CIM Estimation of Mineral Resources and Mineral Reserves Best Practice Guidelines

Prepared by the
CIM Mineral Resource and Mineral Reserve Committee
(Second Draft: May 2, 2019)

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Adopted by CIM Council on *month xx, 2019*

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1. INTRODUCTION

The Estimation of Mineral Resources and Mineral Reserves Best Practice Guidelines (MRMR Guidelines) were prepared by the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Mineral Resources and Mineral Reserves Committee (CIM MRMR Committee) to update an earlier version that was accepted by CIM Council on November 23, 2003 (CIM, 2003). These 2019 MRMR Best Practice Guidelines are not intended to be either prescriptive or exhaustive but rather are intended as minimum standards to assist professional geoscientists and engineers in preparing high quality estimates of Mineral Resources and/or Mineral Reserves that incorporate sound evaluation practices and mine design. They are based on long-established estimation and mine planning principles and are designed to provide general guidelines of best professional practices employed in the preparation of MRMR estimates.

Although the 2019 MRMR Best Practice Guidelines are intended for use by Canadian-based mining/exploration Practitioners, many of the concepts and practices presented herein are in general agreement with current industry practices in jurisdictions with membership in the Committee for Mineral Reserves International Reporting Standards (CRIRSCO).

These 2019 MRMR Best Practice Guidelines do not preclude individuals and companies from setting up their own additional guidelines designed to suit their specific needs. In all cases, these 2019 MRMR Best Practice Guidelines are to be regarded as minimum criteria to be considered by Canadian-based mining/exploration Practitioners when preparing Mineral Resource and Mineral Reserve estimates.

For this document, persons preparing estimates of Mineral Resources or Mineral Reserves are called Practitioners. Preparation of MRMR estimates should be carried out by Practitioners who either hold the status of Professional Geoscientist (or equivalent) or Professional Engineer (or equivalent), or who prepare the estimates under the supervision of a Professional Geoscientist (or equivalent) or Professional Engineer (or equivalent). For the purposes of this document, all references to reporting describe such necessary reports that are created as part of the normal-course work flow of preparing Mineral Resource or Mineral Reserve estimates. For clarity, all public disclosure of Mineral Resource or Mineral Reserve estimates made by or on behalf of an issuer and intended to be, or reasonably likely to be, made available to the public in a jurisdiction of Canada must comply with the requirements of National Instrument 43-101 Standards of Disclosure for Mineral Projects (NI 43-101). At least one Qualified Person (QP) must take responsibility for all parts of the estimation process when publicly disclosing the results of MRMR estimates.

The intended audience for these 2019 MRMR Guidelines includes Practitioners at all levels of skill and experience, government agencies, academic institutions, and the investing public.

2. HISTORY

On January 9, 2018 the CIM Council formed the CIM MRMR Committee, which is a combination of the previous Standing Committee on Reserve Definitions and the Best Practices Committee. Among others, the CIM MRMR Committee's mandate was to update the 2003 MRMR Best Practice Guidelines.

A sub-committee of the CIM MRMR Committee composed of Reno Pressacco, John Postle, Greg Gosson, and Tomasz Postolski was formed to assist in the preparation of these 2019 MRMR Best Practice Guidelines. The sub-committee wishes to express their appreciation and acknowledge the significant contributions from Lawrence Devon Smith, Grant Malensek, Keith Boyle, John Goode, Ian Ward, and Kathryn Wherry, and to extend their appreciation to the many individuals and organizations who provided useful comments. The new document was adopted by CIM Council on ________, 2019. NTD - Update date

3. GENERAL GUIDELINES – MINERAL DEPOSITS

This document deals primarily with the description of best practice guidelines as they apply to the preparation of MRMR estimates for metalliferous and other deposits. The CIM MRMR Committee recognizes that preparation of Mineral Resource or Mineral Reserve estimates for certain commodities, deposit types, and recovery practices require specialized estimation methodologies and considerations. Additional Best Practices Guidelines have been prepared for those commodities, deposit types, and recovery practices, and these are available on the CIM website at www.cim.org.

In planning, implementing, and directing any MRMR estimation work, the Practitioner(s) should ensure, to the extent practicable, that the estimates are prepared using sound evaluation practices, sound estimation and scientific principles, and according to good mining practices. They should also ensure that the provisions of the CIM Definition Standards on Mineral Resources and Mineral Reserves adopted by CIM Council, as amended ("CIM Definition Standards") and the CIM Mineral Exploration Best Practices Guidelines adopted by CIM Council as amended have been adhered to. These documents are updated on a periodic basis so Practitioner(s) should consult the CIM website at www.cim.org to ensure that they are viewing the current version.

In addition to assisting the Practitioner(s) in the preparation of MRMR estimates, these 2019 MRMR Guidelines are intended to promote a quality of work and a broad consistency of form and content that will increase public confidence in the validity of publicly disclosed estimates. Practitioners should ensure that all main assumptions, methods, and procedures which were used in preparation of MRMR estimates are disclosed using clear and concise language.

While Practitioners are encouraged to follow the concepts and principles presented within these 2019 MRMR Guidelines, it is certain that some deposit-specific situations will be encountered for which the Guidelines remain silent. In general, where guidance has not been provided for such situations, the Practitioner(s) should be guided by good scientific and engineering principles and conduct MRMR estimation in such a manner as to be able to support and defend their methodology to their peers.

4. THE MINERAL RESOURCE DATABASE

4.1. General Comments

This section considers important factors in the creation and maintenance of a Mineral Resource Database (Database) and other information (e.g. photographs, topographic surfaces, digital imagery, and excavation models) used to prepare Mineral Resource estimates. The Database is established by the collection, verification, recording, storing, and processing of the relevant primary geological and technical data that forms the critical foundation necessary for the estimation of Mineral Resources. The Database can include information collected from exploration stage properties, advanced properties, or from producing mines and hence can evolve over time.

The Database is a record of all the data collected throughout the work history of a mineral deposit and includes dates work was conducted, observations relating to the work, and reports inferences derived from the results obtained. The Database should contain all of the information available to support current geological interpretations and modeling and should be easily accessible.

The Database typically may include information for such items as geological data (e.g. lithology, mineralogy, mineralization style, alteration, structure, etc.), collar location/orientation, drill hole length, and down-hole deviation survey data, topographic data, geophysical data, geotechnical data, geochemical and geometallurgical data, sample type, assay data, quality assurance and quality control data, rock quality and bulk density information and activity dates. Additional information can be added to the Database to suit the circumstances of specific situations.

The Practitioner must evaluate the suitability of information in the Database for use in the preparation of Mineral Resource/Reserve estimates: this evaluation includes examining data-input protocols and validating the database content. The utilization of a Database Management Protocol is recommended for the collection and addition of new information. This protocol should be designed to validate, store, and secure all data that is used in the preparation of Mineral Resource estimates. Independent verification of data within the Database should be undertaken to assure the accuracy, completeness, and suitability of the information for Mineral Resource estimation.

A Database consists of two types of data, primary observed and measured data, and interpreted data. Primary data are features amenable to direct physical measurement. Common examples include geological attributes, assay results for various sample types, drill hole survey data, weathering state, core photography, etc. Primary data can also include excavation volumes, topography, and mine production and processing plant information.

Interpreted data are derivations or interpretations based on primary information. Examples are geological projections, correlation of mineralized intervals, depicted mineralization limits, and multiple estimation domains.

4.2. Data collection, recording, storing and processing

It is recommended that the Database be maintained in an electronically-stored digital format using a documented, standard format and a reliable medium that allows for secure storage, access, documentation of any changes made to entered data, and easy and complete future retrieval of the data.

All primary data collected must be recorded even if not used for MRMR estimate. Digital storage of data is encouraged in a standard format on a reliable medium. Guidance regarding standardization of digital data formats has been proposed by the Prospectors and Developers Association of Canada (2017). An additional example regarding standardization of digital data formats can be found in the guidelines put forward by the Australian Government Geoscience Information Committee (2017).

All sampling, sample preparation, analytical procedures, and methodologies must be described clearly and a discussion provided for the choice of particular methods used.

Drill hole, channel sample, or other sample data that have been acquired over multiple periods and by various workers should be verified and checked prior to entry into the Database. In addition, data records should possess unique identifiers (e.g. unique drill hole, zone and sample numbers, etc.). Distinctions should be made between samples collected by different methodologies (e.g. reverse circulation drill holes versus diamond drill holes, etc.) and an explanation should be provided on how these data sets are integrated.

The analytical method and sample preparation procedures can have a major effect on recorded values and these must be recorded. Original assay data should be recorded in the Database in the units of measure as received by the laboratory (e.g. large ppm values should not be reported as percentages). Analytical data should be converted into common units of measure, where possible. Original and converted values should be reported, including the conversion factor(s). Where multiple analytical data have been created from such activities as re-assaying of samples or by multiple analytical methods, a clear description must be provided of how the final analytical results used for preparation of Mineral Resource estimates were derived.

A series of Database management protocols that describe the standards, procedures, and security measures used to manage and update the database should be prepared and maintained on a regular basis. This protocol should be designed to validate, store, and secure not only analytical data, but all data as well as other technical and scientific information that is used in the preparation of Mineral Resource estimates. Duplicate, secure off-site storage of data is recommended, along with frequent backups. An archived copy of a Database, documentation, and all support data that was used to prepare a Mineral Resource estimate should be assembled and stored for reference and audit purposes.

4.3. Bulk Density Measurements

Method(s) used to determine bulk density values must be described in detail and must account for any void spaces or cavities that may be present so as to avoid over-estimation of tonnage. Density values determined for materials such as drill cuttings or for highly fractured materials must have their porosity satisfactorily taken into account. Useful guidance on sample collection and preparation for bulk density measurement is given in Lipton and Horton (2014).

Factors such as mineralogy, weathering, primary alteration and moisture content can be highly variable and have significant control on bulk density: such effects must be described by the Practitioner. For these materials, where Mineral Resource estimates are to be prepared on an in-situ, dry bulk tonnage basis, it is important to document the nature and spatial distribution of the moisture content.

For deposits characterized by highly variable density values, direct measurement of the sample density for each sample assayed is preferred.

In certain cases, the density of a sample can be estimated using a formula that relies on the chemistry or the mineralogy of the sample. The data and methods used to derive such formulae should be clearly documented. The accuracies of any formulae used to estimate the bulk densities should be examined by comparison of the estimated values with the actual measured values and included in the consideration of the resource confidence classification criteria.

For those materials where bulk density information is not available, estimates of the bulk density of the geological unit in question may be estimated by comparison with deposits of similar character. In these cases, the source of the density values used to prepare the Mineral Resource estimate should be clearly documented and included in the consideration of the resource confidence classification criteria.

Pre-existing density measurements must be validated. Validation procedures include duplicating measurements, use of alternative procedures, or use of materials of known density. Monitoring the collection of density values and the application of quality control procedures is recommended as new data are collected. Additional discussion regarding collection of density information is provided in the CIM Mineral Exploration Best Practices Guidelines and the references quoted therein.

In all cases, it is important to document all sample collection and measurement procedures. Review and reporting of the results for all major material types is important in understanding the distribution of the density values for the materials comprising a Mineral Resource estimate. In cases where the initial data are modified (such as to address outlier sample values), the Practitioner should provide a discussion supporting all such modifications.

4.4. Quality Assurance/Quality Control

Quality Assurance and Quality Control (QA/QC) information must be considered and evaluated for all data used for MRMR estimation. Historic data require validation. In general, a program of active data collection must have quality control measures integrated into the normal sampling-subsampling-analytical protocol. QA/QC protocols should include replicate analyses of appropriate standards and blanks and duplicate analyses of field samples, crushed sample material and pulps. Regular monitoring of assays by and independent laboratory is desirable. The results of the QA/QC program, a description of the pass/fail criteria, and the actions taken to address results that are outside of the pass/fail limits of the QA/QC program should be documented.

The QA/QC programs should be structured to include all the grade attributes reported in the Mineral Resource statement and should also include evaluation of any deleterious elements.

The results from the QA/QC program should be reviewed and evaluated upon receipt so that any errors and discrepancies can be addressed in a timely manner. Discussion regarding QA/QC practices and procedures have been presented in Long (1998), Abzalov (2011), and Roden and Smith (2014).

4.5. Data Adequacy

Geological and sample information of suitable quality and completeness remain the foundation of Mineral Resource estimates. A key step prior to the commencement of a Mineral Resource estimate is the assessment of data adequacy and its representativeness of the mineralization to be modeled. While the contents of the Database are frequently collected by a number of individuals over time other than the Practitioner, the Practitioner has the primary responsibility of judging whether the Database is suitable for use in the preparation of Mineral Resource estimates. If the sample population size, quality, and spatial distribution of data are inadequate to understand the variability and distribution of the economically significant minerals, the Practitioner should estimate how much additional data may be needed before a Mineral Resource estimate can be completed.

The Practitioner must be diligent in ensuring that the Database fairly represents the primary information. Data verification is an essential part of determining whether the resource database is suitable to support estimation of a Mineral Resource. Data integrity verification activities on such items as the accuracy of drill hole collars and sample locations, down-hole deviation, accuracy and internal consistency of lithological and alteration data, and the accuracy and precision of analytical information should form an integral component in the construction/review of a Database. The Practitioner should carry out his/her own data verification activities on the Database to search for (1) factual errors, (2) completeness of the lithological and assay data (e.g. intervals with no information), and (3) suitability of the primary data. As part of the Database verification activities, the Practitioner is encouraged to examine assay information and certificates which are under the signature of an authorized individual. It is considered best practice to examine analytical information obtained directly from the analytical laboratory whenever possible.

A key step before relying on the Database includes reviews and personal inspection by the Practitioner of any geological and sample information that is used in the preparation of a Mineral Resource estimate.

The Practitioner must ensure that the available information and sample density allow preparation of a reasonable estimate of the geometries, tonnage, and grade continuity of the mineralization in accordance with the level of confidence established by the Mineral Resource categories in the CIM Definition Standards.

5. GEOLOGICAL AND MINERALIZATION INTERPRETATIONS

5.1. Introduction

This section outlines the requirements for the interpretation of geological and mineralization data, the consideration of economic and mining criteria, and the linkage of that information to the grade distribution and volume component of the Mineral Resource estimate.

Interpretation of the deposit's geology, alteration, and structure, along with a clear understanding by the Practitioner of the types, distribution, character, and controls on the mineralization forms the fundamental basis of the Mineral Resource estimate. **Indeed, the preparation of an accurate interpretation is the single most important activity when preparing a Mineral Resource estimate.** An understanding of the mineralogy and mineral assemblages, textural/structural character, and their spatial variations can be helpful in preparing geological, interpretations. The data should be integrated into, and reconciled with, the geological interpretations as part of the estimation process. The interpretation should include the consideration and use of reasonable assumptions on the limits and geometry of the mineralization, mineralization controls, and internal un-mineralized or 'waste' areas (e.g. barren dikes, sills, etc.).

In general terms, all primary data should be recorded in their entirety, in original form. For those cases where, in the opinion of the Practitioner, the primary data are deemed not of adequate quality for use in Mineral Resource estimation, the Practitioner must clearly explain their exclusion. Every effort must be made to analyze the primary data in an unbiased, scientific fashion to develop a "Geological Concept" which forms the underlying premise upon which the geological and mineralization interpretations are developed. The Geological Concept should include consideration of the geological setting, analogous deposits, styles of mineralization, mineralogical characteristics, and genesis. The Geological Concept should also include a preliminary view of such operational-related items as potential mining and processing methods so as to develop a preliminary view of a conceptual operating scenario. Development of a conceptual operating scenario is also a necessary first step in Mineral Resource estimation. Clearly, this preliminary view is a forward-looking item that is formed by the Practitioners based on their judgement, experience and consultations with their colleagues.

An understanding of the possible mining methods, mineral deposit location, mineral processing methods and potential product quality is necessary to ensure that the resulting Mineral Resource estimate is consistent with the assumed physical and operational limits. For mineral properties that are currently in production, the selection of operational scenarios can be guided by the existing operations or can contemplate potential changes to the current operations.

