QUALIFICATION SPECIFICATION							SECTION A
QUALIFICATION DEVELOPER	University of Botswana						
TITLE	Bachelor of Engineering (Honors) in Mineral Engineering			**NCQF LEVEL**	8		
FIELD	Mining		**SUB-FIELD**	Mineral Engineering			
New qualification	√	Review of existing qualification					
SUB-FRAMEWORK	General Education		TVET		Higher Education	✓	
QUALIFICATION TYPE	Certificate		Diploma		Bachelor		
	Bachelor Honours	√	Master		Doctor		
CREDIT VALUE					644		

PURPOSE AND RATIONALE OF THE QUALIFICATION

Rationale

In 2011, when the qualification was developed, government was sponsoring students to study Mineral Process Engineering abroad. At the time consultations with the mining industry through the Botswana Chamber of Mines, indicated that there were deficiencies in the number of Mineral Processing Engineers. All stakeholders supported the development of this qualification (see Appendix – Minutes of the Ad Hoc Mining Industry Advisory Board).

The mining industry is cyclical and this has presented challenges on the mismatch between the supply and demand of Mineral Engineers. Tertiary institutions have to keep this cyclicality in mind when they plan for the supply of mineral engineering graduates. To respond to this challenge and in recognition of the importance that mining continues to play in Botswana's economy, the HRDC has established the Mining, Minerals, Energy and Water Resources Committee to, among others, provide advice on the supply and demand of graduates in this sector.

While diamond mining continues to be the anchor in Botswana's mining industry in terms of contribution to GDP and employment, the outlook for other mines, such as in base metals and coal, are very positive. For instance, the planned development of two new copper mines in the Kalahari Copper Belt in the Ghanzi and Maun areas and the likely re-opening of the BCL Group at its mines in Selebi Phikwe and near the village of Matsiloje provide a sound basis for the demand of Mineral Engineering graduates. Globally, demand for base metals such as copper is forecasted to experience high growth rates due to new uses in the Electric Vehicle market.

In a mine, there are specific functional divisions, some core while others are support, that play their part to produce a unit of saleable mineral product. The two core divisions are Mining and Ore Processing. The former is run by Mining Engineers while the latter is by Mineral Processing or Mineral Engineers. At a very basic level, Mining Engineers focus on delivering the ore to the ore treatment plants while the Mineral Engineers process the ore into products that can be sold into the international markets. The rationale of this qualification, therefore, is to expand the available qualification options to address the full

needs of the mining industry at the national, regional and international levels. The rationale for qualification includes the following:

- To provide students with highly specialized knowledge and skills in mineral processing and a sound basis for future growth and development by providing education in basic sciences, engineering sciences and in the field of humanities and social sciences.
- To offer courses that focus on providing graduates with highly specialized knowledge necessary to enter a variety of sectors of the mining industry.
- To provide graduates with highly specialized knowledge to find and evaluate the earth's mineral resources as well as to plan, develop and operate mineral processing operations in a safe and environmentally sensitive way; and
- To respond to the needs of the mining and mineral processing industry and Botswana Government through research and consultancy.

The qualification will not only produce creative, competent and motivated professional graduates for the mining industry but also graduates who are capable of independent, critical and innovative thinking as well as lifelong learning. It will contribute significantly to national strategic goals by among others:

- Fulfilling the needs of the Botswana mining industry for degree holders in Mineral Engineering.
- Contributing to the National Development Plan 11 objectives with respect to development of the mi industry, and
- Increased diversity of mining industry qualifications offered in Botswana.

Purpose

The purpose of the Bachelor of Engineering Honors (Mineral Engineering) qualification is to provide the specialized knowledge, skills and competence to:

i) Facilitate the progression of the graduate to become a Professional Mineral Engineer.

ii) Enable the graduate to apply scientific approaches in solving problems in the processing of mineral ores and concentrates.

iii) Develop the best technical solutions to treat a given ore.

iv) Design the mineral processing flow sheet and select and size the major pieces of plant equipment.

v) Monitor the technical performance of a mineral processing plant.

vi) Ensure efficient materials handling of mineral processing plant products including the disposal of waste products in a safe and environmentally compliant manner.

ENTRY REQUIREMENTS (including access and inclusion)

- Certificate IV (NCQF level 4) with a pass in Biology, Chemistry, Physics, Mathematics and English.
- RPL shall apply where candidates do not meet the minimum entry qualifications prescribed. RPL CAT will be assessed in accordance with institutional and national policies.

