Water Resources Management System (WRMS) Executive Summary

Andy Clay[1] and Jeff Aldrich[1]

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[1]AAPG Division of Environmental Geosciences

Executive Summary

This Water Resources Management System (WRMS) has been prepared here as a necessary initiative to classify water resources that are becoming a critical issue for mankind and life on earth in general. It has followed the tried and tested principles for reporting of oil and gas under the Petroleum Resources Management System since we are dealing with the primary state of water as a liquid and a mineral. However, we clearly need to cater for the solid and gaseous phases as well. A singular difference of water as a resource compared to other minerals is that in many cases it is renewable as the reservoirs are repeatedly depleted and recharged.

It should also be stated here that the primary objective of the WRMS is to classify water as an "asset" for which quantities and qualities can be defined and for accounting purposes it can be valued. The reason for this, is to enable the ownership and management of water resources to be seamlessly transferred from government to commerce and treated as a properly managed resource for the benefit of all. This is also needed because in most cases the development and exploitation of water is a financial engineering exercise that needs securitization of assets.

However, given the rising shortage of water and the complications of climate change water cannot continue to be considered a "human right" when in fact human created pollution is fast compromising the integrity of access to potable water.

According to some (National Water Resource Strategy of South Africa) (DWS, 2013), a water resource is water that can be used to contribute to economic activity, including a water course, surface water, estuary, rainfall and ground water in an aquifer.

In itself this definition is inadequate and a complication in water management is the plethora of government laws and legislation that impinge on the ability to define water resources as an asset which is simply "is a resource controlled by an enterprise from which future economic benefits will flow".

A further objective of this WRMS is to create a common framework for classification and to use that process to minimize corruption and inappropriate exploitation of these valuable, life sustaining resources.

Water Resource assessments estimate and calculate total quantities in known and yet-to-be discovered accumulations; resource evaluations are focused on those quantities that can potentially be recovered and marketed by commercial or governmental type projects. The WRMS provides a consistent approach to estimating water quantities, evaluation development projects, and presenting results within a comprehensive classification framework.

An overarching philosophical issue with water, as with oil and gas and minerals is that State's consider these all belong to them. Commercial access is gained through licensing and therefore these mineral assets should fall under the same process. However, in many cases water is regarded as a residual problem and linked to long term rehabilitation and environmental liabilities. The intention of the WRMS is to quantify the technical and commercial characteristics of reservoirs in a consistent manner and allow for the efficient utilization of water and effective management of remediation requirements. This is intended to turn liabilities into assets for the water volumes and put them onto a balance sheet and ensure commercial ownership is controlled by the development entity thus meeting the accounting objectives for investor confidence and financing.

What makes water different?

Historically mineral assets have been regarded as a wasting nature so that as you mine to exhaustion you get to a point where there is nothing left. Water can be a renewable and sustainable resource providing that it is managed in a responsible and sensible manner. If it isn't, it is likely that water inadequacy will lead to next round of global conflict.

In recent years, the dramatic impact of a significant warming period in earth's history has led to many countries experiencing serious drought and water scarcity. This has been particularly evident in many countries which have virtually run out of water and even instituted emergency regulations to deal with unusual and exceptional drought conditions. The authors of this WRMS have identified a specific need to classify water beyond the limits of that which would be required for national strategic planning.

In this regard, the commercial imperative is to link the human right of access to water to the efficient utilisation of the various water resources. To this end, the very principle and philosophy of ownership is at the heart of the classification system, which is intimately related to the cost of producing various types of water and the price at which it can be sold.

There are many approaches that have been taken to planning water management, primarily driven by government agencies. However, in many ways this is similar to other national planning issues including road, rail, health, retirement planning, farming, and air pollution. As a result, the governmental process is invariably in conflict with the realities of commerce since the concept that "nothing is for free" is an increasing global human population problem.

Another aspect of water is its numerous uses. Many countries use water to create electricity and in valuation the principle of “highest and best use” is important to consider how such a water reservoir is valued. These idiosyncrasies should not be used to separate water form a rational process of definition and management but rather enhance its role and place by direct comparison with other minerals.

Water has always been cheap at source. This legacy of an inadequately priced commodity is ending and the viability of water projects requires significant increases in the downstream sales price. The obvious arbitrage between bulk water prices to the cost of bottled water is unsustainable.

These definitions and guidelines are designed to provide a common reference for the international water industry, including national reporting and regulatory disclosure agencies, and to support water projects and portfolio management requirements.

They are intended to improve clarity in global communications regarding water resources. It is expected that this document will be supplemented with industry education programs and application guides addressing their implementation in a wide spectrum of technical and/or commercial settings.

A key aspect of water is the ability to create and monitor a “water balance” as defined here to measure inflows and outflows and recharge. The water balance is a cornerstone of the WRMS as prepared here.

It is understood that these definitions and guidelines allow flexibility for users and agencies to tailor application for their particular needs; however, any modifications to the guidance contained herein should be clearly identified. The definitions and guidelines contained in this document must not be construed as modifying the interpretation or application of any existing regulatory reporting requirements.

This WRMS document, including its Appendix, may be referred to by the abbreviated term “WRMS” with the caveat that the full title, including clear recognition of the co-sponsoring organizations, has been initially stated.

As a final note, the WRMS has been directly modelled and modified from the Petroleum Resources Management System (PRMS) as writing a new code from scratch is a time consuming and difficult exercise as there are so many stakeholders. The headings and content follow PRMS but with extensive reworking to incorporate water specific issues. However, it is hoped that the Society for Petroleum Engineers (SPE) and the Society for Petroleum Evaluation Engineers (SPEE) and the American Association for Petroleum Geologist (AAPG) and the World Petroleum Council (WPC) who administer the PRMS will assist in maintenance and improvement of the WRMS as created here.

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1. Basic Principles and Definitions

The estimation of water resource qualities and quantities involves the interpretation of volumes and values that have an inherent degree of uncertainty. These qualities and quantities are associated with development projects at various stages of design and implementation. Use of a consistent classification system enhances comparisons between projects, groups of projects, and total company portfolios according to forecast production profiles and recoveries. Such a system must consider both technical and commercial factors that impact the project's economic feasibility, its productive life, and its related cash flows.

A unique aspect of water is that in many cases it can be considered renewable as it is often subject to recharge which can be measured. This makes is different to other minerals and oil and gas.

However, the preparers of this standard have extensive experience in mineral resource and oil and gas resource quantification and classification. As such, have relied upon the PRMS for oil and gas as an existing template to create a new unique system.

1.1 Water Resource Classification Framework

Water is defined as a colourless, transparent, odourless, liquid which forms the seas, lakes, rivers, and rain and is the basis of the fluids of living organisms. Water can also be in gaseous, liquid, or solid phase.

Figure 1 is a graphical representation of the water resources classification system. The system defines the major recoverable resources classes: Production, Reserves, Contingent Resources, and Prospective Resources, as well as Unrecoverable water.