For non-producing properties, the selection of conceptual operational scenarios, by necessity, requires assumptions consistent with the deposit type, location, and available operational procedures for comparable deposits. It is acknowledged that the conceptual view is often required to be established at an early stage using incomplete knowledge or limited testing results, and therefore requires application of judgement and experience of the Mineral Resource estimation team based upon all information available at the time. The Practitioner is encouraged to consult with colleagues in other disciplines for guidance and assistance in establishing an appropriate set of initial parameters for a conceptual operational scenario. As the preparation of a Mineral Resource estimate is often an iterative process, the Practitioner and colleagues may wish periodically to re-visit the assumptions and update the proposed inputs as more current and detailed information becomes available. Multiple Mineral Resource estimates can be prepared to reflect the impact of alternate conceptual operational scenarios. Geostatistical simulation methods can also be applied to quantify uncertainties.

Information used to prepare Mineral Resource estimates can include surface or underground geology at suitable scales (lithologies, mineralogical zones, structural data, alteration, etc.), topographical data, density information, a complete set of all available and verified sample results and surveyed locations of all sample sites (chips, drill samples, etc.), excavation models, weathering surfaces, and the like. This information is typically captured and stored in a Database as described above, or as a series of maps and sections in either digital or physical format, or in various digital formats.

Preparation of geological, alteration and structural models should be developed to scales that are consistent within the regional and local context of the mineral deposit. Accordingly, an understanding of the regional geology and property geology in relation to the style of mineralization under consideration are important parts of the geological database.

5.2. Primary Data Visualization

Data collection and display must support the geological interpretation of the various mineralization styles of a deposit as a prerequisite for the Mineral Resource estimation process.

It is essential that systematic recording of geological observations from field mapping, drill hole logging, and core photography be easily retrievable and stored in an organized manner.

The important primary data (e.g., lithologies, assays, etc.) should be identified and accurately presented in three dimensions.

Where local mine coordinates are used on geological maps and sections, a procedure for conversion to universal coordinates should be provided as appropriate. Maps and sections should include appropriate grid coordinates, elevation, scale, date, author(s), and appropriate directional information such as a north arrow or viewing direction.

Data positioning information should be relative to a common property co-ordinate system and should include the methodology and accuracy used to obtain that information. Accurate location of data points is essential, and proper survey procedures and control systems must be established to ensure a high degree of confidence. If data points are located in relation to a particular map or grid reference system, those reference data should be included as part of the Database, the map properly identified and the coordinate system clearly stated. The details of the projection system used should also be described.

If primary data have been modified or intentionally omitted from preparation of a Mineral Resource estimate, those data should be identified with an explanatory note for the modification or exclusion.

5.3. Geological Modelling

Understanding the relationship between the mineralization and the geological processes that govern its spatial distribution, geometry and paragenesis is a key concept in the preparation of a Mineral Resource estimate. A sound understanding of the applicable mineral deposit model(s) and a current understanding of the mineralization character of the deposit under consideration is a fundamental requirement of the Practitioner. This understanding can be greatly improved by input from individuals with direct personal knowledge of the deposit gained through either mapping or core logging programs for development-stage properties, or via detailed knowledge gained thorough grade control programs in operating mines. Personal inspection of the host geological units is also of great benefit to the Practitioner.

Preparation of digital three-dimensional lithological, alteration, and structural interpretations are often beneficial in aiding the Practitioner to understand the type, spatial location, distribution, and continuity of the mineralization under consideration. The geological limits within which the Mineral Resources are to be estimated must consider the three-dimensional distribution and continuity of the mineralization, along with any alteration, structural, or other relevant information. This information is typically viewed, interpreted, and depicted in plan, cross section, longitudinal sections, or in three-dimensional renderings. Digital models of the deposits' geological, alteration, weathering and structural features should honour the informing data as closely as practical. Viewing the resulting digital interpretations in at least two orthogonal directions is helpful to ensure that the digital interpretations are reasonable and internally consistent.

Where Mineral Resource estimates are carried out using non-digital methods, all geological information for a deposit should be transposed from plan onto sections (or vice versa) to assess reliability and continuity of the geology and mineralization interpretations using all available data (drill holes, mine workings, etc.). Two directions of vertical sections (usually orthogonal) and plans should be used to ensure that the manual interpretations are internally consistent.

The degree of weathering and other secondary alterations to which the mineralization has been subjected often has important implications across the entire scope of the project from the drill recoveries to the metallurgical characteristics of the mineralization. Consequently, the Practitioner should develop a clear understanding of how the nature and degree of weathering or alteration may influence not only the Mineral Resource estimates, but the other disciplines as well.

Digital models of the various types and intensities of weathering are often prepared as integral components of a Mineral Resource estimate. The selection of the criteria upon which these weathering models are to be prepared is best accomplished by consultation of the Practitioner with their colleagues in the other disciplines such as mining, metallurgy and environmental. In general, digital models of the weathering surfaces should honour the informing data as closely as practical.

5.4. Mineralization Modelling

Once the lithological model of the deposit has been established, three-dimensional models of the mineralization can be prepared. Attention to detail is vital for early recognition of important features that control the spatial distribution, variability and continuity of potentially economic mineralization. Personal inspection of the mineralization character by the Practitioner is a critical element in developing an understanding of the spatial distribution, variability, character and continuity of the mineralized zones.

Where Mineral Resource estimates are carried out in digital formats, all interpretations of mineralization information within the deposit should be examined and considered in three-dimensions to assess the continuity of the mineralization and reasonableness of the interpretations relative to available observation points such as drill holes, channel samples, or geological mapping information. Interpreted mineralization models should honour the primary data as closely as possible.

Different styles and geometries of a deposit under investigation should be identified and understood to allow the Practitioner to prepare acceptable three-dimensional models of the mineralized zones, correctly establish domains, and permit reasonable interpolation. Grade continuity can be variable from zone to zone and should be documented.

Mineralization styles may be defined or limited by some combination of features such as:

- structure,
- lithology,
- mineralogy,
- degree of weathering,
- oxidation,
- alteration,
- timing of mineralization,
- elevation of the deposit top or bottom,
- metallurgical characteristics, or
- other relevant factors.

These controls should be described and used to constrain the interpolation of grade or quality within the Mineral Resource model as appropriate. An assessment of alternate interpretations can be carried out to evaluate the risk on the tonnage of the different interpretations. When determining limits of mineralization, the Practitioner should recognize that mineral deposits can consist of more than one type of mineralization, be telescoped, consist of multiple mineralizing events, be controlled/influenced by different lithologies or structured, be overprinted by different mineralizing events, be affected by supergene processes, or be affected by weathering, all within a single deposit. The characteristics of each mineralization type may require adaptations of the modeling techniques and/or parameters to suit the specific segments of the mineralization.

When establishing criteria for interpretation of mineralized zones or domains the Practitioner should consider potential controlling factors such as:

- anticipated mining method and mining rate,
- anticipated economic limits of the extraction (such as a grade, grade equivalent or a value parameter) and processing scenario under consideration,
- spatial distribution and continuity of the mineralization,
- continuity and distribution of the grade of the mineralization,
- spatial density and distribution of the sample information
- pertinent geological features such as lithology and structure, and
- nature of the boundaries (e.g., sharp or gradational).

For clarity, the use of a grade equivalent or a value parameter should be for the sole purpose of preparing the outlines of potentially economic mineralization only. Subsequent estimations should be carried out for each grade element separately.

5.5. Estimation Domains

The identification of estimation domains is an important precursor to Mineral Resource estimation. The estimation domains are often based on a combination of geologic variables that have a relationship with the attribute being estimated. For example, the estimation domain can be defined by a combination of structural and oxidation controls on mineralization. The determination of estimation domains should be supported by a clear understanding of the controls on the mineralization, extensive statistical analysis (exploratory data analysis), and variography studies. The geometry of the estimation domains need to reflect the style of mineralization being modelled, and reflect the operational constrains associated with the conceptual operating scenario.

6. MINERAL RESOURCE ESTIMATION

6.1. Introduction

Estimation of Mineral Resources is best achieved by a multi-disciplinary effort that includes consideration of such topics as:

- land title issues,
- surveying,

- exploration techniques,
- geophysics,
- sampling theory,
- sample preparation equipment and methods,
- assaying equipment and methods,
- quality assurance and quality control,
- mineralogy,
- comminution characteristics and how they relate to geology,
- processing methods and how they relate to geology,
- acid rock drainage modeling of waste rock,
- hydrology,
- permafrost,
- effects of weathering,
- strip ratios,
- mining methods,
- selective mining unit sizes as they relate to geology,
- estimations of mine dilution and mine recovery,
- application of cut-off and recovery formulas, and
- geostatistical and geological knowledge.

A multi-disciplinary approach might involve geologists, metallurgists and mining engineers. For example, one person or team may be responsible for collecting the data, another person or team may be responsible for the metallurgical testing program, another person or team will deal with environmental issues, another person or team will deal with mine planning and scheduling, and another person or team may be responsible for preparing the Mineral Resource estimate. As a general principle, all parts of the Mineral Estimation process should be documented to a suitable degree to facilitate independent peer reviews and reproduction of the results to within reasonable limits.

This section provides guidelines with respect to data analysis, sample support, model setup, interpolation, and model validation. Critical elements to a Mineral Resource estimate are:

- consideration of the appropriate geological interpretation,
- assumed mining method and mining rate,
- assumed mineral processing method and recoveries, and
- the application of reasonably developed economic parameters based on generally accepted industry practice, experience, and understanding based on available testwork of product recoverability and value.

The iterative nature of Mineral Resource estimation permits the Practitioner and team to re-examine any initial assumptions in light of the results and update as deemed necessary. While innovation is acceptable in preparing Mineral Resource estimates, comparisons and validations with other established and tested methods are essential prior to publicly disclosing Mineral Resource estimates prepared using novel methods or approaches.

Preparation of transparent, concise, and comprehensive documentation of the various procedures used, assumptions made, and parameters selected are essential elements in preparation of a Mineral Resource estimate.

6.2. Exploratory Data Analysis

The Practitioner should use a comprehensive approach to, and appropriate methods of exploratory data analysis to understand the statistical and spatial character of variables on which the estimate depends, to detect possible errors, and recognize any information that is useful for deposit model validation.

Such data analysis includes interrelationships among variables of interest, recognition of systematic spatial variation of the variables (e.g. grade, thickness, density, etc.), definition of distinctive domains that must be evaluated independently for the estimate, and identification and understanding of outliers. In particular, it is necessary to understand the nature and magnitude of the "nugget effect" and its impact on estimation. This is often a major concern for precious metal deposits and may be important in other types of deposits. Important decisions resulting from data analysis should be documented.

The Practitioner is encouraged to examine whether un-sampled intervals, treatment of below detection limit and method over-limit values, evidence of multiple types of analytical methods, negative values, the presence of special characters (e.g. a "<" symbol), or other data artifacts and anomalies exist in the Database in order to appreciate their implications to resource estimation. Where modifications to raw assay values are required (e.g. ppm to grams per tonne, oz. per ton to grams per tonne, etc.), a clear description of the rationale and procedures must be documented. Preparation and maintenance of a list of the changes or modifications to the raw assay information is recommended as good practice.

Data analysis can include a range of univariate, bivariate, and/or multivariate statistical procedures applied to data for each mineralization (or waste) domain. Results should be summarized in part by tables and diagrams that supplement the text and will include such features as statistical summaries (mean, median, standard deviation, etc.), histograms, boxplots, probability plots, swath plots scatter plots, quantile-quantile plots, relative differences plots, contact plots, regression analysis and various multivariate procedures such as trend analysis, multiple regression (e.g. bulk density – metal relationships) and multiple variable plots (e.g. ternary diagrams).

In addition to basic statistical tools, examination of the raw assay data by visual methods is an essential component of data analysis and is often helpful in characterizing and understanding the spatial distributions of the various mineralized intervals. Visual methods can include traditional two-dimensional presentations in plan, cross section, or longitudinal views, or can be accomplished by three-dimensional means.

6.3. Outlier Values

Outliers, those values inconsistent with the majority of the data, must be recognized because significantly high grades or data values contribute significantly to nugget effect. Without careful consideration, the presence of outliers can lead to serious overestimation of global and local grades.

Recognition of the spatial extent of outlier values (grade continuity) must be investigated and a procedure devised for incorporating such data appropriately into an estimate. Procedures including domaining, grade capping (also known as top cutting), spatially restricting the influence of high-grade assays, single and multiple indicator kriging, and Monte Carlo simulation methods that consider mine production rates compensate to varying degrees for potential overestimation. Regardless of the methodology selected, the Practitioner must provide a discussion of the approach selected, along with justification and support for the decision possibly including reconciliation of estimated block model grades with available production information. Comparisons of the outcome of the different approaches can be useful.

The selection of the parameters for the treatment of outlier values is best carried out by reconciling the resulting estimated block model grades with production information. In the absence of production data, statistical methods may be used to guide the selection of an initial set of parameters.

6.4. Sample Support and Compositing

Sample or data supports (size, shape, and orientation of samples) must be considered. Data for the Mineral Resource estimate generally are obtained with a variety of supports and statistical parameters that can differ substantially. If composites are used as a basis for estimation, the data should be combined in a manner to produce composites of approximately uniform support prior to grade estimation.

Selection of a composite length should be appropriate for the data, deposit, and conceptual operational scenario (e.g. bench or half bench height, dominant assay interval length, vein thickness). Commonly, compositing of samples is specific to a geological or mineralization domain, and composite samples do not cross domain boundaries. The methods and procedures used to prepare composite samples should be clearly described.

Preparation of descriptive statistics of the composited sample values is useful for evaluating both the nature of the mineralization being modelled, for evaluating the accuracy of the compositing method by comparison with the descriptive statistics of the un-composited assay values, and for evaluating the global accuracy of the estimated grades of the Mineral Resources.

6.5. Bulk Density Estimation

Estimation of the bulk density is a critical component in the preparation of an accurate tonnage estimate of not only the mineralized volumes, but also for the adjoining non-mineralized or weakly mineralized material. Lithologies, weathering characteristics, alteration types and character, variations in ore mineral assemblages, and primary and secondary porosity all contribute to possible spatial variations in bulk density and require examination.

Bulk density can be integrated into mineral resource/mineral reserve estimates by use of average density values for a given geological or mineralization domain, estimation of bulk density values directly from sample data, and estimation of the bulk density values by means of a mathematical relation with other variables such as grade(s) or gangue mineralogy. In all cases the Practitioner should include a clear explanation of the procedures used and why they are appropriate.

6.6. Topography and Excavation Models

The effective date of digital models of topographic surfaces or excavation pits used for MRMR estimates should be clearly stated in the supporting documentation, along with a description of the methods used in their preparation. For advanced stage properties, digital models of the current topographic surface should be prepared to enable the proper coding of the grade block model.

For open pit mines, current digital models of the as-mined topographic surfaces should be prepared to enable the proper coding of the grade block model for that portion of the Mineral Resource that has already been exploited. In circumstances where material has been placed back into the open pit excavation, the Practitioner may deem it appropriate to include this information into the grade block model. The accurate determination of the bulk density of any pit back fill or sloughed material is an important component of this task.

For underground mines, current models of all excavation voids in digital format should be prepared for coding into the grade block models. Many tools and approaches are available to collect, process and prepare this information, and the Practitioner should be aware of the strengths and limitations of each so that the accuracy of the method can be considered. In certain circumstances, either the grade or the bulk density of any stope back fill or caved material is an important component of an estimate.

6.7. Trend Analysis

An understanding of the two-dimensional or three-dimensional distribution of metal grades or other parameters, or values throughout a mineral deposit can provide important information regarding metal zoning or spatial trends as well as aid in conducting autocorrleation studies. This understanding is facilitated by preparation of two-dimensional contour maps in either level or bench plan, longitudinal, or cross-sectional views using available analytical data contained within a selected mineralization or estimation domain. Preparation of fully rendered three-dimensional contours of the element contents is also useful, provided that sufficient care is exercised with the selection of the input parameters. A description of the methods and parameters used to prepare any trend analysis maps, including identification of software used, is essential. The results should be carefully reviewed to ensure that the results are a reasonable reflection of the informing data points.

