AUSTRALIAN GUIDELINES FOR THE ESTIMATION AND CLASSIFICATION OF COAL RESOURCES

(Issued as an Exposure Draft to Industry – March 2014)

Contents

Figures

Appendices

1 Preface

Prior to September 1999 the estimation and reporting of Coal Resources and Coal Reserves in Australia were prescribed by the "Australian Code for Reporting Identified Coal Resources and Reserves (February 1986)". This code was ratified by the Government Geologists’ Conference in April 1986 and appended to the "Australasian Code for Reporting of Identified Mineral Resources and Ore Reserves", prepared by the Joint Ore Reserve Committee (JORC) in February 1989. This document (known as the JORC Code) was subsequently revised in 1992 and 1996.

In 1999, a significant revision occurred which resulted in the inclusion of the reporting of Coal Resources and Coal Reserves into the “Australasian Code for Reporting of Mineral Resources and Ore Reserves”. This version of the JORC Code referenced the 1999 edition of the “Guidelines for the Estimation and Reporting of Australian Black Coal Resources and Reserves”. The guidelines were updated in 2003 as the “Australian Guidelines for Estimating and Reporting of Inventory Coal, Coal Resources and Coal Reserves”, and were referenced in the 2004 and 2012 editions of the JORC Code.

“The JORC Code 2012 Edition”, herein referred to as “the Code”, provides minimum standards for public reporting of Exploration Results, Mineral Resources and Ore Reserves to the investment community. The Code states in Clause 42: “For guidance on the estimation of Coal Resources and Reserves and on statutory reporting not primarily intended for providing information to the investing public, readers are referred to the ‘Australian Guidelines for Estimating and Reporting of Inventory Coal, Coal Resources and Coal Reserves’ or its successor document as published from time to time by the Coalfield Geology Council of New South Wales and the Queensland Resources Council.”

This successor document, the “Australian Guidelines for the Estimation and Classification of Coal Resources”, herein referred to as “the Coal Guidelines”, represents a substantial update of that work. It will continue to be reviewed periodically and re-issued as required.

Adherence to the processes and procedures outlined in the Coal Guidelines is recommended. This document must be read in conjunction with the Code, and if any conflict is perceived between this document and the Code, the Code takes precedence. Some of the wording in the Coal Guidelines has been copied from the Code and the reader should note that requirements of the Code are mandatory if an estimate is said to meet the standard of the Code. The reader may also refer to relevant publications listed in the Recommended Reading section of the Coal Guidelines.

2 Scope

The scope of this document is to:

- Provides guidance reflecting good practice, and which is recommended to be followed when classifying and estimating Coal Resources;
- Provide guidance for the determination of reasonable prospects for eventual economic extraction (reasonable prospects) as this pertains to coal deposits;

- Provide a variety of assessment tools that can be used by the Estimator for the estimation and classification of Coal Resources**,** rather than solely the application of suggested maximum distances between Points of Observation that were included for guidance in previous versions of this document; and
- Define Inventory Coal which is not defined in the Code.

The Coal Guidelines are broad in nature to accommodate the wide variation of coal deposits in terms of rank, quality and geological environment.

References to Coal Reserves in the previous version of this document were a partial replication of Ore Reserves documented in the Code. Since Coal Reserves are adequately covered by the Code they are not replicated in the Coal Guidelines.

In this document important terms have a definition provided in the Glossary of Terms (Section 3).

3 Glossary of Terms

The following terms and their intent are used in this document.

Term	**Definition and Usage**
Australian Standards	Australian Standards are the standards published by Standards Australia and which govern, amongst many other things, the manner in which coal and coke are sampled, analysed, tested and the results reported. There are Australian Standards to cover virtually all tests relevant to coal resource evaluation and it is anticipated that coal analysis work carried out in Australia will be conducted according to these standards. AS1038 is the prefix used to identify the principal Australian Standards that detail the methods for analysis, testing and reporting of Quality in higher-rank coal and coke. AS2434 is the prefix used for a similar series of Australian Standards for analysing and testing lower rank coals. There are other relevant standards, including AS4264 (sampling), AS2419 (technical evaluation of hard coals) and those applicable to coke analysis.
Basis (Reporting)	Reporting Basis refers to the state of the sample on which the Quality assessment is based, and considers the moisture and ash components within the sample. The Competent Person should state the Reporting Basis of any Quality parameter in all forms of data storage, in the Inventory Coal or Coal Resource estimate and in all reports. Raw data may include data at a range of Reporting Bases and it is important that the Reporting Basis is known. The most common are: as received, air dry, dry and dry ash free and these are defined in the following table. There are others that are rarely seen (ash-

	Term	Definition and Usage
		free moist, dry mineral matter free and dry, minerals and inorganics free) and these are not defined here. In terms of coal quality parameters that are relevant to reporting of Coal Resources, most that are moisture dependent are reported at air dried basis (the value of which should be stated). In terms of reporting of coal quantities, in situ moisture is the correct reporting basis and this should also be stated. In situ moisture is the moisture content of the coal, undisturbed in the ground.
58	Coal Reserve(s)	Coal Reserve(s) has the same meaning as “Ore Reserve(s)” as defined in the Code.
59	Coal Resource(s)	Coal Resource(s) has the same meaning as “Mineral Resource(s)” as defined in the Code.
60	Competent Person	Competent Person(s) has the same meaning as “Competent Person(s)” as defined in the Code.
61	Composition	Composition of coal refers to the chemical characteristics of a coal sample. These in turn depend on the combination of rank, type and grade of the coal, and also the extent to which the coal may have been modified by beneficiation.
62	Confidence	Confidence in Resource classification refers to the Estimator’s assessment of the critical data for a coal deposit and the likelihood of change or unexpected results from additional exploration.
63	Critical Variables	Critical variables are those physical and chemical properties of coal that may potentially limit reasonable prospects for eventual economic extraction. Understanding the distribution of critical variables within the deposit is of importance in defining the confidence of classification for the Coal Resource.
64	Density	The density of a coal sample is dependent on the mineral matter and moisture content of the coal. The moisture content of a sample will be affected by the manner it has been handled, broken, dried, or analysed. The determination (best estimate) of the density of coal in situ requires the conversion of those densities and moistures determined in a laboratory. The industry standard method follows the Preston and Sanders formula (Preston and Sanders, 1993) which utilises the best estimate of the in situ moisture (from a Moisture Holding Capacity test or an Equilibrium Moisture test) in conjunction with the laboratory-determined air dried density and air dried moisture content of the sample.
65	Domains	Coal deposits are typically heterogeneous and a key aspect of any

	Term	Definition and Usage
		resource estimation is to define the areas of a deposit that have similar features, known as geological domains. Domains may encompass features that impact on the mineability (reasonable prospects), marketability or confidence of that part of the deposit. Analysis and modelling of data should be undertaken on a domain basis.
66	Estimator	"Estimator" is a generic term describing a person(s) who contributes to the estimation of Inventory Coal and/or Coal Resources. For the purposes of public reporting, where an Estimator does not qualify as a Competent Person, then the Estimator must be supervised by a Competent Person.
67	Exploration Target	Exploration Target has the same meaning as "Exploration Target" as defined in the Code.
68	In situ	In situ refers to the condition of the coal as being undisturbed in the ground. An estimate of Coal Resources should state the condition of the coal in the ground and use appropriate values for moisture and density.
69	Inventory Coal	Inventory Coal refers to an estimate of in situ coal that does not consider or does not pass the reasonable prospects test. It may include coal that currently has low prospectivity due to natural or cultural features that preclude mining.
70	Modifying Factors	Modifying Factors has the same meaning as defined in the Code.
71	Quality	Coal Quality is a term that encompasses all aspects of rank, type and grade that contribute to giving a coal its properties, as indicated by a standard suite of tests. Coal quality is normally considered in the context of its potential utilisation and how it might favourably or unfavourably affect the utilisation process.
72	Rank	Coal rank is a concept that describes the degree of coalification (physical and chemical transformation from vegetable material to coal) that has been achieved by coal forming materials, as a consequence of elevated temperature maintained over time and to a much lesser degree, pressure. The causal factor is principally deep burial of coal forming materials within the earth's crust. Coal rank is indicated by a range of properties, notably mean maximum reflectance of vitrinite as measured under standard conditions. Coal type refers to the composition of a coal in terms of its organic components, recognised as its macerals. The macerals are recognised according to a standard classification system, which refers to the original plant material from which they were formed and the degree of subsequent decomposition and degradation.

Term	Definition and Usage
	Coal Grade refers to the inorganic constituents of a coal (the mineral matter) in terms of their total proportion (% mineral matter or its proxy, ash) and in terms of their individual constituents (e.g. % Na, S, P etc.).
Reasonable prospects for eventual economic extraction	Refer Section 7
Points of Observation	Refer section 4
Supportive Data	Refer section 4

4 Points of Observation and Supportive Data

Data includes both Points of Observation that are definitive in nature and Supportive Data that are more indirect.

Points of Observation are sections of coal-bearing strata, at known locations, which provide information about the coal by observation, measurement and/or testing. They allow the presence of coal to be unambiguously determined. Points of Observation have varying degrees of reliability, and can include surface or underground exposures, bore cores, down-hole geophysical logs, and drill cuttings in non-cored boreholes.

Points of Observation for coal quantity estimation may not necessarily be used for coal quality evaluation. A Point of Observation for coal quality evaluation is normally obtained by testing samples obtained from surface or underground exposures, or from bore core samples having an acceptable level of core and sample recovery to be representative, and that should be justified and clearly documented. Points of Observation should be clearly tabulated and presented in plans on a seam by seam basis.

Appropriate coal analysis data should be acquired to determine the nature of the coal and the potential products. If beneficiation is required to achieve a desired product mix and/or additional quality parameters are required to confirm the suitability of the coal then yield and relevant product quality data should be included in the relevant Points of Observation. If this is not the case then the absence of such data should be justified.

Where practical, suitable representative samples should also be analysed to assess the geotechnical conditions of the overburden, interburden, roof and floor strata, the seam gas content and composition, the propensity of the coal for spontaneous heating, the potential of relevant materials for frictional ignition, and any other parameters pertinent to the consideration of reasonable prospects for eventual economic extraction.

Supportive Data are observations supporting the existence of coal, gathered by interpretive or indirect methods. Supportive Data may include results from mapping, 2D and 3D seismic, magnetic, gravity and other geophysical and geological surveys. Supportive Data can be used to improve confidence in seam continuity, but should not be used quantitatively in any estimate. The Estimator, when reporting Supportive Data, shall state the technical basis of the interpretation. Supportive Data may be used in conjunction with Points of Observation to improve confidence levels.

5 Assessing Confidence

5.1 Overview

Resources are classified based on the confidence the Estimator has in the geological data and the estimation. As defined by the Code, the Resource categories are Inferred, Indicated and Measured, which in order reflect increasing levels of confidence in the Resource estimation.

In order to classify Inventory Coal and Coal Resources the Estimator should assess his/her confidence in the estimates for all variables that are of significant interest. Classification categories are also likely to cover a range of confidence limits. The Estimator should clearly define and document the criteria for determining the confidence used to classify Inventory Coal and Coal Resources.

For example, reporting a Coal Resource of coking quality requires that appropriate coking coal test work has been undertaken. It needs to be established that there is sufficient confidence that the stated product can be produced, and it would be misleading to report such a product type without suitable evidence.

In the same way it is necessary to establish sufficient confidence in the estimation of the thickness of thin interbedded coal seams which would be subject to greater sensitivity than a thick and continuous seam.

The accuracy and precision of an estimate can also impact on confidence when the variable of interest is of a critical nature. Where variables of interest have a range that is likely to produce a negative impact in the reasonable prospects test, it is important for the Estimator to define the confidence in the measurement and estimation of those variables.

Confidence in an estimate can be determined by a variety of methods and criteria. The Estimator should select the appropriate method and criteria to demonstrate confidence in the estimate and support the classification assigned to either Inventory Coal or a Coal Resource. Such methods and criteria include but are not limited to:

- Critical assessment of relevant local, geographical and geological settings
- Data analysis, error and verification
- Identifying critical data
- Statistical analysis
- Geological modelling
- Geostatistical analysis

Any Resource estimation should be accompanied by an assessment of the most influential risks to that estimation. Risk assessment is the determination of a quantitative or qualitative value of risk related to a specific condition and a recognized threat (or hazard). The purpose of resource risk assessment is to analyse the fundamental risks that exist with respect to the Resource estimation process, and the potential impacts these may have on the results. Risks associated with Resource estimation include (but are not limited to) regulatory compliance and governance issues, drill and sampling management, and geological modelling risk, as well as computational uncertainty due to structure, stratigraphy, and coal quality variability.

5.2 Critical assessment of relevant local, geographical and geological settings

A comprehensive understanding of the relevant geology and geography of the deposit will guide the Estimator to determine the data resolution required to define Resource confidence. Understanding the geology of the deposit should be the most important factor and the starting point in Resource classification and estimation.

Assessment of the geology of the coal deposit should include, but not be limited to, consideration of the following:

- Regional geological setting;
- Comparison to neighbouring projects, including an understanding of geological similarities and differences; and potential hazards previously encountered in the region;
- The nature of the coal seam, including whether the seam is thick and continuous or is made up of multiple thin seams, has abundant splitting etc.;
- Structure of the deposit, including seam dip, faulting, folding etc.;
- Post-depositional influences, including depth of weathering, unconformities and wash-outs;
- Intrusions, including the impact on seam persistence or structure and on coal quality;
- Geotechnical properties of the coal and the non-coal strata and their influence on the proposed mining method;
- Coal composition and rank and the impact upon coal quality parameters and potential coal product(s);
- Geographical features and the relationship between structural and depositional features, particularly with respect to topographical variability, river systems, weathering and oxidation.

