Management of Saline Fluids for Hydraulic Fracturing Guideline

VERSION 1.3: April 2026

About the Regulator

The British Columbia Energy Regulator (Regulator) oversees the full life cycle of energy resource activities in B.C., from site planning to restoration. The Regulator ensures activities are undertaken in a manner that protects public safety and the environment, supports reconciliation with Indigenous peoples, conserves energy resources and fosters a sound economy and social well-being. We work collaboratively across government and industry sharing policy and technical expertise in support of B.C.'s transition to low-carbon energy and helping meet future global energy needs.

Vision, Mission and Values

Vision

A resilient energy future where B.C.'s energy resource activities are safe, environmentally leading and socially responsible.

Mission

We regulate the life cycle of energy resource activities in B.C., from site planning to restoration, ensuring activities are undertaken in a manner that:

- Protects public safety and the environment
- Supports reconciliation with Indigenous peoples and the transition to low-carbon energy
- Conserves energy resources
- Fosters a sound economy and social well-being

Values

Respect is our commitment to listen, accept and value diverse perspectives.

Integrity is our commitment to the principles of fairness, trust and accountability.

Transparency is our commitment to be open and provide clear information on decisions, operations and actions.

Innovation is our commitment to learn, adapt, act and grow.

Responsiveness is our commitment to listening and timely and meaningful action.

Additional Guidance

As with all Regulator documents, this document does not take the place of applicable legislation. Readers are encouraged to become familiar with the acts and regulations and seek direction from Regulator staff for clarification.

The Regulator publishes both application and operations manuals and guides. The application manual provides guidance to applicants in preparing and applying for permits and the regulatory requirements in the planning and application stages. The operation manual details the reporting, compliance and regulatory obligations of the permit holder. Regulator manuals focus on requirements and processes associated with the Regulator's legislative authorities. Some activities may require additional requirements and approvals from other regulators or create obligations under other statutes. It is the applicant and permit holder's responsibility to know and uphold all legal obligations and responsibilities. For example, Federal Fisheries Act, Transportation Act, Highway Act, Workers Compensation Act and Wildlife Act.

Throughout the document there are references to guides, forms, tables and definitions to assist in creating and submitting all required information. Additional resources include:

- Glossary and acronym listing on the Regulator website.
- Documentation and guidelines on the Regulator website.
- Frequently asked questions on the Regulator website.
- Advisories, bulletins, reports and directives on the Regulator website.
- Regulations and Acts listed on the Regulator website.
- Guidance Documents available on the Canadian Dam Association website.

In addition, this document may reference some application types and forms to be submitted outside of the Application Management System but made available on the Regulator's website. Application types and forms include:

- Heritage Conservation Act
- Road use permits
- Water licences
- Master licence to cut
- Certificate of restoration
- Waste discharge permit
- Experimental scheme application
- Permit extension application
- Disposal Well Application

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Manual Revisions

The Regulator is committed to the continuous improvement of its documentation. Revisions to the documentation are highlighted in this section and are posted to the Energy Professionals section of the Regulator's website. Stakeholders are invited to provide input or feedback on Regulator documentation to Systems@bc-er.ca or submit feedback using the feedback form.

Version Number	Posted Date	Effective Date	Chapter Section	Summary of Revision(s)
1.1	April 11 2019	May 1 2019	Section 2.4 & 3.4	Changed "within 48 hours" to "immediately" when referring to the submission requirements for spills.
1.2	Dec 2023	Dec 2023	Various	Changes relating to rebranding from OGC to BCER.
1.3	April 7, 2026	April 7, 2026	Various	Changes relating to dam safety, groundwater monitoring, annual reporting, guidance structure, among others. For more information, refer to Technical Update TU 2026-08 on the Regulator's website.

Preface

About

The Management of Saline Fluid for Hydraulic Fracturing Guideline is a reference document for oil and gas permit holders detailing the requirements and expectations for siting, design, construction, operation, and decommissioning of lined containment systems used for the storage of saline fluids. These fluids are used in, or returned to surface from, hydraulic fracturing operations and can include flowback from hydraulic fracturing operations, produced water, and saline source water. Where the term "saline fluids" is used throughout this guideline, it applies to each of these three types of fluid, including any combination of these fluids as well as any combination of these three fluids that have been mixed with fresh water.

Lined containment systems are structures that use engineered synthetic materials as the primary means of containment to prevent saline fluids from contacting soil and groundwater. This includes lined in-ground earthen containment ponds and lined above-ground walled storage systems (AWSS), commonly known as c-rings. Facilities used for the storage of saline fluids are classified as "Water Hubs" for the purpose of BCER applications.

For permit holders, the guideline provides an overview of their obligations under the Energy Resource Activities Act (ERAA), and the Environmental Management Act (EMA). It is intended as guidance for permit holders to demonstrate ongoing compliance with these acts and their supporting regulations with respect to the storage of saline fluids.

The guideline has been prepared to be as comprehensive as possible; however, it is not all encompassing and may not cover all site-specific situations. Where circumstances or scenarios arise and are not covered by the guideline, contact one of the Regulator's Environmental Stewardship staff members at waste.management@bc-er.ca for assistance.

Guideline Scope

This guideline is limited in scope to the regulatory provisions applicable to the storage and disposal of saline fluids found in the Energy Resource Activities Act (ERAA), Environmental Management Act (EMA), Contaminated Sites Regulation (CSR), Oil and Gas Waste Regulation (OGWR), Hazardous Wastes Regulation (HWR), Spill Reporting Regulation (SRR), Drilling and Production Regulation (DPR), and Environmental Protection and Management Regulation (EPMR).

