Evaluation of secondary diamond (and gemstone) deposits according to the SAMREC Code

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Synopsis

Alluvial diamond and other gemstone deposits have, typically, been exploited by small artisanal operations with little or no geological control. Over the last decade, however, alluvial deposits have become more interesting to larger (often listed), mid-tier companies wishing to benefit from the higher incomes generated by high-quality stones.

The difficulties associated with evaluation and valuation of such alluvial diamond/gemstone deposits are widely known but, regrettably, often not widely understood – leading to several misconceptions over what can and cannot be expected from such deposits. Fortunately, there is a reasonably well-established body of knowledge on alluvial diamonds that has resulted in accepted industry-standard practices of how to evaluate these deposits.

The 2016 version of the SAMREC Code includes several sections specific to the requirements of secondary diamond and gemstone deposits, both alluvial and marine. Consequently, it is possible to define Diamond/Gemstone Resources in accordance with the major international Committee for Mineral Reserves International Reporting Standards (CRIRSCO) type codes. This paper outlines some of the requirements and some of the pitfalls that need to be appreciated while estimating Diamond/Gemstone Resources and/or Reserves on such deposits.

Keywords
Reporting Codes, SAMREC, alluvial diamonds, gemstones, Resources, Reserves.

Introduction

Historically, alluvial diamond and gemstone deposits (the term 'alluvial' in this paper includes all secondary fluvial, marine, and/or aeolian deposits) have been mined on a small-to-medium scale by artisanal operators/diggers or by so-called 'professional diggers'. Seldom do these kinds of operators do any substantial formal exploration ahead of mining and, because they are generally not listed on a public stock exchange, they rarely have need for Competent Persons Reports (CPRs) or geological reports.

However, over the past decade, a number of mid-tier listed companies have invested significantly in alluvial diamond deposits in South Africa (Etruscan Diamonds and Rockwell Diamonds, for example) and in other parts of Africa (Zimbabwe, the DRC, Angola, Liberia, and Sierra Leone, specifically). Marine deposits (onshore and offshore) have also been successfully mined along the South African and Namibian west coast. Examples of current, commercial alluvial diamond mining operations include those in Angola (Lucapa Diamonds NL, TransHex) along the Sewa River, Sierra Leone (Allotropes/Newfields NL), and South Africa (TransHex). The same is true with gemstone deposits in Zambia and Mocambique (Gemfields Group Limited), Israel (Shefa Gems), Colombia/Mocambique (Fura Gems), and elsewhere.

Since most of these companies are publicly traded (in Australia, Canada, South Africa, or the UK), they require Code-compliant documentation. Although not a public company, NAMDEB (De Beers' mining company in Namibia) reporting procedures are still Code-compliant, to assure their partners and investors of their application of best-practice, transparency, materiality, and competence.

Because alluvial diamond deposits have long been associated with artisanal operators, resource estimations for these types of deposits have historically been deemed to be impossible. The 2016

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SAMREC Code (The South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves), and especially the associated Diamond/Gemstone Guideline document (SAMREC Guideline Document for the Reporting of Diamond Exploration Results, Diamond Resources and Diamond Reserves (and other Gemstones, where Relevant) v.1.2) include several sections that will assist in the production of technical reports that comply with Resource/Reserve estimation codes internationally. While much of this discussion focuses on diamond deposits, the guidelines are equally applicable to gemstone deposits and such operators should take cognisance of these guidelines in the evaluation and public reporting of such deposits.

Diamond deposits are different from deposits of other commodities such as precious and base metals for a number of reasons:

- Their low diamond content and high heterogeneity (Lock, 2003)
- The term 'quality' cannot be substituted for 'grade'
- The widely differing nature of deposits in varying fluvial and marine environments and their associated forms of mineralization results in differing estimation methods that may be applicable under unique circumstances
- The specialized field of diamond valuation. The particulate nature of diamonds, and their individual physical characteristics and underlying diamond size frequency distribution (SFD) patterns, have a significant impact on diamond value.

Notwithstanding these differences, alluvial diamond deposits can be evaluated and classified using the standard SAMREC Code classification system (SAMREC Code Figures 1 and 3 – not reproduced here). In this document, both fluvial and marine deposits are included in the term 'alluvial'. It is important to note that for all diamond exploration and evaluation reporting the correct terminologies are: Diamond Exploration Results, Diamond Resources, and Diamond Reserves, as per SAMREC Figure 3.