5.3 Data Analysis, Error and Verification

Coal exploration data are dominantly obtained from exploration boreholes, in the form of cuttings and/or cores supplemented with down-hole logs, and from aerial topographic surveys, but may also be derived from surface, underground and highwall mapping, or possibly from trenching, and are often augmented by aerial and ground geophysical surveys.

The importance of understanding the history of the data, including the processes of collection, transfer, validation, conversion and storage, and the time taken to thoroughly understand the data, identify errors and cleanse the data, without which it is not possible to proceed further, cannot be underestimated.

All data should be statistically analysed to understand the properties and relationships within the data-set and to identify any rogue results. The attention of the Estimator is drawn to the requirement to consider the criteria in the Code (Table 1, Section 1) - Sampling Techniques and Data on an “if not, why not” basis.

Some considerations pertinent to analysis of coal exploration data are highlighted as follows:

- **Geographic data**

  Borehole collar, topographic survey and other geographic data need to be validated to confirm that the correct survey datum and grid system has been used. The Estimator also needs to consider the accuracy of survey methods used and check collar information against topographic data to identify anomalous locations.

  Boreholes are not always vertical as assumed in many coal exploration programmes. Borehole deviations need to be checked using downhole surveys, especially for deeper boreholes and holes near significant geological structures.

- **Sample Representivity**

  The Estimator needs to consider that potential loss of material from within a sample may be critical, irrespective of the relative percentage lost. The analysed sample should be representative of the in situ material within the interval of interest. Down-hole geophysical data should be used to confirm the location and nature of any core loss in coal seams.

  Good sample recovery is required for representative samples. The Estimator should identify and document what is considered acceptable for sample recovery. Unacceptable losses must be identified and the sample rejected as a valid Point of Observation where appropriate. Calculated mass recovery (from raw sample mass, relative density, core diameter) can be used to identify field measurement errors. Sample integrity and its impact on particle size distribution should be considered.

  Sampling methods, sample preparation and analysis protocols need to be carefully reviewed to identify potential sources of error that may result in problems with data precision and accuracy.

  In the design of coal sampling and testing programmes consideration needs to be given to the sample top size and available mass to conduct the required tests.

  Checks should be carried out on the various types of data, tracing the results back to the original source(s) and validating the relevant quality assurance / quality control (QAQC) systems”

  Ideally sampling should be carried out using data collected at the ply level for the full coal measures. This will provide a better understanding of the geological controls on coal quality characteristics. Sampling should not be controlled by mining criteria, the parameters of which may change in the future, depending on factors such as economics or client product specifications.

- **Sample History and Impact on Coal Quality and Geomechanical Properties**

  The Estimator needs to carefully evaluate the history of the sample storage and handling from the field to the final analysis. Oxidation is of great importance in the early loss of coking properties; drying has impacts on geomechanical properties, coal moisture and density; and freezing and sample handling has impacts on particle size distribution.

- **Coal Quality**

  An initial check of coal quality data should be carried out to confirm agreement between sampling intervals and lithological intervals.

  The data can then be filtered, sorted, statistically analysed, cross plotted (e.g. relative density vs. ash, calorific value vs. ash), and graphed (e.g. histograms) to understand the data and to check for errors.

  The Estimator should confirm that samples have been taken and analysis has been done to appropriate testing standards.

  The basis of analysis of all parameters needs to be confirmed, and also used consistently when data are combined.

  Coal quality data may require normalisation where exploration has been in progress for a number of years and different approaches to sampling and test-work have been undertaken over time.

  Quality data gathered from individual plies will usually require compositing into working sections. The Estimator’s attention is drawn to the fact that data from many analyses, by their nature, cannot be validly composited (e.g. caking properties).

- **Spatial Analysis**

  The Estimator should confirm coal seam correlations and evaluate geological structure using down-dip and along-strike cross sections, and fence diagrams crossed at appropriate locations.

  Careful evaluation of data posting and contour plots for the various parameters (e.g. thickness, coal quality), on a seam by seam and/or ply by ply basis, is required to validate the data (e.g. by checking for bulls-eyes in contour plots), to understand the lateral and vertical variations in the coal deposit, and to identify any separate geological domains (which can be confirmed using variography).

- **Accuracy, Precision and Error**

  Data measurements must be considered in terms of both precision and accuracy. The differences between precision and accuracy are demonstrated graphically in Figure 1.

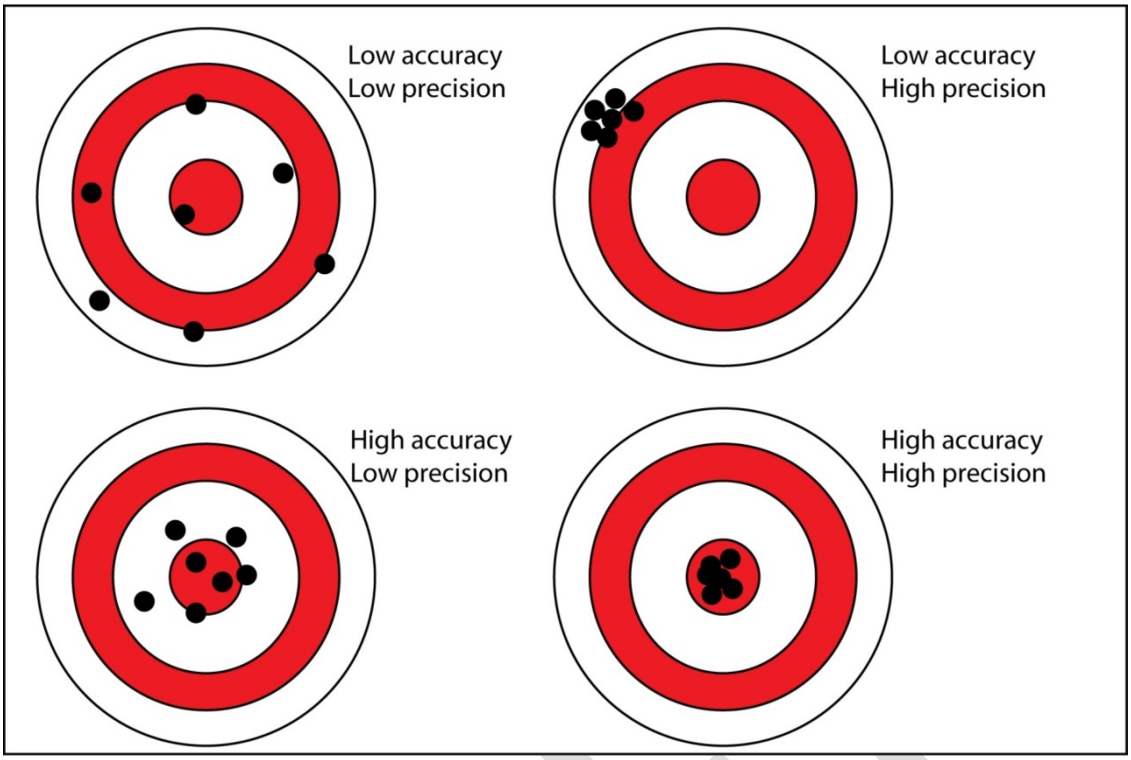

Figure 1: Relationship between Precision and Accuracy

Errors may occur throughout the process of data collection. It is important that the Estimator understands the various forms of error that may occur and how they may be dealt with in reporting (refer Appendix C).

Error may occur in:

- Sampling
- Data measurement
- Data management
- Interpretation
- Estimation
- Reporting

All measurements taken contain some statistical error (observational error). Error does not refer to a mistake, but rather is the deviation between the measured value and its true value.

The Estimator should consider the error(s) that may occur in each form of measurement and accumulate those errors appropriately to provide an indication as to the precision and accuracy of the estimate being made. Data should be stored, used and reported with an appropriate precision.

A variety of techniques can be applied by the Estimator to assess error in all forms of data capture. This requires implementation of rigorous and documented quality assurance and quality control (QAQC) systems to assess the measurement, undertake evaluation and determine the significance of any error. The following techniques should be considered in developing QAQC protocols:

- Documented work practices
- Training and accreditation of personnel taking measurements
- Repetitive testing of known standards throughout normal data capture cycles
- Evaluation of standard and blank measurements over time
- Duplication testing by independent parties
- Independent audits

5.4 Identifying Critical Data

Most deposits contain a number of key attributes which are critical to the economic potential of the contained coal seams. These attributes will be paramount to the determination of reasonable prospects, cut-off limits and Resource Confidence. The Estimator should firstly identify and then focus on those parameters that are critical to the economic viability of the Resource. Since Resources are reported on a seam basis, establishing seam continuity is also critical to the Resource estimate.

Confidence in a resource model is a function of data distribution, adequacy and reliability of critical data, mean value and variability of that data, as well as the understanding of structural complexity, seam continuity and issues related to the proposed mining method.

An assessment must be made which considers, among other things, the attributes that determine the marketability of the coal and the physical attributes of the deposit that may affect future mining.

Seam thickness, areal extent and in situ density are the main attributes which will affect tonnage estimates. The Estimator should estimate tonnages as they are in the ground (i.e. on an in situ moisture content basis) and provide an outline of the methodology employed to determine both in situ moisture and density. The Estimator should ensure that the moisture basis used in the estimate is appropriate and the methods used to mathematically manipulate the data are valid and transparent.

The Estimator must consider quality parameters that may be critical to the mineability and marketability of the coal products from the deposit. This is crucial if the value of the marketable products has an impact on both cut-off limits and reasonable prospects. For example, if washed coal is to be marketed, then product yield should also be considered as a critical parameter in the estimate. If data on product yield are not included in all Points of Observation (for all seams being estimated), then the Estimator should consider downgrading the confidence categories or conversely demonstrate satisfactory correlations between yield and other product parameters (including ash percentage) which can be used to support retention of the confidence categories determined for the in situ coal.

The Estimator should identify critical parameters that may result in contractual penalties or customer rejection. Such an assessment may result in the identification of a critical parameter that needs to be further tested during ongoing exploration and/or incorporated into resource cut-off limits and categorisations.

If PCI or coking products are proposed to be marketed from the deposit, and therefore used to define cut-off limits and support the notion of reasonable prospects, the Estimator should document the appropriate test results to support this marketing appraisal. Additional parameters need to be analysed, including coal rank (vitrinite reflectance), coal petrography, various coking properties, phosphorous and critical trace elements. If hard coking coal is considered to be part of the product mix, the results of coke tests should be considered in order to support such a conclusion.

The Estimator should also consider other quality parameters that characterise the deposit and provide additional information regarding reasonable prospects. These parameters need not necessarily be incorporated in all Points of Observation, but should be available in sufficient quantity both laterally and stratigraphically to characterise each seam in the deposit. These quality parameters include but are not limited to ash chemistry, forms of sulphur, trace elements, equilibrium moisture, ash fusion temperature, abrasiveness and grindability properties. Consideration should be given to the inclusion of gas content, gas composition and permeability test results.

The Estimator should consider defining different spatial and stratigraphic domains within the deposit if required. For example, the coal quality and seam thickness characteristics of a deposit may meet the specifications and criteria for marketability over most of the deposit. There may, however, be specific areas (domains) within the deposit where the structural complexity, key quality parameters or other critical attributes may impact on coal mineability, or on the marketability of the mine product(s).

The Estimator will need to analyse variability and confidence for individual seams in relation to critical parameters and assign confidence and cut-off limits on a seam basis as appropriate. In a multi-seam deposit it may be necessary or appropriate to consider groups of seams, but this should be clearly justified by the Estimator. The Estimator should document the distribution of Points of Observation and critical data on a seam basis, using appropriately scaled and legible plans as well as in a tabulated format (per borehole). Variability in critical parameters may change in different parts of the deposit (such as thickness and ash yield adjacent to palaeo-channels or subcrop). Lateral seam thickness variations (rapid thickening and thinning) can also occur, often as a function of the environment of deposition.

5.5 Statistical Analysis

If a coal deposit is sampled in a fashion that is appropriate to demonstrate the variability in geological and coal quality characteristics, then a reasonable estimate of the population distribution for the key parameters may be obtained. It is important that the sampling techniques undertaken should represent both the spatial distribution and the variability of those parameters considered critical to the deposit.

The Estimator can undertake an analysis to develop an understanding of population sample statistics for key parameters, such as:

- Number of samples,
- Minimum and maximum variable values,
- Mean and median,

- Standard deviation,
- Variance,
- Coefficient of variation,
- Standard error of mean,
- Confidence limits of the mean, etc.

The Estimator should consider the use of such tools as histograms (normal and/or log), scatter plots, box and whisker plots, the coefficient of variation and cumulative distribution frequencies to illustrate the distribution of data in the sampled population. These should support the Estimator's understanding and confidence in the geological domains defined throughout the geological terrain.

Examination of the extreme ends of a sampled population distribution may indicate the presence of outliers (anomalous results). Good practice is to check such results and determine a likely cause for the anomaly, and hence the data adequacy, before inferring anything about the sample value. The Estimator should undertake appropriate data analysis prior to excluding (with supporting justification) such samples from the population.

Not all variables sampled will follow a normal (Gaussian) distribution and the Estimator should consider the impacts of this when reporting certain statistical results.

5.6 Geological Modelling

5.6.1 Geological Interpretation

A geological model is a mathematical depiction of the data which honours the geological interpretation of the deposit. . The Estimator should have a good understanding of the geology before constructing the model, as this will guide selection of the modelling technique for the deposit.

The model may be divided into several domains based upon the geology and data distribution. Key features for domain definition may include: seam splitting and coalescing, intensity of structural deformation, seam dip, igneous intrusions, washouts, seam subcrop and coal quality trends. Care should be taken in extrapolating trends across domain boundaries.

