ENGINEER OF RECORD (EOR) SERVICES FOR TAILINGS FACILITIES

Authors: Paul W. Ridlen, PE; Thomas F. Kerr, PEng, PE; David Morgan, C.Eng

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ARGENTINA
mendoza@knightpiesold.com
+54 (261) 422 4042

AUSTRALIA
perth@knightpiesold.com
+61 8 9223 6300

BRAZIL
brazil@knightpiesold.com
+55 31 3286 3099

CANADA
vancouver@knightpiesold.com
+1 604 685 0543

CHILE
santiago@knightpiesold.com
+56 2 2594 6400

GHANA
accra@knightpiesold.com
+233 30 702 1155

MEXICO
denver@knightpiesold.com
+1 303 629 8788

PERÚ
lima@knightpiesold.com
(51-1) 202-3777

SOUTHERN AFRICA REGION
pretoria@knightpiesold.com
+27 12 991 0557
Includes locations in Botswana, Democratic Republic of Congo, Swaziland, Ghana, Namibia, South Africa, and Zambia.

UNITED KINGDOM
london@knightpiesold.com
+44 (0)203 096 0959

USA
denver@knightpiesold.com
+1 303 629 8788

Introduction

The Engineer of Record (EOR) concept originated in North America and has been used for private and public works construction since at least the early 20th century. It gained significant attention in the U.S. after the 1981 Hyatt Regency disaster in Kansas City, Missouri, which led to written guidance in the 1980s and 1990s by professional organizations and regulatory bodies to define typical duties and obligations of an EOR.

Applying the EOR concept to a tailings facility is more challenging than for a building, bridge, or water dam, largely because of the ongoing nature of construction. In addition, the complex behaviors associated with tailings and the potential for brittleness and/or liquefaction require special knowledge and training for proper design and monitoring of tailings facilities through their lifespan. Forensic investigations for recent tailings dam failures have identified the importance of the EOR role to reduce risk and prevent failures. These forensic investigations and efforts by the professional engineering and mining communities have led to a consensus in the industry that Owners are best served when continuity in the EOR is maintained through design, construction, and operational phases (and into closure when possible). The Global Industry Standard on Tailings Management ("Global Standard") reinforces the importance of EOR continuity.

The term **Engineer of Record** came to prominence in the mining industry after the 2014 Mt. Polley tailings failure. The Global Standard requires adherents to "engage an engineering firm … to provide EOR services".

There remains significant uncertainty about what an EOR is and how to implement the concept on tailings projects. Knight Piésold has prepared this guide for implementation of the EOR concept for the projects and Owners we support. This paper addresses only the case of an external EOR, which is one of the two primary models recognized by the Global Standard.

Implementation of the EOR concept involves both an individual and a company, as reflected in the Global Standard. Knight Piésold clarifies these relationships by using the term "EOR Company" to refer to the Knight Piésold operating company that enters into a contract with an Owner to provide EOR services. The individual EOR is appointed by the EOR Company, subject to the Owner's approval, to act on behalf of Knight Piésold to provide technical advice and leadership to the Owner.

What is an EOR?

The EOR role should not be confused with a Third-Party Reviewer, a Responsible Tailings Facility Engineer, or other key roles in tailings management.

The primary responsibility of an EOR is to advise the Owner regarding the design aspects of the facility – assuring the Owner and other stakeholders that the facility is designed according to accepted standards of practice and then is constructed and operated consistent with the design intent.

The EOR should be responsible for the design of the facility. In cases where another party performed/performs the design, the EOR has a responsibility to thoroughly review and understand the design and take ownership for the design concept as if it were prepared under the EOR's direct responsible charge.

Knight Piésold has been an industry leader in clarifying the role of the EOR for tailings dams, having influenced or informed the policies and guidelines of several mining companies, industry groups, and professional organizations. This white paper has been written to be consistent with the latest guidance from the International Council on Mining and Metals (ICMM), the Mining Association of Canada (MAC), the International Commission on Large Dams (ICOLD), and similar organizations.

