

Standards Pertaining to the Estimating and Auditing of Oil and Gas Reserves Information

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Foreword

The principles and concepts established in the original version of this document in 1977 were well-founded given the state of the petroleum industry at that time. However, the industry has now become significantly more diversified and complex through epochal changes in technology, contractual and licensing terms, corporate governance issues, and regulatory reporting and compliance. The original principles remain unchanged in this revision, but an attempt has been made to incorporate the increased need for somewhat more-stringent requirements in the expectations and standards imposed on Reserves professionals today. The 2019 revision of this document includes those modifications required to incorporate the *2018 Petroleum Resources Management System* (PRMS), published jointly by the Society of Petroleum Engineers, World Petroleum Council (WPC), American Association of Petroleum Geologists (AAPG), Society of Petroleum Evaluation Engineers (SPEE), Society of Exploration Geophysicists (SEG), Society of Petrophysicists and Well Log Analysts (SPWLA), and the European Association of Geoscientists and Engineers (EAGE). This document is the result of an ongoing update process for this and all other vital components of the PRMS, but it remains limited to those quantities contained within the system that are classified as Reserves. The second objective is to change the term “qualified reserves estimator” to “qualified reserves evaluator,” and the term “reserves auditor” to “qualified reserves auditor”. The third objective is to change the qualifications of being a qualified reserves evaluator.

Article I—The Basis and Purpose of Developing Standards Pertaining to the Estimating and Auditing of Oil and Gas Reserves Information¹

1.1 The Nature and Purpose of Estimating and Auditing Oil and Gas Reserves Information

Estimates of Reserves information are made by or for entities as a part of their ongoing business practices. Such Reserves information typically may include, but may not be limited to, estimates of the Reserves quantities, the future producing rates from such Reserves, the future net revenue from such Reserves, and the present value of such future net revenue. The exact type and extent of Reserves information must necessarily take into account the purpose for which such Reserves information is being prepared and, correspondingly, statutory and regulatory provisions, if any, that are applicable to the intended use of the Reserves information. Reserves information may be limited to Proved Reserves or may involve other categories of Reserves as appropriate to the estimate.

1.2 Estimating and Auditing Reserves Information in Accordance With Generally Accepted Engineering and Evaluation Principles

The estimating and auditing of Reserves information is predicated upon certain historically developed principles of geoscience, petroleum engineering, and evaluation methodologies, which are in turn based on principles of physical science, mathematics, and economics. Although these generally accepted geological, engineering, and evaluation principles are predicated on established scientific concepts, the application of such principles involves extensive judgments by qualified individuals and is subject to changes in existing knowledge and technology; fiscal and economic conditions; applicable contractual, statutory, and regulatory provisions; and the purposes for which the Reserves information is to be used.

1.3 The Inherently Imprecise Nature of Reserves Information

The reliability of Reserves information is considerably affected by several factors. Initially, it should be noted that Reserves information is imprecise as a result of the inherent uncertainties in, and the limited nature of, the accumulation and interpretation of data upon which the estimating and auditing of Reserves information is predicated. Moreover, the methods and data used in estimating Reserves information are often necessarily indirect or analogical in character rather than direct or deductive. Furthermore, the persons estimating and auditing Reserves information are required, in applying generally accepted petroleum engineering and evaluation principles, to make numerous unbiased judgments on the basis of their educational background, professional

¹These Standards Pertaining to the Estimating and Auditing of Oil and Gas Reserves Information (the “Standards”) are not intended to bind the members of the Society of Petroleum Engineers (the “Society”) or anyone else, and the Society imposes no sanctions for the nonuse of these Standards. Each person estimating and auditing oil and gas Reserves information is encouraged to exercise his or her own judgment concerning the matters set forth in these Standards. The Society welcomes comments and suggested changes in regard to these Standards.

training, and professional experience. The extent and significance of the judgments to be made are, in themselves, sufficient to render Reserves information inherently imprecise.

1.4 The Need for Standards Governing the Estimating and Auditing of Reserves Information

The Society of Petroleum Engineers (the “Society”) has determined that the Society should adopt these Standards Pertaining to the Estimating and Auditing of Oil and Gas Reserves Information (the “Standards”). The adoption of these Standards by the Society fulfills at least three useful objectives.

First, although some users of Reserves information are cognizant of the general principles that are applied to databases in the estimation of Reserves information, the judgments required in estimating and auditing Reserves information, and the inherently imprecise nature of Reserves information, many users of Reserves information continue to fail to understand such matters. The adoption, publication, and distribution of these Standards should enable users of Reserves information to understand these matters more fully and therefore place the appropriate level of confidence on Reserves information.

Second, the wider dissemination of Reserves information through public financial reporting, such as that required by various governmental authorities, makes it imperative that the users of Reserves information have a general understanding of the methods of, and limitations on, estimating and auditing Reserves information.

Third, as Reserves information proliferates in terms of the types of information available and the broader dissemination thereof, it becomes increasingly important that Reserves information be estimated and audited on a consistent basis by competent, well-trained professional geoscientists and engineers.

Compliance with these Standards is a method of facilitating evaluation and comparisons of Reserves information by the users thereof. To accomplish the three objectives detailed above, the Society has included in these Standards (i) definitions of selected terms pertaining to the estimation and evaluation of Reserves information, (ii) qualifications for persons estimating and auditing Reserves information, (iii) standards of independence and objectivity for such persons, (iv) standards for estimating Reserves and other Reserves information, and (v) standards for auditing Reserves and other Reserves information. Although these Standards are predicated on generally accepted geoscience, petroleum engineering, and economic evaluation principles, it may in the future become necessary, for the reasons set forth in Section 1.2, to clarify or amend certain of these Standards. Accordingly, the Society, as a part of its governance process, will periodically review these standards and determine whether to amend them or publish clarifying statements.

Note that these Standards apply independently of the classification system and associated guidelines adopted by the entity; the reference system should be clearly identified.

Article II—Definitions of Selected Terms

2.1 Applicability of Definitions

In preparing a report or opinion, persons estimating and auditing Reserves information shall ascribe, to Reserves and other significant terms used therein, current petroleum Reserves and resources definitions and the classification system promulgated by the Society or such other definitions as he or she may reasonably consider appropriate in accordance with generally accepted petroleum engineering and evaluation principles, provided that (i) such report or opinion should define, or make reference to a definition of, each significant term that is used therein, and (ii) the definitions used in any report or opinion must be consistent with statutory and regulatory provisions, if any, that apply to such report or opinion in accordance with its intended use.