QUALIFICATION SPECIFICATION B	SECTION
GRADUATE PROFILE (LEARNING OUTCOMES)	**ASSESSMENT CRITERIA**
1. Demonstrate highly specialized knowledge and skills in the design processes of mineral processing systems	1.1 Awareness of the benefits of working with other professionals such as mining engineers and geologists in the geometallurgical process to obtain an early understanding of the type of ore and therefore the treatment possibilities for an ore. 1.2 Conduct research on possible treatment routes and the reagents to be tested. 1.3 Use appropriate equipment and tools in conducting bench scale tests to support the development of mineral treatment flowsheets. 1.4 Apply results of bench scale and pilot plant tests in the design of mineral processing plant flow sheets. 1.5 Analyze and compare the different treatment methods for a given ore from given test data or based on desk top studies. 1.6 Apply scientific and mineral engineering principles to the design, development and operation of mineral processing systems, taking into account best practice for risk management, occupational health and safety.
2. Apply mathematical, science and engineering knowledge in a mineral processing plant environment.	2.1 Apply the knowledge of comminution and liberation principles in developing techniques for solving engineering problems associated with mineral size reduction. 2.2 Apply the knowledge of froth flotation, flocculation, dense media separation, gravity concentration and X-ray sorting

	in developing techniques for solving engineering problems associated with mineral separation. 2.3 Apply the knowledge of coal preparation in solving engineering problems associated with coal treatment. 2.4 Apply knowledge of diamond processing and recovery technology used in Botswana mines. 2.5 Apply knowledge of sampling and results of bench scale and pilot plant test work in the design of mineral plant processes. 2.6 Apply knowledge of mineral concentration processes focusing on the selection and sizing of concentration equipment for various treatment processes. 2.7 Apply sound engineering approaches in the selection of major equipment for mineral processing plants with due regard to both capital and operational costs of these units. 2.8 Apply knowledge of fluid mechanics in the transport and handling of slurries in a mineral processing plant; tailings and wastewater disposal and long distance slurry transport.
3. Demonstrate highly specialized skills and knowledge of the scientific and technological aspects of mineral processing systems	3.1 Demonstrate highly specialized knowledge in mineral processing plant unit operations and their applicable technologies. 3.2 Analyze the impact of the various technologies such as flotation, gravity concentration and magnetic separation on the recovery of saleable products. 3.3 Demonstrate knowledge of mineral engineering technologies and best practice in the field as well as awareness of the current research and development work.
4. Demonstrate highly specialized skills and knowledge in the selection of major pieces of equipment for comminution circuits	4.1 Develop and analyze comminution circuits for a given crushing job. 4.2 Select the right primary crushers for a given crushing circuit. 4.3 Match the primary crusher with the appropriate secondary, tertiary and quaternary crushers in multi-stage crushing circuits. 4.4 Compare and match the suitability of crushing circuits to given ore types.
5. Demonstrate highly specialized skills and knowledge in the selection of major pieces of equipment for milling circuits	5.1 Apply power-based methods that rely on the bench scale test results of an ore's Bond's work index in the selection

	of mill sizes and mill motor sizes for the Rod, Ball, Semi and Fully Autogenous Grinding mills. 5.2 Compare and match the suitability of milling circuits to given ore types. 5.3 Design and select major pieces of equipment for a mineral treatment process. 5.4 Analyze material balances for circuits for instance to size the various pieces of equipment in a Dense Media Separation plant.
6. Demonstrate highly specialized skills and knowledge in the selection of major pieces of equipment for the separation or concentration circuits	6.1 Apply results from batch flotation tests to design and select the number of flotation cells for a given treatment capacity. 6.2 Apply the results from bench scale and pilot tests on solid liquid separation to design and select the size of thickeners for both the concentrate and the tailings. 6.3 Apply the knowledge of coal preparation in solving engineering problems associated with coal treatment.
7. Demonstrate highly specialized skills and knowledge in the extraction of metals from their ores and concentrates	7.1 Apply the knowledge of extractive metallurgy in solving metallurgical problems in the extraction of copper, nickel, cobalt. 7.2 Apply knowledge of gold ore processing and those of other precious group metals.
8. Demonstrate highly specialized skills and knowledge in the handling of materials within the plant and also the proximate environment	8.1 Analyze the mineral processing circuits, such as the grinding circuit, to determine the mass balance of materials to the key operational units such as the hydro cyclone and the ball mill. 8.2 Design and select pumps and pipes for pumping slurry between the ball mill and the hydro cyclone and the hydro cyclone to the flotation circuits. 8.3 Select the size of conveyor belts for use in the handling of materials within the plant. 8.4 Design systems for the disposal of wastewater and tailings from mineral processing plants. 8.5 Select the appropriate silos and hoppers for use in a mineral processing plant. 8.6 Select the appropriate units for drying concentrates.
9. Demonstrate specialized knowledge in accessing, evaluating, synthesizing and analyzing scientific information in Mineral Engineering	9.1 Identify, evaluate and synthesize multiple sources of knowledge in the areas of Mineral Engineering and apply these in the development of sustainable technical and