Application guidance is available within the BCER Energy Resource Activity Application Manual.

For a detailed list of the applicable regulatory provisions, see Chapter 1 of this document.

Additional BCER manuals and guidelines are available in the documentation section of the Regulator's website.

Compliance and Enforcement

This document does not replace legislation or affect legislative requirements. All permit holders are ultimately responsible for ensuring they understand and meet all requirements of the Energy Resource Activities Act and their permits. It is the permit holder's responsibility to know and uphold all their legal obligations. Should a person not comply with ERAA, the Regulator may take compliance and enforcement actions. For more information regarding the Regulator's Compliance and Enforcement processes, please refer to the Compliance and Enforcement Manual.

1 Legislation, Regulation, and Expectations

This section provides references to the legislation, regulation and guidance that provide the basis for the management of saline fluids generated from and/or for use in hydraulic fracturing in British Columbia.

1.1 Energy Resource Activities Act

The Energy Resource Activities Act (ERAA) defines what constitutes energy resource activity and is the primary legislation that governs energy resource activity in British Columbia. The Act itself contains requirements to minimize waste during the conduct of energy resource activities (Section 35) and requirements to prevent, report, contain, and eliminate spillage, and to remediate land or water affected by spillage (Section 37). The following ERAA regulations are also relevant to saline fluid storage.

1.1.1 Drilling and Production Regulation

The Drilling and Production Regulation (DPR) is a set of regulations governing the oil and gas industry, specifically focusing on activities related to drilling, completion, production, and abandonment of wells, as well as the construction, operation, maintenance, and abandonment of related facilities. Section 51 (5) and 51 (6) of the DPR specifically discusses the storage and disposal of waste, respectively.

Section 78.1 of the DPR requires that a facility permit holder must develop and maintain an adequate and effective integrity management program (IMP) – a preventive framework over the entire life cycle of the regulated asset types for anticipating, preventing, managing and mitigating conditions of and around their assets that may adversely affect safety of people and the environment. Compliance and verification procedures relating to IMPs for water hubs and other facilities are addressed within the BCER Compliance Assurance protocol for IMP for Facilities.

Section 78 (4) requires that facility permit holders submit record drawings sealed by a Professional Engineer within 3 months of beginning production. For the purposes of produced water storage, this is interpreted as within 3 months of the introduction of produced water in the storage facility.

1.1.2 Environmental Protection and Management Regulation

The Environmental Protection and Management Regulation (EPMR) provides the statutory authority to the BCER for the management and protection of environmental values on crown land.

1.1.3 Emergency Management Regulation

Permit holders should be aware of the requirements for emergency preparedness and response under the Emergency Management Regulation (EMR) including the requirement for permit holders to comply with Canadian Standards Association standard CSA Z246.2 - Emergency preparedness and response for petroleum and natural gas industry systems. For facilities where failure consequence analysis has been performed, permit holders should ensure that any potentially affected parties / critical infrastructure downstream of the facility are properly incorporated into emergency planning as required per the EMR and CSA Z246.2.

1.2 Environmental Management Act

The Environmental Management Act (EMA) is the primary provincial legislation that governs the introduction of wastes into the environment. It defines those discharges that require authorization and those exempt from requiring authorization. EMA also defines what constitutes contamination in soil, sediment, water, and groundwater across the province. Section 6 of EMA prohibits a person from introducing, causing, or allowing waste to be introduced into the environment from a prescribed industry or activity unless it occurs under permit, approval, or in accordance with a regulation under EMA. The oil and gas industry is a prescribed industry under the Waste Discharge Regulation of EMA and any unauthorized discharge of waste from oil and gas activities is a violation of EMA. The following EMA regulations also contain provisions relevant to saline fluid storage.

1.2.1 Oil and Gas Waste Regulation

The Oil and Gas Waste Regulation (OGWR) provides authorization for the majority of temporary and low risk discharges associated with oil and gas activities. Section 7(1) of this regulation authorizes the disposal of flowback fluids from hydraulic fracturing and produced water to deep underground formations via disposal wells that have been authorized by the Regulator by an ERAA Section 75 Special Project approval. Section 5(2) of this regulation prohibits stored fluids from causing objectionable odors at the perimeter of the property.

1.2.2 Hazardous Waste Regulation

Hazardous wastes generated by the oil and gas industry are subject to the provisions of the *Hazardous Waste Regulation*. This includes requirements for the storage, transport, treatment, and disposal of hazardous wastes that may be generated at produced water storage facilities (scale, sludges, spent filters, etc.). This regulation is administered by the Ministry of Environment and Climate Change Strategy.

1.2.3 Spill Reporting Regulation

The Spill Reporting Regulation defines what constitutes a reportable spill and requires the person who had possession, charge, or control of a substance immediately before the spill to report the spill to Emergency Management BC at 1-800-663-3456.Any leakage through the synthetic liners of a containment structure and into the native soil must be promptly reported to the Regulator at waste.management@bc-er.ca as a spill per section 37(1)(b) of the ERAA.

If spills / leakage result in likely or actual offsite migration of contaminants above applicable guidelines, the BCER shall be notified.