5.6.2 Data Selection

Inputs into the model should be verified as reliable and representative of the geology prior to construction of the geological model. Any data that have been excluded from the model should be documented, with justification for exclusion. The Estimator should ensure the selection of data does not introduce bias to the model.

The impact of combining data from different sources and/or of different resolution into one model should be understood, such as the combination of ply and working section data. The impact of different generational sources of data may also be manifest as modelling discontinuities, such as boundaries between different mines or regional data sets.

If it is necessary to include artificial or 'dummy' data to ensure the model is consistent with the geological representation, these should be clearly identified in the model and recorded in the supporting documentation. Such data should be reviewed and reassessed as new data are obtained.

5.6.3 Modelling Software and Computations

Appropriate modelling parameters should be selected based on the density and distribution of the data, the data trends and the local geological interpretation. The suitability of these settings should be confirmed using quantitative methods.

Consideration of modelling parameters may include:

- Selection of modelling algorithm;
- Selection of model type;
- Resolution of the grid mesh/block size;
- Search neighbourhood;
- Interpolation between data; and
- Extrapolation of trends in thickness and coal quality which should not be unreasonable.

The selection of modelling parameters may differ by variable (e.g. quality and structure). The model should be constructed so as to provide maximum flexibility for subsequent mine planning options; however, this may be limited by the available data. The version of the model used for the estimation of Resources should be archived. Modelling documentation should be clear and thorough.

The Estimator should understand the principles underlying the software package being used. This includes understanding the steps required in the modelling process, and the order in which they must be completed so that the finished model honours the geological interpretation.

A workflow is the sequence of steps that must be followed to ensure that nothing is missed in the modelling process and to help ensure that the resultant model is appropriately developed. A workflow helps to ensure that the process for generating a model is followed correctly, and is transparent and auditable.

5.6.4 Model Validation

Model validation should occur at all stages of the modelling process, and should identify and quantify the strengths and limitations of the model. The intended use of the model should be clear in the documentation, and the model should be confirmed as fit for purpose through validation/audits. ***An audit or peer review of the geological model should be carried out in the event of a material change***.

A geological model should represent the geological interpretation and honour the data. Typical validation checks may include:

- Visual checks of the data such as by contour plots and sections;
- Statistical checks between the borehole and model data;
- Reconciliation with previous models;

- Validation of the model in relation to local geological understanding and trends; and
- An assessment of the sensitivity of the model to changes in geological interpretation, modelling assumptions or additional data.

Common issues in geological models that can effect or compromise Resource estimations include:

- Not checking computer calculations;
- Over-smoothing or overcomplicating the model;
- Phantom coal being generated through automated modelling processes, a poor geological interpretation or not understanding mined-out areas;
- How the model caters for missing seams in boreholes;
- Coal losses being generated through incorrect pinching out of seams;
- Unreasonable extrapolation of trend surfaces;
- How models are affected by unconformities and other limiting surfaces such as weathering and topography;
- Dealing with different data densities in the same model;
- Not confirming digital data against original data;
- How the model deals with composited data, and whether correct weighting is applied to composite calculations;
- Assumptions about the reliability and accuracy of the data; and
- Edge effects (including flattening of seam dips away from real data).

5.7 Geostatistical Analysis

5.7.1 Overview

Geostatistical analysis provides a mechanism to understand and quantify a variable’s continuity and the degree to which it is spatially correlated. The process can also provide an evaluation of the sample data geometry, and considers the volume (‘support’) of the data and the volume or area being estimated. It provides a useful measure of the uncertainty of an estimate. Careful consideration of data selection, data validation, domain definition and identification of critical data are required for reliable geostatistical analysis.

Because coal represents a heterogeneous mixture of constituents, there are a range of coal quality parameters that should be considered by the Estimator. Where multiple variables require consideration, the Estimator needs to consider the primary defining drivers in the choice of appropriate critical variables. Continuity for different variables should be considered by the Estimator when determining the maximum influence of any data applied in any estimate. When a number of variables are assessed, the critical variable with the highest variability should take precedence in determining this maximum influence. This could be a deleterious component with a negative economic impact. In all circumstances, the geostatistical result should be rationalised with the geological interpretation and the judgement of the Estimator.

If a specialist geostatistician undertakes this work, it should be done in consultation with a coal geologist who has familiarity and understanding of the geological interpretation and the features of the deposit and the dataset. The results of geostatistical analysis should never be applied in isolation from other factors in the resource estimation, such as the mining method, the geological interpretation, and the data reliability.

The project area may need to be divided into domains of geological and statistical consistency for variography and geostatistical analysis. Estimates can often be more easily executed if the same domains are selected for all variables, but the geological and geostatistical validity of this should be considered by the Estimator. If the spatial controls on one variable are clearly different to those of the others, then recognition of different domains may be warranted. There need to be sufficient data points available within each domain for the analysis to be representative.

5.7.2 Variography

A variogram (Figure 2) provides an assessment of the spatial continuity of a given variable. The variogram consists of parameters quantifying very short range variability (the nugget), the total variability (the sill) and the distance at which there is no correlation (the range). The nugget incorporates a component of sampling and analytic error, as well as the difference expected from two nearly coincident Points of Observation.

The range can be isotropic (same in all directions) or anisotropic (different ranges in different directions). Anisotropy is always influenced by geology. Several types of mathematical functions (‘variogram models’) may be fitted to the experimental variogram calculated from the data (eg spherical, exponential), and the type of model should be stated in reports. The shape of the variogram model close to the origin (especially the slope) is important and can have a significant impact on further applications.

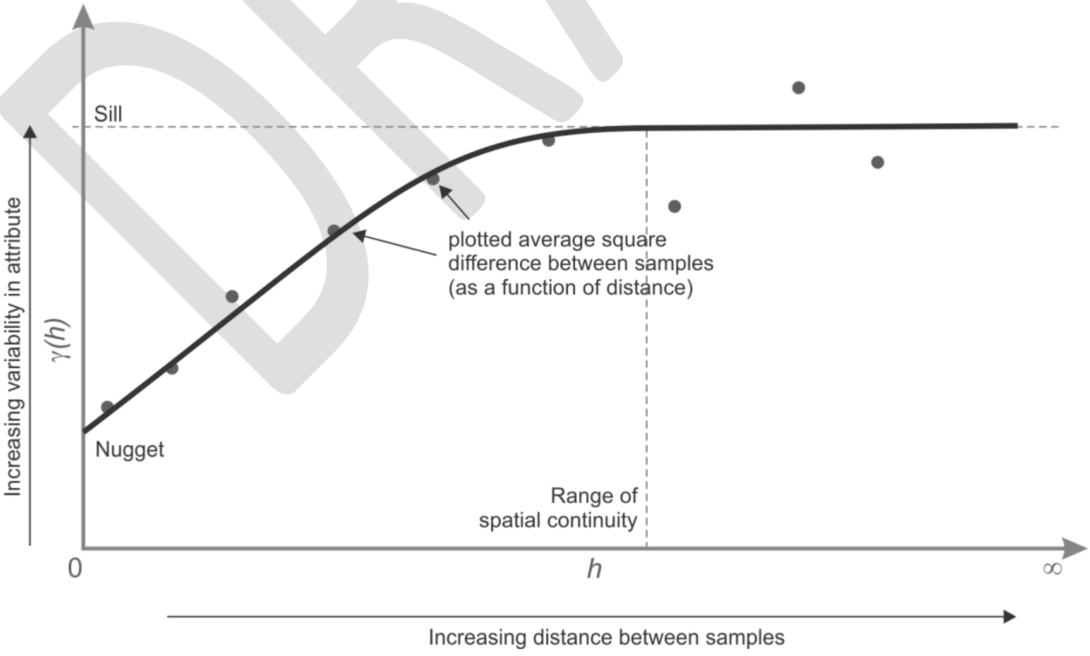

Figure 2: Representation of a Variogram

Variography for coal variables is challenging when there are no closely spaced boreholes, because the nugget becomes difficult to define and there is a risk that the continuity of the variable may be overestimated. Variograms modelled using few data points also risk underestimating or overestimating the continuity of a variable, especially if those data points are broadly spaced.

An increasing or decreasing trend in the data as a function of the direction considered (or "drift") is a common feature of coal variables. When considering variables with drift, the domains, variography or geostatistical estimates can be adjusted in an effort to minimise the impact upon the variogram and the estimate.

Sensitivity analysis, which involves changing the parameters of the variogram or search, and back-estimation (or "cross-validation") are both useful validation tools. A reliable variogram will be unbiased, and have a small range of error. Clear documentation of the data selected for use in variogram modelling, any manipulations of the data, and the domains used are required in reports. If a variogram is applied for more than one seam, cross-validation should also be conducted on those seams.

5.7.3 Range of the Variogram

The variogram may assist in defining distances of continuity between Points of Observation. In isolation this is not considered appropriate because it fails to consider all the other necessary factors contributing to the confidence in the estimate, such as sample geometry, mining methodology, local geological features and reliability of sample data. Sole use of the variogram is risky, in particular for variables with high nugget variance and/or short ranges.

5.7.4 Geostatistical Methods to aid Resource Classification

There are several methods for using geostatistical analysis as an aide for Resource classification. Some of the more common methods are described below, but the reader is referred to the literature for more information.

Geostatistical techniques enable the Estimator to calculate a variance that is dependent upon the scale (volume) being estimated, referred to in geostatistical parlance as "support". In most circumstances, support relates to a block or area. Larger volumes will be less variable than smaller ones. When quoting variances, the scale of the estimated blocks should be stated. This scale for Resource classification may be considered in terms of the expected mine production over a given time period.

5.7.5 Global Estimation

A geostatistical approach to assessing global estimation variance (i.e. a measure of the variance of errors for a given volume or area, informed by a specific number and pattern of observation points) can be used to calculate the theoretical optimum drill hole spacing for a deposit at a given confidence interval and volume. This is sometimes termed Drill Hole Spacing Analysis. The optimum spacing may be used to recommend a distance of continuity between points of observation for use in resource assessment. The method is simple to implement, and correctly uses the variogram as a measure of the continuity of the variable.

Issues using this method can arise if variograms are based on sparse, broadly spaced data, where the continuity of the variable is consequently overestimated. As a consequence the results of this method should be applied with due consideration of the geological interpretation.

5.7.6 Kriging Variance

Kriging is an estimation method that is adapted to the variogram model, the sample geometry and the volume (or area) of the region being estimated. It is often described as a best linear unbiased estimate, meaning of all weighted averages, kriging will attain the lowest error variance for a given data geometry, variogram and search. An estimate of the error variance can be calculated for each block known as the “kriging variance”. The kriging variance is a measure of the confidence in an estimate. Several different methods of using kriging variance to aid Resource classification are possible, including the use of relative kriging variances or kriging efficiencies (which are derived from the kriging variance).

The method is advantageous as it uses the geometry of the sample data, and allows a local assessment of the uncertainty of the estimate; however, kriging can have a smoothing effect on the estimate.

One of the key questions the Estimator can ask in a Resource classification is whether the addition of new data would materially change the estimate. Kriging variances can be useful in answering this question.

5.7.7 Conditional Simulation

Conditional simulation is a process for assessing the uncertainty of a parameter within a geological context. A simulation model consists of a large number of ‘realisations’ or spatial images of the variable that are compatible with the variogram, histogram and data observations, each one having an equal probability of representing the unknown reality. Conditional simulation realisations agree with each other at points of observation, but differ away from these locations in a manner consistent with the variogram model.

The variation in a set of conditional simulation realisations can be used to assess the uncertainty associated with the Resource estimate and also to generate confidence intervals at global (domain) or local (block) scale.

A larger number of realisations in a set of conditional simulations will allow more reliable analysis. It is also important to check that the set of realisations is unbiased. To ensure this, the simulation characteristics (histogram, variogram etc) should closely reproduce the original data. The average of a set of realisations for conditional simulation may also be compared to the kriged estimate, and should closely agree at global and local level. Conditional simulation requires more familiarity with geostatistics than kriging; it can be computationally intensive, and is more sensitive to the effects of drift than kriging.

5.8 Domains

Coal deposits are typically heterogeneous and include variations in seam characteristics that in parts of the deposit may impact on reasonable prospects. There may be both lateral and vertical variation in the structural complexity, quality characteristics, or other attributes. A key aspect of any resource estimation is to define the areas of a deposit that have similar features. These areas are known as geological domains.

Key features for domain definition may include: seam splitting and coalescing, intensity of structural deformation (such as folding or faulting), seam dip, igneous intrusions (and their impact on coal characteristics), washouts, seam subcrop (and weathering effects) and coal quality trends. Different domains may need to be identified for each of these features for each seam.

Domains may encompass features that impact on the mineability (reasonable prospects) or marketability of that part of the deposit. Analysis and modelling of data should be undertaken on a domain basis.

It is likely that a deposit may have several geological domains and that the data point types and distribution will need to vary in terms of their density to provide the same level of confidence in the estimation of a Coal Resource (tonnage and/or quality).

6 Inventory Coal

Inventory Coal is a term that enables a more complete estimate of coal ‘in ground or gross in situ’ to be reported for Government or internal company purposes. Inventory Coal is a category of coal not recognised by the Code and therefore must not be publicly reported (refer Figure 3).

