Water Source, Injection and Disposal
Service Wells
Summary Information

November 2014
Version 3.0
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Table of Revisions
The Commission is committed to the continuous improvement of its documentation. The table below summarizes revisions to the Water Source, Injection and Disposal Service Wells Summary Information. Revisions are posted to the documentation section of the Commission’s website at the beginning of every month and are effective one month after posting, unless otherwise noted. For more information about the Commission’s monthly revisions, and for details of this month’s revisions, please visit the documentation section of the Commission’s website.
Stakeholders who would like to provide input or feedback on Commission documentation may send comments to OGC.Systems@bcogc.ca.

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<th>Effective Date</th>
<th>Chapter</th>
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<td>November 10, 2014</td>
<td>December 1, 2014</td>
<td>Various</td>
<td>Various updates have been made to this document. Users are encouraged to review the document in full. Specific sections of change to note include: clarification on wellbore integrity, facility requirements and pressure testing.</td>
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Preface
This document provides guidance for understanding of subsurface water management as it applies to the oil and natural gas production industry. It is not intended to take the place of the applicable legislation. The user is encouraged to read the full text of legislation and each applicable regulation and seek direction from Commission staff, if and when necessary, for clarification.

Historically, water source wells were drilled to supply injection wells for water flooding of oil pools. Disposal wells primarily handled by-product effluent from high water-ratio producing gas and oil wells.

Current focus on exploitation of unconventional resources – shale gas and tight gas – has increased the need for water for formation fracture stimulation, with a related requirement for deep disposal of increased flowback volumes.

In this document, the term “usable water” refers to water with total dissolved solids (TDS) of 4,000 PPM or less.
Water Source Wells

A water source well is any well used for the purpose of providing water for underground injection (enhanced recovery from oil pools or hydraulic fracture stimulation of wells). A water source zone may range from shallow quaternary sediments to deep saline aquifers.

Permit

A water source well requires the submission of a normal Well Permit application form and approval prior to drilling; the well operational type “water source”. Information on the Well Permit application process can be found in the manual posted at Well Permit Application Manual.

Note: A shallow well for the purpose of supplying fresh water for drilling, camps or hydrostatic testing of pipelines is defined as a “water supply well” and is regulated under the Water Act and Ground Water Protection Regulation. Information in this document does not apply to a water supply well.

Well Classification, Spacing and Tenure

A water source well is assigned a classification (development, exploratory outpost or exploratory wildcat) based on the provisions of Section 2 of the Drilling and Production Regulation, with well data receiving a confidential period as specified in Section 17 of the Oil and Gas Activities Act General Regulation. For well classification determination, the spacing distance used is that which applies in the nearest offsetting designated pool (for example, a gas spacing area distance if measured from a gas pool).

Well spacing and target area restrictions do not apply to a water source well. Production of water does not require ownership of the subsurface tenure in the completed zone; however, some water source wells have produced sufficient rates of associated natural gas, typically evolving from solution in water with pressure loss, to require capture and conservation. In such a case the primary product of the well is changed to “gas” (despite the well purpose being for water), requiring valid petroleum and natural gas tenure for the formation over the complete gas spacing area. Holding tenure to a water producing formation is advised.

Currently, no additional application or approval is required for withdrawal of water from a subsurface aquifer, unless the withdrawal rate exceeds 75 litres/second, in which case BC Environmental Assessment Office permitting process applies.

Wellbore Integrity

For existing wells, all porous zones, in addition to the source zone, must be isolated by cement.

All new wells drilled for the purpose of water source must ensure that:

- Surface casing is set below the deepest usable water zone and cemented to surface, or
- If surface casing is not set below the deepest usable water zone, the next casing string is cemented to surface, and
- Hydraulic isolation is established between all porous zones.

The preferred cement evaluation/inspection log is a radial log displaying 3’ amplitude, 5’ VDL and cement map with both a non-pressure pass and pressure pass.
Notification and Reporting
The form BC-11, Notice of Commencement or Suspension of Operations, must be submitted to the Ministry of Finance by the 20th day of the month following the date of initial water production, informing of date of initial operation.

For each month during which water is produced a, BCS-1 (Monthly Production) Statement and a BC-S2 (Monthly Disposition) Statement must be filed with the Ministry of Finance, reporting producing hours and volume. For more details, please check here: [http://bcogc.ca/industry-zone/documentation/Subsurface-Disposal](http://bcogc.ca/industry-zone/documentation/Subsurface-Disposal).

