# Appendix A – Use of Supporting Studies in Process Evaluation and Assessment

## A1. Foreword

Appendix A serves as support documentation within the LPGMP and supplements the Principles of Process Support for Mineral Resources and Mineral Reserves estimation. The tables included in this document serve only as a guideline as the nature of mineral deposits can vary significantly in terms of tonnage, grade, continuity, and complexity. It is the role of the Practitioner to make the assessment of the proper level of work appropriate to the mineral deposit and consider what would be appropriate in the judgment of their peers.

As Mineral Resources are converted to Mineral Reserves, a large amount of work should be performed to support the conversion including engineering studies which should be completed to provide both technical and economic assessments of the mineral deposit. After the initial identification of the Mineral Resource, typically three levels of studies with increasing detail and precision are undertaken. The process involvement in these studies generally begins with a preliminary economic assessment or scoping study, then advances to a prefeasibility study, and finally to a feasibility study, with an increasing degree of project definition at each stage. Particularly important in the conversion of Mineral Resources to Mineral Reserves is the use of the prefeasibility study, as required by the CIM Definition Standards.
Given the importance of these engineering studies as supporting documents, a general definition of the contents relevant to the development of the selected metallurgical and process associated contributions is warranted. This definition is provided in the tables below.

In general, the level of detail increases with the progression of the study stages. Definition at each succeeding level is built on the work of the previous stage. From a process viewpoint, these studies typically contain the following content and objectives:

## A2. Level of Sample Verification

| FACTOR | PRELIMINARY ECONOMIC ASSESSMENT | PREFEASIBILITY | FEASIBILITY |
|---|---|---|---|
| **Intent of Sample Representativity** | Indicative | Representative | Comprehensive |
| **Sample Types** | Composites and Point Samples | Point Samples & Domain Composites | Domain Samples and Variability Samples (either point or composite). |
| **Identification of Samples in the Report** | List to identify sample source and attributes. The Practitioner should comment on how representative the sample is believed to be in terms of grade and domain. | List to identify sample source and attributes. For composites, there should be an explanation of how these are derived. Sample attributes should be reconciled to the resource model to describe the limits of the influence of the sample. | List identifying sample source and attributes. Sample sources typically located on diagram of the deposit. |

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| **Information Supporting Process Concept** | Concept developed from mineralogy, typical practice for the type of deposit investigated, and selected bench-scale tests on samples. | Concept developed from previous information and optimization factor testing of domain composites. On large or complex deposits, key unit operations or novel process steps may be pilot tested under simulated plant conditions. Testing of the impact of grade variance is typically included in the testwork. Testing of metallurgical variance by domain is also a recommended task especially for complex deposits. | Concept brought forward from previous studies and performance confirmed by additional testwork. Key unit operations or novel process steps should be pilot plant tested under simulated plant conditions. Variability due to grade, domain, and spatial location is determined. |
| **Environment** | Samples might be tested if issues are expected. | Process and environmental experts should select initial samples and undertake standard and other environmental tests on waste rock, tailings and effluent. | Process and environmental experts should select samples and undertake standard and other environmental tests needed to support the process design and satisfy environmental regulations. |
| **Definition of Saleable Product** | Product output should match process selected. Marketability of the product is indicated. | Actual product(s) are produced by testing and marketability is assessed. Identification of deleterious components should be performed, and the impact identified. | Building upon prior work, there is a further demonstration that a product of acceptable quality produced regardless of feed variability. Produced products should undergo market assessment with the exception of bullion products. |
| **Testing QA/QC** | Chain of sample custody is demonstrated. Credibility of testing lab is assessed. | Internal QA/QC procedures in testwork should be explained. The ability to duplicate the results of the primary process (es) should be demonstrated. | Internal and external QA/QC procedures in the testwork program are explained. Key tests are duplicated by a reference lab to demonstrate consistent results. Where duplication of tests is not possible, the alternative is an independent peer review. |