Diamond Exploration Results

For the most part, all of the provisions of SAMREC dealing with Exploration Results and Exploration Targets (Conceptual and pre-resource Mineralisation) apply equally to alluvial diamond deposits. Diamond-specific issues such as bulk sampling or trial mining, diamond size/value frequency distributions, the number of diamonds required for valuation purposes, *etc* are addressed in the Diamond Guidelines.

Most importantly, it must be noted that neither kimberlitic indicator minerals (KIMs) nor microdiamond data are applicable to alluvial deposits. KIMs and microdiamond data pertain specifically to primary deposits. Since alluvial deposits may be the result of erosion of any number of primary sources (both barren and diamondiferous), this data has no relevance for secondary deposits.

Diamond Resources

As with any other Mineral Resources, it is fundamental for a Diamond Resource to have Reasonable Prospects for Eventual Economic Extraction (RPEEE). With reference to the requirements of SAMREC Table I, RPEEE needs to be demonstrated through a high-level, reasoned assessment of applicable factors and justified to the satisfaction of the Competent Person (CP). This assessment is not a Scoping, Pre-feasibility (PFS), or Feasibility Study (FS) and cannot be used for conversion to a Diamond Reserve. However, it must include an assessment, at an appropriate level, of the geological, engineering (including mining and processing parameters), metallurgical, legal, infrastructural, environmental, marketing, socio-political, and economic assumptions which, in the opinion of the CP, are likely to influence the prospect of economic extraction.

According to the Diamond Guidelines, such an assessment must be based on the principle of reasonableness and be justifiable and defendable. The assumptions used to test for RPEEE must be within known/assumed tolerances or have examples of precedence and be applied at an appropriate and practicable scale. The principle of reasonableness shall be applied together with the primary SAMREC Code principles of Materiality, Transparency, and Competency.

In order to demonstrate that a Diamond Resource has RPEEE, some appreciation of the likely stone size distribution and value is necessary, however preliminary this estimate may be. Furthermore, spatial data distribution, as well as geological and grade continuity, must also be considered. It is also critical that project economics risk factors be clearly defined, and that these are current, reasonably developed, and based on generally accepted industry practice and experience. As an example, the potential capital cost may be relevant and should always be shown to be recoverable from project revenue.

SAMREC does not define any drill spacing or sampling number/size criteria; rather, this is determined by the site-specific geological model. Drilling and sampling must be optimized appropriate to the deposit type and style of mineralization. The programme needs to consider factors such as shape, number, and type of sedimentary facies and the average grade as well as grade variation expected. In complex deposits it may be difficult to ensure that bulk samples are truly representative of the whole deposit. As a result, drilling and sampling on such deposits may need to be significantly more extensive than for primary deposits in order to attain to the same level of resource classification. In extrapolating both stratigraphic and grade/value data, the CP needs to keep in mind the uncertainty in known or expected spatial continuity of the particular depositional environment.

Classification of a Diamond Resource requires actual sampling information from the project property or particular geological domain. Resource grades or values cannot be based on production data from adjacent properties. Neither can Resource parameters be based on unverified or unverifiable historical estimates, anecdotal evidence, or artisanal results. Estimates of quantity, grade, or value based on limited information and analogies with known deposits of similar geological character are inadequate for classification as Inferred Diamond Resources.

Note that geological evidence of continuity of mineralization based on outcrops, trenches, pits, workings and/or drill-holes is required to estimate a Diamond Resource. Geophysical anomalies, remote sensing data, satellite images and/or aerial photograph evidence alone are insufficient to estimate volumes. Any such data requires an appropriate amount of corroborating drilling

and/or pitting information, with realistic extrapolation around data-points. If volumes are converted to tonnages, then sufficient density determinations need to exist – the CP will decide what is sufficient, based on the consistency of results.

The requirement of actual sampling data is one of the main stumbling blocks for acceptable Resource estimation on alluvial diamond projects. Many promoters try to 'shoehorn' Exploration Targets into the Inferred Resource category, where such projects lack surveyed sample volumes, verifiable production data, and/or sufficient Kimberley Process-compliant diamond sales/valuation data. Without such information, the project cannot be classified as a 'Resource'.