Evaluations of the local-scale distribution of the thickness of the mineralized zones are also of benefit to the Practitioner and their colleagues in the other disciplines. For horizontal or shallowly dipping deposits, the thickness is typically measured in the vertical direction. For dipping deposits, the thickness of the mineralized zones is commonly measured either as the true thickness (e.g. approximately perpendicular to the dip of the mineralization), or as the horizontal or vertical thicknesses. The resulting trend analyses should clearly state the basis of the thickness being presented. Where thickness of a mineralized zone is the variable under consideration, the nature of the thickness variable should be clearly stated (e.g., vertical, horizontal or apparent thickness relative to a specified dip orientation).

Where evaluations of the grade times thickness product (commonly referred to as the GxT product) is examined it is important to verify that contoured GxT maps are a reasonable reflection of the thickness of the mineralization because high grades can introduce significant bias. When preparing grade-thickness maps using drill hole information, the Practitioner is strongly cautioned to carefully consider whether the core lengths are a reasonable reflection of the thickness of the mineralization prior to preparing any evaluations of the grade-thickness product, as a significant bias can result.

6.8. Autocorrelation Studies (Measures of Spatial Continuity)

In practice, both semivariograms (variograms) and correlograms are common autocorrelation functions used to quantify average grade continuity in 2D or 3D space; both autocorrelation functions are widely used in defining data selection criteria for block estimation and are essential to geostatistical estimation procedures. Spatial variability of grade can differ significantly among deposit types and within different zones of the same deposit. Autocorrelation modelling of this variability has become a standard step in Mineral Resource estimation which commonly is assisted by the preparation of contour maps for the element or value under consideration. The Practitioner must ensure that data abundance, appropriateness, and spatial distribution are adequate to produce acceptable experimental variograms/correlograms to which models can be fitted with confidence. These variograms/correlograms should be developed using data selected within carefully designed EDA envelopes. Parameters (e.g., nugget effect, ranges, anisotropy) of theses models are the basis of critical decisions in estimation procedure and must be consistent with established geological features. Behaviour of the autocorrelation function near the origin, which impacts block model selectivity analysis, should be fitted by an appropriate structure type. For properties with current or previous mining operations, the ranges of the variogram models should reflect the distribution of the metal under consideration at the stope scale.

Outlier grades are a complicating factor in establishing autocorrelation models to be considered by the Practitioner, as are variations of the informing data from a simple tabular arrangement.

In the cases where locally varying anisotropies are present (such as in folded stratigraphy or in areas of faulting), consideration can be given to a coordinate transformation to reconstitute the data and account for the spatial correlation on a pre-deformation or pre-faulting basis prior to variogram analysis.

The results of autocorrelation studies should be documented along with a description of all parameters of the model(s), and should specify the conventions used for the anisotropy rotation angles (e.g. left-hand or right-hand rotation around respective axes). Well-labelled diagrams are particularly useful in this regard. The commercial software version used should be specified. Where non-commercial software has been used, adequate descriptions must be provided.

Additional guidance on the preparation of variogram models can be found in Srivastava and Parker (1988), Isaaks and Srivastava (1989), Sinclair and Blackwell (2002) and Rossi and Deutsch (2014).

6.9. Mineral Resource Block Models

The modeling work flow (i.e. the series of procedures that are carried out for the development of a resource block model) adopted for the preparation of a resource block model should consider the distribution of the informing data, along with the size, distribution, and geometry of the mineralized zones, all of which must be compatible with the anticipated mining method(s) and related equipment. The modelling work flow will be influenced by the anticipated end use of the Mineral Resource estimate. Estimates of global mean grade and overall tonnage may suffice for early-stage projects but for advanced stage projects, or producing properties the objective may be to prepare a Mineral Resource estimate which will be suitable for short to medium range planning. The Practitioner must select appropriate estimation method(s) or techniques for the resource model. Estimation methods include polygonal, nearest neighbour, inverse distance to a power, various kriging approaches (e.g. ordinary kriging, simple kriging, and multiple indicator kriging) conditional simulations, and other non-linear estimation methods. The choice of method(s) should be based on the geology, the attribute/variable being modelled, quantity and spatial distribution of data, complexity of grade distribution within the deposit, presence of high-grade outliers, results of reconciliation studies, and the anticipated end use of the Mineral Resource block model.

The choice of estimation techniques to be employed are dependent to a degree on the size and geometry of the deposit and the quantity and spatial distribution of available data. Simple geometric methods may be acceptable in some cases (e.g. early stage deposit definition) or for some deposits (e.g. potash and coal deposits). Three-dimensional modeling techniques may be more appropriate for more spatially complex deposits. In some cases, different estimation techniques might be necessary for different parts of the deposit.

Block size is dependent on features including geometry of mineralization controls, mining method, drill hole and sample spatial distribution, and anticipated grade control method. A change in either cut-off grade or the mining method(s) can necessitate the development of new block models and perhaps require additional sampling. Block size should be justified and a summary of the block model size, origin and limits, model orientation, sub-blocking parameters, and list of attributes or variables modelled should be prepared. The possible loss of critical geological and assay details through smoothing inherent in the selection of estimation parameters should be considered. General validation of the block model against raw data, degree of "smoothing", and expected mining selectivity is required to ensure reasonableness of the interpolated results.

A clear description of the data conditioning procedures undertaken and the search strategies employed in preparing estimated attributes, including grades within the block model, are considered as best practice. The Practitioner should ensure that the selected estimation method is adequately documented and should not rely solely on the computer software to produce a comprehensive document or report 'trail' of the interpolation process.

6.10. Resource Block Model Validation

6.10.1. Validation of Global and Local Estimates and Model Selectivity

The Practitioner must ensure that the final resource block model is consistent with such primary data as the geology and mineralization wireframe models, structural models, topography and excavation surfaces and volumes, and the analytical data that were used to prepare estimates of the modelled attributes. The validation steps could include:

- comparison of volume estimates between the block model and the three-dimensional wireframe models,
- visual inspection of interpolated results on suitable plans and sections and comparison with the informing data,
- check for global bias (comparison of interpolated and nearest neighbour or declustered composite statistics), by estimation pass, by domain, or by resource category, etc.,
- check for local bias considering the supporting information (analysis of local trends in estimates using, for example swath plots),
- checks to ensure the boundary conditions between estimation domains are honoured, and
- a change of support check using such models as affine, indirect lognormal correction, and discrete Gaussian to introduce the desired resource model selectivity (degree of smoothing in the estimated model).

Manual validation of all or part of a digital grade block model may also be completed. Additional guidance in carrying out global and local estimation validation can be found in Isaaks and Srivastava (1989), Sinclair and Blackwell (2002), and Rossi and Deutsch (2014).

6.10.2. Reconciliation Studies

For Mineral Resource block models of deposits that have had mine production or are currently being mined, the validation should include a reconciliation of production against the Mineral Resource model, to the extent that reconciliation data are available and are in a format suitable for comparison purposes. These reconciliation studies are useful in evaluating both the long-term and short-term accuracy of the data collection, sample collection, preparation and analysis procedures, and modelling procedures and parameters used to prepare a Mineral Resource block model. A number of methods and techniques exist for reconciling mine and process production information with a Mineral Resource model. Descriptions of these methods have been presented by Morley (2014) and Hargreaves and Morley (2014). While selection of appropriate reconciliation methods resides with the Practitioner, the method or methods used should be described in detail, along with the results. Two principle types of reconciliation studies may carried out in the validation of a Mineral Resource block model.

6.10.2.1. Long Term Model vs. Short Term Model

The goal of the first type of block model reconciliation study is to compare the performance of block models prepared using only results from exploration drill hole data (LT models) with the performance of block models prepared using all information, including all results collected from grade control programs (ST models). The information used to prepare ST models typically includes information collected from chip/channel samples, blast hole samples, or detailed grade control drilling programs in addition to the results from exploration programs.

The purpose of this type of reconciliation study is to examine the LT model for its accuracy in predicting the tonnage, grade, and metal content of the mineralized material at various time scales. A discussion of the procedures followed for this type of reconciliation study is provided in Parker (2014). This type of reconciliation provides information regarding the adequacy of the exploration drill hole spacing and the modelling parameters and procedures.

In all cases, the key consideration is to ensure that the mineralized material being evaluated is comparable between the two models. Location of the mineralized material in the LT model commonly differs in its location when compared to the ST model due to the increased density of sample information that was not available for LT models. Consequently, the Practitioner must take care to consider this potential difference when conducting these reconciliation studies.

A LT model vs. ST model reconciliation study can be carried out at various time scales ranging from monthly to the total production of the mine from inception. The results of the reconciliation study can be presented in either tabular or graphical formats for the time period under consideration. Inclusion of a variance analysis is commonly presented in graphical displays of reconciliation, and to establish thresholds for acceptable levels of variance.

6.10.2.2. Long Term Model vs. Plant Production Data

A typical approach in these cases is to compare the performance of the LT models against information obtained from the process plant. The purpose of these studies is to examine the accuracy and effectiveness of the sample collection procedures, sample reduction and analytical protocols, and Mineral Resource estimation procedures and parameters. A discussion of the procedures followed for this type of reconciliation study is provided in Parker (2014). It is important to understand that several key items must be considered in these situations before any studies can be carried out.

The first item to consider is that the material excavated from the block model is not necessarily the source of the process plant feed in the time period studied, since many mining operations employ stockpile strategies. In these situations, a clear understanding of the flow of materials is important to preparing a meaningful reconciliation study. Preparation of a material flow diagram is often of great assistance.

A second item to consider is the fact that the Mineral Resource model presents the estimated tonnage and grade of the mineralized material on an in-situ basis, with no allowances for dilution or mining losses. The material received by the processing plant on the other hand includes diluting materials and the mining losses. Care must be taken to ensure that any tonnage and grade reports prepared from the Mineral Resource block model for reconciliation purposes have adequately accounted for any diluting materials and mining losses to the extent possible.

It is also important to ensure that the information obtained from the block model be compared to the plant feed data rather than the plant production data.

The preparation of a LT model vs. process plant reconciliation study can be carried out at different time scales ranging from monthly to the total production of the mine from inception. The results of the reconciliation study can be presented in either tabular or graphical formats for the time periods under consideration. Inclusion of a variance analysis is commonly presented in graphical displays of reconciliation, whereby thresholds for acceptable levels of variance are established.

6.11. Mineral Resource Categorization

Mineral Resources are categorized into three confidence categories, Measured, Indicated and Inferred. These terms are defined under the CIM Definition Standards. Since each Mineral Resource estimate contains its own unique set of conditions, the selection of the criteria by which the mineralized material is assigned to each category relies on the judgement and experience of the Practitioner. In selecting these criteria, the Practitioner must have a clear understanding of the practical limitations of the conceptual operating scenario and ensure that the minimum requirements presented in the CIM Definition Standards are satisfied. The choices should consider uncertainty and risk existing in the mineral resource estimate.

With many computer-based estimation methods, the criteria used for separating the mineralized material into the various Mineral Resource confidence categories relies solely on numeric-based parameters that are included into the individual blocks along with the estimated grade or value. Examples of such numeric-based parameters include:

- The number of data points used for estimating the grade or value of a given block,

- The number of drill holes or drill hole composites used,
- The estimation pass (and underlying assumptions) used to estimate a given block,
- The kriging variance of the estimate,
- The slope of regression of the "true" block grade on the "estimated" block grade (Vann, Jackson, and Bertoli, 2003),
- The relative distance from a data point based on the range of the selected variogram model,
- The assessment of relative confidence in grade / tonnage estimation, i.e. geostatistical drill hole spacing studies (Verly, Postolski, and Parker, 2014), and

While the advantages of this numeric-based approach can be rapid implementation and reproducibility, the approach often results in a solution that, while being mathematically correct, offers little resemblance to what may be practically achieved during a mining operation. Examples of typical outcomes were presented in Stephenson and Stoker (1999) and Stephenson, et. al. (2006) who coined the phrase "spotted dog" to describe this phenomenon. Mineral Resource statements produced from stand alone, numeric-based classification criteria may not provide a reasonable reflection of what may be eventually economically extracted. Furthermore, the phenomenon may generate difficulties when preparing Mineral Reserve estimates.

The use of numeric-based criteria should be viewed merely as the first step in the Mineral Resource confidence categorization process. Practical solutions currently in common usage to remedy the "spotted dog" effect include preparation of resource categorization wireframes which are then used to modify and refine the initial numeric-based categorization. While this approach is an effective method that allows the Practitioner to exercise judgement in situations where only a limited number of cases must be addressed, the method is not of practical use when large number of cases must be evaluated. In these situations, the use of computer scripts, known as "categorization smoothers" designed to reduce the impact of the "spotted dog" phenomenon may be considered.

In addition to numeric-based parameters, it is important to consider the relative confidence of all of the data inputs during the assignment of the resource classification. Additional criteria can include:

- The age of the drilling data,
- Reliability or certainty of the geological model and assay data,
- reliability of inputs to assess reasonable prospects of eventual economic extraction and cut-offs (e.g. metallurgical testwork, geotechnical data, ability to obtain permits, social acceptability, etc.), or
- legal and land tenure considerations.

Regardless of which criteria or methods are used, they should be documented in sufficient detail so that the results are reproducible by others.

Classification of material into either the Measured, Indicated, or Inferred categories need not apply solely to material within mineralization wireframe outlines. Depending upon the end use of a Mineral Resource model, classification of materials beyond the mineralization wireframe boundaries (e.g. for the diluting materials) may also be required.

In addition, for those Mineral Resource models which will be used in preparation of Mineral Reserve estimates, Practitioners are encouraged to work in collaboration with their colleagues who will be preparing the Mineral Reserve estimates so as to select modelling software packages and estimation parameters that are compatible for each groups' requirements. Practitioner(s) are encouraged to select Mineral Resource categorization parameters so as to conform to the practical limitations of the potential mining methods (e.g. matching up Mineral Resources category boundaries to mining levels, stope edges, or zone boundaries, where reasonable to do so) to the extent possible.

6.12. Mineral Resource Statements

By definition, a Mineral Resource must have "reasonable prospects for eventual economic extraction". Regardless of the specific approach used or the procedures followed, the Practitioner(s) must ensure that all Mineral Resource statements satisfy the "reasonable prospects for eventual economic extraction" requirement.

Factors significant to technical feasibility and economic viability must be considered and clearly stated when preparing Mineral Resource statements. These will include such items as:

- the size and legal conditions of the land tenure are sufficient to fully enclose the Mineral Resource,
- the extraction selectivity for the mining methods under consideration relative to the size and geometries of the mineralization interpretations,
- the processing method under consideration, the expected recovery from the mined material to a commercially marketable product,
- the price and value of the product, and
- the factors significant to cut-off grades or values (e.g. process recovery, smelter payability, treatment charges, operating costs, and the like) used for reporting of Mineral Resource estimates.

For a Mineral Resource, factors significant to technical feasibility and economic viability should be current, reasonably developed, and based on generally accepted industry practice and experience. Assumptions should have a reasonable basis and be clearly defined, and should reflect the level of information, knowledge and stage of the mineral deposit at the time.

Tonnage and grade figures should be quoted only to the level of accuracy of the estimate. This can be accomplished by rounding off to an appropriate number of significant figures. There will be occasions, however, where rounding to one significant figure may be necessary in order to convey properly the uncertainties in estimation. This would usually be the case with Inferred Mineral Resources.

6.12.1. Economic Parameters

Cut-offs used for preparing Mineral Resource estimates are largely determined by consideration of:

- reasonable long-term commodity price(s),
- exchange rate(s),
- mineral process recovery, and
- operating costs relating to mining, processing, general and administration, and smelter terms, among others.

Additional considerations include:

- the location,
- deposit scale,
- geologic and grade continuity,
- assumed mining method,
- concentrate quality (where applicable), and
- metallurgical processes.