2.2 Defined Terms

The definitions set forth in this section are applicable for all purposes of these Standards:

- (a) **Reserves Information**—Reserves information consists of various estimates pertaining to the extent and value of oil and gas properties. Reserves information will include estimates of petroleum Reserves and may, but will not necessarily, include estimates of the future production rates from such Reserves, the future net revenue from such Reserves, and the present value of such future net revenue. All such Reserves information should be estimated and classified as appropriate to stated Reserves definitions.
- (b) **Entity**—A legal construct capable of bearing legal rights and obligations. In resources evaluations, this typically refers to the lessee or contractor, which is some form of legal corporation (or consortium of corporations). In a broader sense, an entity can be an organization of any form and may include governments or their agencies.
- (c) **Qualified Reserves Evaluator (QRE)**—A QRE is a person who is designated to be in responsible charge of estimating and evaluating Reserves and other Reserves information. A QRE may personally make the estimates and evaluations of Reserves information or may supervise and approve the estimation and evaluation of Reserves information conducted by others. A QRE may be an employee of the entity or an employee of an external independent firm.
- (d) **Qualified Reserves Auditor (QRA)**—A QRA is a person who is designated to be in responsible charge of the conduct of an audit with respect to Reserves information estimated by others. A QRA may personally conduct an audit of Reserves information or may supervise and approve the conduct of an audit performed by others. A QRA may be an employee of the entity or an employee of an external independent firm.
- (e) **Entity Reserves Report**—An entity Reserves report may be prepared by an internal or external QRE for any of several purposes, all of which should be clearly disclosed in the report. The report is to be considered valid for only those properties identified and included in the report as of the effective report date. To be termed an entity Reserves report, the report should represent all or at least 80% of an entity's Reserves, future production, and/or revenues. (This is in contrast with a property Reserves report, defined in section (f) below.) An entity Reserves report should clearly indicate what percentage it is representing, the relative importance of the properties included and any properties

excluded from the report. An entity Reserves report for any purpose should contain adequate disclosures to fully inform the user about the definitions and Reserves classifications used, qualifications and independence of the QRE, confidentiality restrictions, and any unusual circumstances or report qualifiers, and it should include, but not be limited to, authorization for the report, the sources and adequacy and reliability of the underlying geological and engineering data, assumptions made, and any limitations imposed on the distribution and use of the report.

- (f) **Property Reserves Report**—A property Reserves report may contain Reserves information limited to one or more reservoirs, fields, and/or projects, but is not sufficiently extensive to be considered an entity Reserves report. All other qualifications detailed in (e) for an entity Reserves report apply.
- (g) **Reserves Audit**—A Reserves audit is the process of reviewing certain of the pertinent facts interpreted and assumptions made that have resulted in an estimate of Reserves and/or Reserves information prepared by others and the rendering of an opinion about the appropriateness of the methodologies used, the adequacy and quality of the data relied upon, the depth and thoroughness of the Reserves estimation process, the categorization of Reserves appropriate to the relevant definitions used, and the reasonableness of the estimated Reserves quantities and/or the Reserves information. The term “reasonableness” cannot be defined with precision, but should reflect a quantity or value difference of not more than $\pm 10\%$, or that the subject Reserves information does not meet minimum recommended audit standards. This tolerance can be applied to any level of Reserves or Reserves information aggregation, depending on the nature of the assignment, but is most often limited to Proved Reserves information. A separate predetermined and disclosed tolerance may be appropriate for other Reserves categories. Often, a Reserves audit includes a detailed review of certain critical assumptions and independent assessments with acceptance of other information less critical to the Reserves estimation. Typically, a Reserves audit letter or report is prepared that clearly states the assumptions made. A Reserves audit should be of sufficient rigor to determine the appropriate Reserves categorization for all Reserves in the property set evaluated and to state clearly the Reserves classification system being used. In contrast to the term “audit” used in a financial sense, a Reserves audit is generally less rigorous than a Reserves report. As with an entity Reserves report, an entity Reserves audit should represent all or at least 80% of an entity’s reserves. The portion of Reserves audited must be clearly stated.
- (h) **Financial Audit**—A financial audit, in contrast to a Reserves audit, is typically described as a periodic examination of an organization’s financial records and accounts, performed in an effort to verify that funds were used as they were intended and consistent with established financial management practices.
- (i) **Process Review**—A process review is the result of an investigation by a person who is qualified by experience and training equivalent to that of a QRA to address the adequacy and effectiveness of an entity’s internal processes and controls relative to Reserves estimation. These internal processes and controls most often include some form of independent internal or external Reserves audit system. The process review should not include an opinion relative to the reasonableness of the Reserves quantities or Reserves

information and should be limited to the process and control system reviewed. A process review includes reports that have been termed “procedural audits” or “procedural reviews” in the industry. Although such reviews may provide value to the entity, an external or internal process review is not of sufficient rigor to establish appropriate categorizations and quantities of Reserves and should not be represented to the public as being equivalent to a Reserves audit.

Article III—Professional Qualifications of Reserves Evaluators and Reserves Auditors

3.1 The Importance of Qualified Reserves Evaluators (QREs) and Qualified Reserves Auditors (QRAs)

Reserves information is prepared and audited, respectively, by QREs and QRAs, who are often assisted by other professionals, paraprofessionals, and clerical personnel. QREs and QRAs may be employees of an entity itself or stockholders, proprietors, partners, or employees of an independent firm of petroleum consultants with which an arrangement has been made for the estimating or auditing of Reserves information. Regardless of the nature of their employment, QREs and QRAs must (i) examine and interpret the available data necessary to estimate or audit Reserves information, (ii) perform tests and consider all matters necessary to evaluate the sufficiency of the database, and (iii) make calculations and estimates and apply any tests and standards necessary to estimate or audit Reserves and other Reserves information. For the reasons discussed in Section 1.3, the proper determination of these matters is highly dependent upon the numerous judgments QREs and QRAs are required to make on the basis of their educational background, professional training, integrity, and professional experience. Consequently, to ensure that Reserves information is as reliable as possible given the limitations inherent in the estimating and auditing process, it is essential that those in responsible charge of estimating and auditing Reserves information have adequate professional qualifications such as those set forth in this Article III.