The Diamond Resource classification categories (Figure 1) are fundamentally the same as for any other mineral deposit. However, it should be noted that few diamond deposits ever get to Measured Resource classification (Lock, 2003), and marine deposits often will not even attain Indicated Resource status. While achieving a Measured Resource classification is not impossible for an alluvial diamond deposit, it is most unlikely due to the lack of geological homogeneity and uncertainty in spatial continuity of size, grade, and price/value relationships in such deposits. This means that Proved Diamond Reserves are also most unlikely.

SAMREC Clause 24 notes that where untested practices are applied, they must be justified by the CP. This is especially applicable where novel, untested, nonstandard, or little-understood methodologies are used for the determination of RPEEE and Resource estimation. Where such methods are used, they need to be accompanied by peer-reviewed academic or technical references, and they require detailed explanations, discussion, and justification.

These issues apply most directly to the use of geostatistical estimation methods. While such methods can be of inestimable value (Oosterveld, 1972, 2008; Phillips, 1971; Rombouts, 1987; Sichel, 1972; Jacob, 2016), geostatistical estimations based on small samples have not been universally successful, especially on fluvial deposits. Therefore, when applied in these environments, careful consideration and justification is required.

Irrespective of the class of Resource selected, the estimate must identify separate geological domains, where applicable. Each domain should have, at least (however preliminary), initial indications of area/volume, diamond grade, diamond size frequency distribution, diamond value, and RPEEE. This is specifically applicable to alluvial deposits where different depositional environments can have widely differing diamond carrying characteristics.

Also required for all classes of resource estimation is a size-frequency distribution (SFD) with a minimum of 100 ct recommended for a low confidence SFD. It is important for the CP to discuss the sizing definition used (*i.e.* DTC, Rubin/Antwerp, Christensen, grainers, square mesh, Tyler mesh, *etc.*) and to note whether the size classifications are the same for SFD and value data and provide correlations/conversions where more than one system has been used.

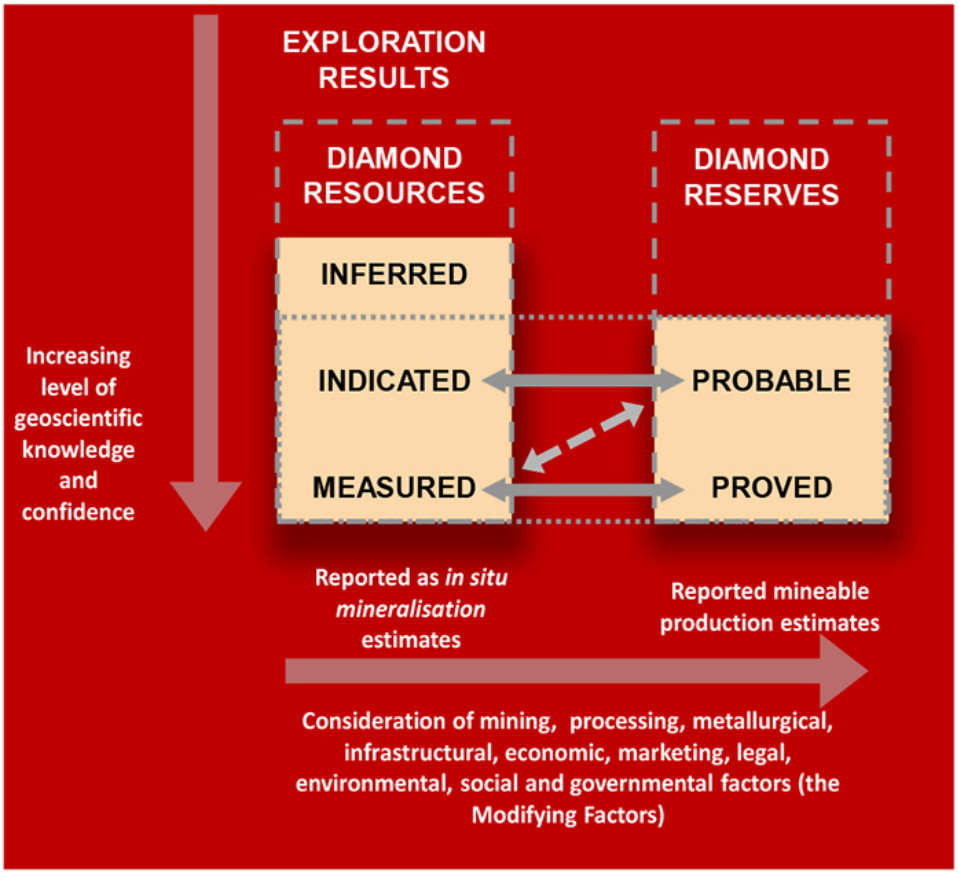

Figure 1—Classification of Diamond Exploration Results, Diamond Resources, and Diamond Reserves (SAMREC, 2016)