If the water source well event is not linked to a facility, a facility code must be obtained by the operator prior to submitting a BC-S1/BC-S2. To do this, the operator must contact the Oil and Gas Commission Facility Department.

Water Injection Wells
Water injection into a suitable oil pool, termed a “waterflood”, can achieve a higher oil recovery than by primary depletion alone. Prior to water injection, a Pressure Maintenance Waterflood Approval is required from the Commission, issued as a Special Project Order under Section 75 of the Oil and Gas Activities Act. The waterflood approval specifies wells that may be used for injection service, as well as other operating conditions. Details of the waterflood application and approval process are provided in the guideline [Pressure Maintenance or Improved Recovery](http://bcogc.ca/industry-zone/documentation/Subsurface-Disposal).

Permit
For a water injection well, the standard Well Permit application form and requirements apply; the well operational type is “water injection”. Information on the Well Permit application process can be found in the manual posted at [Well Permit Application Manual](http://bcogc.ca/industry-zone/documentation/Subsurface-Disposal).

Well Classification, Spacing and Tenure
A water injection well is classified (development, exploratory outpost or exploratory wildcat) and receives a confidential period based on the standard rules of Part 2 of the Drilling and Production Regulation, with well data receiving a confidential period as specified in Section 17 of the Oil and Gas Activities Act General Regulation. For well classification determination, the spacing distance used is that which applies in the nearest offsetting designated pool (for example, a gas spacing area distance if measured from a gas pool).

The well permit holder is required to have registered ownership, or consent from the owner, of subsurface petroleum and natural gas tenure for the formation in which injection is occurring. In the Dominion Land Survey this is an area of ¼ Section; in the National Topographic System of survey this area is one unit of land. Most waterflood operations in pools with mixed interests are unitized. A Unit Agreement or Unit Operating Agreement is separate from an OGC Special Project Order to waterflood.

Well spacing and target area restrictions do not apply to a water injection well. However, owners of offsetting wells, outside of the waterflood approval area, may raise technical concerns with the Commission regarding potential negative impact of injection on their producing well(s). However past experience has shown that such wells generally benefit from increased oil recovery.
Wellbore Integrity and Logging
For existing wells, all porous zones, in addition to the injection zone, must be isolated by cement.

If production casing is not cemented to surface or cement returns to surface are not maintained during setting, a log must be run to locate the cement top. In either case, the permit holder must conduct adequate logging to demonstrate hydraulic isolation of the injection zone and all porous zones. Permit holders may reference ERCB Directive 51 for logging guidelines.

A full length casing inspection log is required for injection wells greater than ten years in age. The preferred cement evaluation/inspection log is a radial log displaying 3’ amplitude, 5’ VDL and cement map with both a non-pressure pass and pressure pass. Log results and interpretation must be submitted as part of the waterflood injection well application.

All new wells drilled for the purpose of injection must ensure that:
- Surface casing is set below the deepest usable water zone and cemented to surface, or
- If surface casing is not set below the deepest usable water zone, the next casing string is cemented to surface, and
- Hydraulic isolation is established between all porous zones.
- The Commission does not favour the use of wellbores for injection service that have uphole zones with cement squeeze abandonment. Experience has shown that cement squeeze abandonments may be prone to isolation failure. The use of multiple packers to isolate former completion intervals in the wellbore is problematic to test for continued seal. Application for injection service for a well with uphole former completion intervals must adequately address this concern.

Pressure Monitoring
Injection pressure must not exceed the formation fracture pressure, and recommended practice is to not exceed 90 per cent of this value. Any changes to injection fluid density, usually due to salinity, must be accounted for. Injection above formation fracture gradient may lead to over-pressuring of formations above and below the completed formation, a well drilling and operating safety hazard, and a potential loss of producible hydrocarbons.

Production performance of oil wells in the waterflood project, typically increasing oil rate and reduction in producing gas-oil ratio, indicate the effectiveness of waterflooding via connective displacement of fluids and re-saturation of the free gas. Ongoing and cumulative voidage balance (production withdrawal vs injection volumes, at comparative reservoir conditions of temperature, pressure and relative solubility) should prevent the reservoir pressure from exceeding initial conditions. Periodic bottom-hole pressure testing of injection wells is further confirmation that water injection is not resulting in areas of localized high pressure due to poor connectivity to producing wells.

