and followed a semi-structured approach. During the interviews, the discussions revolved around the significance of the specific environmental impacts in the context of the mining industry the company operates in, the demand for various skills, the critical importance of these skills at different stages of their life cycle, the shortages of skills experienced and the reason behind these, as well as the career pathing opportunities.

- In addition to the engagement with the mining companies, the project team also engaged with the Department of Environmental affairs, the South African Qualification Authority, Rhodes University's Learning Centre of Environmental Education, and the Mining Council of South Africa.

The data gathered during the study assisted the team to create a comprehensive insight into the significance of air quality, water quality and quantity, waste management and biodiversity related to green skills in the context of the MMS sub-sectors and provide practical recommendations for development of those that are current in short supply.

Green skills in MMS - working definition

Green skills in general are seen by other countries as abilities and competencies that a person possesses that enable him/her to perform general or specific duties and tasks to develop and support an environmentally sustainable outcome in business, industry, and the community. The engagement with various MMS representatives further revealed that South African mining companies approach green skills as the means to guarantee compliance to environmental regulations and to achieve sustainable operations.

In this context, and drawing from the different definitions for skills and general green skills, the study proposes the following **working definition for green skills in the MMS**:

> **Competencies and abilities** required to **predict (identify and qualify) prevent, detect, mitigate, and monitor any environmental impact** during exploration, exploitation (extracting and processing) and beneficiation processes to **ensure sustainability of operations and environmental compliance**

Green skills in MMS – critical and in short supply

The review of policies, legislative documents, regulations, and conventions that South Africa comply with or align to lead to an identification of the environmental compliance requirements related to air quality, water quality and quantity, biodiversity, and waste management issues. Using the expertise of the project team and engagement with the industry, these compliance requirements were then translated into the green skills necessary to uphold them. This in turn resulted in identification of 13 green skills related to air quality, 10 – to water quality and quantity, 12 – to waste management, and 13 to biodiversity. All of these skills were initially deemed to be essential to ensure environmental compliance and/or sustainability of mining operations, which was then confirmed during the engagement with the MMS sub-sectors. However, the study revealed that many of these skills are currently in short supply either due to absolute scarcity (absence of qualified professionals) or relative scarcity (not available in the area, no sufficient experience, or do not comply with equity requirements).

The distribution of scarce skills among the four environmental fields under analysis is almost equal. While most of the skills have been in demand for many decades as they were required to ensure adherence of the mining operations to the respective environmental legislation and policies, there were a few green skills related to air quality and waste management that have emerged relatively recently as a result of the new legislative requirements. These specifically refer to skills related to carbon emissions reporting, carbon accounting, and climate change, as well as waste sorting and separation.

The following diagram summarises the essential green skills identified to be needed by the MMS in dealing with air quality, water quality and quantity, waste management, and biodiversity issues. It also highlights the skills that are in short supply and whether such skills are registered under the QCTO qualification framework.

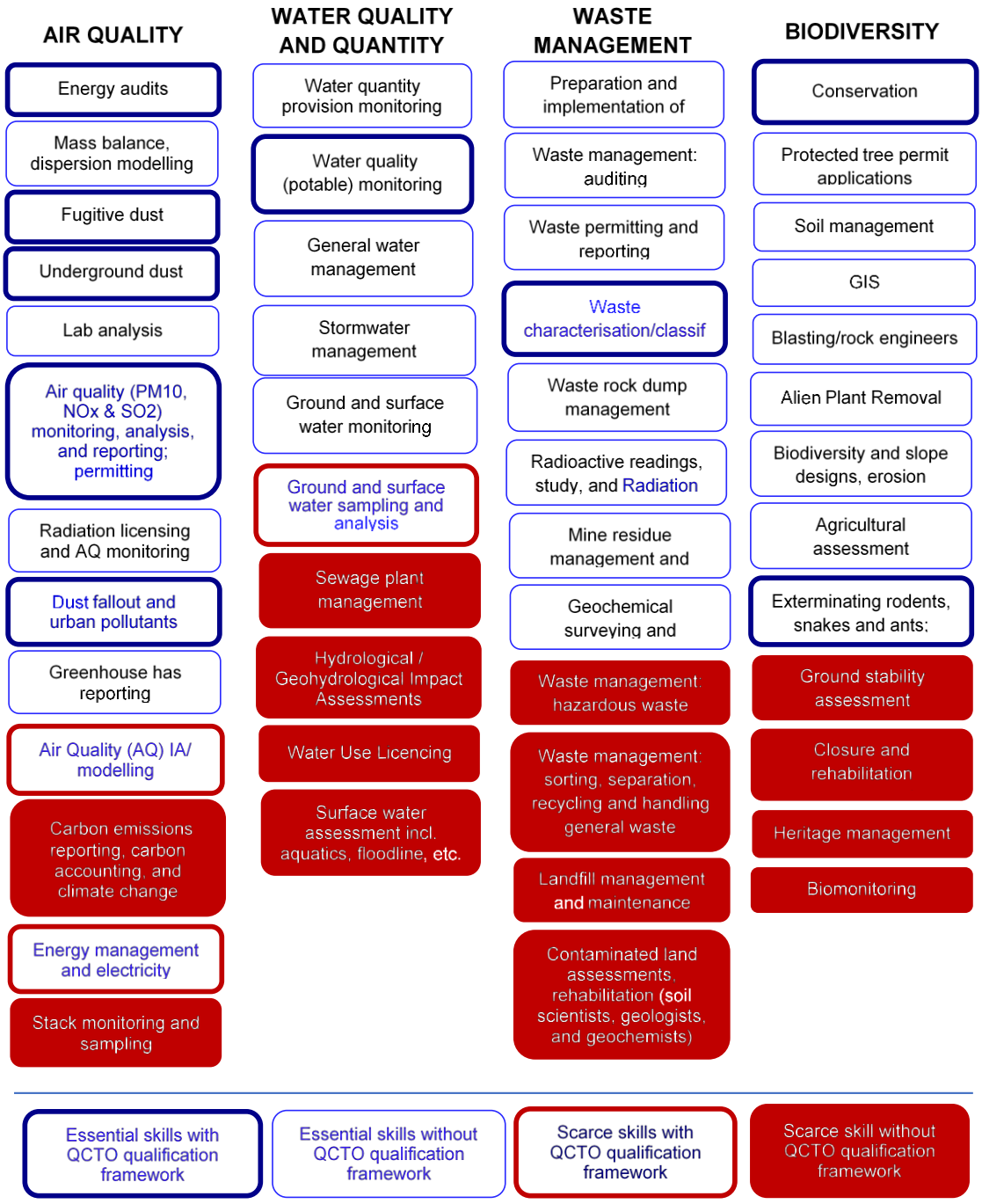


Figure A: Essential and scarce green skills in MMS sub-sectors

The following observations were made with respect to each of the environmental fields investigated and the demand for green skills related to these:

- The scarce green skills related to **air quality** in the MMS primarily include skills that require five or more years of experience to become proficient. Many of these skills though are being outsourced and in most instances the outsourcing is done due to practical (not required on a continuous basis) and financial considerations (most cost-effective to outsource than put on a payroll). In some instances, though, specifically in the Other mining and gold mining, a relative scarcity of skills was observed, where the green skills available in the country lacked exposure to the air quality issues related to these two sub-sectors specifically. A particular concern was also raised for stack monitoring skills – these green skills are not possible to obtain through a formal qualification of technical diploma and are associated with difficult working conditions, which contribute to high job turnover.

> **"Ambient air quality** is defined as the physical and chemical measure of pollutant concentrations in the ambient atmosphere to which the general population will be exposed." (DEA, 2018)

- With respect to **water-related issues**, the green skills in demand primarily relate to water quality issues as these appear to be of the greater significance in the most MMS sub-sectors that water-quantity issues. Similar to air quality, some of the water related green skills are outsourced. Lack of experience and the gap between the training offered at various education institutions and practices have been cited to be among the most common reasons outside the financial and practical considerations. Shortages in skills are primarily experienced by the Gold mining and the PGM sectors due to the lack of experienced professionals with exposure to water-related issues in these industries specifically.

> "**Water quality** refers to the physical, chemical and biological characteristics of water with regard to how suitable the water is for its intended use." (DEA, 2018)
>
> "The **quantity of water** available for direct human use or to support aquatic ecosystems depends on the availability and sustainability of the resource." (DEA, 2018)

- The shortages of green skills in **waste management** primarily include those that require a limited experience (1-3 years), except for the green skills related to assessment and rehabilitation of contaminated land, which demand more than ten years of experience in the field to become proficient. These waste management related skills are also generally outsourced.

> **Waste** is any substance that is "surplus, rejected, discarded, abandoned or disposed of; which the generator has no further use of for the purpose of production; that must be treated or disposed of". (SAWIC, 2018)

- **Biodiversity** related green skills appears to be the least undersupplied in South Africa compared to the other three environmental fields analysed. Where shortages are experienced, these relate to the lack of knowledge, inadequate training, and practical experience obtained in specific sub-sectors. Lack of training on mine closure has been identified to be one of the most significant gaps in the industry.

> **"Biodiversity** means the variability among living organisms from all sources including, terrestrial, marine and other aquatic 35 ecosystems and the ecological complexes of which they are part and also includes diversity within species, between species, and of ecosystem" (Portfolio Committee on Environmental Affairs and Tourism , 2003)

From the above, it is clear that the **scarcity of green skills** that has been identified in the MMS (except for coal mining) is largely **relative (i.e. skill gaps)**, where suitably skilled people are available in the

labour market, but they do not possess other employment criteria such as sector-specific work experience and willingness to locate to the geographical locations where mining operations take place (mostly in rural and remote locations). Only in a few cases, an **absolute scarcity (i.e. skill shortages)** has been identified and it referred to the emerging skills in carbon emissions, climate change, carbon auditing.

The review of the National List of Occupations in High Demand for 2018 (DHET, 2018), gazetted on 22 June 2018, also suggests that many of the identified green skills and particularly those green skills that have been confirmed to be scarce in the MMS are also included in the National List of Occupations in High Demand. The identified scarce skills that overlap with those that have been included in the National List of Occupations in High Demand are predominantly related to waste and biodiversity green skills and include energy efficient technicians, water plant operator, waste materials plant operator, environmental manager/engineer, environmental impact and restoration analyst, hazardous materials removal workers, forest and conservation worker, chemical engineer, biotechnologist/biochemist/biologist.

While the skills shortages and gaps are primarily addressed through outsourcing, the following alternative solutions have been indicated to be employed by the industry at different stages:

- Offering bursaries
- Providing in-house accredited training to staff and informal training programmes
- Taking staff on external courses such as legal environmental training
- Multi-skilling of employees by introducing specialists to various other fields through bridging courses that align various courses across the environmental management discipline
- Mentorship programmes
- Environmental awareness training which is outsourced as and when needed.

Green skills in MMS – career pathing

Numerous career opportunities can be pursued in air quality, water quality, waste management, and biodiversity fields in the MMS. Air quality and water quality and quantity related fields offer a considerably wider choice of career opportunities and career paths than waste management and biodiversity. Having, said this, individuals pursuing careers in all four green skills fields considered in the MMS can achieve management positions.

Requirements for individuals to pursue careers in the air quality, water quality and quantity, biodiversity, and waste management fields in the MMS generally involve post-matric qualifications, for example a formal BSc degree or certification (NQF level and higher). In instances of greater specialisation, an individual may need to continue to postgraduate level with a relevant specialisation. Having a relevant degree or certification though is not sufficient to become proficient in the majority of green skills discussed in this report. Many individuals require a minimum of 3-5 years of experience to become recognised specialists.

The engagement with the National Union of Mineworkers (NUM) revealed that there is a concern that most of the green skills in the MMS require a post-matric qualification. Since the majority of their representatives are workers with matric certificates or less, it could be argued that this cohort of employees within the MMS value chain will have limited opportunities for career development in green skills considering the above-mentioned requirements.

Having said this, a number of green skills in the MMS can be filled by individuals with matric qualifications and those who also completed additional certifications. These include:

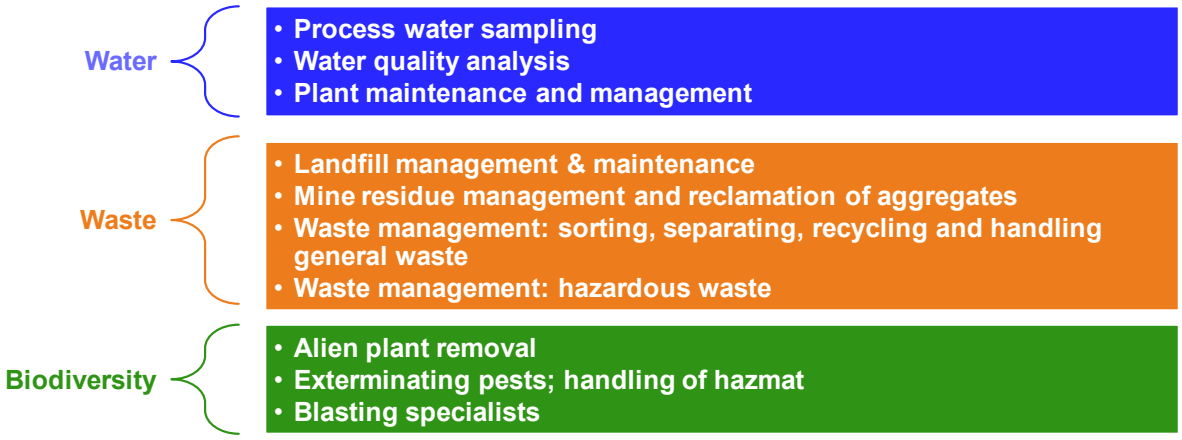


Figure B: Green skills in the MMS that can be filled by mineworkers

Some fields, such as air-quality related fields, are highly specialised fields and would in most instances require an individual obtaining a degree from HEIs. However, there are a number of career path opportunities that start with obtaining occupation certification, which provide opportunities for upskilling of mineworkers. These include certifications that allow practicing skills such as fugitive dust sampling, underground dust suppression, dust fallout and urban pollutants monitoring, as well as air quality monitoring skills. Water quality and quantity and waste management, though provide for a wider opportunity for career path development for semi-skilled and low-skilled workers, as indicated below. Bridging courses and programmes will need to be designed, though, to enable the workers to pursue these career paths.

Table A: Green skills career pathing opportunities for semi-skilled and low-skilled workers in the MMS

Skill	Career Path
Process water sampling	Environmental Assistant – Environmental Coordinator - Environmental Officer– Environmental Superintendent – Group Environmental Manager
Potable water sampling (OHSA)	HSEC Coordinator – HSEC Superintendent – HSEC Manager – HSEC Executive Director
Water quality analysis	Laboratory technician – Laboratory supervisor – Quality Assurance Manager
Plant maintenance and management	Sewage plant and settler operators – Site Supervisor/Level 5 Operator
Waste separation and management	Waste separator – Waste Operators – Foreman – Site Supervisor/Level 5 Operator
Landfill management & maintenance	Foreman – Site Supervisor/Level 5 Operator

Green skills in MMS – supply and demand drivers

A number of factors have been identified to drive the demand and supply for green skills in the MMS, as outlined in the following diagram. The most critical drivers from a demand-side perspective has been citied to be **the risk of losing a licence to operate. Legislation, compliance, and experience are considered to be the most critical from a supply-side perspective.**

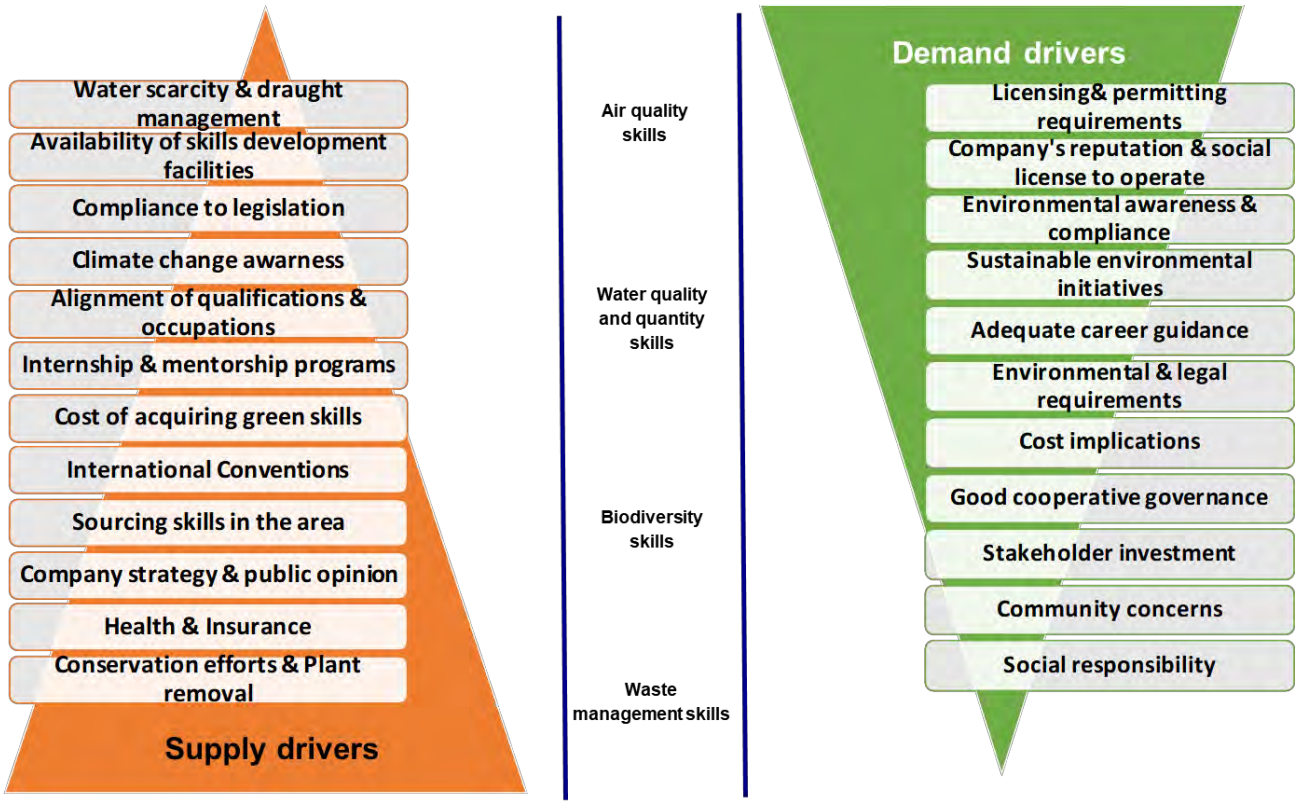


Figure C: Demand and supply drivers of green skills in the MMS

Recommendations

A number of recommendations emerge from the study. These are:

1. **Revise QCTO qualification framework to better align with the needs of the MMS in relation to green skills**: The study revealed that most green skills arise from knowledge gained from universities in the form of "green skill" diplomas and degrees and not necessarily through educational institutions such as TVET colleges which produce artisans. Furthermore, only selected green skills in air quality and water quantity fields are currently possible to develop by obtaining QCTO qualifications. This specifically refers to the following scarce green skills that are currently not reflected in the QCTO qualification framework:
    - Carbon emissions reporting, carbon accounting, and climate change
    - Stack monitoring and sampling
    - Sewage plant management
    - Hydrological / Geohydrological Impact Assessments
    - Water Use Licencing
    - Surface water assessment incl. aquatics, floodline, etc.
    - Waste management: hazardous waste
    - Waste management: sorting, separation, recycling and handling general waste
    - Landfill management and maintenance
    - Contaminated land assessments, rehabilitation (soil scientists, geologists, and geochemists)

- Ground stability assessment
- Closure and rehabilitation
- Heritage management
- Biomonitoring

2. **Bridge the gaps between the educational programmes and industry requirements by means of specialised courses**: The engagement with stakeholders further revealed that structural changes along with the alignment of NQF levels and the workplace are required to assist in broadening the skills of the workforce and to match the needs of the industry with the supply of educational programmes. This for example, refers to the scarce skills in radioactivity which could be addressed by providing specialised courses and more qualifications in this field.
3. **Broaden skills sets and develop sector-specific experience through internships and learnerships:** Though the majority of shortages of green skills found in the MMS (except for coal mining) are associated with relative scarcity, creating new training programmes will not be sufficient to address these gaps. Therefore, internships and learnership programmes in green skills provided by independent parties and mining houses will be paramount to bridge gaps between tertiary education and the workplace. These specifically refer to the following sub-sectors:
    - Other mining
    - Gold mining
    - PGM mining
4. **Strengthen the dialogue among the key industry stakeholde**r: There should be mutual engagements between mining companies, independent consultants offering various green skills, government departments such as the Department of Environmental Affairs amongst others and tertiary education institutions. Consequently, the engagements and action plans set out by these stakeholders would enable them to bridge the gap between tertiary education and the workplace. Also, trends in the demand for specific green skills can be monitored and the demand can be satisfied timeously when all these stakeholders work as a collective.
5. **Extending the MQA's, register of companies along the entire MMS value chain**: Although not the main objective of the study, it was noted that the MQA's register of companies excludes the companies operating at Stage 5 of the MMS value chain. it would be advisable to include these in the register, even if such companies are not responsible for reporting to the MQA. Furthermore, it would be recommended to extend the register to include information on the MMS value chain stages that each company is representing or operating at.

Considering the above recommendations, the following actions are proposed for the MQA:

Table B: Proposed action list for the MQA

Recommendations	Actions list
Revise QCTO qualification framework to better align with the needs of the MMS in relation to green skills	• Engage with relevant stakeholder and investigate the potential to set up new qualifications for the following green skills: o Carbon emissions reporting, carbon accounting, and climate change o Stack monitoring and sampling o Sewage plant management o Hydrological / Geohydrological Impact Assessments o Water Use Licencing

Recommendations	Actions list
	○ Surface water assessment incl. aquatics, floodline, etc. ○ Waste management: hazardous waste ○ Waste management: sorting, separation, recycling and handling general waste ○ Landfill management and maintenance ○ Contaminated land assessments, rehabilitation (soil scientists, geologists, and geochemists) ○ Ground stability assessment ○ Closure and rehabilitation ○ Heritage management ○ Biomonitoring • MQA in partnership with HEIs and industry to develop curriculum for new qualifications (as per the previous bullet) • Register new qualifications with QCTO and SAQA
Bridge the gaps between the educational programmes and industry requirements by means of specialised courses	• Develop specialised courses to match skills requirements in the industry in: ○ Radioactivity ○ Stack monitoring
Broaden skills sets and develop sector-specific experience through internships and learnerships	• Develop workspace learning materials and programmes focusing on green skills in the following sub-sectors: ○ Other mining ○ Gold mining ○ PGM mining • Conduct a country-wide survey of MMS workers to investigate their interests in selected career paths, identify their existing gaps in qualifications, and develop programmes focusing on those career path that are expected to be in greatest demand and associated with the largest gap between current and required qualifications • Undertake a study into the change in demand and skill requirements associated with the 4th industrial revolution
Strengthen the dialogue among the key industry stakeholder	• Review the requirements for Sector Skills Plans and integrate the elements of green skills in air-quality, water quality and quantity, waste management, and biodiversity that would enable collection of data for future decision-making concentring training and qualifications associated with green skills in the MMS • Set up forums to discuss the industry needs and existing shortages in green skills, as well as the best approaches to address them
Extending the MQA's register of companies along the entire MMS value chain	• Review the MMS value chain and clearly define the stages that the MQA has control over or mandated to oversee • Revise the structure of the registrar of companies that form part of the MMS sub-sectors to: ○ Indicates the involvement of these companies in the value chains ○ Include companies that are operating outside the immediate control of MQA but still within the MMS value chain

1 INTRODUCTION

1.1 Project background

The **Mining Qualification Authority** (MQA) is a statutory body established in terms of the Mine Health & Safety Act. No 29 of 1996 and is registered as a Sector Education Training Authority (SETA) for the mining and minerals sector in terms of the Skills Development Act No.97 of 1998. As such, the MQA is responsible for administering skills development programmes for the MMS sector. The proximity of SETAs to industry places SETAs in a good position to facilitate the essential skills planning and develop the fit to purpose skills development interventions that equip the workforce with relevant skills, necessary knowledge and appropriate values and attributes to address challenges such as disjuncture between learning sites and skills requirements as well workplace experience.

In accordance with its mandate, the MQA has identified a need to be better positioned to contribute to sustainable development goals and transformation towards the green economy. In preparation for this, the MQA needs to have an in-depth understanding of the demand and supply of green skills among various MMS sub-sectors. More specifically, it has called for an investigation of the status of the essential '*green skills'* in the entire MMS and its sub-sectors' value chains, except for the coal sector (similar research study was conducted in this sub-sector).

Urban-Econ Development Economists supported by **Exigo Sustainability (Exigo[3])** was appointed by the MQA to undertake a research study and produced several reports, findings of which were consolidated in the current document. These include:

- Policy and literature review report
- Supply analysis report
- Eight demand analysis reports for the following sub-sectors:
    - Gold mining
    - Diamond mining
    - Diamond processing
    - Platinum Group Metals (PGM)
    - Cement, limestone, aggregates and sand (CLAS)
    - Jewellery manufacturing
    - Services incidental to mining (SITM)
    - Other mining

1.2 Project Scope

1.2.1 Purpose

The purpose of the study was to investigate the status of essential *'green skills'* in the entire mining and minerals sector across sub-sectoral value chains, except for the coal sector that was investigated during the pilot stage.

1.2.2 Study objectives

The specific objectives of the investigation into the green skills in the eight MMS sub-sectors included:

6. Investigation of the essential 'green skills' that are important for environmental considerations such as Air/Water Pollution and Mining Waste/Biodiversity (where relevant) in the Core Mining and Beneficiation (where relevant) of the mining and minerals sector
7. Investigation of the 'green skills' that are considered scarce in the Air/Water Pollution and Mining Waste/Biodiversity (where relevant) in the Core Mining and Beneficiation (where relevant) of the mining and minerals sector that can help in mitigating the effects of Core Mining and Beneficiation (where relevant)
8. Determining factors that affect both 'green skills' supply pipelines and demand in each sub-sector and how
9. Investigation of whether the current 'green skills' that aim to address Air/Water Pollution and Mining Waste/Biodiversity (where relevant) in the Core Mining and Beneficiation (where relevant) of the mining and minerals sector are integral to the new Qualification Council for Trades and Occupations (QCTO) qualifications
10. Specifying the implications of the green skills in the mining and minerals sector, when it comes to career pathing
11. Providing practical recommendations that the study can make for the development and implementation of 'essential green skills' in the Core Mining and Beneficiation (where relevant) of the mining and minerals sector.

1.3 Study boundary

Sectoral focus

The MMS sector involves a range of industries such as mining of minerals, processing of mined minerals, and export or domestic sales of raw or refined /manufactured mineral products. Concerning this project, the study boundary of the research will be limited to **eight MMS sub-sectors**. Coal mining was omitted from the study as it has already been assessed by Rhodes University's Environmental Learning Research Centre (ELRC). The eight sub-sectors that were investigated are illustrated below:

Figure 1-1: Study boundary- MMS sub-sectors

MMS value chain and stages of life cycle

The following diagram illustrates the generic value chain that is applicable to the MMS and outlines the phases of this value chain that are common to the eight sub-sectors under analysis. Furthermore, at each phase of the value chain, one can differentiate several life cycle stages of the respective activities, starting with design and ending with closure and rehabilitation.