All assumptions and sensitivities must be clearly identified. Additional guidance on selection of appropriate commodity prices for use in cut-off determinations is provided in CIM (2015).

Variations within the Mineral Resource model such as rock characteristics, metallurgy, mining methods, processing methods etc. may necessitate more than one cut-off or economic limit in different parts of the deposit model. All of the factors and assumptions for each cut-off or economic limit must be clearly stated when preparing Mineral Resource statements.

6.12.2. Constraining Surfaces and Volumes

For those Mineral Resources that are amenable to open pit mining methods, the “reasonable prospects for eventual economic extraction” should consider not only an economic limit (such as the cut-off grade or value), but technical requirements as well (such as the wall slope angles). As a minimum, these constraints can be addressed by creation of constraining surfaces (pit shells) using either commercial software packages or manual methods. These constraining surfaces can then be used in conjunction with other criteria for the preparation of Mineral Resource statements.

For properties with currently producing operations, the derivation of the input parameters for creation of the constraining surfaces can be determined using factual data from the current operations. For properties that are in the discovery or study stage, the input parameters are best determined from first principles. All input parameters used to prepare constraining surfaces used in the preparation of Mineral Resource statements should be fully documented.

For those Mineral Resource statements which are predicated on the assumption of underground mining methods, the Practitioner is strongly cautioned to carefully review the results of all Mineral Resource statements that are prepared by application of an economic limit (such as a cut-off value) only, as reliance on an economic limit alone may produce undesired results due to a selective reporting bias. Practitioners are reminded that Mineral Resource statements for underground mining scenarios must demonstrate spatial continuity of the mineralization within a potentially mineable shape. In the cases where mineralization is present that has a grade or value below the stated cut-off grade or value and is located within the potentially mineable shape, this material must be included in the Mineral Resource statement. As a minimum, these constraints can be addressed by creation of constraining volumes using either software packages or using manual methods. These constraining volumes can then be used in conjunction with other criteria for the preparation of Mineral Resource statements. For properties with currently producing operations, the derivation of the input parameters for creation of the constraining volumes can be determined using factual data from the current operations. For properties that are in the discovery or study stage, the input parameters are best determined from first principles. All input parameters, methods, and techniques used to prepare constraining volumes used in the preparation of Mineral Resource statements should be fully documented.

In many cases where the Mineral Resource estimate is prepared by digital methods, isolated and discontinuous blocks may be present that have grades or values above the stated cut-off. For both open pit and underground mining methods, these blocks should be excluded from the Mineral Resource statement if their spatial continuity or their size is insufficient to achieve a potentially mineable shape above the nominated cut-off grade or value.

Preparation of images of the categorized Mineral Resources are effective tools to assist Practitioners to ensure the spatial continuity requirements of a Mineral Resource are met. For steeply dipping tabular deposits, these images are most effective when presented as longitudinal views. Plan views or cross-sectional views are also effective in other geological settings. Practitioners are encouraged to include images that display the spatial continuity of the Mineral Resources to accompany the Mineral Resource statements. As a minimum, the images should include a display of all blocks comprising the Mineral Resource estimates, including confidence categories, along with drill-hole projections, and any other relevant information used to prepare the Mineral Resource statements. As a minimum, all images should contain suitable legends, scale bars, and annotations disclosing the viewing directions.

6.13. Mineral Resource Peer Reviews

Best practice includes the use of internal or, if required, external peer reviews of the Mineral Resource estimate prior to release of the Mineral Resource statement to the public domain. Considerations should include:

- Suitability of the drill hole and sample database,
- Appropriateness of analytical methods and sample representativity,
- Appropriateness of the geological domains, mineralization wireframes, and estimation domains,
- Appropriateness of the volume/tonnage of the mineralized zones
- Treatment of outlier assay values,
- Sufficiency and reliability of inputs, and underlying assumptions,
- Estimation methodology,
- Resource model validation and selectivity,
- Mineral Resource categorization criteria,
- Mineral Resource reporting criteria, and
- Mineral Resource reports.

6.14. Mineral Resource Risk Assessment

While the categorization of the Mineral Resources into the Measured, Indicated, or Inferred categories allows the Practitioner(s) to identify technical risk in broad terms, best practice includes the establishment of a methodology to identify and rank risks associated with each input of the Mineral Resource estimate. A common approach is a quantitative measure of uncertainty related to a production volume over a given time period, accompanied by a probabilistic confidence statement. This will assist the Practitioner(s) in establishing the Mineral Resource confidence category criteria, thus providing an understanding of the various technical risks associated with the Mineral Resource estimate. Information regarding common approaches is provided in Verly, Postolski, and Parker (2014) as well as Murphy et. al. (2004). The methodology applied, ranking and analysis should be well documented.

7. MINERAL RESERVE ESTIMATION

7.1. Introduction

Estimation of Mineral Reserves should be a team effort involving a number of technical disciplines with geologists, mining engineers, metallurgists, and specialists dealing with commodity pricing and marketing, environment, social, pricing/marketing, permitting, and economic modelling all having roles. This section considers important factors in preparing a Mineral Reserve estimate and documenting the estimation process.

Mineral Reserves are estimates of the tonnage and grade or quality of material contained in a Mineral Resource that can be economically mined and processed. To be considered a Mineral Reserve, modifying factors must be applied to the Mineral Resource estimate as part of the preparation of a prefeasibility study or a feasibility study as outlined in the CIM Definition Standards. The estimated amount of saleble material contained in the final product must demonstrate a positive Net Present Value (NPV) using an appropriate discount rate, and must demonstrate that eventual extraction could be reasonably justified. The major categories of modifying factors include:

1. Mining
2. Processing
3. Metallurgical
4. Geotechnical/Hydrogeological
5. Environmental
6. Location and Infrastructure
7. Market Factors
8. Legal (including land tenure and third-party ownership)
9. Economic
10. Social, and
11. Governmental

A Mineral Resource estimate and a mine plan based on open pit and/or underground mine designs, and production schedules to at least a prefeasibility level are required elements for a Mineral Reserve. A processing option for the production of a saleable product is also required along with product recovery estimate(s) and capital and operating costs to mine and process the mineral of interest and deliver the product to market. Because a Mineral Reserve estimate often requires a collaborative effort by numerous professional disciplines, the Practitioner(s) responsible for producing the Mineral

Reserve estimate must understand the significance of each discipline's contribution towards assessing the technical feasibility and economic viability of the project.

The test of economic viability should be well documented as part of the Mineral Reserve estimation process. The demonstration of economic viability requires estimation of annual cash flows and the project's NPV and inclusion of all the parameters that have an economic effect on the project. As a minimum, the NPV must be positive using a reasonable discount rate appropriate for all project risks, in order for the grade and tonnage to qualify as a Mineral Reserve.

The Mineral Reserves are estimated from the Measured and Indicated portions of the Mineral Resource estimate. Inferred Mineral Resources must not be converted to Mineral Reserves.

Practitioner(s) should document all aspects of the estimated Mineral Reserves to ensure that no significant factor is omitted. Pre-planning is important to identify the factors affecting the Mineral Reserve estimate. For a Mineral Reserve estimate, checklists can be used to ensure that all relevant aspects have been considered.

7.2. Cut-off Grades or Values

The concept of a cut-off grade or value is a key, fundamental component in the preparation of Mineral Reserve estimates, mine designs, and mine production schedules. The cut-off(s) applied should be clearly stated, unambiguous and easily understood. Sample calculations should accompany these cut-offs. Complex deposits may require more comprehensive procedures to determine economic cut-offs and to define the Mineral Reserves. The procedures used to establish the cut-off strategies should be well documented, easily available for review, and clearly stated in reporting statements.

A cut-off is defined as the grade or value that is used to differentiate between ore and waste for a given set of conditions, parameters and time frame. As such, the criteria and processes by which a cut-off grade or value are determined will often be different between mineral properties, for different situations within a given mining operation, and at different times.

A large variety of cut-off grade definitions and cut-off grade strategies are employed in the mining industry. The concepts and strategies involved with establishing cut-offs have been discussed in Lane (1988), Rendu (2008), and Hall (2014). Given the large number of conditions and situations in which a cut-off is applied, clarity is of the greatest importance when defining, describing, and stating a cut-off.

7.2.1. Cut-off Definitions

While a detailed review of each of the definitions of cut-off grades and cut-off grade strategies is beyond the scope of these MRMR Guidelines, some of the more commonly used terms and definitions include:

Break-Even Cut-off: The lowest grade or value of material that can be mined and processed at an operating profit, considering all applicable costs. It is used as a first estimate in the early mine planning phases of a project. The break-even cut-off assumes that the material does not have to be mined to access other above cut-off material and classifies this material as ore or waste.

Mine Design Cut-off: Also referred to as the planning cut-off, this is used to prepare initial mine designs. The input parameters are selected to reflect the average Life-of-Mine values or parameters. These are typically calculated on a breakeven cut-off basis for underground mines. For open pit mines, these are typically calculated on an open pit discard cut-off basis, but a breakeven cut-off basis can also be applied. For development stage properties (properties for which Mineral Reserves are being estimated as part of a Prefeasibility or a Feasibility study), estimation of the input parameters will be based on an envisioned operating scenario. For producing properties (active mines), the input parameters can be based on the current operating parameters, or they can consider the technical and economic parameters for any expansion projects.

Mineral Reserve Reporting Cut-off: Used to prepare the Life-of-Mine schedule and reports of the Mineral Reserves. The technical and economic parameters can be identical to those used to derive the mine design cut-off, or can be more conservative.

Optimal Mineral Reserve Cut-off: Used to identify the maximum value from an initial Mineral Reserve statement and Life-of-Mine plan. The optimal Mineral Reserve cut-off reflects the corporate strategy which can include such goals as:

- maximization of a project's NPV or achieving a target economic goal,
- maximization of a project's mine life,
- controlling the metal or value production through a project's mine life,
- controlling the distribution of a project's cash flow through time, or
- maximization of contained metal or value in the Mineral Reserve category.

Open Pit Discard Cut-off: The lowest grade or value of material in an open pit mine at which all costs, excluding mining costs, are equal to the revenue received. The open pit discard cut-off grade assumes that the material must be excavated, as it is contained within either the pit shell or designed pit outline.

Operational/Marginal Cut-off: Used on a short-term basis in both open pit and underground mines to consider the technical and economic conditions at the time of excavation. The operational cut-offs can vary from those used to prepare the Life-of-Mine plans or the Mineral Reserve statements. The basis for these cut-offs can consider current metal prices, sunk costs, appropriate variable costs, material destinations, and equipment capacities. These cut-offs apply only to material which must be excavated due to the normal course workflow of the mining operation.

Open Pit Stockpile Cut-off: The lowest grade or value in an open pit mine below which the material is destined to be placed in a temporary location for potential treatment at a later date or using an alternative process. The open pit stockpile cut-off assumes that the material must be mined either within a Life-of-Mine open pit design or at the operational stage. The basis for establishing this cut-off can include either economic criteria or strategic objectives and should include estimated re-handling costs.

Underground Internal/Incremental Cut-Off: The lowest grade or value of material in an underground mine at which all costs, excluding mining costs, are equal to the revenue received. The underground internal cut-off assumes that the material forms part of the Life-of-Mine design, must be excavated, and must be transported to the surface. The final destination of this material can be either the processing plant, or a stockpile. The underground internal/incremental cut-off can be applied either at the planning stage, or at the operational stage.

7.2.2. Cut-off Inputs

The types of input costs will depend on the mining methods and processing methods selected. A summary of operating cost types generally used in cut-off calculations for open pit and underground mines is presented in Table 7-1. These operating costs are commonly expressed on a per-tonne of processed material basis. It is important to note that these operating cost inputs represent those items that are commonly encountered in open pit and underground mines and are presented as guides. Additional inputs are possible depending on the specific circumstances of the operations under consideration.

It is important to note that these cost types are general descriptions of the common work types encountered in mining operations, since a detailed listing of the specific work types for all mining situations is beyond the scope of these Guidelines.

The metal price assumptions, along with foreign exchange rates and inflation factors are some of the critical input parameters for determination of the various cut-off grades described above. Guidance regarding the selection of metal prices for use in the preparation of Mineral Reserve estimates has been presented in CIM (2015). Additional inputs include metallurgical recoveries and the relationship between recovery and head grades.

Table 7-1 Summary of Typical Cut-off Operating Cost Inputs

Cost Centre	Work Type
Underground Mines:	Payroll costs including burdens Stope Costs (drilling, blasting, mucking, and ground support) Haulage Transportation and Hoisting Pumping, Electrical & Ventilation Backfill Waste and Ore Development Planning, Grade control, Supervision, and Technical

	Equipment and Infrastructure Maintenance Sampling and Assaying
Open Pit Mines:	Payroll costs including burdens Drill and Blast Costs Loading Costs Haulage Costs Dewatering Costs Planning, Grade Control, Supervision, and Technical Equipment and Infrastructure Maintenance Sampling and Assaying
Processing:	Payroll costs including burdens Plant Maintenance, including contracted services Crushing and Grinding Mineral Recovery Process Consumables, fuel, and power Costs Product Dewatering, Handling and Shipping Tailings Storage and Monitoring Costs Sample and Analytical Laboratory Costs Effect of grade on product recovery and processing cost
General and Administration:	Site G&A Business unit G&A, as applicable Other cash costs
Royalties:	Government mandated Surface and mineral title holders Contractual

7.2.3. Net Smelter Return and Metal Equivalents

In many types of deposits, the value of a given tonne of mineralized material results from the extraction and sale of more than one metal (e.g. copper and gold). Two principle methods are in wide application in the mining industry to address the polymetallic nature of such deposits. These include the use of a metal equivalent or the calculation of the Net Smelter Return (NSR). For the NSR method, the dollar value that each metal contributes towards the total value is calculated and is expressed as one value referred to as the NSR value. The calculation of an NSR value considers revenues, recoveries, treatment charges, penalties and transportation costs for all metals of potential economic interest. This NSR value can then be used to derive a cut-off value, where the NSR cut-off value is then the dollar value of a given sample or block that equals the total operating costs, as appropriate.

It is important to note that the calculations of NSR values will vary substantially depending on such inputs as the commodity type, treatment and refining methods and rates, penalty terms, contract terms, transportation details, and the like. A sample calculation of an NSR is provided in Goldie and Treger (1991).

In some cases where there are multiple elements in the deposit that contribute to the deposit value, a one commodity equivalent calculation is sometimes used as the cut-off. In this approach, all the grades for the various commodities are converted to an equivalent metal grade by consideration of the metal prices and recoveries. The calculation of equivalent grade is based on a formula developed by the Practitioner(s). This formula, and the parameters used for its development must be clearly stated. The metal equivalent grades are then used as the cut-off to estimate the Mineral Reserves.

7.3. Mining Methods

The location, shape, and physical properties of a mineral deposit generally determine the selection of the appropriate mining method. In general terms, deposits located on or close to the surface are usually considered as candidates for use of open pit mining methods. Deposits located deeper below the earth's surface are generally considered for application of underground mining methods. At an early stage of the Mineral Reserve estimation process, various mining methods should be considered for mining the deposit. The advice of rock mechanics specialists should be considered when selecting an appropriate mining method. In many deposits more than one mining approach may be taken, often with open pit methods used initially with underground methods used for the deeper portions of a deposit. Indeed, several different mining methods can be utilized in an underground mine to accommodate variations in the character of the mineralization.

In the case of an extension to an existing mining and processing operation, operating cost and production data are readily available to assist in selection of parameters for the preparation of a Mineral Reserve estimate. Some changes to operating cost estimates may be required if the mining or processing operation is to be modified or throughput changed. Capital costs for any changes will have to be built into the profitability analysis. For new deposits, the capital and operating costs are usually estimated from first principles or can be derived from benchmarked information from similar operations.

In many cases, a combination of open pit and underground methods may need to be used. In these cases, the cut-off grades will be different for each mining method. Where a blending strategy of various mineralization types is contemplated for a Mineral Reserve scenario, the strategy should be considered by the metallurgist on the team to determine if the blending strategy is technically and economically viable.