EOR Definition

The EOR is one of four key roles identified in the Global Standard, as well as MAC and other industry guidelines, that are critical to maintaining effective governance and reducing the risk of unfavorable outcomes for tailings dams. The other key roles are the Accountable Executive, the Responsible Tailings Facility Person, and the Independent Reviewer(s). Knight Piésold has developed the following group-wide definition of EOR:

The **EOR** is a qualified engineer, employed and appointed by the **EOR Company** to act on behalf of that company, who:

1. Has ***responsible charge*** over the design of a facility and provides assurance that the design conforms to proper technical criteria and the accepted state of practice, consistent with current and applicable standards, guidelines, and regulatory requirements.
2. Provides sufficient observation during construction activities to advise whether the facility has been or is being constructed consistent with the design intent, and that any changes to the design implemented during construction are consistent with the design intent.
3. Provides ongoing support during operations and through the lifespan of the facility (including decommissioning), advising the Owner, regulatory authorities, and other appropriate stakeholders whether the facility is being operated and is performing according to the design intent, accepted principles for safe operation, and the current standard of practice.

This definition is consistent with Principle 9 of the Global Standard, the ICMM Best Practice Guide (ICMM, 2021), and ICOLD guidelines (in progress).

Responsible charge is defined as "direct control and personal supervision of engineering work" (see inset).

What is Responsible Charge?

"The professional engineer in Responsible Charge is actively engaged in the engineering process, from conception to completion. Engineering decisions must be personally made by the professional engineer or by others over which the professional engineer provides supervisory direction and control authority. Reviewing drawings or documents after preparation without involvement in the design and development process does not satisfy the definition of Responsible Charge."

-- NSPE (2019)

EOR Qualifications

Experience requirements for Knight Piésold EORs are provided in Table 1. Knight Piésold requires an EOR to either be registered as a professional engineer in the local jurisdiction where the project is performed or in an appropriate international jurisdiction. A Bachelor's degree, or equivalent, in civil engineering, geotechnical engineering, mining engineering, or a similar approved degree is a minimum requirement for an EOR. Exceptions to these minimum requirements are made at Knight Piésold by our senior management, with concurrence from the Owner.

An EOR also requires the following attributes:

- Good written and oral communication skills.
- Trusted by peers, colleagues, and other industry professionals.
- Ability to work as part of a team (e.g., Owner's staff, regulatory agencies, other consultants, construction contractors, etc.).
- Capable of giving "bad news" to a group that does not expect or want to hear it.
- Open and supportive of independent review.
- Ability to apply critical thinking.
- Familiar with consequence and risk-based decision-making.

- Relevant experience with site investigations, designs, inspections, construction, operation and closure of tailings facilities and aspects that influence good performance.
- Knowledge and experience with tailings facility guidelines and regulations.

Table 1
EOR Experience Requirements

Consequence Classification[1]	Minimum Years Relevant Experience[2, 3]
Low	6
Significant	8
High	12
Very High	15
Extreme	15

[1]Consequence classification is defined in the Global Standard.

[2]A Master of Science (MS) degree or equivalent in a relevant field will count for 1 year experience and a PhD in a relevant field will count for an additional 2 years' experience.

[3]The experience requirements are considered minimum. Additional years may be required based on the type of experience in the individual's employment history and demonstrated performance on past projects. The educational and experience requirements do not automatically qualify someone as an EOR.

Many companies also wish to identify a Deputy EOR for each facility. Generally, a Deputy EOR holds the same qualifications of an EOR, but usually with less experience. The purpose of appointing a Deputy EOR is to provide technical and project management support to the EOR and to establish succession planning.

EOR Authority and Responsibility

Appropriate authority must be granted by the Owner in order for Knight Piésold to accept an assignment as an EOR Company. This authority is typically transferred and managed through the contract between the Owner and the EOR Company. Given the authority from the Owner, the EOR Company and the EOR follow through on the responsibilities required to achieve the goal of a safe and productive tailings facility.