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Diamond Resource classification

In the selection of the Resource category, classification criteria need to be disclosed and justified using a systematic methodology utilizing transparent criteria which must be discussed explicitly and in sufficient detail so as to be clearly understood. The SAMREC Code stresses that higher levels in the Diamond Resource classification are dependent on both increasing geological knowledge and confidence in the geological data. Therefore, the amount of direct sampling, and the level of uncertainty in spatial continuity of size, grade, and price/value relationships should determine the appropriate Resource category. It is incumbent on the CP to justify the classification in a transparent and professional manner.

Unlike most other commodities, for the classification of any category of Resource, there needs to be verifiable information regarding volume/tonnage, diamond grade, and diamond value. In addition, bottom cut-off screen sizes need to be reported for each Diamond Resource statement/tabulation. As with all Mineral Resource statements, Exploration Results may not be included in a Diamond Resource statement.

Due to the importance of diamond value, the SAMREC Code provides guidance on the (run-of-mine) parcel size required for valuation. It is fundamental to appreciate that under specific circumstances, the number of carats or stones required to estimate the diamond value to a low, reasonable, or high confidence may need to be significantly different from the numbers given for guidance (typically higher, seldom lower). The CP must discuss (transparently, on an 'if not, why not' basis) the rationale behind the number of stones or carats selected and the level of confidence in the estimate.

SAMREC Clause 62 notes that '*Where the valuation is used in the estimation of Diamond Resources or Diamond Reserves, the valuation shall be based on a parcel representative of the size distribution and assortment of the diamond populations in the deposit. The CP shall explain the rationale behind the parcel size that has been used in the estimation of value for the Diamond Resource or Diamond Reserve and the level of confidence in the estimate. The minimum representative size of the valuation parcel depends on the characteristic stone distribution and quality of stones in the deposit. For all valuations (irrespective of Resource classification), associated diamond size frequency distributions shall be provided, along with a discussion of the relevant applicable parcel size.*'

The guidelines recommend that for an Inferred Diamond Resource, 500 ct may be sufficient for a low confidence valuation, depending on the SFD. For an Indicated Resource, 2000 ct may be sufficient for a deposit where the SFD indicates low variability of size (typically primary deposits), while more than 2500 ct would be required for a high variability environment such as an alluvial deposit (see also NAPEGG, 1997 for reference). Under specific circumstances, parcels of more than 5000 ct may be required, and in extreme cases an adequate parcel size may never be achieved during industry-standard evaluation sampling. or even trial mining. Such cases would likely include deposits characterized by large, high-quality/value stones. A marine environment, which is typically not highly variable, may be valued by 500 ct (Inferred Resource) to 1000 ct (Indicated Resource), depending on how well the SFD is constrained. A revenue estimate is date-specific and linked to a value or price that should not be more than six months old. Although it might not be practicable under all circumstances, best practice would be to try and keep all evaluation parcels for future use.

For all Resource categories, the diamond parcel (for value) must come from the property (and from the deposit being estimated) – it must not be a regional value nor extrapolated from adjacent/nearby operations, nor even from a satellite deposit.

One of the challenges with any diamond deposit is that it is not possible to assay for diamond content. As shown above, geostatistical estimations of grade based on a small sample size have not always been universally successful, especially for alluvial deposits. Consequently, the most reliable information can only be obtained from bulk sampling. Typically, this involves taking large, representative samples by pitting, trenching, and/or large-diameter diameter drilling (LLD) in the land environment, and through diver sampling and probe drilling platforms offshore. The advantage of such bulk-sampling operations is that they can grow seamlessly into trial mining (where they can form the basis of a Pre-feasibility or Feasibility Study) and, thereafter, to full-scale production.