Packer Isolation Testing
A pressure integrity test is required, the casing or casing/tubing annulus must be pressure tested to a minimum pressure of 7000 kPa or the for 15 minutes prior to the commencement of injection or disposal operations. A pressure test is considered successful if the pressure does not vary by more than three per cent during the test period.
Annual packer isolation tests must be conducted in accordance with Section 2.3 of the Wells Completion, Maintenance and Abandonment Guideline which can be found on the Wells page of the OGC website.

Hydraulic Fracture Stimulation
A completed wellbore interval may require an acid or hydraulic fracture stimulation to bypass formation damage (caused by well drilling/cementing operations) and to increase connectivity.

Permit holders are cautioned to design and limit fracture stimulations to remain contained within the disposal formation. Where it appears there is significant potential that the induced fractures, and thus pathways for disposal fluid migration, has occurred out of zone, the Commission may require additional tests and data to confirm isolation and integrity of the bounding formations.

Facilities
A separate facility application must be submitted to the Commission if additional surface equipment is required for the injection well.

Notification and Reporting
The form BC-11 Notice of Commencement or Suspension of Operations must be submitted to the Ministry of Finance by the 20th day of the month following the date of initial injection, informing the date of initial operation.

The quantity and rate of fluid injected into a well must be metered, as per section 74 of the Regulation.

For each month during which water is injected into the well, the form BC-S18 Monthly Injection/Disposal Statement must be filed, reporting total injection hours, volume and wellhead tubing pressure. The BC-S18 is due by the 25th day of the month following injection. Both the form and instructions are available on the Commission website.

A change in operations, such as at start-up or a rate change, can result in momentary pressure spikes. The BC-S18 reported wellhead pressure is the maximum pressure, sustained for a period of a minimum of 5 minutes continuous duration, experienced during the reported month.

Water Disposal Wells
Water produced in association with oil and gas must be disposed into a subsurface formation via an approved disposal service well. Disposal is not permitted into an aquifer containing water usable for domestic or agricultural purposes, or a zone that may pose risk of contamination of such a water aquifer. The protection of water resources is of primary importance to the Commission. Disposal formations are generally > 800 meters below ground level.

Deep Disposal Options
i. Depleted hydrocarbon pools - have demonstrated the ability to contain a fluid at initial discovery conditions. Depleted pools contain a known reservoir void space, based on the cumulative production volume of fluids, converted to their volume under reservoir conditions and accounting for relative
solubility. This voidage volume can be used to approximate ultimate fill-up capacity. Periodic reservoir pressure measurements will confirm this prediction. In some cases, approval has been granted to dispose water into a producing pool below the gas/water or oil/water contact, where it can be demonstrated that disposal will not be detrimental to ultimate pool hydrocarbon recovery.

ii. **Deep aquifers** - contain water of high salinity trapped underground for millions of years, at a variety of depths. These aquifers vary widely in thickness, reservoir quality and area. Capacity for disposal of water, a virtually incompressible fluid, introduced into a system of limited compressibility, is determined by aquifer size, if not connected to a pool of compressible fluid (gas) providing additional storage capacity.

Aquifers targeted for disposal are generally regional in area. Some have shown a vast capacity for disposal, with limited, if any, pressure required at surface for injection, accepting liquids “on vacuum”. During injection some aquifers show characteristics of compartmentalization by geologic barriers of low porosity and permeability or faulting. As well, over the disposal life of a well the pressure required to sustain disposal rates typically increases in part due to mobilization of fines and precipitates that gradually block pore throats, that may not be remediated by work-over operations.

Disposal formations must be shown to be contained by impermeable cap and base formations, competent to contain fluid within the area of influence. With recent development of unconventional resources, such as shale, the bounding formations must also be considered for future hydrocarbon potential and must not be sterilized from development by disposal into proximal formations that would preclude future fracture stimulation for hydrocarbon production.

**Permit**
The standard Well Permit application form and requirements apply to a disposal service well; the well operational type noted as “water disposal”. Information on the Well Permit application process can be found in the manual posted at [Well Permit Application Manual](#).