## A3. Level of Design Definition

| FACTOR | PRELIMINARY ECONOMIC ASSESSMENT | PREFEASIBILITY | FEASIBILITY |
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| **Process Design Criteria (PDC)** | Preliminary design criteria used to support resource/reserve modelling are recommended. These | In addition to process design criteria, major design selection criteria for | Design criteria for process, major equipment and support systems (water, air, HVAC, etc.) are established. |

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| | should include tonnage, feed grade, recovery, and major design parameters considered important in the judgment of the Practitioner. | equipment (size, power, type) are established. | |
| **Process Flow Diagram (PFD)** | A block flow diagram of the major unit operations showing significant flows is sufficient. | The PFDs indicate the major inputs and outputs of the major unit operation equipment components. | The PFDs show the process flow diagrams of major and minor equipment including bleed and intermittent streams. P&IDs are needed to allow proper cost estimating and a HAZOP review. |
| **Process Description (PD)** | The process description should define the concentration or extraction method | Selection of candidate process flowsheet should be confirmed, and selection explained. Major components and sizing influences should be described. | Details of major and minor processes within process are provided. This includes major components, power draws and sizing influences. |
| **Equipment List (EL)** | Type of equipment is indicated. | Major equipment components are identified. | Major equipment and supporting equipment are identified and power requirements are indicated. |
| **Control & Operations Strategy** | None is recommended | Basic description should be provided. | The control and operating strategy including strategy in dealing with ore variability should be described. |
| **Mass Balances (MB)** | A simplified MB should be provided. | A plant MB of the major flows complete with stream densities is provided. | A plant MB of major and minor flows complete with stream characteristics (pH, densities, etc.) product and intermediate grades, is provided. |
| **Energy Balances (EB)** | Very high level analysis, possibly a simple factored estimate based on similar operations. | A preliminary energy balance should be constructed indicating ability to source electrical power and other energy sources, and the level of consumptions. | A detailed energy balance should be constructed indicating ability to source electrical power and other energy sources, and the level of consumptions. |
| **Environment** | The project will likely require waste rock and tailings storage areas, aqueous effluent treatment plant, and perhaps gaseous emission controls. These should be discussed at a preliminary level. | The waste rock and tailings storage areas should have definition, environmental characteristics determined, and all necessary testwork undertaken to demonstrate that an environmentally acceptable project can be constructed, operated and decommissioned. | All environmental aspects of the project should be designed and costed in detail. Acceptance by local communities and the regulatory agencies is a key aspect of any project. |

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| **Level of Capital Expenditures (Capex)**<br>Reference: AACE Recommended Practice No. 47R-11: Cost Estimate Classification System – As Applied in the Mining and Mineral Processing Industries | Capex is by factored comparison to similar project in similar location considering site location impacts (e.g. elevation, geography). Capex may also be by major equipment quotes and factoring from this basis.<br>**Accuracy should be from: -20% to -50% and +30% to +100%.** | Capex is determined with major equipment by budgetary quotations, minor equipment from database, and installation costs by factoring.<br>The basis of estimate is developed from database information.<br>Material take-offs developed or indicated as not developed.<br>**Accuracy should be from: -15% to -30% and +20% to +50%.** | Capex is determined with major and minor equipment by firm supplier quotations, and installation costs by material take-offs<br>The basis of estimate is developed from local information.<br>Construction and logistical execution plans are developed and support the design.<br>**Accuracy should be from: -10% to -20% and +10% to +20%.** |
| **Level of Operating Costs (OPEX)**<br>Reference: AACE Recommended Practice No. 47R-11: Cost Estimate Classification System – As Applied in the Mining and Mineral Processing Industries | Operating cost can be developed by benchmarking for very early-stage studies. Alternatively, or where a higher level of resource category above inferred is being considered, an effort to derive major costs (labour, power, reagents, etc.) should be developed for the project location.<br>**Accuracy should be from ±25 to ±35%.** | Operating costs are developed from testwork (reagent and energy consumption) and local or database costing of labour and reagents relevant to the locale. Cost of power is an especially important local cost, and its derivation should be identified and described. Operating costs include sustaining capital.<br>**Accuracy should be from ±25 to ±15%.** | Process operating costs are developed from testwork (reagent and energy consumption) and using local costs for labour and reagents.<br>Cost of power is an especially important local cost, and its derivation should be identified and described.<br>Individual influence of major operating costs components identified.<br>Supply costs are from creditable, preferably local suppliers capable of providing the supplies.<br>Supply costs from remote suppliers include supply-chain costs, duties, freight, taxes, etc.<br>Labour rates for locals and expatriates should be realistic.<br>Influence of ore variability on operating costs is identified.<br>Operating costs include sustaining capital.<br>Influence of variable operating costs in the financial model is identified.<br>**Accuracy should be from ±15 to ±10%.** |