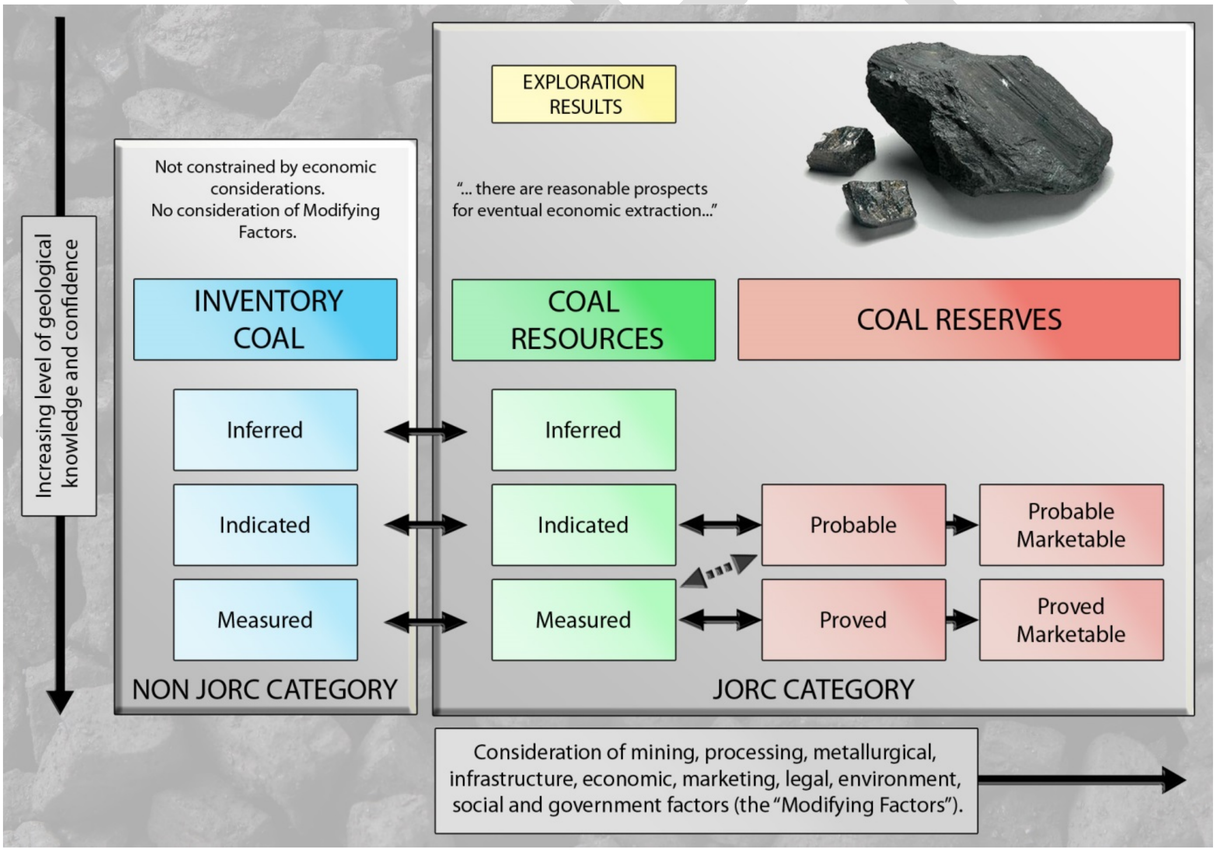

Figure 3: **Relationship between Inventory Coal, JORC Resource and Reserve Classifications**

Inventory Coal is any occurrence of coal in the ground that can be estimated and reported without being constrained by economic potential, geological or other modifying factors. That is to say estimates of Inventory Coal tonnages are not subject to or constrained by the ‘reasonable prospects for eventual extraction’ test. By definition Inventory Coal includes all Coal Resources.

The location, quantity, quality, geological characteristics and continuity of Inventory Coal are known, estimated or interpreted from specific geological evidence and knowledge. Inventory Coal is sub-divided in order of increasing geological confidence into Inferred, Indicated and Measured categories.

An estimate of Inventory Coal is fundamentally different from an Exploration Target as defined in the Code, in that the latter is generally restricted to either one of two situations being:

- an aspirational or hypothetical (coal exploration) target based on little or no direct data but perhaps at best, supported by regional trends or a conceptual geological model or
- an estimate of potential coal in situ, which is at best an ‘order of magnitude’ estimate and which is based on extremely limited data (insufficient coverage, density or integrity) to properly allow the classification of Inventory Coal or Coal Resources estimates in accordance with the provisions of the Code or the Coal Guidelines.

Inventory Coal is a term that enables a more complete estimate of unconstrained coal tonnages ‘in ground’ to be reported to Government for the State’s purposes or for purposes of strategic planning internally within companies who hold or manage mineral tenements.

Where estimates of Inventory Coal and Coal Resources are presented together, a statement must be included in the report which clearly indicates whether the Inventory Coal, as reported, is inclusive of, or additional to the Coal Resource.

A Resource estimate including Inventory Coal would not be in accordance with the Code and must not be publicly reported.

7 Exploration Target

Where some exploration has been conducted on an area, but insufficient to enable the Estimator to reasonably estimate and report either Inventory Coal or Coal Resources with at least an Inferred level of confidence, it may be appropriate to report an Exploration Target based on those exploration results.

The reader is referred to clauses 17-19 of the Code for the strict public reporting conditions, including cautionary statement and the required information to be disclosed to enable investors to assess the significance of the Exploration Target based on exploration results and the likelihood of any Coal Resources being defined with further exploration.

8 Reasonable Prospects

The term ‘reasonable prospects for eventual economic extraction’ implies an assessment (albeit preliminary) in respect of matters likely to influence the prospects for economic extraction. A Coal Resource is not simply a summation of all coal drilled or sampled, regardless of coal quality, mining dimensions, location or continuity. It is a realistic estimate of the coal that, under assumed and justifiable technical economic and development conditions is more likely than not to become economically extractable. ***The conditions and time frame within which economic extraction is envisaged should in all***

cases be disclosed and discussed to comply with the transparency and materiality principles of the Code.

These Coal Guidelines do not prescribe a specific approach to arriving at the key assumptions, or the level of detail required. Neither do they set out the economic indicators that need to be satisfied or the level of satisfaction that needs to be achieved for the coal to be said to have “reasonable prospects for eventual economic extraction” (reasonable prospects) and hence be classified as a Resource. The Coal Guidelines simply provide prompts as to the factors that need to be considered, but not limited to mining, processing, metallurgical, infrastructure, economic, marketing, legal, environmental, social, governmental and regulatory factors. Whilst the assessment can in part be qualitative, there generally needs to be at least a basic quantitative evaluation that considers financial indicators.

In assessing reasonable prospects is a vital step in the estimation process, but is often a source of variance between different Resource estimates of the same deposit. Such an assessment is based on the Estimator’s experience and also on a good understanding of the key technical issues associated with the deposit. Any material considerations and assumptions made in determining reasonable prospects should be clearly documented. Inadequate or uncertain data or materially adverse findings should also be disclosed in the supporting documentation.

An assessment must be made that considers those factors which will affect costs and revenues, as well as those factors which might affect the “licence to operate”. The physical attributes of the deposit, together with the beneficiation characteristics, are those which heavily influence costs. Critical product coal quality attributes that determine the potential utilisation of the coal and the mix of product types will be the major influences on revenue. Licence to operate includes the regulatory, social, cultural, political and environmental factors that may inhibit or limit mine development, or add to the cost of development.

Realistic cut-off parameters should be determined and applied to the deposit that take into account the likely mining scenario, the potential utilisation of the coal and the Estimator’s experience regarding similar operations.

The results of any relevant technical and economic studies should be considered. Reference to existing operations in a similar region and geological setting should also be referred to where possible and relevant. Caution should be exercised if limits on coal quality, including ash percentage and deleterious trace elements (e.g. sulphur, phosphorus, etc.) are strictly applied. Such quality aspects should be noted, but may not be of sufficient significance to declare that such a coal is not considered a Resource. Incorporation of mining limits, including depth, strip ratio, minimum (and maximum, if appropriate) mineable thickness, seam dips or intra-seam parting thickness are similarly to be treated with caution.

In a potential open cut mining scenario, emphasis on strip ratio, minimum mineable seam thickness, maximum non-separable parting thickness, pit wall stability and depth of weathering are important considerations. If beneficiation of the raw coal is envisaged, the clean coal yields should be factored into cut-off considerations, including strip ratios.

The Estimator may also consider the use of pit optimisation software to examine various options in the planning process and support an assessment of appropriate cut-offs.

In an underground mining scenario, aspects such as depth, faulting, igneous intrusions, working section thickness, seam dip, physical properties of roof and floor lithologies, hydrogeology, stress regime, gas content and permeability should be considered. In multi-seam underground deposits, the nature and thickness of the interburden material may be a critical consideration, as this might preclude extraction of some of the target coal seams.

In deposits where both open cut and underground Coal Resources are considered to exist, the assumed limits/cut-offs between the coal for each mining method, as well as thickness and grade constraints relevant to each mining method, should be documented.

The Estimator should also consider whether the tonnage and coal quality are sufficient to ensure satisfactory returns over a reasonable life of mine. If the estimated coal tonnage is not sufficient to support a mining operation this may preclude the coal's potential for future development unless the Estimator can identify a sufficient upside (e.g., potential to increase the tonnage, or potential synergies with adjacent Coal Resources).

Additionally a coal deposit may be alienated from current markets if it is located in an extremely remote area devoid of relevant infrastructure, and where potential development in a reasonable timeframe may be difficult to justify.

The Estimator should consider whether all of the coal is accessible for exploration and/or development. Coal Resources may only be estimated within the boundaries of valid exploration, development or mining tenures held by the reporting company, its subsidiary companies or its Joint Venture partners.

Areas with surface land access restrictions, such as a gazetted or proposed national park, would normally be excluded and the coal within these areas excised from a Coal Resource estimate. There may also be instances where coal adjacent to or underlying major rivers, bodies of stored water, urban developments or major infrastructure, such as railway lines, major bridges and highways, will need careful consideration in terms of potential future development of all or parts of the deposit. In these instances (and always assuming that the coal is sufficiently attractive and technically possible to mine) there may be additional costs, social or legal impediments to mining. The Estimator needs to consider these and come to a determination as to whether there are reasonable prospects for mining to take place within the time frame stated.

Clearly the reasonable prospects test is sensitive to the geological, geotechnical and coal quality parameters that will have been investigated as a precursor to the estimation process and which are previously described. In some cases the prospectivity of a coal deposit can be assessed by comparing the known parameters with analogues in nearby areas. However, rarely is it easy to properly assess the economic worth of a coal deposit without at least a basic appreciation of costs of extraction and likely revenues to be received. These matters are normally considered during the Resource study and in concert with engineers and other specialists.

Assumptions should be made and documented regarding both on-site costs (mining, processing, maintenance, administration etc.) and off-site costs (transport, marketing costs, royalties etc.), and the costs of appropriate start-up and sustaining capital. Revenue assumptions form the other side of the equation, and these typically require a view on what products will be marketed, their likely realisable price and the exchange rate. Cost and revenue factors could then be brought together in a discounted cash flow analysis to determine a range of economic indicators for the deposit.

Assessments of this type will provide a level of rigour in determining the prospects for development of a greenfield site, determining prospects for an extension of an existing site into deeper or laterally more extensive seams and, of course, in determining depth cut offs for current operations.

9 Audits

It is good practice to undertake an audit of the Resource estimate particularly where a material change has occurred from previous Resource estimates.

10 Future Reviews

These Coal Guidelines will be reviewed, in conjunction with future reviews of the Code, by a committee of industry and government representatives authorised by the Coalfield Geology Council of NSW, the Queensland Resources Council and representatives from other coal producing states. The aim of subsequent revisions will be to provide any clarification considered appropriate and to extend the level of commentary within the Coal Guidelines. Submissions in writing should be directed to the Secretary of the Coalfield Geology Council of NSW, c/o New South Wales Department of Trade and Investment, P.O. Box 344, Hunter Regional Mail Centre NSW 2310; or the Director of Operations, Queensland Resources Council, 133 Mary Street, Brisbane, Qld, 4000.

11 Recommended Reading

ASX, 1 December **2013**, *ASX Listing Rules Chapter 5; Additional reporting on Mining, Oil and Gas Production and Exploration Activities* http://www.asx.com.au/documents/rules/Chapter05.pdf

ASX, 1 December **2013**, *ASX Listing Rules Guidance Note 31 Reporting on Mining Activities* http://www.asx.com.au/documents/rules/gn31_reporting_on_mining_activities.pdf

AusIMM, **2011**, *Field Geologists' Manual (Fifth Edition), Monograph 9*, The Australasian Institute of Mining and Metallurgy; Carlton, Victoria 3053, Australia.

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Sinclair, A.J. and Blackwell, G.H., **2002**, *Applied Mineral Inventory Estimation*. Cambridge University Press.

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Stephenson, PR, Allman, A, Carville, DP, Stoker, PT, Mokos, P, Tyrrell J and Burrows, T., **2006**, *Mineral Resource Classification – It's Time to Shoot the 'Spotted Dog'!*, 6th International Mining Geology Conference.

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12 Review Committee Members

David Arnott; Lynne Banwell; Andrew Barger; Mark Biggs; Mal Blaik; David Coffey; Michael Creech; Monica Davis; Rod Doyle; Doug Dunn; Ian Goddard; David Green; Paul Gresham; Malcolm Ives; Chris Knight; Gerard McCaughan; Alastair Moyes; Wes Nichols; Ken O'Reilly; Ken Preston; Kevin Ruming; John Sheehan; Dale Sims; Peter Stoker; Ben Thompson; Patrick Tyrrell; Kerry Whitby; Andrew Willson.