Authority

Knight Piésold must be authorized to perform the following activities, in keeping with international standards/guidelines and local regulations:

- **Characterize the Tailings and the Site.** Perform or provide direct oversight to site investigation efforts sufficient to adequately characterize the tailings, foundations, and all materials comprising the structural zones of the tailings dam.
- **Develop Design Criteria Document.** Prepare a design criteria document establishing the performance criteria against which the acceptability of the design will be assessed and clearly defines the battery limits for which Knight Piésold is responsible. Design criteria must be consistent with the assumed or demonstrated Consequence classification. Development of design criteria is an iterative process, done in coordination with the Owner, Independent Reviewers, and other appropriate stakeholders. It is modified only with mutual agreement between Knight Piésold and the Owner as the designs are developed.
- **Perform Design Analyses.** Perform or provide direct oversight to the design analyses and calculations required to develop the design basis of the facility, in accordance with applicable laws, appropriate industry standards, and the standard of care, as appropriate to the site conditions.
- **Prepare Design Documentation.** Prepare design drawings, specifications, reports, and other required documentation appropriate to the required level of completion.
- **Observe and Document Construction.** Provide sufficient construction support services and observation during construction of all stages to provide an informed professional opinion on whether the facility has been constructed in conformance with the intent of the design and specifications. Prepare or review the preparation of as-built (record) documentation.

- **Provide Operational Support and Observation.** Provide sufficient oversight during the operation of all stages of the facility. Conduct regular, on-site visual inspections to confirm that the facility is being monitored and managed in accordance with the intent of the design, which may need to be modified to reflect actual conditions. Review geotechnical and hydraulic monitoring on a regular basis. Knight Piésold may develop regular instrumentation reports on behalf of the Owner, or these instrumentation reports may be generated by the Owner with detailed review performed by KP staff. For active facilities, perform no less than one site visit per year and be allowed to perform a dam safety inspection of the facility (which may or may not be combined).
- **Report to Owner's Accountable Executive.** Report to Accountable Executive (or Designate) at least once per year on the performance of active facilities. Provide notification to the Accountable Executive and/or Board of Directors in the event the EOR identifies any concern that has not been resolved by the entity responsible for operation to the satisfaction of the EOR.

The authority granted to Knight Piésold as EOR Company must be communicated throughout the Owner's organization to ensure that Knight Piésold is able to perform its duties as EOR Company and that the individual EOR is also able to perform his/her duties.

Adequate time and budget must be agreed to between Knight Piésold and the Owner prior to Knight Piésold accepting an EOR role. Knight Piésold will endeavor to maintain fair and reasonable costs throughout the assignment, but adjustments to the required time and budget may need to be made to suit any changed or modified conditions.

Knight Piésold must reserve the right to terminate the EOR role at any time if, in Knight Piésold's opinion, insufficient time, budget and resources are made available or if the reasonable recommendations made by Knight Piésold are not followed by the Owner, or if the Owner does not conform to accepted international guidelines and standards. Additional information on transitions of EOR responsibility are provided later in this paper.

Responsibility

The EOR (acting on behalf of Knight Piésold) will be in responsible charge for the technical aspects of the project, within the battery limits defined in the contract. The EOR, with the support of the appropriate technical team, will fulfill the following responsibilities to the best of his/her ability:

- Make design, construction, operating and closure decisions and recommendations based on safety and environmental responsibility as the highest priorities, that follow the intent of the design, are appropriate for the conditions observed, and conform to relevant standards, guidelines, and good practices.
- Take responsible charge of the work being performed by or under the direct control of Knight Piésold; exercise the required degree of control and supervision for the service and deliverables; and review and either reject or approve the services and deliverables being produced.
- Answer questions relevant to the design, construction and operation, with such answers being in sufficient detail to demonstrate reasonable knowledge of and proficiency of the design, construction and operation.
- Have personal knowledge of the technical abilities of the personnel doing the work and be satisfied that the technical credentials and abilities of such personnel are suitable for the performance of the work.
- Be responsive to Owner input and requests, as well as input from Independent Reviewers.

Creation of a RASCI (Responsible, Accountable, Supporting, Consulted, Informed) matrix is a good practice to clarify and communicate the roles of all members of a tailings management system.

Typical EOR Services

Each tailings facility project is unique, and the scope of work for each assignment will be agreed to between the Owner and Knight Piésold. Certain core functions or services are essential to the safety of a dam, and Knight Piésold requires direct authority/responsibility to perform these elements in-house. Other services may be performed by other parties, including Owner's internal resources, but the EOR must have access to review work by other parties. This section describes "Mandatory" versus "Optional" Services to be included in Knight Piésold's scope of services.