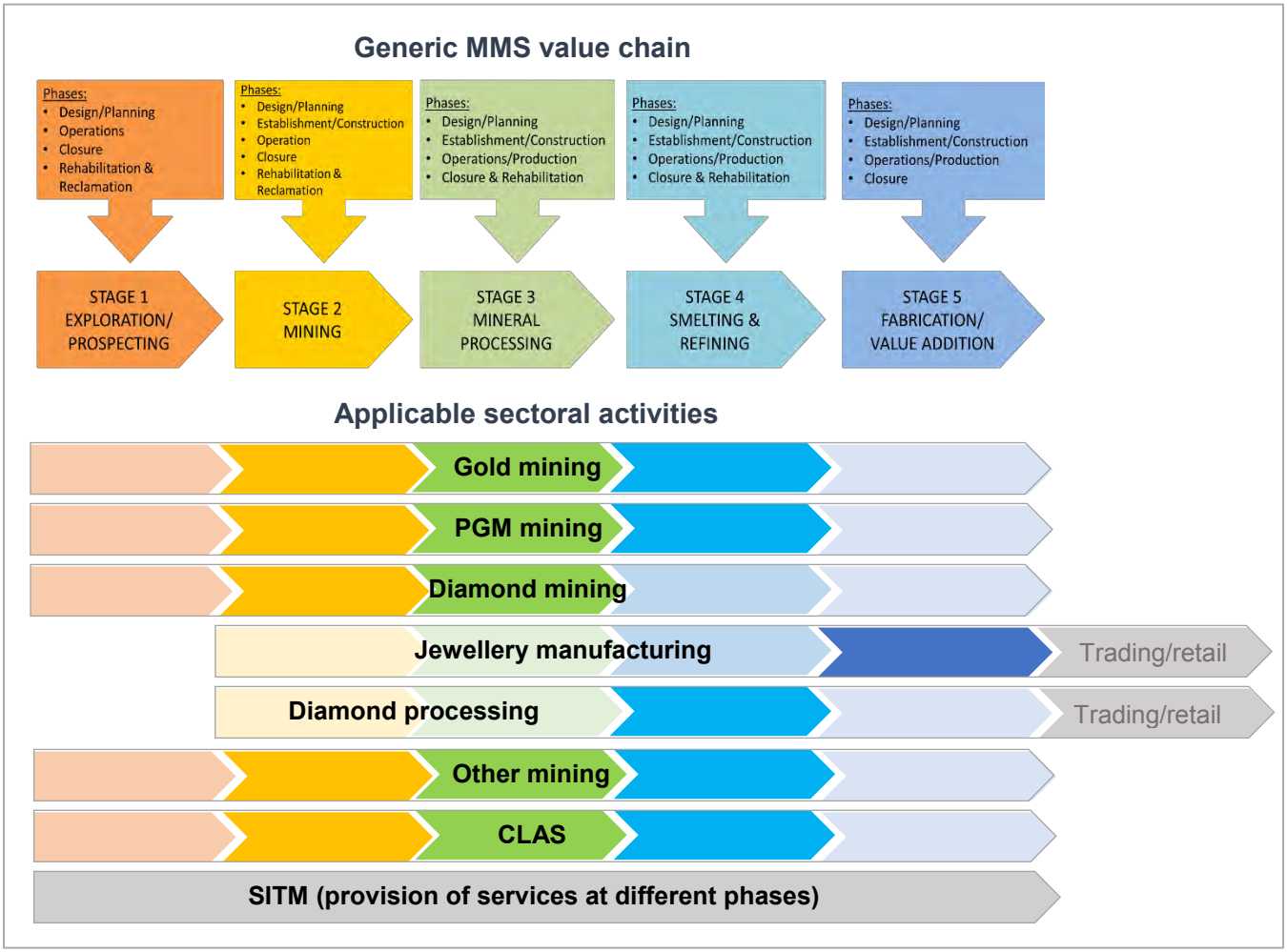


Figure 1-2: Generic value chain and stages of the life cycle applicable to the eight MMS sub-sectors

When considering the eight MMS sub-sectors analysed, it should be noted that Gold mining, PGM mining, Other mining, and CLAS are the four sub-sectors that are well represented by all stages of the MMS value chain; however, Stages 2-4 encompass activities that are associated with the greatest negative effect on the environment. Diamond mining is primarily associated with the upstream activities with Diamond processing taking off where Diamond mining usually ends. Jewellery manufacturing, on the other hand, is primarily associated with the value adding activities and has linkages to Gold mining, PGM mining, and Diamond processing as the outputs of these three activities serve as inputs into Jewellery manufacturing.

Green skills focus

Considering the range of environmental challenges experienced during various stages of the lifecycle experienced by the businesses operating in the MMS, the **focus of this study** will be limited to the following four, as outlined in the Terms of Reference for the project:

- Air quality related environmental issues, where "ambient air quality is defined as the physical and chemical measure of pollutant concentrations in the ambient atmosphere to which the general population will be exposed" (DEA, 2018).
- Water quality and quantity related environmental issues, where (DEA, 2018):
    - "Water quality refers to the physical, chemical and biological characteristics of water with regard to how suitable the water is for its intended use", and
    - "Quantity of water available for direct human use or to support aquatic ecosystems depends on the availability and sustainability of the resource."
- Waste generation issues: volume of waste and hazardous level of waste, where waste is defined any substance that is "surplus, rejected, discarded, abandoned or disposed of; which the generator has no further use of for the purpose of production; that must be treated or disposed of" (SAWIC, 2018).
- Biodiversity-related issues, where "biodiversity means the variability among living organisms from all sources including, terrestrial, marine and other aquatic 35 ecosystems and the ecological complexes of which they are part and also includes diversity within species, between species, and of ecosystem" (Portfolio Committee on Environmental Affairs and Tourism, 2003).

2 OVERVIEW OF THE RESEARCH PROCESS

The methodological approach to probing into green skills in the eight MMS sub-sectors comprised of four key steps as outlined in the figure below. Each of these steps is discussed in greater detail below.

Figure 2-1: Research process in brief

2.1 Defining research objectives

At the inception of the study, the research objectives had been translated into key research questions, which then informed the data collection methods and approaches. These research questions are listed in Annexure A. In short, though, the key research questions included:

1. What are the essential green skills?
2. Which of these green skills are considered to be scarce in the country?
3. What factors affect the supply and demand for the green skills?
4. Which of the green skills are integral to the new QCTO and where gaps exist?
5. What are the career-pathing implications of the green skills?

2.2 Research methodology

Considering the research questions posed for the study, the investigation into green skills in the MMS required a description of the situation with respect to the supply and demand for green skills within the eight MMS sub-sectors and identification of the commonalities among them to determine essential and scarce green skills. This in turn implied that a **qualitative approach** was most suitable for the study, which informed the selection of the **descriptive and exploratory approaches**, where**:**

- *Descriptive approach*, which involves a description of a phenomenon as it exists, was applied to describe the situation with respect to the supply and demand for green skills within the eight MMS sectors under review as it exists, and
- *Exploratory approach,* which looks for patterns or themes, was used to determine the commonalities among different MMS sub-sectors in terms of the demand for various green skills and identify those that are essential and those that are scarce.

A review of the research questions listed in Annexure A allowed determining whether a response to a particular question is expected to be gathered from secondary data, would rely on primary data, or make use of both primary and secondary data sources. While secondary information was identified to be an important data source, it was clear at the onset of the study that much of the data required to respond to the questions was not in the public domain and therefore need to rely largely on primary data sources. this necessitated the project team to design a sample for the study.

Approach to sampling

Several criteria were defined at the beginning of the project which informed the approach to determine the sample for the study. These included:

a) The selection of companies was to be *representative of the geographical spread* of the businesses in the respective sub-sector
b) Selected companies were to *include large, medium, and small businesses* to ensure consideration of challenges and demand implications by all business sizes
c) *Three companies* were to be selected and engaged with- representing each sub-sector

Considering the above criteria, it was decided that a four-tiered approach to sampling will be employed:

- Firstly, the population (i.e. mining companies) was stratified in terms of eight sub-sectors (i.e. Gold mining, PGM mining, Other mining, CLAS, SITM, Diamond mining, Diamond processing, and Jewellery manufacturing.
- Secondly, companies were divided into groups of small, medium and large sizes as per the MQA database.
- Thirdly, companies were then grouped in terms of their geographical distribution within each sub-sector to identify the spatial representation of the industry.
- Lastly, a **quota sampling technique** was applied, with three businesses being selected for engagement from each sub-sector representing large, medium, and small business and balanced geographical spread. Generalising the information acquired though a quota sample is "dangerous" due to deliberate or subconscious bias exerted when selecting companies to be interviewed; thus, caution needs to be taken when interpreting the data (Page & Meyer, 2000). In order to address the downside of the technique and improve the quality of quota samples, instead of selecting the first company or companies from a stratum related to business size, these were chosen randomly while ensuring the geographical representation.

Experience shows that the response rate of randomly selected companies is not always high and quite the opposite can occur. Therefore, to mitigate against this occurrence and to ensure that the research managed to secure the data from the sample as per the variables mentioned above, for each business size stratum two and sometimes three options (first, second, and third choices) were selected. This was done by ensuring that the sample still aligns with the geographical representation and the quota criteria. The following table contains the list of companies that were interviewed.

Table 2-1: Range of companies engaged with

Company	Company size	Location
Gold mining		
Sibanye Gold	Large	Gauteng
Tau Lekoa Gold mining	Large	North West
PGM		
Sibanye Rustenburg Platinum Mines	Large	North West
Impala Platinum Services Ltd (Mine)	Large	North West
Impala Platinum Limited (Refineries)	Large	Gauteng
Wesizwe Platinum Limited	Medium	North West/Gauteng
CLAS		
PPC Cement SA Pty Ltd	Large	Gauteng
Cape Lime	Medium	Western Cape
UCOSP Quarry (Pty) Ltd	Small	KwaZulu-Natal

Company	Company size	Location
SITM		
DRA Global	Large	DRA Global
Mintek	Medium	**Mintek**
Triton Training & Development Pty Ltd	Small	Triton Training & Development Pty Ltd
Diamond mining		
Petra Diamonds: Koffiefontein Diamond Mine	Large	Free State
Frontier Mining (Pty) Ltd	Medium	Northern Cape
Kareevlei Mining	Small	Northern Cape
Diamond processing		
KGK Diamonds SA Pty Ltd	Medium	Gauteng
Schacter & Namdar Pty Ltd	Small	Gauteng
Rand Vaal Diamonds Pty Ltd	Small	Gauteng
Jewellery manufacturing		
Keith White Designs	Medium	Gauteng
Oro Africa (Pty) Ltd	Small	Western Cape
Havilah Gold Creations	Small	Eastern Cape
Other mining		
Glencore Operations South Africa (Pty) Ltd	Large	North West & Gauteng
Exxaro Ferroalloys (Pty) Ltd	Medium	Gauteng
Sepfluor Ltd	Small	Gauteng

2.3 Data gathering: Approach and tools

As mentioned previously secondary and primary data were gathered during the study, the following paragraphs explain the approach to data gathering.

2.3.1 Secondary data gathering approach and tools

Secondary data is an invaluable additional to any research (Page & Meyer, 2000). Prior to investigating the demand for green skills, the research required answering the following, among others:

- What is green skills and what skills are considered essential and scarce?
- What do the value chains of different mining sub-sectors look like?
- What are the key environmental issues faced by the various MMS sub-sectors that are related to air quality, water quality and quantity, waste management, and biodiversity?
- What are the implications of various policies on green skills in the MMS sub-sectors?
- What type of qualifications are provided by the current education system in South Africa that satisfy the “green skill” definition?

The research into the above questions and others made use of a variety of secondary information sources which are publicly available and sourced from the internet. In gathering secondary data, the team also engaged with the Mining Qualification Authority (MQA), the Department of Environmental Affairs (DEA), the South African Qualification Authority (SAQA), Rhodes University’s Learning Centre of Environmental Education, and the Mining Council of South Africa to obtain additional existing information on the topics investigated during the study.

The secondary data provided sufficient background information but was not adequate to respond to most of the questions posed at the start of the research. The review of the secondary data revealed that the topic of green skills is not well researched in South Africa, which made it particularly challenging to find any recent and comprehensive data related to green skills in the MMS. Having said that, the DEA’s

Environmental Sectors Skills Plan released in 2010 and the study into green skills conducted by the Rhodes University provided an excellent backdrop against which the topic would be researched and further built on.

2.3.2 Primary data gathering approach and tools

Primary data was gathered following an **interactive procedure.** This approach introduces human and social communication elements into the research that can sometimes bring unwanted bias. On the upside, it allows for probing and poking into the topic to ensure complete understanding of the response given by the interviewee and gathering of comprehensive and exhaustive feedback, leaving no gaps in answers (Page & Meyer, 2000). This is particularly important considering the qualitative nature of the research undertaken.

The interactions followed a **semi-structured approach** where a designed questionnaire agreed with the MQA was used to guide the discussion (refer to Annexure A for the copy of the questionnaire). This assured that the data obtained responded to the key research objectives and was gathered in a consistent manner regardless of the person interacting with the interviewee.

Data gathering was done using telephonic or in-person interviews. **Telephonic interviews** were opted for in cases when it was the only option that the respondent was willing to consider; however, considering the limitation of telephonic interviews (since the voice is the only contact and source of interpretation) (Page & Meyer, 2000), the preference was always given to **face-to-face interviews** and all efforts were directed towards securing that type of interaction. Importantly, no incentives were offered to the participants of the research.

Depending on the size of the company and the availability of the staff, the interviewed personnel represented the following occupations, which were identified to be knowledgeable in the aspects related to environmental compliance, demand for green skills, and the experienced shortages in that regard:

- Company's director/manager
- Environmental Manager/coordinator
- Environmental Specialist/Superintendent
- Safety & Environmental Manager (Refineries)
- Training & Development Manager
- Ventilation Occupational Hygiene Engineer
- Group Learning and Development
- Head of Sustainability
- Social Labour Plan Coordinator
- Occupational Hygiene Officer
- HR Manager
- HR: project administrator
- Health, Safety and Environmental Compliance (HSEC)/Safety, Health and Environment (SHE)/Safety, Health, Environment and Quality (SHEQ) Manager
- Climate Change Senior Specialist
- Mining consultant

A total 50 managers and professionals representing the above-mentioned occupations working for 24 companies in the MMS were interviewed.

Table 2-2: Summary of the number of people interviewed per sub-sector

Sub-sector	Number of people interviewed	Number of companies engaged with
Gold mining	6	2
PGM	8	4
CLAS	6	3
SITM	3	3
Diamond mining	6	3
Diamond processing	4	3
Jewellery manufacturing	3	3
Other mining	14	3
TOTAL	50	24

In addition, the study also involved engagements with officials that possess relevant expertise and knowledge from the DEA, SAQA, Rhodes University's Learning Centre of Environmental Education, and the Mining Council of South Africa.

2.4 Data analysis methods

The data that was gathered from each of the three interviews was aggregated and analysed, which was then used to produce the report at hand. The aggregated data was presented in tabular and diagrammatic forms.

The tables reflecting essential green skills (for example, Table 5-2, Table 6.2, etc.) that have been identified to be critical referred only to those critical skills that the industry representatives have highlighted to be "high critical value", which corresponded to ranking them 4 out of 5 or 5 out of 5 on a critical scale.

Since the data gathered was qualitative in nature and was primarily gathered through interviews, a **content analysis** method was employed. The content analysis method assisted in identifying the key concepts and themes contained in the data (Page & Meyer, 2000). Since the variables that have been investigated were related to the demand, criticality, and shortages of the specific skills in the MMS sub-sectors, the review of the data using content analysis method resulted in the identification of the categories of skills and occupations that the companies were particularly struggling with in acquiring. The results of this analysis coupled with the literature review on the current qualifications related to the green skills informed the recommendations of the study.

2.5 Assumptions and limitations

The following assumptions and limitations applied to the study:

- **Green skills along the MMS value chain analysis**: At the start of the research, the investigation into green skills within the MMS was planned to be conducted considering the MMS value chain. At the same time, the selection of companies to be engaged with to gather data with respect to green skills demand and shortages was done using the MQA's list of registered companies. It was only later in the project that is became clear that such a list does not reflect the companies that operate along the entire MMS value chain and are largely limited to the companies that operate at Stages 2-4 of the value chain outlined in Figure 1-2. Furthermore, the existing database of the MQA does not differentiate among the value chain stage that each company on the register gets involved in. Having said this, engagement with the companies' representatives revealed that,

in most instances, Stage 2 (Mining) and 3 (Mineral processing), and in some instances Stage 1 (Exploration) and Stage 4 (Smelting and refining) are undertaken by the same companies and at the same locations, with boundaries among the four stages often blurred. The engagement with representatives of the respective sub-sectors assisted in identifying the nature of issues that are being faced with during each of these stages and this information was included in the reports prepared for each sub-sector. The following can be noted, though:

- The environmental issues related to air quality, water quality and quantity, biodiversity, and waste management are particularly acute during Stage 2 (mining) and Stage 3 (mineral processing) stages. This means that the demand for and shortages of green skills captured for these two stages encompass the demand and shortages of green skills applicable to other stages of the value chain.
- The environmental issues faced by companies during Stage 2 (Mining) and Stage 3 (Mineral processing) are often similar. This suggest that the demand and subsequently shortages for respective skills created during Stage 2 and Stage 3 of the MMS value chain will be similar for each MMS sub-sector.
- Stage 1 (Exploration) and Stage 4 (Smelting and refining) are associated with a smaller range of negative environmental impacts. During Stage 4 these issues are more concerned with the emissions from smelting, the use of water for beneficiation processes, waste management, and vegetation and habitat loss during construction and rehabilitation during closure. Therefore, it could be argued that the range of green skills in demand during this stage will be more limited than that of Stage 2 and Stage 3. Importantly though, these skills are not unique to Stage 4 and often overlap with those skills required during Stage 2 and Stage 3 activities.

In conclusion, it can be stated that while the insight into the green skills at each stage of the value chain is informative, the fact that there is an overlap of green skills among the various stages of the MMS value chain means that such information would not affect the recommendations contained in the study.

- **Project duration**: The study was planned to be undertaken over a period of 12 months, which was believed to be a sufficient timeframe, despite a complex nature of the research and the range of sub-sectors that required to be analysed. However, the project experienced a number of delays that affected the submission of interim deliverables and moved the submission of the drafts and final reports by a month. These delays were related to the following:
  - The sample of companies to be engaged with was initially highly prescriptive and allowed engagement only with two possible options for each combination of “sub-sector – company size – geography”. Engagement with the second choice was only initiated when it was evident that the first choice was taking too long to respond or has indicated its unwillingness to participate in the research. This delay could be entirely avoided in the future by selecting and engaging at the same time with at least three companies representing a combination of “sub-sector – company size – geography”.
  - A considerable amount of time was lost due to the decline to participate in the research by various companies and the need then to identify, engage, confirm and conduct meetings with companies that had to be chosen to replace the ones that declined.
  - In some instances, where companies would initially indicate their interest and willingness to participate in the study, agreeing on the suitable date for a meeting sometimes took up four to eight weeks.

- **Data reliability**: The success of the research in identifying the demand and supply of green skills in the MMS was reliant on the accuracy and completeness of the data gathered throughout the study. This in turns means that the data and sources needed to conform to the highest research standards and be valid, reliable, authentic, relevant, recent, and sufficient. A preliminary scan of the published and unpublished data obtained from the MQA revealed that not much is known about the field of study, which means that primary data gathering was key. While the project team experienced some difficulties in obtaining initial commitment from some industry participants, those companies that have been engaged with were highly responsive and knowledgeable in the fields discussed. The only limitation that can be brought forward was that the businesses operating in the MMS sub-sectors make use of external consultants for environmental management during the planning phase as well as during the other phases where legislation requires that an independent party be used. The respondents interviewed did not have an in-depth knowledge of the green skills in as external consultancies were used and this may have posed some limitations to the research.
- **Company sampling**: When selecting a sample of companies, the focus was on ensuring a representation thereof in terms of sub-sectors, geographical areas, and size of companies. All provinces are presented in the sample, except for Limpopo, and a balanced mix of small, medium, and large size companies are achieved.
- **Representation during interviews**: At the individual interview level, the focus was on ensuring a representation of the relevant occupations; no requirements in terms of race and gender was posed as these factors were not critical for the study.

3 CONTEXTUAL ANALYSIS

This chapter sets the context within which the study was undertaken and introduces several terms and definitions that form the cornerstone of the study. These include explanations of skills, essential skills, scarcity of skills, as well as the definition of green skills. The introduction of these terms and definitions is important to ensure consistency in the analysis, as they could be viewed differently depending on the background, experience, and disciplinary predisposition.

3.1 What are skills?

"Employment is central to human dignity, sustainable economic development and social cohesion" (National Treasury, 2010). However, for one to receive such an employment opportunity, it is incumbent upon them to prove their competence by possessing the matching skill as stipulated in the relevant job specifications. Often, **the level of skill acquired is linked to the learning process received through formal education**.

The Taxonomy of Educational Objectives is a framework consisting of three domains considered essential in facilitating the learning process. These domains are (Forehand, 2010):

- **Cognitive** (knowledge-based domain)
- **Affective** (attitudinal-based domain)
- **Psychomotor** (skills-based domain)

The Psychomotor (skills-based domain) primarily refers to discreet physical functions, reflexive actions, interpretive movements, automatic responses, or reflexes. Such skills are often manual tasks ranging from a simple task such as digging a hole to more complex tasks like operating complex machinery (Wilson, undated). Essentially, these skills are the actual expertise developed during education and training making the skills-based domain more inclined to the literal and physical expertise (Gregory, 1987). This is not only inclusive of trade and craft skills acquired through apprenticeship but high-level performance skills in various fields such as the arts, games, and athletics (Wilson, undated).

Hard skills are "Technical and analytical competencies and know-how that allows workers to perform the mechanical component of the job."

Soft skills are "Psychological and interpersonal skills that help people make informed decisions, think critically and creatively, communicate effectively, build healthy relationships empathise with others and cope with and manage their own healthy lives." (Nam, 2009).

Enhancing skills requires dedicated practice, and performance is measured in terms of speed, precision, distance, procedures, or techniques used in execution (Wilson, undated). Since the skills-based domain is more linked to the "doing" part of the job, training or learning process, **skills cannot be explained in words but can be observed through videos, demonstrations, descriptions, or accumulated experience**. Since some activities span across all the domains, underlying the psychomotor domain is the cognitive domain as one primarily must think and have prior knowledge regarding a particular topic before and whilst executing a technique (Kasilingam, Ramalingam, & Chinnavan, 2014).

In the face of technological progress, globalisation and demographic shift, the demand for skills in the labour market is undergoing substantial change (OECD, 2017). While competencies and know-how that allows a person to perform the technical aspect of the job is still important (**hard skills**), there is a greater emphasis on **soft skills** that allow people to make informed decisions, communicate effectively, and think critically (Nam, 2009).

According to the **Department of Labour** (DoL), **skills** refer to the **necessary competencies that can be expertly applied in a particular context for a defined purpose**. Competencies are said to have three elements (DoL, 2008):

- **Practical competence** – the ability to perform a set of tasks
- **Foundational competence** – the ability to understand what one, and others around are doing why
- **Reflexive competence** – the ability to integrate or connect ones' performance with an understanding of the performance of others, so as to facilitate the process of learning from each other and adapt to changes as well as unforeseen circumstances.

According to the the **Department of Higher Education & Training** (DHET), a **skill refers to the ability to carry out the tasks and duties of a given job**. Skills are necessary for achieving and completing the stipulated tasks (DHET, 2013). To arrange occupations into groups, the DHET categorises occupations according to skill level and skill specialisation (DHET, 2013). The linkages among occupations, jobs, skills, skills levels and specialisations as well as the definitions thereof are provided in Figure 3-1.

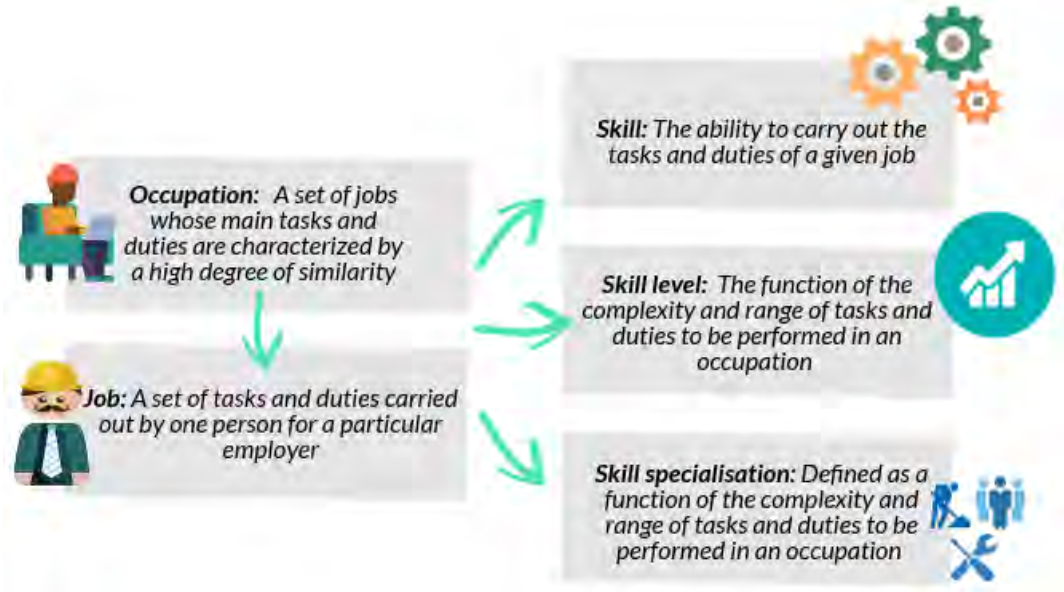


Figure 3-1: Definitions (DHET, 2013)

Considering the above, the following working definition for **"skills" is** adopted for this study:

Skills represent abilities and competencies that a person possess to perform specific tasks and duties for a defined purpose

3.2 Scarce, essential, and green skills defined

Scarce and critical skills

Under the former President, Thabo Mbeki, the 2006 government launched the Accelerated and Shared Growth Initiative for South Africa (AsgiSA). One of the primary goals of this initiative was to enable the country to achieve an average growth of 6% per annum. With this growth target in place, it was believed that there would be an accompanying reduction in unemployment and a subsequent better quality of life for all South Africans. When this target was not met, an investigation of the reasons impeding the economic growth revealed that the shortage of a suitably skilled labour force was one of the six key constraints (The Presidency: RSA, 2011).

In response to this shortfall, the Joint Initiative on Priority Skills Acquisition (JIPSA) was launched in the same year by the then Deputy President, Phumzile Mlambo-Ngcuka, and it was tasked with the role of identifying urgent skills needs and providing quick effective solutions. Under the JIPSA, the skills were divided into **"scarce"** and **"critical skills"**. Today, this terminology is used by Sector Education Training Authorities (SETAs) and is included in their Sector Skills Plans (SSPs) (The Presidency: RSA, 2011).

Figure 3-2 below illustrates the skills path followed by South Africa.