1.2.4 Contaminated Sites Regulation

Environmental quality standards within the Contaminated Sites Regulation (CSR) are used to determine whether contamination is present within environmental media in BC. Permit holders shall compare to CSR standards when evaluating groundwater quality associated with saline fluid storage facilities.

1.3 Additional Regulatory Considerations

In addition to the references provided above, it is the permit holder's responsibility to know and uphold all of their legal obligations associated with other applicable legislation. These include, but are not limited, to the examples listed in the following section.

1.3.1 Wildlife and Migratory Birds

The Wildlife Act details the provincial regulatory requirements related to wildlife. Federal requirements related to migratory birds are detailed in the Migratory Birds Convention Act.

The Regulator does not oversee or regulate either of these Acts but expects that permit holders will implement reasonable measures to prevent wildlife and migratory birds from entering, landing in, or ingesting fluids from open-topped storage tanks and containment ponds.

Methods that permit holders have implemented or considered to achieve this objective include fencing, netting, predator decoys, sound deterrents (predatory bird calls, distress calls, and noise cannons), mechanical distractions, and radar-controlled bird deterrents (i.e. LRADs).

1.3.2 NORM Management and Disposal

Permit holders shall regularly survey their facilities for Naturally Occurring Radioactive Material (NORM) and where necessary have a NORM Management Plan in place for the protection of workers. Permit holders are responsible for ensuring that materials sent to an appropriately licensed landfill or for recycling comply with the requirements of EMA.

1.3.3 Transportation of Dangerous Goods

Permit holders shall ensure that transportation of produced waters is performed in accordance with the requirements of the Transportation of Dangerous Goods Act. Guidance on this topic is provided within the following Transport Canada bulletin:

- Transport Canada TDG Bulletin - Produced Water (January 2020)

1.3.4 Live Storage

When containment facility designs incorporate saline fluid storage above the natural surrounding grade (i.e., live storage), the lined-containment structure shall be considered as a dam-like structure. For all dam-like structures, permit holders are required to provide additional documentation related to the design, operation, maintenance and security of these structures, including:

- Analysis of hazards, potential failure modes and environmental failure consequence classification in the event of a breach of the lined embankments and considering corresponding inundation map.

- Development and adherence to an Operations, Maintenance and Surveillance (OMS) Plan;
- Provision of a Safety Assurance Statement, authenticated by appropriate Professional Engineer following construction to verify adherence to permit conditions, design, and QA/QC procedures.
- Annual inspections, conducted by a Qualified Professional Engineer.

Permit holders and their Qualified Professional should consider the Canadian Dam Association (CDA) for applicable Guidelines and Technical Bulletin, as well as BC Dam Safety Regulation (DSR) and provincial dam safety technical resources. Note that dam-like structures are not required to be registered with a Dam File number under the DSR.

1.3.5 Engineers and Geoscientists BC

Qualified Professionals taking responsibility for the design and oversight of construction for storage facilities should consider the following guidance documents from EGBC:

- EGBC Professional Practice Guidelines – Site Characterization for Dam Foundations in BC
- EGBC Practice Advisory – Determining Dam Hydrologic Loading
- EGBC Professional Practice Guidelines – Sustainability Guidelines

Submissions made to the Regulator containing engineering or geoscience work related to the practice of Professional Engineering or Professional Geoscience (including hydrogeological investigations), must follow the Professional Governance Act, [SBC 2018], c. 47 and the Bylaws of EGBC. This includes any requirements related to the authentication of documents such as the application of the firm's permit to practice number.

- Requirements for Engineering or Geoscience Work (IU 2023-01) | BC Energy Regulator (BCER)

1.3.6 Recycled / Reclaimed Waters

To help offset industrial freshwater demand, the Regulator supports efforts to re-use industrial and reclaimed municipal waste waters for hydraulic fracturing operations. Requirements concerning reclaimed municipal waste waters are discussed within Part 7 of the Municipal Wastewater Regulation and may also be subject to local municipal bylaws.

Saline fluids may be re-used for subsequent hydraulic fracturing operations. Once there is no longer any operational use for saline fluid it should be disposed of by means of a disposal well permitted by the Regulator. The treatment and subsequent surface discharge of saline fluids is not permitted in British Columbia.

1.3.7 Conversion of Freshwater Storage Reservoirs and Dams to Saline Fluid Storage Facilities

Freshwater storage reservoirs and associated dams are authorized as 'works' under the Water Sustainability Act (WSA) through a Water Licence and are regulated under the WSA and the Dam Safety Regulation (DSR). The WSA and the DSR specify required activities for an owner and owner's engineering consultant to perform on a regulated dam during the asset's entire life cycle. Removing all or a significant part of a dam, decommissioning a dam or stopping the normal operation of a dam for a period longer than one year are considered "restricted activities" as per Section 17 of the DSR. Dam owners who intend to perform restricted activities must adhere to the requirements with Section 17 of the DSR.

Conversion of Freshwater Dams to Saline Fluid Storage Facilities

Conversion of a regulated freshwater storage reservoir and dam to a saline fluid storage facility [to be authorized as a newly-designated facility as a "water hub" under the Energy Resource Activities Act (ERAA) and the Drilling & Production Regulation (DPR)] is a "restricted activity" as per Section 17 of the DSR.

An owner of a dam who intends to do a conversion must give written notice to the BCER's Dam Safety Officer (DSO) of the proposed activity at least 120 days before the expected commencement of the proposed conversion work as per Section 17 of the DSR.