Mandatory Services

The following services are considered mandatory and are to be performed directly by or under the direct control of Knight Piésold:

- Site investigation, characterization of foundations and construction materials, and tailings strength characterization.
- Geotechnical design and analysis.
- Design of key hydraulic structures (e.g., outlet works, spillways, diversion structures, etc.).
- Preparation of design drawings and specifications.
- Construction support services (Quality Assurance, Quality Control, or both).
- Annual dam safety audits/inspections.
- Regular operational support to confirm the design objectives are met through operations.

Knight Piésold may choose to subcontract portions of these core services to supplement internal resources, but will remain in responsible charge of the work. Procedures for approval of subcontractors may be defined in the contract terms of Knight Piésold's engagement.

Other Services

Other services may be provided by or contracted directly by the Owner, subject to review and consultation with Knight Piésold's designated EOR. The EOR is required to review and advise on the methods to be used, must have access to the results of the services, and must have the authority to reject work that does not conform to international standards of practice. These other services may include:

- Geochemistry
- Geophysics
- Climate data collection and interpretation
- Water balance analysis
- Geologic and seismic hazard studies
- Hydrogeology
- Tailings deposition modelling
- Laboratory testing
- Closure and reclamation designs

For these other services, Knight Piésold will review the results and may perform independent checks for very complicated work (such as geochemistry or water balance analysis), as needed. However, Knight Piésold will formally rely on the professional judgments of the professionals preparing the work and assumes no liability for the errors and omissions of other parties.

Knight Piésold's role as EOR Company is typically extended through closure and into post-closure, if on-going services are required to confirm the closed facility is being managed in accordance with the intent of the closure design.

EOR Transitions

There are three primary types of transition of responsibility for EOR services on a project, as described below:

- Scenario 1: Transition from one person to another person within Knight Piésold (i.e., normal succession).
- Scenario 2: Assumption of EOR responsibility by Knight Piésold from another company.
- Scenario 3: Relinquishment of EOR responsibility by Knight Piésold to another company.

Normal Succession

Transfer of EOR responsibility from one engineer to another within Knight Piésold is an expected process on many tailings facilities, due to the typical longevity of these projects and the desire to promote professional growth in emerging leaders. As the EOR Company, Knight Piésold recognizes the need to closely coordinate with Owners in the case of changes. When an internal change is proposed or needed, the current EOR or a member of Knight Piésold's management will communicate with the Owners' Accountable Executive to develop a transition plan suitable to both Knight Piésold and the Owner.

Many Owners request Deputy EORs, especially for High to Extreme Consequence facilities. Knight Piésold supports the formal designation of a Deputy EOR to provide redundancy for this key role and to facilitate an orderly transition when required.

Accepting EOR Role from another Company

Knight Piésold may accept responsibility as the EOR Company for a tailings facility that is already under design, construction or operation or on some projects that have never had a designated EOR. However, because of the risks inherent to these types of transitions, a due-diligence process is required before Knight Piésold can take over the responsibilities as the EOR Company. In order to consider such an appointment, Knight Piésold's Board of Directors requires the following conditions to be met:

- The Owner agrees to assign to Knight Piésold the Authority previously defined.
- Contractual and insurance obligations are satisfactory to both parties.
- The EOR Company Regional Manager and EOR-designate agree to accept the responsibilities previously described for the facility(ies), subject to successful completion of the due diligence described below.
- Knight Piésold is authorized to conduct, and be fully compensated for, appropriate due diligence on the project to identify potential gaps in information and to understand and accept the basis of design and quality of previous or ongoing construction.
- Knight Piésold is authorized to conduct, and be fully compensated for, appropriate follow-up actions to fill the gaps identified in the due diligence.

Upon agreeing in principle to consider taking over the EOR responsibility, Knight Piésold will issue a letter to the Owner conditionally accepting the EOR responsibility and outlining the specific due-diligence and other services to be performed. During this time, the EOR-designate may be referred to as "Conditional EOR".