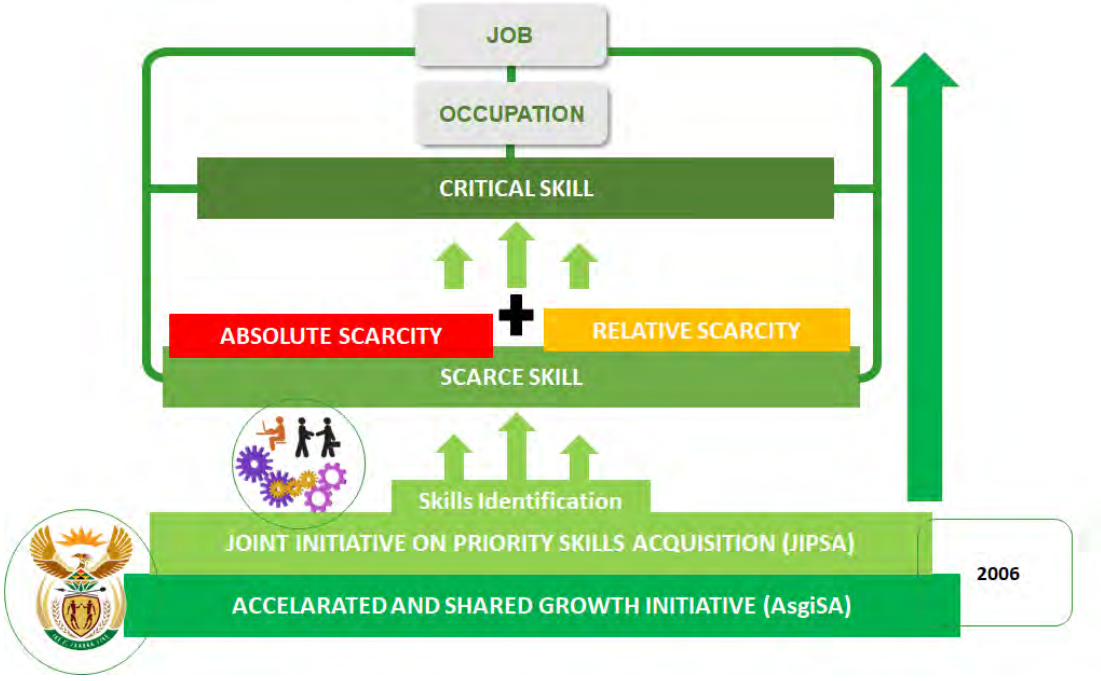


Figure 3-2: Skills identification pathway - South Africa (The Presidency: RSA, 2011)

Scarce skills refer to occupations, in which there is a scarcity of qualified or experienced people, either now or in the future, which in turn are viewed in terms of absolute or relative scarcity:

- **Absolute scarcity** refers to instances when suitably qualified people are not available in the labour market, e.g. when there is a new or emerging occupation
- **Relative scarcity** refers to occasions when suitably skilled people are available in the labour market, but they do not possess other employment criteria, e.g. **high-level work experience** (e.g. the lack of exposure to a specified discipline), **geographical locations** (e.g. unwillingness to

relocate to areas outside the urban area) and **equity considerations** (e.g. few candidates with the requisite skills from specific groups available to meet the skills requirements)

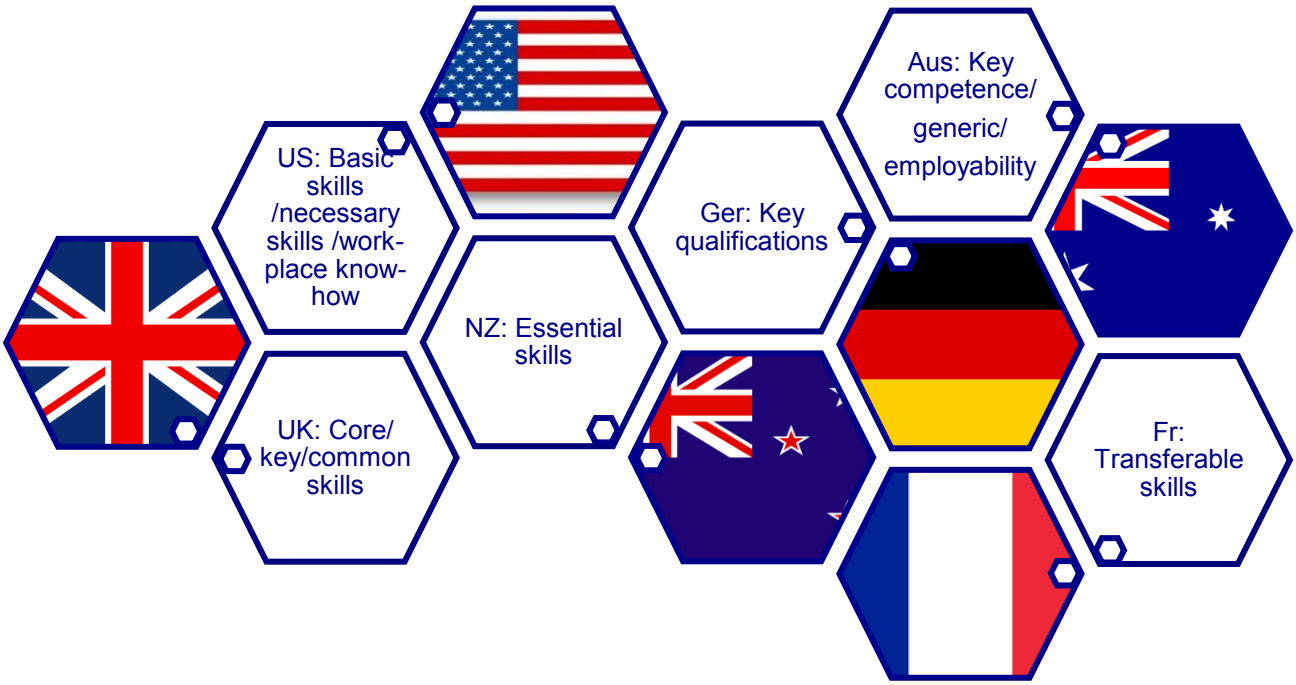
Critical skills refer to specific skills or capabilities, which are required within an occupation such as general management skills, communication and customer handling skills, team-work skills etc. These may also include generic skills such as problem solving and report writing (DoL, 2008).

Considering the above, the following working definition for **"scarce skills"** is adopted for this study:

Scarce skills refer to occupations, in which there is a scarcity of qualified or experienced people, either now or in the future, whether due to absence of qualified individuals in general, or lack of one or more employment criteria such as work experience, geographical location, or equity.

Essential skills

A scan through South African literature for the definition of **essential skills** from a local context revealed that **there is no formal definition of essential skills**. As a result, the research looked into the definition of essential skills in other countries. The review of the literature revealed that essential skills are labelled differently across various countries and organisations; thus, they are often synonymous with some of the following terms:



One of the most comprehensive definition of essential skills comes from the United States Department of Labour, which identified skills that American workers required for success in a global market. These skills are divided into two aspects namely, **workplace competencies** and **foundational skills.** Together,

these concepts make up the **Essential Workplace Skills** that are also intended to be developed by all citizens, i.e. in the classroom and workplace (U.S Department of Labour, 2000).

Table 3-1: Essential workplace skills in the US

<table>
<tr><th colspan="2">ESSENTIAL WORKPLACE SKILLS</th></tr>
<tr><th>WORKPLACE COMPETENCIES</th><th>FOUNDATIONAL SKILLS</th></tr>
<tr><td>Resources
Allocates Time
Allocates Money
Allocates Materials and Facility Resources
Allocates Human Resources</td><td rowspan="2">Basic skills
Reading
Writing
Arithmetic
Mathematics
Listening
Speaking</td></tr>
<tr><td>Information
Acquires and evaluates information
Organizes and maintains information
Interprets and communicates information
Uses computers to process information</td></tr>
<tr><td>Interpersonal
Participates as a member of a team
Teaches others
Serves clients/customers
Exercises Leadership
Negotiates to arrive at a decision
Works with cultural diversity</td><td>Thinking skills
Creative thinking
Decision making
Problem solving
Seeing things in the mind’s eye
Knowing how to learn
Reasoning</td></tr>
<tr><td>Systems
Understands systems
Monitors and corrects Performance
Improves and designs systems</td><td rowspan="2">Personal Qualities
Responsibility
Self-Esteem
Social
Self-Management
Integrity/Honesty</td></tr>
<tr><td>Technology
Selects Technology
Applies Technology to Task
Maintains and Troubleshoots Technology</td></tr>
</table>

(U.S Department of Labour, 2000)

It can be deduced that **essential workplace skills are those skills, which are necessary to have to be considered for employment as they represent the foundational skills**. In addition to this, it is important to note that essential skills are independent of the job-specific skills often required as part of the eligibility criteria of a specific job making them suitable for all types of business environments.

Ideally, country-specific skills-related frameworks such as SCANS imply that it is essential for all countries to document frameworks that are suitable to the needs of the countries workforce and developmental context. Considering that South Africa is embarking towards transforming the economy into a green economy, it is essential to consider the types of skills that will be required for the smooth transition towards the green economy.

Green skills

Whilst most countries have been embarking on the development of a green economy path, very few of these countries have introduced accompanying skills policy development strategies and training programs to make the envisioned sustainable pathways effective (ILO, 2011).

The review of the international literature revealed that one cannot entirely divorce the green economy and transition towards a low-carbon economy path from the actual green skills concept. The reason behind this is because most of the international literature reveals a consensus that the successful adoption of more environmentally-friendly approaches to economic production envisioned by the green economy will eventually change the nature of the actual work required in the workplace. A change in the required work, thus, alters the type of skills required to perform the job (ILO, 2011).

In **South Africa**, there is no clear-cut definition for green/environmental skills, however, the environmental sector skills plan broadly refers to these as **skills encompassing the knowledge, values and skills required to fulfil all environmental mandates** (DEA, 2010). In order to develop a working definition for green skills, a review of green skills' definitions adopted in other countries was conducted, which revealed the following:

- According to the **OECD**, **green skills** are those skills **needed to adapt products, services and processes to climate change and the related environmental requirements and regulations**. Whilst the European Centre for the Development of Vocational Training (CEDEFOP) defines green skills as the knowledge, abilities, values and attitudes needed to live in, develop and support a sustainable and resource efficient society (OECD, 2014).
- Closely linked to CEDEFOP's definition of green skills, is the **Australian Green Skills Agreement** definition which refers to green skills or "skills for sustainability" as those **skills which, are needed in the workforce to develop and support a sustainable social, economic, and environmental outcome in business, industry, and the community**. This Agreement primarily emerged to build the capacity of the Vocational Education and Training sector to deliver the skills required for the sustainability required in the workplace thus enabling individuals, businesses and communities to adjust in a sustainable low carbon-economy (Council of Australian Governments, 2010).
- The 2009 **Michigan Green Skills Report** refers to green skills as those **skills, which actively contribute to environmental improvement, such as energy auditing, installing insulation, and working with new materials** (Bureau of Labour Market Information and Strategic Initiatives, 2009).

> **Green skills** are the knowledge, abilities, values and attitudes needed to live in, develop, and support a sustainable and resource efficient society (OECD, 2014).
>
> **Green skills** often function as an overlay on existing skills and cannot be understood or acquired independently.

Important to note is that most literature highlights that many of the skills required for the low carbon economy transition can be readily found in existing occupations. This is mostly because **green skills often function as an overlay on existing skills and cannot be understood or acquired independently.**

According to the OECD and CEDEFOP, the demand for green skills is driven by a range of factors, which are defined by the following trends (OECD, 2014):

- **Across occupations and industries** – greening requires upgrading of skills and adjusting qualification requirements

- **In instances of new or emerging economic activities** – such cases inevitably create new or renewed occupations and related qualifications affecting the desired skills pool
- **Structural changes** – these create a need to realign sectors that will potentially decline because of greening of the economy and retrain workers accordingly

Considering the above definition of green and environmental skills as well as the working definition for "skills" presented earlier in the report, the following working definition of "**green skills"** was adopted for the study:

Green skills refer to abilities and competencies that a person possesses that enable him/her to perform general or specific duties and tasks to develop and support an environmentally sustainable outcome in business, industry, and the community

4 GREEN SKILLS IN THE CONTEXT OF THE MINING SECTOR

Having defined the generic terms such as skills, essential skills, and green skills, which was provided in the previous chapter, this section of the report examines green skills in the context of the mining sector. In addition to presenting a working definition of green skills in mining, the chapter provides a comprehensive list of green skills when they relate to air quality, water quality and quantity, waste management, and biodiversity areas.

4.1 Green economy concept and mining

According to CSIR (2014), the determination of goods, outputs, income distribution in the market, demand and supply are all economic concepts, which embody the traditional economic theory and practice. Omitted from this approach however, is the inclusion of the value of natural resources and environmental degradation in pricing and other market mechanisms. Conventionally, global economic growth has always been at the expense of the natural environment. As a result, resources such as water, fertile soil, and fossil fuels have been fast reaching their potential for exploitation. Accompanying implications have been natural disasters, climate change, disrupted ecosystems, increasing socio-political unrest, as well as threatened food security.

In response to the increasing concentration in crisis, the United Nations Environmental Program (UNEP) proposed the revival of the global economy whilst simultaneously increasing employment and fighting against the looming effects of climate change and environmental degradation (CSIR, 2014). Since then, the **green economy concept** gained global focus and is hailed as the global development trajectory. Figure 4-1 below presents three definitions of the green economy concept by various organizations:

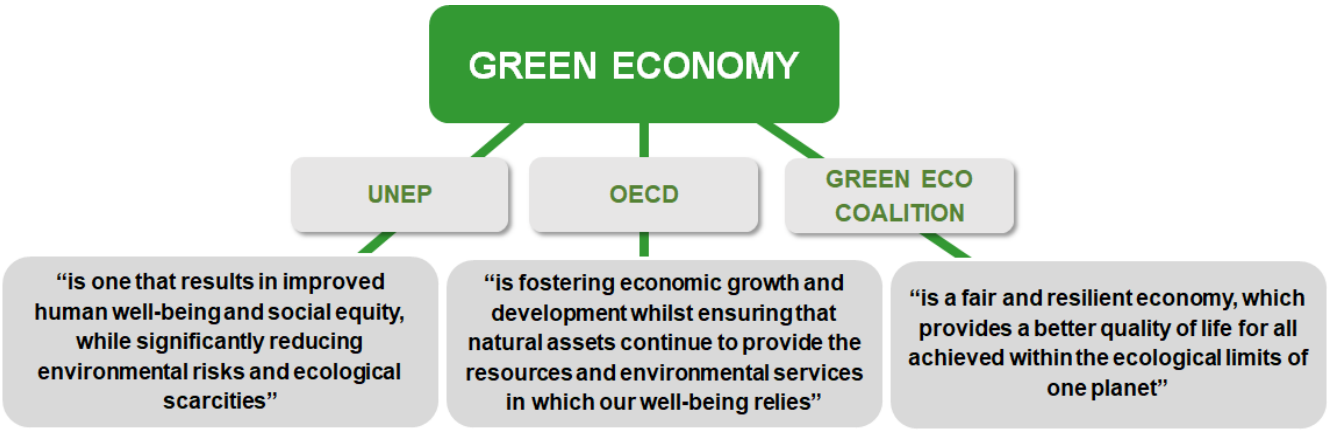


Figure 4-1: Green economy international definitions

In South Africa, the DEA defines the green economy as **growth which implies the decoupling of resource use and environmental impacts from economic growth** (DEA, 2011). An assessment of all mentioned definitions reveals the common goal of reorienting the global economy towards a developmental path which is **resource efficient, socially inclusive and equitable** (equal distribution of wealth and benefits which ultimately improve human well-being) (CSIR, 2014).

As the global economy strives to adopt the path towards a green economy, it is important to consider all economic sectors directly contributing to the key environmental challenges such as climate change and environmental degradation. One such prominent sector is the global **mining and minerals industry**, which is involved in the primary exploitation of mineral resources.

Mining is

"derived from the Latin word **mineralis** – which describes the process of extracting economically valuable minerals and ores for the benefit of humankind" *(National Confederation of Industry, 2012)*

Minerals have an increasing impact on human lives and on the overall development of a country (National Confederation of Industry, 2012). As such, as the global population increases, the demand for minerals and resources is also expected to increase, thereby fuelling the interaction between the natural environment and the mining industry. This in turn is expected to create a demand for skills that would assist in decoupling of environment impact from the growth of the industry and enable minimisation and mitigation of environmental impact across the entire mining value chain.

When it comes to green skills, despite the differences in value chains and the nature and type of environmental impacts exerted by various MMS sub-sectors, companies' understanding and views of what green skills entail are homogenous as indicated below. This is demonstrated by the diagram below which provides perspectives on what is green skills:

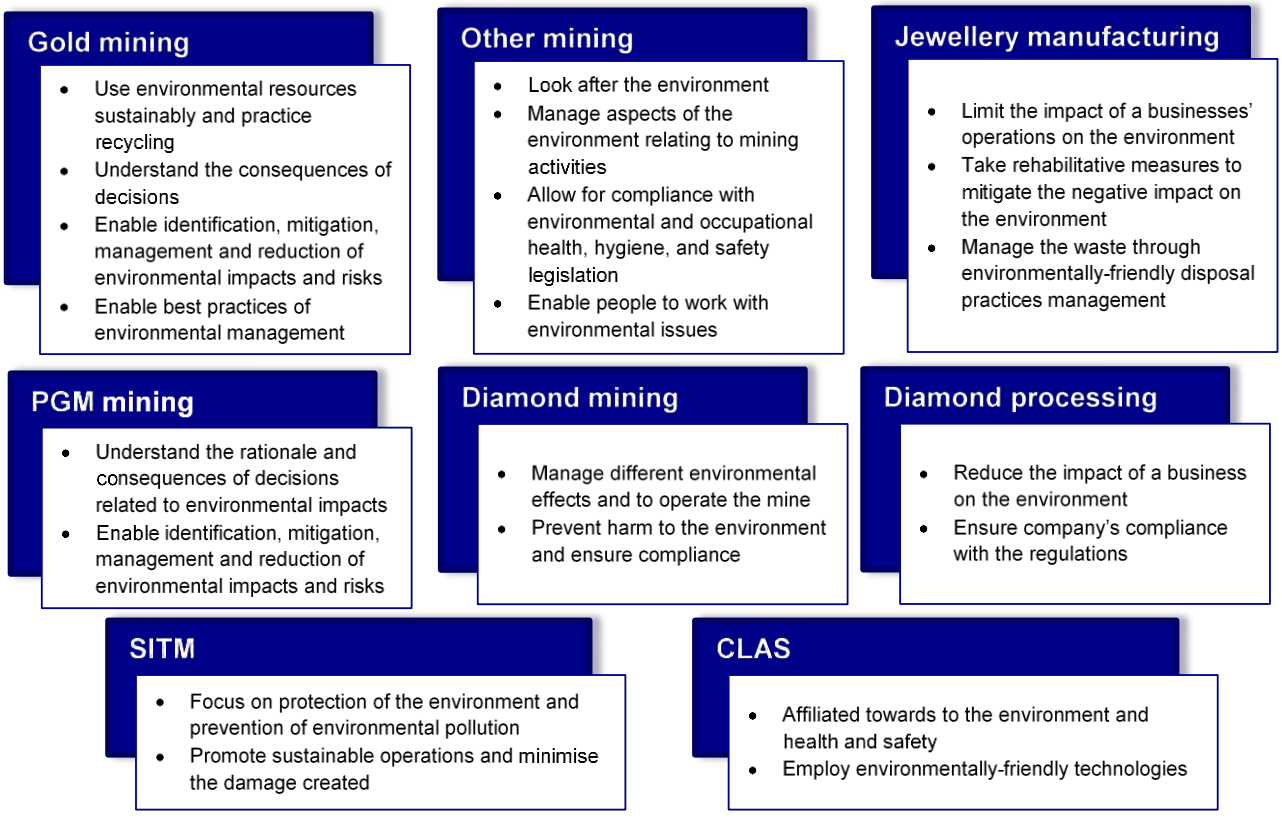


Figure 4-2: Green skills from perspective of different MMS sub-sectors

From the above, it is clear that the MMS companies approach green skills as the means to ensure compliance to environmental regulations and to achieve sustainable operations that ensure protection of the environment and result in limited environmental impact, which are identified and adequately managed and mitigated.

Considering the above, as well as the working definition of green skills presented earlier in the report, the proposed working definition of **green skills** for the MMS is as follows:

Green skills in **Mining and Mineral Sector** of South Africa
are **competencies and abilities** required
to **predict (identify and qualify) prevent, detect, mitigate, and monitor any environmental impact** during exploration, exploitation (extracting and processing) and beneficiation processes
to **ensure sustainability of operations and environmental compliance**

4.2 Policy and legislative implications on green skills

The vision for south Africa up to 2030 is articulated in the National Development Plan (NDP), which was launched in 2012. The National Development Plan 2030 (NDP) emphasis the need for improving skill levels of the workforce and equipping people with the skills they need to facilitate economic growth, job creation, and address the challenges of inequality, poverty, and unemployment in the country.

Following the adoption of the NDP 2030, the national government drew up the Medium-Term Strategic Framework (MTSF) covering the period between 2014 and 2019, which set out actions that government and its partners were to take to implement the NDP. The first MTSF 2014-2019 identified 14 priorities of the NDP that required urgent attention. Of these 14 priorities, four outcomes presented in Figure 4-3 are of relevance to the current study including:

- Outcome 1: Education
- Outcome 4: Economy
- Outcome 5: Skills
- Outcome 10: Environment

From the diagram below, it is clear that skills development, economic growth that lead to job creation, and environmental protection are some of the priorities that currently received urgent attention from government. The investigation into the green skills will contribute to generation of knowledge and identification of actions that could be implemented within the MMS. More specifically, it will assist in identifying:

- the range of green skills that are required to ensure environmental protection of natural resources (i.e. Outcome 10)
- green skills that are demanded in the MMS and their current supply (Outcome 5)
- gaps in green skills and importantly the shortages where it is linked to the chasm in educational programmes and associated qualifications (Outcome 4)

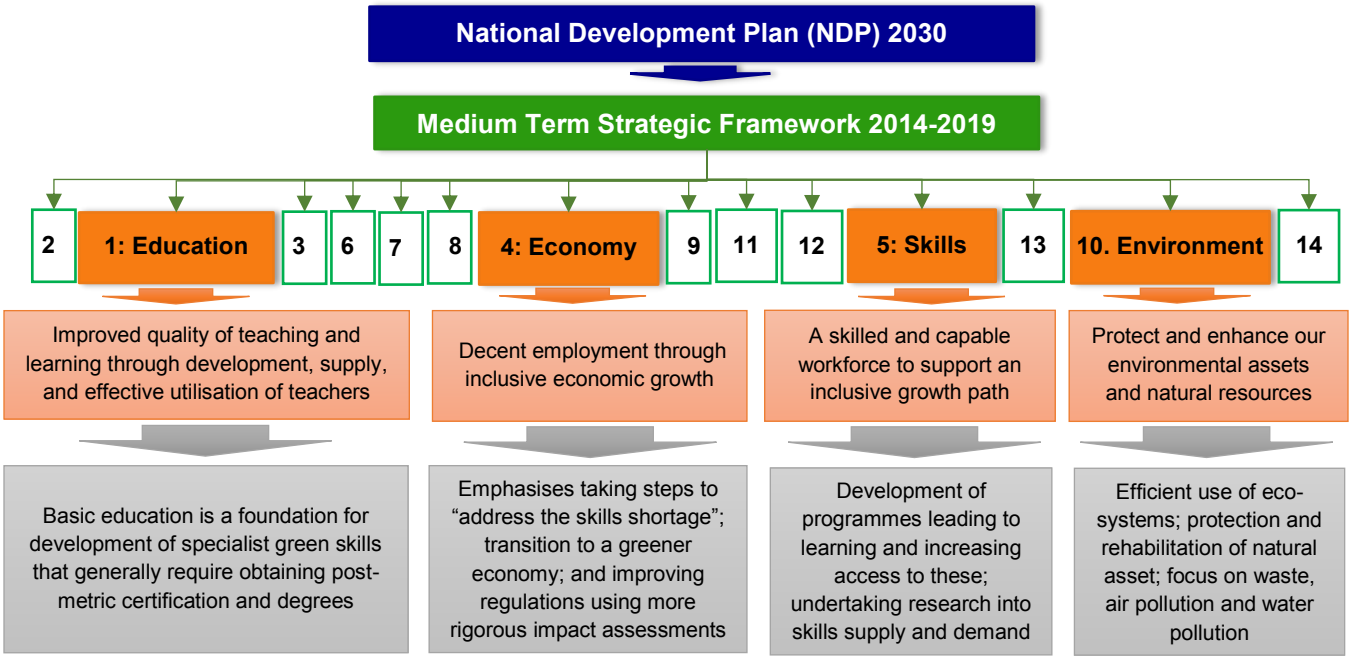


Figure 4-3: Implications of government priorities outlined in the MTSF on the green skill study

The MMS in South Africa is subject to various legislation, policy frameworks, guidelines, and conventions that have implications on the green skills on demand at various stages of the mining value chains. These are briefly summarised below by grouping them in terms of national and international policies, frameworks, and conventions.

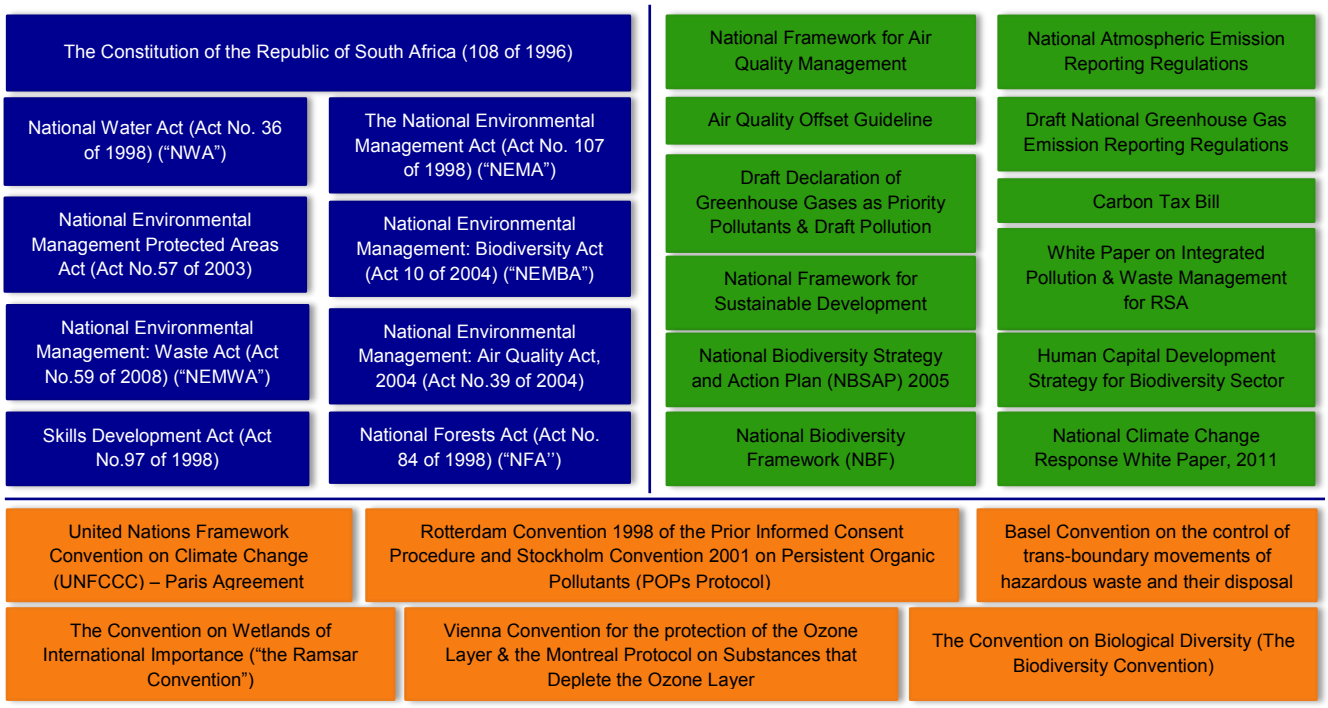


Figure 4-4: National and international policies and frameworks with implications on green skills demand

In addition to the above-mentioned general environmental and skills-related policies and frameworks that the mining sector needs to adhere to, South Africa includes several mining sector-specific policies and legislative documents:

Mineral and Petroleum Resources Development Act, 2002 (Act No 28 of 2002) ("MPRDA") (108 of 1996) (*Makes provision for equitable access to and sustainable development of the nation's mineral and petroleum resources, and to provide for matters connected in addition to that*)	• Law & Policy knowledge, analysis and interpretation • Skills relating to sustainable development in the mineral and petroleum sector • Environmental management and environmental engineering skills • Compiling an Environmental Management Programme and the implementation thereof • Skills in integrating social, economic and environmental factors in the mining project throughout all its phases (as stated by regulation 37(2)) of the Act • Conducting compliance audits • Regulatory skills with regards to the issuing of Mining Rights, Prospecting Rights, Permits, etc.
Mine Health and Safety Act No. 29 of 1996 (*Provides for the protection of health and safety of employees and other persons at mines*)	• Health and safety law and policy knowledge, analysis and interpretation • Implementation of health and safety systems in terms of the Mine and Safety Act • Assessing and mitigating health and safety impacts • Risk identification, evaluation and monitoring skills • Risk management skills • Hazard identification and management skills • Health and safety investigation skills • Compliance auditing skills
Explosives Act, 1956 (Act No. 26 of 1956) read with Mine Health and Safety Act, 1996 (Act No. 29 of 1996) (*Makes provisions regarding the management, storage, and disposal of explosives)*	• Blasting and vibration specialist skills • Skills relating to issuing of explosive permits & licences • Skills in storing and transporting hazardous materials i.e. explosives • Skills relating to health and safety Hazard identification and management skills
Mining and Biodiversity Guideline *(A tool to facilitate the sustainable development of country's mineral resources in a way that enables stakeholders to minimise the impact of mining on the country's biodiversity and ecosystem services.)*	• Biodiversity management skills in the mining sector • Stakeholder engagement • Skills in applying the Biodiversity Act No. 10 of 2004 • Skills in identifying areas where mining is prohibited • Skills in identifying critically endangered ecosystems • Skills in identifying critical biodiversity areas • Skills in identifying river and wetland freshwater ecosystem priority areas
Draft Mine Water Management Policy Position 7 July 2017 (*Provides the position of the Department of Water and Sanitation on mine water management)*	• Water management skills related to mining and Acid Mine Drainage • Green technology development skills • Skills pertaining to sustainable mining methods • Skills in applying environmental and water legislation to mining projects • Skills in classifying and differentiating mines
Mining Charter, 2010 *(set to drive transformation and competitiveness of the sector)*	• Skills in rehabilitation of disturbed land • Skills in design, development, and provision of waste storage and disposal processes

Figure 4-5: Mining-related policies and guidelines with implications on green skills demand in the MMS

It is clear from the above that the mining sector in South Africa is a well-regulated industry from an environmental perspective. Non-compliance with the relevant environmental legislation poses risks relating to costly operational delays or stoppages, licences being revoked, loss of investment, or legal

prosecution of directors of unlawful companies. This cannot only prove to be potentially costly but can pose a risk to maintaining a social licence to operate, which is often the recognition and acceptance of a company's contribution to the community, in which it operates (IFC, 2014). Having access to the necessary green skills, these risks can be managed and negated.