The permit holder must not begin the work until (a) the proposed work plan has been accepted by the DSO and (b) they have obtained a Leave to Commence Conversion Authorization from the BCER. After the completion of the accepted conversion, the company must submit a post-conversion report, including as-built drawings to the BCER DSO for review, acceptance and filing into the E-Licence database.

Other Requirements

Upon completion of the conversion, the Water Licence holder must amend or abandon the Water Licence and notify the BCER DSO and request changes to the regulatory and operational codes for the dams in the ELicence database.

2 Above-Ground Walled Storage System (AWSS) Requirements (<6600m^3)

2.1 General Requirements

The Regulator expects that the wall system of an Above-Ground Walled Storage System (AWSS) will be designed and engineered to withstand the hydraulic pressure of the contents at full capacity. The design must be certified by a Professional Engineer in good standing with EGBC and consider the following:

- The design / construction methodology include measures to ensure that synthetic liners are not damaged during construction / operations and provide for the containment of spills from hoses or fittings during loading and unloading.
- The synthetic liner of an AWSS must be tested for integrity and have a quality assurance/quality control (QA/QC) report from the manufacturer specifying the liner properties, anticipated lifespan and construction requirements.
- Synthetic liners used for containment be at least 30 mil (760 µm) thick, have a permeability of 10^{-12}m/s or less, and have properties (i.e. density, tensile strength, chemical resistance, tear resistance, puncture resistance) that are fit for the purpose intended and the conditions and temperature extremes encountered.
- The permit holder must ensure and document that the ground surface preparation is acceptable prior to installation. Consideration should be given to site-specific conditions including the geotechnical and hydrogeological properties, topography and the potential need for a geotextile cushion.
- For the protection of the AWSS, it should be isolated as much as practicable from drilling and fracturing operations / vehicle traffic.
- Consideration shall be given to ensure facility access for maintenance, emergency drawdown, incident response and end of life reclamation.
- To prevent the introduction of waste into the environment, all fittings and hoses should be non-leaking, with spill control devices installed at fluid transfer points, and connections and overflow prevention measures implemented.
- Before directing completion fluids into an AWSS, flow must first be directed through a pressurized separator to remove gas and liquid hydrocarbons. The flow may then be directed to other equipment in order to perform additional treatment and reduce the fluid temperature.

The following general requirements must be met during operations:

- A minimum of 0.50 m freeboard must be always maintained within an AWSS.
- Each AWSS must be inspected and monitored daily for leaks and the inspection results must be documented.
- Results of the inspections must be maintained until the site is reclaimed and submitted to the BCER upon request.

Once an AWSS is no longer required or is at the end of its authorized duration of use, the AWSS must be dismantled and removed from the site, and the liner recycled or disposed of; they cannot be re-used. Upon dismantling an AWSS the Regulator expects the operator will investigate the quality of soils and groundwater, as applicable, below the AWSS to determine the presence of any residual contamination. Where residual contaminants are identified it must be reported to the Regulator (waste.management@bc-er.ca) and managed as spillage per section 37 of ERAA.

2.2 Short Term AWSS (<6600 m^3) Requirements

The Drilling and Production Regulation, Section 51 (6), outlines specific requirements for short term (< 1 year) AWSS with less than 6600 m^3 of capacity.

2.3 Long Term AWSS (<6600 m^3) Requirements

Long term storage (> 1 year) of saline fluids in above ground storage systems (AWSS) that are less than 6600m^3, is permitted under the DPR, Section 51(6)(l), provided the following conditions are met:

- There must be a synthetically lined secondary containment system surrounding the storage system that is designed and maintained to be capable of holding a minimum of 110 per cent of the fluid in the largest AWSS.
- The bottom of any secondary containment will remain above the groundwater level at all times.
- The service life of an AWSS that has secondary containment will not exceed the engineered design life of the liner.
- The initial date of service beyond the first year of operation and the geographical location of the AWSS shall be reported to the Regulator via a Notice of Intent (NOI) to Modify Equipment or a Facility in Kermit under the NOI (Upstream) for Facility. The NOI can be submitted under a well facility permit located in close geographical proximity to the AWSS.

3 Long Term, High Volume Storage (>6600m^3)

Long term storage of saline fluids in volumes exceeding 6600 m³ (hereafter termed high-volume) may be conducted using either a lined containment pond or a lined engineered tank system. Storage of high-volume saline fluids requires a facility permit pursuant to the Energy Resource Activities Act.

High-volume containment systems must incorporate multiple impermeable synthetic liners with adequate interstitial space. These systems must also include a leak detection and monitoring system within each interstitial layer to demonstrate that saline fluids are not migrating into the environment.

Where referenced herein,

- The primary synthetic liner refers to the uppermost synthetic liner that is considered an integral component of the synthetic containment system, i.e. excluding rub sheets or other protective layers that may be installed to protect the primary synthetic liner.
- Successively deeper liners (i.e., secondary synthetic liner; and tertiary synthetic liner if present) are each separated by an interstitial layer that incorporates a leak detection and monitoring system.
- The sub-drain refers to the fluid collection system located under the lowest (deepest) liner layer. The primary purpose of the sub-drain is for groundwater management and any contamination in this layer may represent leakage to the environment.