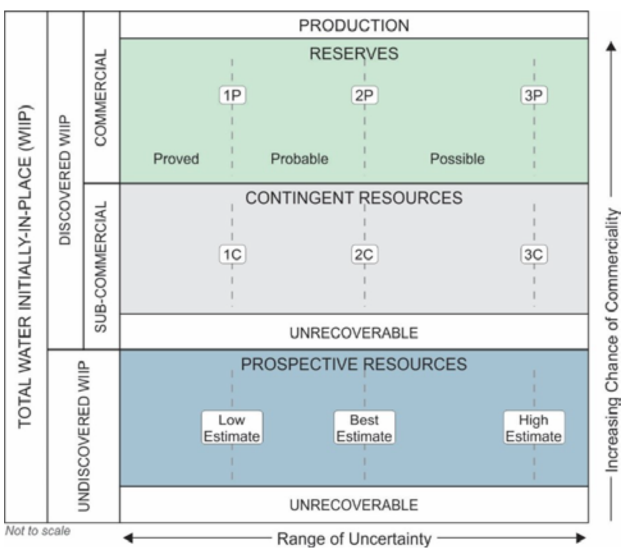

Figure 1. Resources Classification Framework

The “Range of Uncertainty” reflects a range of estimated quantities potentially recoverable from an accumulation by a project, while the vertical axis represents the “Chance of Commerciality”, that is, the chance that the project that will be developed and reach commercial producing status.

The primary method of estimating a water resource is to create a “Water Balance” which is a generally accepted process to indicate inflows and outflows and the static reservoir volume capacity. In oil and gas permeability and porosity and flow rates are critical factors and is similar to water quantity estimation. However, flow rates are generally more easily measured for water.

The following definitions apply to the major subdivisions within the water resources classification:

TOTAL WATER INITIALLY-IN-PLACE is that quantity of water that is estimated to exist originally in naturally occurring accumulations. It includes that quantity of water that is estimated, as of a given date, to be contained in known accumulations prior to production plus those estimated quantities in accumulations yet to be discovered (equivalent to “total resources”).

DISCOVERED WATER INITIALLY-IN-PLACE is that quantity of water that is estimated, as of a given date, to be contained in known accumulations prior to production.

PRODUCTION is the cumulative quantity of water that has been recovered at a given date. While all recoverable resources are estimated and production is measured in terms of the sales product specifications, raw production (sales plus non-sales) quantities are also measured and required to support engineering analyses based on reservoir voidage (see Production Measurement, section 3.2).

Multiple development projects may be applied to each known accumulation, and each project will recover an estimated portion of the initially-in-place quantities. The projects shall be subdivided into Commercial and Sub-Commercial, with the estimated recoverable quantities being classified as Reserves and Contingent Resources respectively, as defined below.

In most cases recharge is a significant factor and the impact on sustainable volumes should be clearly indicated in the Water Balance and clearly quantified in the Resource Statement.

RESERVES are those quantities of water anticipated to be commercially recoverable by application of development projects to known accumulations from a given date forward under defined conditions. Reserves must further satisfy four criteria: they must be discovered, recoverable, commercial, and remaining (as of the evaluation date) based on the development project(s) applied or represent a “sustainable” volume. Reserves are further categorized in accordance with the level of certainty associated with the estimates and may be sub-classified based on project maturity and/or characterized by development and production status.

CONTINGENT RESOURCES are those quantities of water estimated, as of a given date, to be potentially recoverable from known accumulations, but the applied project(s) are not yet considered mature enough for commercial development due to one or more contingencies.

Contingent Resources may include, for example, projects for which there are currently no viable markets, or where commercial recovery is dependent on technology under development, or where evaluation of the accumulation is insufficient to clearly assess commerciality. Contingent Resources are further categorized in accordance with the level of certainty associated with the estimates and may be sub-classified based on project maturity and/or characterized by their economic status.

A complication for movement from "Contingent" to Reserves is often regulatory and the ability to licence the water resource to a point of sale. This may be a primary issue relating to the price for the water at a point of sale to make the economical exploitation commercial and hence create a "Reserves Booking" as an asset. Each case must be treated on its own merits in just the same way as any other mineral resource or oil and gas project.

UNDISCOVERED WATER INITIALLY-IN-PLACE is that quantity of water estimated, as of a given date, to be contained within accumulations yet to be discovered.

PROSPECTIVE RESOURCES are those quantities of water estimated, as of a given date, to be potentially recoverable from undiscovered accumulations by application of future development projects. Prospective Resources have both an associated chance of discovery and a chance of development. Prospective Resources are further subdivided in accordance with the level of certainty associated with recoverable estimates assuming their discovery and development and may be sub-classified based on project maturity.

UNRECOVERABLE is that portion of Discovered or Undiscovered Water Initially-in Place quantities which is estimated, as of a given date, not to be recoverable by future development projects. A portion of these quantities may become recoverable in the future as commercial circumstances change or technological developments occur; the remaining portion may never be recovered due to physical/chemical constraints represented by subsurface interaction of fluids and reservoir rocks

Estimated Ultimate Recovery (EUR) is not a resources category, but a term that may be applied to any accumulation or group of accumulations (discovered or undiscovered) to define those quantities of water estimated, as of a given date, to be potentially recoverable under defined technical and commercial conditions plus those quantities already produced (total of recoverable resources).

In specialized areas, such as basin potential studies, alternative terminology has been used; the total resources may be referred to as Total Resource Base or Water Endowment. Total recoverable may be termed Basin Potential. The sum of Reserves, Contingent Resources, and Prospective Resources may be referred to as "remaining recoverable resources." When such terms are used, it is important that each classification component of the summation also be provided. Moreover, these quantities should not be aggregated without due consideration of the varying degrees of technical and commercial risk involved with their classification.

1.2 Project-Based Resources Evaluation

The resources evaluation process consists of identifying a recovery project, or projects, associated with water accumulation(s), estimating the quantities of Water Initially-in Place, estimating that portion of those in-place quantities that can be recovered by each project, and classifying the project(s) based on its maturity status or chance of commerciality.