Inferred Diamond Resources

In many instances an Inferred Diamond Resource has erroneously been taken to mean almost the same as an inventory, with pretty much everything potentially occurring on a property being included. The requirements of SAMREC 2016 make it clear that a significant amount of work has to be done on an alluvial deposit before even an Inferred Resource can be estimated – an Inferred Diamond Resource is a low-level estimate, not a no-level estimate and definitely not a 'guesstimate'. The associated increase in confidence is expected to help to increase investor confidence and the ability to raise finance from stock exchanges and other public institutions.

The SAMREC Diamond Guidelines highlight a number of features required to make certain that the Inferred (alluvial) Diamond Resource estimate is at an acceptable standard:

- The majority of Inferred Diamond Resources are reasonably expected to be upgraded to Indicated Diamond Resources with continued exploration. However, often an Inferred Diamond Resource is presented as covering a very large area (up to farm scale), being an average of data collected from very specific locations. Subsequently, an expanded drilling/pitting programme has shown that 80–90% of the Resource actually cannot be mined economically for one reason or another, and the resulting Indicated Resource is a very small proportion of the original. This is not an acceptable practice.
- An Inferred Diamond Resource is often based on interpolation between widely spaced data where there is reason to expect geological continuity of mineralization. However, the extent of extrapolation outside of the nominal drilling or sampling grid spacing needs to be justified. The reader needs to be provided with sufficient information in respect of:

  - The maximum distance that the Diamond Resource is extrapolated beyond the sample points
  - The proportion of the Diamond Resource that is based on extrapolated data
  - The basis on which the Diamond Resource is extrapolated to these limits
  - Diagrammatic representations (maps) should be included which clearly and unambiguously show the part of the Inferred Diamond Resource that has been extrapolated beyond actual sample points.
- Where the Diamond Resource being reported is predominantly an Inferred Diamond Resource, sufficient supporting information must be provided to enable the reader to evaluate and assess the risk associated with the reported Diamond Resource.
- Some 500 ct of diamonds (run-of-mine production) should be recovered for purposes of diamond valuation (revenue estimation). Typically, on alluvial deposits this means 500 ct sold through an applicable Kimberley Process mechanism.

Bulk sampling vs trial mining

On alluvial deposits, bulk sampling programmes expand into trial mining, which typically moves seamlessly into full production mining once the techno-economic or Modifying Factors of the gravels are determined. In the interests of standardized terminology (SAMREC Diamond Guidelines):

- *Bulk sampling* is taken to be the initial period of sampling during which Exploration Targets are investigated and Diamond Resources are identified.
- *Trial mining* is the period during which the relevant mining, processing, and other economic factors (the Modifying Factors) are evaluated that may, ultimately, lead to the conversion of some or all of the Indicated Diamond Resources to Probable Diamond Reserves. Trial mining typically forms the basis of the PFS/FS. In certain circumstances (specifically marine projects), trial mining may not always be justifiable, and Modifying Factors are, typically, projected from engineering design specifications and historical performance. These are then used to estimate production with appropriate ranges which are imported into the financial and risk assessment models. The methods of mining and processing used in the bulk sampling, trial mining, and production mining phases of alluvial operation may be similar (but not necessarily so), except for the volumes processed. Full production is typically initiated once Diamond Reserves have been identified. Due to the nature of alluvial diamond deposits, it is often not possible to complete a single-stage PFS that converts all of the Indicated Resources to Probable Reserves. Ongoing production from Diamond Reserve blocks typically acts as a continuous trial mining (PFS/FS) programme for the adjacent Indicated Diamond Resource. As a result, as mining of existing Probable Diamond Reserves proceeds and as confidence in the geological and mining parameters is upheld (or increases), then surrounding Indicated Diamond Resources can be upgraded to Probable Diamond Reserves on a continual basis, without the need for a separate technical study (see, for example Lock, 2004). It is, generally, only in situations where new processing methodologies are introduced (or where any of the Modifying Factors change materially) that an additional PFS/FS may need to be completed.

Technical Studies

There are no differences in the requirements for Technical Studies on alluvial diamond deposits and for any other mineral deposit. The same Modifying Factors need to be considered to the same levels of confidence and in the detail required by SAMREC Table II. Indicated Diamond Resources can be converted to Probable Diamond Reserves through a PFS/FS. On alluvial diamond projects, a trial mining programme typically fulfils the role of a PFS or FS.