3.2 Professional Qualifications of a QRE

A QRE shall be considered professionally qualified in such capacity if he or she has sufficient educational background, professional training, and professional experience to enable him or her to exercise prudent professional judgment and to be in responsible charge of the estimating of Reserves and other Reserves information. The determination of whether a QRE is professionally qualified should be made on an individual-by-individual basis. A QRE would normally be considered to be qualified if he or she has a minimum of 5 years of practical experience in petroleum engineering or petroleum production geology, with at least 3 full years of such experience being in the estimation and evaluation of Reserves information, and either has obtained, from a college or university of recognized stature, a bachelor’s or advanced degree in petroleum engineering, geology, or other discipline of engineering or physical science or has received, and is maintaining in good standing, a registered or certified professional engineer’s license or a registered or certified professional geologist’s license, or the equivalent thereof, from an appropriate governmental authority or a recognized self-regulating professional organization.

In the context used herein, it is recommended that experience and competency levels should generally include a clear understanding of several areas of knowledge pertinent to the circumstances and conditions to which they are being applied, which could include industry accepted practices related to the creation and understanding of geological maps and models, the judicious selection of and reliance upon appropriate reservoir analogs, suitable application of and reliance upon seismic information in Reserves evaluation, fundamentals and limitations of reservoir simulation, basic knowledge and applicability of probabilistic and deterministic assessment methodologies, the use of numerous performance-evaluation techniques to confirm and/or refine geological interpretations, the consequences of reliance on computer software without a full understanding of the internal calculation processes, various forms of production licensing and fiscal systems, ongoing training in the relevant or pertinent Reserves definitions, and ethics training—all of which should be refreshed periodically through some form of internally or externally provided continuing education.

QREs and QRAs are encouraged to recognize the professional obligation to secure ongoing training in the areas described above, whether or not this is provided or required by their employer. A QRE should decline an assignment for which he or she is not qualified.

3.3 Professional Qualifications of a QRA

A QRA shall be considered professionally qualified in such capacity if he or she has sufficient educational background, professional training (similar to that of a QRE), and professional experience to enable him or her to exercise prudent professional judgment while assuming responsible charge for the conduct of an audit of Reserves information estimated by others. The determination of whether a QRA is professionally qualified should be made on an individual-by-individual basis, with the recognition and respect of his or her peers. A QRA normally would be considered to be qualified if he or she has a minimum of 10 years of practical experience in petroleum engineering or petroleum production geology, with at least 5 years of such experience being in responsible charge of the estimation and evaluation of Reserves information, and either has obtained, from a college or university of recognized stature, a bachelor's or advanced degree in petroleum engineering, geology, or other discipline of engineering or physical science or has received, and is maintaining in good standing, a registered or certified professional engineer's license or a registered or certified professional geologist's license, or the equivalent thereof, from an appropriate governmental authority or professional organization. A QRA should decline an assignment for which he or she is not qualified.

Article IV—Standards of Independence, Objectivity, and Confidentiality for QREs and QRAs

4.1 The Importance of Independent or Objective QREs and QRAs

In order that users of Reserves information may be assured that the Reserves information has been estimated or audited in an unbiased and objective manner, it is important that QREs and QRAs maintain, respectively, the levels of independence and objectivity set forth in this Article IV. The determination of the independence and objectivity of QREs and QRAs should be made on a

case-by-case basis. To facilitate such determination, the Society has adopted standards of independence for consulting QREs and QRAs and standards of objectivity for QRAs employed internally by entities to which the Reserves information relates. To the extent that the applicable standards of independence and objectivity set forth in this Article IV are not met by QREs and QRAs in estimating and auditing Reserves information, such lack of conformity with this Article IV shall be disclosed in any report or opinion relating to Reserves information that purports to have been estimated or audited in accordance with these Standards.

4.2 Requirement of Independence for Consulting QREs and QRAs

Consulting QREs and QRAs, or any firm of petroleum consultants of which such individuals are stockholders, proprietors, partners, or employees, must be independent from any entity with respect to which such QREs, QRAs, or consulting firms estimate or audit Reserves information that purports to have been estimated or audited in accordance with these Standards. A statement of such independence shall be made a part of any report containing Reserves information.

4.3 Standards of Independence for Consulting QREs and QRAs²

Consulting QREs and QRAs, and any firm of petroleum consultants of which such individuals are stockholders, proprietors, partners, or employees, would not normally be considered independent with respect to an entity if, during the term of their professional engagement, the QRE, QRA, or consulting firm participated in:

- (a) **Investments**—Either owned or acquired, or were committed to acquire, directly or indirectly, any material financial interest in an entity or any corporation or other person affiliated therewith or any property with respect to which Reserves information is to be estimated or audited. Any such financial interest, stock, or other ownership in the properties held through direct ownership, trusts, partnerships, or incorporated entities should be disclosed in writing to the entity to determine materiality by the entity and maintained on file by the entity for review by financial auditors.
- (b) **Joint Business Ventures**—Either owned or acquired, or were committed to acquire, directly or indirectly, any material joint business investment with an entity or any officer, director, principal stockholder, or other person affiliated therewith.
- (c) **Borrowings**—Were indebted to an entity or any officer, director, principal stockholder, or other person affiliated therewith, provided, however, that retainers, advances against work-in-progress, and trade accounts payable arising from the purchase of goods and services in the ordinary course of business shall not constitute indebtedness within the meaning of this Section 4.3(c).

² For purposes of this Section 4.3, the term “affiliated” shall, with respect to an entity, describe the relationship of a person to such entity under circumstances in which such person directly or indirectly, through one or more intermediaries, controls or is controlled by, or is under common control with, such entity; provided, however, that commercial banks and other bona-fide financial institutions shall not be considered to be affiliated with the entity to which the Reserves information relates unless such banks or institutions actively participate in the management of the properties of such entity. Unless the context requires otherwise, the term “material” shall, for purposes of this Section 4.3, be interpreted with reference to the net worth of the consulting QRE or the consulting QRA, or any firm of petroleum consultants of which such individuals are stockholders, proprietors, partners, or employees.