External Review: Professor Colin Ward

Appendix A - Questions and Answers

The 2012 JORC Code is, by design, not prescriptive in nature. The Code deals with minimum standards for public reporting of Exploration Results, Mineral Resources and Ore Reserves for all solid mineral deposits. This section of the Coal Guidelines attempts to provide guidance to coal resource Competent Persons on the main issues that in the past have often led to a wide variety of interpretations amongst geologists. The issues are discussed through a series of focussed Questions and Answers (Q&A's). Where necessary, the intent of the JORC Code is clarified, and aspects to be taken into account are suggested. A number of techniques may be applicable and it is up to the expertise of the Competent Person to select and to justify the technique that is suitable for the coal deposit in question.

Q1. The JORC Code makes no mention of the term "Inventory Coal". Why do the Coal Guidelines allow the term to be used, and what does it include?

Inventory coal is the term that applies to all coal in the ground that can be estimated and classified according to geological confidence, without a need for a Competent Person to account for either potential commercial considerations or land use constraints when identifying Inventory Coal. All coal that can be estimated on the basis of relative confidence levels and has passed the "reasonable prospects for eventual economic extraction" test can become a Coal Resource as defined by the JORC Code.

Coal companies very often have a category, similar in concept to Inventory Coal that is used for internal company purposes – terms such as "global coal estimate", "in situ coal" have been widely used for many years.

Coal Resource estimates may tend to increase or decrease over time, depending on the views and perceptions of what passes or fails the "reasonable prospects" test between different Competent Persons and also the economic considerations and limitations adopted by different coal mining and exploration companies. However, within a coal deposit, defined by the extent (lateral and vertical) of geological data (Points of Observation), the Inventory Coal estimate will tend to remain relatively constant until the geological data limits change, i.e. new holes are drilled or old holes deepened.

The concept of Inventory Coal, within the Coal Guidelines, but outside the scope of the JORC Code, fulfils this need and provides a platform for estimates of Coal Resources to be updated and reviewed over time as and when conditions which impact the 'reasonable prospects' test change. When first introduced into the 2003 edition of the Coal Guidelines the term was defined as "*…any occurrence of coal in the ground that can be estimated and reported without necessarily being constrained by economic potential, geological or other modifying factors.*"

Estimates of Inventory Coal (like those of Coal Resources) are based primarily on Points of Observation and may be supplemented by Supportive Data. If sufficient geological data and other supporting information exists, Inventory Coal is estimated and classified (on the basis of confidence categories) in the same manner and using the same methodology used for estimating and classifying Coal Resources. As data density and distribution allows, estimates of Inventory Coal are to be reported in terms of Measured, Indicated and Inferred confidence categories and rounded to an appropriate level of accuracy (refer to Clause 25 of the JORC Code). Estimates of Inventory Coal are to be expressed as raw coal on an in situ basis.

If not otherwise reported as Coal Resources, the Competent Person may report as Inventory Coal, coal that is not currently accessible for mining because of statutory restrictions on access to land (gazetted or proposed national parks or environmental conservation areas). These may include features such as rivers or watercourses, reservoirs or lakes (particularly those of major regional significance), major public infrastructure (e.g. rail, bridges) or areas of urbanisation. The Competent Person may in many cases choose to exclude coal underlying such features from a Coal Resource estimate, but should report such coal in the Inventory Coal category wherever sufficient data is available.

The JORC Code does not contemplate use of the term Inventory Coal, nor does it provide for the estimation of coal which might fall into this category or allow for it be publicly (as defined in the Code) reported. The main application of the Inventory Coal report is likely to be for submission to relevant government agencies and internally by coal exploration companies for priority setting.

Q2 *Why estimate Inventory Coal?*

Estimates of Coal Resources and/or Coal Reserves alone, do not present a complete picture of what is in the ground. In considering only these types of estimates, decision makers, either regulatory (e.g. the Crown/State) or those within exploration or mining companies themselves, may be completely unaware of what other coal is present in an area. Inventory Coal estimates can be used by various agencies representing the State's interest, to make fully informed, 'arms-length' decisions regarding a mining or development proposal. One of the considerations required is whether or not a proposed coal mining project will maximise recovery and minimise the potential for the project to impact on, or potentially sterilise, other identified mineral (broad 'common usage' context to include coal) occurrences.

Another use of Inventory Coal estimates is in the estimation of fugitive gas.

Examples where Inventory coal can be significantly greater than the resource include the following:

- selective mining of a single coal seam or coal seams within multiple seam sequences;
- partial recovery (mining) of a thick coal seam using underground mining methods;
- rendering coal uneconomic by overlaying spoil or diverting watercourses

Q3 *I am preparing a report containing an estimate of Coal Resources. Can I include any estimates of Inventory Coal that I may have also estimated over the area covered by the report?*

That depends upon the type of report being prepared and its intended purpose.

<u>Reports intended for the investment market – 'Public Reports'</u>

The 2012 JORC Code defines what it means by a 'Public Report' as those……..”prepared for the purpose of informing investors or potential investors and *their advisors on Exploration Results, Mineral Resources or Ore Reserves (as defined)…..”*. The 2012 Code provides examples that include but are not limited to *“…..annual and quarterly company reports, press releases, information memoranda, technical papers, website postings and public presentations.”*

If a report is being prepared for the purpose of informing investors, potential investors or their advisors, as set out in the Code, the report must not include estimates of Inventory Coal.

For example, if the report was being prepared for inclusion in a company prospectus for a proposed listing on the Australian Securities Exchange, it **would not** be acceptable to include or make reference to estimates of Inventory Coal in the report.

Similarly, if a company or individual is preparing a report based on the results of drilling activities for intended release as an announcement on the Australian Securities Exchange, the report must not include any mention of, or reference to, coal which in the opinion of the Competent Person, does not meet the ‘reasonable prospect’ test required by the JORC Code.

Other (‘Non-public’) Reports

The 2012 Code recognises however that at times, the need may arise for the preparation of a report which contains certain ‘documentation’ that does not comply with the Code.

Reporting on, and documentation of, coal exploration either internally within a company or to government agencies may be required from time to time. Reports of this nature could generally be referred to as ‘non-public reports’ in that their primary purpose is not to inform the investing public or their advisors.

It could for example be to allow for a more complete record of all coal occurrences to be presented, to assist with an internal company decision or in making a recommendation to management. At this stage in the internal decision-making process within a company, there may simply be a need to be aware of, but not necessarily make a determination on, the technological, economic, land use or other constraints that might apply to a particular area under consideration.

In these cases, some of the coal occurrences documented in these types of reports may fall within the definition of ‘Inventory Coal’ as defined in the Coal Guidelines. So if a report is being prepared for internal company purposes ONLY – then it may be appropriate to include Inventory Coal in the report. The Coal Guidelines could be used to assist in the preparation and reporting of Inventory Coal estimates in these types of reports.

If a report is primarily prepared as a technical geological report documenting the results of exploration activity undertaken by a company on an exploration tenure and is being submitted to a government department or other regulatory agency for compliance purposes, then ‘YES’, estimates of Inventory Coal may, and indeed should be included in the report. When Coal Resources are included in such ‘non-public’ reports, the Coal Guidelines may be used to help with preparing the estimates but the JORC Code should still apply to the manner in which these estimates are presented in that report. For example, Inventory Coal must be classified in terms of confidence in the Inventory estimate, as Measured, Indicated or Inferred.

The report must include a clear and unambiguous statement as to whether or not the estimates of Inventory Coal are inclusive or exclusive of the Coal Resources.

When reporting estimates of inventory Coal, any factors or physical features used to ‘limit’ the estimates should be clearly stated. Where these limits relate to the areal extent of the estimates, it should be clearly represented graphically on maps, plans or sections that accompany the report.

In doing so, in accordance with the recommendation of the Code, all reports of this type should include a statement to the effect that …”*In so far as the report includes estimates of Inventory Coal (a term not recognised by the JORC Code) the report does not comply with the Code.*” (see Guidelines to Section 6 of the JORC Code, page 5, 4th paragraph).

Q4 How is coal density applied to the Coal Resource estimate?

The expression to determine in situ coal tonnes is simply:

Coal Tonnes = seam area (metres^2) x seam thickness (metres) x in situ coal density (tonnes/m^3)

Seam area and thickness are simple, well known concepts, but coal density is less well understood. Nevertheless it needs to be considered just as carefully as the other two factors.

For coal resource estimates to be both numerically accurate with respect to the density factor and correct from a process logic perspective, all coal quantities should be estimated at *in situ* moisture and *in situ* density. The approach to estimating *in situ* moisture must be supportable and the resultant values realistic.

Whilst it is not strictly correct to equate density with relative density, for most practical purposes in resource estimation, density and relative density are numerically the same. In Australia density determinations are reported according to Australian Standards as relative density, in accordance with two testing methods, namely:

i. Most commonly on air dried coal according to AS1038.21.1.1-2008 (the density bottle method). This is the recommended method;

ii. Less commonly, on coal of unknown moisture according to AS1038.26-2005 (apparent relative density). Use of this method is not recommended.

Using as reported air dry relative density (RD) values to estimate coal tonnes (i.e. as determined by the density bottle method) will lead to an over estimate. However after correction to in situ moisture basis, these values are the ones that should be used to model in situ density for tonnage estimation.

If apparent relative density (ARD) is determined according to the second method, the moisture will not be known, thereby making it very difficult to properly correct this to in situ moisture and in situ relative density. Use of this standard and of uncorrected apparent relative density values is not recommended.

Methods for adjusting air dry relative densities to in situ relative densities and also for bringing apparent relative densities to an acceptable level of accuracy are outlined in Preston and Sanders, (1993) and Preston (2005).

Note that in most cases In situ relative density < Apparent relative density < Relative density. In situ relative density has a range generally between 0.02 to 0.05 t/m^3 below the laboratory determined (AS1038.21.1.1-2008) relative density for bituminous coal.

Q5 *How is In situ Moisture estimated?*

It is currently not possible to measure In situ moisture empirically as the methods of sampling changes the moisture content. It can best be estimated by reference to other moisture indicators (e.g. air dried moisture, moisture holding capacity etc.) and to coal rank, type and grade. Generally as rank increases, in situ moisture decreases. Certain inertinite macerals have greater moisture carrying capacity than others and can give rise to high moisture relative to rank. Coals high in liptinite tend to display lower moisture relative to coals rich in other macerals of the same rank. High ash coals tend to carry less moisture, since there is a lower proportion of the more porous coal in the sample.

ACARP Report C10041 (Fletcher, IS and Sanders RH, 2003, Estimation of In situ moisture and product total moisture) details studies of in situ moisture and provides some mechanisms for its estimation, primarily by relating it to parameters such as air dried moisture, Moisture Holding Capacity, Equilibrium Moisture and others. These methods are based upon statistical analysis and whilst they do provide indicative results for a range of coals, they may not necessarily provide correct results for “your” coal. Judgemental overlay must be applied to any results obtained from application of equations published in the ACARP report.

Q6 *The revised Coal Guidelines no longer include suggestions regarding maximum distances between Points of Observation for the various confidence categories. Why were these removed?*

The wording of the 2003 Guidelines made it clear that the distances between Points of Observation for the various confidence categories (Measured, Indicated and Inferred) are those which would not normally be exceeded unless there was sufficient technical justification to do so. These were recommended maximum distances thought to be applicable in the main coalfields of eastern Australia. They were not prescribed distances or distances endorsed by the Guidelines regardless of the geological characteristics of the coal being classified.

It was apparent that there was confusion on this topic within the coal industry in that there were numerous examples of Competent Persons misinterpreting the intent of this aspect of the 2003 Coal Guidelines and using these recommended maximum distance guides in a manner that suggested a prescriptive intent. Assignment of an associated level of confidence based on those maximum distance guides would then result, without due and deliberate consideration of whether the distance chosen for a particular confidence category was appropriate for that coal deposit.

By removing suggested maximum distances between Points of Observation for each confidence category, in the current (2014) Coal Guidelines, it places responsibility back with the Competent Person to determine the criteria for classification.

Q7 When estimating Coal Resources, is it reasonable to extrapolate beyond the last Points of Observation?

Continuity is defined as being '…the state of being continuous or unbroken'. Continuity of a coal seam and its characteristics, both physical and quality, is demonstrated with greater confidence between Points of Observation than outside the last Point of Observation. Nevertheless it is considered that some level of extrapolation may be justifiable if a solid case can be made to support this approach. This case would take into account the known characteristics of the coal seam both at a regional and local level and specifically where there is good data to support an understanding of its nature. In all cases it will be the confidence that the Estimator has in the critical variables that will determine the extent of extrapolation.

Where the coal seam is known to show a high level of variability in either physical character or key quality variables, it is difficult to see how a case could be made for extrapolation of any significant distance. Equally there may be a case for no extrapolation. Where a coal seam is known to be persistent and predictable in character, the case (again supported by evidence) may be made to extrapolate by some percentage of the allocated Point of Observation spacing. These Guidelines do not support the view that there is an automatic licence to extrapolate a distance "half the nominal drill spacing".

In all cases, transparency and materiality require that the basis on which the resource is extrapolated to these limits is explained clearly. Note also that in the instance of extrapolation beyond Points of Observation, the provisions of the JORC Code Clause 21 apply.

Q8 When reporting, how should the Coal Resource estimate be rounded to reflect the level of confidence in the estimate?

The JORC Code suggests the Competent Person consider the use of 2 significant figures (Clause 25) in most situations and one significant figure may be necessary on occasions to convey properly the uncertainties in resource estimation. Clause 25 should be considered the initial default for rounding for every resource estimate. The accuracy of coal quality parameters are defined by their relevant standards. Reporting of values for these parameters should not exceed the relevant significant figures or level of accuracy.

Q9 How are downhole geophysical logs used in the classification of a coal resource?