In order to adequately respond to the legislative requirements, regulation, policy framework and international conventions that the South Africa's mining sector needs to comply with, the MMS requires access to a vast diversity of green skills. A comprehensive review of these documents during the earlier stage of the study assisted in identifying the need and opportunities for general environmental management skills and green skills in air quality, water quality and quantity, waste management, and biodiversity. The following table summarises these green skills.

Table 4-1: Green skills required to adhere to environmental and mining-related policies and legislations

Issues	Skills required	Qualifications/Occupations
Air quality (including climate change)	Atmospheric Dispersion Monitoring	Air Pollution Control Officer
		Biofuels Processing Technician
		Air Quality Specialist
		Energy Auditor
	Carbon Accounting Energy Efficiency Climate Change Risk and Opportunity Assessors	Climate Change Managers
	Energy Analysis	Climate Change Analyst/Specialist
	Air Quality Modelling	Air Quality Specialist Engineers
		Atmospheric Scientists
		Air Quality Compliance Monitoring Technicians Licencing Officers
		Climate Change Risk and Opportunity Assessors Climatologists
		Combustion Engineers
		Emission Control Technologists
		Materials Engineers
		Renewable Energy Technologist
	Plant Management	Plant Managers
Water quantity and quality	Water modelling	Hydrologists
	Water Policy and Regulatory Implementation Skills	Competent Authority issuing licenses and permits
	Groundwater modelling	Hydrogeologist (groundwater specialist)
		Water Quality Monitors
		Water Plant Operators
		Chemical / water quality engineers
	Aquaculture skills	Freshwater ecologist/aquatic specialist
	Wetland Delineation	Wetland specialist
	Flood line Delineation	Flood line specialist

Issues	Skills required	Qualifications/Occupations
	Storm water management	Storm water Engineer
Waste generation and management	Pollution incident management	Waste Researchers and Scientists
	Waste minimization technologies	Toxicologist
		Remediation Specialists
		Landfill Designers and Managers
		Environmental Science Technician (with specialist competence for waste management)
		Waste recyclers
		Waste Management Technicians
		Geochemists
		Waste transporters
Biodiversity	Biodiversity conservation & management	Biodiversity specialists, alien species control officers
		Wildlife Veterinarians
	Spatial biodiversity management	Policy developers & analysts; urban and regional planners with biodiversity insight
		GIS Specialists and Technicians
		Urban and Rural Planners
	Rehabilitation skills: research and development into effective rehabilitation	Curators of biodiversity collections
		Geneticists: Genomic investigator, molecular biologist, molecular geneticist
		Conservation and Environmental Scientist
		Engineers (civil) with biodiversity specialism
		High level biodiversity education and Biodiversity Human Capital (HCD) specialists, human resource & training professionals
		Monitoring specialists, species protection officers and inspectors
		Information and Communications Technology (ICT) specialist and technicians with biodiversity skills: Service Managers, systems analysts, web and multimedia developers, applications programmers, database designers and administrators
		Monitoring specialists, species protection officers and inspectors
		Resource economists with biodiversity related specialism
		Social scientists specialising in environment; intellectual property & indigenous biodiversity knowledge specialists
		Soil scientists
		Agricultural extensionists with biodiversity specialism
	Marine & Coastal Management technical and enforcement skills	Biodiversity monitors in marine and other ecosystems
		Oceanographic Engineers/Technicians

Issues	Skills required	Qualifications/Occupations
		Taxonomists, systematists for marine and terrestrial systems
		Fisheries Control Officers
		Protected Area Managers
		Social Ecologists
		Ecologists: esp. in marine but also aquatic and terrestrial systems
	Bioprospecting Biosafety	Biotechnologists
		Soil Scientist
		Statistical Ecologists & Modellers
General Environmental	Environmental Management	Environmental Managers
		EIM Managers/Compliance Officers
		Environmental Assessment Practitioners (EAP's)
		Environmental Science Technician
		Environmental Impact Management Officers
		Environmental Risk Assessors
		Environmental Researchers
	Sustainability reporting	Sustainability Officers
	Sustainable development planning	Corporate Sustainability Managers
	Environmental accounting and costing	Environmental and Resource Economists
	Environmental Law, Policy knowledge & Policy Analysis	Lawyers with environmental specialist, legislators
		Environmental Assessment Practitioners
	Environmental Monitoring, Evaluation & Auditing	Environmental Compliance Officers
		Environmental Control Officers
		Environmental Management Inspectors & Compliance Officers
		SHEQ Practitioner
		Health and Safety Manager or Officer
		Environmental Engineers
	Cleaner Production Skills	Process Engineers Cleaner Production Technicians
	Community Facilitation and Engagement	Community Liaison Officer Stakeholder Engagement Facilitators
		Marketing and Communications Staff with Green Skills/Capabilities
		Social Scientist
		SHE Officers/SHEQ Officers
		Public Participation Specialists

5 AIR QUALITY-RELATED SKILLS ANALYSIS

The previous chapter presented the wording definition for green skills in the MMS and outlined a range of green skills within the four fields of the study, i.e. air quality, water quantity and quality, waste management and biodiversity. This and the following three chapter present the significance of air-quality related green skills in the either sub-sectors under analysis and highlight the shortages that are current experienced in the industry based on the information gathered during interviews with the industry stakeholders. The chapter also provides an insight into the alignment of the green skills required by the industry with the QCTO qualification framework, which assisted in informing recommendations for the way forward.

5.1 Significance of air quality issues and critical skills required

South Africa's air quality remains one of its most challenging environmental issues and is an issue that has been raised on several occasions with regards to the health and welfare of South Africa's population. Pollutant concentrations, particularly for sulphur dioxide and particulates, exceed recognised thresholds and are worsening in several so-called priority areas. Fugitive dust and spontaneous combustion emission from the mining sector are some of the most common sources of atmospheric emission that impact on air quality (DEAT, 2008).

In addition, South Africa's dependence on coal-driven energy sources and the energy intensive nature of the economy has resulted in extremely high carbon emission levels. South Africa is also located in one of the geographical areas most susceptible and vulnerable to climate change. The country is already experiencing the early effects of global warming and climate variability in the form of average land and sea surface temperature increases, rising sea levels, changing rainfall patterns, and increasing extreme weather events, e.g. flooding and droughts (DEAT, 2008). This will result in a greater impact on air quality.

The review of the significance of air quality issues during various stages of the mining activities in the analysed sub-sectors revealed that the most significant impacts related to air quality occur primarily during operations, as indicated below, with some negative effects taking place during the construction and closure phases.

Table 5-1: Significance of air quality issues at different stages of the life cycle

MMS sub-sector	Design/ planning	Construction	Operation	Closure	Rehab
Gold mining					
PGM mining					
Other mining					
CLAS					
Diamond mining					
Diamond processing					
Jewellery manufacturing					NA
STM					

LEGEND:	*Negative - negligible*	*Negative - low*	*Negative - moderate*	*Negative – high*	*Positive*

As indicated above, **Gold mining, PGM mining, Other mining, CLAS, and Diamond mining activities** are associated with the greatest possible negative effect on air quality during operations. These are generally associated with the **fugitive dust** and emissions **of sulfur dioxide** (SO_2) and **nitrogen dioxides** (NO_2) from smelting and/or processing activities (where involved). More specifically:

- **Gold mining**: Dust from open cast mines, such as fugitive dust, can have health impacts (i.e. pulmonary fibrosis, silicosis, and lung cancer due to dust inhalation) on mine workers and local communities if not mitigated. Dust from tailings storage facilities could also contain chemicals such as cadmium and arsenic. The heating process in the processing plant can also result in the release of emissions such as nitrogen and sulphur dioxide. The process of extracting gold from the ore requires the application of heat and chemicals, such as cyanide.
- **PGM mining:** Air quality impacts during the operational phase can be considered high due to smelting processes (release of SO_2 and NO_2), transport of materials and product and the use of mobile equipment resulting in carbon dioxide emissions. Fugitive dust can also become a severe hazard for human health if not mitigated.
- **Other mining:** Other mining activities can make use of underground or open cast mining methods, with the open cast method resulting in more air quality impact. These impacts relate to fugitive dust from vehicular movement on unpaved surfaces and materials handling during the construction and operational phases of mining.
- **CLAS:** Dust emissions are prevalent in all activities. Emissions of gases such as sulphur dioxide, nitrogen oxides, grey dust, carbon dioxide and carbon monoxide during limestone mining specifically.
- **Diamond mining:** Diamond mining often consists of open cast pit mining. Air quality impacts are therefore associated with fugitive dust emissions from vehicular movement on unpaved roads and materials handling as well as from mine residue stockpiles and deposits.

It is no surprise then that the need for air quality-related skills is created particularly during the operational phase of the abovementioned mining activities, as outlined in Table 5-2. As indicated, there is a considerable demand for **skills in fugitive dust sampling and monitoring; dust fallout and urban pollutant monitoring; stack monitoring and sampling; and air quality assessment and modelling**. It is also important to note that the **skills for carbon emissions reporting and energy auditing** are considered to be essential by Other mining and SITM sub-sectors at this stage as indicated in the table below. The situation is expected to change significantly once the Carbon Tax legislation comes into effect, and the demand for these skills is expected to grow not only in the MMS but also in other industries of the economy which will likely compete for the available skills.

Critical skills - air quality

- Fugitive dust sampling and monitoring
- Dust fallout and urban pollutant monitoring
- Stack monitoring and sampling
- Air quality assessment and modelling

Table 5-2: Critical requirement of air quality-related skills at different stages of life cycle of mines

Skill	Design/ planning	Construction	Operation	Closure	Rehab
Air quality impact assessment/modelling					
Fugitive dust sampling and monitoring					
Lab analysis					
Underground dust suppression					
Dust fallout and urban pollutants monitoring					
Radiation licensing and air quality monitoring					
Stack monitoring and sampling					
Energy management and electricity consumption monitoring					
Air quality monitoring - PM10 monitoring, NOx & SO_2 monitoring					
Carbon emissions reporting, carbon accounting, and CC management					
Greenhouse gas reporting					
Mass balance, dispersion modelling & sampling					
Energy audits					

Legend					
Explanation of the colour-coding: the number of sub-sectors that indicated a particular skill to be highly critical	**None**	**1 sub-sector**	**2 sub-sectors**	**3 - 4 sub-sectors**	**>5 sub-sectors**

Sub-sectors' icons	Gold	PGM	Other	CLAS	Diamond	Diamond proc.	Jewellery	SITM

5.2 Skills shortages

Most of the skills identified to be essential and critical at various stages of the mining activities to address the air quality impacts are considered by the MMS representatives to be available in South Africa at this stage. Diamond mining, CLAS and Gold mining sub-sectors tend to maintain the air-quality related skills in-house, while PGM mining activities tend to outsource majority of these skills.

There is a common thread with respect to the **skills that are generally being outsourced**. These include **skills involving air quality impact assessment, laboratory analysis, air compliance monitoring, and stack monitoring**. Some of the skills are being outsourced primarily due to practical (i.e. not required on a continuous basis) and financial considerations (it is more affordable to outsource these than to have them on payroll); however, as indicated in the diagram below, some of these skills are in short supply in the country. Therefore, the need to outsource in these instances is not linked only to the operational considerations but to the accessibility and availability of the skills.

There appears to be a different perspective among the MMS sub-sectors with respect to shortages of skills. Some industries that outsource certain skills believe they are not in shortage (for example, PGM, Diamond mining, and Diamond processing). Other sectors, such as Other mining and Gold mining, experience a more prominent shortage of selected skills, which is largely related to not necessarily the fact that skills are not available but that such skills are lacking exposure to these sub-sectors. Therefore, it can be surmised that it is not only important to have access to selected air quality related skills but also to have access to skills that have been honed to deal with specific issues that some of the mining sub-sectors face making many of the skills highly specialised in nature.

Nonetheless, a number of skills have been indicated to be in shortage either by one or more sub-sectors. These include **air quality impact assessment and modelling, stack monitoring and sampling, as well as the emerging skills related to carbon emissions reporting and energy management**. It is important to note that air quality and stack monitoring skills are also critical skills in the majority of the MMS sub-sectors. Furthermore, the working conditions associated with stack monitoring in most cases are difficult and this occupation has a high job turnover. In addition, no formal qualification or technical diploma is available for those interested in stack monitoring.

Skills in short supply - air quality

- Air quality assessment and modelling
- Stack monitoring and sampling
- Carbon emissions reporting, carbon accounting, and climate change management
- Energy management

The above is illustrated in Figure 5-1, which shows the range of green skills related to air quality issues in the mining sector, grouped by the average experience (in years) that the industry expects an individual to have to be proficient in that skill. The figure also highlights the green skills that have been identified to be in no immediate shortage and those that have been indicated by the industry representatives to be scarce in the country either as a result of absolute scarcity or relative scarcity. For example, fugitive dust sampling and monitoring skills usually require 3-5 years of experience and are currently not considered to be in short supply in the country; on the other hand, air quality impact assessment and modelling skills require between 5 and 10 years of experience to be proficient and are currently scarce.

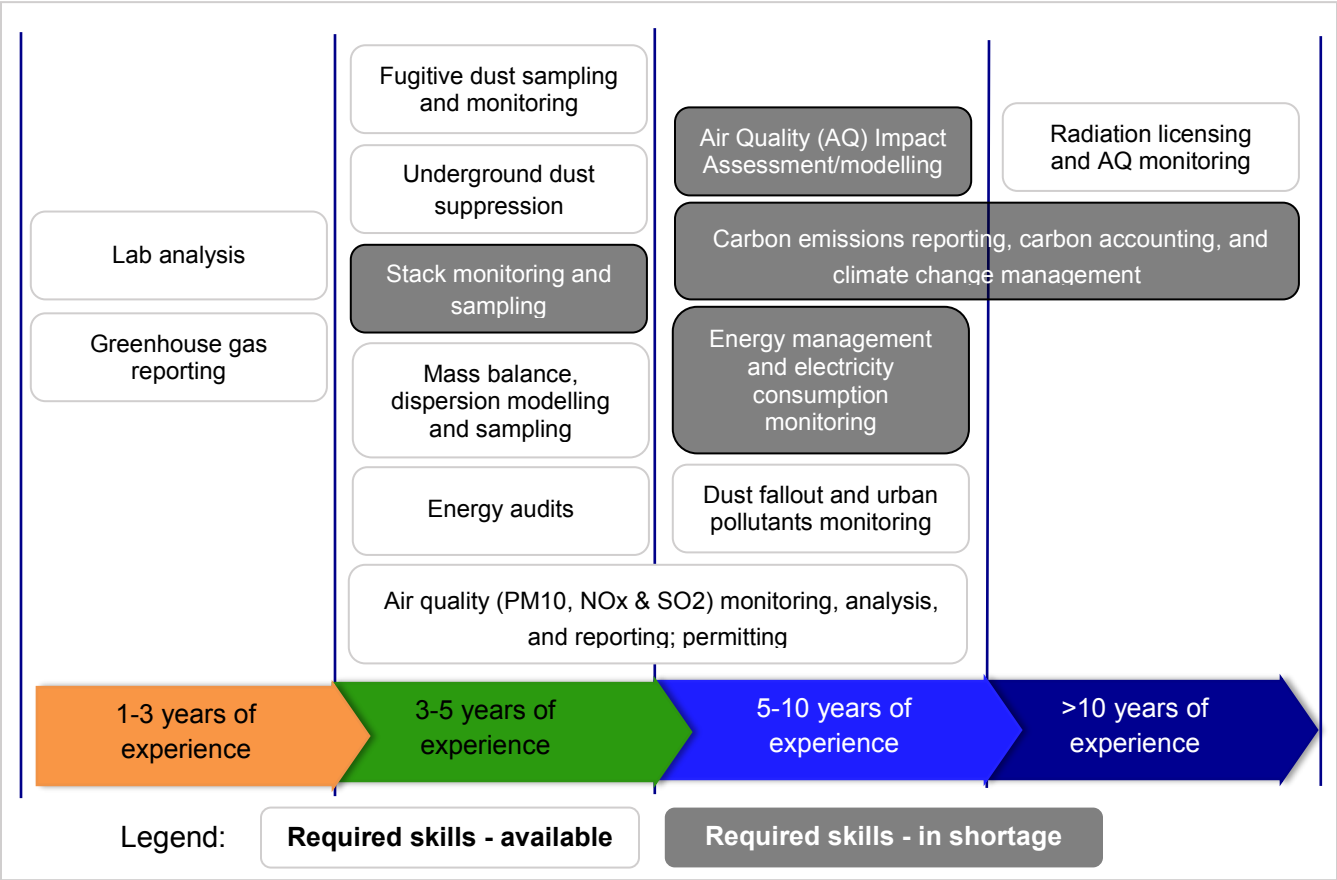


Figure 5-1: Demand versus supply perspective - air quality-related skills shortages

5.3 Alignment of skills requirements and qualifications

Green skills and required qualifications and experience

The shortages of the abovementioned green skills are largely linked to the highly specialised and regulated nature of such skills. Although as indicated in the table below many of the air-quality related skills can be obtained by studying a variety of degrees, some of these require specialising in chemical and engineering backgrounds. Fugitive dust sampling, underground dust suppression, dust fallout and urban pollutants monitoring, as well as air quality monitoring skills can also be developed by firstly obtaining occupation certification and do not necessarily require getting enrolled in a Higher Education Institution (HEI) programme as outlined in the table below.

Table 5-3: Skills and required qualifications

Skill	Qualification requirements	Experience
Air quality impact assessment/modelling	• BSc Hons/MSc Air Quality • BSc Medical Technology • BSc/MSc Environmental Science/Management • BSc Chemical Engineering • BSc Natural Sciences and accreditation with SACNASP • Chamber of Mines Certificate in Mine Environmental Control	5-10 years

Skill	Qualification requirements	Experience
Fugitive dust sampling and monitoring	• NQF5 BTech Environmental Management with Air Quality specialisation/BTech Air Quality Monitoring • BSc Environmental Science/Management	3-5 years
Lab analysis	• Specific according to SANS/BSc Honours in Environmental Management	1-3 years
Underground dust suppression	• Occupational Hygienist Degree/Health and Safety Degree/The Mine Environmental Control qualification obtained through the Chamber of Mines/Mine environmental control certificate	3-5 years
Dust fallout and urban pollutants monitoring	• Occupational Hygienist Degree/Chamber of Mines Certification in mining environment control and certificate in occupational hygiene	5-10 years
Radiation licensing and air quality monitoring	• RPO – NNR certificate, PhD in Air-borne pollutants	>10 years
Stack monitoring and sampling	• BTech Degree in Environmental Management with Air Quality specialisation • BEng/BSc Environmental Science with relevant air quality courses/ BTech Air Quality Monitoring	3-5 years
Energy management and electricity consumption monitoring	• BEng Electrical	5-10 years
Air quality monitoring - PM10 monitoring, NOx & SO_2 monitoring	• B Chemical Engineering/ BTech Environmental Science/MSc Environmental Science • Occupational Certificate: Environmental Science Technician (NQF 6)	3-10 years
Carbon emissions reporting, carbon accounting, and CC management	• BEng Chemical • BSc/MSc Environmental Management • BSc Hons/MSc Air Quality	>5 years
Greenhouse gas reporting	• Short courses in greenhouse gas and carbon tax awareness	1 year
Mass balance, dispersion modelling & sampling	• BEng Chemical	1 year
Energy audits	• BSc Environmental Science/BSc Electrical Engineering	3-5 years

Legend:	
Black – not in short supply	Identified to be in shortage

Green skills and identified shortages

The following diagram illustrates the air quality related skills that are demanded by the MMS sub-sectors and alignment thereof with registered QCTO qualifications or those that are currently under profiling with the Quality Council. It highlights that there are currently no qualifications that can develop stack monitoring and sampling; mass balance, dispersion modelling and sampling; lab analysis; and radiation licensing capabilities. The **absence of the certification of stack monitoring and sampling professions is a definite gap, considering that these skills have been identified to be in short supply in the country when it comes to the MMS exposure.** The emerging need for carbon emissions and carbon accounting skills, which is expected to increase once the Carbon Tax regulations become effective, will likely widen that gap further.

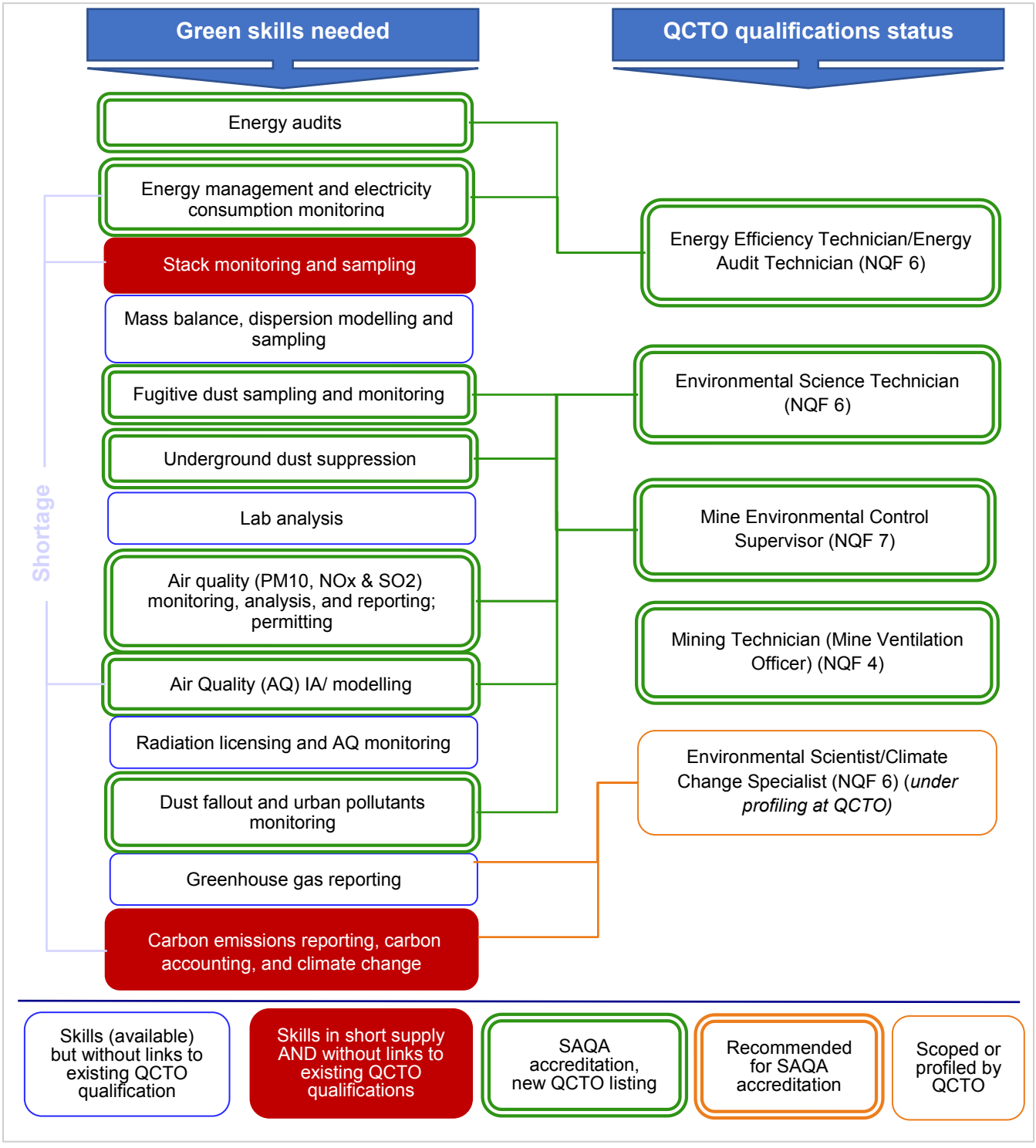


Figure 5-2: Alignment of skills requirements with QCTO qualification framework - air quality

The review of the National List of Occupations in High Demand for 2018 (DHET, 2018) suggests that only a few of the green skills related to air-quality in the MMS are aligned with the occupations that are currently in high demand in the country. These include energy management and electricity consumption monitoring skills as represented by such occupations as energy efficiency technicians, as well as lab analysis skills represented by high demand for laboratory managers. Importantly, the occupations

associated with two green skills that are currently scarce in the MMS - stack monitoring and climate change specialists - are not reflected in the DHET list.

Capability and capacity of local institutions to supply of green skills

As mentioned previously the majority of air0quality related green skills in the MMS require individuals to to graduate from higher educational institutions (HEIs). Thus, **the analysis of the number of people training for the respective air quality related green skills and occupations** that have been identified could provide a valuable insight into the potential supply of green skills in the country in the near future and the current capability and capacity of the HEIs to contribute to the development of these skills. Table 5-4 gives a high-level summary of the supply of air quality related green skills based on public university enrolments and graduations.

Table 5-4: Supply of air quality related green skills (2016)

Occupations associated with green skills	Associated qualifications	Enrolments	Graduations
Air Pollution Control Officer/Emission Control Technologist	Environmental Science	1 793	480
	Environmental Management	3 428	679
	Environmental/Environmental Health Engineering	53	17
	Total	**5 274**	**1 176**
Biofuels Processing Technician	Mechanical Engineering	13 396	2 250
	Chemistry	7 114	1 229
	Chemical Engineering	8 630	1 583
	Biotechnology	2 115	557
	Total	**31 255**	**5 619**
Air Quality Specialist/Monitor/Technician	Environmental Science	1 793	480
	Environmental Management	3 428	679
	Environmental/Environmental Health Engineering	53	17
	Meteorology	33	13
	Total	**5 307**	**1 189**
Energy Auditor	Energy Studies	No data available	
Climate Change Manager/Specialist	Environmental Management	3 428	679
	Atmospheric Science and Climatology	5	0
	Total	**3 433**	**679**
Atmospheric Scientist	Geology/Earth Sciences	2 943	814
	Environmental Science	1 793	480
	Atmospheric Science and Climatology	5	0
	Atmospheric Science and Meteorology	103	54
	Total	**4 844**	**1 348**
Climatologist	Meteorology	2 943	814
	Atmospheric Science and Climatology	5	0
	Atmospheric Science and Meteorology	103	54
	Total	**3 051**	**868**
Combustion Engineers	Mechanical Engineering	13 396	2 250
	Chemical Engineering	8 630	1 583

Occupations associated with green skills	Associated qualifications	Enrolments	Graduations
	Total	**22 026**	**3 833**
Materials Engineer	Materials Science and Engineering	433	92
	Metallurgy	2 055	410
	Mechanical Engineering	13 396	2 250
	Chemical Engineering	8 630	1 583
	Total	**24 514**	**4335**
Renewable Energy Technologist	Mechanical Engineering	13 396	2 250
	Chemical Engineering	8 630	1 583
	Renewable Energy Studies	No data available	
	Electrical Engineering	21 333	3 360
	Total	**43 359**	**7 193**

(HEDA, 2016)

All of the qualifications highlighted in Table 5-4 are offered mainly at public higher education institutions (universities and universities of technology) with the exception of the National Certificate in Environmental Management, which is offered at 44 private colleges.