This concept of a project-based classification system is further clarified by examining the primary data sources contributing to an evaluation of net recoverable resources (see Figure 2) that may be described as follows:-

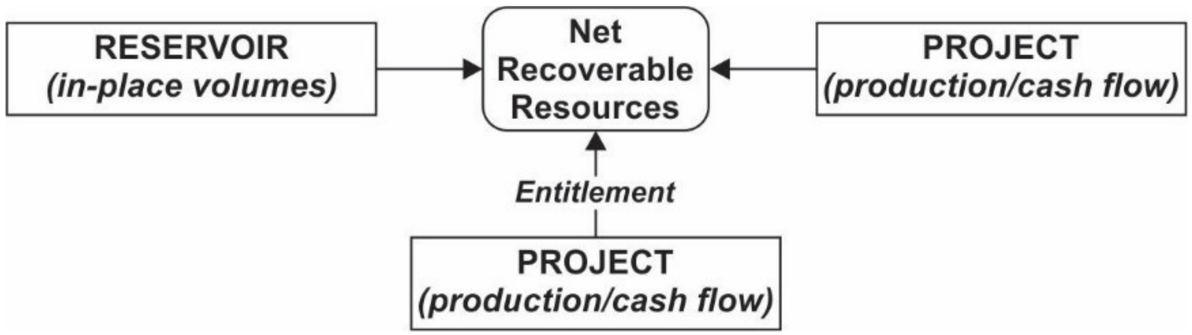

Figure 2. Resources Evaluation Data Sources

• The Reservoir (accumulation): Key attributes include the types and quantities of Water Initially-in-Place and the fluid and rock properties that affect water recovery. A Water Balance must be prepared for each project.

• The Project: Each project applied to a specific reservoir development generates a unique production and cash flow schedule. The time integration of these schedules taken to the project's technical, economic, or contractual limit defines the estimated recoverable resources and associated future net cash flow projections for each project.

• The ratio of EUR to Total Initially-in-Place quantities defines the ultimate recovery efficiency for the development project(s). A project may be defined at various levels and stages of maturity; it may include one or many wells and associated production and processing facilities. One project may develop many reservoirs, or many projects may be applied to one reservoir.

• The Property (lease or license area): Each property may have unique associated contractual rights and obligations including the fiscal terms. Such information allows definition of each participant's share of produced quantities (entitlement) and share of investments, expenses, and revenues for each recovery project and the reservoir to which it is applied. One property may encompass many reservoirs, or one reservoir may span several different properties. A property may contain both discovered and undiscovered accumulations.

In context of this data relationship, “project” is the primary element considered in this water resources classification, and net recoverable resources are the incremental quantities derived from each project. Project represents the link between water accumulation and the decision-making process. A project may, for example, constitute the development of a single reservoir or field, or an incremental development for a producing field, or the integrated development of several fields and associated facilities with a common ownership. In general, an individual project will represent the level at which a decision is made whether or not to proceed (i.e., spend more money) and there should be an associated range of estimated recoverable quantities for that project.

An accumulation or potential accumulation of water may be subject to several separate and distinct projects that are at different stages of exploration or development. Thus, an accumulation may have recoverable quantities in several resource classes simultaneously.

In order to assign recoverable resources of any class, a development plan needs to be defined consisting of one or more projects. Even for Prospective Resources, the estimates of recoverable quantities must be stated in terms of the sales products derived from a development program assuming successful discovery and commercial development. Given the major uncertainties involved at this early stage, the development program will not be of the detail expected in later stages of maturity. In most cases, recovery efficiency may be largely based on analogous projects. In-place quantities for which a feasible project cannot be defined using current, or reasonably forecast improvements in, technology are classified as Unrecoverable.

Not all technically feasible development plans will be commercial. The commercial viability of a development project is dependent on a forecast of the conditions that will exist during the time period encompassed by the project’s activities (see Commercial Evaluations, section 3.1). “Conditions” include technological, economic, legal, environmental, social, and governmental factors. While economic factors can be summarized as forecast costs and product prices, the underlying influences include, but are not limited to, market conditions, transportation and processing infrastructure, fiscal terms, and taxes.

The resource quantities being estimated are those volumes producible from a project as measured according to delivery specifications at the point of sale or custody transfer (see Reference Point, section 3.2.1). The cumulative production from the evaluation date forward to cessation of production is the remaining recoverable quantity. The sum of the associated annual net cash flows yields the estimated future net revenue. When the cash flows are discounted according to a defined discount rate and time period, the summation of the discounted cash flows is termed net present value (NPV) of the project.

The supporting data, analytical processes, and assumptions used in an evaluation should be documented in sufficient detail to allow an independent evaluator or auditor to clearly understand the basis for estimation and categorization of recoverable quantities and their classification. A Water Balance must always be prepared.

It should be noted that a standard in water resource assessment is the creation of Water Balance that identifies and quantifies the flows in a reservoir. This process is crucial to the classification system.

2. Classification and Categorization Guidelines

To consistently characterize water projects, evaluations of all resources should be conducted in the context of the full classification system as shown in Figure 1. These guidelines reference this classification system and support an evaluation in which projects are "classified" based on their chance of commerciality (the vertical axis) and estimates of recoverable and marketable quantities associated with each project are "categorized" to reflect uncertainty (the horizontal axis). The actual workflow of classification vs. categorization varies with individual projects and is often an iterative analysis process leading to a final report. "Report," as used herein, refers to the presentation of evaluation results within the business entity conducting the assessment and should not be construed as replacing guidelines for public disclosures under guidelines established by regulatory and/or other government agencies.

2.1 Resources Classification

The basic classification requires establishment of criteria for water discovery and thereafter the distinction between commercial and sub-commercial projects in known accumulations (and hence between Reserves and Contingent Resources).

2.1.1 Determination of Discovery Status

A discovery is one water accumulation, or several water accumulations collectively, for which one or several exploratory wells have established through testing, sampling, and/or logging the existence of a significant quantity of potentially moveable water. If wells are not drilled such as in the case of classifying a dam or other surface reservoir a water balance must have been prepared.

For example, for a dam, water inflows such as rivers should be measured, precipitation and outflows through the dam wall should be measured. Evaporation and other forms of loss should also be defined and then adjusted for seasonal changes. The issue of sustainable water is crucial if the reservoir volume is to be maintained.

In this context, "significant" implies that there is evidence of a sufficient quantity of water to justify estimating the in-place volume demonstrated by the well(s) and a water balance and for evaluating the potential for economic recovery. Estimated recoverable quantities within such a discovered (known) accumulation(s) shall initially be classified as Contingent Resources pending definition of projects with sufficient chance of commercial development to reclassify all, or a portion, as Reserves.

Where in-place water identified but are not considered currently recoverable, such quantities may be classified as Discovered Unrecoverable, if considered appropriate for resource management purposes; a portion of these quantities may become recoverable resources in the future as commercial circumstances change or technological developments occur. This might specifically related to artesian water sources.

2.1.2 Determination of Commerciality

Discovered recoverable volumes (Contingent Resources) may be considered commercially producible, and thus Reserves, if the entity claiming commerciality has demonstrated firm intention to proceed with development and such intention is based upon all of the following criteria:-

• Evidence to support a reasonable timetable for development;

• Legal framework for water sales;

• An off-take agreement with prices and tarrifs to sustain the future cashflows of the project;

• Water qualities to be defined for the purpose and meeting local legislative requirements;

• A reasonable assessment of the future economics of such development projects meeting defined investment and operating criteria;

• A reasonable expectation that there will be a market for all or at least the expected sales quantities of production required to justify development;

• Evidence that the necessary production and transportation facilities are available or can be made available; and

• Evidence that legal, contractual, environmental and other social and economic concerns will allow for the actual implementation of the recovery project being evaluated.