From a resource estimation perspective, downhole geophysical logs when used and interpreted appropriately, help to provide increased confidence in an understanding of the physical attributes (i.e. location, depth and thickness etc) of coal seams in an area, as well as contributing, to a more limited extent, to an increased level of confidence regarding the variability in and continuity of certain basic chemical properties of those seams.

In coal exploration drilling, downhole geophysical logging (sometimes referred to as '*wireline logging*') is undertaken on a routine basis; to assist with identifying the lithologies intersected within a hole, in particular coal seams. Where borehole conditions allow, theses logs (in particular the natural gamma, density and caliper combination) can be used to make reasonably accurate estimates of the top and bottom (roof and floor) boundaries of the coal seams intersected, making them of particular use in holes where no coring has been undertaken and only cuttings are available - particularly in deep non-cored holes.

When sampling coal for analytical testing in holes where coal seams have been cored, geophysical logs (in particular density/caliper log combinations) can also be used to more reliably determine zones of significant core loss than would otherwise be the case.

Downhole geophysical logs are also an invaluable tool to assist with stratigraphic and coal seam correlations in coalfield studies, both on a regional scale and at a more localised ‘deposit’ or mine level.

In coal exploration, the suite of logs run routinely in each hole should include at least long and short spaced density, (natural) gamma and caliper logs. Within an area of investigation/deposit, the responses of geophysical logs can be interpreted through comparison of the trace responses with the detailed core description from the core holes. This can then enable more reliable use to be made of the geophysical log responses (data) obtained from logs of other non-cored holes in the vicinity. Logs should be compared, or standardised, using the typical response from one, or more, reference holes within each deposit.

An intersection of the full coal seam in a non-cored hole that has been geophysically logged (with at least density and caliper logs) may be used as a ‘structural’ point of observation. The descriptor *‘structural’* meaning: a point (of observation) where the location, depth and thickness of a particular coal seam (or seams) has been reliably (i.e. unambiguously) determined that would allow for that point to be used for the purposes of volumetric estimation/calculation.

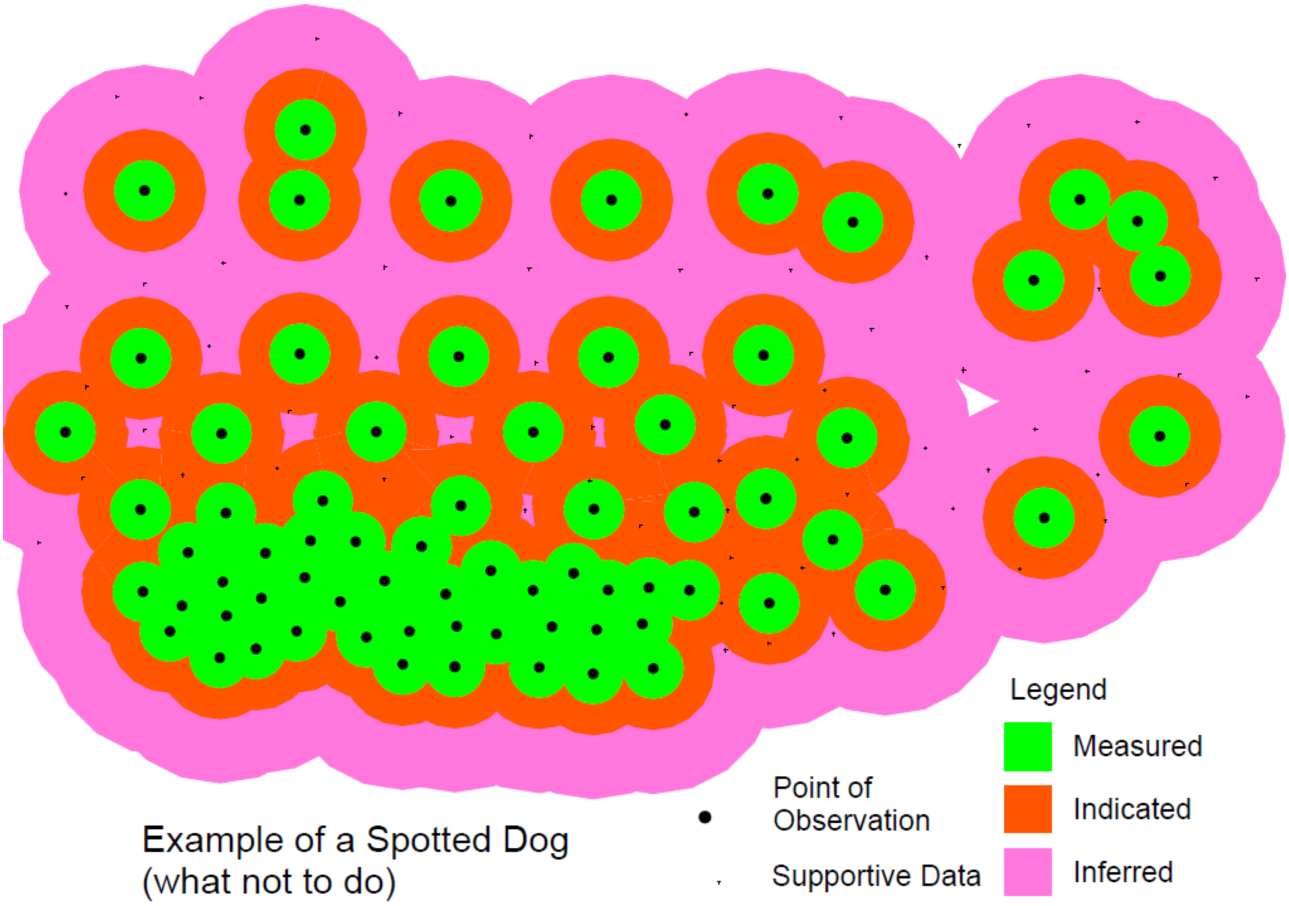
Visual ‘calibration’ of the geophysical responses against the lithologies logged within cored boreholes is recommended before geophysical logs from other non-cored holes elsewhere within the area of evaluation be considered for use in this way, to ensure that the interpretation of the geophysical responses is compatible with the lithologies observed in the cored boreholes.

When visually ‘calibrated’ in this way, geophysical logs of non-cored holes may be used for making approximate qualitative comparisons of certain basic coal quality and rock strength parameters with adjacent (or nearby) cored boreholes. In cases where the geophysical responses have been calibrated against laboratory derived coal quality analyses, and where the reproducibility of a particular geophysically derived parameter (for example ash content or density derived from the density/caliper log) is within acceptable tolerances, then that geophysically derived coal quality parameter may be used to support the raw coal quality continuity. However geophysically derived coal quality attributes will not include any coking parameters - these can only be determined by the physical testing of coal samples.

Some borehole geophysical responses, particularly density, gamma, neutron-neutron and sonic logs, may be correlated to the physical laboratory test results obtained from borehole core samples. From this, relationships may be established between, for example, laboratory-determined rock strength and sonic velocity. These geophysical tools respond to rock density, fracture spacing, rock strength and porosity. More specialized geophysical logs, such as dip-meter logs and acoustic scanner logs may be used to measure the structural orientation of the bedding and the identification of structural features.

Q10 What is a "spotted dog"?

The 'spotted dog' is a Resource estimate classification which displays the poor practice of estimating Measured, Indicated and Inferred Resources over disconnected circles of influence around individual Points of Observation or along a line of Points of Observation. An example is given below:


Example of a Spotted Dog (what not to do)

Confidence regarding the extent of a zone of Measured, Indicated or Inferred Resources is always inadequate where there is a lack of support in both x and y dimensions from adjacent Points of Observation. An isolated point, two connected points or a line of points do not demonstrate continuity in both directions (unless there is Supportive Data within the area of extrapolation).

The spacing of Points of Observation in the diagram above is considered sufficient by the Competent Person to demonstrate continuity to an Inferred status over the whole deposit and extrapolation in all directions. There is not always sufficient confidence in both x and y dimensions to support Measured and Indicated status between every Point of Observation. Consequently it is invalid to draw circles of Measured and Indicated status around every Point of Observation. This example has only considered spacing of Points of Observation and not any other matters discussed in the Coal Guidelines that the Competent Person needs to consider in classification of the estimate (refer section 5).

For further discussion refer to the paper by Stephenson et al, 2006.

Q11 What is a "JORC compliant" resource estimate?

Resource estimates are not "JORC Compliant". The JORC Code is a Code for Public Reporting, not a Code that regulates the manner in which a Coal Resource is estimated. The term "JORC compliant" therefore refers to the manner of reporting not to the estimates. Use of the words "JORC compliant" to describe resources or estimates is potentially misleading. The words "JORC compliant" should be replaced by: "Reported in accordance with the JORC Code". Additionally it could be stated that "Resources are estimated (or based on documentation prepared) by a Competent Person as defined by the JORC Code". Refer to Clause 6 of the JORC Code, 2012.

Q12 Is tonnage of coal the only parameter required to be reported in public reports?

No, the quality of the actual coal tonnage estimated should also be reported. In terms of reporting of coal quantities, in situ moisture is the correct reporting basis and this should also be stated. In situ moisture is the moisture content of the coal, undisturbed in the ground. In terms of coal quality parameters that are relevant to reporting of Coal Resources, most that are moisture dependent are reported at air dried basis (of which the moisture value should be stated).

Coal tonnage estimates should ideally be reported on depth range (i.e. 0-100 m; 100-200 m etc) and possibly also on ranges of thickness and quality so that the investor can make a judgement/assessment of what type of deposit is being reported and what are the reasonable prospects for eventual economic extraction.

In addition, the perceived coal product type should be clearly documented (e.g. coking/PCI/thermal) provided there is adequate supportive quality data. Claims of high value quality status (such as coking coal) should not be made where there is inadequate quality data to support the claim. If the product requires beneficiation for sale then there should be adequate washability and clean coal composite data.

Q13 Can material comprising more than 50% ash be estimated as coal?

The international standard for coal classification (ISO X11760) describes material with an ash content of more than 50% dry basis as either "non-coal" or "shale". Coal is heterogeneous consisting of high and low ash material above and below 50% ash. To qualify as a coal, the composited seam (or working section) should have a raw ash content <50%. Thick separable non coal bands should not be included in the coal resource. The nominal industry minimum thickness limit for non coal bands varies between 0.1 to 0.3m depending on the mining method.

In uncommon cases where the bulk of the potential resource has a raw ash >50% the rationale for the reasonable prospects of eventual economic extraction should be detailed.

The international standard for coal classification (ISO11760-2005) defines coal as being *"carbonaceous sedimentary rock largely derived from plant remains with an associated mineral content corresponding to an ash yield less than or equal to 50% by mass (dry basis)"*.

It follows then, that to qualify as coal, the composited seam (or working section) being considered for inclusion in a resource estimate should have a raw ash content <50% (db). However it is recognised that coal is heterogeneous, consisting of bands of material above and below 50% (db) ash. Multiple thin non coal bands with ash content > 50% (db) may be included, whilst thick separable non coal bands should not be included in the coal resource. The nominal industry minimum thickness for separable non coal bands varies between 0.1 to 0.5m depending on the mining method.

In uncommon cases where the bulk of the potential resource has a raw ash >50% db, the rationale for this departure from the accepted norm should be explained and further reasoning should be provided to support the case for there being reasonable prospects for eventual economic extraction.

Q14 How is coal quality data composited?

The methodology of compositing coal quality needs to be clearly understood. Be aware that some parameters are not additive (such as caking properties or ash fusion temperatures). Quality parameters should be composited in an appropriate way. Some examples are below:

- Relative Density (RD) is composited on a length or thickness basis
- Raw Quality parameters should be composited by length * RD (or sample length in the absence of mass data)
- Clean coal composites should be calculated on a mass* yield basis
- Clean coal composites yield should be calculated on a mass basis
- Clean coal composite ash analyses (dry basis) should be calculated on a mass*yield/ash (db) basis

Q15 Can a single sample that covers several seams or plies be used as a coal quality Point of Observation.

Best sampling practice requires samples be taken in a way that represents the variability of the geological population. It is only by sampling in such a manner that the distribution is then understood. Often sample analysis may be made available that does not adhere to this principle, yet rather comprises samples or composited samples that have the internal variability over a short range masked by the sample being taken over wider intervals or having intervals (sometimes discontinuous in nature) combined together.

The Estimator needs to consider in their decision to allow such data to be used as a Point of Observation whether or not the sample is representative of the way in which the analysis will be reported. For example taking a composited sample value for a number of plies (in isolation of any other supportive data) and then stating each ply had a consistent value would be misleading. It may however be valid to state that as a combined unit the analysis values are representative.

Should the Estimator not be confident that the analysis reported for a sampled interval is not representative of the geological zone being reported then this must be taken into account during the assessment of confidence.

Q16 What does good Geological Modelling Documentation include?

It is recommended that each model has documentation that details the following:

- The model should be date stamped or have some date identification;
- Seam and variable codes need to be defined including moisture basis for quality variable;
- Those involved in the construction of the model should be identified;
- The intended purpose of the model ("Fitness for Purpose") and any limitations or risks associated with using the model should be noted;
- Reference the data used to construct the model, reasons for excluding any data, and the date of the last data used in the model;
- The survey datum;
- The source and accuracy of Digital Terrain Model (DTM) data and any manipulation of the data;
- Methods used to construct the model should be clearly described;
- Any manipulation of data (such as changes in moisture basis) should be documented;
- Notes on differences with previous models;
- Model validations and audits of the process should be referenced (and stored with the archived model).