The Practitioner(s) must then assess the various proposals for mining at various production rates when estimating a Mineral Reserve. When appropriate, alternative mine and plant configurations should be considered. Selecting the appropriate mining and processing methods and rates may involve several iterations and will involve input from members of other disciplines. Preliminary Economic Assessments may be required as a prelude to the completion of a Pre-Feasibility Study. Unlike a Pre-Feasibility Study, these other studies are not sufficient to support the designation of the estimated tonnage and grade as a Mineral Reserve.

Care should also be taken to ensure that the mining equipment selected is appropriate for the selected mining method. Inappropriate equipment selection may adversely influence both dilution and extraction factors. Practitioner(s) must have a high level of confidence in the viability of the mining and processing methods considered in determining the Mineral Reserves.

Maximum mineral extraction with minimal dilution is usually the principal criteria for the mining method selected, but tempered by economic considerations in the context of the Life-of-Mine schedule. Metallurgical recoveries applied should be based on process test work which must include determination of the relationship between process plant feed grade and the recovery of the commodity of interest and operating costs. Any mixing of waste in feed to the mill circuit may affect the recovery or operating costs and this possibility should be recognized during metallurgical testing.

7.3.1. Open Pit Mining Methods

The pit shells that define the ultimate pit limit, as well as any internal phases, are usually derived using open pit optimization algorithms, however, direct block scheduling or stochastic simulation methods can also be used. The information stored in the Mineral Resource model, including grades, block percentages, material density, slope sectors and rock types, and net smelter return, are entered into the optimization software. The optimization process is carried out using Measured and Indicated Mineral Resources only to define the optimal mining limits. The optimization process includes various pit shells which are defined according to different revenue factors, where a revenue factor of 1 is the base case. In order to select the ultimate pit limit, a pit-by-pit analysis to evaluate the contribution of each incremental shell to NPV is performed at a constant processing plant capacity.

Processing rate, mining capacity, and discount rate are used in determining preliminary production schedule strategies and maximizing the NPV of the final pit shell selection.

Optimization results from each of the shells are analyzed independently to determine a final pit shell recommendation to use for preparation of the final pit design, along with any starter or phase pit selections. The objectives of the pit shell recommendations are usually to maximize grade and project NPV. To determine the optimum pit shell, cash flow analyses are performed considering the sequence of mining for all the nested pit shells.

The final pit designs are based on the final pit shell recommendations, which are used as a guide for detailed pit design on a bench-by-bench basis. The final pit designs include all benches and berms and all haulage ramps. The ramp design criteria include maximum gradients and design widths for traffic flow, safety berms, water table, and drainage.

7.3.2. Underground Mining Methods

Key parameters in the selection of the underground mining methods may include:

- minimum mining width, height and length,
- pillar sizes and location,
- ground support type

- sequencing considerations,
- geological/structural considerations,
- equipment selection,
- ventilation and air quality,
- geotechnical considerations, and
- health and safety considerations (e.g. heat exposure).

A detailed discussion of all possible mining methods in all possible situations is far beyond the scope of these Best Practice Guidelines. Many reference sources are available on the topic, including the SME Mining Engineering Handbook (2014).

Representative drawings of the planned stoping methods should be included to clearly demonstrate the methodology being used on the model shapes. Dilution assumptions and calculations should be outlined.

Technical analysis of the rock properties (rock mechanics) should be reviewed and discussed.

For those instances where both open pit and underground mining methods are to be used for preparation of a Mineral Reserve estimate, an analysis of the many possible scenarios that are typically possible is required to identify the most favourable option for the transition from one mining method to the next. The open pit and underground Life-of-Mine designs are then prepared from the optimized mining shapes of the most favourable scenario.

7.4. Geotechnical, Hydrogeological, and Hydrological

Geotechnical and hydrogeological data gathering activities are an important input to the engineering design for both surface and underground mines. Soil and rock quality can have a significant effect on surface and underground mine design and on the location and siting decisions for process plants, hoists and shafts, and perhaps most importantly, tailings impoundment facilities and waste rock storage areas (RPM Global, 2015).

Geotechnical and groundwater conditions have a major influence on mine design and related infrastructure, and specific investigations are necessary to establish appropriate design parameters for each application (Whitham, 2014). Seismic activity in the area and other natural hazards or environmental conditions should be considered.

7.4.1. Geotechnical Investigation

The type of proposed mine development and infrastructure should determine the nature and extent of the geotechnical investigation. Key aspects are the scale and required stability of the structure and the following items need to be taken into account:

- Site conditions
- Mine development
- Tailings management facilities
- Waste rock storage and earthworks
- Surface infrastructure

Information to address these items may be gained from drilling programs, excavations and/or trial mining where the goals are to confirm the accuracy of the key assumptions. The key areas to address include the underlying geology, presence and character of major discontinuities, rock mass strength, and hydrogeology. Additional discussion and information is presented in Sullivan (2014).

7.4.2. Hydrogeological and Hydrological Investigation

Hydrogeological and hydrological investigations are required to identify and assess the presence of any major aquifers, the likely water balance and potential impacts on open pit wall slopes, underground design, and production rates.

Where groundwater is considered a risk to extraction, a specific investigation will be required to establish the characteristics of the site hydrogeological domains and the response to mining.

In the design and operation of open pit mines, groundwater has two principle areas where it needs to be considered: the quantities and location within the operations areas and the influence of groundwater pressures on pit wall stability, pit floor stability, and in-pit waste dump or waste rock storage area stability.

For underground mines, groundwater inflows during operations are usually handled by the mine pumping system; however, there are exceptions and care is required wherever significant aquifers or high permeability units are close to operations.

For both open pit mines and underground mines, it is important to evaluate the groundwater chemistry and the rock acid generation potential since this will determine if such water can be used in the process plant or, if it is to be discharged to the environment, what sort of prior treatment it will require.

Surface water studies need to be undertaken using available rainfall and catchment data to provide flood predictions and drainage provisions for the mine site and infrastructure, and as an input to water balance analysis for process and mine waste engineering.

7.5. Mine Designs

The process of mine planning and preparation of mine designs and schedules is the foundation of value for a mining company. Sound mine planning requires a solid understanding of the mineral deposit, rigorous standards and processes, robust and useful information technology, and skilled people. Life-of-Mine planning is key to identifying the strategic direction for any mine and short-range mine planning is key to delivering on forecast and budget expectations. Geotechnical design criteria are typically the primary drivers for the design of the size and shape of all safe excavations. It is imperative that a rigorous mine planning review process is implemented to ensure that the design criteria are met. The feasibility and success of any mine plan is contingent upon the accuracy of the input assumptions. The level of granularity and accuracy should increase as the mine plan progresses from the initial study level through the advanced study level and through to the operational stage.

The preparation of Life-of-Mine designs typically begins with the preparation of optimized surfaces or volumes for either open pit or underground mines using either software algorithms or by manual methods.

7.5.1. Optimization

7.5.1.1. Open Pit Mines

While manual methods are still used to prepare initial open pit outlines in rare cases, the majority of initial open pit shells are created using digital methods. Identification of initial pit shells is achieved by applying open pit optimization routines to the Mineral Resource block model. While several optimization routines are in use by the mining industry, the Lerchs-Grossmann algorithm is a common choice for creating optimized open pit surfaces. These optimization routines can generate a series of preliminary surfaces that satisfy the specific technical and economic parameters that were used as input parameters for the optimization runs. The input parameters typically include:

- Overall wall slope angles,
- Metal/commodity prices,
- Metal/commodity recoveries,
- Operating costs, and
- Royalties and streams (as applicable).

The selection of input parameters for open pit optimization runs should be supported by as much relevant, factual data as are available. Where factual data are not available, estimated values can be derived based upon comparable situations. In these cases, the limitations of the available data must form a consideration when classifying the materials into either the Proven Mineral Reserve or the Probable Mineral Reserve categories.

It is important to understand that the resulting surfaces represent a series of mathematical solutions to the given input parameters. These surfaces do not consider the detailed technical and economic criteria that are required to prepare the final Life-of-Mine designs. As such, surfaces generated from open pit optimization software programs must never be used to prepare statements of the Mineral

Reserves. Rather the selected surface simply acts as a guide for preparation of the final Life-of-Mine design.

Considering that the Mineral Reserve statements are the end product of a series of steps, validation of the results from any open pit optimization runs as soon as they have been completed is an important component of ensuring the quality of the ensuing Mineral Reserve statements. Practitioners are strongly encouraged to conduct all validation exercises as judged necessary and appropriate to ensure that results from the optimization runs are mathematically correct and are in general agreement with the expected outcomes.

7.5.1.2. Underground Mines

For preparation of Life-of-Mine design for an underground mine, the process typically begins by generating a series of potential stoping panels that satisfy a series of input parameters such as:

- Continuity,
- Cut-off grade or value,
- Geometry,
- Geotechnical parameters,
- Ground conditions,
- Minimum mining width,
- Maximum stope height,
- Maximum stope length,
- Minimum dip,
- Maximum panel-to-panel change in strike and dip,
- Variation in the strike and dip of the mineralization, and
- Ground conditions.

By necessity, selection of a preferred mining method (or combination of mining methods) is a required prerequisite to completion of this stage of work. The creation of these initial stoping panels can be achieved by using either manual or digital methods.

As the shapes, locations, geotechnical characteristics, and metallurgical characteristics of the mineralization can change from place-to-place within a given deposit, it is important for Practitioners to possess an understanding of how these changes may affect the creation of the initial stoping panels including mining losses and dilution. The input parameters should then be varied and adjusted to accommodate for changes in the spatial, geometric, and metallurgical characteristics of the mineralization as appropriate.

For stoping panels prepared using digital methods, it is important for Practitioners to understand that the resulting potential stoping panels are the simple mathematical solution to the given set of input parameters. They do not necessarily demonstrate the technical and economic viability required for preparation of Mineral Reserve statements. As such, mining shapes generated from any underground optimization software programs must never be used to prepare statements of the Mineral Reserves without inspection, validation, and review. Rather, the initial shapes are to simply act as guides for preparation of the final Life-of-Mine design.

The selection of input parameters for preparation of underground stoping panels should be supported by as much relevant, factual data as is available. Where factual data are not available, estimated values can be derived based upon comparable situations. In these cases, the limits of the available data must form one of the items considered when classifying the materials into either the Proven Mineral Reserve or the Probable Mineral Reserve categories.

Validation of the results from underground optimization runs and from manually created stopes are an important step in creating high quality Mineral Reserve estimates. The Practitioner(s) should carry out such validation exercises as are deemed appropriate and necessary to ensure that the results are mathematically correct, are reasonable, and are in line with expectations. Modifications and edits to the proposed stope panels should be applied manually where necessary to correct for any undesired outcomes prior to proceeding to the next phase of work.

7.5.2. Life-of-Mine Designs

7.5.2.1. Open Pit Mines

For existing open pit mines, the design stage should begin with the most current version of the excavated surface and current Life-of-Mine design. This would then be updated to reflect any changes in the underlying input parameters and assumptions. Any additions to the Mineral Resource base can also be accounted for.

For development-stage open pit mines, the starting point of the Life-of-Mine design stage begins with examination of the series of pit surfaces that have been generated from the optimization stage. The advantages and disadvantages of the various pit surfaces generated from the optimization runs are examined, and a final surface is selected to act as a guide for preparing the Life-of-Mine design. The ultimate pit shell may not always be the preferred candidate for the Life-of-Mine design.

Design considerations for preparation of a Life-of-Mine open pit design include:

- Ramp starting collar location, maximum gradient, minimum road bend radii, and width,
- Safety berm height and width,

- Drainage ditch width,
- Bench height, bench face angle and berm width for all materials,
- Geotechnical slope sectors,
- Minimum excavation and fleet mobility dimensions,
- Maximum size of the haulage fleet, and
- Inter-ramp slope angle.

A report of the tonnage and grade of the mineralized material, along with the tonnage of all waste materials contained within the Life-of-Mine design, is typically prepared following completion of the design phase of work and examined for suitability. It is recommended to prepare a shell-to-design reconciliation to examine the effectiveness of the design in maintaining the optimized shell configuration. Depending upon the results of the initial tonnage and grade reports, changes to the initial Life-of-Mine design may be required to achieve various goals or to address specific issues. Several iterations of the Life-of-Mine design may be required before a final design is identified and accepted. In many cases, the Life-of-Mine design will not follow the outline of the selected optimized pit, as the Practitioner(s) often must evaluate whether inclusion of additional waste materials or exclusion of mineralized material will yield a better outcome when establishing the final design.

7.5.2.2. Underground Mines

For existing underground mines, the design stage should begin with the most current version of the excavation model and Life-of-Mine design. This can then be updated to reflect any changes in the underlying input parameters and assumptions and any new mineralized areas that may have been discovered.

For development-stage underground mines, the overall layout is determined by the size and shape of the mineral deposit as defined in the Mineral Resource block model. The design process begins with a confirmation of the assumptions and parameters used to create the series of potential stoping panels. The relative size of the deposit, dimensions of the mineralized zones, and the spatial orientation of the mineralization will influence the choice of the production rates that may be achievable. Among the objectives that should be considered in preparation of underground mine designs are:

- Minimize construction or development cost/time required to access ore faces,
- Allow for the supply of ventilation and mine services (air/water/power),
- Provide for required infrastructure to support the mining strategies,
- Adhere to recommended geotechnical parameters including the recommended mining sequence,

- Maximize drilling, blasting, and excavation productivities,
- Ensure proper drainage and dewatering,
- Backfill infrastructure if required,
- Minimize dilution and maximize ore recovery,
- Minimize operating costs,
- Maximize ore extraction, and
- Maximize people and equipment safety.

Once the production rates and the final mining method(s) are selected, selection of the appropriate equipment fleet can be carried out. The selection of the equipment fleet will dictate the dimensions of all accesses to the stoping areas and between production levels. Allowances for ventilation ducting, air and water lines, communication lines, and electrical chases must be included in the design of all primary underground access ways.

The means of access to the potential stoping panels on each production level are designed to ensure maximum equipment productivity and worker safety while minimizing the amount of excavations in non-mineralized areas. Level access designs include all cross cuts necessary to access the mineralized zones, and all sill drifts and drill drifts. Once all level accesses have been designed, the design of the final ramp or shaft access can be carried out.

Mine designs for underground mines must include provisions for fresh air intake, exhaust air, and secondary escape ways. Additional considerations include provisions for pumping stations, electrical transformer stations, safety bays, backfill infrastructure, and refuge stations. Ore and waste passes and fill raises may also be required.

7.5.3. Phase and Sequence Designs

7.5.3.1. Open Pit Mines

Following completion of the Life-of-Mine open pit design, an analysis of the various options available within the Life-of-Mine open pit design is carried out to assist the selection of the optimal sequencing of the mining schedule. These options can be identified using open pit optimization software, which yields a set of nested pit shells. Care should be taken that the shells for the various pit phases form reasonably contiguous surfaces that are operationally feasible. The resulting designs from this pit sequencing activity will then be used as inputs to the mine schedule.

The various interim designs should always maintain a business focus that seeks to maximize the value of the mineralization being mined while guaranteeing safety and operational feasibility. Some considerations for selecting and designing the various interim open pit phases include:

- Ensuring sufficient feed to the process plant throughout the mine life,
- Consider any blending requirements to achieve the desired plant feed grade or quality,
- Maximize the drilling, blasting, and equipment productivities,
- Minimize dilution and ore losses,
- Minimize transportation costs,
- Minimize operating costs,
- Minimize waste removal,
- Maximize ore extraction, and
- Maximize people and equipment safety.

7.5.3.2. Underground Mine

Typically, the ultimate Life-of-Mine design is completed as an initial step. This is then followed by breaking the Life-of-Mine design into a series of smaller phases that are designed to maximize the value of the asset while ensuring safety and operational feasibility. These smaller phases then form the basis for production scheduling. Allowances are required for sufficient time between unit processes (e.g. Definition drilling, development, stope drilling and blasting, stope mucking, backfill, etc.) in the selection of both production rates and equipment sizing.