Table 5-4 shows that engineering programmes in the universities are central in providing the necessary foundation to green skills in air quality. However, there is limited supply of skills in specialised fields such as Climate Change, Climatology, Renewable Energy, Atmospheric Science and Materials Engineering. The most common qualifications related to air quality skills appear to be Mechanical and Chemical Engineering, Environmental Science and Environmental Management.

An analysis of the enrolment and graduation trends in the above-mentioned qualifications over the last five years shows marginal increases in both enrolment and graduation numbers. Noteworthy is that:

- Atmospheric Science and Climatology and Atmospheric Science and Meteorology are not popular fields of study among the students.
- Environmental Engineering, Earth Sciences, Meteorology and Physical Sciences are the least popular qualifications offered at the various education institutions.

The following table includes an example of some of the South African HEIs that offer the degrees that enable the development of green skills related to air-quality.

Table 5-5: HEIs where qualifications for the short-listed air quality-related skills can be obtained

Identified skills with existing shortages	Qualification requirements	HEIs where these qualifications can be obtained from
Stack monitoring and sampling	• BTech Degree in Environmental Management with Air Quality specialisation	• CPUT • UP • UNISA • CPUT
	• BEng/BSc Environmental Science with relevant air quality courses/ BTech Air Quality Monitoring	• RU • UP • WITS • UCT • UNISA
Carbon emissions reporting, carbon accounting, and CC management	• BEng Chemical	• UP • UJ • DUT • CPUT

Identified skills with existing shortages	Qualification requirements	HEIs where these qualifications can be obtained from
		• VUT
	• BSc/MSc Environmental Management	• UFS • UKZN • UNISA • UJ
Air quality impact assessment/modelling	• BSc Natural Sciences and accreditation with SACNASP	• UNISA
	• BSc Chemical Engineering	• UCT • WITS • UKZN • UP • UNISA
	• BSc/MSc Environmental Science/Management	• RU • UP • WITS • UCT • UNISA
	• BSc Medical Technology	• NMMU • CUT
Energy management and electricity consumption monitoring	• BEng Electrical	• UP • TUT • Stellenbosch • UKZN • NMU • UFS

5.4 Career path development opportunities

As indicated above, to be able to work in the field of air quality, one would require a formal BSc degree or certification (NQF level and higher) and in instances of greater specialisations may need to continue to postgraduate level with a relevant specialisation. Having a relevant degree or certification though is not sufficient to become proficient in the matters of air quality monitoring and management and would require five and more years to become a recognised specialist. The latter is also important considering the expensive nature of equipment used in stack monitoring, PM10, SO_x and NO_x monitoring.

Having said that, obtaining a formal BSc degree or certification is the first step in building one's career in the air quality monitoring and assessment field. However, the opportunities for career development are quite vast as outlined in the table below:

Table 5-6: Career path opportunities for air quality related skills and occupations

Skill	Pursued professional field	Career Path
Air Quality monitoring, analysis, interpretation, modelling and permitting	Environmental	Environmental Assistant – Junior Environmental Officer – Environmental Officer – SHE Manager
		Environmental Practitioner – Junior Environmental Practitioner – Senior Environmental Practitioner
	Radiation	Radiation Trainee - Radiation Officer - Specialist Radiation Officer when acquiring certain qualifications and NNR Experience

Skill	Pursued professional field	Career Path
	Engineering	Junior Engineer – Engineer – Specialist Engineer – Engineering Director – Managing Director – Board Appointment
Air quality management		Junior Engineer – Engineer – Project Manager – Project Director – Managing Director – Board Appointment
	Air Quality and Climate Change	Air Quality Specialist – Air Quality Manager
Air quality modelling	Legal Compliance	Air Quality Legal Compliance Officer – SHEQ or Sustainability Manager – Corporate Services General Manager
Atmospheric Dispersion Monitoring	Energy Auditing	Energy Auditor – Facilities Manager
		Energy Auditor – Project Manager
		Energy Auditor – Move to another company that specialises in energy
Inline stack monitoring & Isokinetic Monitoring and sampling	Technical field	Instrumentation Technician (with trade test, National Certificate and experience) moves up to Foreman
Heavy Current Electricity consumption monitoring; Energy management & coal handling	Engineering	Junior Engineers with GCC ticket move up to Engineering Manager as experience increases and ultimately to Senior Engineering Manager.
Air Quality reporting, licencing and carbon accounting	Air Quality and Climate Change	Specialist ***position – no career path***
Dust monitoring (sampling)	Environmental	Environmental Assistant – Environmental Officer – Environmental Superintendent – Environmental Coordinator – Environmental Superintendent/supervisor/Specialist – HSEC Manager
Stack monitoring (sampling)	Technical	Not known
Mass balance, dispersion modelling & sampling	Chemical Engineer	Junior Engineer – Environmental Engineer – HSEC Manager

The following can be noted from the above:

- In terms of Air Quality Monitoring, Analysis, Interpretation, Modelling and Permitting, a few career path options are available:
    - These skills are generally performed by Environmental Officers. The career pathway for these skills starts with the position of Environmental Assistant with a vertical growth path from Junior to Senior Environmental Officer until one ultimately becomes an SHE Manager.
    - These skills are also often performed by environmental practitioners creating a separate career path. The career pathway in this instance starts with the position of Environmental Practitioner with a vertical growth path from Junior to Senior Environmental Practitioner.
    - A specialised career path is also available for those pursuing radiation field of work. Radiation trainees conduct air quality monitoring and can move up to the position of Radiation Officer and further up to the position of Specialist Radiation Officer upon acquiring further qualifications and NNR Experience.
- The career growth path of the Energy Auditor outside the research and development organisation is limited because growth in the **energy space** is not available; therefore, an Energy Auditor will often leave the company if the individual wishes to progress in the energy space.
- Air Quality and Climate Change activities are done by the respective managers who start out as Air Quality Specialists before moving to a managerial position. Due to this being a specialised position, there is no further career path in this regard.
- **Instrumentation Technicians** start out with a trade test, a National Certificate and experience before becoming a foreman.
- Assistant Environmental officer/field assistants perform green skills in the form of **dust monitoring** (sampling). These Environmental Assistants can move up to Environmental Officers then to Environmental Superintendents and further up to Environmental Coordinator positions until reaching the Unit Manager position with experience being the main factor enabling one to move up in the ranks.
- Plant and Instrumentation technicians conduct **stack monitoring (sampling)** and their career growth path is unknown.
- An Air Quality **Legal Compliance** Officer can move onto an SHEQ or Sustainability Manager position and then a Corporate Services General Manager position. Experience in the research and development organisation and preferably a Master's degree is required to progress to senior management.
- The career path opportunity for **Engineers** is dependent on the experience with that position; therefore, an engineer will start a career in engineering as a junior and progress onwards. Junior Engineers perform green skills relating to heavy current electricity consumption monitoring; energy management and coal handling. They then move up to an Engineering Manager position as their experience increases and ultimately become a Senior Engineering Manager. Engineers generally stay in the **specialised engineering field** or move onto a career in project management at the global engineering consulting group interviewed. Chemical Engineers can also compile **mass balances and perform dispersion modelling and sampling**.

The engagement with the National Union of Mineworkers (NUM) revealed that there is a concern that most of the green skills related to air-quality in the MMS require a degree from HEIs. Since the majority of their representatives are workers with matric certificates or less, it could be argued that this cohort of employees within the MMS value chain will have limited opportunities for career development in green

skills related to air-quality. Having said this, as mentioned previously, fugitive dust sampling, underground dust suppression, dust fallout and urban pollutants monitoring, as well as air quality monitoring skills can also be developed by firstly obtaining occupation certification and do not necessarily require getting enrolled in a Higher Education Institution (HEI) programme. These green skills and associated career paths do present opportunities for upskilling of mineworkers and providing them with career development prospects.

6 WATER QUALITY AND QUANTITY RELATED SKILLS

Similar to the previous chapter, this section of the report provides insight into the green skills' demand and supply shortages but within the water quality and quantity area of investigation. The chapter also includes the alignment of green skills within the water quality and quantity field with the QCTO qualification framework that assist in identifying the need for changes in the framework and introduction of new formal training and education interventions.

6.1 Significance of water quality and quantity issues and critical skills required

Water shortage is a major problem in South Africa, which has been exacerbated by changing rainfall patterns due to climate change. Insufficient water could limit large-scale mine development and restrict other economic and livelihood activities as it makes the social and ecological reserve vulnerable to water demands from new developments, which may affect the region's resilience to climate change. There has subsequently been a call by the former Minister of Mining, Susan Shabangu, for new technologies that use less water (ELRC, 2015).

Perhaps the most severe immediate water pollution-related problem in mining is that of acid mine drainage (AMD), associated with Coal and Gold mining. The issue of acid mine drainage is widespread in the Gold and Coal fields of South Africa (McCarthy, 2011). In the Olifants River, the issue has led to the destruction of biodiversity, reduced agricultural production, soil erosion, and severe water pollution (Eberhard, 2011). Similar issues are starting to emerge in the Vaal River catchment. This problem is highlighted by the Council of Geosciences' research into quantifying the extent of the acid mine drainage problem (ELRC, 2015).

The analysis of water-related issues that different MMS sub-sectors deal with at different stages of the project's life cycle suggest that such negative high impact issues emerge particularly during operations and in some instances during the closure and rehabilitation phases of mining activities. Gold mining, Other mining, CLAS, and Diamond processing are particularly susceptible to dealing with water-related issues, whether associated with quality or quantity of water.

Table 6-1: Significance of water quality and quantity issues at different stages of the life cycle

MMS sub-sector	Design/ planning	Establishment/ Construction	Operation	Closure	Rehab
Gold mining					
PGM mining					
Other mining					
CLAS					
Diamond mining					
Diamond processing					
Jewellery manufacturing					N/A
STM					

LEGEND:	*Negative - negligible*	*Negative - low*	*Negative - moderate*	*Negative – high*	*Positive*

The issues that MMS sub-sectors deal with when it comes to water quality or quantity in many instances are sector-specific, but some are also common. Furthermore, the negative effects of water quality appear to be more prominent than the negative impacts on water quantity as indicated below:

- **Gold mining**: During operations, waste products from the mining and processing of gold can accumulate and leach into the soil and pollute groundwater resources. Surface water resources can also be polluted due to poor storm water and waste management practices. Cyanide, arsenic, mercury and other heavy metals are the most significant concern with regard to water pollution from Gold mining. During closure and rehabilitation, the impacts on water arise from leaching from tailings storage facilities as well as a result of AMD. Water quantity impacts in Gold mining relate to the use of water for mining processes as well as dewatering which can impact on local groundwater and surface water resources.
- **PGM mining:** Platinum mining consumes on average 400 m^3 of water per kilogram of platinum produced (Cairncross, 2014) and can have a moderate impact on its quality due to pollution from chemicals, fuel, and other materials. Compared to Gold mining, however, the chemicals used in platinum mining are not as toxic as those used in Gold mining, such as cyanide and arsenic. Platinum mining usually occurs in areas, which geology is characterised by deposits being non-acidic; therefore, PGM mining has less of an impact on water resources from leachate and Acid Mine Drainage.
- **Other mining:** The significance of impacts on water quality and quantity by Other mining would depend on the mineral mined. With chrome mining, water contamination is relatively limited to surface water, and will not affect groundwater because chromium attaches strongly to soil and is contained and unlikely to leach into groundwater (Sneddon, 2016). Copper mining, on the other hand, contributes significantly to AMD, which could pollute nearby surface water resources. This impact will have a high significance during the closure and rehabilitation phases. Phosphate mining uses large amounts of water. In general, though, the significance of the impact on water quality and quantity in all the Other mining activities can be considered high specifically during the operational, closure and rehabilitation phases of mining.
- **CLAS:** During the construction and operational phases, water quality and quantity impacts are highly probable due to pollution from chemicals, fuel and other materials. In limestone mining particularly, groundwater conditions in terms of both quality and quantity will be affected during the operational phase of the mining. Surface water such as nearby streams and rivers can also be altered during limestone mining when the mines pump out the excess water from the limestone quarry into downstream water channels ultimately increasing the prevalence of floods. Furthermore, there will be significant changes in the quality of the surface water in limestone mining (Csanyi, 2017).
- **Diamond mining:** Diamond mining, and particularly marine (seabed) mining and mining of alluvial diamonds, is the only sector that is associated with a highly significant impact on water during construction activities as this kind of mining results in large-scale excavation along coastal areas and modification of the land. During operations, Diamond mining uses large quantities of water for extraction of the diamonds and therefore, has a high impact on quantity of water reserves.

Critical skills - water

- Potable, surface and ground water monitoring and analysis
- Impact assessment skills (hydrological, geohydrological, aquatic, floodline)
- Stormwater and plant management skills

The above water shortage and water pollution problems create a demand for specific green skills that are summarised in the following table. It is quite clear that the need for water-related green skills arises specifically during the operational, closure, and rehabilitation phases and the demand is largely driven by the Gold mining, PGM, Other mining, and Diamond mining activities. **Skills that enable monitoring and analysis of potable, surface, and ground water quality are particularly critical** for the MMS sub-sectors during the abovementioned stages of the mining activities. In addition, water quality and quantity impact assessment skills, plant management, and stormwater management are also deemed to be critical during long-term and later stages of mining activities. During the earlier stages of the mining activities, the need for hydrological, geohydrological, quality, flood line, and other associated impact assessments is particularly apparent. These aspects are also captured in the table below, where the more dark (orange and red) colour-cording is used to indicate the green skills that are considered to be highly critical during a specific stage of operation by three or more sub-sectors.

Table 6-2: Critical requirement of water quality and quantity-related skills at different stages of life cycle of mines

Skill	Design/ planning	Construction	Operation	Closure	Rehab
Water use licencing					
General water management					
Ground and surface water sampling					
Hydrological/Geohydrological Impact Assessments					
Surface water assessment incl. aquatics, floodline, etc.					
Sewage plant management					
Stormwater management					
Water quality (potable) monitoring and analysis					
Ground and surface water monitoring					
Water sample analysis					
Water quantity provision monitoring					

Skill	Design/ planning	Construction	Operation	Closure	Rehab
Legend:					
Explanation of the colour-coding: the number of sub-sectors that indicated a particular skill to be highly critical		**None**	**1 sub-sector**	**2 sub-sectors**	**3 - 4 sub-sectors**	**>5 sub-sectors**

Sub-sectors' icons	Gold	PGM	Other	CLAS	Diamond	Diamond proc.	Jewellery	SITM

6.2 Shortages and gaps

The engagement with the MMS representatives revealed that many of the critical skills required by the sub-sectors at various stages of the project's life cycle are in limited supply in the country. These include **skills related to surface water assessment, water use licensing, ground and surface water sampling, sewage/water plant management, and hydrological/geohydrological impact assessments**. Majority of these skills require between 3-5 years to develop as outlined in Figure 6-1.

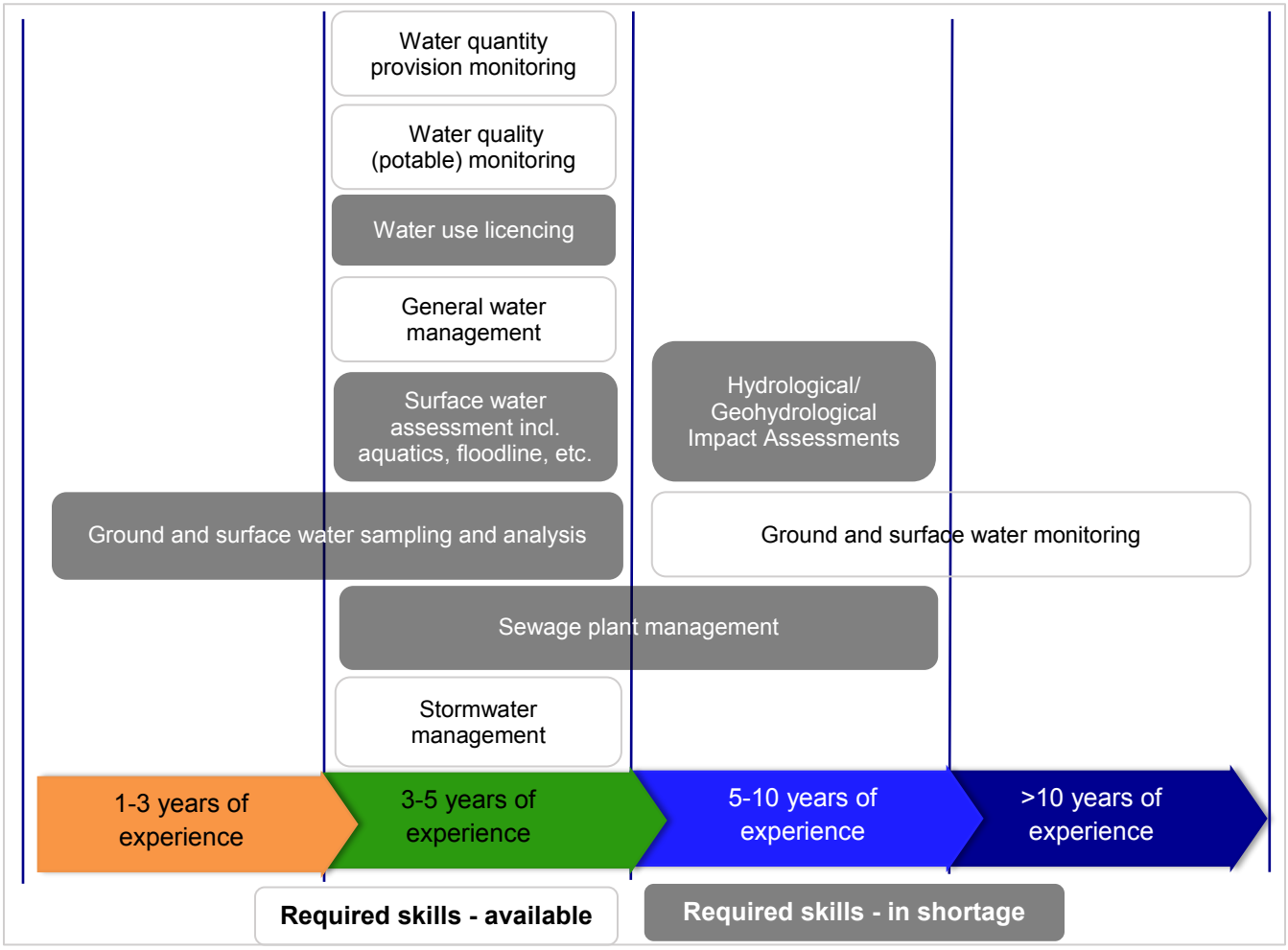


Figure 6-1: Demand versus supply perspective - water-related skills shortages

Some of the water-related skills required by the MMS sub-sectors at different stages of the project lifespan are being **outsourced**. This refers particularly to **impact assessments and water sampling, monitoring and analysis**. Outsourcing practices in these instances is largely due to the mining houses' approach to reduce operational expenses and therefore opt to outsource the abovementioned skills that are not required on an on-going basis to independent consultants while also ensuring compliance. Budget constraints, though, is not the only reason why companies outsource the abovementioned skills. It is also related to the lack of experience and the gap between the training offered at various education institutions and practices.

Skills in short supply - water

- Surface water assessment incl. aquatics, floodline, etc. (Gold and PGM)
- Water Use Licensing
- Ground and surface water sampling and analysis (Gold and PGM)
- Sewage/water plant management
- Hydrological / Geohydrological Impact Assessments (Gold and PGM)

Also, it is important to note than in some instances the ability to outsource the skills appears to not be a concern among the businesses involved in the MMS and is therefore not seen as an area of short supply. However, such perspective differs from business to business and sub-sector to sub-sector and it seems that the shortage, if it arises, comes specifically, not necessarily in the possession of a specific skill, but in the experience of application of that skill in a specific sector due to the nature of some water-related problems that selected mining sub-sectors deal with (e.g. AMD, leaching from tailings, etc.). Therefore, when looking at the shortages of skills related to surface water assessment, impact assessment, water use licensing, and water monitoring and analysis these refer specifically to skills with practical knowledge and experience in Gold mining and PGM mining. Notably, there is a shortage of skills in managing sewage and water plants.

6.3 Alignment of skills requirements and qualifications

Green skills and required qualifications and experience

Water-related green skills critical in the MMS largely require an undergraduate or postgraduate degree and a few years' experience, as outlined in the table below. Registration with the Department of Water Affairs and a Professional Engineer membership are required for sewage plant management and hydrological/geohydrological impact assessment respectively.

Table 6-3: Required qualifications and experience to gain water-related skills in short supply

Skill	Qualification requirements	Experience requirements
Water Use Licencing	• BSc Environmental Management • MSc Aquatics/MSc. Hydrogeology	3-5 years
General water management	• BEng	3-5 years
Ground and surface water sampling	• Grade 12 or equivalent NQF level 4 qualification AND Environmental Management Diploma (or similar qualification)	1-5 years

Skill	Qualification requirements	Experience requirements
Hydrological/ Geohydrological Impact Assessments	• BSc Hydrogeology/ Pr Engineer	5-10 years
Surface water assessment incl. aquatics, floodline, etc.	• BSc Hydrogeology/Hydrology/Environmental Science/Botany • Honours degree in relevant discipline	3-5 years
Sewage plant management	• BEng/BSc Eng. Chemical AND Registration with DWS regulation	3-10 years
Stormwater management	• BEng/BEng Civils/BSc Hydrology	3-5 years
Water quality (potable) monitoring and analysis	• Grade 12 with Chamber of Mines Intermediate Certificate in Mine Environmental Control (minimum) • Degree in Occupational Management/National diploma/degree in Environmental Management/Sciences	3-5 years
Ground and surface water monitoring	• BSc/BSC Hon in Hydrology/Geohydrology	5-10 years
Water sample analysis	• Specific according to SANS	3-5 years
Water quantity provision monitoring	• BSc Degree/Pr Engineer/BEng with Government Certificate of Competency (GCC)/National Diploma in Instrumentation Engineering	3-5 years

Green skills and identified shortages

Figure 6-2 aligns the required skills with QCTO qualifications. The diagram illustrates green skills identified to be essential within the MMS in relation to water quality and quantity fields, whether these skills are in short supply or not, and whether these skills have respective qualifications registered with SAQA and/or QCTO.

Figure 6-2 shows that most of the water-related green skills needed in the MMS can currently be developed by firstly acquiring a formal degree in Science or Engineering. The composition and diversity of the QCTO qualifications that can assist in developing water quality and water quantity-related skills are limited, which could also partially explain the shortage of some of the skills in the country. This refers specifically to the skills in surface and groundwater impact assessments, floodline assessments, toxicology, and surface water monitoring and sampling.

There are two new qualifications that are currently being scoped or are already recommended for registration to SAQA. One of these relates to sewage plant management (i.e. Water Plant operator – scoping status), which could assist in alleviating the shortage of these types of skills in the future once the process of profiling and accreditation is complete. The other one is Water Quality Analyst/Water Regulation Practitioner, which has already been recommended to SAQA for registration. Ensuring that institutions throughout the country also provide training for the above-mentioned skills once the qualifications are registered will be paramount.

The review of the National List of Occupations in High Demand for 2018 (DHET, 2018) contains only two occupations that are directly linked to water-related issues - Water Pant Operator and Water Process Controller. This means that green skills related to water issues experienced in the MMS are not considered to be skills that are associated with high demand as per the DHET list.

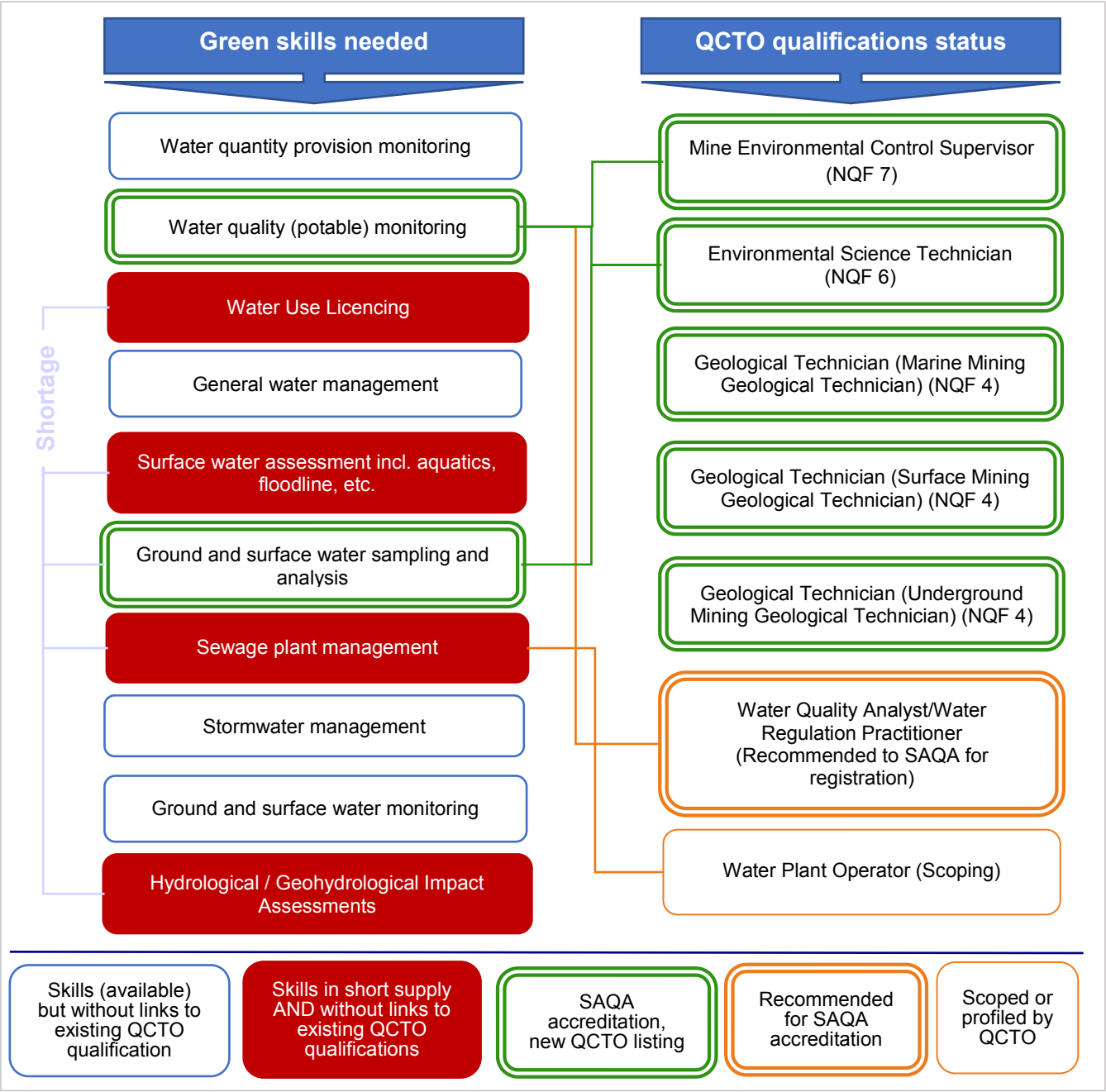


Figure 6-2: Alignment of skills requirements with QCTO qualification framework - water

Capability and capacity of local institutions to supply of green skills

Similar to the case with air-quality related green skills, majority of water quality- and water quantity-related green skills in the MMS require higher educational certifications. Table 6-4 gives a high-level summary of the number of people training for the respective water quantity- and quality-related green skills and occupations that have been identified. This assists in gaining insight into the potential supply of green skills in water-related areas and the capacity of local HEIs to provide these.