- (d) **Guarantees of Borrowings**—Were indebted to any individual, corporation, or other person under circumstances in which the payment of such indebtedness was guaranteed by an entity or any officer, director, principal stockholder, or other person affiliated therewith.
- (e) **Loans to Clients**—Extended credit to an entity or any officer, director, principal stockholder, or other person affiliated therewith or any person having a material interest in any property with respect to which Reserves information was estimated or audited, provided, however, that trade accounts receivable arising in the ordinary course of business from the performance of petroleum engineering and related services shall not constitute the extension of credit within the meaning of this Section 4.3(e).
- (f) **Guarantees for Clients**—Guaranteed any indebtedness owed by an Entity or any officer, director, principal stockholder, or other person affiliated therewith or payable to any individual, corporation, entity, or other person having a material interest in the Reserves information pertaining to such entity.
- (g) **Purchases and Sales of Assets**—Purchased any material asset from, or sold any material asset to, an entity or any officer, director, principal stockholder, or other person affiliated therewith.
- (h) **Certain Relationships With Client**—Were directly or indirectly connected with an entity as a promoter, underwriter, officer, director, or principal stockholder, or in any capacity equivalent thereto, or were otherwise not separate and independent from the operating and investment decision-making process of such entity.
- (i) **Trusts and Estates**—Were trustees, participants, or beneficial owners in any trust, or executors, administrators, or beneficiaries of any estate, if such trust or estate had any direct or indirect interest material to it in such entity or in any property with respect to which Reserves information was estimated or audited.
- (j) **Contingent Fee**—Were engaged by an entity to estimate or audit Reserves information pursuant to any agreement, arrangement, or understanding whereby the remuneration or fee paid by such entity was contingent upon, or related to, the results or conclusions reached in estimating or auditing Reserves information.

The independence of consulting QREs and QRAs, and the independence of any firm of petroleum consultants of which such individuals are stockholders, proprietors, partners, or employees, shall not be considered impaired merely because other petroleum engineering and related services were performed for an entity or any officer, director, principal stockholder, or other person affiliated therewith or in regard to any property with respect to which Reserves information was estimated or audited, provided, however, that such other services must have been of a type normally rendered by the petroleum engineering profession and should be clearly disclosed in all reports relating to independent audits of, or reports containing, Reserves information.

4.4 Requirement of Objectivity for QRAs Employed Internally by Entities

A QRA employed internally by an entity should be empowered by that entity to be objective with respect to auditing of Reserves information relating to such entity if the information purports to have been estimated or audited in accordance with these Standards.

4.5 Standards of Objectivity for QRAs Employed Internally by Entities

A QRA employed internally by an entity would normally be considered to be in a position of objectivity with respect to that entity if, during the time period in which Reserves information was audited, the QRA exhibited:

- (a) **Accountability to Management**—Assigned to an internal-audit group that is accountable to senior-level management or the board of directors of the entity and kept separate and independent from the operating and investment decision-making process of such entity.
- (b) **Freedom to Report Irregularities**—Granted complete and unrestricted freedom to report, to one or more of the principal executives or the board of directors of the entity, any substantive or procedural irregularities of which the QRA became aware during auditing of Reserves information pertaining to that entity. Certain regulatory guidelines may require, or at least suggest, that such reporting by an internal auditor or auditing group be made routinely, directly, and exclusively to a board of directors, a board committee, or one or more of the members of the entity management team. It may further be appropriate to consider that internal QRAs and their supervisors, if any, be excluded from any Reserves-based compensation incentive plans or the budget-allocation processes of the entity. If Reserves-based compensation incentive plans for internal QREs, QRAs, supervisors, or management exist within the entity, then such incentive plans should be clearly disclosed in any Reserves reporting external to the entity. Further disclosures may be appropriate in any circumstance(s) in which the internal QRA(s) and the entity QRE(s) have been unable to reach agreement within the prescribed tolerances for a single property or group of properties.

4.6 Requirement of Confidentiality

QREs, QRAs, and any firm of petroleum consultants of which such individuals are stockholders, proprietors, partners, or employees, should retain in strictest confidence Reserves information and other data and information furnished by, or pertaining to, an entity, and such Reserves information, data, and information should not be disclosed to others without the prior consent of the entity. This practice should be followed whether or not a confidentiality agreement has been executed.

Article V—Standards for Estimating Reserves and Other Reserves Information

5.1 General Considerations in Estimating Reserves Information

Reserves information may be estimated through the use of generally accepted geological and engineering methods that are consistent with both these Standards and any statutory and regulatory provisions that are applicable to such Reserves information, in accordance with its intended use. In estimating Reserves information for a property or group of properties, QREs will determine the geological and engineering methods to be used in estimating Reserves information by considering the sufficiency and reliability of the database; the stage of development; the performance history; the experience of the QRE with respect to such property or group of properties, and with respect to similar properties; and the significance of such property or group of properties to the aggregate oil and gas properties and interests being estimated or evaluated.

The subsequent report on Reserves information should set forth information regarding the manner in which, and the assumptions pursuant to which, the report was prepared. Such disclosure should include, where appropriate: definitions of the significant terms used in the report; the geological and engineering methods and measurement base used in preparing the Reserves information and the source of the data used with regard to ownership interests and to oil and gas production and other performance data; costs of development, operations, and abandonment; product prices; and agreements relating to current and future operations, transportation, and sales of production. Reference is made herein to the PRMS, published jointly in 2018 by the Society, WPC, AAPG, SPEE, SEG, SPWLA, and EAGE. However, these Standards apply regardless of the specified system being used in the evaluation.

5.2 Adequacy of Database in Estimating Reserves Information

The sufficiency and reliability of the database are of primary importance in the estimation of Reserves and other Reserves information. The type and extent of the data required will necessarily vary in accordance with the methods used to estimate Reserves and other Reserves information. In this regard, information must be available with respect to each property or group of properties as to ownership and fiscal terms, marketing arrangements (including product prices), operating interests, expense interests, revenue interests, and future changes in any of such interests that, based on current circumstances, are expected to occur. Additionally, if future net revenue from Reserves, or the present value of such future net revenue, is to be estimated, the database should include, with respect to each property or group of properties, estimated future expenditures for capital required in field development and continued production maintenance, including but not limited to workovers and compression costs, operating costs, taxes, fees, transportation charges, and ultimate dismantlement costs, if appropriate. The foregoing is not intended as a complete listing of all items required for consideration in the estimation of Reserves and other Reserves information.