To be included in the Reserves class, a project must be sufficiently defined to establish its commercial viability. There must be a reasonable expectation that all required internal and external approvals will be forthcoming, and there is evidence of firm intention to proceed with development within a reasonable time frame. A reasonable time frame for the initiation of development depends on the specific circumstances and varies according to the scope of the project. While 5 years is recommended as a benchmark, a longer time frame could be applied where, for example, development of economic projects are deferred at the option of the producer for, among other things, market-related reasons, or to meet contractual or strategic objectives. In all cases, the justification for classification as Reserves should be clearly documented.

To be included in the Reserves class, there must be a high confidence in the commercial producibility of the reservoir as supported by actual production or formation tests. In certain cases, Reserves may be assigned on the basis of well logs and/or core analysis and water balance that indicate that the subject reservoir is water-bearing and is analogous to reservoirs in the same area that are producing or have demonstrated the ability to produce on formation tests.

2.1.3 Project Status and Commercial Risk

Evaluators have the option to establish a more detailed resources classification reporting system that can also provide the basis for portfolio management by subdividing the chance of commerciality axis according to project maturity. Such sub-classes may be characterized by standard project maturity level descriptions (qualitative) and/or by their associated chance of reaching producing status (quantitative).

As a project moves to a higher level of maturity, there will be an increasing chance that the accumulation will be commercially developed. For Contingent and Prospective Resources, this can further be expressed as a quantitative chance estimate that incorporates two key underlying risk components:

• The chance that the potential accumulation will result in the discovery of water. This is referred to as the "chance of discovery."

• Once discovered, the chance that the accumulation will be commercially developed is referred to as the "chance of development."

Thus, for an undiscovered accumulation, the "chance of commerciality" is the product of these two risk components. For a discovered accumulation where the "chance of discovery" is 100%, the "chance of commerciality" becomes equivalent to the "chance of development."

2.1.3.1 Project Maturity Sub-Classes

As illustrated in Figure 3, development projects (and their associated recoverable quantities) may be sub-classified according to project maturity levels and the associated actions (business decisions) required to move a project toward commercial production.

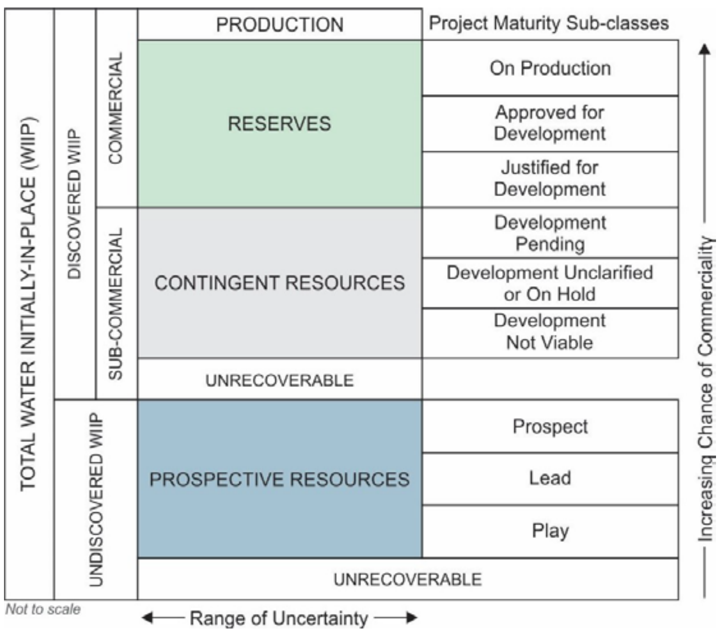

Figure 3. Sub-classes based on Project Maturity.

Decisions within the Reserves class are based on those actions that progress a project through final approvals to implementation and initiation of production and product sales. For Contingent Resources, supporting analysis should focus on gathering data and performing analyses to clarify and then mitigate those key conditions, or contingencies that prevent commercial development. Once again, the water balance is critical. For Prospective Resources, these potential accumulations are evaluated according to their chance of discovery and, assuming a discovery, the estimated quantities that would be recoverable under appropriate development projects. The decision at each phase is to undertake further data acquisition and/or studies designed to move the project to a level of technical and commercial maturity where a decision can be made to proceed with exploration drilling.

Evaluators may adopt alternative sub-classes and project maturity modifiers, but the concept of increasing chance of commerciality should be a key enabler in applying the overall classification system and supporting portfolio management.

2.1.3.2 Reserves Status

Once projects satisfy commercial risk criteria, the associated quantities are classified as Reserves. These quantities may be allocated to the following subdivisions based on the funding and operational status of wells and associated facilities within the reservoir development plan (detailed definitions and guidelines are provided in Table 2):

• Developed Reserves are expected quantities to be recovered from existing reservoirs as defined in the water balance and facilities.

• Developed Producing Reserves are expected to be recovered from completion intervals that are open and producing at the time of the estimate.

• Undeveloped Reserves are quantities expected to be recovered through future investments.

Where Reserves remain undeveloped beyond a reasonable timeframe, or have remained undeveloped due to repeated postponements, evaluations should be critically reviewed to document reasons for the delay in initiating development and justify retaining these quantities within the Reserves class. While there are specific circumstances where a longer delay (see Determination of Commerciality, section 2.1.2) is justified, a reasonable time frame is generally considered to be less than 5 years.

Development and production status are of significant importance for project management. While Reserves Status has traditionally only been applied to Proved Reserves, the same concept of Developed and Undeveloped Status based on the funding and operational status of wells and the water balance and producing facilities within the development project are applicable throughout the full range of Reserves uncertainty categories (Proved, Probable and Possible).

Quantities may be subdivided by Reserves Status independent of sub-classification by Project Maturity. If applied in combination, Developed and/or Undeveloped Reserves quantities may be identified separately within each Reserves sub-class (On Production, Approved for Development, and Justified for Development).

2.1.3.3 Economic Status

Projects may be further characterized by their Economic Status. All projects classified as Reserves must be economic under defined conditions (see Commercial Evaluations, section 3.1). Based on assumptions regarding future conditions and their impact on ultimate economic viability, projects currently classified as Contingent Resources may be broadly divided into two groups:

• Marginal Contingent Resources are those quantities associated with technically feasible projects that are either currently economic or projected to be economic under reasonably forecasted improvements in commercial conditions but are not committed for development because of one or more contingencies.

• Sub-Marginal Contingent Resources are those quantities associated with discoveries for which analysis indicates that technically feasible development projects would not be economic and/or other contingencies would not be satisfied under current or reasonably forecasted improvements in commercial conditions. These projects nonetheless should be retained in the inventory of discovered resources pending unforeseen major changes in commercial conditions.