Table 6-4: Supply of water quality and quantity related green skills (2016)

Occupations associated with green skills	Associated qualifications	Enrolments	Graduations
Hydrologists	1. Hydrology	493	179
	2. Water Resource Management	782	232
	3. Earth Science	2 943	814
	4. Civil Engineering	11 573	1 904
	Total	**15 791**	**3 129**
Hydrogeologist	1. Hydrology	493	179
	2. Geology	2 943	814
	3. Water Resource Management	782	232
	4. Earth Science	2 943	814
	5. Environmental Science	1 793	480
	Total	**8 954**	**2 519**
Water Quality Monitor	1. Hydrology	493	179
	2. Geology	2 943	814
	3. Microbiology	2 402	431
	4. Chemistry	7 114	1 229
	5. Water Resource Management	782	232
	6. Earth Science	2 943	814
	7. Environmental Science	1 793	480
	Total	**18 470**	**4 179**
Water Plant Operator	1. Hydrology	493	179
	2. Water Resource Management	782	232
	Total	**1 275**	**411**
Chemical/Water Quality Engineer	1. Hydrology	493	179
	2. Geology	2 943	814
	3. Chemistry	7 114	1 229
	4. Chemical Engineering	8 630	1 583
	5. Water Resource Management	782	232
	6. Earth Science	2 943	814
	7. Environmental Science	1 793	480
	Total	**24 698**	**5 331**
Freshwater ecologist/aquatic specialist	1. Aquaculture	25	9
	2. Water Resource Management	782	232
	3. Aquatic Biology	99	40
	4. Ecology	336	77
	5. Nature Conservation	63	30
	6. Zoology	1 495	301
	Total	**2 800**	**649**
Wetland specialist	1. Aquaculture	25	9
	2. Water Resource Management	782	232
	3. Ecology	336	77
	4. Environmental management	3 428	679
	5. Nature Conservation	63	30

Occupations associated with green skills	Associated qualifications	Enrolments	Graduations
	6. Zoology	1 495	301
	Total	**6 129**	**1 328**
Flood-line specialist	1. Hydrology	493	179
	2. Geology	2 943	814
	3. Civil Engineering	7 114	1 229
	4. Water Resource Management	782	232
	5. Earth Science	2 943	814
	Total	**14 275**	**3 268**
Storm-water Engineer	1. Civil Engineering	7 114	1 229
	2. Hydrology	493	179
	3. Environmental Science	1 793	480
	4. Environmental Engineering	53	17
	Total	**9 453**	**1 905**

(HEDA, 2016)

From the above it is clear that Hydrology, Geology and Water Resource Management are the common qualifications associated with water quality and quantity green skills. There appears to be relevant curricular to train individuals in water quality and quantity green skills. There are few individuals however who enroll and graduate in qualifications suited for a career in aquaculture. Again, engineering programmes, specifically, Civil and Chemical Engineering, play a role in water quality and quantity green skills.

The following table includes an example of some of the South African HEIs that offer the degrees that enable the development of green skills related to air-quality.

Table 6-5: HEIs where qualifications for the short-listed water-related skills can be obtained

Identified skills with existing shortages	Qualification requirements	HEIs where these qualifications can be obtained from
Water Use Licencing	• BSc Environmental Management	• UFS • UKZN • UNISA • UJ
	• MSc Aquatics/MSc. Hydrogeology	• WITS • UP • UFS
Hydrological/ Geohydrological Impact Assessments	• BSc Hydrogeology/ Pr Engineer	• Western Cape University • University of Pretoria
Surface water assessment incl. aquatics, floodline, etc.	• BSc Hydrogeology/Hydrology/Environmental Science/Botany	• RU • UNIZULU • UP • WITS • UCT
Sewage plant management	• BEng/BSc Eng. Chemical AND Registration with DWS regulation	• UCT • WITS • UKZN • UP • UNISA

6.4 Career path development

Numerous career opportunities can be pursued in the water-related field in the MMS, as outlined below in the table.

Table 6-6: Career path development – water quality and quantity

Skill	Pursued professional field	Career Path
Process water sampling	Engineering	Chemical Engineer – Senior Chemical Engineer – Technical Projects Manager or Plant Manager
	Environmental	Environmental Assistant – Environmental Coordinator - Environmental Officer– Environmental Superintendent – Group Environmental Manager
Potable water sampling (OHSA)	Occupation and hygiene	HSEC Coordinator – HSEC Superintendent – HSEC Manager – HSEC Executive Director
Surface and groundwater monitoring	Specialisation: Hydrology	Junior water specialists - Specialists Water Manager - Senior Water Specialists – Manager
	Environmental	Environmental Practitioner – Junior Environmental Practitioner – Senior Environmental Practitioner
		Environmental Coordinator - Environmental Officer– Environmental Superintendent – Group Environmental Manager
Water Use Licencing	Environmental	Environmental Coordinator – Unit Manager
General water management	Engineering	Graduate trainees – Junior Engineer – Section Engineer – Unit Manager – engineering Manager
Water quality analysis	Technical	Laboratory technician – Laboratory supervisor – Quality Assurance Manager
Plant maintenance and management	Technical	Sewage plant and settler operators – Site Supervisor/Level 5 Operator
	Engineering	Graduate trainees – Junior Engineer – Section Engineer – Unit Manager – engineering Manager
Storm water management	Engineering	Professional in Training (PIT) – Engineer – Principle Engineer – Engineering Manager Specialist - Manager

From the above, the following can be noted:

- **Process water sampling skills are applied by professionals with two different career choices – environmental or engineering.**
    - Those who follow an engineering career path make use of water sampling skills starting as Chemical Engineers whose career growth paths start from a Chemical Engineer position then to Senior Chemical Engineer till one can finally become a Technical Projects Manager or Plant Manager.

    - Those who follow an environmental career path start as Environmental Assistants at level C1. These can then move to being Environmental Coordinators, then Officers, Superintendents and finally Group Environmental Managers.
- Green skills in the form of **surface and groundwater monitoring** are conducted by water specialists. The horizontal growth path entails Junior Water Specialists moving up to Specialists Water Managers as their experience increases, thereafter the Specialist Water Managers can become Senior Water Specialists.
- **Portable water sampling** in terms of the OHSA are done by an Occupational Health and Hygiene Coordinator (level C4-C5). This career can develop to an HSEC Coordinator, followed by an HSEC Superintendent, HSEC Manager and finally an HSEC Exertive Director subject to further qualifications and experience.
- Laboratory technicians with green skills in the form of **water sample analysis** start off as Laboratory technicians, move up to Laboratory supervisor positions and lastly to a Quality Assurance Manager position.
- **Water Monitoring** is conducted by either a Hydrogeologist or an Environmental Practitioner. The career path for the Hydrogeologist is from Specialist to Manager. Water quality monitoring can also be conducted by Environmental Officers with a level C3 to C5. Environmental Officers can horizontally develop into Occupational Hygienist Superintendents should they complete the relevant occupational hygiene qualification.
- In some organisations, **water use licencing** and **general water management** is conducted by the environmental manager and this position has a vertical growth path only to a Unit Manager position. In other organisations, **general water management** is conducted by the Chemical Engineer. The career growth path in this regard starts with Graduate trainees who move up to Junior Engineer positions then to Section Engineers, Unit Managers and finally Engineering Managers.
- The opportunities for those who developed skills in **sewage plant management and maintenance** are twofold - one can follow a technical route and the other entails following an engineering route.

Considering the requirements for selected green skills and the career pathing, the greatest opportunities for upskilling on low-skilled and semi-skilled mine workers, who represent the largest labour cohort in the MMS, lie within the general water management and plant maintenance and management career paths.

7 WASTE MANAGEMENT RELATED SKILLS

This chapter presents the needs for green skills in the MMS related to waste management. It highlights the green skills that are considered to be essential and critical, as well as provides information on the identified shortages of skills. Similarly to the previous chapters, it also includes an insight into the alignment of the green skills required and the existing new QCTO qualification framework.

7.1 Significance of waste management issues and critical skills required

Historically South Africa has followed an "end of pipe" waste management approach which focused on the disposal of waste to landfills (Ramsarup & Ward, 2017). However, the environmental risks associated with landfill operations, reduced land availability for new landfills, and the valuable recyclable resources (glass, metal, paper and certain plastics) discarded at landfills are incompatible with the aims of sustainable development (DEAT, 2008). Mine residue waste, such as tailing storage facilities and waste rock facilities, can result in contamination of water and soil, and can pose substantial environmental challenges if not managed correctly.

The formulation of the National Environmental Management Waste Act (NEMWA) has also called for a new approach to waste management emphasising waste avoidance in line with international best practice and introducing a hierarchy of reduce, re-use and recycle (DEAT, 2008).

As indicated in the table below, waste management is the most pertinent issue in the Gold mining and Other mining sub-sectors and specifically during the operational phase. These and other sub-sectors such as the PGM mining and Diamond mining sub-sectors also experience moderate levels of waste impacts during more temporary phases, i.e. construction and closure. CLAS, Jewellery manufacturing, and SITM appear to deal with lower significant waste management issues than the sectors mentioned above.

Table 7-1: Significance of waste management issues at different stages of the life cycle

MMS sub-sector	Design/ planning	Establishment/ Construction	Operation	Closure	Rehab
Gold mining					
PGM mining					
Other mining					
CLAS					
Diamond mining					
Diamond processing					
Jewellery manufacturing					N/A
SITM					

LEGEND:	*Negative - negligible*	*Negative - low*	*Negative - moderate*	*Negative – high*	*Positive*

The nature and type of waste that the MMS sub-sectors deal with during various stages of mining activities vary from sub-sector to sub-sector and sometimes from mine to mine. In general, though, the following are the most common waste management challenges that the businesses operating in the MMS are faced with:

- **Gold mining**: Gold mining generates large amounts of waste. Waste impacts during the operational phase will relate to the establishment of mine residue stockpiles and deposits, such as waste rock and tailings, which can have an impact on soils and groundwater if not managed adequately due to the presence of nitrates from blasting as well as other chemicals in the waste material. The storage of chemicals and fuels can also have an impact on soils and water resources if not adequately mitigated and managed.
- **PGM mining:** The type, amount, and properties of mine waste produced at different mines vary depending on the resource being mined, process technology used, and geology at the mine site. While platinum mine waste (mine residues) are considered to have less of an impact on the environment due to the physical and chemical composition of the geology and the chemicals used in the process, large volumes of waste (general and hazardous) are still produced and need to be managed.
- **Other mining:** Waste stored in waste rock dumps or tailings facilities that are created as a result of Other mining activities, if not adequately managed, can leach chemicals and minerals into groundwater and nearby surface water sources, thereby causing pollution or an increase to the water quality that is beyond the prescribed drinking water standards. The waste impacts during the operational phase can be considered long-term, resulting in a high impact significance. Some tailings facilities and discarding dumps previously treated by conventional processes can provide a viable resource for future re-treatment, thereby limiting the environmental impacts from the remaining footprints during the closure and rehabilitation phases. The waste impacts during the closure and rehabilitation phases are of moderate significance.
- **CLAS:** During cement, lime, aggregate and sand mining, large volumes of mineral residues are generated, mainly as fine-grained materials, which are either stockpiled or disposed at waste sites. The generation of waste is most significant in the operational phase with long-term duration, however, due to the nature of the mine residue not being hazardous, the impact can be considered moderate.
- **Diamond mining:** Waste impacts in Diamond mining relate to the establishment of residue deposits and stockpiles during the operational phase. These are usually not extremely hazardous, due to the Diamond mining not making use of extremely hazardous chemicals but require extensive management to prevent pollution to surface water, groundwater and generation of dust. Reclamation, however, results in the removal of residue deposits and stockpiles and will significantly lessen the impact to the environment.
- **Jewellery manufacturing:** Cyanide in the form of sodium and potassium cyanide can be used in the jewellery manufacturing industry for electroplating and metal stripping, and generates process baths, waste water and sludge or residues containing metals and cyanide (DTSC, 2002).

Critical skills - waste

- Waste characterisation
- Preparation and implementation of WMP
- Mine residue management and reclamation of aggregates
- Waste management: sorting, separating, recycling and handling general waste

Given the fact that the waste management issues are particularly significant in Gold mining and Other mining activities, it is no surprise that these two sub-sectors will have a number of related critical skills. Interestingly, although the PGM mining sub-sector does not face the same level of waste issues as the other two sub-sectors, the feedback received from the representatives of the PGM mining sub-sector suggested that their need for selected waste management skills are as high as that of Gold mining and Other mining, and sometimes even greater. Overall though, **waste characterisation; preparation and implementation of WPs; mine residue management and reclamation of aggregates; as well as waste management related to sorting, separating, recycling and handling of general waste are the most common critical skills** in the MMS sub-sectors under analysis when it comes to waste management. These are closely followed by skills required to assess and rehabilitate contaminated land and landfill management.

The following table summarises the need and critically for green skills related to waste management in the MMS sub-sectors. It also highlights the green skills that are considered to be critical by more than three sub-sectors (colour-coded cells in dark orange), making them particularly high in demand in South Africa.

Table 7-2: Critical requirement of waste management-related skills at different stages of life cycle of mines

Skill	Design/ planning	Construction	Operation	Closure	Rehab
Preparation and implementation of WMP	✓	✓	✓	✓	✓
Waste characterisation/classification	✓	✓	✓	✓	✓
Contaminated land assessments, rehabilitation	✓	✓	✓	✓	✓
Landfill management & maintenance		✓	✓	✓	
Mine residue management and reclamation of aggregates		✓	✓	✓	✓
Waste management: sorting, separating, recycling and handling general waste	✓	✓	✓	✓	
Waste management: hazardous waste		✓	✓	✓	✓
Waste permitting and reporting			✓		
Waste rock dump management	✓	✓	✓	✓	
Radioactive study, reading and RPM readings	✓		✓	✓	
Waste management: auditing			✓		
Geochemical surveying and assessments	✓				

Skill	Design/ planning	Construction	Operation	Closure	Rehab
Legend					
Explanation of the colour-coding: the number of sub-sectors that indicated a particular skill to be highly critical		**None**	**1 sub-sector**	**2 sub-sectors**	**3 - 4 sub-sectors**	**>5 sub-sectors**

Sub-sectors' icons	Gold	PGM	Other	CLAS	Diamond	Diamond proc.	Jewellery	SITM

7.2 Shortages and gaps

The engagement with various MMS sub-sector representatives revealed that the largest skills gaps exist among the skills that require the least number of years' experience and those that require substantial experience:

- In the case of the former, it relates to **sorting, separating, recycling and handling of waste; management of hazardous waste; and landfill management**. Most of these skills are being outsourced.
- In the case of the latter, the industry experiences a shortage of **Environmental Liability Specialists with regard to rehabilitation and financial accounting for closure purposes**. Contaminated land assessment and rehabilitation skills are believed to be available in the country, but the scarcity exists when it comes to finding the specialists with applicable experience in the specific sub-sectors. Further difficulty is created by the fact that specialists who perform these skills also hold Doctoral Degrees in Soil Sciences, Geochemistry and Geology, have significant years of experience and often require a combination of the environmental management, rehabilitation, and financial accounting skills. Due to the shortage of such skills, and in many instances financial constraints that the mining houses experience, specialists in land contamination assessment and rehabilitation are usually outsourced.

Skills in short supply - waste

- Waste management: sorting, separating, recycling and handling general waste
- Waste management: hazardous waste
- Landfill management and maintenance
- Contaminated land assessments, rehabilitation (soil scientists, geologists, and geochemists)

The above is summarised in Figure 7-1, which illustrates the distribution of waste management related skills in the MMS by the required experience. The diagram also highlights the green skills that are considered to be available in the country and those that are seen to be in short supply.

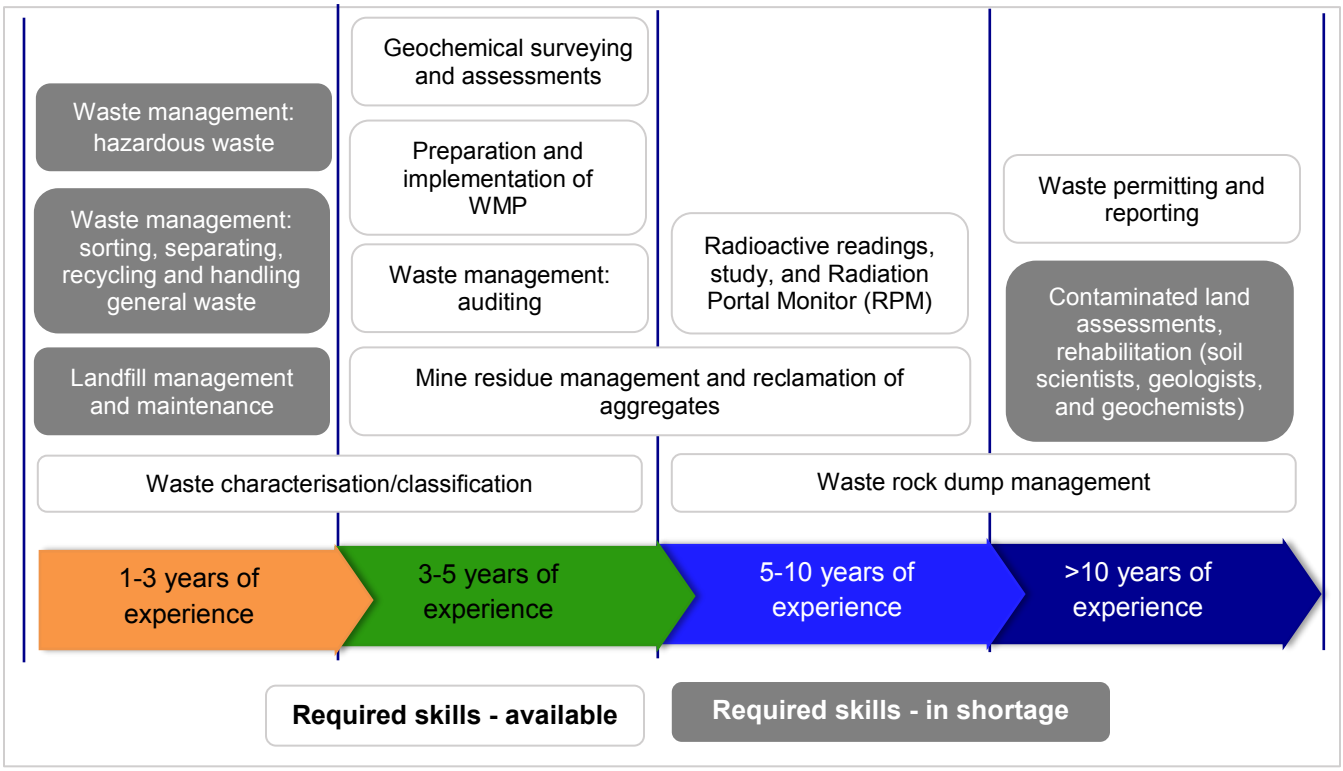


Figure 7-1: Demand versus supply perspective – waste management-related skills shortages

It appears that the general approach to waste management related skills is outsourcing. This is because in most instances, businesses operating in the MMS sub-sectors under analysis do not need waste management specialists on an on-going basis and prefer to make use of contractors than take these on their payroll.

7.3 Alignment of skills requirements and qualifications

Green skills and required qualifications and experience

Waste management related-skills needed in the MMS sub-sectors under analysis are wide-ranging and require different levels of experience, specialisation, and education. As indicated in the table below, most of the skills in the waste management field can be developed by obtaining a formal degree in environmental science, chemistry or engineering and acquiring at least three to five years' experience. Not all the skills, though, need to be backed by a degree and some can be developed by attending specific qualifications at NQF level 3 and NQF level 4. These skills particularly refer to the much-needed waste management activities involving sorting, separating, recycling, and handling of waste, as well as landfill management.

Table 7-3: Required qualifications and experience to gain waste-related skills in short supply

Skill	Qualification requirements	Experience requirements
Preparation and implementation of WMP	• Degree in Environmental Management/BSc Environmental Management/Science/BSc Chemical/Geology	3-5 years

Skill	Qualification requirements	Experience requirements
Waste characterisation/classification	• BEng Civils/BSc Hons Environmental Science/BSc Soil Chemistry/BEng Chemistry/Diploma/Hazardous Materials Training	1-3 years
Contaminated land assessments, rehabilitation	• PhD Soil Science • PhD Geology • PhD Geochemistry/BEng Chemistry	>10 years
Landfill management & maintenance	• Artisanship (NQF4)	1-3 years
Mine residue management and reclamation of aggregates	• DQS qualification; ISO Compliant; NNR license/BEng/BTech Engineering	3-10 years
Waste management: sorting, separating, recycling and handling general waste	• Grade 12 • Artisanship (NQF4)/Occupational Certificate: Paper and Packaging Collector (NQF 3)/Occupational Certificate: Truck Driver (NQF 6)	2-3 years
Waste management: hazardous waste	• Knowledge of legislative requirements//Hazmat competency/Chamber of Mines Safety Officer Certificate Level 1	1-3 years
Waste permitting and reporting	• MSc Environmental Science	>10 years
Waste rock dump management	• BEng degree/Chamber of Mines Certification in rock engineering	5-20 years
Radioactive study, reading and RPM readings	• Specific courses in radioactivity	5-10 years
Waste management: auditing	• BSc Environmental Science	3-5 years
Geochemical surveying and assessments	• Degree in Geochemistry	3-5 years

Green skills and identified shortages

Figure 7-2 aligns the required skills with QCTO qualifications. It shows that the Quality Council has a very limited range of qualifications that can be received that would enable the individuals in developing the skills in the waste management field. And those that can be developed are acquired through the completion of the Environmental Science Technician programme. This programme, though, is not able to develop skills in waste management – auditing; waste permitting and reporting; Waste Management Plan formulation and implementation; mine residue management; and others. Importantly, all of the abovementioned skills can at the moment only be developed by acquiring a formal degree from a higher educational institution and obtaining a required number of years' experience.

It is particularly concerning that the skills with the most notable shortage in the country – sorting, handling, recycling, and separating waste; management of hazardous materials; and landfill management do not have matching QCTO qualifications. These skills do not require a person first acquiring a formal degree, and the fact that they are currently deemed to be in short supply could be attributed to the lack of adequate training programmes available in the country.

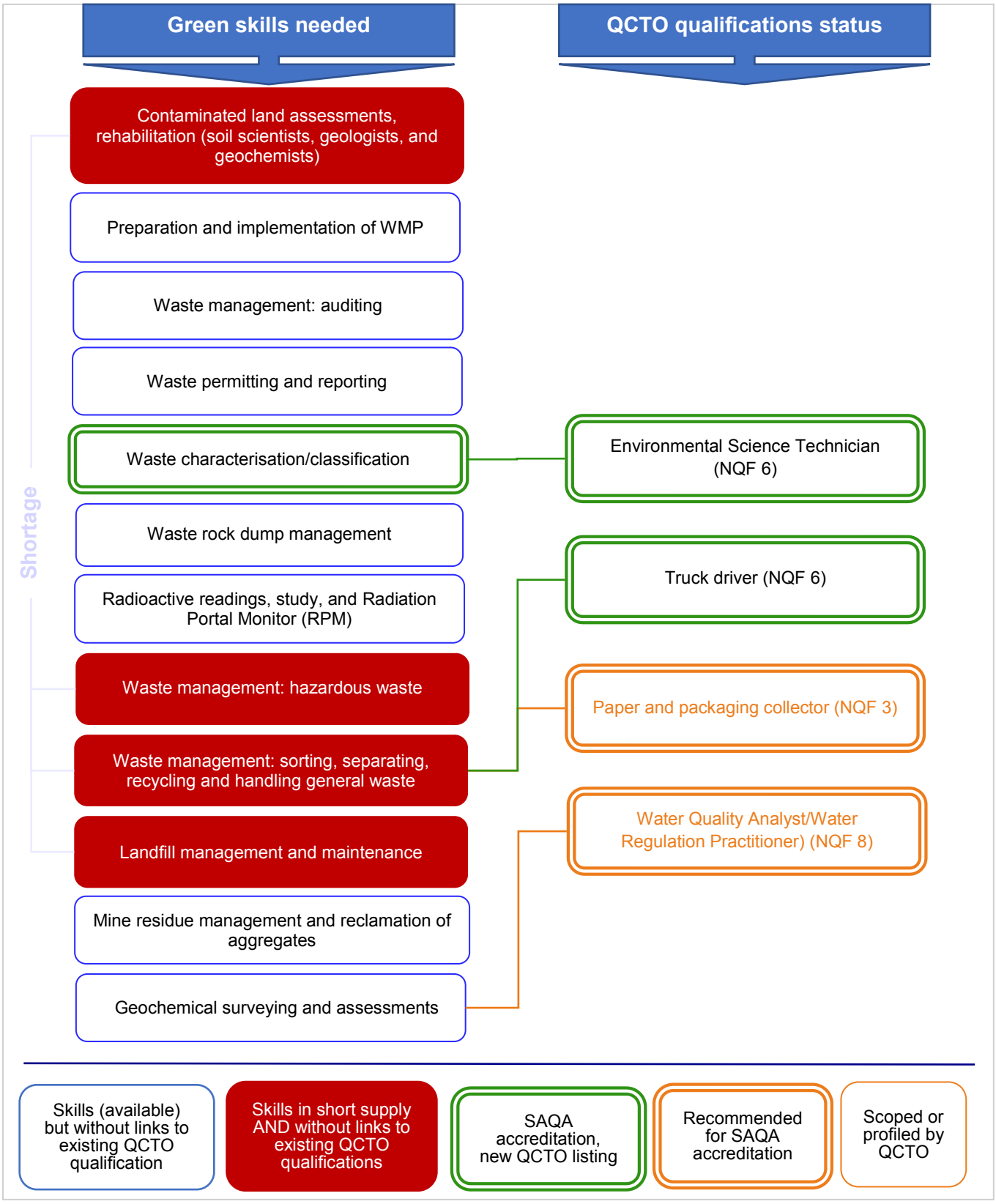

Green skills needed
QCTO qualifications status
Shortage
Contaminated land assessments, rehabilitation (soil scientists, geologists, and geochemists)
Preparation and implementation of WMP
Waste management: auditing
Waste permitting and reporting
Waste characterisation/classification
Waste rock dump management
Radioactive readings, study, and Radiation Portal Monitor (RPM)
Waste management: hazardous waste
Waste management: sorting, separating, recycling and handling general waste
Landfill management and maintenance
Mine residue management and reclamation of aggregates
Geochemical surveying and assessments
Environmental Science Technician (NQF 6)
Truck driver (NQF 6)
Paper and packaging collector (NQF 3)
Water Quality Analyst/Water Regulation Practitioner) (NQF 8)
Skills (available) but without links to existing QCTO qualification
Skills in short supply AND without links to existing QCTO qualifications
SAQA accreditation, new QCTO listing
Recommended for SAQA accreditation
Scoped or profiled by QCTO

Figure 7-2: Alignment of skills requirements with QCTO qualification framework - waste

The National List of Occupations in High Demand for 2018 (DHET, 2018) specifies two occupations that is directly linked to waste management – Waste Material Plant Operator and Hazardous Materials Removal Workers. Similar with the other areas investigated, this suggests that the identified shortages of green skills in waste management are not associated with the current list of occupations in high demand.

Capability and capacity of local institutions to supply of green skills

Similar to the other environmental aspects considered, **there are a number of qualifications that one could choose in order to pursue a career in waste management**, although they do not specifically deal with waste management. However, there are several environmental, engineering and natural science programmes which contain modules that may provide the skills to meet the needs associated with waste management. These qualifications are highlighted in Table 7-4.

Table 7-4: Supply of waste management related green skills (2016)

Occupations associated with green skills	Associated qualifications	Enrolments	Graduations
Waste Researchers and Scientists	Environmental Science	1 793	480
	Environmental/Environmental Health Engineering	53	17
	Total	**1 846**	**497**
Toxicologist	Biology	3 871	369
	Chemistry	7 114	1 229
	Chemical Engineering	8 630	1 583
	Toxicology	78	53
	Total	**19 693**	**3 234**
Remediation Specialists	Environmental Science	1 793	480
	Environmental/Environmental Health Engineering	53	17
	Geology/Earth Science	2 943	814
	Soil Science	620	111
	Hydrology	493	179
	Geological/Geophysical Engineering	96	41
	Chemistry	7 114	1 229
	Chemical Engineering	8 630	1 583
	Civil Engineering	11 573	1 907
	Toxicology	78	53
	Total	**33 393**	**6 414**
Landfill Designers and Managers	Geological/Geophysical Engineering	96	41
	Environmental/Environmental health Engineering	53	17
	Civil Engineering	11 573	1 907
	Total	**11 722**	**1965**
	Natural Resources and Environmental Management and Policy	3 428	679

Occupations associated with green skills	Associated qualifications	Enrolments	Graduations
Waste Management Technicians	Environmental/Environmental health Engineering	53	17
	Environmental Science	1 793	480
	Total	**5 274**	**1 176**
Geochemists	Geochemistry	255	58
	Geological/Geophysical Engineering	96	41
	Geology/Earth Science	2 943	814
	Physical Science	1 185	125
	Mining and Mineral Engineering	2 721	488
	Chemical Engineering	8 630	1 583
	Total	**15 830**	**3 109**

(HEDA, 2016)

The **most common qualifications related to waste management skills as indicated above appear to be Environmental Science, Environmental Engineering and Environmental Management**. There is only one QCTO qualification that deals directly with waste management, namely, Paper and Packaging Collector but this is not yet SAQA accredited. The Environmental Science Technician is however designed to cover a number of environmental aspects including waste management.