5.3 Estimating Reserves

The acceptable methods for estimating Reserves include (i) the volumetric method; (ii) evaluation of the performance history; (iii) development of a mathematical model through consideration of material balance and computer-simulation techniques; and (iv) analogy to other reservoirs if geographic location, formation characteristics, or similar factors render such analogy appropriate. In estimating Reserves, QREs should use the particular methods and, if possible, a combination of a number of methods that, in their professional judgment, are most appropriate given the geographic location, reservoir rock and fluid characteristics, nature of the property or group of properties for which Reserves are being estimated, the amount and quality of available data, and the significance of such property or group of properties in relation to the oil and gas properties for which Reserves are being estimated. For all methodologies, the current reservoir conditions, such as pressures and fluid contacts, must be given consideration because these may vary with time over the producing life of the property. Any or all of the methods identified above may need adaptation to conform to the Reserves definitions that are applicable to the purpose of the estimate. In no event should the result of two or more methodologies be averaged to provide an estimate of Reserves.

5.3.1 Estimating Reserves by the Volumetric Method. Estimating Reserves in accordance with the volumetric method involves estimation of petroleum in place on the basis of review and analysis of such documents and information as: ownership and development maps; geological maps and models; open-hole and cased-hole well logs and formation tests; relevant reservoir, fluid, and core data; relevant seismic data and interpretations; and information regarding the existing and planned completion of oil and gas wells and any production performance thereof. An appropriately estimated recovery efficiency is applied to the resulting oil- and gas-in-place quantities to derive estimated original Reserves. The unmodified term “Reserves” is applicable to remaining quantities of petroleum, net of cumulative production, at any effective reporting date. The estimated recovery efficiency may also vary as a function of the appropriate Reserves category.

5.3.2 Estimating Reserves by Analyzing Performance Data. For reservoirs with respect to which performance has disclosed reliable production trends, Reserves may be estimated by analysis of performance histories and projections of such trends. These estimates may be predicted primarily on an analysis of the rates of decline in production and on appropriate consideration of other performance parameters including, but not limited to, reservoir pressures, oil/water ratios, gas/oil ratios, and gas/liquid ratios. Particular attention should be given to the use of proprietary or commercial software programs that use various types of mathematical routines to assist in the projection of future production rates or pressure trends. Professional judgment and experience, perhaps derived from appropriate analogies, should always be used in confirming mathematically derived projections.

5.3.3 Estimating Reserves Using Mathematical Models (Reservoir Simulation). Reserves and future production performance can be estimated through a combination of detailed geological and reservoir engineering studies and mathematical or computer-simulation models. The validity

of the mathematical simulation models is enhanced by the degree to which the calculated history matches the performance history, particularly at individual well locations. Where performance history is unavailable, special consideration should be given to determining the sensitivity of the calculated ultimate recoveries to the data that are the most uncertain. After making such sensitivity determinations, the ultimate recovery should be based on computed results using a combination of input parameters appropriate for the categorization of Reserves assigned. Again, the user is advised to exercise caution in accepting results produced through use of proprietary or commercial software without a full understanding of the internal mathematical algorithms and correlations.

5.3.4 Estimating Reserves by Analogy to Comparable Reservoirs. If performance trends have not been established with respect to oil and gas production, future production rates and Reserves may be estimated by analogy to reservoirs in the same formation and in the same geological environment having similar reservoir rock and fluid characteristics, drive mechanisms, and established performance trends. Care should be taken to recognize current reservoir rock and fluid characteristics and conditions (particularly the stage of depletion), because these can vary substantially during the producing life of any property and could affect the validity of the analogy used. The choice and selection of acceptable analogs for Reserves categorization may be described in certain regulatory reporting applications.

5.4 Categorization of Reserves

Reserves must be categorized according to the level of certainty at which they are perceived to be recovered. To guide the categorization of Reserves, Reserves and resource definitions have been promulgated by various regulatory bodies and professional organizations throughout the world. Most such definitions allow for different categories of Reserves depending on the level of certainty associated with the Reserves estimate. The highest category of Reserves in many systems is “Proved Reserves,” which require the highest degree of confidence. Other categories of unproved Reserves, such as “Probable” or “Possible,” imply decreasing levels of certainty. Proved plus Probable (2P) Reserves may represent the best estimate for many purposes, including regulatory reporting in some countries. When presenting a set of Reserves quantities, the QRE should always identify the definitions under which those Reserves were determined. Different categories of Reserves are used for different purposes. Proved Reserves are always included in reports used for financial reporting and lending; however, the incorporation of both Proved and Probable Reserves is becoming increasingly common in regulatory and financial reporting. Many, if not most, entities and other users of Reserves information routinely rely on a recognition of all Reserves categories for virtually all related business decisions.

The SPE 2018 definitions contain a general requirement that Proved Reserves have a “reasonable certainty” of being recovered. Other more-specific criteria must also be met for Reserves to be classified as Proved. The definition for Probable Reserves is less stringent, requiring that a general test of “more likely than not” be satisfied. Possible Reserves are those unproved Reserves that analysis of geological and engineering data suggests are less likely to be recoverable than Probable Reserves.

5.5 Deterministic and Probabilistic Methods of Estimating Reserves

Under the PRMS 2018, Reserves estimates may be prepared using deterministic or probabilistic methods. With the deterministic method, the QRE selects a single value for each parameter to be used in the calculation of Reserves. The discrete value for each parameter is selected on the basis of the QRE's opinion of the value that is most appropriate for the corresponding Reserves category.

With the probabilistic method, a full range of possible values is described for each parameter. A mathematical technique, such as Monte Carlo simulation (being one of several techniques), is then used to perform a large number of random, repetitive calculations to generate a range of possible outcomes for the Reserves and their associated probability of occurrence. Care should be given to all parameter values chosen, but particularly for the endpoints of the relevant parameters, to ensure that the possible outcomes generated are reasonable. In principle, the two methods use comparable calculation techniques. Conceptually, a deterministic estimate is a single value taken from a range of possible Reserves values that can be expressed by a probabilistic analysis.