It is worth noting that Scoping Studies require the estimation of Inferred Resources, at least. No Technical Study can be done on conceptual Exploration Targets or pre-resource Mineralisation and Scoping Studies cannot be used to convert Resources to Reserves. However, during the early stages of exploration (to generate Exploration Targets or identify pre-Resource Mineralisation), some level of financial analysis is often carried out by a company on exploration data which might not include Diamond Resource estimates, to assess the potential for the project to proceed to the next phase of exploration. These analyses are considered to be a part of the exploration programme planning and are *solely for internal company decision-making purposes. They are not for public disclosure*.

Since conventional macro-diamond processing techniques are not designed to liberate or recover all contained diamonds, there is no such thing as an '*in-situ*' grade – it is only a processed or recovered grade, which is dependent on the plant or process employed. Therefore, the relative efficiencies of sampling and subsequent mining technologies must be addressed. These recovery factors are given more confidence through the use of tailings and tracer audits.

Diamond reserves

Likewise, the principles of Diamond Reserve Estimation of alluvial diamond deposits do not vary significantly from those determining Mineral Reserves on other types of deposits, and all the relevant clauses (no. 35 to 43) in the SAMREC Code apply equally to alluvial diamond deposits. Especially important in the estimation of Diamond Reserves is the degree of confidence that can be placed in the diamond revenue model.

Since a Proved Diamond Reserve is based on a Measured Diamond Resource, and since this status is seldom achieved on alluvial diamond deposits, it follows that Proved Diamond Reserves will rarely be attained.

One common mistake made in many alluvial diamond projects is the assumption that a Diamond Reserve is a fixed parameter and can be transferred from one operator to the next. Diamond Reserve grades cannot be measured absolutely (there is no such thing as an (*in-situ alluvial diamond grade*'). Grades estimated through the use of one processing technology may not be applicable to another type of plant. The Modifying Factors must be determined for each specific project and operator.

Mine planning

The SAMREC Code allows that mine planning and design may include a portion of Inferred Resources. However, there are a number of caveats and provisos that need to be borne in mind when including such Inferred Resources in a mine plan – these are the same as for any other mining operation. Modifying Factors and assumptions that were applied to the Indicated and Measured Diamond Resources to determine the Diamond Reserves must be equally applied to the Inferred Diamond Resources, if such are considered as part of the Life-of-Mine Plan. Although included in a Life-of-Mine Plan, Inferred Diamond Resources cannot be converted to Diamond Reserves and must not be stated as part of the Diamond Reserve.

Compiling a CPR for an alluvial diamond project

The SAMREC Code contains a section dealing specifically with the reporting of Diamond Exploration Results, Diamond Resources, and Diamond Reserves (Clauses 60 to 72), inclusive of diamond-specific classification categories. These clauses include modified definitions; probably the most important is that volume/tonnage (quantity) and grade and diamond value are all required for all classification levels of Resources and Reserves. Section 11 of Table I in the SAMREC Code lists the diamond-specific requirements that are to be included in a CPR. Such information is not to be appended as a separate chapter of the CPR but must be incorporated into the general reporting sections.

The reporting of diamond projects requires the application of the Diamond Guideline document, which provides the methodologies and definitions of the relevant terms that must be considered when preparing reports on Diamond Resources and Diamond Reserves. This Guideline document addresses various issues specific to alluvial/marine deposits. The Guideline document also contains (Appendix A) a guide to a Table of Contents that may be used when compiling CPRs.

Due to the nature of alluvial diamond deposits, they often give rise to abuse of environmental, social, and/or governance issues. As a result, its is important for the CP to pay more than the usual attention to these matters. The South African Guideline for the Reporting of Environmental, Social and Governance parameters within the Solid Minerals and Oil and Gas Industries (SAMESG, 2017) has been compiled to assist CPs in completing the relevant sections of Table 1 in the SAMREC Code.

Valuation of an alluvial diamond deposit

As with any mineral asset, valuation of alluvial diamond deposits must be done in accordance with SAMVAL 2016 and must be based on a SAMREC-compliant Resource/Reserve estimation report (or any CRIRSCO-based Code). Since most alluvial diamond valuations will, likely, be for projects in early-stage exploration, most valuations will be based on Cost and Market methodologies (McDonald, 2017; van der Merwe, 2017). It is only when Diamond Reserves (based on Indicated Resources and at least a PFS) have been estimated that Income-based methods, particularly the popular Discounted Cash Flow, are acceptable (Marshall, 2016). Inferred Resources can be valued by such methods only if subjected to the caveats required by SAMVAL.

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