There are **few students** who are **enrolled and graduating in Environmental Engineering, Toxicology and Geological Engineering** qualifications. Given that these qualifications are prerequisites for attaining green skills in majority of waste-related fields, this could mean current and future supply gap in these skills.

The following table highlights some of the HEI's where selected degrees that are required to develop green skills related to waste management that are currently in short supply could be obtained.

Table 7-5: HEIs where qualifications for the short-listed waste-related skills can be obtained

Identified skills with existing shortages	Qualification requirements	HEIs where these qualifications can be obtained from
Contaminated land assessments, rehabilitation	• PhD Soil Science	• Stellenbosch • UP • UNIVEN • UFS
	• PhD Geology	• NWU • UP • RU • WITS • UCT
	• PhD Geochemistry/BEng Chemistry	• UCT • WITS • UKZN • UP • UNISA

7.4 Career path development

The career opportunities and paths in the waste management field in the MMS are more linear and less diverse than what was observed in career choices for the air quality and water quality and quantity

management fields. Having said this, individuals pursuing careers in waste management in the MMS can achieve management positions, as is reflected in the table below.

Table 7-6: Career path development – waste

Skill	Pursued professional field	Career Path
Waste management, auditing, permitting and reporting	Environmental	Environmental Assistant – Junior Environmental Officer – Environmental Officer – SHE Manager
Mine residue and deposits Waste management	Engineering	Junior Mine Residue Engineers - Mine Residue Manager - Senior Mine Residue Manager
		Junior Engineer – Environmental Engineer – HSEC Manager
Implementation of WMP	Environmental: waste specialisation	Environmental Coordinator – Unit Manager
Waste separation	Waste separators	Waste separator – Waste Operators – Foreman – Site Supervisor/Level 5 Operator
Waste separation and management	Technical	Waste separator – Waste Operators – Foreman – Site Supervisor/Level 5 Operator
Oversees Radioactive Protective Management	Radioactive Operator (Radioactive Protective Services)	Specialist position – no career path
Landfill management & maintenance	Landfill foreman	Foreman – Site Supervisor/Level 5 Operator

The following can be noted with respect to each of the skills and career pathing implications mentioned above:

- Green skills relating to **waste management, auditing, permitting and reporting** are performed by environmental officers whose horizontal growth path starts off from an Environmental Assistant to a Junior Environmental Officer, then to an Environmental Officer and finally to an SHE Manager.
- **Mine residue and deposits waste management** is conducted by a Junior Mine Residue Engineer.
- A Waste Specialist/Environmental Coordinator ensures the **implementation of the WMP** and the said Waste Specialist/Environmental Coordinator can only move up to the position of Unit Manager.
- The **green skills in the form of waste separation and management; landfill management and maintenance and waste management** on site are conducted by Waste Separators, who

have an opportunity to move to a position of a Foreman, and finally to the position of Site Supervisor/Level 5 Operator.

- Graduate trainees can become Junior Engineers, then Section Engineers and further become Unit Managers until reaching an Engineering Manager position.
- **Radioactive Operators** (Radioactive Protective Services) who oversee the Radioactive Protective Management and who are usually only required in Gold mining occupy a specialised position which has no career path in this regard.
- **Waste management skills relating to rehabilitation** of mine residue are performed by a Rehabilitation Specialist or Mine Residue Specialist/Manager.

Waste management related area is the field where opportunities for upskilling of mine workers is particularly evident.

8 BIODIVERSITY RELATED SKILLS

This chapter contains the fourth sets of analysis of the green skills in the MMS with a focus on biodiversity. It highlights the green skills required by the MMS within the biodiversity field and outlines those that are currently in short supply. It also indicates the green skills in biodiversity that are currently possible to obtain formal qualification on.

8.1 Significance of biodiversity issues and critical skills

South Africa is one of the most biologically diverse countries in the world (containing over 10% of the planet's plant species and 7% of its reptile, bird and mammal species (SAEO, 2007)). South Africa's biodiversity provides an important basis for economic growth and development through the provision of natural resources and vital ecosystem services. South Africa's biodiversity is increasingly threatened by human activities, including mining. Some of the major threats to biodiversity include habitat loss, fragmentation and degradation; invasive alien species, over-exploitation and climate change (DEA, 2018).

To address the conservation of biodiversity, the National Biodiversity Framework (NBF) was formulated. The NBF looks at ensuring conservation of biodiversity in the context of sustainable development and addresses where and how development takes place.

Impacts on biodiversity vary significantly depending on the type of mine, the scale and extent of the mining activity, and the environmental management approach adopted. Impacts can range from short-term (construction), medium term, long-term (mining) or even permanent where these impacts result in permanent changes to the landscape or water regime. According to the Green Skills Study on Coal mining conducted for the MQA in 2015, mine rehabilitation is also challenging, and skills associated with it are largely scarce (ELRC, 2015).

The following table indicates that many of the biodiversity impacts ensue during construction and operational phases, particularly in Gold mining, Other mining, and Diamond mining sub-sectors. Issues of biodiversity are also significant during construction in CLAS and during closure in Other mining.

Table 8-1: Significance of biodiversity issues at different stages of the life cycle

MMS sub-sector	Design/ planning	Establishment/ Construction	Operation	Closure	Rehab
Gold mining					
PGM mining					
Other mining					
CLAS					
Diamond mining					
Diamond processing					
Jewellery manufacturing					N/A
SITM					

LEGEND:	*Negative - negligible*	*Negative - low*	*Negative - moderate*	*Negative – high*	*Positive*

The following can be highlighted with respect to the sub-sectors that have a particularly significant impact on biodiversity during various stages of mining activities:

- **Gold mining**: Gold mining is usually undertaken as open cast pit mining and therefore, has a higher impact during the construction and operational phases than other underground mining practices due to having larger footprint. The effects of Gold mining on the biodiversity are of high significance. Most impacts relating to the loss of biodiversity take place due to construction activities, such as clearing of vegetation resulting in habitat fragmentation and destruction.
- **PGM mining:** Due to platinum mines being mostly underground mining, the establishment and construction phase will have a moderate biodiversity impact due to the smaller footprint. Loss of biodiversity will however, still take place during the construction phase due to the establishment of the mining infrastructure and processing plant as well as during the operational phase where the establishment of the waste rock facilities and tailings storage facilities will also have a moderate impact on biodiversity.
- **Other mining:** Iron ore, Chrome, Manganese, Copper, Phosphates and Salt mining are likely to cause significant biodiversity impacts as the mining of these materials is undertaken as open cast pit mining with large project footprints. The removal of topsoil alters the natural state of the environment and could lead to soil erosion, even after mine closure, should rehabilitation measures not be implemented. The biodiversity impacts will be of high significance during the construction, operational and closure phases. Where phosphate mining is concerned, the strip-mining process can cause land modification thus altering the biodiversity, and nearby surface water resources could be left with low water quantities or could run completely dry even after mine closure. Water contaminated with chromium will result in increased mortality rates in fish. When consumed by animals, the effects can include respiratory problems, a lower ability to fight diseases, birth defects, infertility and tumour formation (Lenntech, 1998-2018). The biodiversity impacts would have a long-term duration and could at times be irreversible after mine closure. Thus, the mine areas would not be easily rehabilitated.
- **CLAS:** Biodiversity impacts relate to inter alia vegetation destruction, loss of habitat and habitat fragmentation. This is because cement, limestone, aggregates and sand mining are undertaken as open cast pit mining. Most impacts relating to biodiversity loss take place during the construction and operational phases. This is particularly significant in sand mining where mining activities occur in many rivers and floodplains. The biodiversity impacts during sand mining will be long term as this type of mining disturbs the functionality of river ecosystems and degrades the area until it has no use (Amphonsah-Dacosta & Mathada, 2017). Floodplain sand mining can also form large and deep open pits which can accumulate water (Amphonsah-Dacosta & Mathada, 2017). In limestone mining, as water and rock are removed from the mines, underground features do not receive adequate support and in that regard, sinkholes are formed. The previous examples highlight a clear alteration of the natural state of the environment. The significance of impacts will be high.
- **Diamond mining:** Diamond mining techniques can consist of open-pit mining, hard-rock mining, alluvial mining and marine mining. Enormous amounts of soil and rock are removed and processed to extract diamonds, and Diamond mining often takes place in environmentally sensitive ecosystems resulting in widespread biodiversity impacts. The effect of Diamond mining during the establishment and construction phase as well as during the operational phase on biodiversity is of high significance.

Due to a diverse nature of the biodiversity field, a wide variety of related skills are needed to deal with the impacts on biodiversity exerted by mining activities in the MMS. As indicated in Table 8-2, the **most critical of these skills include biodiversity assessment; heritage management; as well as closure**

and rehabilitation management. Other critical skills that are important to deal with impacts on biodiversity which are limited to only a few of the sub-sectors include ground stability assessment skills; GIS skills; soil management skills; biomonitoring; and alien plant removal. The demand for many of the biodiversity skills will be linked to the location of the mining activities – in highly sensitive areas, the needs for selected biodiversity skills will be greater. Furthermore, due to the fact that such skills are not usually needed on an on-going basis, many of these are outsourced.

Critical skills – biodiversity

- Biodiversity assessment
- Heritage management
- Closure and rehabilitation

Table 8-2: Critical requirement of biodiversity-related skills at different stages of life cycle of mines

Skill	Design/ planning	Construction	Operation	Closure	Rehab
Heritage management					
Biodiversity assessment and action plan					
Ground stability assessments					
GIS					
Soil management					
Exterminating pests; handling of hazmat					
Closure and rehabilitation management					
Agricultural assessment					
Protected tree permit applications					
Biodiversity and slope design, erosion management					
Alien Plant Removal					
Ecological Assessments					
Blasting/rock engineers					
Conservation					
Marine and coastal management					
Biomonitoring					

Legend					
Explanation of the colour-coding: the number of sub-sectors that indicated a particular skill to be highly critical	**None**	**1 sub-sector**	**2 sub-sectors**	**3 - 4 sub-sectors**	**>5 sub-sectors**

Skill		Design/ planning	Construction		Operation	Closure		Rehab
Sub-sectors' icons	Gold	PGM	Other	CLAS	Diamond	Diamond proc.	Jewellery	SITM

The following diagram summarise the required green skills within the biodiversity field grouping them by the experience needed to become proficient (i.e. 1-3 years, 3-5 years, etc.) and highlighting the skills that are considered to be scarce at the moment.

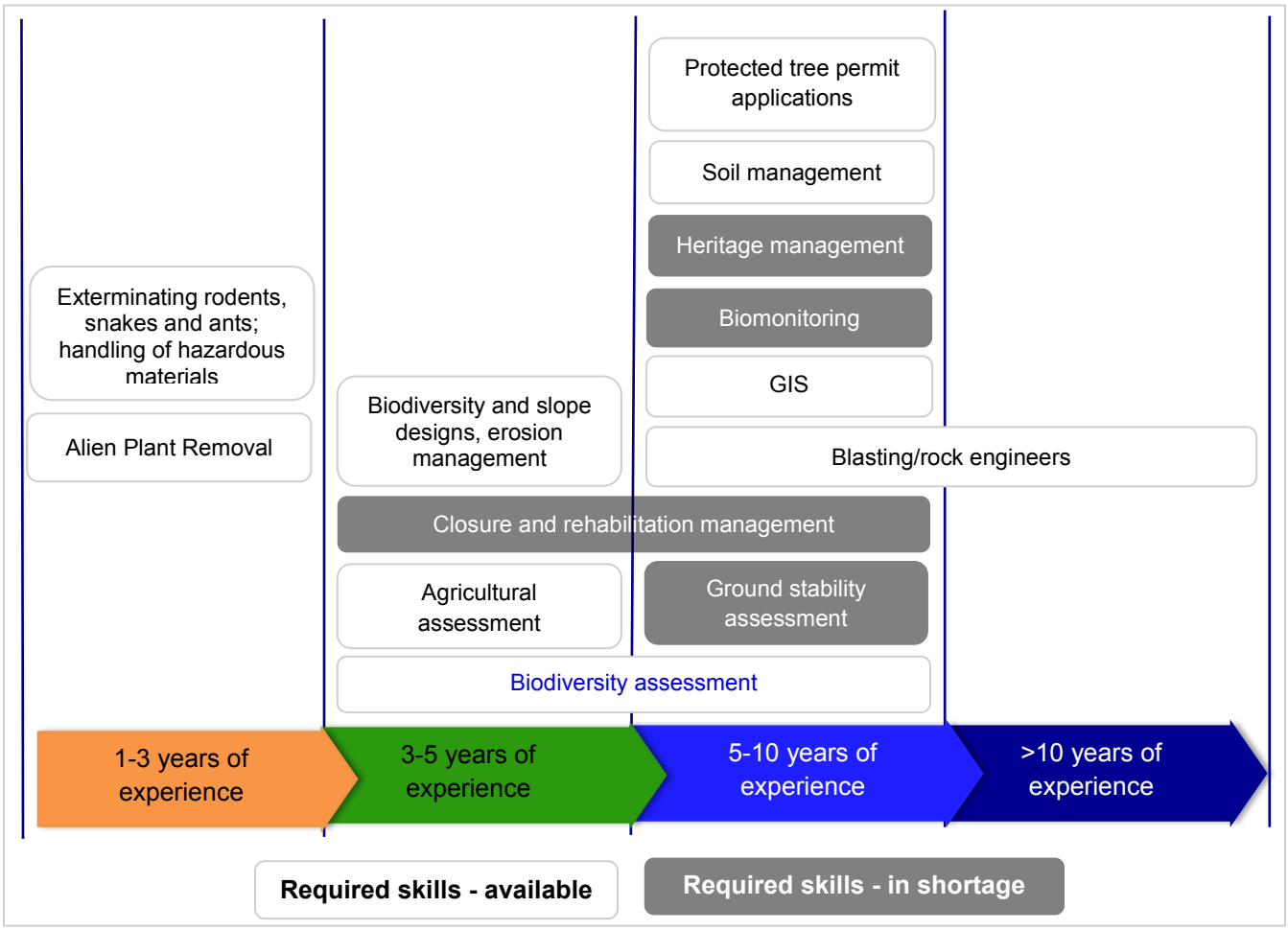


Figure 8-1: Demand versus supply perspective - biodiversity-related skills shortages

Since most of the skills are outsourced due to practical or financial considerations, the MMS sub-sectors do not experience a direct shortage in supply of skills. Having said this, **heritage management; biomonitoring, closure and rehabilitation; and ground stability assessment skills have been identified to have some shortages at the moment**. The shortages experienced, like in many other green skills areas, are largely related to the lack of knowledge, inadequate training, and practical experience obtained in specific sub-sectors. Lack of training on mine closure has been mentioned by many respondents engaged during the study to be one of the most significant gaps in the industry.

8.2 Alignment of skills requirements and qualifications

Green skills and required qualifications and experience

Most of the green skills related to the management of biodiversity issues faced by the sub-sectors in the MMS at various stages of the project life cycles require specialists with a formal engineering, environmental, or science degree with five or more years' experience.

Table 8-3: Required qualifications and experience to gain biodiversity-related skills in short supply

Skill	Qualification requirements	Experience requirements
Heritage management	• BSc Archaeological Sciences/ Archaeology	5-10 years
Biodiversity assessment and action plan	• BSc Ecology/Botany/Zoology/Herpetology/BSc Biodiversity/Ecology/Botany and Zoology/BSc Natural Science or a BSc Biology	3-10 years
Ground stability assessments	• BSc Geology with specialisation in ground stability	5-10 years
GIS	• GIS related qualification	5-10 years
Soil management	• BSc Soil Science/Landscape Architecture degree (LArch)	5-10 years
Exterminating pests; handling of hazmat	• Hazardous materials handling qualification	1-3 years
Closure and rehabilitation management	• BSc Botany & Soil Science/Environmental Management	5-10 years
Agricultural assessment	• BSc Agriculture	3-5 years
Protected tree permit applications	• BSc Environmental Science	5-10 years
Biodiversity and slope design, erosion management	• BEng Civils	3-4 years
Alien Plant Removal	• Not known	1-3 years
Blasting/rock engineers	• Mining diploma and a qualified rock engineer/Engineering degree and a blasting ticket	5-10 years
Biomonitoring	• Biotechnology degree	5-10 years

Green skills and identified shortages

Figure 8-2 aligns the required skills with QCTO qualifications. Similar to the situation with waste management related skills, there are only two QCTO qualifications that offer selected skills in biodiversity management. All four of the critical skills that have also been identified to be in short supply due to various reasons currently do not have applicable QCTO qualifications. These refer specifically to heritage

management; biomonitoring; ground impact assessment; as well as closure and rehabilitation management. Importantly, many other biodiversity-related skills which have been identified to be in short supply at the moment, are also not aligned with any of the QCTO qualifications.

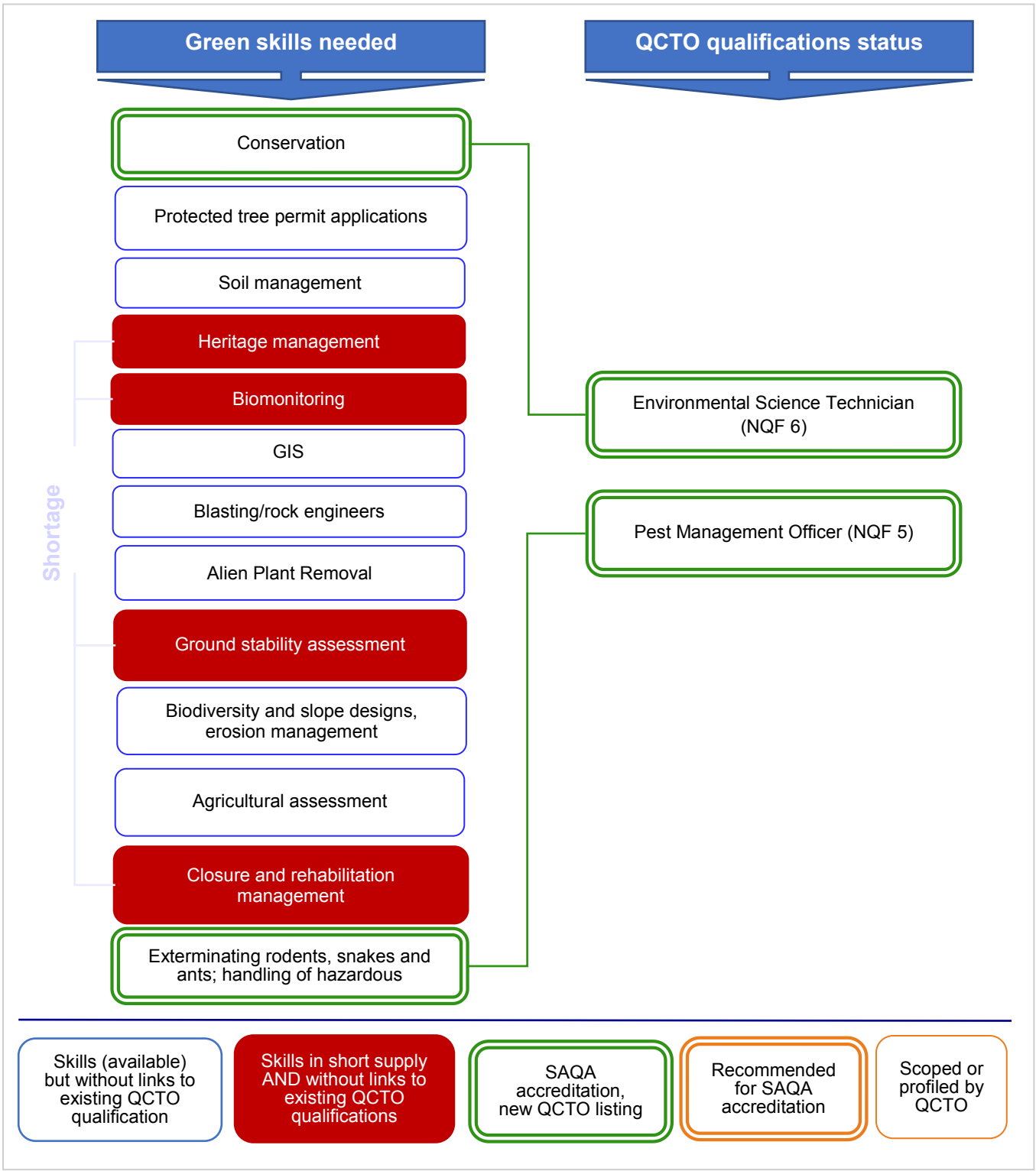


Figure 8-2: Alignment of skills requirements with QCTO qualification framework – biodiversity

Biologists, biotechnologists, forest and conservation workers, blasters, agricultural consultants and scientists, agricultural engineers are just a few of the occupations that have been included in the DHET list of occupations in high demand. All of these occupations are linked to the green skills identified to be essential when it comes to dealing with biodiversity-related issues in the MMS.

The most common qualifications, related to biodiversity skills appear to be Biology, Ecology, Botany, Zoology, Environmental Science and Environmental Management, and as indicated above (Figure 8-2) there are only two SAQA accredited QCTO qualifications that were identified in relation to biodiversity – Environmental Science Technician and Pest Management Officer.

Capability and capacity of local institutions to supply of green skills

Biology, Zoology and Botany are vital qualifications offered to enter the field of biodiversity. However, given the highly specialised nature of some of the skills related to biodiversity, it is essential for students to have a specialist background, not only to enter the field of biodiversity, but also for career advancement. Table 8-4 shows that while there are a number of students who enrol and graduate in the broader biodiversity related qualification, fewer students enrol and graduate in areas of high specialisation. Undersubscribed courses include; Conservation and Environmental Biology, Wildlife Biology, Fisheries Science and Management and Biostatistics where less than 100 students are enrolled per course.

Table 8-4: Supply of biodiversity related skills (2016)

Occupations associated with green skills	Associated qualifications	Enrolments	Graduations
Biodiversity specialists	Biology including plant biology	4 037	407
	Conservation Biology	63	30
	Ecology/Evolution	619	162
	Natural Resources and Environmental Management	3 428	679
	Environmental Biology	27	13
	Environmental Science	1 793	480
	Zoology	1 495	301
	Total	**11 462**	**2 072**
Alien species control officers	Biology including plant biology	4 037	407
	Conservation Biology	63	30
	Ecology/Evolution	619	162
	Natural Resources and Environmental Management	3 428	679
	Environmental Biology	27	13
	Botany	1 685	296
	Plant Pathology	248	64
	Total	**10 107**	**1 651**
Agricultural extensionists with biodiversity specialism	Agricultural Science	640	161
	Agricultural Extension	1 019	243
	Total	**1 659**	**404**
Curators of biodiversity collections	Horticultural Science	273	83
	Botany	1 685	296
	Zoology	1 495	301

Occupations associated with green skills	Associated qualifications	Enrolments	Graduations
	Total	**5 112**	**1 084**
Ecologists	Ecology/Evolution	619	162
	Conservation Biology	63	30
	Total	**682**	**192**
Conservation and Environmental Scientist	Environmental Science	1 793	480
	Conservation Biology	63	30
	Total	**1 856**	**510**
Engineers (civil) with biodiversity specialism	Civil Engineering	11 573	1 907
	Ecology/Evolution	619	162
	Conservation Biology	63	30
	Total	**12 255**	**2 099**
Geneticists	Life Sciences	1 338	341
	Genetics	752	236
	Total	**2 090**	**577**
Species protection officers and inspectors	Environmental Science	1 793	480
	Conservation Biology	63	30
	Ecology/Evolution	619	162
	Total	**2 475**	**672**
Resource economists with biodiversity related specialism	Agricultural Economics	1 510	387
	Botany	1 685	296
	Zoology	1 495	301
	Ecology/Evolution	619	162
	Total	**5 309**	**1 146**
Social scientists	Geography	4 901	1156
	Environmental Science	1 793	480
	Total	**6 694**	**1 636**
Soil scientists	Soil Science	620	111
	Plant Science	311	81
	Total	**931**	**192**
Taxonomists, systematists for marine and terrestrial systems	Botany	1685	296
	Entomology	210	57
	Zoology	1 495	301
	Conservation Biology	63	30
	Total	**3 453**	**684**
Biodiversity Monitors in marine and other ecosystems	Marine Biology	401	101
	Conservation Biology	63	30
	Ecology/Evolution	619	162
	Geography	4 901	1156
	Natural Resources and Environmental Management	3 428	679
	Environmental Biology	27	13
	Environmental Science	1 793	480
	Zoology	1 495	301

Occupations associated with green skills	Associated qualifications	Enrolments	Graduations
	Total	**12 727**	**2 922**
Protected Area Managers	Conservation Biology	63	30
	Ecology/Evolution	619	162
	Natural Resources and Environmental Management	3 428	679
	Environmental Science	1 793	480
	Total	**5 903**	**1 351**
Wildlife Veterinarians	Wildlife and Other Reserve Management	853	219
	Wildlife Biology	46	16
	Veterinary Science	1 457	217
	Total	**2 356**	**452**
Entomologists	Botany	1 685	296
	Entomology	210	57
	Zoology	1 495	301
	Biology	4037	407
	Total	**7 427**	**1 061**
Biotechnologists	Biotechnology	2 115	557
	Biology	4 037	407
	Microbiology	2 402	431
	Total	**8 554**	**1 395**
Fisheries Control Officers	Marine Biology	401	101
	Fishing and Fisheries Sciences and Management	0	0
	Total	**401**	**101**
Statistical Ecologists & Modellers	Conservation Biology	63	30
	Ecology/Evolution	619	162
	Biostatistics	66	35
	Total	**748**	**227**

(HEDA, 2016)

Considering the identified green skills that are currently in short supply, the following table provides examples of some of the universities where the above-mentioned qualifications could be obtained from.

Table 8-5: HEIs where qualifications for the short-listed biodiversity-related skills can be obtained

Identified skills with existing shortages	Qualification requirements	HEIs where these qualifications can be obtained from
Heritage management	• BSc Archaeological Sciences/ Archaeology	• UCT • WITS • RU • UP • UNISA
Ground stability assessments	• BSc Geology with specialisation in ground stability	• NWU • UP • RU • WITS • UCT

Identified skills with existing shortages	Qualification requirements	HEIs where these qualifications can be obtained from
Closure and rehabilitation management	• BSc Botany & Soil Science/Environmental Management	• RU • UNIZULU • UP • WITS • UCT
Biomonitoring	• Biotechnology degree	• UCT • UP • RU • UKZN • UNISA

8.3 Career path development

The career paths for specialists focusing on biodiversity management are limited. The fact that many of the skills are also being outsourced suggests that such career paths are mainly available outside the mining businesses themselves. Many of the skills are also specialist skills and have limited career pathing opportunities.

The following table summarises the most prominent career path choices in the biodiversity field in the MMS:

Table 8-6: Career path development – biodiversity

Skill	Pursued professional field	Career Path
Rehabilitation skills: research and development into effective rehabilitation	Occupation and hygiene	Occupational Hygienist – Mine Manager
	Environmental	Environmental Monitor – Environmental Officer – Environmental Specialist – HSE Manger – Head Office Manager
	Rehabilitation	Rehabilitation Specialist – Environmental Group Lead
Ground stability assessments	Geotechnical specialisation	Specialist position – no career path
GIS	GIS specialisation	Specialist position – no career path
Protected tree permit applications	Environmental	Environmental Practitioner – Junior Environmental Practitioner – Senior Environmental Practitioner Specialist – Manager

The following should be noted:

- Ground stability assessments and GIS green skills are conducted by geotechnicians and surveyors and GIS specialists respectively. These are specialist positions, therefore there is no career path in this regard.
- Environmental Practitioners and specialists are used for biodiversity-related skills. This occupation starts out from an Environmental Practitioner with a vertical growth path from Junior to Senior Environmental Practitioner. Specialists can move to a managerial position.