Where evaluations are incomplete such that it is premature to clearly define ultimate chance of commerciality, it is acceptable to note that project economic status is “undetermined.” Additional economic status modifiers may be applied to further characterize recoverable quantities; for example, distribution networks for potable water and power infrastructure for hydro electric schemes and information related to these matters may be separately identified and documented in addition to sales quantities for both production and recoverable resource estimates (see also Reference Point, section 3.2.1). Those discovered in-place volumes for which a feasible development project cannot be defined using current, or reasonably forecast improvements in, technology are classified as Unrecoverable.

Economic Status may be identified independently of, or applied in combination with, Project Maturity sub-classification to more completely describe the project and its associated resources.

In some cases, the water resource may be classified as “strategic” in which case economic factors may be created that would not relate to normally accepted investment return expectations. These cases must be based upon their own merits but the reservoir quantity and quality principles should remain the same in order to still achieve the “asset” definition.

2.1.3.4 Water Balance

Irrespective of the source of the water a water balance must be created which quantifies inflows and outflows. The individual water balances need to be fit for purpose and each reservoir project. The terminology is generic and the idiosyncrasies of each project should be catered for to define a resource as contemplated in this WRMS.

As with other codes of reporting for minerals and oil and gas the objective is for “standardized” reporting so that projects can be easily compared. It is also hoped that if the units of measure and the classification methods are identical then a global inventory and measuring capacity can be implicated for such a crucial resource.

2.2 Resources Categorization

The horizontal axis in the Resources Classification (Figure 1) defines the range of uncertainty in estimates of the quantities of recoverable, or potentially recoverable, water associated with a project. These estimates include both technical and commercial uncertainty components as follows:

• The total water remaining within the accumulation (in-place resources);

• That portion of the in-place water that can be recovered by applying a defined development project or projects; and

• Variations in the commercial conditions that may impact the quantities recovered and sold (e.g., market availability, contractual changes).

Where the water balance indicates a sustainable level of extraction this needs to be quantified.

Where commercial uncertainties are such that there is significant risk that the complete project (as initially defined) will not proceed, it is advised to create a separate project classified as Contingent Resources with an appropriate chance of commerciality.

2.2.1 Range of Uncertainty

The range of uncertainty of the recoverable and/or potentially recoverable volumes may be represented by either deterministic scenarios or by a probability distribution (see Deterministic and Probabilistic Methods, section 4.2). The water balance should be the primary basis for this work and volume sensitivity should take into account those modifying factors that can be used to statistically establish levels of probability, especially seasonal ones.

When the range of uncertainty is represented by a probability distribution, a low, best, and high estimate shall be provided such that:

• There should be at least a 90% probability (P90) that the quantities actually recovered will equal or exceed the low estimate;

• There should be at least a 50% probability (P50) that the quantities actually recovered will equal or exceed the best estimate; and

• There should be at least a 10% probability (P10) that the quantities actually recovered will equal or exceed the high estimate.

When using the deterministic scenario method, typically there should also be low, best, and high estimates, where such estimates are based on qualitative assessments of relative uncertainty using consistent interpretation guidelines. Under the deterministic incremental (risk-based) approach, quantities at each level of uncertainty are estimated discretely and separately (see Category Definitions and Guidelines, section 2.2.2).

These same approaches to describing uncertainty may be applied to Reserves, Contingent Resources, and Prospective Resources. While there may be significant risk that sub-commercial and undiscovered accumulations will not achieve commercial production, it useful to consider the range of potentially recoverable quantities independently of such a risk or consideration of the resource class to which the quantities will be assigned.

2.2.2 Category Definitions and Guidelines

Evaluators may assess recoverable quantities and categorize results by uncertainty using the deterministic incremental (risk-based) approach, the deterministic scenario (cumulative) approach, or probabilistic methods. In many cases, a combination of approaches is used.
Use of consistent terminology (Figure 1) promotes clarity in communication of evaluation results. For Reserves, the general cumulative terms low/best/high estimates are denoted as 1P/2P/3P, respectively. The associated incremental quantities are termed Proved, Probable and Possible. Reserves are a subset of, and must be viewed within context of, the complete resources classification system. While the categorization criteria are proposed specifically for Reserves, in most cases, they can be equally applied to Contingent and Prospective Resources conditional upon their satisfying the criteria for discovery and/or development.

For Contingent Resources, the general cumulative terms low/best/high estimates are denoted as 1C/2C/3C respectively. For Prospective Resources, the general cumulative terms low/best/high estimates still apply. No specific terms are defined for incremental quantities within Contingent and Prospective Resources.

Without new technical information, there should be no change in the distribution of technically recoverable volumes and their categorization boundaries when conditions are satisfied sufficiently to reclassify a project from Contingent Resources to Reserves. All evaluations require application of a consistent set of forecast conditions, including assumed future costs and prices, for both classification of projects and categorization of estimated quantities recovered by each project (see Commercial Evaluations, section 3.1). Remember the water balance must be the basis of the work.

Table 3 presents category definitions and provides guidelines designed to promote consistency in resource assessments. The following summarizes the definitions for each Reserves category in terms of both the deterministic incremental approach and scenario approach and also provides the probability criteria if probabilistic methods are applied.

• Proved Reserves are those quantities of water, which, by analysis of geoscience and engineering data, and the water balance can be estimated with reasonable certainty to be commercially recoverable, from a given date forward, from known reservoirs and under defined economic conditions, operating methods, and government regulations. If deterministic methods are used, the term reasonable certainty is intended to express a high degree of confidence that the quantities will be recovered. If probabilistic methods are used, there should be at least a 90% probability that the quantities actually recovered will equal or exceed the estimate;

• Probable Reserves are those additional Reserves which analysis of geoscience and engineering data and the water balance, indicates they are less likely to be recovered than Proved Reserves but more certain to be recovered than Possible Reserves. It is equally likely that actual remaining quantities recovered will be greater than or less than the sum of the estimated Proved plus Probable Reserves (2P). In this context, when probabilistic methods are used, there should be at least a 50% probability that the actual quantities recovered will equal or exceed the 2P estimate; and

• Possible Reserves are those additional reserves which analysis of geoscience and engineering data and the water balance suggests that they are less likely to be recoverable than Probable Reserves. The total quantities ultimately recovered from the project have a low probability to exceed the sum of Proved plus Probable plus Possible (3P) Reserves, which is equivalent to the high estimate scenario. In this context, when probabilistic methods are used, there should be at least a 10% probability that the actual quantities recovered will equal or exceed the 3P estimate.

Based on additional data and updated interpretations that indicate increased certainty, portions of Possible and Probable Reserves may be re-categorized as Probable and Proved Reserves.