**Well Classification, Spacing and Tenure**
A water disposal well is classified (development, exploratory outpost or exploratory wildcat) and receives a confidential period based on the standard rules of Part 2 of the Drilling and Production Regulation, with well data receiving a confidential period as specified in Section 17 the Oil and Gas Activities Act General Regulation. For well classification determination, the spacing distance used is that which applies in the nearest offsetting designated pool (for example, a gas spacing area distance if measured from a gas pool).

Well spacing and target area restrictions do not apply to a water disposal wells. A disposal well permit holder is required have registered ownership, or consent from the owner, of subsurface petroleum and natural gas tenure of the disposal formation, leasing the reservoir void space for fluid storage. In the Dominion Land Survey this is an area of ¼ Section, in the National Topographic System of survey this area is one unit of land.

**Disposal Well Approval Application**
The OGC guideline [Deep Well Disposal of Produced Water](#) provides a comprehensive listing of the information for inclusion in an application. Two copies of the application, in hardcopy format, must be submitted to the
Commission’s Reservoir Engineering Department in Victoria, with a third copy submitted to the Drilling and Production Department in Kelowna.

For the purposes of defining disposal fluids, produced water includes recovered fluids from a well completion or workover operations (including flowback fluids from fracture stimulations); the same application/approval applies for disposal of associated produced water, flowback fluids, or both. Further reference to “disposal” or “produced water” in this document includes both sources.

Disposal of oilfield nonhazardous waste down a wellbore follows these same criteria, with the additional requirement of obtaining a waste discharge permit under the authority of the Waste Management Act. The Commission guide may be found at Deep Well Disposal of Non-hazardous Waste.

Upon receipt of an application, a notice of application for operation of a disposal well is posted to the Commission’s website for a 21-day period to allow any concerns to be filed with both the Commission and the applicant. The notice includes contact information for obtaining a copy of the application. During the posting period applicants are required to provide a copy of the application to requesting parties. Requesting parties are not required to demonstrate ownership of off-set wells or tenure rights. Additional information on the posting of application notice and the process regarding the filing of objections is available here.

An approval to operate a water disposal well is granted by the Commission as a Special Project Order under Section 75 of the Oil and Gas Activities Act. The approval contains conditions that must be met to remain valid, including:

a) **Maximum wellhead injection pressure**
   
i. Disposal injection pressure must not exceed the formation fracture pressure. The Commission approved maximum wellhead injection pressure, when calculated to bottom-hole pressure, will not exceed a value of 90 per cent of the formation fracture pressure. The Commission has conducted extensive data analysis to populate a provincial database of fracture gradients for several common disposal formations in NEBC. These values are derived from hydraulic fracture treatment ISIP values, accepted as indictors of the formation fracture pressure. Caveats for usage of this data are that reported ISIP values lack precision, often rounded to the nearest MPa, and values occasionally vary substantially between locations in close proximity. Mapping and contouring of values has provided a methodical approach to establish a reliable value for the area of influence for a disposal well, a value that is not overly influenced by a single anomalous reported number. These contoured maps are available on our website at Active Disposal Wells Map.

Variability in disposal fluid density, due to salinity or composition, requires use of a hydraulic wellbore gradient to calculate a conservative wellhead pressure value. The Commission typically utilizes a value of 10.5 kPa/m as the disposal fluid gradient for calculating the maximum wellhead injection pressure. The well operator is responsible for adjusting the wellhead injection pressure to a lower value if a higher density/gradient value fluid is being disposed. Measured or inferred competency of bounding formations and wellbore cement are not criteria to inject above formation fracture pressure, as existing natural fractures, faults, planes of weakness and wellbores within the area of influence may provide migratory paths for fluids at a pressure below the formation fracture pressure. Injection above formation fracture gradient may lead to over-pressuring of formations in proximity above and below the completed formation, a well drilling and operating safety hazard, and a potential loss of producible hydrocarbons.
Recent studies indicate that the formation closure pressure, measured at the injection interval, may be a more suitable limit for injection pressure for 2 reasons: (1) it provides a conservative safety factor as existing fractures cannot propagate and provide a conduit for waste fluids potentially out of the disposal zone, and (2) it is determined from standardized calculation methods. Further study of the relationship between closure pressure and an ISIP in various formations is on-going. Subsequent releases of this document will detail results as they become available.