## A4. Process Risks

| FACTOR | PRELIMINARY ECONOMIC ASSESSMENT | PREFEASIBILITY | FEASIBILITY |
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| **Deposit/Orebody Complexity** | Influence of mineral deposit complexity (mineralogically complex materials, variances in hardness, etc.) upon the process should be identified. | Influence of deposit complexity on recovery or product quality should be indicated. Indicate if this complexity has been considered with the process design. | Influence of orebody complexity upon the process should be assessed. The impact of this complexity on recovery and ability to produce a marketable product should be indicated. Explains how the process design deals with orebody complexity. |
| **Flowsheet Complexity or Novelty** | It should be indicated whether the process is novel or is a common process involving well known techniques for this sort of mineralogy. | Where either complexity or novelty is present, bench scale testwork confirming proof of concept is recommended. Where the process has not previously been implemented on an industrial level, pilot plant testing should be carried out. | Pilot plant or demonstration scale work has been conducted for novel processes. Variances in performance should be confirmed and explained. Typically, an independent peer review process should be performed. |
| **Reference to Ramp-up** | Not recommended. | Suggested. Indicate expected ramp-up for production and costs and assumptions for the basis. | Recommended. Indicate expected ramp-up for production and costs and assumptions for the basis. |

## A5. Other Risks

| FACTOR | PRELIMINARY ECONOMIC ASSESSMENT | PREFEASIBILITY | FEASIBILITY |
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| **Tailings Disposal, Effluent Treatment, and Gaseous Emissions Control** | The nature of the tailings, effluents and gaseous emissions should be indicated, and the form of tailings disposal and effluent and gaseous emissions treatment being contemplated. | An appropriate level of detail should go into the definition of plant emissions and how they will be handled in an appropriate manner. Environmental experts should be involved as necessary tonsure a solid design and mitigate risk. Review social acceptance and regulatory compliance. | At this level, consideration should be made of the impact of ore variability on the ability to provide proper tailings disposal and effluent treatment. The process expert will typically work with environmental experts in the review of all environmental aspects of the project to ensure social acceptance and regulatory compliance. |
| **Health and Safety** | It should be indicated where the process involves the use of potentially hazardous processes or chemicals and the level of risk which might | In delineating the process, accommodation should be made for the appropriate control of worker health and safety risks. Where a | At this level, the presence of hazardous processes or chemicals means plans should indicate how these issues will be dealt with. There should be |

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| | be encountered. | hazardous process is envisaged, there should be consideration as to how uncontrolled incidents will be managed | a response plan in the event of an uncontrolled incident. A HAZOP review should be completed. |
| **Interactions with Other Disciplines** | Influence of non-process factors (weather, location, potential ARD, etc.) should be identified if they are likely to impact the process. | In addition to factors indicated as problems at the scoping level, water supply and quality is an especially critical process factor and comments should be made regarding any potential difficulties. | Impact from other areas on the process and plant design should be indicated and described. In particular, the plans for storage of tailings and release of excess water to the environment should be reviewed and commented on considering the local environmental regulations. |
| **Community Relations (CSR)** | Contribute process and process design specific information to assist in determining the influence of location on local community or communities, and the general community perception of mining development. | Input to CSR activities related to the processing plant, including use of specific reagents, environmental discharges or emissions, noise from operations, etc. | Input to CSR activities related to the processing plant, including use of specific reagents, environmental discharges or emissions, noise from operations, etc. Develop processing-related plans to minimize impacts and manage community relations. |