For Proved Reserves, the PRMS 2018 definitions specify that there should be at least a 90% probability that the quantities actually recovered will equal or exceed the estimate if probabilistic methods are used. Similarly, the definitions specify that there should be at least a 50% probability that the quantities actually recovered will equal or exceed the sum of estimated 2P Reserves. Finally, there should be at least a 10% probability that the quantities actually recovered will equal or exceed the sum of estimated Proved plus Probable plus Possible Reserves.

It should be noted that the probability distribution of Reserves values associated with the aggregation of a number of individual entities may be different from the arithmetic sum of the probability distributions for those entities. As the number of entities increases, the spread between the tails of the aggregated probability distribution decreases with respect to the spread observed for the arithmetic sum. In general, however, the arithmetic sum of a set of mean estimates will equal the mean of a probabilistic sum of such estimates. The aggregation method used should be appropriate to the use of the results. Without specific regulatory guidance, the PRMS 2018 definitions recommend that reported Reserves should not be based on probabilistic models beyond the field, property, or project level, and that further aggregation be by arithmetic summation by Reserves category. In all cases, the aggregation method and any additional conditions should be stated clearly.

5.6 Estimated Future Rates of Production

Future rates of oil and gas production may be estimated by extrapolating production trends where such trends have been established. If production trends have not been established, future rates of production may be estimated by analogy to the respective rates of production of reservoirs in the same geographic area having similar geological features, reservoir rock, drive mechanism, and fluid characteristics. If (i) production trends from the property or group of properties with respect to which Reserves are being estimated or (ii) rates of production from similar reservoirs

are not available, the estimates of future rates of production may be predicated on an assumed future decline rate that takes into proper consideration the cumulative oil and gas production that is estimated to occur before the predicted decline in such production in relation to the estimated ultimate production. Reservoir simulation is also an accepted method of estimating future rates of production. Irrespective of the method used, however, proper consideration should be given to (i) the producing capacities of the wells; (ii) the number of wells to be drilled in the future, together with the proposed times when such are to be drilled and the structural positions of such wells; (iii) the energy inherent in, or introduced to, the reservoir; (iv) the estimated ultimate recovery; (v) future remedial work to be performed; (vi) the scheduling of future well abandonments; (vii) normal downtime that may be anticipated; and (viii) artificial restriction of future production rates that is attributable to statutory and regulatory provisions, purchaser proration, marketing limitations, and other factors.

5.7 Estimating Other Reserves Information

A QRE often estimates Reserves information other than Reserves and future rates of production to make his or her report more useful. Reserves net to the interests appraised are estimated using the entity's ownership interest in the property or group of properties, or in the production therefrom, with respect to which Reserves were estimated. The nature of the ownership interest of the entity may be established or affected by any number of arrangements, which the QRE must take into account. Estimated future revenues are calculated from the estimated future rates of production (attributable to the entity's entitlement) by applying the appropriate sales prices furnished by the entity or by using such other pricing levels as may be required by statutory and regulatory provisions that are applicable to such a report in accordance with its intended use. Where appropriate, the QRE deducts from such future revenues any existing production or severance taxes; taxes levied against property or production; estimates of future operating costs; estimates of any future development; equipment or other significant capital expenditures required for the production of the Reserves; and net costs of abandonment, decommissioning and restoration. Such deductions normally include various overhead and management charges.

For some purposes, it is desirable to subtract income taxes and other governmental levies in estimating future net revenues. The foregoing may need to be modified to use the "economic interest" method in the estimation of Reserves (and Reserves information) owned or controlled by an entity through a production-sharing agreement or other various forms of contracts or licensing agreements, as may be applicable. Legal advice may be critical to the full understanding of specific contract language affecting the right to report Reserves in compliance with various regulatory bodies.

In estimating future net revenues, the QRE should consider, where appropriate, any known or likely changes resulting from historical operating costs, current estimates of future capital expenditures, or any other factors that may affect estimated limits of economic production.

Article VI—Standards for Auditing Reserves and Other Reserves Information

6.1 The Concept of Auditing Reserves and Other Reserves Information

An audit is an examination of Reserves information that is conducted for the purpose of expressing an opinion as to whether such Reserves information, in the aggregate, is reasonable and has been estimated by qualified individuals and presented in conformity with generally accepted petroleum engineering and evaluation principles and in compliance with the relevant Reserves definitions. (See expanded definition of a Reserves audit and types of Reserves reports in Section 2.2).

As discussed in Section 1.3, the estimation of Reserves and other Reserves information is an imprecise science because of the many unknown geological and reservoir factors that can only be estimated through sampling techniques. Reserves are therefore only estimates, and they cannot be audited for the purpose of verifying exactness. Instead, Reserves information is audited for the purpose of reviewing in sufficient detail the policies, procedures, methods, and data used by an entity in estimating its Reserves information so that the QRA may express an opinion as to whether, in the aggregate, the Reserves information furnished by the entity is reasonable within established and predetermined tolerances and has been estimated and presented in conformity with generally accepted petroleum engineering and evaluation principles and the controlling Reserves definitions.

The methods and procedures used by an entity, and the Reserves information furnished by that entity, must be reviewed in sufficient detail to permit the QRA, in his or her professional judgment, to express an opinion as to the reasonableness of the entity's Reserves information. In some cases, the auditing procedure may require independent estimates of Reserves information for some or all properties. The desirability of such re-estimation will be determined by the QRA exercising his or her professional judgment in arriving at an opinion as to the reasonableness of the entity's Reserves information.

There may be some instances in which the QRA cannot issue an unqualified report attesting to "reasonable" agreement in the aggregated Reserves information compiled by the entity. In such circumstances, the entity may be requested to review and revise certain portions of its Reserves information in a joint effort to produce an aggregated result within the predetermined tolerances comprising "reasonableness." Failure to do so may result in a qualified report containing full disclosure of the inability to reach the desired result.