The opportunities for upskilling employees in the MMS whose higher education levels are matric or less are limited within the biodiversity-related field. This means though that in order to enable the employees to pursue careers in the biodiversity, bridging courses and programmes will need to be designed.

9 DRIVERS OF GREEN SKILLS DEMAND AND SUPPLY

This chapter provides a summary of the drivers that effect the supply and demand of green skills within the MMS and the four environmental fields of study – air quality, water quality and quantity, waste management, and biodiversity. It also highlights the implications of the future mining trends on the demand for green skills.

9.1 Demand and supply drivers today

The demand and supply of green skills in the MMS is driven by various factors, some of which exude more pressure than others. The following table summarises the most prominent drivers of supply and demand of green skills in the MMS in no particular order.

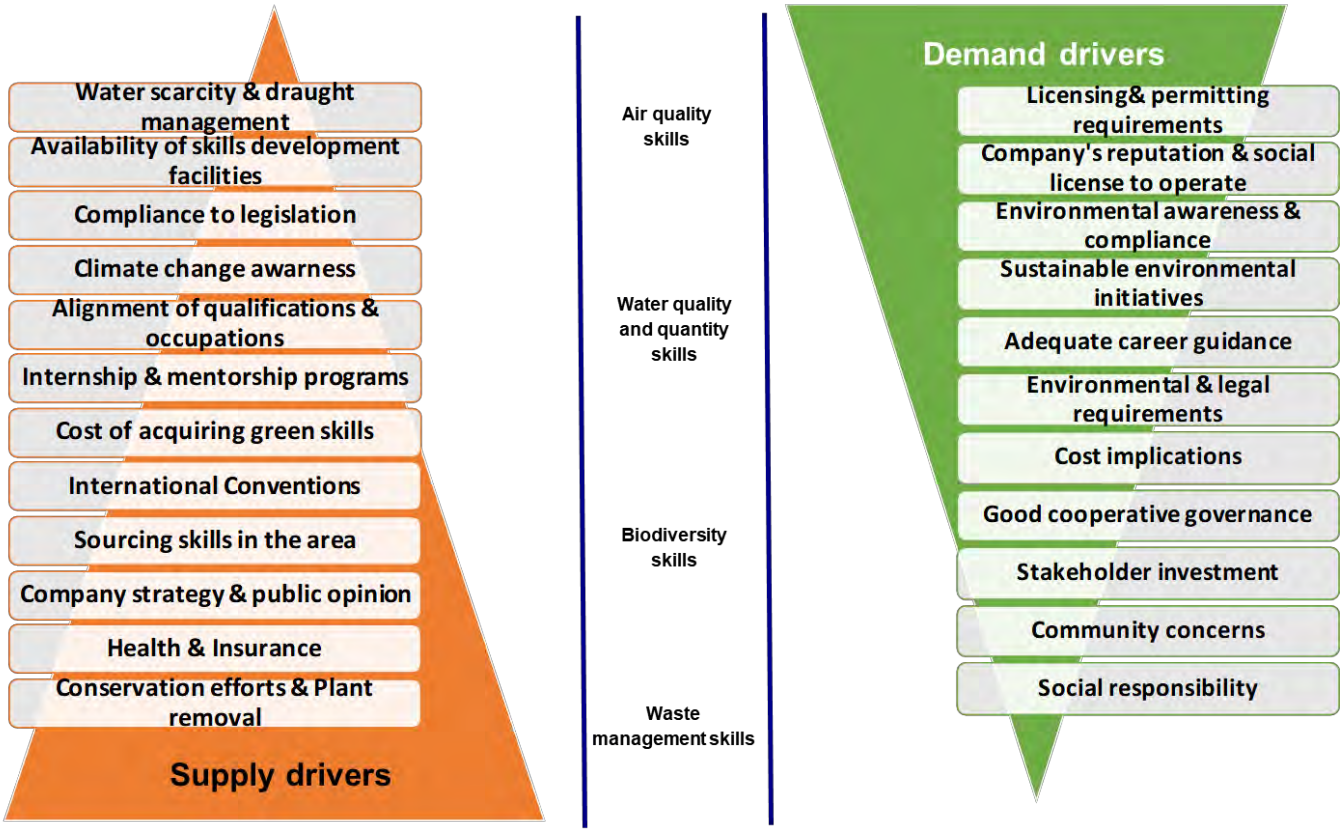


Figure 9-1: Demand and supply drivers of green skills in the MMS

The **demand** for green skills in the MMS is largely driven by the need to continue producing value for shareholders and owners of the businesses and therefore, the need to remain sustainable in the long-term. Many of the organisations interviewed indicated that the **most critical implication of not having access to the required green skills was the risk of losing their licence to operate**. As might be expected, the loss of the licenses to operate will likely lead to an increase in unemployment and negatively impact on the economy of South Africa considering its reliance on mining activities for wealth generation, foreign exchange earnings, and labour absorption.

The loss of a licence to operate is closely linked to **compliance with legislation**. Mines are generally compelled and regulated by legal and environmental requirements, which need to be observed; hence, awareness and compliance to environmental laws is also considered as important factors that affect demand for green skills which are essential for companies' reputations. For example, complying with the NEMA's Air Quality Act requires green skills to mitigate, monitor, manage, and measure air emissions.

The loss of a license to operate and the need to ensure compliance with relevant legislations are closely followed by a set of the following risks that companies in the MMS aim to avoid by acquiring access to green skills:

- Legal costs, penalties and fees associated with non-compliance
- Reputational damage
- Delays in operations
- Claims against the company from affected communities

These risks have a direct implication on the profitability and sustainability of the businesses.

Similarly, to demand factors, legislation and compliance are critical **drivers of the supply** of green skills. Experience is another critical driver of supply, and there is a call for individuals to widen their green skills rather than specialise. To obtain this experience, there is a need for institutions to offer graduates more experience in related green skills and a certificate of competence in these areas. Such skills development depends on the availability of internships, apprenticeships, mining orientation and learnerships. There also needs to be alignment between qualifications being offered and experience. Furthermore, access to career guidance also influences the supply of green skills. Another factor that affects the supply of green skills is the availability of the skills in the vicinity of the mines as it is sometimes difficult to relocate skilled personnel from developed areas to mine locations, which are often situated in rural and remote areas that do not enjoy the same level of social and economic infrastructure as urban areas do.

9.2 Outlook for green skills in mining

Although the entire mining industry's core practices have remained largely unchanged over the years, in assessing the journey of mining towards the future, it is evident that the mines of the future will be characterised by a strong realisation of their obligations towards the community and heightened responsiveness to the issues of social and environmental responsibility. The mining industry is under immense pressure to find new ways of improving production efficiency and optimising safety obligations (Kirkby, 2002). Since there exists an evident growing realisation of future mining practices to function within a sustainable development framework, green skills (i.e. **knowledge, abilities, values and attitudes needed to live in, develop and support a sustainable and resource efficient society**) can be viewed as one of the key enabling factors that will assist the mining and minerals industry in adopting and moving towards a sustainable and production efficient working environment.

In the context of the above, all the mining sub-sectors are likely to experience an increased demand for green skills, considering that green skills are part of the critical investor requirements and that there will always be a need for green skills to fulfil legislative requirements regarding sustainable development. For example, with regard to CLAS, the Carbon Tax Bill is perceived as a major future threat that will require more green skills to reduce the impact of carbon emissions on the environment.

Furthermore, the demand for green skills is likely to increase as compliance to environmental policies grows. New legislation (such as Carbon Tax) and amendment of existing legislation (which tends to

strengthen regulatory environment) is also expected to increase the demand for green skills. The use of renewable energy will increase the demand for specialist related green skills; while the closure of the mines will create a further pressure on acquiring rehabilitation and closure specialists.

Over the years, though, the mining and minerals sector has been strongly characterised by a conventional blueprint methodology from exploration through to the refining stage of the mining value chain. While this has worked well in the past, mining companies can no longer achieve optimal productivity without recognising their role in the broader economic, social, and technological ecosystem (PWC, 2017). Today, "public perspective sees mining as old, dirty, dangerous and environmentally contentious" (IBM Corporation, 2009) highlighting the impending need for the industry to evolve.

It is envisaged that to remain competitive and continue operating as a going concern, mining practices are expected to transform from manual underground work (conventional practices) to automated and remote-controlled processes (emerging practices associated 4th industrial revolution). "Automating a mining operation makes the entire process leaner, delivering more products with less cost, less waste and less effort". Driverless trucks and remote-controlled processes are among the most dominant automated trends in mining. Remote monitoring and control of equipment allows miners to automate industrial processes such as blasting, drilling and transportation (Somarin, 2014). This means that unlike in the past when mining was strongly characterised by manual and physical underground work often subjected to harsh working conditions, the adoption of automation processes will result in a more efficient and safer industry (Unknown, 2017).

The following table summarises some of the changes that can be expected to characterise the "future of mining":

Table 9-1: Description of selected emerging practises in the Future of Mining

Characteristic	Conventional practice	Emerging practices to adopt
Safety	▪ Workers' safety is solely a function of training, procedures, policy and chance	▪ New smart programs and technologies, such as location awareness technologies, GPS, RFIDs and collision detection/avoidance
	▪ Access, privileges, status and management employees is delegated to line managers and informal processes	▪ Companies deploy automated Identity and Security Management programs that centrally track employees' access rights, location, duration, training, certification, compliance and site security
Energy and environment	▪ Carbon, water, energy and waste are managed manually with little automation or integration	▪ Processes, information and analytical tools are used to proactively manage environmental and energy consumables, such as modelling carbon trade-offs, carbon trading, water management fuel optimisation and waste control
	▪ Mining is perceived by prospective employees, the public and the media as environmentally unfriendly	▪ The perception of mines is positive, attracting environmentally-aware advocates to work and support clean mining operations
Productivity, efficiency & cost reduction	▪ Few or poorly supported programs exist to support, promote quality and efficiency	▪ Quality and efficiency programs are used to manage productivity and to define optimal processes
Remote Operations	▪ Managers and teams are mentally and physically locked into local operations	▪ Sites across the enterprise are managed centrally and synergies and advanced capabilities are realized by unifying processes, information, control and knowledge
	▪ Staff must be physically on	▪ Automated, robotic and remotely controlled

Characteristic	Conventional practice	Emerging practices to adopt
	site ▪ Equipment and transport are fully manned at location	equipment and transportation are used to improve productivity, safety and boost employee retention

(IBM Corporation, 2009)

Overall, the future mining practices will create a demand for more specialised high-tech skills (Abrahamsson & Johansson, 2008). It is evident from the table above that to achieve sustainability will require access to Information Technology (IT) experts and scientists with extensive knowledge and experience in modelling application and IT tools. The envisioned increase in demand for IT skills will be a result of the impending need of the workforce to continually enhance their abilities in performing several tasks through automated and remote-controlled operations and monitoring. As such, within the sphere of technological innovations, the future workforce is likely to be multi-skilled.

Considering the above, some sub-sectors may experience a decrease in the demand for green skills that are currently in need and that have been identified to be in short supply or readily available; this has also been confirmed during interviews with stakeholders. The need for one type of skill will, however, be replaced by the need for another type, and re-skilling as well as the restructuring of the labour force in the MMS will be required.

10 CONCLUDING REMARKS AND RECOMMENDATIONS

Since the inception of the **sustainable development** notion by the Brundtland Commission in 1987, there has been a growing realisation of the impending need of the current generation to live within a safe operating space i.e. ensuring a content generation without leaving future generations in a worse-off position. This is often said to be achieved when there is a balance between the social, economic and environmental (commonly known as "triple-bottom line) aspects. Today, this realisation has climaxed itself into the recent economic development trajectory formally known as the green economy.

The **green economy** envisions a resource efficient, socially inclusive, and equitable global economy, it is imperative for dominant industries such as the mining and minerals sector to align their practices with goals closely linked to achieving this development path. The **mining landscape is constantly changing**, and the associated benefits linked to adopting emerging practices which are linked to being sustainably-aware do not only guarantee and maintain mining companies' social licence to operate, but also increase the individual mining company's competitive advantage. Thus, to maintain long-term growth and to adapt to the changing landscape, the global mining industry is revealing a considerable shift from a conventional approach of achieving productivity towards greater integration between mining processes across the value chain. Thus, important to note is that, the future of mining is characterised by increased commitment to sustainability issues. Although this trend is common across mining companies, to ensure effective compliance to the emerging trends in the mining and minerals industry, mining companies should develop practical and unique company-specific processes suited to the surrounding mining context.

The review of the various South African policies, legislative frameworks, and conventions indicated a **need for a wide-ranging environmental skill set related to air quality, water quality and quantity, waste management and biodiversity fields required by the mining industry** to possess and have access to for it to be able to adhere to these legislations and guidelines and secure and ensure sustainability of operations.

A total of **24 companies within the MMS (except for Coal mining) comprising 50 managers and professionals working for these companies were interviewed** to gain an insight into the demand and scarcity of the environmental skills within the above-mentioned fields. The gathered data revealed that most green skills arise from knowledge gained from university in the form of "green skill" diplomas and degrees and not necessarily through educational institutions such as TVET colleges which produce artisans. In addition to this, some skills are rather mine- and/or sector-specific; therefore, the lack of knowledge of the mining operations holistically creates a further gap in the demand for green skills from educated graduates or learners who have no mining experience whatsoever. In short, **the scarcity of green skills that has been identified in the MMS (except for Coal mining) is largely *relative*,** where suitably skilled people are available in the labour market, but they do not possess other employment criteria such as sector-specific work experience and willingness to locate to the geographical locations, where mining operations take place (mostly in rural and remote locations). Only in a few cases, an absolute scarcity has been identified and it referred to the merging skills in carbon emissions, climate change, carbon auditing.

The following figures summarises essential and scarce green skills within the MMS. It should be noted that the review of the National List of Occupations in High Demand for 2018 (DHET, 2018), gazetted on 22 June 2018, suggests that many of the identified green skills and particularly those green skills that have been confirmed to be scarce in the MMS are also included in the National List of Occupations in High Demand. The identified scarce skills that overlap with those that have been included in the National

List of Occupations in High Demand are predominantly related to waste and biodiversity green skills and include energy efficient technicians, water plant operator, waste materials plant operator, environmental manager/engineer, environmental impact and restoration analyst, hazardous materials removal workers, forest and conservation worker, chemical engineer, biotechnologist/biochemist/biologist.

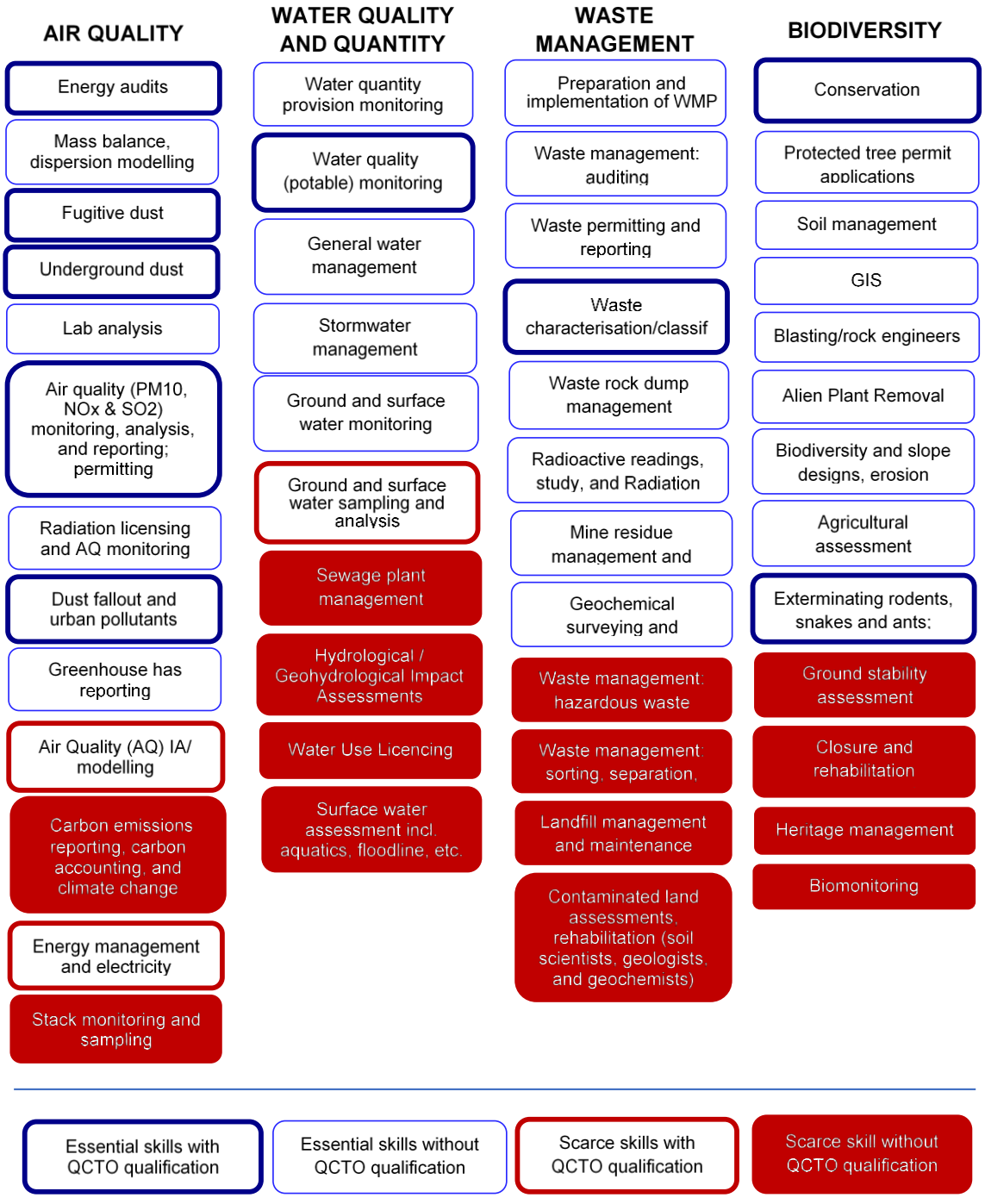


Figure 10-1: Summary of essential and scarce skills in air quality, water quality and quantity, waste management and biodiversity fields experienced by the MMS

In the diagram above, it is clear that scarcity of green skills exists throughout the different environmental fields focused in the study; however, only selected green skills in air quality and water quantity fields are currently possible to develop by obtaining QCTO qualifications. The review of the demand for skills, though highlighted that to become proficient in many of these skills, a skilled employee will need to obtain 3-5 years of experience and in some instances experience within the specific MMS sub-sector. This again confirms that the shortages mainly come in the form of relative scarcity.

Currently, companies address skills gaps through the following interventions:

- Outsourcing independent consultants
- Offering bursaries
- Providing in-house accredited training to staff and informal training programmes
- Taking staff on external courses such as legal environmental training
- Multi-skilling of employees by introducing specialists to various other fields through bridging courses that align various courses across the environmental management discipline
- Mentorship programmes
- Environmental awareness training which is outsourced as and when needed.

Although the above-mentioned initiatives assist in dealing with the current shortages of skills, the situation is likely to exacerbate in the future. In this context, the following recommendations are proposed to be considered by the MQA to address the identified gaps, shortages, and weaknesses in the system:

1. **Revise QCTO qualification framework to better align with the needs of the MMS in relation to green skills**: The study revealed that most green skills arise from knowledge gained from universities in the form of "green skill" diplomas and degrees and not necessarily through educational institutions such as TVET colleges which produce artisans. Furthermore, only selected green skills in air quality and water quantity fields are currently possible to develop by obtaining QCTO qualifications. This specifically refers to the following scarce green skills that are currently not reflected in the QCTO qualification framework:
    - Carbon emissions reporting, carbon accounting, and climate change
    - Stack monitoring and sampling
    - Sewage plant management
    - Hydrological / Geohydrological Impact Assessments
    - Water Use Licencing
    - Surface water assessment incl. aquatics, floodline, etc.
    - Waste management: hazardous waste
    - Waste management: sorting, separation, recycling and handling general waste
    - Landfill management and maintenance
    - Contaminated land assessments, rehabilitation (soil scientists, geologists, and geochemists)
    - Ground stability assessment
    - Closure and rehabilitation
    - Heritage management
    - Biomonitoring
2. **Bridge the gaps between the educational programmes and industry requirements by means of specialised courses**: The engagement with stakeholders further revealed that

structural changes along with the alignment of NQF levels and the workplace are required to assist in broadening the skills of the workforce and to match the needs of the industry with the supply of educational programmes. This for example, refers to the scarce skills in radioactivity which could be addressed by providing specialised courses and more qualifications in this field.

3. **Broaden skills sets and develop sector-specific experience through internships and learnerships:** Though the majority of shortages of green skills found in the MMS (except for coal mining) are associated with relative scarcity, creating new training programmes will not be sufficient to address these gaps. Therefore, internships and learnership programmes in green skills provided by independent parties and mining houses will be paramount to bridge gaps between tertiary education and the workplace. These specifically refer to the following sub-sectors:
    - Other mining
    - Gold mining
    - PGM mining
4. **Strengthen the dialogue among the key industry stakeholde**r: There should be mutual engagements between mining companies, independent consultants offering various green skills, government departments such as the Department of Environmental Affairs amongst others and tertiary education institutions. Consequently, the engagements and action plans set out by these stakeholders would enable them to bridge the gap between tertiary education and the workplace. Also, trends in the demand for specific green skills can be monitored and the demand can be satisfied timeously when all these stakeholders work as a collective.
5. **Extending the MQA's register of companies along the entire MMS value chain**: Although not the main objective of the study, it was noted that the MQA's register of companies excludes the companies operating at Stage 5 of the MMS value chain. it would be advisable to include these in the register, even if such companies are not responsible for reporting to the MQA. Furthermore, it would be recommended to extend the register to include information on the MMS value chain stages that each company is representing or operating at.

Considering the above recommendations, the following actions are proposed for the MQA:

Table 10-1: Proposed action list for the MQA

Recommendations	Actions list
Revise QCTO qualification framework to better align with the needs of the MMS in relation to green skills	• Engage with relevant stakeholder and investigate the potential to set up new qualifications for the following green skills: o Carbon emissions reporting, carbon accounting, and climate change o Stack monitoring and sampling o Sewage plant management o Hydrological / Geohydrological Impact Assessments o Water Use Licencing o Surface water assessment incl. aquatics, floodline, etc. o Waste management: hazardous waste o Waste management: sorting, separation, recycling and handling general waste o Landfill management and maintenance o Contaminated land assessments, rehabilitation (soil scientists, geologists, and geochemists)

Recommendations	Actions list
	○ Ground stability assessment ○ Closure and rehabilitation ○ Heritage management ○ Biomonitoring • MQA in partnership with HEIs and industry to develop curriculum for new qualifications (as per the previous bullet) • Register new qualifications with QCTO and SAQA
Bridge the gaps between the educational programmes and industry requirements by means of specialised courses	• Develop specialised courses to match skills requirements in the industry in: ○ Radioactivity ○ Stack monitoring
Broaden skills sets and develop sector-specific experience through internships and learnerships	• Develop workspace learning materials and programmes focusing on green skills in the following sub-sectors: ○ Other mining ○ Gold mining ○ PGM mining • Conduct a country-wide survey of MMS workers to investigate their interests in selected career paths, identify their existing gaps in qualifications, and develop programmes focusing on those career path that are expected to be in greatest demand and associated with the largest gap between current and required qualifications • Undertake a study into the change in demand and skill requirements associated with the 4th industrial revolution
Strengthen the dialogue among the key industry stakeholder	• Review the requirements for Sector Skills Plans and integrate the elements of green skills in air-quality, water quality and quantity, waste management, and biodiversity that would enable collection of data for future decision-making concentring training and qualifications associated with green skills in the MMS • Set up forums to discuss the industry needs and existing shortages in green skills, as well as the best approaches to address them
Extending the MQA's register of companies along the entire MMS value chain	• Review the MMS value chain and clearly define the stages that the MQA has control over or mandated to oversee • Revise the structure of the registrar of companies that form part of the MMS sub-sectors to: ○ Indicates the involvement of these companies in the value chains ○ Include companies that are operating outside the immediate control of MQA but still within the MMS value chain

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ANNEXURE A: RESEARCH QUESTIONS

Relevant objective	Key questions to be answered

Investigate the essential 'green skills' that are important for environmental considerations such as Air/Water Pollution and Mining Waste/Biodiversity (where relevant) in the Core Mining and Beneficiation (where relevant) of the mining and minerals sector	• Provide theoretical definition of the notion of "skill"
	• What is the definition of "green skills" as applicable to the MMS?
	• What is the definition of "essential skills"?
	• What are the key international trends with respect to green skills in the mining industry and what are the possible implications of these on SA?
	• How does mining fit in the context of green economy?
	• How does the value chain look like for each mining and minerals sub-sector?
	• How does each mining and minerals sub-sector affect the environment with a specific focus on air, water, waste, and biodiversity?
	  ○ What are the environmental issues associated with each of the mining and minerals sub-sector under consideration?
	  ○ Which of the issues are the most acute to each sub-sector?
	  ○ At which point in the value chain do these issues arise?
	• What essential green skills are required to deal with each of the environmental issues related to:
	  ○ Air pollution
	  ○ Water pollution
	  ○ Mining waste
	  ○ Biodiversity
	• What are the typical occupations in the mining sector's value chain that require these skills?

Investigate the 'green skills' that are considered scarce in the Air/Water Pollution and Mining Waste/Biodiversity (where relevant) in the Core Mining and Beneficiation (where relevant) of the mining and minerals sector that can help in mitigating the effects of Core Mining and Beneficiation.	• What is the definition of "scarce skills"? • What are the specific green skills that are considered scarce in the mining and minerals sub-sectors? • Which of the scarce green skills are essential to mitigating the environmental issues associated with the mining and mineral sub-sectors? • To what extent does the lack of green skills in the mining and minerals sub-sectors contribute to the environmental challenges in the mining industry?

What factors affect both 'green skills' supply pipelines and demand in each sub-sector and how do they affect them?	• On demand for green skills in the MMS:
	  ○ What is the current demand for green skills?
	  ○ What are the factors affecting the demand?
	  ○ How do these factors influence the demand?
	  ○ Who controls/influences these factors?
	  ○ Do these factors differ for different sub-sectors?
	  ○ What is the expected future demand for green skills?
	  ○ What is international demand regarding green skills?
	• On supply of green skills in the MMS:
	  ○ What is the current supply for green skills (based on how many graduates qualifying a year per area of speciality)?
	  ○ What are the drivers of supply of green skills in the MMS?
	  ○ How do these drivers influence the supply?
	  ○ Who/what influences these drivers?
	  ○ How long does it take to train/acquire relevant green skills?
	  ○ Does SA have the relevant curricular and modules to assist in skills development?
	  ▪ What are these?

Relevant objective	Key questions to be answered
	○ How many people are training in respective skills and where are the gaps? ○ What is international supply regarding skills?
Are the current "green skills" integral to the new Qualification Council for Trades and Occupations (QCTO) qualifications?	• What types of qualifications that satisfy the "green" definition currently exist? • What is the status of these in terms of accreditation? • Are the currently existing green skills SAQA accredited and listed as part of the new QCTO qualifications? • What are the gaps in terms of green skills that are currently included under QCTO qualifications?
What are the implications of the green skills in the mining and minerals sector when it comes to career pathing?	• What is the importance of green skills in the context of MMS? ○ How important are these skills during each stage of the value chain? ○ What impact do green skills have on business operations? • What are the career path opportunities for people with green skills? • What are academic path opportunities regarding green skills? • What additional skills and qualifications are required for individuals to progress along the career path? • What additional skills and qualifications are required to realise academic progression within the PSET system? • Which occupations in the MMS can enhance green skills in an effort to add value and increase employability?
What are the recommendations concerning the development and implementation of 'essential green skills' in the mining and minerals sector?	• What changes need to be considered by QCTO in its role to monitor design, quality assurance and certification of trade skills and qualifications? • What new qualifications will be required to be developed to address the gaps? • What are the additional training/modules/curricular required? • Which green skills related training should the MQA focus on?