The mining sequence should reflect the selected mining method, and be aligned with the geotechnical and excavation design constraints. Mining direction, and timely backfilling should provide enough mining fronts to achieve the target production and development rates while guaranteeing the overall stability of the existing and future working areas.

7.6. Dilution and Mining Losses

Dilution is material that is intentionally or inadvertently mined that is below the cut-off grade and must be considered in Mineral Reserve estimates because it "dilutes" the average grade estimate and increases the volume mined. The Practitioner(s) must describe how dilution was applied in preparation of the Mineral Reserve estimate. Preparation of a diagram to explain the dilution calculation used is often very useful. The following briefly describes some common types of dilution encountered in open pit and underground mines.

7.6.1. Open Pit Dilution

In open pit mines, a mining outline is established where mining is to take place. The mining outline sometimes includes material that is below the cut-off grade because the material cannot be selectively removed during the digging operation. This material is referred to as internal dilution. External or planned dilution must also be considered when preparing Mineral Reserve estimates. This type of dilution results from the mining of waste material that is mixed with the mineralized material at the time of excavation. An estimate of this type of material must also be included in the Mineral Reserve tonnage and grade estimates.

7.6.2. Underground Dilution

Similarly to the open pit situation, in underground mines some material that is below the cut-off grade must be mined because it cannot be selectively excluded from within planned mining shape at the time of excavation. This is also typically referred to as internal dilution. In the stope design stage, in many cases the shapes of the planned excavation cannot be matched to the mineralized outlines. Areas outside of the mineralized outline, but inside the planned stope are typically referred to as planned dilution and must be excavated for technical, and operational reasons. In addition to the above planned dilution, dilution can result from additional material that is mined as a result of uncontrolled or unforeseen reasons (unplanned dilution). This material is often referred to as overbreak or external dilution.

An estimate of both the planned and unplanned dilution must be included in the preparation of Mineral Reserve tonnage and grade estimates.

In operating underground mines, an additional type of dilution can occur. This dilution occurs when blasting of new stope panels takes place adjacent to a previously excavated stope containing backfill material. In these situations, a portion of the backfilled volume can become entrained with the newly blasted material. The grades of the backfill material are typically far below the breakeven cut-off grade or value, and this material contributes to the total dilution of the newly blasted material. Furthermore, the backfill usually has very different chemical characteristics to the mineralized material and its inclusion in the process plant feed can have serious adverse consequences. This dilution is referred to as secondary dilution.

Accurate reconciliation studies are required to estimate the tonnage and grade of the planned and unplanned dilution in an underground mine. The tonnage of the unplanned dilution can be measured by comparing the excavated volume of a given stope to the planned or designed volume. The grade of the planned and unplanned diluting materials can be estimated from the available sample information. The volume of the secondary dilution can be estimated by comparing the surveyed excavation shape of the backfilled stope with the surveyed excavation shape of the newly blasted stope.

7.6.3. Mining Losses

Mining losses refer to the percentage material within the mine designs that will not be extracted for various reasons. These materials are sometimes expressed in terms of mining recovery, however the term mining loss(es) is preferred so as to reduce confusion with process recovery.

Examples of mining losses include broken material left in a stope that cannot be recovered due to operational or safety constraints in an underground mine, or blasted material in an open pit mine that is destined to be sent to the processing plant but which cannot be recovered.

The mining losses must be quantified and considered in the preparation of a Mineral Reserve statement.

7.7. Mineral Reserve Categorization

Categorization of the Mineral Resources into either the Proven Mineral Reserve or the Probable Mineral Reserve categories can be completed once estimates of the diluted and recovered material have been prepared. In all cases, the requirements of the CIM Definition Standards must be satisfied when assigning categories of Mineral Reserves. Classification of Mineral Reserves can be an iterative process for underground mines, where several iterations may be required before a final classification is achieved. Only those portions of the Mineral Resources that are classified into either the Measured or Indicated Mineral Resource categories can be converted to Mineral Reserves.

Inferred Mineral Resources must never be classified as Mineral Reserves. If Inferred Mineral Resources are used in the development of mine plans and production schedules, they should be treated as waste materials. The classification of any such Inferred Mineral Resources can be reviewed and updated as new information becomes available. Unclassified material must never be classified as Mineral Reserves.

The Practitioner(s) should be mindful of all the inputs used in establishing the Mineral Reserve that affect the confidence in the categories. The methodology of establishing the categorization should be well documented and easily understood. Best practice includes providing a narrative description of the qualitative reasons behind the categorization selection. Where practical, empirical evidence (e.g. production data) should be used to calibrate and justify the categorization.

7.8. Mineral Process

For more information on this subject please refer to the Canadian Mineral Processors (CMP) of CIM for their Best Practice Guidelines for Mineral Processing. CMP is a Technical Society of the CIM and incorporates those members of CIM, who are concerned with the processing of material from mineral deposits. The guidelines contained in the document include:

- CIM Best Practice Guidelines for Mineral Processing,
- Appendix A – Use of Supporting Studies in Process for NI 43-101 Documentation, and
- Appendix B – Glossary of Terms Used in the Best Practice Guidelines in Mineral Processing.

These guidelines provide guidance specifically for those Practitioners using mineral process information when preparing Mineral Resource and Mineral Reserves estimates and preparing supporting documentation.

7.8.1. Development Stage Properties

Mineral processing recovery, design and cost requirements in support of the preparation of Mineral Reserve statements for development-stage projects should include test work on samples of mineralized material and waste material that might be incorporated in the feed to the process plant. Testwork can conveniently be performed on one or more master composites selected and prepared so as to represent what is expected to be delivered to the process plant. The testing objectives are to determine the optimal processing selection, the nature of the variability within the deposit, metal or mineral recovery level to a saleable product(s), mineral hardness and abrasion values, and required consumables such as reagents to achieve the predicted recovery. In the course of such testing the handling or treatment for deleterious elements should be determined and samples for tailings disposal design will be generated.

Once a suitable process flowsheet has been developed on such samples, it is important to determine the response of variability samples covering a range of feed grades (or mineral content), deposit domains, lithological types, extents of weathering, etc., as is appropriate.

The testwork must define process design parameters for all flowsheet segments including comminution, beneficiation, hydrometallurgical processing, liquid-solid separation, etc. Equally important is the definition of the relationship between process plant feed grade and recovery and operating cost determinants such as grinding energy and reagent consumptions.

In cases where the processing selection includes new or novel designs or equipment, or the deposit contains highly variable grades or mineralogy, testing might include pilot plant testing of a bulk sample to improve confidence in the design and cost estimates. Otherwise, testing at bench scale of smaller samples obtained by drilling or trenching is typically adequate to support reliable and accurate designs, recovery values, and cost estimates

Processing facilities are designed to produce marketable products for shipment directly to the consumers or to subsequent processing facilities. In some cases, test work will be required to yield samples of the intended product that can be evaluated by potential customers for the product.

Process engineering studies can be initiated upon completion of metallurgical test work. Such studies should generate designs for the processing plant in sufficient detail to generate capital and operating costs to the required level of accuracy. The process plant capital and operating costs generated in this way will be integrated with the capital and operating costs of other project areas such as mining and environment, to arrive at an assessment of the overall project economics.

Components of the process engineering study used to demonstrate mineral economics will include:

- A description of samples used and their sources,
- Mineralogical studies,
- Metallurgical test work results and methods,
- Determination of processing design criteria and description,
- Selection of processing flow sheet and design basis,
- Equipment sizes and specification,
- Processing facilities layout,
- Processing plant services and infrastructure,
- Consideration of project site conditions,
- Identification of tailing containment location and form,
- Estimates of initial and sustaining capital cost, and
- Estimate of processing operating cost for periods through to life-of-mine.

7.8.2. Current Operations

When a Mineral Reserve statement is being prepared for current operations with an operating process plant it is necessary to obtain and document the current operating conditions including process plant feed source and characteristics, process flowsheet, operating cost parameters, and recovery correlated with feed characteristics. For expanded or modified processing facilities, a detailed engineering study including flowsheet, layouts and capital and operating costs will be required to support the Mineral Reserve statement.

For those cases where the Mineral Reserves for current operations are expanded as a result of newly discovered mineralization, the metallurgical characteristics of the new mineralization must be evaluated and compared to the material being processed in the current operation. The goal of this metallurgical testing is to demonstrate that the existing process selection and facility are suitable for the newly discovered mineralization, or to develop the processing design change or additions necessary to economically process the new mineralization. If the new mineralization is expected to be very similar to that historically processed at the operation, it is reasonable to confine testing to demonstrate recovery and consumables required for the existing processing route. For differing mineralization, testing scope should be expanded to examine other process routes before the optimum design is selected.

7.9. Production Schedules

The production schedule of a mining operation is a timetable containing the estimate of all material moved (ore, waste, and marginal material) in each time period of the plan. The goals of a production schedule are to establish production targets, and to serve as a base to calculate the costs of the mine. The main output of the production schedule is the forecast metal (or product) yield in its final, saleable form.

When defining production schedules, frequently the key objective is the maximization of the deposits economic value. However other strategies can be applied when considering a production schedule. Considerations can include:

- Compliance with Health, Safety, and Environmental standards, and social acceptability considerations,
- Feeding ore as uniform in quality and as close to target feed grades as possible to the plant in every period,
- Maintaining the material movement level in the mine,
- Maintaining a smooth stripping ratio over time for open pit mines,
- Providing ore to the plant at agreed upon rates and grades, and
- Optimizing operating costs.

Production schedules are initially prepared from the Life-of-Mine designs. Subsequent schedules are prepared using any staged phase designs for either open pit or underground mines. While production schedules can be prepared with the assistance of various software programs, care must be taken in the selection of the input parameters.

In all cases, close scrutiny of the results of any production schedules must be carried out to ensure that they are feasible and achievable. Schedules should be consistent with the established overall mining sequence and reflect dilution and ore losses. Mine schedules should be achievable with the budgeted resources and under reasonable productivity calculations/assumptions.

Preparation of digital images of the proposed mining sequence are of great assistance for visual confirmation in both open pit and underground mines.

7.10. Workforce and Equipment Requirements

Estimates of workforce and equipment requirements are necessary to support estimates of human resource management, operating costs, initial capital requirements, and sustaining capital requirements.

7.10.1. Workforce

The estimation of the workforce requirements includes a detailed estimate of the number of persons required for each position for a given mine. The estimated workforce operating costs are then calculated for each position. Workforce estimates are prepared on monthly, quarterly and annual bases, as appropriate.

The Life-of-Mine plans should include an estimate of the overall workforce requirements, broken down by functional areas, along with each of the detailed mine design stages. Wage rates for the particular area are required to estimate operating costs.

In the case where the operation uses a contractor for all or a portion of its mining or support operations, the specific cost component of the operating costs should account for the workforce requirements to carry out the planned work and the appropriate allowances for wages, benefits and other obligatory payments.

For properties with currently producing operations, the estimation of the workforce requirements can be determined using factual data from the current operations. Workforce requirements for contemplated expansions at operating mines can be determined using productivity information from the current operations or other productivity information. For properties that are in the study stage, the workforce requirements are best determined from first principles. The use of productivity information from comparable operations can be of great assistance.

7.10.2. Equipment

The estimation of the equipment requirements includes a detailed estimate of the number of units required for each work type for a given mine. The number of units required are calculated for each piece of equipment in the mobile fleet, long-life equipment, and such supporting equipment as fans and pumps for the entire life of mine. Equipment requirements are prepared on monthly, quarterly and annual bases, as appropriate.

The Life-of-Mine plans should include an estimate of the overall equipment estimates for the Life-of-Mine, along with each of the detailed mine design stages.

In the case where the operation uses a contractor for all or a portion of its mining or support operations, the specific cost component of the operating costs should account for the equipment requirement to carry out the planned work and the appropriate allowances for fuel, parts and consumables, maintenance, rebuilds, replacements and ownership costs.

For properties with currently producing operations, the estimation of the equipment requirements can be determined using factual data from the current operations. Equipment requirements for contemplated expansions at operating mines can be determined using productivity information from the current operations. For properties that are in the study stage, the equipment requirements are best determined from first principles. The use of productivity information from comparable operations can be of great assistance.

7.10.2.1. Open Pit Mines

Selection of the appropriate type, specific model, size, and number of pieces of equipment for a given open pit mine design stage will require consideration of a number of parameters as follow:

Drilling and Blasting:

- Bench height,
- Penetration rate,
- Hole diameter, depth, angle, burden and spacing,
- Sub-drill,
- Explosive type, and
- Purpose (ore, waste, pre-split).

Loading:

- Material type (ore, waste),
- Production rate,
- Bench height, and
- Selectivity requirements (dilution).

Haulage:

- Production rate,
- Transportation distance,
- Moisture content,
- Haulage profile, and
- In-pit crushing.

Ancillary Equipment:

- Supervisor equipment,
- Lighting,
- Communication,
- Surveying,
- Waste rock storage handling,
- Marginal rock pile requirements,
- Primary loader support,
- Road maintenance,
- Field equipment maintenance,
- Fuel and lubrication, and
- Dewatering requirements.

7.10.2.2. Underground Mines

Selection of the appropriate type, specific model, size, and number of pieces of equipment for a given underground mine design is governed chiefly by the mining method, the means of access, and the required mining rates. While a large number of possible combinations are possible for any given deposit, in general, the primary areas of consideration include:

Drill and Blast:

- Production or Development (Level development, ramps, shafts, ore/waste passes),
- Hole diameter and penetration rates, and
- Size of opening required (stopes vs access).

Haulage:

- Level haulage,
- Moisture content,
- Ramp haulage, and
- Shaft skipping.

Ancillary Equipment:

- Supervisor equipment,
- Communication,
- Surveying,
- Pumping system,
- Supply conveyances,
- Haulage way maintenance,
- Equipment maintenance,
- Fuel and lubrication,
- Dewatering support,
- Ground support,
- Backfilling,
- Construction, and

Logistics and Supply.

7.11. Capital Cost Estimates

In relation to the preparation of a Mineral Reserve statement, capital costs are considered as those costs required to build a new project (i.e. a greenfields project), or to increase the throughput capacity of an existing operation (i.e. a brownfields property). Capital costs include the following:

Direct Costs
These typically comprise quantity-based cost estimates encompassing all the permanent equipment, bulk materials, labor, and subcontractors associated with the physical construction of the project. In general, they include the following major functional areas:

1) Mining

    a. Mine Development

    7.12. Underground development (e.g. haulage ways, production shafts, ventilation, pumping, and electrical requirements)

    7.13. Open Pit development (e.g. waste stripping, waste rock storage, ore stockpiles)

    b. Mine fleet equipment

2) Processing facilities (from ore receipt through to product shipment and tailings disposal)

3) Waste Management Facility (typically defined as beginning at the processing plant and extending to tailings and waste storage area, including effluent water treatment facilities)

4) Infrastructure

    a. On-site facilities such as camps, maintenance shops, administration buildings, analytical and metallurgical laboratories, water supply and management structures, etc.,

    b. Off-site facilities such as access roads, airstrips, port or rail facilities, power lines or power generation facilities, concentrate pipelines, desalination plants and water pipelines, etc.

Indirect Costs
These costs are typically defined as those costs that cannot be directly attributed to the construction of the physical facilities but are required to support the construction effort. These costs may include the following:

1) Construction Indirects (construction camp, temporary facilities, support services)

2) Engineering, Procurement, and Construction (EPC)/ Engineering, Procurement, and Construction Management (EPCM) Costs/Fees

3) Commissioning and start-up costs (including vendor commissioning engineers and staff)

4) First Fills and Critical Spares

Owner Costs
These are generally defined as those costs that are specifically attributable to the Owner that are not included elsewhere in the estimate. The Owner's role will vary if the Owner elects to select an Owner-

directed project rather that selecting an EPC/EPCM contractor for project delivery. Regardless of delivery model, certain responsibilities are included in the Owner costs including the following:

1) Owner's project management team,
2) Owner's project support staff (finance, travel, administrative, technical),
3) Owner's project expenses (insurance, permitting, land purchase, legal, marketing, IT),
4) Owners technical contributions (on-going drilling, metallurgical testing, studies),
5) Owners socio-economic work including liaison with local communities, and
6) Owner's operations team (from pre-commissioning through start-up phases).