Uncertainty in resource estimates is best communicated by reporting a range of potential results. However, if it is required to report a single representative result, the “best estimate” is considered the most realistic assessment of recoverable quantities. It is generally considered to represent the sum of Proved and Probable estimates (2P) when using the deterministic scenario or the probabilistic assessment methods. It should be noted that under the deterministic incremental (risk-based) approach, discrete estimates are made for each category, and they should not be aggregated without due consideration of their associated risk.

2.3 Incremental Projects

The initial resource assessment is based on application of a defined initial development project. Incremental projects are designed to increase recovery efficiency and/or to accelerate production through making changes to wells or facilities, infill drilling, or improved recovery. Such projects should be classified according to the same criteria as initial projects. Related incremental quantities are similarly categorized on certainty of recovery. The projected increased recovery can be included in estimated Reserves if the degree of commitment is such that the project will be developed and placed on production within a reasonable timeframe.

Circumstances where development will be significantly delayed should be clearly documented. If there is significant project risk, forecast incremental recoveries may be similarly categorized but should be classified as Contingent Resources (see Determination of Commerciality, section 2.1.2).

3. Evaluation of Reporting Guidelines

The following guidelines are provided to promote consistency in project evaluations and reporting. “Reporting” refers to the presentation of evaluation results within the business entity conducting the evaluation and should not be construed as replacing guidelines for subsequent public disclosures under guidelines established by regulatory and/or other government agencies, or any current or future associated accounting standards.

3.1 Commercial Evaluations

Investment decisions are based on the entity’s view of future commercial conditions that may impact the development feasibility (commitment to develop) and production/cash flow schedule of water projects. Commercial conditions include, but are not limited to, assumptions of financial conditions (costs, prices, fiscal terms, taxes), marketing, legal, environmental, social, and governmental factors. Project value may be assessed in several ways (e.g., historical costs, comparative market values); the guidelines herein apply only to evaluations based on cash flow analysis. Moreover, modifying factors such contractual or political risks that may additionally influence investment decisions are not addressed.

3.1.1 Cash Flow-Based Resources Evaluations

Resources evaluations are based on estimates of future production and the associated cash flow schedules for each development project. The sum of the associated annual net cash flows yields the estimated future net revenue. When the cash flows are discounted according to a defined discount rate and time period, the summation of the discounted cash flows is termed net present value (NPV) of the project. The calculation shall reflect:

- The expected quantities of production projected over identified time periods;

- The estimated costs associated with the project to develop, recover, and produce the quantities of production at its Reference Point (see section 3.2.1), including environmental, abandonment, and reclamation costs charged to the project, based on the evaluator’s view of the costs expected to apply in future periods;

- The estimated revenues from the quantities of production based on the evaluator’s view of the prices expected to apply to the respective commodities in future periods including that portion of the costs and revenues accruing to the entity;

- Future projected production and revenue related taxes and royalties expected to be paid by the entity;

- A project life that is limited to the period of entitlement or reasonable expectation thereof; and

• The application of an appropriate discount rate that reasonably reflects the weighted average cost of capital or the minimum acceptable rate of return applicable to the entity at the time of the evaluation.

While each organization may define specific investment criteria, a project is generally considered to be “economic” if its “best estimate” case has a positive net present value under the organization’s standard discount rate, or if at least has a positive undiscounted cash flow.

3.1.2 Economic Criteria

Evaluators must clearly identify the assumptions on commercial conditions utilized in the evaluation and must document the basis for these assumptions.

The economic evaluation underlying the investment decision is based on the entity’s reasonable forecast of future conditions, including costs and prices, which will exist during the life of the project (forecast case). Such forecasts are based on projected changes to current conditions. Alternative economic scenarios are considered in the decision process and, in some cases, to supplement reporting requirements. Evaluators may examine a case in which current conditions are held constant (no inflation or deflation) throughout the project life (constant case). Evaluations may be modified to accommodate criteria imposed by regulatory agencies regarding external disclosures. For example, these criteria may include a specific requirement that, if the recovery were confined to the technically Proved Reserves estimate, the constant case should still generate a positive cash flow. External reporting requirements may also specify alternative guidance on current conditions (for example, year-end costs and prices).

There may be circumstances in which the project meets criteria to be classified as Reserves using the forecast case but does not meet the external criteria for Proved Reserves. In these specific circumstances, the entity may record 2P and 3P estimates without separately recording Proved. As costs are incurred and development proceeds, the low estimate may eventually satisfy external requirements, and Proved Reserves can then be assigned.

Project financing should be confirmed prior to classifying projects as Reserves, this may be another external requirement. In many cases, loans are conditional upon the same criteria as above; that is, the project must be economic based on Proved Reserves only. In general, if there is not a reasonable expectation that loans or other forms of financing (e.g., farm-outs) can be arranged such that the development will be initiated within a reasonable timeframe, then the project should be classified as Contingent Resources. If financing is reasonably expected but not yet confirmed, the project may be classified as Reserves, but no Proved Reserves may be reported as above.

3.1.3 Economic Limit

Economic limit is defined as the production rate beyond which the net operating cash flows from a project, which may be an individual well, lease, or entire reservoir, are negative, a point in time that defines the project’s economic life. Operating costs should be based on the same type of projections as used in price forecasting. Operating costs should include only those costs that are incremental to the project for which the economic limit is being calculated (i.e., only those cash costs that will actually be eliminated if project production ceases should be considered in the calculation of economic limit). Operating costs should include fixed property-specific overhead charges if these are actual incremental costs attributable to the project and any production and property taxes but, for purposes of calculating economic limit, should exclude depreciation, abandonment and reclamation costs, and income tax, as well as any overhead above that required to operate the subject property itself. Operating costs may be reduced, and thus project life extended, by various cost-reduction and revenue-enhancement approaches, such as sharing of production facilities, pooling maintenance contracts, or marketing of associated water (see Associated Water Components, section 3.2.4).

A crucial aspect of water is the pricing for various points of sale. Each reservoir should account for extraction costs, infrastructure to treat and distribute the water as well as possible quantity based tariff structures, connection charges and levies.

Interim negative project net cash flows may be accommodated in short periods of low product prices or major operational problems, provided that the longer-term forecasts must still indicate positive economics.

3.2 Production Measurement

In general, the marketable product, as measured according to delivery specifications at a defined Reference Point, provides the basis for production quantities and resources estimates.

For water this is often quite complex such as extraction from a dam to a bottling plant where transfer pricing is essential for the reservoir economics. The unique recharge and sustainability of a particular reservoir should be assessed on a project by project basis.

The following operational issues should be considered in defining and measuring production. While referenced specifically to Reserves, the same logic would be applied to projects forecast to develop Contingent and Prospective Resources conditional on discovery and development.

3.2.1 Reference Point

Reference Point is a defined location(s) in the production chain where the produced quantities are measured or assessed. The Reference Point is typically the point of sale to third parties or where custody is transferred to the entity’s downstream operations. Sales production and estimated Reserves are normally measured and reported in terms of quantities crossing this point over the period of interest.