Appendix B - List of Relevant Australian Standards (as at 2014)

Standard	**Description**
AS-1038.10.0-2002 (R2013)	Determination of trace elements - Guide to the determination of trace elements
AS 1038.10.1-2003 (R2013)	Determination of trace elements - Coal, coke and fly-ash - Determination of eleven trace elements - Flame atomic absorption spectrometric method
AS 1038.10.2-1998 (R2013)	Determination of trace elements - Coal and coke - Determination of arsenic, antimony and selenium - Hydride generation method
AS 1038.10.3-1998 (R2013)	Determination of trace elements - Coal and coke - Determination of boron content - ICP-AES method
AS 1038.10.4-2001 (R2013)	Determination of trace elements - Coal, coke and fly-ash - Determination of fluorine content - Pyrohydrolysis method
AS 1038.10.5.1-2003 (R2013)	Coal, coke and fly-ash - Trace elements - Determination of mercury content - Tube combustion method
AS 1038.10.5.2-2007	Coal and fly-ash - Trace elements - Determination of mercury content - Acid extraction method
AS 1038.11-2002 (R2013)	Coal - Forms of sulfur
AS 1038.12.1-2002	Higher rank coal - Caking and coking properties - Crucible swelling number
AS 1038.12.2-1999 (R2013)	Higher rank coal - Caking and coking properties - Determination of Gray-King coke type
AS 1038.12.3-2002	Higher rank coal - Caking and coking properties - Dilatation
AS 1038.13-1990 (R2013)	Tests specific to coke
AS 1038.14.1-2003 (R2013)	Higher rank coal ash and coke ash - Major and minor elements - Borate fusion/flame atomic absorption spectrometric method
AS 1038.14.2-2003 (R2013)	Higher rank coal ash and coke ash - Major and minor elements - Acid digestion/flame atomic absorption spectrometric method
AS 1038.14.3-1999 (R2013)	Higher rank coal ash and coke ash - Major and minor elements - Wavelength dispersive X-ray fluorescence spectrometric method
AS 1038.16-2005	Assessment and reporting of results
AS 1038.17-2000 (R2013)	Higher rank coal - Moisture-holding capacity (equilibrium moisture)
AS 1038.18-2006	Coke - Size analysis
AS 1038.19-2000 (R2013)	Higher rank coal - Abrasion Index

Standard	Description
AS 1038.2-2006	Coke - Total moisture
AS 1038.20-2002 (R2013)	Higher rank coal - Hardgrove grindability index
AS 1038.21.1.1-2008	Higher rank coal and coke - Relative density - Analysis sample/density bottle method
AS 1038.21.1.2-2002 (R2013)	Higher rank coal and coke - Relative density - Analysis sample/volumetric method
AS 1038.22-2000 (R2013)	Higher rank coal - Mineral matter and water of constitution
AS 1038.23-2002 (R2013)	Higher rank coal and coke - Carbonate carbon
AS 1038.24-1998 (R2013)	Guide to the evaluation of measurements made by on-line coal analysers
AS 1038.25-2002 (R2013)	Coal - Durham cone handleability
AS 1038.26-2005	Higher rank coal and coke - Guide for the determination of apparent relative density
AS 1038.4-2006	Coke - Proximate analysis
AS 1038.5-1998	Gross calorific value
AS 1038.6.1-1997 (R2013)	Higher rank coal and coke - Ultimate analysis - Carbon and hydrogen
AS 1038.6.2-2007	Higher rank coal and coke - Ultimate analysis - Nitrogen
AS 1038.6.3.1-1997 (R2013)	Higher rank coal and coke - Ultimate analysis - Total sulfur - Eschka method
AS 1038.6.3.2-2003 (R2013)	Higher rank coal and coke - Ultimate analysis - Total sulfur - High-temperature combustion method
AS 1038.6.3.3-1997 (R2013)	Higher rank coal - Ultimate analysis - Total sulfur - Infrared method
AS 1038.6.4-2005	Higher rank coal and coke - Ultimate analysis - Carbon, hydrogen and nitrogen - Instrumental method
AS 1038.8.1-1999 (R2013)	Coal and coke - Chlorine - Eschka method
AS 1038.8.2-2003 (R2013)	Coal and coke - Chlorine - High-temperature combustion method
AS 1038.9.1-2000 (R2013)	Higher rank coal and coke - Phosphorus - Ash digestion/ molybdenum blue method
AS 1038.9.2-2000 (R2013)	Higher rank coal - Phosphorus - Coal extraction/ phosphomolybdovanadate method
AS 1038.9.3-2000 (R2013)	Coal and coke - Phosphorus - Ash digestion/ phosphomolybdovanadate method
AS 1038.9.4-2006	Higher rank coal - Phosphorus - Borate fusion/molybdenum blue method

Other Australian Standards that may require consideration for analysis and testing in lower rank coals include:

Standard	Description
AS 2434.1-1999 (R2013)	Determination of the total moisture content of lower rank coal
AS 2434.2-2002 (R2013)	Lower rank coal - Determination of volatile matter
AS 2434.3-2002 (R2013)	Lower rank coal - Determination of the moisture holding capacity
AS 2434.4-2002 (R2013)	Dried lower rank coal and its chars - Determination of apparent density - Mercury displacement method
AS 2434.5-2002 (R2013)	Lower rank coal and its chars - Determination of moisture in bulk samples of lower rank coal and in analysis samples of char
AS 2434.6-2002 (R2013)	Lower rank coal - Ultimate analysis - Classical methods
AS 2434.7-2002 (R2013)	Lower rank coal - Determination of moisture in the analysis sample
AS 2434.8-2002 (R2013)	Lower rank coal - Determination of ash
AS 2434.9-2000 (R2013)	Method for the analysis and testing of lower rank coal and its chars - Determination of four acid-extractable ions in lower rank coal
AS 2519-1993	Guide to the Evaluation of Higher Rank Coal Deposits

Additional standards that may also require consideration include:

Standard	Description
AS 2096-1987	Classification and coding systems for Australian coals
AS 2418-1995	Coal and coke - Glossary of terms
AS 2916-2007	Symbols for graphic representation of coal seams and associated strata
AS 2519-1993	Guide to the technical evaluation of higher rank coal deposits
AS 2617-1996	Sampling from coal seams
AS 2856.1-2000 (R2013)	Coal petrography - Preparation of coal samples for incident light microscopy
AS 2856.2-1998 (R2013)	Coal petrography - Maceral analysis
AS 2856.3-2000 (R2013)	Coal petrography - Method for microscopical determination of the reflectance of coal macerals
AS 3899-2002 (R2013)	Higher rank coal and coke - Bulk density
AS 3980-1999 (R2013)	Guide to the determination of gas content of coal - Direct desorption method

Standard	**Description**
AS 4156.1-1994 (R2013)	Coal preparation - Higher rank coal - Float and sink testing
AS 4156.2.1-2004	Coal preparation - Higher rank coal - Froth flotation - Basic test
AS 4156.2.2-1998 (R2013)	Coal preparation - Higher rank coal - Froth flotation - Sequential procedure
AS 4156.3-2008	Coal preparation - Magnetite for coal preparation plant use - Test methods
AS 4156.3-2008/Amdt 1-2009	Coal preparation - Magnetite for coal preparation plant use - Test methods
AS 4156.4-1999 (R2013)	Coal preparation - Flowsheets and symbols
AS 4156.6-2000 (R2013)	Coal preparation - Determination of dust/moisture relationship for coal
AS 4156.7-1999 (R2013)	Coal preparation - Coal size classifying equipment - Performance evaluation
AS 4156.8-2007	Coal preparation - Sample pre-treatment - Drop-shatter
AS 4264.1-2009	Coal and coke - Sampling - Coal - Sampling procedures
AS 4264.1-2009/Amdt 1-2011	Coal and coke - Sampling - Coal - Sampling procedures
AS 4264.2-1996	Coal and coke - Sampling - Coke - Sampling procedures
AS 4264.4-1996	Coal and coke - Sampling - Determination of precision and bias
AS 4264.5-1999	Coal and coke - Sampling - Guide to the inspection of mechanical sampling systems

Appendix C – Laboratory Precision – Critical Variables

PRECISION OF TEST METHODS AND SCHEDULE FOR REPORTING OF RESULTS

Uncertainty of measurement

Users of the Australian Standards (AS 1038 and AS 2434) series of coal and coke test methods and those who use the results obtained by these methods should be aware of the variability of the results which may be obtained, which is commonly referred to as the uncertainty of measurement.

The best estimate of the variability of these test methods is the repeatability (within laboratory) and reproducibility (between laboratories) values quoted within each test method in the Standard and summarised below. Reference should be made to Clauses 5 and 6 in AS 1038 for explanation of their use. In addition, reference should be made to the latest edition of the relevant Standard to verify the repeatability and reproducibility data.

Repeatability

The Repeatability of the determination of the volume percentage of a component is that difference between two single determinations each based on the same number of point counts carried out by the same operator on the same sample using the same apparatus, within which 95% of such differences would be expected to lie.

Reproducibility

The Reproducibility of the determination of the volume percentage of a component is that difference between two single determinations each based on the same number of point counts carried out by two different operators on two different sub samples taken from the same sample, using different equipment, within which 95% of such differences would be expected to lie.

Extracts are from AS 2856.3-2000 Table 2; AS 2856.2-1998 Table 1 and AS 1038.16-2005 Table C1.

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Repeatability and Reproducability of Test Methods

Australian Standard	Corresponding ISO Standard	Material	Determination	r (Repeatability)	R (Reproducibility)	See Note 1	Report to nearest
AS 1038.1	589	coal	Mas total moisture %	0.5	1.5	A	0.1
AS 1038.3	331562	coal	Mad analysis moisture % <5	0.1	—	A	0.1
AS 1038.3	331562	coal	Mad analysis moisture % ≥5	0.15	—	A	0.1
AS 1038.3	331562	coal	Aad ash % <10	0.1	0.15	A	0.1
AS 1038.3	331562	coal	Aad ash % ≥10 ≤30	0.15	0.25	A	0.1
AS 1038.3	331562	coal	Aad ash % >30	0.2	0.6	A	0.1
AS 1038.3	331562	coal	Vmad volatile matter % <25	0.2	0.5	A	0.1
AS 1038.3	331562	coal	VMad volatile matter % ≥25	0.2	1	A	0.1
AS 1038.5	1928	coal, coke	qgr,v,ad (SE) gross calorific value MJ/kg (gross specific energy)	0.13	0.30	A	0.01
AS 1038.6.1	609	coal	Cad carbon (total) %	0.3	0.6	A	0.1
AS 1038.6.1	609	coal	Had hydrogen %	0.1	0.2	A	0.01
AS 1038.6.2		coal	Nad nitrogen %	0.03	0.08	A	0.01
AS 1038.6.3.1	334	coal, coke	Sad sulfur (total) % (Eschka) ≤2	0.05	0.1	A	0.01
AS 1038.6.3.1	334	coal, coke	Sad sulfur (total) % (Eschka) >2	0.1	0.2	A	0.01
AS 1038.6.3.2	351	coal, coke	Sad sulfur (total) % (high temperature combustion) ≤1.5	0.03	0.08	A	0.01
AS 1038.6.3.2	351	coal, coke	Sad sulfur (total) % (high temperature combustion) >1.5	2%	10%	A	0.01
AS 1038.6.3.3		coal	Sad sulfur (total) % (Infrared) ≤1.5	0.03	0.05	A	0.01
AS 1038.6.3.3		coal	Sad sulfur (total) % (Infrared) >1.5 < 6	2%	8%	A	0.01
AS 1038.8.1	587	coal, coke	Clad chlorine (Eschka) %	0.01	0.02	A	0.01
AS 1038.8.2	352	coal, coke	Clad chlorine (high temperature combustion) %	0.01	0.02	A	0.01
AS 1038.9.1,9.2,9.3	622	coal, coke	Pad phosphorus % <0.02	0.002	0.003	A	0.001
AS 1038.9.1,9.2,9.3	622	coal, coke	Pad phosphorus % ≥0.02	10%	15%	A	0.001
AS 1038.11	157	coal	Ss,ad sulfate sulfur %	0.02	0.03	A	0.01
AS 1038.11	157	coal	Sp,ad pyritic sulfur % <0.5	0.05	0.1	A	0.01
AS 1038.11	157	coal	Sp,ad pyritic sulfur % ≥0.5	0.07	0.15	A	0.01
AS 1038.12.1	501	coal	CSN crucible swelling number 3 determinations	½	1	A	½
AS 1038.12.1	501	coal	CSN crucible swelling number 5 determinations	½	1	A	½
AS 1038.12.2	502	coal	Gray-King coke type	one letter, or one unit in the subscript	one letter, or one unit in the subscript	A	N/A
AS 1038.12.3	8264	coal	T1, T2, T3 dilatometer characteristics: temperature °C	7	15	A	5
AS 1038.12.3	8264	coal	c dilatometer characteristics max. contraction %	5	8	A	See Standard
AS 1038.12.3	8264	coal	d dilatometer characteristics max. Dilatation negative %	5	8	A	See Standard
AS 1038.12.3	8264	coal	dilatometer characteristics: Dilatation positive %	5[1+(d/100)]	5[2+(d/100)]	A	See Standard
AS 1038.12.4.1		coal	Gieseler plastometer properties (continuous torque)— max. fluidity dd/min < 20	0.3 log10	0.6 log10	A	See Standard
AS 1038.12.4.1		coal	Gieseler plastometer properties (continuous torque)— max. fluidity dd/min ≥ 20 to <10 000	0.1 log10	0.2 log10	A	See Standard
AS 1038.12.4.1		coal	Gieseler plastometer properties (continuous torque)— max. fluidity dd/min ≥ 10 000	0.2 log10	0.4 log10	A	See Standard
AS 1038.12.4.1		coal	Gieseler plastometer properties (continuous torque)— characteristic temp °C	7	15	A	See Standard
AS 1038.12.4.2		coal	Gieseler plastometer properties (discontinuous torque)— max. fluidity dd/min < 20	0.3 log10	0.6 log10	A	See Standard
AS 1038.12.4.2		coal	Gieseler plastometer properties (discontinuous torque)— max. fluidity dd/min ≥ 20 to <5 000	0.1 log10	0.2 log10	A	See Standard
AS 1038.12.4.2		coal	Gieseler plastometer properties (discontinuous torque)— characteristic temp °C	7	15	A	See Standard