6.2 Limitations on the Responsibility of QRAs

Because the primary responsibility for estimating and presenting Reserves information pertaining to an entity rests with the management of such entity, the responsibility of the QRA is necessarily limited to any opinion they express with respect to such Reserves information. In discharging such responsibility, the QRA may accept, generally without independent verification, information and data furnished by the entity with respect to ownership terms and interests, oil and gas production, historical costs of operation and development, product prices, agreements relating to current and future operations and sales of production, and other specified matters. If during the course of the

audit, however, questions arise as to the accuracy or sufficiency of any information or data furnished by the entity, the QRA should not rely on such information or data unless such questions are resolved or the information or data are independently verified. If Reserves information is used for financial accounting purposes, certain basic data would ordinarily be tested by an entity's independent public accountants in connection with their examination of the entity's financial statements. Such basic data would include information such as the property interests owned by the entity; historical production data; and the prices, costs, and discount factors used in valuations of Reserves. The QRA should, however, review estimates of major expenditures for development and equipment and any major differences between historical operating costs and estimated future operating costs.

6.3 Understanding Among an Entity, Its Independent Public Accountants (Where Applicable), and the QRA

An understanding should exist among an entity, its independent public accountants (where applicable), and the QRA with respect to the nature of the work to be performed by the QRA. Irrespective of whether the QRA is a consultant or employed internally by the entity, the understanding between the entity and the QRA should include at least the following:

- (a) **Availability of Reserves Information**—The entity will provide the QRA with (i) all existing Reserves information prepared by that entity, (ii) access to all basic data and documentation pertaining to the oil and gas properties of that entity, (iii) access to all personnel of that entity who might have information relevant to the audit of such Reserves information, and (iv) the right to use additional nonconfidential information available to the QRA from other reliable sources.
- (b) **Performance of Audit**—The QRA will (i) study and evaluate the appropriateness of the methods and procedures used by the entity in estimating and documenting its Reserves information; (ii) review the Reserves definitions and classifications used by the entity; (iii) test and evaluate the Reserves information of the entity and the underlying data to the extent considered necessary by the QRA; and (iv) express an opinion as to the reasonableness, in the aggregate, of the entity's Reserves information.
- (c) **Availability of Audit Report to Independent Public Accountants**—The QRA will, upon written request, permit his or her audit report to be provided to the independent public accountants of the entity, when appropriate, for use in their examination of its financial statements and be available to discuss the audit report with the independent public accountants or others as authorized by the entity.
- (d) **Coordination Between the QRA and Independent Public Accountants**—The QRA and the entity's independent public accountants will coordinate their efforts and agree on the records and data of the entity to be reviewed by each, where such coordination is necessary. In the case of an audit to be conducted by the consulting QRA, it is preferable that such understanding be documented, as through an engagement letter between the entity and the consulting QRA.

6.4 Procedures for Auditing Reserves Information

Irrespective of whether the Reserves information pertaining to an entity is being audited by a consulting QRA or a QRA employed internally by that entity, the audit should be conducted in accordance with the following procedures:

- (a) **Proper Planning and Supervision**—The audit should be adequately planned, and assistants, if any, should be properly supervised. Clear paths of communication by the QRA with all relevant individuals shall be established, along with unrestricted access to pertinent data, work papers, and Reserves information to be audited during normal business hours.
- (b) **Early Appointment of a QRA**—Where appropriate, early appointment of a QRA is advantageous both to the entity and to the QRA. Early appointment enables the QRA to plan his or her work so that it may be performed expeditiously and to determine the extent to which such can be completed before the balance sheet date. Preliminary work by the QRA benefits the entity by facilitating the efficient and expeditious completion of the audit of that entity's Reserves information.
- (c) **Disclosure of the Possibility of a Qualified Audit Opinion**—Before accepting an engagement, the QRA should ascertain whether circumstances are likely to permit an unqualified opinion with respect to an entity's Reserves information and, if such will not, the QRA should discuss with the entity the possible necessity of the QRA rendering a qualified opinion and the possible remedies to the circumstances giving rise to the potential qualification of such an opinion.
- (d) **Interim Audit Procedures**—Many audit tests can be conducted at almost any time during the year. In the course of interim work, the QRA may test the entity's methods, procedures, and controls to determine the extent to which such are reliable. It is acceptable practice for the QRA to complete substantial parts of an audit examination at interim dates. When a significant part of an audit is completed during the year and the entity's methods, procedures, and controls are found to be effective, the year-end audit procedure may consist primarily of an evaluation of the impact of new data. The QRA must nevertheless be satisfied that the procedures and controls are still effective at the year's end and that new discoveries, recent oil and gas production, and other recent information and data have been taken into account. The QRA would not be required to retest the database pertaining to an entity's properties and interests unless his or her inquiries and observations indicate that conditions have changed significantly.
- (e) **General Matters To Be Reviewed With Respect to Reserves Information**—An audit of the Reserves information pertaining to an entity generally should include a review of the policies, procedures, controls, documentation, and guidelines of that entity with respect to the estimation, review, and approval of its Reserves information; the qualifications and independence of QREs employed internally by the entity; ratios of the entity's Reserves to annual production for, respectively, oil, gas, and natural-gas liquids; historical Reserves and revision trends with respect to the oil and gas properties and interests of the entity; ranking by size of properties or groups of properties with respect to estimates of Reserves

or the future net revenue from such Reserves; percentages of Reserves estimated by each of the various methods set forth in Section 5.3 for estimating Reserves; and the significant changes occurring in the entity's Reserves, other than from production, during the year with respect to which the audit is being prepared.