3.1 Siting of High-Volume Containment Systems

The siting of high-volume containment systems shall consider the requirements listed below:

- The site shall not situated within a ravine, coulee, or gully.
- The site shall not within a 200 year floodplain.
- The site shall not within 100m of the normal high-water mark of a stream or natural body of water.
- The bottom liner of any leak detection system will always remain above the groundwater level, whether naturally or because of active groundwater management.
- Site accessibility to facilitate maintenance, emergency drawdown, emergency response and end of life restoration.
- Characteristics of the local groundwater and surface water including groundwater and surface water elevations and flow patterns, including seasonal variations (to assist in determining the seasonal high- and low-groundwater table).
    - Note: Shallow groundwater conditions in Northeast BC are variable, and at some locations, shallow groundwater may not be readily encountered during drilling and/or immediately following monitoring well installations. However, the BCER expects that reasonable efforts are made to investigate groundwater conditions. Where groundwater is not encountered after

reasonable efforts are made, a Qualified Professional must provide an assessment of the potential impacts that the proposed facility will have on local surface and subsurface water resources should a leak or spill occur at the sited location

- Potential inundation pathways and effects in the event of a catastrophic facility breach / failure; and the health of humans, animals and plants during the construction, operation, and decommissioning of the storage facility.
- High volume containment systems will not be situated at a site unless the following exists between the base of the containment system and any aquifer or underlying bedrock:
  - A natural confining geologic unit having a minimum of 10m thickness and an in-situ saturated hydraulic conductivity of 10^{-8}m/s, or less, as represented by the geometric mean of appropriately spaced in-situ measurements; or
  - An engineered compacted clay liner covering the entirety of the base and walls of the pond and providing a barrier of no less than 60cm thickness (measured perpendicular to the slope) with in-situ saturated hydraulic conductivity of 10^{-9}m/s, or less; or
  - Other engineered solution(s) such as a composite liner that achieves equivalent performance.

Siting must also consider the geotechnical setting of the proposed facility. A geotechnical investigation of the site must be completed by a Professional Engineer or Geoscientist with the appropriate experience, and in good standing with EGBC. The resulting geotechnical report shall include but not be limited to:

- Identification of potential geotechnical risks such as rockfall, slope stability, dispersive clays and seismic activity.
- Discussion of the degree of understanding based on the site investigations performed.
- Discussion of the suitability of the site based on factors of safety, subgrade stability, global stability, bearing capacity, site grades, surficial conditions and geotechnical cushion.
- Berm or dike dimensional design suggestions.
- Minimum construction quality control and assurance requirements.
- Factors of Safety for slope stability including static and seismic assessments, under the applicable loading conditions.

The Engineer or Geoscientist must attest that the analysis completed is appropriate for and adequately represents the conditions expected to be present during the operation of the site, including groundwater conditions, and that the containment pond is stable in accordance with standard engineering principles. For further geotechnical guidance, please refer to the CDA Dam Safety Guidelines.

3.2 Design and Construction

The design must be certified by a Professional Engineer in good standing with Engineers and Geoscientists BC (EGBC) and meet the following requirements:

- The construction of the containment structure must be overseen by a Professional Engineer who can certify that the ground preparation, sub-drain system, liners, and leak detection and monitoring system(s) have been constructed in accordance with the design.
- Construction of earthworks should only be done under non-frozen conditions. Where earthworks are intended to be undertaken during frozen ambient conditions, the application must include details of measures to be taken during construction to ensure the structure will meet the design criteria.
- The synthetic liners must be tested for integrity and have quality assurance/quality control (QA/QC) reports from the manufacturer specifying the liner properties and construction.
- The design must include measures to ensure that synthetic liners are not damaged during the course of operations. The design must also provide for the collection and containment of spills from hoses or fittings during loading and unloading.
- All synthetic liners must be a minimum of 60 mil (1.5 mm) thick, have a minimum permeability of 10^{-12} m/s and possess properties (i.e. density, tensile strength, chemical resistance, tear resistance, puncture resistance) that are fit for the intended purposes and conditions encountered.
- Synthetic liners must be separated by an engineered seepage system with an interstitial layer that prevents direct contact between liners, incorporates leak detection and dewatering/sampling access from the lowest point, and enables accurate leakage measurement.
- The design must incorporate a sub-drain below the lowest synthetic liner, engineered compacted clay or composite liner, with at least one fluid removal well, vault, or port. This must allow for dewatering and sampling from the lowest point of the excavation, positioned below the lowest synthetic liner, engineered compacted clay or composite liner, and be designed for accurate measurement of volumetric flow.
- The design must consider groundwater conditions, including but not limited to the potential for hydrostatic uplift of the liners. The permit holder must prevent the hydrostatic uplift of components such as synthetic liners, including, if necessary, by controlling groundwater levels below the containment structure. The subdrain may be used both for leak detection as well as for groundwater control to prevent hydrostatic uplift of the synthetic liners. Where an engineered compacted clay or composite liner is proposed as part of the containment pond design, the sub-drain refers to the l layer below the compacted clay or composite liner.
- The leak detection and monitoring system(s) and sub-drain fluid removal and monitoring system shall be designed to avoid perforation of the liners below the maximum fluid elevation level of the pond.
- To prevent the introduction of waste into the environment, fittings and hoses must be non-leaking, spill control devices must be installed at fluid transfer points and connections, and overflow prevention measures implemented.