	economic solutions or improvements to existing processes. 9.2 Design and apply appropriate procedures for generating relevant information, which must be used with due regard to ethical and safety considerations. 9.3 Communicate effectively in ways appropriate to the Mineral Engineering discipline, audience and purpose.
10. Demonstrate specialized knowledge in generating scientific information in Mineral Engineering	10.1 Design, select, and apply appropriate procedures for generating or collecting relevant information in line with ethical and safety considerations. 10.2 Apply best practice procedures for conducting research within the discipline of Mineral Engineering. 10.3 Collect and record data accurately, truthfully and in appropriate formats in line with best practice in Mineral Engineering. 10.4 Analyze and evaluate data and scientific evidence from which valid arguments and conclusions are presented.
11. Demonstrate highly specialized skills in Mineral Engineering methods, skills and tools, including information and communication technology	11.1 Apply computer techniques to formulate and solve the practical problems in mineral processing such as mass and water balance in grinding circuits. 11.2 Apply discounted cash flow analysis methods, using MS Excel, to evaluate mineral projects and select from among mining investment project alternatives. 11.3 Apply knowledge for the control and management of a mineral treatment process. 11.4 Apply chemical, metallurgical and process engineering fundamentals to production processes. 11.5 Solve metallurgical problems by applying modified or additional unit processes. 11.6 Apply techno-economic analysis in the trade-off studies of production processes. 11.7 Plan the production, budgets, operational and management reporting. 11.8 Plan, develop and operate mineral treatment operations in a safe, environmentally and socially sustainable manner. 11.9 Apply simulation software for major process equipment such as crushers, grinding mills, cyclones. 11.10 Incorporate safety, occupational health and environmental considerations in designing mineral treatment processes.

12. Demonstrate knowledge of key transferable skills appropriate to Mineral Engineering practice.	12.1 Demonstrate sustainability skills in the design and management of mineral treatment plants and processes. 12.2 Demonstrate comprehensive research capability in designing mineral treatment plant processes as well as operational improvements to existing processes to improve mineral process efficiencies. 12.3 Demonstrate the ability to work in a project environment in teams tasked with development of new treatment processes, development of new treatment facilities, major treatment plant equipment replacement projects. 12.4 Apply creative skills in problem solving and design of mineral plant operational challenges. 12.5 Demonstrate the ability to critically review information gathering, synthesis of data, evaluation and management processes in specialized contexts in order to develop creative responses to problems and issues. 12.6 Demonstrate the ability to use a range of engineering process design and operational skills to identify, analyze and address complex or abstract problems drawing systematically on the body of knowledge and methods appropriate to Mineral Engineering practice.
13. Demonstrate knowledge of professional and technical communication skills in the workplace	13.1 Demonstrate the ability to effectively present and communicate academic, and professional ideas, visually and textually to a range of audiences, offering creative insights, rigorous interpretations and solutions to problems and issues appropriate to the context. 13.2 Use effective verbal communication skills when dealing with clients. 13.3 Demonstrate the ability to work with other professionals to ensure that mineral processing operations are carried out smoothly.
14. Apply the principles of economic decision methods as a way of identifying value adding options that may arise from innovations in Mineral Engineering	14.1 Demonstrate understanding of the Discounted Cash Flow analysis tool for investment analysis. 14.2 Apply scientific methods used in the management of small businesses.
15. Demonstrate ethical conduct and professionalism in Mineral Engineering practice.	15.1 Demonstrate ethical considerations when designing sustainable mineral treatment plant processes. 15.2 Demonstrate ethical considerations when carrying out design projects, dealing with providers of services such as those for bench and pilot scale testing, plant process equipment manufacturers, and managing mineral treatment plants.

	15.3 Identify and address ethical issues based on critical reflection on the suitability of different ethical value systems to specific contexts. 15.4 Take full responsibility for their work, decision-making and use of resources, and full accountability for their decisions and actions of others where appropriate.