Contingency
An estimate to provide for the unknown costs that are likely to occur but are not readily identifiable. Inclusion of contingency is essential to ensure that the capital cost estimate will be adequate to complete the project.

Capital costs are typically broken down into three categories as discussed below.

7.11.1. Initial/Development Capital

For development-stage properties, the initial capital represents the total investment required to establish the mining production. These costs should typically include the following areas:

- Open Pit Pre-stripping,
- Underground development (shafts, declines, ventilation raises, etc.),
- Purchase of mining equipment fleet,
- Process plant construction or refurbishment/upgrade,
- Construction of tailing storage facility, waste dump preparation and water management facilities,
- Development of required infrastructure and facilities (power distribution, maintenance and administration buildings, water supply and distribution, access road, and the like),
- Camp accommodation facilities (in the case of remote sites),
- Land purchases and/or leases and rights-of-way,
- Maintenance and operating equipment (e.g. tools, computers, support systems, office equipment, and the like),

- Surface preparation (e.g. roads, storage areas, buildings),
- Pre-production/commissioning
- Payments under government or first nations agreements,
- Working capital (e.g. initial fills of consumables, initial capital and critical spares inventory, initial warehouse inventory, operating cost required to build work in process inventories and operating cost required to be spent during the time to receive revenue from sales of product, recoverable value added tax, and the like),
- Taxes on capital purchases (e.g. sales taxes or value added taxes that are not recovered),
- Financial assurance and mine closure/reclamation bonds (different companies can finance these costs differently but need to be identified for the jurisdiction),
- EPCM costs, and
- Contingency.

A contingency allowance must be included in the capital cost estimate and allows for the fact that the capital cost estimate will not have specifically included for every item or function needed for the completion of the project. It must be clearly understood that the contingency allowance will be spent and that it is not intended to cover scope changes and the like.

Working Capital is a term used to describe an amount of cash required during the initial capital phase that accounts for inventory and cash to allow operation until revenue is received. This includes:

- Initial fills of reagents and consumables that are required to start the plant (e.g. balls in ball mills, reagents in flotation cells, fuel in tank, etc.). Initial fills are often included as a separate line item rather than included in Working Capital.
- Warehouse Inventory of parts and consumables that will be used during operation (e.g. explosives, mobile and process equipment parts, wear parts, mechanical or electrical spares, personal protective equipment).
- Capital Spares Inventory consists of large components of the equipment or even a duplicate for the purposes of managing the risk of loss of production (e.g. ball mill bull gear, spare skips and cage, electric motors).
- During the development phase, an inventory of product is stockpiled at the mine and the process plant and output does not become available for sale until the working inventory of the project has been reached. The operating cost required for these activities is also covered in working capital as the operation will carry the inventory until the end of mine life (e.g. longhole

stope drilled inventory, in pit drilled inventory, broken ore and waste inventory, ore stockpiles, product in process and otherwise at site).

- Cash is required from the time the product is sold and leaves the mine site to the time the cash is received in the account. Various commercial terms will dictate the need for more or less working capital in these instances.
- Furthermore, net proceeds from saleable mineral material produced in the development phase while bringing the mine to the point of commercial production are deducted from the pre-production operating cost.

The initial capital that the project will incur during the pre-production period should be estimated with sufficient accuracy to represent the actual costs to an accuracy commensurate with the level of the study. The Practitioner(s) should ensure that the quantity and quality of engineering and costing supports such level of accuracy. The Practitioner(s) should also state clearly to what level of accuracy the report is has been prepared.

7.11.2. Sustaining Capital

Generally, sustaining capital is required by a mining operation to maintain production at the planned level. This sustaining capital is distinct from the routine operating costs associated with labour, consumables, maintenance, and third-party supply, and is generally of a shorter-term nature. Examples of sustaining capital items include the following:

- Mine development (OP pre-stripping, UG haulage drifts and ventilation raises),
- Push-back waste stripping,
- Equipment rebuild (mining fleet, plant equipment) costs required to extend the useful life of asset,
- Equipment replacement or expansion as required by the reserve Life-of-Mine plan,
- Process facility replacements,
- Expansion of tailing storage facility,
- Progressive rehabilitation and on-going closure costs,
- Infrastructure facility replacements,
- Additional land purchases,
- Dewatering and pumping, and
- Contingency.

The Practitioner(s) should list all assumptions that determine the sustaining capital policy. The sustaining capital should be estimated with an accuracy commensurate with the level of the study and in current dollars. The Practitioner(s) should detail all assumptions regarding sustaining capital and also ensure that the quantity and quality of engineering and costing supports such level of accuracy.

7.11.3. Expansion Capital

An investment in expansion capital would be required when an operating mine plans an expansion in production capacity given an adequate reserve and market capacity and demand.

The expansion capital that the project will incur should be estimated with to an accuracy commensurate with the level of the study and in current dollars. The Practitioner(s) should detail expected expenditures and ensure that the quantity and quality of engineering and costing supports such level of accuracy.

7.12. Operating Cost Estimates

In general terms, operating costs are commonly considered as those costs that are incurred in the current year of production. However, preproduction operating costs such as those incurred during the ramp-up period or some pre-stripping activities in open pit mines are often capitalized. A general description of the basis for calculation of operating costs include the following common cost centres:

1) **Mining**: all costs to extract and haul waste rock to a storage facility or for extraction and haulage of ore to the process facility battery limit which is generally either the feed hopper of a ROM crusher or one or more stockpiles.

2) **Processing**: all costs to process ore delivered from the mine to either the hopper ahead of the ROM crusher or ore stockpile(s) through to, and including, the tailings disposal and effluent treatment processes. In some reporting systems, tailings disposal, effluent treatment and related environmental costs will be reported as a separate cost centre, as is the cost to process tailings through a backfill preparation facility.

3) **General and Administration (G & A):** general and administrative expenses represent the necessary costs to maintain a mine's daily operations and administer its business, but these costs are not directly attributable to the production of goods and services. It is important to note that G & A costs can vary widely depending on such items as the country, project location, type of operation, production rates, and the like.

Table 7.2 provides details for operating cost estimates in the major cost categories of a mine. The list of costs is by no means exhaustive. The items to consider will depend on the specifics of a given mining operation under examination and can be estimated in several ways. However, in each case the cost components will include the costs for labour, consumables or materials, maintenance parts and third-party services. Additional information relating to estimation of operating costs can be found in the AusIMM Cost Estimation Handbook (2012).

In the case of an extension to an existing mining and processing operation, there is usually readily-available operating cost data. Some of the cost data will require modifications if changes are made to mining and processing methods or throughput rates. In cases where no operating history is available then estimates must be made from "first principles". To check these estimates, it is wise to compare or benchmark these estimates with operating costs of similar operations.

Table 7.2 Typical Operating Costs Inputs for Mining Operations

Cost Centre	Work Type
Mining	Definition Drilling: Diamond drilling, RC drilling or other such drilling to upgrade the resource confidence during operations or get better information for design and/or grade control purposes.
	Development: open pit stripping costs that have not been capitalized, and underground development.
	Production: Open pits: drilling, blasting, loading, haulage, dump management, road maintenance, dewatering, power Underground: drilling blasting, loading, haulage, backfill, dewatering, power, level maintenance, rehabilitation, ventilation.
	Technical Services: Geological and Engineering services.
Processing	Crushing, grinding, flotation, leaching, refining, product dewatering, product marketing and sales, tailings management, environmental, power, assaying services, technical services, heap leaching, solvent extraction electrowinning, etc. as appropriate.
G & A	Management, accounting, procurement and logistics, human relations (HR), Safety and health, Community Relations, Insurance, information technology (IT), software licenses, other Infrastructure, Support, and maintenance costs, security costs, camp costs, travel for remote sites, Royalty payments, External consultants, office and equipment leases, satellite office expenses. Legal and regulatory, property taxes, mineral tenure maintenance, and permitting costs. Additional information on estimation of G & A costs can be found in AusIMM (2012).

7.13. Additional Factors

In addition to the technical requirements related to the extraction of mineralized materials, Mineral Reserves must also consider a number of integral components in other areas such as location and infrastructure, environmental, marketing, legal, and social issues.

7.13.1 Location and Infrastructure

The location of the deposit has a significant effect on the approach taken to all aspects of a mining project and the cost of construction and operations. Climate, topography, and vegetation at the deposit location can have a significant effect on cost and schedule for a mining project construction, and on operations. The transport of supplies to support a mining operation will also be affected by location.

The infrastructure requirements for mining projects are site specific. The capital cost for infrastructure can vary substantially from site to site as a percentage of the total capital cost, and is usually more a function of the location rather than the choice of the mining or processing methods. Infrastructure covers a wide range of facilities and services, examples of which are summarized below:

- Access and service roads,
- Utilities – especially power availability and costs,
- Water supply,
- Communications,
- Port and Marine,
- Fuels,
- Waste disposal systems,
- Administration facilities,
- Industrial facilities,
- Transportation, and
- Townsite and/or camp site.

7.13.2. Environmental Management

An understanding of Sustainability and Corporate Social Responsibility requirements and commitments plays a fundamental role in the preparation of Mineral Reserve statements for both development stage properties and on-going mining operations.

For development stage properties, Mineral Reserve statements should include consideration of any environmental studies, whether they are planned, in progress, or completed. Environmental studies should consider all factors that may be impacted by the proposed operational scenario and, depending on the regulatory jurisdiction, often include the characterization of the air quality and background noise in and about the project area, characterization of the surface and groundwater quality, characterization of the terrestrial and aquatic flora and fauna and identification of any protected or sensitive species, and identification of any cultural or archeological features. Any factors that act to restrict the mine design, such as sensitive wildlife areas, fish habitat, forest reserves, and the like, must be identified and considered.

All known environmental constraints, or those discovered as a result of these studies that may affect mine development or permitting requirements should be identified.

The water management scenarios/systems, as well as the identification of sufficient area/capacity for the storage of tailings and any waste rock material for the stated Mineral Reserves should also be considered. The safety and stability of any tailings storage or waste rock facilities should be considered.

All costs related to the mitigation and treatment of any non-compliant liquid effluent, and progressive reclamation and final closure requirements must be identified and addressed.

7.13.3. Closure and Reclamation Planning

The level and detail of closure and reclamation plans is dependent on whether it is a development stage property or operating mine, the current stage of development of the project (greenfield vs. brownfield), and the presence or absence of a previous closure plan. General closure and reclamation concepts based on the known project facilities, environmental interactions, and monitoring and reporting requirements should be provided at a minimum. For development stage properties, estimated closure costs should be provided in sustaining capital.

For operating mines, all costs related to on-going monitoring and compliance with requirements set out in the various permits issued must be identified and included in the economic models. All costs related to final closure activities and post-closure monitoring should be identified and considered in the economic model. All financial assurance posted for closure of exploration, construction, or operation activities also needs to be addressed in the economic model.

7.13.4. Environmental Assessments and Regulatory Permitting

The environmental laws and regulations applicable to the specific jurisdiction in which proposed development is to occur, must be identified.

For development stage properties, all required environmental assessment processes, authorizations and/or permits and land tenure requirements must have been identified and there must be a reasonable expectation of eventual approval. Various jurisdictions have their own processes to be completed to obtain approval of an environmental impact assessment and issuance of operating permits and approvals. Practitioner(s) should ensure that a complete list of the certificates, permits, licenses and approvals for a given project is compiled along with a practical assessment of the expectation of eventual approval.

The current status of each permit should be documented and include either the main conditions of approval for those currently held, or alternatively, a practical assessment of the expectation of eventual approval.

As a minimum, all permits required by operating mines for the continued operation of the mine must be current, their conditions and requirements must be met and all financial obligations must be satisfied for the preparation of Mineral Reserve statements.

For both development stage properties and operating mines, all costs related to permitting and, where applicable, monitoring and compliance activities associated with permit requirements (operating projects) must be identified and included in the economic models.

7.13.5. Social Considerations

Mine development may impact on the surrounding communities, people, and their respective economies, including housing requirements, health and safety, employment opportunities and community displacement. Impacted stakeholders should be provided with the social/community studies conducted in support of the Mineral Reserve estimate. Indigenous peoples and their rights as Indigenous people in certain jurisdictions may require specific actions such as consultation and binding agreements.

Any restrictions placed on the mine design caused by social factors, cultural, or archeological issues must be identified. All public or government stakeholder meetings or consultations, hearings as well as proposed or actual stakeholder agreements must be discussed.

7.13.16. Product Marketing

To determine if a mineral product is saleable, it will often be a necessity that the physical and chemical characteristics of the product be demonstrated by preparing a representative sample of the final product. Some products of a mining operation can be sold directly from the mine site but others require additional off-site treatment (e.g. by a smelter). Some products are sold on an open market basis but many are sold on a contract basis. The method and costs of transporting the product to the ultimate buyer must be considered.

Depending on the product, deleterious elements may restrict the saleability of the mine product. Some customers are able to treat such elements while others may not. The Practitioner(s) should provide an assessment of the risk of the marketability of the product being evaluated and penalties that might be paid for off-specification products. Where possible, the Practitioner(s) should also identify the limitations for marketing the product by providing particular customer restrictions.

Sources of market information may include any relevant market studies for the commodity, including supply and demand, commodity price projections, product valuations, or product specifications.

The Practitioner is advised to consult with marketing experts for the intended commodity where appropriate to determine expected quality, costing, market capacity, and other parameters.

7.13.6. Legal

Clear title regarding the extraction, processing, and sale of the mineralized material and final product must be demonstrated.

7.14. Economic Analysis

7.14.1. Introduction

As described in the CIM Definition Standards, a fundamental requirement for the declaration of a Mineral Reserve statement, whether it is relating to a current mining operation or a mineral property being evaluated at the study stage, is the demonstration of the economic viability (profitability) of the technical parameters under consideration. This is most commonly achieved by preparation of an economic model on a discounted cash flow (DCF) basis.

DCF models are used by the business community in a large variety of settings to achieve various goals. In relation to the mining industry, economic models are used to determine and validate such business or investment decisions as:

- Declaration of Mineral Reserves,
- Decisions to proceed with additional investments in a property,
- Decisions on capital allocations between properties, and
- Valuations of mining properties, mining projects, and business entities.

While the nature and scope of an economic model reflects the specific situation for which it is being prepared, the following language considers construction of economic models that are prepared in support of Mineral Reserve statements only. For clarity, in the context of these Best Practice Guidelines, the economic model is constructed for the sole purpose of evaluating and demonstrating the economic viability of the selected technical parameters, and so supporting the statement of Mineral Reserves.

Economic models are commonly constructed using one-year periods and provide several DCF metrics such as NPV, internal rate of return (IRR), and payback period. Economic models should be prepared on both a pre-taxation and a post-taxation basis.

While a detailed discussion regarding the construction of economic models is beyond the scope of this document, examples of best practices and procedures used to prepare economic models have been presented in Smith (1999), Lattanzi (2000), Smith (2002), and Stermole and Stermole (2014).

7.14.2. Base Case

An economic analysis of the given set of technical parameters under consideration will include at least one cash flow model that will be referred to as the base case. This base case should include the following conventions:

- No debt. The reason for this is that debt and financing are not a measure of the economic viability of the technical parameters that are under consideration in relation to the preparation of a Mineral Reserve statement. They are more a measure of the borrowing ability of the owner company or companies. Additionally, debt-leveraged cases can be manipulated to give a wide range of positive outcomes that do not reflect the technical parameters under consideration.

- No inflation. Mining project forecasts are forward-looking exercises that can cover long periods of time. The addition of inflation over time to a DCF model requires numerous projections. Predictions of future costs and product values with any degree of accuracy are difficult at best and future predictions of inflation are likely to be inaccurate. These can cause unreasonable distortions to the base case DCF metrics.