See the **Step-Rate or Mini-Frac Formation Testing** section below for information addressing direct testing for formation fracture pressure.

b) **Maximum formation pressure**
Disposal well approvals contain a condition limiting the ultimate formation “fill-up” pressure to a specific value. This pressure limit is typically calculated based on 120% of the virgin reservoir pressure, prior to any production or injection within the reservoir. This virgin pressure is initially tested in the disposal well and is supported by tests in other wells in the same or proximal reservoir. The maximum formation pressure limit provides confidence of containment of the fluids injected, at a pressure value that is within reasonable proximity to that which provided an existing geologic seal. Existing natural fractures, faults, planes of weakness and wellbores within the area of influence may provide migratory paths for fluids at a pressure that remains below the formation fracture pressure. The 120% limit is also a measure to protect offsetting wells from potential casing collapse, of particular concern with area wells of earlier vintage.

c) **Pressure Monitoring**
The initial reservoir pressure of the disposal formation in the well must be measured and reported. Periodic measurement of the reservoir pressure in the disposal well confirms that continued disposal is viable, remaining below the maximum formation pressure limit, and provides information to forecast remaining disposal well life. A pressure transient analysis (PTA) of a fall-off test that has achieved radial flow will predict an extrapolated average reservoir pressure P* value, at infinite time. For the purpose of this disposal condition, the maximum average reservoir pressure is the pressure measured at the injection well within 60 days of shut-in of the well. The well does not need to be shut-in 60 days, if the pressure drops below the reservoir pressure limit value in a shorter time period, or if fall-off data is of a quality that PTA can confidently extrapolate to a 60-day shut-in value. The 60-day value provides assurance that the formation porosity and permeability allows fluid to dissipate without creation of a zone of excessive pressure at the injection location. Despite the minimum expectation that tests verify current pressure remains below the ultimate limit, it is highly recommended that reservoir pressure tests be of sufficient quality to extrapolate to stabilized conditions, to predict future disposal capacity, based on pressure vs cumulative disposal volume.

Wells that accept fluid at low wellhead pressure, demonstrated to be significantly below the maximum formation pressure limit, may be approved for less frequent reservoir pressure testing.

**Production Testing**
Prior to an injectivity test or disposal operation, the intended disposal zone must be production tested for any hydrocarbon potential. The well must be swabbed down to 80% of perforated depth to ensure no potential hydrocarbon reserves and obtain an uncontaminated formation fluid sample, with results included in the application.
Wellbore Integrity and Logging
For existing wells, all porous zones, in addition to the disposal zone, must be isolated by cement.

If production casing is not cemented to surface or cement returns to surface are not maintained during setting, a log must be run to locate the cement top. In either case, the permit holder must conduct adequate logging to demonstrate hydraulic isolation of the injection or disposal zone. Permit holders may reference ERCB Directive 51 for logging guidelines.

A full length casing inspection log is required with all disposal well applications for wells greater than 10 years in age. The preferred cement evaluation/inspection log is a radial log displaying 3’ amplitude, 5’ VDL and cement map with both a non-pressure pass and pressure pass. Log results and interpretation must be submitted as part of the disposal well application.

All new wells drilled for the purposes of disposal must ensure that:
- Surface casing is set below the deepest usable water zone and cemented to surface, or
- If surface casing is not set below the deepest usable water zone, the next casing string is cemented to surface, and
- Hydraulic isolation is established between all porous zones.
- Wellbores containing uphole zones with cement squeeze abandonment may not be suitable for disposal service. Experience has shown that cement squeeze abandonments can be prone to isolation failure. The use of multiple packers to isolate former completion intervals in the wellbore is problematic to test for continued seal. Application for disposal service for a well with uphole former completion intervals must adequately address this concern.

Additional wellbore logging of casing integrity, cement bond and zonal isolation is required at time intervals specified in the approval Order, and submitted to the Commission, to confirm the well remains suitable for continued service use.

The casing age, grade and collapse pressure of wells within the area of pressure influence (5km recommended) must be ascertained and tabulated in the application, a potential further limiting factor to the maximum wellhead injection pressure. As casing integrity may degrade with age, an appropriate safety factor must be applied.