QUALIFICATION STRUCTURE		**SECTION C**	
FUNDAMENTAL COMPONENT (Subjects / Units / Modules /Courses)	**Title**	**Level**	**Credits**
	Mathematics	5	32
	Physics	5	32
	General Chemistry	5	32
	Computing & Information Skills	6	20
	Communications & Study skills	6	24
	Analytical Chemistry	6	12
	Inorganic Chemistry	6	12
	Engineering Materials	6	12
	Statics	6	12
	DC Circuit Principles	6	12
	Engineering Drawing	6	12
	Strength of Materials	6	8
	AC Circuit Principles	6	8
	Dynamics	6	12
	Engineering Mathematics	6	24
CORE COMPONENT (Subjects / Units / Modules /Courses)	Introduction to Mining Engineering	6	12
	Introduction to Mine Safety & Health	6	12
	Industrial Training	6	16
	Basic Microeconomics	6	12
	Basic Macroeconomics	6	12
	Introduction to Mineral Processing	7	12
	Measurement and Instrumentation	7	12
	Mining and the Environment	7	12
	Fluid Mechanics and Hydraulics	7	12
	Physical Mineral Processes	8	12
	Flotation	8	12
	Extractive Metallurgy	8	12
	Coal Preparation	8	12
	Processing of Precious Metals	8	12
	Diamond Processing Technology	8	12
	Mining Industry Economics	8	12
	Mine Management	8	12
	Mineral Separation Processes	8	12
	Plant Process and Flow Sheet Design	8	12
	Project I	8	12
	Project II	8	12

	Mineral Processing Plant Project Development	8	12
	Processing Plant Equipment Selection	8	12
	Materials Handling and Transport	8	12
	Tailings and Wastewater Disposal	8	12
	Engineering Ethics and Professional Conduct	8	12
ELECTIVE COMPONENT Subjects / Units / Modules /Courses			
	Level 6		
	Environmental Science	6	12
	Foundation of Engineering Law	6	12
	Foundations of Business Law	6	12
	Psychology	6	12
	Level 7		
	Computer Aided Drafting	7	8
	Public Administration in Botswana	7	8
	CAD for Civil Engineers	7	8
	Environmental Engineering	7	8
	Engineering Geology	7	8
	Level 8		
	Industrial Relations	8	12
	Small Business Management	8	12

Rules of combinations, Credit distribution (where applicable):

Level 6
Students select three twelve credit electives
Level 7
Students select two eight credit electives
Level 8
Students select one twelve credit elective

NB: Student will select 2 out of 5 modules of 8 credits and 4 out of 6 modules at 12 credits for a total of 64 credits.

The Table below presents the credit distribution for the Bachelor's Degree in Mineral Engineering. The number of credits for this qualification is **644.**

Credit distribution

Level	**Credit Value**			
	Fundamental	**Core**	**Elective**	**Total**
5	96			96
6	168	64	36	268
7	0	48	16	64
8	0	204	12	216
Total	264	316	64	**644**

ASSESSMENT STRATEGIES, WEIGHTINGS AND MODERATION

Assessment Arrangements

There will be two types of assessments:

- Formative (Continuous Assessment) and
- Summative (Final Exam)

Weightings

In line with the Outcome Based Education principle, the Formative will be weighted more than the Summative assessments, and will be in the proportion, CA: 60% and Final Exam: 40%.

Assessments shall be carried out by BQA accredited Assessors.

Moderation

- There is a commitment to have all examinations moderated both internally and externally.
- This will be done in accordance with institutional policy and in line with national policy, and
- Moderators and assessors should be BQA accredited.

RECOGNITION OF PRIOR LEARNING (if applicable)

- RPL and CAT will be applicable for award of credits to contribute to the award of the qualification, and
  both will be done in line with institutional and national RPL and CAT policies.

PROGRESSION PATHWAYS (LEARNING AND EMPLOYMENT)

Horizontal Pathways for Learning

- Bachelor of Engineering Honors (Mining Engineering);
- Bachelor of Engineering Honors (Civil Engineering), or
- Bachelor of Engineering Honors (Geotechnical Engineering).

Vertical Pathways for Learning

- Master of Engineering, Mineral Engineering,
- Master of Science, Mineral Economics,
- Master of Engineering, Environmental Engineering, and
- Master of Science, Environmental Economics.

Employment Pathways

Mining industry

- Plant Metallurgist
- Plant Manager
- Processing Engineer
- Mine Manager
- General Mine Manager
- Mine Entrepreneur
- Mining Investment Analyst

QUALIFICATION AWARD AND CERTIFICATION

Qualification Award

The minimum requirements for the student to be awarded this qualification are as follows:

- the student should have accumulated a minimum of 644 credits, and
- students who have accumulated a minimum of 644 credits will be awarded the Bachelor of Engineering Honors in Mineral Engineering.