The Reference Point may be defined by relevant accounting regulations in order to ensure that the Reference Point is the same for both the measurement of reported sales quantities and for the accounting treatment of sales revenues. This ensures that sales quantities are stated according to their delivery specifications at a defined price.

Sales quantities are equal to raw production less non-sales quantities, being those quantities produced at the outflow point but not available for sales at the Reference Point. Non-sales quantities include water lost in processing, plus water that must be removed prior to sale; each of these may be allocated using separate Reference Points but when combined with sales, should sum to raw production at outflow point as identified in the water balance.

Raw production measurements are necessary and form the basis of engineering calculations (e.g., production performance analysis) based on total reservoir voidage with recharge and the details of the water balance.

3.2.2 Natural Water Re-Injection

Natural water production can be re-injected into a reservoir for a number of reasons and under a variety of conditions. It can be re-injected into the same reservoir or into other reservoirs located on the same property for recycling, storage, or other enhanced water recovery processes. In such cases, assuming that the water will eventually be produced and sold, the water volume estimated as eventually recoverable can be included as Reserves.

If water volumes are to be included as Reserves, they must meet the normal criteria laid down in the definitions including the existence of a viable development, transportation, and sales marketing plan. Water volumes should be reduced for losses associated with the re-injection and subsequent recovery process. Water volumes injected into a reservoir for water disposal with no committed plan for recovery are not classified as Reserves.

3.2.3 Underground Natural Water Storage

Water injected in a storage reservoir to be recovered at a later period (e.g., to meet peak market demand periods) may be included as Reserves as identified in the water balance as water not lost.

The water placed in the storage reservoir may be purchased or may originate from prior production. It is important to distinguish injected water from any remaining native recoverable volumes in the reservoir. On commencing water production, its allocation between native water and injected water may be subject to local regulatory and accounting rulings. Native water production would be drawn against the original field Reserves. The water balance is the defining principle.

There may be occasions, such as water acquired through a production payment, in which water is transferred from one lease or field to another without a sale or custody transfer occurring. In such cases, the re-injected water could be included with the native reservoir water as Reserves. The same principles regarding separation of native resources from injected quantities would apply to underground water storage.

3.2.4 Production Balancing

Reserves estimates must be adjusted for production withdrawals based upon the water balance information. Production overlift or underlift can occur in water production records because of the necessity for participants to lift their production in supply volumes to suit infrastructure and off take arrangements as agreed among the parties. Similarly, an imbalance in water deliveries can result from the participants having different operating or marketing arrangements that prevent water volumes sold from being equal to entitlement share within a given time period and under off take agreements.

Actual production and entitlements must be reconciled in Reserves assessments using the water balance. Resulting imbalances must be monitored over time and eventually resolved before project abandonment.

3.3 Resources Entitlement and Recognition

While assessments are conducted to establish estimates of the total Water Initially-in-Place and that portion recovered by defined projects, the allocation of sales quantities, costs, and revenues impacts the project economics and commerciality. This allocation is governed by the applicable contracts between the mineral owners (lessors) and contractors (lessees) and is generally referred to as “entitlement.” For publicly traded companies, securities regulators may set criteria regarding the classes and categories that can be “recognized” in external disclosures. The water balance should be the reference mechanism to assess entitlements.

Entitlements must ensure that the recoverable resources claimed/reported by individual stakeholders sum to the total recoverable resources; that is, there are none missing or duplicated in the allocation process.

3.3.1 Water Use Licensing

Although water is subject to its own specific regulatory legislation it should regarded as a naturally occurring mineral resource and treated in a similar manner to minerals and oil and gas for the purpose of classification of quantities and qualities and the calculation of resources and reserves.

Typically, water use licenses follow a similar process to licensing on other minerals and the objective is largely the same for orderly and responsible exploitation.

The role of government and commerce and civil society should be aligned to the extent that water ultimately provides a benefit for all. Recognition of the unique potentially sustainable nature of water is crucial in any exploitation plan especially in the prevention of pollution and the destruction of water reservoirs and resources in any way.

The alignment of licensing regulations with other parts of the minerals industry is needed to promote efficient and optimal production-sharing or other types of agreements. An inalienable extraction or production right is a fundamental requirement for financing and accounting of water projects. In many cases, exploitation of water is a financial engineering exercise and reliable and sustainable licensing is a necessary basis for financing.

Reserves should not be claimed for those volumes that will be produced beyond the ending date of the current agreement unless there is reasonable expectation that an extension, a renewal, or a new contract will be granted. Such reasonable expectation may be based on the historical treatment of similar agreements by the license-issuing jurisdiction. Otherwise, forecast production beyond the contract term should be classified as Contingent Resources with an associated reduced chance of commercialization. Moreover, it may not be reasonable to assume that the fiscal terms in a negotiated extension will be similar to existing terms.

Similar logic should be applied where water sales agreements are required to ensure adequate markets. Reserves should not be claimed for those quantities that will be produced beyond those specified in the current agreement or reasonably forecast to be included in future agreements.

In either of the above cases, where the risk of cessation of rights to produce or inability to secure water contracts is not considered significant, evaluators may choose to incorporate the uncertainty by categorizing quantities to be recovered beyond the current contract as Probable or Possible Reserves.

4. Estimating Recoverable Quantities

Projects should be classified according to their project water balances and the estimation of associated recoverable quantities under a defined project and their assignment to uncertainty categories may be based on one or a combination of analytical procedures. Such procedures may be applied using an incremental (risk-based) and/or scenario approach; moreover, the method of assessing relative uncertainty in these estimates of recoverable quantities may employ both deterministic and probabilistic methods. It is preferable to use statistical methods to simulate water balance fluctuations as multivariant analysis. The reason why this is preferred is that the statistical outputs volumetrics should eliminate, as far as reasonably possible, pure judgmental inputs.

4.1 Analytical Procedures

The analytical procedures for estimating recoverable quantities fall into three broad categories: (a) analogy, (b) volumetric estimates, and (c) performance-based estimates, which include water balance, production decline, and other production performance analyses. Reservoir simulation may be used in either volumetric or performance-based analyses. Pre- and early post-discovery assessments are typically made with analog field/project data and volumetric estimation, but all parameters should be incorporated into the water balance.

After production commences and production rates information become available, performance-based methods can be applied. Generally, the range of EUR estimates is expected to decrease as more information becomes available, but this is not always the case especially when recharge in the reservoir creates a sustainable balance.

By applying consistent guidelines (see Resources Categorization, section 2.2.), evaluators can define either remaining recoverable quantities or a sustainable balance using either the incremental or cumulative scenario approach. The confidence in assessment results generally increases when the estimates are supported by more than one analytical procedure.