- The site must have adequate wildlife exclusion measures to prevent wildlife from coming into contact with the stored fluid.
- The structure must be constructed in a manner that does not allow surface runoff from the site to enter the pond.
- If the proposed containment pond incorporates live storage volumes:
    - A failure mode and consequence analysis shall be prepared by a Qualified Professional Engineer in good standing with EGBC to categorize the facility in terms of its failure consequence classification. The consequence of failure analysis should refer to and incorporate the Environmental Consequences per the CDA Technical Bulletin: Revision to Consequences of Failure – Environmental Consequence Classification.
    - Prior to Leave to Open for live storage facilities, a Safety Assurance Statement and an Operation, Maintenance and Surveillance (OMS) Plan prepared and authenticated by a Professional Engineer representing the applicant shall be provided. The OMS Plan shall include the following at a minimum:
        - Facility description
        - Safety details including contacts, access routes and public safety considerations
        - Roles and responsibilities
        - Operating procedures
        - Procedures for rapid drawdown in case of emergency
        - Maintenance programs
        - Inspection and monitoring procedures and schedules
        - Leak detection monitoring procedures and schedules
        - Groundwater monitoring procedures and schedules
    - Guidance for live storage requirements can be found within the BCER Application Manual, the Provincial Dam Safety Regulation, and the Canadian Dam Association (CDA) guidelines.
- A groundwater monitoring well network must be installed around the perimeter of the lined containment system, and a baseline groundwater assessment completed, prior to commencement of storage facility operations (i.e., prior to filling), as per the permit holder's Groundwater Monitoring Plan (refer to Section 3.4 below and Appendix A). At this time, groundwater monitoring is only required at facilities with lined containment ponds. While groundwater monitoring is not required at facilities with lined engineered tank systems (i.e., c-rings), the BCER may require implementation of groundwater monitoring at these facilities in the future if it is determined that operation of these systems pose a risk to water resources.

3.3 Operation

The following section outlines the requirements that must be met to ensure the integrity of the environment is upheld. If the facility incorporates live storage, these requirements must be discussed within the permit holders OMS plan.

- The permit holder will have a site-specific leak response plan that will ensure the protection of environmental values at the site in the event of a failure of the liner system. The leak response plan should include provisions for monitoring groundwater quality following a failure event.
- As constructed drawings of the structure shall be provided to the BCER within 3 months of introduction of produced fluids.
- An annual report documenting the facilities performance over the previous calendar year shall be submitted per Appendix B. Note that the BCER is developing an electronic submission procedure for these annual reports, and this new system is expected to be rolled out in early 2027.
- A minimum of 1.0 m freeboard must be always maintained within the containment structure, unless otherwise authorized. The design engineer must provide assurance that the proposed freeboard is sufficiently protective of the environment.
- Before directing completion fluids into a structure, the flow must first be directed through a pressurized separator to remove gas and liquid hydrocarbons. The flow may then be directed to other equipment in order to perform additional treatment and reduce the fluid temperature.
- The primary synthetic liner shall be regularly inspected for evidence of leaks and damage and records of issues related to inspections and corrective actions shall be maintained.
- Liner systems must not be relied upon beyond their design service life unless their continued suitability is demonstrated through laboratory testing, material quality verification, and assessment by a Qualified Professional. Replacement of liner systems may be used to extend the service life of the containment structure.
- The fluids within the leak detection system(s) and sub-drain must be pumped out on a daily basis or as necessary to maintain the interstitial layer(s) and the sub-drain as free of fluid as practical. This may involve the use of an automated pumping system. The permit holder must maintain a record of the daily volumes pumped from the interstitial layers and the sub-drain system.
- Field measurements from the leak detection system(s) and sub-drain must be collected and analyzed on a weekly basis for at least pH, electrical conductivity and chlorides.
- Samples from the leak detection system(s), and sub-drain must be collected and analyzed on a quarterly basis. The analysis must be conducted by an accredited laboratory and include pH, electrical conductivity, TDS, major ions (including Ca, Mg, Na, K, NO3, SO4, Cl, Br, PO4), BTEX, VPH, VH, EPH(10-19), EPH(19-32), LEPH/HEPH, PAH and CSR dissolved metals. After the first year of interstitial and sub-drain characterization is completed, the frequency of laboratory characterization may be reduced to an annual basis unless results of the field analysis indicate a need for additional characterization.

- The fluid being stored in the containment structures shall be characterized through laboratory testing at a frequency that ensures the characterization is representative.

3.4 Groundwater Monitoring Requirements for Long Term Storage Facilities

3.4.1 New Applications

The Regulator expects the permit holder of a new long term saline fluid storage facility to implement a groundwater monitoring program at the facility to verify that the activities do not impact groundwater. The intent of the groundwater monitoring program is to provide monitoring well infrastructure around the perimeter of the lined containment system, within the facility boundaries, that allows groundwater sampling and provides data to:

- Establish baseline groundwater level and chemistry conditions (where baseline conditions are established prior to the commencement of storage facility operations)
- Demonstrate compliance with results-based regulations for groundwater protection during the life of the facility.

The implementation of a groundwater monitoring program does not preclude any future requirements for investigative groundwater monitoring should an incident occur and is separate from any other groundwater monitoring requirements associated with specific activities.

Groundwater Monitoring Plan: A Groundwater Monitoring Plan describing the groundwater monitoring program is to be submitted as part of the facility permit application for review and acceptance by the Regulator. The Groundwater Monitoring Plan is to be prepared by a Qualified Professional, registered with Engineers and Geoscientists of BC (EGBC). The plan may be submitted as a stand-along document or incorporated into the facility Operation, Maintenance and Surveillance plan where applicable.