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Repeatability and Reproducability of Test Methods

Australian Standard	Corresponding ISO Standard	Material	Determination	r (Repeatability)	R (Reproducibility)	See Note 1	Report to nearest
AS 1038.13		coke	Tests specific to coke				
AS 1038.13	616	coke	Shatter index % 40 mm	6	—	B	1
AS 1038.13		coke	Shatter index % 10 mm	6	—	B	
AS 1038.13	556	coke	M40 Micum index %	3	—	B	0.1
AS 1038.13		coke	M10 Micum index %	1	—	B	
AS 1038.13	556	coke	I40 IRSID index	5		B	
AS 1038.13		coke	I20 IRSID index	2.5	—	B	0.1
AS 1038.13		coke	I10 IRSID index	2	—	B	
AS 1038.13		coke	ASTM tumbler test stability + 25 mm %	2	—	B	0.1
AS 1038.13		coke	ASTM tumbler test hardness + 6.3 mm %	2	—	B	
AS 1038.13		coke	JIS drum test 30 revs < 90% + 15 mm	4.0	—	B	0.1
AS 1038.13		coke	JIS drum test 30 revs ≥ 90% + 15 mm	1.5	—	B	
AS 1038.13		coke	JIS drum test 150 revs < 80% + 15 mm	2.5	—	B	0.1
AS 1038.13		coke	JIS drum test 150 revs ≥ 80% + 15 mm	1.5	—	B	
AS 1038.13		coke	CRI coke reactivity index % ≤30	2.5	—	B	
AS 1038.13		coke	CRI coke reactivity index %>30	5.0		B	
AS 1038.13		coke	CSR coke strength after reaction % >60	2.5	—	B	
		coke	CSR coke strength after reaction % ≤60	5.0	—	B	
AS 1038.14.3		ash	Ash analysis (XRF) For other Ash Analyses Methods refer to the Standards			A	
AS 1038.14.3		ash	SiO2% 45 to 70	0.42	1.44	A	
AS 1038.14.3		ash	Al2O3% 20 to 35	0.25	1.01	A	
AS 1038.14.3		ash	Fe2O3% 1.5 to 13	0.007X + 0.035	0.027X + 0.063	A*	
AS 1038.14.3		ash	CaO% 0.5 to 3.5	0.035	0.089	A	
AS 1038.14.3		ash	MgO% 1.0 to 2.0	0.073	0.13	A	
AS 1038.14.3		ash	Na2O% 0.1 to 1.0	0.063	0.11	A	
AS 1038.14.3		ash	K2O% 0.5 to 2.0	0.012X + 0.009	0.062X + 0.016	A*	See Standard
AS 1038.14.3		ash	TiO2% 1.0 to 2.5	0.037	0.10	A	
AS 1038.14.3		ash	Mn3O4% 0.02 to 0.25	0.010	0.017	A	
AS 1038.14.3		ash	P2O5% 0.05 to 1.0	0.022X + 0.01	0.078X + 0.014	A*	
AS 1038.14.3		ash	SO3% 0.5 to 1.5	0.049X + 0.001	0.16	A*	
AS 1038.14.3		ash	BaO% 0.04 to 0.2	0.021	0.043	A	
AS 1038.14.3		ash	SrO% 0.01 to 0.1	0.004	0.195	A	
AS 1038.14.3		ash	ZnO% 0.01 to 0.03	0.006	0.011	A	
AS 1038.15	540	ash	Ash fusion temperature °C deformation < 1300°C	30	80	A	10
AS 1038.15	540	ash	Ash fusion temperature °C deformation ≥ 1300°C	50	150	A	10
AS 1038.15	540	ash	Ash fusion temperature °C sphere	30	60	A	10
AS 1038.15	540	ash	Ash fusion temperature °C hemisphere	30	60	A	10
AS 1038.15	540	ash	Ash fusion temperature °C flow	40	80	A	10

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Repeatability and Reproducability of Test Methods

Australian Standard	Corresponding ISO Standard	Material	Determination	r (Repeatability)	R (Reproducibility)	See Note 1	Report to nearest
AS 1038.17	1018	coal	MHC Moisture-holding capacity %	0.6	1.2	A	0.1
AS 1038.19	12900	coal	AI Abrasion index ≤ 20	2	—	C	1
AS 1038.19	12900	coal	AI Abrasion index > 20	10%	—	C	1
AS 1038.20	5074	coal	HGI Hardgrove grindability	2	5	C	1
AS 1038.21.1.1		coal, coke	RD Relative density—Analysis sample/density bottle < 1.6	0.03	0.08	A	0.01
AS 1038.21.1.1		coal, coke	RD Relative density—Analysis sample/density bottle ≥ 1.6	0.04	0.08	A	0.01
AS 1038.21.1.2		coal, coke	RD Relative density—Analysis sample/volumetric < 1.6	0.03	0.1	A	0.01
AS 1038.21.1.2		coal, coke	RD Relative density—Analysis sample/volumetric ≥ 1.6	0.04	0.12	A	0.01
AS 1038.23	925	coal	Cm,ad carbonate carbon %	0.01	0.02	A	0.01
AS 1038.25		coal	Fs Handleability s /kg <1	5%	10%		0.1
AS 1038.25		coal	Fs Handleability s /kg ≥1	10%	20%		1
AS 2856.3—2000	7404-5	Coal	**Microscopical determination of the reflectance of coal macerals**	%	%		
AS 2856.3—2000		Coal	Maximum Reflectance Sample Size 30	0.026	0.076		0.01
AS 2856.3—2000		Coal	Maximum Reflectance Sample Size 50	0.019	0.073		0.01
AS 2856.3—2000		Coal	Maximum Reflectance Sample Size 100	0.014	0.071		0.01
AS 2856.3—2000		Coal	Random Reflectance Sample Size 30	0.027	0.092		0.01
AS 2856.3—2000		Coal	Random Reflectance Sample Size 50	0.02	0.088		0.01
AS 2856.3—2000		Coal	Random Reflectance Sample Size 100	0.015	0.087		0.01
AS 2856.2-1998		Coal	**Coal Petrography Maceral Analysis**				
AS 2856.2-1998		Coal	Theoretical Standard Deviation and repeatability of the percentage of a component based on 500 count points				
AS 2856.2-1998		Coal	Volume % of component 5 Standard deviation of the volume percentage 1	2.8	not specified		0.1
AS 2856.2-1998		Coal	Volume % of component 20 Standard deviation of the volume percentage 1.8	5.1	not specified		0.1
AS 2856.2-1998		Coal	Volume % of component 50 Standard deviation of the volume percentage 2.2	6.3	not specified		0.1
AS 2856.2-1998		Coal	Volume % of component 80 Standard deviation of the volume percentage 1.8	5.1	not specified		0.1
AS 2856.2-1998		Coal	Volume % of component 95 Standard deviation of the volume percentage 1	2.8	not specified		0.1

* X in the equations = concentration of analyte NOTES: 1 Recent precision statistics from Australian interlaboratory test programs are designated by an 'A' in the final column, whereas those adapted from earlier versions of BS 1016-100 and which are due for revision are designated 'B'. Precision data obtained from International Standards are designated 'C'. The allocation of precision statistics is based primarily upon the results of the test program, but consideration is given also to results from recent NATA surveys as well as the corresponding ISO, BS and ASTM statistics where advisable. 2 Strictly, results obtained under reproducibility conditions should be compared only on a dry basis. 3 '—' denotes the unavailability of sufficient information, or that statistics are not applicable in this instance. 4 '%' values quoted in precision columns are percentages relative to the mean result, not absolute percentages as is otherwise the case where this symbol is applicable.

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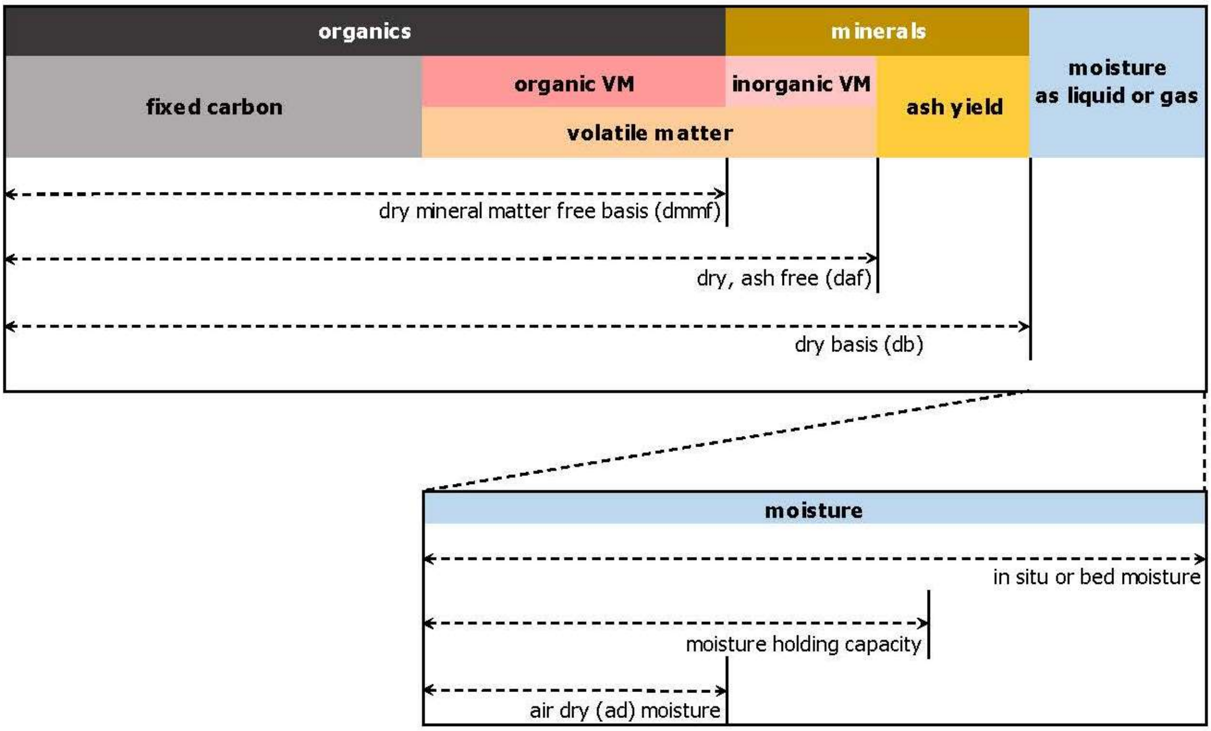
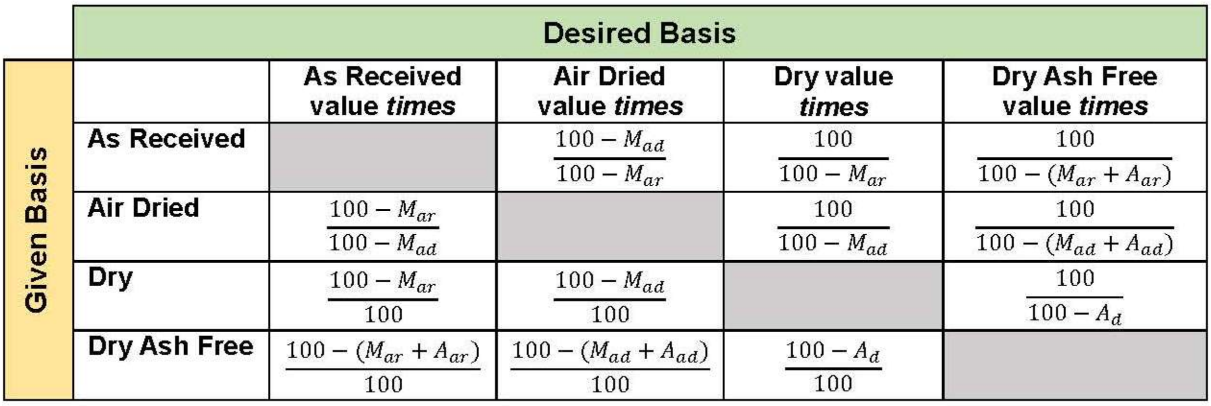
Appendix D: Coal Composition, Moisture States and Reporting Bases



Notes:
(1) water of hydration of minerals and organically bound water form part of the volatile matter.
(2) as received (ar) moisture may be greater or less than in situ moisture depending upon the condition of the sample and the presence of surface moisture.



		Desired Basis			
		As Received value *times*	Air Dried value *times*	Dry value *times*	Dry Ash Free value *times*
Given Basis	As Received	▨	$\frac{100 - M_{ad}}{100 - M_{ar}}$	$\frac{100}{100 - M_{ar}}$	$\frac{100}{100 - (M_{ar} + A_{ar})}$
	Air Dried	$\frac{100 - M_{ar}}{100 - M_{ad}}$	▨	$\frac{100}{100 - M_{ad}}$	$\frac{100}{100 - (M_{ad} + A_{ad})}$
	Dry	$\frac{100 - M_{ar}}{100}$	$\frac{100 - M_{ad}}{100}$	▨	$\frac{100}{100 - A_d}$
	Dry Ash Free	$\frac{100 - (M_{ar} + A_{ar})}{100}$	$\frac{100 - (M_{ad} + A_{ad})}{100}$	$\frac{100 - A_d}{100}$	▨