4.1.1 Analogs

Analogs are widely used in resources estimation, particularly in the exploration and early development stages, when direct measurement information is limited. The methodology is based on the assumption that the analogous reservoir is comparable to the subject reservoir regarding reservoir and fluid properties that control ultimate recovery of water. By selecting appropriate analogs, where performance data based on comparable development plans (including exploitation methods) are available, a similar production profile may be forecast. This comparison process is considered crucial in water to link global reservoir information for optimal global exploitation of water resources.

Analogous reservoirs are defined by features and characteristics including, but not limited to, reservoir type, subsurface or surface, geographical location and local drainage and catchment criteria, man made or natural, recharge characteristics, water balance, water quality and origin if not naturally occurring and climate.

Comparison to several analogs may improve the range of uncertainty in estimated recoverable quantities from the subject reservoir. While reservoirs in the same geographic area and of the same age typically provide better analogs, such proximity alone may not be the primary consideration. In all cases, evaluators should document the similarities and differences between the analog and the subject reservoir/project. Review of analog reservoir performance is useful in quality assurance of resource assessments at all stages of development. Water balance comparison is critical especially with respect to reservoir volumes.

4.1.2 Volumetric Estimates

This procedure uses reservoir properties to calculate the water balance and then estimate that portion that will be recovered by a specific development project(s). Key uncertainties affecting in-place volumes include:

- Reservoir geometry and water balance;

- Physical characteristics that define inflows and outflows for the water balance.

- Water origin either natural or manmade.

- Recharge characteristics.

- Downstream use and reliance of interested and affected parties.

- Water quality.

- Possible pollution and sustainability requirements;

• Elevation of fluid characteristics; and

• Combinations of reservoir quality, usage types, and demand side requirements.

For water, the water balance must be used to make estimates of the in-place water, that portion that can be recovered by a defined set of inflow and outflow criteria and operating conditions must then be estimated based on the unique reservoir characteristics but importantly with analog field performance and/or water balance studies using available reservoir information. Key assumptions must be made regarding reservoir drive mechanisms embedded in the water balance.

The estimates of recoverable quantities must reflect uncertainties not only in the water in place but also in the recovery efficiency, recharge and water balance characteristics of the development project(s) applied to the specific reservoir being studied.

Additionally, geostatistical and statistical methods can be used to assess spatial distribution information and incorporate it in subsequent reservoir and water balance parameters. Such processes may yield improved estimates of the range of recoverable quantities.

4.1.3 Water Balance

The importance of the water balance cannot be underestimated as the balance methods to estimate recoverable quantities involve the analysis of reservoir behavior. Clearly the inflow and recharge and outflow parameters are the most important parameters for reservoir simulation and ranges in these parameters, particularly for seasonal variation, should be defined from historical and current and forecast information.

Computer reservoir modeling can be considered a sophisticated form of water balance analysis. While such modeling can be a reliable predictor of reservoir behavior under a defined development program, the reliability of input properties is critical. Predictive models are most reliable in estimating recoverable quantities when there is sufficient production history to validate the model through history matching.

4.1.4 Production Performance Analysis

Analysis of the change in production rates vs. time and vs. cumulative production for drawdown charateristics must be used to simulate inflows and outflows in the water balance to predict ultimate recoverable quantities. Reliable results require a sufficient period of stable operating conditions for a reservoir to be established. In estimating recoverable quantities for Reserve and Resource classification, evaluators must consider complicating factors affecting production performance behavior as defined in the water balance.

In early stages of depletion or drawdown there may be significant uncertainty in both the ultimate performance profile and the commercial factors that impact abandonment rate. Such uncertainties should be reflected in the resources categorization as defined in the water balance. Where a reservoir is anticipated to be ultimately depleted abandonment, decommissioning and rehabilitation must be defined. This should be considered even if the reservoir will not be depleted but the operating license is expected to terminate.

4.2 Deterministic and Probabilistic Methods

Regardless of the analytical procedure used, water resource estimates may be prepared using either deterministic or probabilistic methods. A deterministic estimate is a single discrete scenario within a range of outcomes that could be derived by probabilistic analysis.

In the deterministic method, a discrete value or array of values for each parameter is selected based on the estimator's choice of the values that are most appropriate for the corresponding resource category. A single outcome of recoverable quantities is derived for each deterministic increment or scenario.

In the probabilistic method, the preferred choice for the water balance, the estimator defines a distribution representing the full range of possible values for each input parameters. These distributions may be randomly sampled (typically using Monte Carlo simulation software) to compute a full range and distribution of potential outcome of results of recoverable quantities. This approach is most often applied to volumetric water resource calculations in the early phases of an exploitation and development projects. The Resources Categorization guidelines include criteria that provide specific limits to parameters associated with each category. Moreover, the resource analysis must consider commercial uncertainties. Accordingly, when probabilistic methods are used, constraints on parameters may be required to ensure that results are not outside the range imposed by the category deterministic guidelines and commercial uncertainties.

Deterministic volumes are estimated for discrete increments and defined scenarios. While deterministic estimates may have broadly inferred confidence levels, they do not have associated quantitatively defined probabilities. Nevertheless, the ranges of the probability guidelines established for the probabilistic method (see Range of Uncertainty, section 2.2.1) influence the amount of uncertainty generally inferred in the estimate derived from the deterministic method.

Both deterministic and probabilistic methods may be used in combination to ensure that results of either method are reasonable. However, the probabilistic method is preferred for water.

4.2.1 Aggregation Methods

Water quantities are generally estimated and categorized according to certainty of recovery within individual reservoirs or portions of reservoirs; this is referred to as the "reservoir level" assessment.

In oil and gas the aggregation of reservoir information is a recognized process. This is often in order to streamline reporting information and accumulate project values. An unintended consequence of this is limited or severely reduced information and reporting of project information.

To be clear, for water, aggregation is prohibited as each reservoir with its individual water balance. As such each project with Resources or Reserves as defined in the WRMS must be reported separately. This section is retained to keep consistency in headings with the PRMS.

In practice, there is likely to be a large degree of dependence between reservoirs in the same field, and such dependencies must be assessed for the individual water balances and the co-dependency defined.

4.2.1.1 Aggregating Resources Classes

Water quantities classified as Reserves, Contingent Resources, or Prospective Resources should not be aggregated with each other without due consideration of the significant differences in the criteria associated with their classification. In particular, there may be a significant risk that accumulations containing Contingent Resources and/ or Prospective Resources will not achieve commercial production.

Where the associated discovery and commerciality risks have been quantitatively defined, statistical techniques may be applied to incorporate individual project risk estimates in portfolio analysis of volume and value.

5. Conclusion

This Water Resources Management System has been based upon PRMS which is a globally adopted standard for reporting Oil and Gas in a very significant industry. Water is the commodity of the future and from this humble beginning it is hoped that the water industry can similarly align in a classification process in order to develop and manage the planets water for the future benefit of mankind.