Certification

There is a commitment that upon meeting the minimum requirements for the qualification for the Bachelor of Engineering Honors in Mineral Engineering, the student will be issued with:

- a Certificate, and
- an Official Transcript.

There will be no provision for early exit.

REGIONAL AND INTERNATIONAL COMPARABILITY

The proposed qualification was compared with a total of four similar qualifications in the region and internationally being: University of Zambia, University of Johannesburg, Curtin University in Western Australia, and Murdoch University also in Australia.

Synopsis

The University of Johannesburg (South Africa) offers a four-year Bachelor of Engineering Technology (Extraction Metallurgy) programme with a total of 480 Credits at level 7 (SAQA). The exit outcomes are to systematically diagnose and solve metallurgical problems demonstrate knowledge and understanding of the impact of metallurgical activity on the society, and to design components, systems, works, products or processes. It covers Math & Science, Fundamental Engineering and Extractive Metallurgy and general education courses. It uses written tests and examinations, major term projects in the final years as assessment strategies.

The University of Zambia offers a 5-year Bachelor of Minerals Sciences programme in Mineral Processing and Extractive Metallurgy, but the total number of credits and national qualification level are not indicated. The structure is composed of Math & Sciences, Fundamental Engineering Courses, courses in mineral processing and extractive metallurgy, and general education courses. Assessment strategies include written tests and examinations as well as major term projects in the final year. Exit level outcomes are not indicated in the program.

Curtin University of Western Australia offers a 3-year B.Sc. Degree in Extractive Metallurgy with a total of 600 credits. The domains include the following: Math & Science; Fundamental Core Engineering and Extractive Metallurgy and general education courses. The exit outcomes are applying minerals and metallurgical scientific principles to metallurgical process operation, using and applying technologies, recognizing their advantages and limitations in minerals engineering and metallurgy. Assessment strategies include written tests and examinations and major term projects in the final year.

Murdoch University offers a 4-year BEng (Hons) in Chemical and Metallurgical Engineering Degree with 96 credits. The domains include Math & Science; Fundamental Core Engineering; Chemical & Mineral Processing, Design Project, Thesis (research project) and general education courses. Assessment strategies include written tests and examinations as well as major term projects in the final year. The exit level outcome is to apply minerals and metallurgical scientific principles to metallurgical process operation.

Similarities

• The structure of the 5-year degree programmes is similar with the first year providing the prerequisite Mathematics and Science for students to be admitted into the common year engineering or year 2, which is essentially the first year of the major engineering qualification. The common year focuses on Fundamental Engineering Courses and may include some include introductory courses in the disciplines. The penultimate and final years deal with detailed core discipline courses, which are the technology courses, as well as some design and application. In addition, apart from the 3-yr B.Sc. programme at Curtin, all programmes have some design or application aspect as well as a major design or research project in their final year.

- Post graduate learning pathways are largely similar.
- Employability pathways are largely similar.
- Assessment is generally formative, involving diagnostic in class tests and homework assignments. For examinable courses, there are final exams while for major research or design projects, reports are used as tools for assessments.

Differences

- Qualifications awarded vary. The University of Zambia awards Bachelor of Minerals Sciences, Curtin University-B.Sc. Extractive Metallurgy, Murdoch University- B.Eng. (Hons) Chemical & Metallurgical Engineering and University of Johannesburg- Bachelor of Engineering Technology (Extraction Metallurgy).
- The BEng Technology (NQF 7) from the University of Johannesburg produces Technologists as opposed to Engineers. These graduates would progress to Professional Engineering Technologists as opposed to Professional Engineer.
- The B.Sc. Extractive Metallurgy from Curtin is a 3-Yr degree and lacks design or application modules in the final year and therefore based on this, the professional path for the graduates may be that of Technologists.

Summary

The B.Eng. (Honors) Mineral Engineering Degree qualification offered by the University of Botswana is largely similar to the ones from Zambia (5 years) and Australia (4 years), where the structure emphasizes a solid background in Math & Science in the first year of study followed by a good grounding in Engineering Fundamentals in the common year. For the three-year programmes such as those at Curtin, the design and project aspects are missing. The exit level outcomes are similar as well as pathways for further study and career growth even though these may be different for the 3-Year qualification from Curtin. The B.Eng. Mineral Engineering qualification compares very favorably with others from around the continent and the world and, additionally, it is unique in offering a specialized major in Mineral Engineering, which presents advantages in relation to the exit level outcomes for the graduate and no doubt places them at an advantage in their career pathways.

REVIEW PERIOD

The qualification will be reviewed after 5 years.