- (f) **Evaluation of Internal Policies, Procedures, Controls, and Documentation**—The QRA should review and evaluate the internal policies, procedures, controls, and documentation of an entity to establish an understanding of the internal processes that the entity uses in its reviews of existing Reserves information. The internal policies, procedures, controls, and documentation to be reviewed with respect to an entity should include Reserves definitions and classifications used by the entity; the entity's policies pertaining to, and management involvement in, the review and approval of Reserves information and changes therein; the frequency with which the entity reviews existing Reserves information and documentation of the Reserves information of such entity, together with the entity's internal distribution thereof; the form, content, and basis for reliance thereon in determining the nature, extent, and timing of the audit tests to be applied in the examination of the entity's Reserves information and other data and matters; and the flow of data to and from the entity's Reserves inventory system.
- (g) **Testing for Compliance**—The QRA should conduct tests and spot checks to confirm that there is adherence on the part of an entity's internal QREs and other employees to the policies, procedures, and controls established by such entity, and that the data flowing into the Reserves inventory system of such entity is complete and consistent with other available records.
- (h) **Substantive Testing**—In conducting substantive tests, the QRA should give priority to each property or group of properties of an entity having a large Reserves value in relation to the aggregate properties of such entity; a relatively large Reserves value and major changes in the Reserves information pertaining to such property or group of properties during the audit year; and a relatively large Reserves value and a high degree of uncertainty in the Reserves information pertaining thereto. The selection of properties for substantive testing shall be made independently by the QRA. The amount of substantive testing performed with respect to particular Reserves information of an entity should depend on the assessment of the general degree of uncertainty with respect to such Reserves information; the evaluation of the internal policies, procedures, and documentation of the entity; and the results of the compliance testing with respect to the entity. Such substantive testing could therefore range appropriately from a limited number of tests selected by the QRA to the complete estimation of Reserves information with respect to a majority of an entity's Reserves.

6.5 Records and Documentation With Respect to Audit

The QRA should document and maintain records with respect to each audit of the Reserves information of an entity. Such documentation and records should include, among other things, a description of the Reserves information audited; the review and evaluation of the entity's policies, procedures, and documentation; the compliance testing performed with respect to such entity; and the substantive tests performed in the course of such audit.

6.6 Forms of Unqualified Audit Opinions

Acceptable forms of unqualified audit opinions for consulting QRAs and QRAs employed internally by entities are included with these Standards as Exhibits A and B, respectively.

Exhibit A—Illustrative Unqualified Audit Opinion of a Consulting QRA³

[Date]

Entity

[Address]

Independent Public Accountants of Entity

[Address]

To Whom It May Concern:

At your request, I have examined the estimates as of [dates] set forth in the accompanying table with respect to (i) the proved Reserves of [entity], (ii) changes in such Proved Reserves during the period indicated, (iii) the future net revenue from such Proved Reserves, and (iv) the present value of such future net revenue. My examination included such tests and procedures as were considered necessary under the circumstances to render the opinion set forth herein.

[A detailed description of the audit should be set forth.]

I am independent with respect to [entity], as provided in the *Standards Pertaining to the Estimating and Auditing of Oil and Gas Reserves Information* promulgated by the Society of Petroleum Engineers. It should be understood that the above-described audit does not constitute a complete Reserves study of the oil and gas properties of [entity]. In the conduct of this report, I have not independently verified the accuracy and completeness of information and data furnished by [entity] with respect to ownership interests, oil and gas production, historical costs of operation and development, product prices, agreements relating to current and future operations and sales of production, and [specify other information, data, and matters upon which reliance was placed]. I have, however, specifically identified to you the information and data upon which I so relied so that you may subject such to those procedures that you consider necessary.

Furthermore, if in the course of my examination something came to my attention that brought into question the validity or sufficiency of any of such information or data, I did not rely on such information or data until I had satisfactorily resolved any questions relating thereto or had independently verified such information or data.

Please be advised that, on the basis of the foregoing, it is my opinion that the above-described estimates of [entity]'s Proved Reserves and other Reserves information are, in the aggregate, reasonable within the established audit tolerance guidelines of \pm []% and have been prepared in accordance with generally accepted petroleum engineering and evaluation principles as set forth in the *Standards Pertaining to the Estimating and Auditing of Oil and Gas Reserves Information* promulgated by the Society of Petroleum Engineers.

[Insert, where appropriate and to the extent warranted by the QRA's examination, whether the Reserves information is in conformity with specified governmental regulations.]

[Optional: This letter is solely for the information of (entity) and for the information and assistance of its independent public accountants in connection with their review of, and report upon, the financial statements of (entity). This letter should not be used, circulated, or quoted for any other purpose without the express written consent of the undersigned or except as required by law.]

Very truly yours,

Qualified Reserves Auditor [QRA]

By _____

³ If a QRA is unable to provide an unqualified opinion as to an entity's Reserves information, then the QRA should set forth in his or her opinion the nature and extent of the qualifications to such opinion and the reasons therefore.

Exhibit B—Illustrative Unqualified Audit Opinion of a QRA Internally Employed by an Entity³

[Date]

Entity

[Address]

Independent Public Accountants of Entity

[Address]

To Whom It May Concern:

I have examined the estimates as of [dates] set forth in the accompanying table with respect to (i) the Proved Reserves of [entity], (ii) changes in such Proved Reserves during the period indicated, (iii) the future net revenue from such Proved Reserves, and (iv) the present value of such future net revenue. My examination included such tests and procedures as were considered necessary under the circumstances to render the opinion set forth herein.

[A detailed description of the audit tests and procedures should be set forth.]

I meet the requirements of objectivity for Qualified Reserves Auditor employed internally by [entity] as set forth in the *Standards Pertaining to the Estimating and Auditing of Oil and Gas Reserves Information* promulgated by the Society of Petroleum Engineers.

It should be understood that my above-described audit does not constitute a complete Reserves study of the oil and gas properties of [entity]. In the conduct of my report, I have not independently verified the accuracy and completeness of information and data furnished by other employees of [entity] with respect to ownership interests, oil and gas production, historical costs of operation and development, development, product prices, agreements relating to current and future operations and sales of production, and [specify other information, data, and matters upon which reliance was placed]. I have, however, specifically identified to you the information and data upon which I so relied so that you may subject such to those procedures that you consider necessary. Furthermore, if in the course of my examination something came to my attention that brought into question the validity or sufficiency of any of such information or data, I did not rely on such information or data until I had satisfactorily resolved my questions relating thereto or had independently verified such information or data.

Please be advised that, on the basis of the foregoing, it is my opinion that the above-described estimates of [entity]'s Proved Reserves and other Reserves information are, in the aggregate, reasonable within the established audit tolerances of \pm []% and have been prepared in accordance with generally accepted petroleum engineering and evaluation principles as set forth in the *Standards Pertaining to the Estimating and Auditing of Oil and Gas Reserves Information* promulgated by the Society of Petroleum Engineers.

[Insert, where appropriate and to the extent warranted by the QRA's examination, whether the Reserves information is in conformity with specified governmental regulations.]

Very truly yours,

Qualified Reserves Auditor [QRA]

By _____