Step-Rate or Mini-Frac Fo\text{t}mation TestingMini-frac and step-rate testing are direct test methods widely accepted for determining the conditions under which a formation fracture can be created, extended or opened. The Mini-frac or DFIT test is the preferred method for determining the fracture pressure at the proposed disposal site. The test is performed by injecting non-saline (fresh) water into a short section of the wellbore at a single rate, prior to a stimulation operation, until the rock fractures. Injection is typically continued for a few minutes and then the pumps are shut down and the pressure allowed to bleed off. The ISIP and closure pressures are determined through a DFIT analysis.

However, in some formations the rock may not break. In these situations, a step-rate test can be conducted to establish the formation fracture pressure (FPP), an estimate fracture pressure. Since the FPP is determined under dynamic condition, friction must be considered when calculating the bottom hole pressure. Also, since the propagation pressure is typically on the order of a several hundred to several thousand kPa greater than the closure pressure (static condition), the value determined from this type of procedure yields an upper bound for
closure and may require a higher safety factor in some cases to determine the maximum wellhead injection pressure.

To obtain valid data for determining maximum permissible injection pressure, the step-rate injectivity test must be performed prior to fracture stimulation of the formation. A step-rate test is typically conducted by injecting fluid (usually fresh water) into a well in discrete steps of plotting injection pressure against injection rate. SPE paper 16798, “Systematic Design and Analysis of Step-Rate Tests to Determine Formation Parting Pressure (1987)” provides detailed step-rate injectivity test information.

**Injectivity Testing (Injection Capacity Testing)**

Injectivity testing is conducted to establish the water injectivity potential of the zone of interest. Injectivity testing may not be conducted on open Crown rights, as information provides an unfair advantage in competitive land sales.

An operator may wish to test the water injectivity potential of a zone, prior to testing and completing a well for disposal purposes. OGC approval is required only if the injection test volume will exceed a total of 500 cubic metres, in which case a temporary approval may be granted for the injection test to obtain performance information on the well. An application may be made using the disposal guideline to provide information currently available. Prior to conducting and injectivity test of any size, a Notice of Operation form must be submitted to the OGC Well Data Management group as indicated on the form. The injectivity test report, and any other supplemental data, is then submitted to the Commission to complete the application for disposal operation. As noted in Production Testing above, a pre-test attempt to obtain hydrocarbon inflow must be performed.

**Hydraulic Fracture Stimulation**

A completed wellbore interval may require an acid or hydraulic fracture stimulation to bypass formation damage caused by well drilling/cementing operations and increase connectivity.

Permit holders are cautioned to design and limit fracture stimulations to remain contained within the disposal formation. Where it appears there is significant potential that the induced fractures, and thus pathways for disposal fluid migration, has occurred out of zone, the Commission may require additional tests and data to confirm isolation and integrity of the bounding formations.

Current disposal wells require permission from the Commission for any fracture stimulation in the well – whether intended for the disposal zone or other zones.

**Seismicity**

Disposal wells have been linked to induced seismic events. A demonstrated pattern of cause and effect to disposal operations may result in modification to the disposal approval limiting injection pressure and/or rate to mitigate further seismic activity. Array of seismometers may also be Ordered by the Commission to closely monitor event location and depths.
Packer Isolation Testing
A pressure integrity test is required, the casing or casing/tubing annulus must be pressure tested to a minimum pressure of 1,400 kPa for 15 minutes prior to the commencement of injection or disposal operations. A pressure test is considered successful if the pressure does not vary by more than three per cent during the test period.

Annual packer isolation tests must be conducted in accordance with Section 2.3 of the Wells Completion, Maintenance and Abandonment Guideline which can be found on the Wells page of the OGC website.

Facilities
A separate facility application must be submitted to the Commission for surface equipment associated with a disposal well.

Source of Disposal Fluid
The Commission does not specify or restrict the source formation of produced or flowback water that may be disposed into the well. It is the expectation of the Commission that the well operator will follow good practice in regard to compatibility and treatment of water prior to disposal in order for the disposal formation to continue to be viable for disposal, and as a potential future saline water source zone where practicable.

Notification and Reporting
The form BC-11 Notice of Commencement or Suspension of Operations must be submitted to the Ministry of Finance by the 20th day of the month following the date of initial disposal, informing of date of initial operation.

The quantity and rate of fluid injected into a well must be metered, as per section 74 of the Regulation.