The Groundwater Monitoring Plan must contain information on monitoring well siting, design and timing of installation, as discussed in Section 3.4.1.1 below; and be prepared in accordance with Appendix A - Technical Guidance for Groundwater Monitoring Program for Lined Containment Systems Used for the Storage of Saline Fluids.

3.4.1.1 Monitoring Well Siting and Design

Monitoring Well Locations
It is expected that a minimum of four monitoring wells will be installed around the containment system, with one monitoring well located along each side of the lined containment system. Where more than one containment system is proposed, a commensurate number of monitoring wells must be installed.

The number and locations of perimeter groundwater monitoring wells must consider:

- Coverage along all sides of the lined containment system.
- Locations and operational aspects of fluid storage and transfer infrastructure within the site boundaries.
- Inferred or known groundwater flow direction.
- Site grading.
- Surrounding receptors (e.g., water wells, surface water bodies, environmentally sensitive areas).
- Any other factors as determined by the Qualified Professional.

Monitoring Well Design and Installation
Monitoring wells must be designed and installed in accordance with the BC Groundwater Protection Regulation (gov.bc.ca), and using standard environmental investigation protocols such as those described in the B.C. Field Sampling Manual - Province of British Columbia (gov.bc.ca).

Monitoring wells must be installed and screened to permit the collection of representative groundwater samples from the shallowest aquifer (groundwater-bearing formation). The need for monitoring well installation within deeper aquifers may be considered based on site-specific circumstances.

Monitoring wells must be completed to depths appropriate for assessing leakage from the base of each containment system, as determined by the Qualified Professional.

Timing of Monitoring Well Installation
Groundwater monitoring wells must be installed prior to storage facility operation (i.e., prior to filling) to allow for an assessment of baseline groundwater conditions (refer to **Establishing Baseline Groundwater Conditions** in Appendix A).

Dry Conditions
If groundwater is not encountered in the perimeter monitoring wells following their installation and it can be shown that there is at minimum 10 m of naturally confining materials below the base of the containment system, then further baseline groundwater assessment is not required. However, monitoring wells shall be maintained and used for subsequent annual groundwater monitoring purposes and/or for use as vapour probes.

If groundwater is not encountered during drilling, and it cannot be shown that there is at minimum 10 m of naturally confining materials below the base of the containment system, then it is expected that a reasonable effort be made to locate a groundwater-bearing formation at a depth greater than 10 m, as per the direction of the Qualified Professional. The Qualified Professional must provide justification for the final monitoring well design. If groundwater is not encountered in the perimeter monitoring wells following their installation, the monitoring wells shall be maintained and used for subsequent annual groundwater monitoring purposes and/or for use as vapour probes.

Survey Elevations

Following monitoring well installations, the ground surface elevation and top of standpipe elevation at each monitoring well must be surveyed. For sites with containment ponds, a reference point at each containment pond must be identified to enable measurement of pond levels; the elevation of the reference point at the containment pond(s) must be tied into the monitoring well elevation survey to allow for subsequent comparison of groundwater elevations and pond elevations.

3.4.1.2 Existing Storage Facilities

For permit holders with existing groundwater monitoring requirements, please refer to the section entitled "Request for Modification to Groundwater Monitoring Program" in Appendix A.

3.5 Leakage

The permit holder should calculate an Action Leakage Rate (ALR) for each containment structure and provide this data within annual reporting. The ALR is defined as the amount of leakage that would occur through the primary synthetic liner of a dual synthetic-lined system, based on two (2) holes per hectare each with a diameter of 2mm. Where the structure is operated at less than capacity, the action leakage rate should be calculated to account for actual operating conditions. The ALR should be calculated for each depth of water in 0.5m increments and the closest increment to the average daily level of the structure should be used for daily comparison of ALR. The ALR shall be calculated per Giroud and Bonaparte (1989) as follows:

$$Q = C_b a \sqrt{2gh_w}$$, *where*;

Q – leakage rate (m^3/s)

C_b – dimensionless coefficient 0.6 for sharp edges (default value)

a – hole area (m^2)

g – acceleration due to gravity (m/s^2)

h_w – depth of liquid (hydraulic head) (m)

Any leakage through the primary synthetic liner in excess of the action leakage rate for a period of 3 consecutive days or more must be reported to the Regulator by email at waste.management@bc-er.ca using the subject line "Liner Leakage Report" within 24 hours of discovery and the permit holder must take remedial actions as necessary.

Any indication of leakage through the secondary synthetic liner characterized by chloride levels in excess of the Contaminated Site Regulation drinking water standard (250 mg/L) within the subdrain or interstitial lowest layer (if no subdrain), must be reported to the Regulator by email at waste.management@bc-er.ca using the subject line "Liner Leakage Report" within 24 hours of discovery and the permit holder must take remedial actions as necessary.

Once reported to BCER, follow leak response plan.

3.6 Decommissioning

General requirements for the decommissioning of energy activity facilities are provided within the Dormancy and Shutdown Regulations.

Upon decommissioning a synthetically lined containment structure, an appropriately qualified environmental professional must complete an environmental investigation to evaluate the presence / absence of residual contamination and the report must be submitted to the Regulator. Where residual contaminants are identified, the permit holder must submit a remedial action plan with timelines in addition to the investigation report. Synthetic liners must not be re-used and may be recycled or disposed of at an approved disposal facility.