It must be understood that the conditional acceptance can be rescinded if the investigations identify any "fatal flaw" in the existing conditions or if the Owner does not implement the recommendations made by the EOR to conform to international standards and good practice. In other words, the conditional acceptance does not guarantee that Knight Piésold will transition to the EOR/EOR Company role.

Knight Piésold requires contract terms that clearly define limitations to liability when performing due diligence pursuant to accepting EOR responsibilities on an existing facility. Knight Piésold accepts no liability for any damages brought about or caused by any hidden flaws or pre-existing conditions brought

about before any involvement by Knight Piésold or by any errors or omissions made by previous engineers, current or previous Owners, or other third parties.

Due Diligence Review Process

The general process for due diligence includes:

- Performing at least one site visit with an appropriate team to assess current conditions.
- Review of historical documentation on design, construction, and operation.
- Review of historical geotechnical investigation and laboratory testing data and confirmation that the available data are sufficient and reliable for Knight Piésold to rely on.
- Completion of sufficient check analyses to identify the current state of the facility with respect to internationally accepted design standards. The amount and thoroughness of analysis required to make this assessment will vary on a case-by-case basis and depends largely on the age, complexity, and consequence level of the facility.
- If the historical geotechnical data are not sufficient, then an investigation plan will be prepared to evaluate subsurface conditions and expected engineering behavior of all critical materials. The investigation plan may include field investigations and laboratory testing. Knight Piésold must be allowed to directly supervise and log the investigations to assume responsibility for the results.
- Updated analyses may be required to incorporate the results of the site investigation into the dam safety evaluation.

Upon completion of this process, the KP operating company will issue a letter either accepting the EOR/EOR Company responsibility and identifying the person acting on behalf of Knight Piésold as the EOR; or notifying the Owner that Knight Piésold is not willing to accept such assignment.

Relinquishing EOR Responsibility

Knight Piésold, as the EOR Company, may relinquish this role to another engineering firm when required. This may be initiated by the Owner or by Knight Piésold. The Owner may initiate this action for a number of reasons. Knight Piésold will typically initiate relinquishment as the EOR under the following conditions:

- If it is not provided with the Authority to serve in the role as defined above,
- If the Owner does not implement the reasonable recommendations that the EOR outlines for dam safety, or,
- If the Owner does not compensate Knight Piésold for services in accordance with the contract.
- Knight Piésold will issue an advisory letter providing the Owner the opportunity to resolve any misunderstandings before withdrawing as the EOR Company.
- If the Owner and Knight Piésold cannot resolve any differences and Knight Piésold discontinues serving as EOR/EOR Company, Knight Piésold will document the end of our responsibilities in a written letter. When required, Knight Piésold will notify regulatory agencies with jurisdiction that we are no longer the EOR for such facility(ies).
- Knight Piésold will cooperate with the Owner in the hand-over of responsibility to any potential successor firm. Compensation for the hand-over efforts will be according to the terms of the agreement between Owner and Knight Piésold in effect at the time.

Knight Piésold will not unreasonably terminate our role. The Owner may reserve the right to terminate Knight Piésold if, in the Owner's reasonable opinion, Knight Piésold is not meeting its responsibilities as EOR.

Contract Terms

When performing due diligence pursuant to accepting EOR responsibilities on an existing facility, Knight Piésold requires contract terms that clearly define limitations to liability. It should be understood that Knight Piésold can accept no liability for any damages brought about or caused by any hidden flaws or pre-existing conditions brought about before any involvement by Knight Piésold or by any errors or omissions made by previous engineers, current or previous Owners, or other third parties.

Additional Resources

The following references provide additional information on current and historical definitions, expectations, and requirements for EORs.

Association of Professional Engineers and Geologists of British Columbia (APEGBC), 2016. "Site Characterization for Dam Foundations in BC," APEGBC Professional Practice Guidelines, V1.0., www.egbc.ca.

Canadian Dam Association (CDA), 2019. "Application of Dam Safety Guidelines to Mining Dams, 2019 Edition", www.cda.ca.

GeoProfessional Business Association (GBA), 2018. "Proposed Best Practices for the Engineer of Record (EOR) for Tailings Dams". www.geoprofessional.org.

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