- Constant metal price(s) and foreign exchange rates (as applicable). This is a generally accepted practice in mining evaluations. Constant ("flat") price(s) refers to excluding cycles or trends in the long-term forecast. It is a separate consideration from inflation (see above). The price forecasts should be determined by suitably qualified members of the Mineral Reserve estimation team and should be carried out in consideration of the guidance provided in CIM (2015).

- All taxes, royalties, and streams (revenue-based, tonnage-based, or other) payable by the project should be included in the economic model. Practitioners preparing economic models should consult with suitably qualified individuals for guidance in relation to treatment of the tax or royalty obligations of a project.

Cases in addition to the base case can be provided, but they must clearly identify which conventions and assumptions differ from those in the base case.

7.14.13. Economic Model

Essential elements in an economic model prepared in support of a Mineral Reserve statement should include, as a minimum, consideration of the following items.

7.14.13.1. Production:

Economic models should include annual schedules of mine production including ore tonnes, ore grades, product recovery (which can vary with grade and throughput rate), waste tonnes and grade (if any), and stockpile feed tonnes and grades (if any).

Annual schedules of process plant production must also be included in economic models where the mine production schedules differ from the plant production schedules (e.g. when a stockpiling strategy is employed). Process plant production schedules include ore tonnes, ore grades, metallurgical recoveries, and stockpile reclaim tonnes and grades (if any). The project production schedule should recognize any ramp-up requirements (for example, McNulty 1998) for both the processing plant and the mine.

7.14.13.2. Revenue:

The major inputs required to calculate revenues for an economic model include the following:

- Annual schedules of metal recovered, or tonnes and grades of intermediate products produced (concentrate, dore, etc).
- Annual schedules of smelter and refinery costs including: payable (accountable) metal deductions, treatment and refining charges, marketing costs, freight, material handling, losses in transit, insurance, etc.
- Annual schedules of gross and net revenues.

7.14.13.3. Operating Costs:

The operating cost section of an economic model commonly includes consideration of the following components as separate line items:

- Annualized schedule of mining operating costs,
- Annualized schedule of processing operating costs,
- Annualized schedule of general and administration (G&A) operating costs,
- Annualized schedule of royalties, metal streams, and social contract commitments, and
- Annualized schedule of any other costs of operations, as applicable.

7.14.13.4. Capital Costs:

The capital cost section of an economic model considers the annual schedules of all initial capital costs as separate line items including:

- open pit and underground development and equipment,
- pre-stripping (if any),
- processing facilities,
- services,
- infrastructure,
- construction of initial tailings and waste storage facilities,
- construction indirects,
- EPCM,

- Owner's costs,
- contingency, and
- any other capital costs associated with the initial construction of the facility.

In addition to initial capital costs, the capital cost section of an economic model will also consider the annual schedules of sustaining capital costs including but not limited to:

- mine equipment replacement,
- tailings dam lifts,
- heap leach extensions
- furnace rebuilds, etc., and
- Annual schedule of costs associated with closure, both during and after operations.

7.14.13.5. Working Capital

An annual schedule of working capital requirements on a cash basis is typically included in an economic model as a separate line item.

7.14.13.6. Taxes, Royalties, and Streams

An annual schedule of all significant taxes and royalties (whether based on income, revenue, tonnage, time, or other characteristics) must be included an economic model, each as a separate line item. They can include, but are not limited to, non-government royalties, Impact and Benefit Agreement payments, federal and state income taxes, state/provincial mining taxes, capital taxes, withholding taxes, and special levies by government bodies.

7.14.13.7. Economic Model:

An annual schedule of the cash flows is derived from the items listed above. For clarity, in the context of these Best Practice Guidelines, the economic model is constructed for the sole purpose of evaluating and demonstrating the economic viability of the selected technical parameters, and supporting the statement of Mineral Reserves.

To ensure that the DCF model is a fair evaluation of the economic viability of the selected technical parameters, it is considered good practice to use the same metal price(s) or value for preparation of the base case Mineral Reserve economic model as were used to prepare the tonnage and grade estimates used to prepare the production schedules.

If the metal price(s) or value assumptions used for the economic base case differ from the price assumptions used to prepare the production schedules and the Mineral Reserve statements, the Practitioner should:

- Explain the reasons for the different price assumptions, and
- Provide the DCF metrics at the price assumptions used to determine the production schedules and the Mineral Reserve statements.

Guidance regarding the selection of metal prices (or values) for use in the preparation of Mineral Reserve estimates has been presented in CIM (2015).

The recommended format to show in the cash flow analysis is annual schedules of each of the items that follow:

Physicals:

- Mined quantities and grade
- Processed quantities and grade
- Recoveries and recovered metal
- Payable metals

Cash Flow:

- Metal prices for each metal

+ Gross Revenue for each metal (payable metal times metal price)
- Less transportation and treatment/refining charges
= **Net Revenue**
- Operating Costs
- Non-government royalties and agreements*
- Working Capital Adjustments (cash basis)
= **Operating Cash Flow:**
- Initial Capital costs
- Sustaining Capital costs
- Closure and Reclamation Costs
= **Cash Flow Before Taxes:**
- Government taxes and royalties (income, mining, severance, etc)
- Withholding taxes
= **Free Cash Flow After Tax**

*Note: Non-government royalties and agreements include Impact Benefit Agreements (IBA), Net Smelter Return and other ad valorum-based royalties and production taxes, etc.

7.14.13.8. Net Present Value and Discount Rate

Once the annual cash flows are calculated, calculations of the standard measures of discounted cash flow models are often carried out. These commonly include the total cash flow, IRR, NPV, and payback period.

NPV is typically reported for a specific Risk Adjusted Discount Rate (RADR). The evaluation report must include an explanation of the development of this discount rate. This discount rate may have different names including: hurdle rate, minimum rate, required rate, etc.

If the NPV is positive at this discount rate, the project is considered to be economically viable and therefore a Mineral Reserve statement can be justified.

The risk adjusted discount rate is expected to reflect:

- the cost of capital to the owner of the project,
- the level of risk at the current stage of the project (PEA, PFS, FS, operating mine),
- any jurisdictional or country risk, and
- any other risk that can appropriately be incorporated into a discount rate.

These best practices recommend that the NPV of the annual cash flow be calculated for a range of discount rates from 0% to several percent in excess of the IRR or the RADR, whichever is greater. This should be presented as a table and as a graph. Additional information on selection of appropriate discount rates is provided in Runge (1998) and Smith (2002).

7.15. Sensitivity Analysis

As appropriate, the economic evaluation will include sensitivity or other analysis using variants in commodity price, cut-off grade, capital and operating costs, or other significant parameters, as desired, and discuss the impact of the results. When carrying out a sensitivity analysis, it is important to examine the impact of both positive and negative variations of a given parameter, as examination of a positive variation alone or a negative variation alone may result in misleading conclusions.

Due to the complexities in carrying out such sensitivity analysis, a common approach followed by Practitioners is to hold Mineral Reserves (tonnage, grades, production schedule) constant as well as all other values constant while adjusting the desired variable across a range of values. This approach is commonly referred to as a deterministic approach. Additional information on evaluation of uncertainty and risk analysis is presented in Lattanzi (2000) and Stermole and Stermole (2014).

The results of any sensitivity analysis should be clearly presented in tables and/or graphs. At least one table and graph should be developed that shows the impact of different metal prices on the main DCF metrics. The range of metal prices is at the discretion of the Practitioner but the lower end of the price range should include the price(s) or value at which the total undiscounted cash flow becomes zero and the price at which NPV becomes zero.

7.16. Mineral Reserve Statements

Mineral Reserve statements should be unambiguous and sufficiently detailed for a knowledgeable person to understand the significance of, for example, the economic cut-off(s) and its/their relationship to the Mineral Resource. In the case of open pit Mineral Reserve estimates, the waste to ore ratio (the strip ratio) should be unambiguously stated. There should be an obvious linkage of the Mineral Reserve estimate to the Mineral Resource estimate provided in earlier reporting documents. Best practice includes documentation of those linkages (e.g. dilution, mining losses, plant recovery) that were used in preparing the Mineral Reserve estimation.

Mineral Reserves are developed from the Measured and Indicated portions of the Mineral Resources that meet all of the necessary technical and economic criteria to demonstrate that the material can be extracted, processed and sold at a profit. Mineral Reserves include modifying factors and demonstration of the technical and economic viability through completion of a positive PFS, FS or, for operating mines, preparation of a cash flow model based on a Life-of-Mine plan. The Life-of-Mine cash flow model must use only material in the Proven or Probable Mineral Reserve categories

As a minimum, Mineral Reserve statements must include a summation of the tonnage and grade for each of the Proven and Probable categories for all mineralized zones within the Life-of-Mine design. Additional reports of the Mineral Reserves that are broken out into each of the mineralized zones, by mining method, by period, or by any other criteria can be prepared, with the provision that they conform to the requirements of the CIM Definition Standards.

Reporting of tonnage and grade figures should reflect the order of accuracy of the estimate by rounding off to an appropriate number of significant figures. There will be occasions, however, where rounding to one significant figure may be necessary in order to properly convey the uncertainties in estimation.

At the Practitioners discretion, the metal content of the Mineral Reserves may be disclosed, but only when accompanied by the corresponding tonnage and grade estimates. Metal contents alone must not be disclosed. Mineral Reserve statements should be accompanied by footnotes that provide such information as is relevant to assist in the understanding of the technical and economic inputs to the Mineral Reserve statement.

It is important to understand that a Mineral Reserve statement is based upon a given set of technical and economic parameters which have demonstrated their technical and economic viability at a stated point in time. In many cases, the technical or economic parameters can change with time, such that the viability test may no longer result in a positive outcome at a later date. In this way, the Mineral

Reserve statement for a stated date may no longer be valid at a later time. It is therefore recommended that the Mineral Reserve statements be reviewed on a periodic basis and adjusted as necessary to reflect the technical and economic parameters of the day.

7.17. Stockpiles

Stockpiles may exist on a mining property that may have been sampled during production, or drilled and sampled, or assigned a grade based on a resource block model.

Current stockpile volumes are sometimes resurveyed to obtain a current tonnage and sampled to obtain an estimated the grade and density. In these cases, the original surface contours are helpful in arriving at an accurate volume estimate.

Stockpiles may require ripping with a bulldozer, loading into surface haul trucks with an excavator or loader, and placement into the mill crusher or reclaim stockpile and blending with other mill feed material from other ore sources at the mine. Since drilling and blasting are usually not required, the operating costs are generally lower so the stockpile usually has a lower cut-off grade or value.

The stockpile cut-off grade or value is calculated using the cost data and commodity prices and milling recovery. Smelter returns, treatment costs, and freight costs were included in calculating the NSR for in situ material and should similarly be applied. The mining dilution and ore loss factors are usually already accounted for in the stockpile balances that form the resource estimate and as such no further adjustments are usually applied when determining the reserve unless there are some unusual circumstances.

7.18. Mineral Reserve Risk Assessment

While the classification of the Mineral Reserves into either the Proven or Probable categories allows the Practitioner(s) to identify technical risk in broad terms, establishment of a methodology to identify and rank risks associated with each input of the Mineral Reserve estimate is recommended. This will assist the Practitioner(s) in establishing the Mineral Reserve categorization criteria, thus providing an understanding of the various technical risks associated with the Mineral Reserve estimate. This methodology, ranking and analysis should be well documented.

7.19. Peer Reviews and Audits

Best practice includes the use of an internal or external peer review of the Mineral Reserve estimate including sufficiency and reliability of inputs, methodology, underlying assumptions, the results of the estimate itself, and test for technical feasibility and economic viability. The following items are typically considered when carrying out peer reviews of Mineral Reserve estimates:

7.19.1 Mining

- data to determine appropriate mine parameters, (e.g. test mining, RQD, etc.),
- open pit and/or underground,

- production rate scenarios,
- cut-off grade or economic limit (single element, multiple element, dollar item),
- dilution: material which is not part of the original Mineral Resource estimate; often referred to as a “planned dilution”,
- mining losses with respect to the Mineral Resource model,
- waste rock handling,
- fill management (underground mining),
- grade control method,
- operating cost,
- capital cost, and
- sustaining capital cost.

7.19.2. Processing

- sample and sizing selection: representative of planned mill feed, measurement of variability, is a bulk sample appropriate,
- adequacy of testing performed,
- pilot plant required for process confirmation and production of evaluation samples,
- product recoveries and dependence of recovery and costs on feed grade,
- mineral and rock properties such as hardness,
- bulk density,
- presence and distribution of deleterious elements,
- process selection,
- operating cost,
- capital cost, and
- sustaining capital cost.

7.19.3. Geotechnical/Hydrogeological/Hydrological

- slope stability (open pit),
- ground support strategy (underground), test mining,
- seismic risk,
- site and area hydrogeology, and
- water balance-water suitable for process plant or discharge with/without treatment.

7.19.4. Environmental

- baseline studies,
- tailings management,
- waste rock management,
- effluent water recycle or treatment then discharge,
- acid rock drainage issues,
- closure and reclamation plan, and
- permitting schedule.

7.19.5. Location and Infrastructure

- climate; impact on cost and schedule for mine construction, and operations,
- supply logistics,
- power source(s),
- existing infrastructure; requirements to connect to existing infrastructure (surface rights, permits, time required) and who is expected to pay for infrastructure improvements, and
- labour supply, housing, and skill level.

7.19.6. Marketing Elements or Factors

- product specification and demand,

- off-site treatment terms and costs, and
- transportation costs.

7.19.7. Legal Elements or Factors

- security of tenure
- ownership rights and interests
- Indigenous people and their rights
- environmental liability
- political risk (e.g. land claims, sovereign risk)
- negotiated fiscal regime
- permits to operate, and
- permits to sell or export saleable products.

7.19.8. General Costs and Revenue Elements or Factors

- general and administrative costs
- commodity price and market forecasts
- foreign exchange forecasts
- inflation (considered or not considered)
- royalty and stream commitments
- taxes
- corporate investment criteria

7.19.9. Social Issues

- sustainable development strategy
- impact assessment and mitigation

- negotiated impact/benefit agreements
- cultural and social influences
- restrictions placed on mine design caused by existing infrastructure, socio-economic, cultural, or archaeological issues

Upon completion of a Pre-Feasibility Study, or in the case of significant changes to a Mineral Reserve estimate, a properly-scoped audit should be carried out by qualified, third-party Practitioner(s). The audit should consider the methodology used, test the reasonableness of underlying assumptions, and review conformity to Mineral Reserve definitions and categorization. The methodology for Mineral Reserve risk identification, assessment and management should also be included in the Mineral Reserve audit. The audit should be documented.

8. CONCLUSIONS

Significant decisions that affect many stakeholders are often made on the basis of Mineral Resource and Mineral Reserve estimates. These MRMR Guidelines will provide some necessary and long-awaited directions to ensure that informed and rational decisions are made during the Mineral Resource and Mineral Reserve estimation process. These minimum standards will assist in preparing high quality estimates Mineral Resource and Mineral Reserve that benefit both the industry, and the investing public.

Technological advances permit consideration of a greater number of inputs and a larger and more diverse set of information when preparing Mineral Resource and Mineral Reserve estimates. Consequently, it is necessary to develop current procedures and practices that embrace these technological innovations while maintaining a sound basis in the good mining practices that have been learned over time.

The concepts, procedures and practices presented above represent the current cumulative knowledge, judgement and experience of a broad cross section of members of the Canadian mineral industry. The CIM Mineral Resource and Mineral Reserve committee believes that these Mineral Resource and Mineral Reserve Estimation Best Practice Guidelines will serve Practitioners to achieve these stated goals by providing guidance for preparing Mineral Resource and Mineral Reserve estimates.

9. REFERENCES

The Committee has included a list of documents below that are publicly available and are either cited as sources of specific content in these Best Practice Guidelines or they provide additional details on certain subjects. The list is not intended to be an extensive or complete compilation, but rather a selection of references to cover a range of topics.

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