Appendix A: Technical Guidance for Groundwater Monitoring Programs for Lined Containment Systems Used for the Storage of Saline Fluids

Baseline and annual groundwater monitoring programs must be conducted as per the Permit Holder's Groundwater Monitoring Plan, and must be carried out by a Qualified Professional having appropriate experience and expertise in the implementation of groundwater monitoring programs. The following provides technical guidance regarding the BCER's expectations with respect to groundwater monitoring.

Establishing Baseline Groundwater Conditions

Baseline groundwater conditions shall be established prior to storage facility operations by groundwater level and groundwater quality data that captures seasonal variability in groundwater conditions. The Regulator recommends a minimum of two (2) baseline sampling events, to determine both the high-groundwater and low-groundwater tables; however, the number of baseline events are to be established by the Qualified Professional.

If background groundwater quality data are available from an existing adjacent, or nearby, lined containment system (where "nearby" is determined by the Qualified Professional, and is based on subsurface conditions), these data may be used in support of baseline conditions for the new system, as determined by the Qualified Professional.

Where timing does not allow for pre-operations baseline sampling (e.g., pond operation begins soon after installation), it is expected that groundwater level and groundwater quality data obtained soon after pond operations be evaluated for use as baseline conditions, as appropriate, and as determined by the Qualified Professional.

Water Level Monitoring

During storage facility operation, the pond level(s) and groundwater levels must be measured on a quarterly basis, at a minimum; and the pond level(s) and groundwater levels must be measured concurrently. All water levels must be converted to elevations.

Groundwater Sampling and Analysis

During storage facility operation, groundwater sampling / analysis must be conducted on a quarterly basis using standard environmental sampling and quality assurance/quality control protocols such as those described in the B.C. Field Sampling Manual - Province of British Columbia (gov.bc.ca).

The analysis must be conducted by an accredited laboratory and include the following analyses:

- Field-measured parameters: pH, electrical conductivity, dissolved oxygen, temperature, oxidation-reduction potential
- Laboratory analytical parameters: pH, electrical conductivity, total dissolved solids (TDS), alkalinity, major ions (including calcium, magnesium, sodium, potassium, nitrate, sulphate, bicarbonate, chloride, bromide, phosphate), Benzene, Ethylbenzene, Toluene, Xylenes (BETX), Volatile Hydrocarbons (VHw6-

10), Volatile Petroleum Hydrocarbons (VPHw), Extractable Petroleum Hydrocarbons (EPHw1019 and EPHw19-32), Light Extractable Petroleum Hydrocarbons/Heavy Extractable Petroleum Hydrocarbons (LEPH/HEPH), Polycyclic Aromatic Hydrocarbons (PAHs), and CSR dissolved metals.

Request for Modification to Groundwater Monitoring Programs

Once the baseline conditions have been established for the monitoring wells and sufficient quarterly groundwater monitoring and sampling data have been collected during storage facility operations, the groundwater monitoring program may be revised upon recommendation from a Qualified Professional and acceptance by the Regulator. This may include (though not limited to): frequency of monitoring and sampling and/or implementation of a refined site-specific suite of monitoring and sampling parameters.

Requests for modifications to groundwater monitoring programs can be sent to waste.management@bc-er.ca. For current operators that have submitted modification requests in the past but have not received formal acceptance of these requests by the BCER, please re-submit these requests to waste.management@bc-er.ca.

Appendix B: Technical Guidance for Annual Reporting Required for Saline Fluids Storage Facilities

The following section provides guidance to saline fluid storage facility permit holders with respect to the preparation of annual reports required in facility permit conditions. It is expected that one standalone report (.pdf format) and supporting tables (.xls / .pdf formats) shall be provided for each facility to the email address: waste.management@bc-er.ca.

The report should be prepared by a Qualified Professional, and include the following content, at a minimum:

- Executive summary containing the following for the reporting period:
  - Statement regarding whether or not the Action Leakage Rate for the facility was exceeded.
  - Statement regarding whether or not fluids from the pond have entered into the sub drain.
  - Statement regarding whether or not fluids from the facility have leaked into the environment.
  - Description of incidents, repairs or mitigation measures performed over the previous calendar year.
- Reporting related to leakage monitoring:
  - Calculation of Action Leakage Rate (ALR)
  - Summary of daily pumping volumes from interstitial layers and subdrains
  - Comparison of interstitial space pumping volumes relative to ALR
  - Tabulated data from weekly pH, conductivity and chloride monitoring within leak detection layers and sub drain
  - Analytical results from pond, leak detection and sub drain sampling in tabular form with comparison to appropriate standards.
  - Discussion on whether leak detection data represents a release to the environment
- Reporting related to groundwater monitoring:
  - A site plan showing locations of monitoring wells relative to site boundaries, on-site infrastructure, and surrounding features.
  - Groundwater level measurements and calculated groundwater elevations, and for sites with containment ponds, corresponding pond elevations.
  - Analytical results from groundwater sampling in tabular form with comparison to appropriate standards.
  - Laboratory analytical reports.
  - Data analysis (statistics, trends) and interpretation, as applicable.
  - Any other information or interpretation as deemed appropriate by the Qualified Professional or required by the Regulator.
  - Discussion on potential impacts to groundwater quality and the potential for offsite contaminant migration.
- Reporting related to Dam Safety:
  - Commentary on any updates made to facility Operation, Maintenance and Surveillance manual, if applicable.
  - Discussion on any changes to failure consequence classification.
  - Results of the annual formal engineering inspection, if applicable.