For each month during which water is disposed into the well, a form BC-S18 Monthly Injection/Disposal Statement must be filed, reporting total injection hours, volume and maximum wellhead tubing injection pressure. The BC-S18 is due by the 25th day of the month following injection. Both the form and instructions are available on the Commission website.

A change in operations, such as at start-up or a rate change, can result in momentary pressure spikes. The BC-S18 reported wellhead pressure is the maximum pressure, sustained for a period of a minimum of 5 minutes continuous duration, experienced during the reported month.

The wellhead injection pressure, of both casing and tubing, must be continually measured and recorded, a simple process with modern instrumentation. These data files may be requested and audited by the Commission. Measurement may be connected to equipment and alarms to ensure that operation remains within approval limits of pressure and containment.
Dual Water Source and Water Disposal Well
Several wells, notably completed in the Debolt formation in the Horn River Basin, utilize the same interval as both a water source and for disposal. Additional formations are being investigated, in other areas, for this usage. The Commission encourages practices and technology that minimize surface impacts and minimize withdrawals from potable water sources.

The normal requirements for licensing and seeking an approval order for a disposal well apply.

During cycles of disposal or production the appropriate forms (BC11, BC-S1 or BC-S18) must be filed.

Disposal fluid may require treatment to ensure that reservoir “souring” does not occur as a result of biogenic processes, to minimize later safety and cost requirements.

Commigled Disposal
Unsegregated disposal into more than one zone in a wellbore may be considered by the Commission. Access to more than one zone can improve well disposal capacity while minimizing surface disturbance. Factors for consideration include; depths and vertical separation of zones, difference in hydraulic fracture pressures between zones, zonal reservoir pressures, anticipated well shut-in frequency and durations (cross-flow potential). Allocation factors, for the reporting of monthly disposal volumes, are based on comparative reservoir qualities of thickness, permeability and porosity, and the results of any well testing, such as injectivity tests.

Performance Monitoring
Similar to performance monitoring of producing wells in order to forecast rate, ultimate cumulative volume and identify well performance issues that may require remediation, prudent operators are recommended to track injectivity performance of disposal and injection wells. A plot of the parameters of hourly rate/wellhead injection pressure (m³/hr/kPa) vs Cartesian time scale will normally indicate a continued loss in injectivity over time, due to such factors as fines migration, scale precipitation and reservoir fill-up.
Example Plot

Injectivity (m3/hr/kPa)

- Injectivity...
Appendix A:  
Calculating Maximum Well Head Injection Pressure

\[
P_{\text{Wellhead}} = [P_{\text{ISIP}} \times 0.9] - P_{\text{Hyd}} + P_{\text{Friction}}
\]

\(P_{\text{ISIP}}\) = bottom-hole formation fracture pressure (kPa), derived from;
- Initial post-frac ISIP value of fracture stimulation of disposal formation, subject well or close proximity, or
- Step-rate injection test on disposal formation, subject well or close proximity, or
- Interpolated from OGC Formation Fracture Gradient maps.

Calculated to true vertical depth to top of perforated interval (mCF + 1 m reference). For ISIP or step-rate test, use density of fluid in well bore at time of event to extrapolate pressure to depth.

0.9 = a 10% safety factor is applied.

\(P_{\text{Hyd}}\) = Hydrostatic pressure (kPa) of disposal fluid column in well bore.
- Assume minimum gradient of 10.5 kPa/m, to account for potential high TDS fluids.
- Height of true vertical depth to top of perforated interval (mCF + 1 m reference).
- Table listing water salinity versus gradient can be found [here](#).

\(P_{\text{Friction}}\) = Frictional pressure loss (kPa)
- Use chart below to find frictional pressure loss based on tubing diameter and expected maximum flow rate.

Other Notes:
- Formation fracture pressure is based on an average of area values where possible, due to the potential for an individual well anomalous value.
- Injectivity tests conducted on wells that have had previous fracture treatments are deemed questionable as it is inferred that the conductivity of the fracture distorts the results with the limited volumes used during testing.

**EXAMPLE:**
Depth to top perforations: 1137.0 m (1136.0 mCF + 1m above ground level)
Fracture gradient = 25 kPa/m (from OGC contour maps)

\[
P_{\text{Wellhead}} = [25 \text{ kPa/m} \times 1137.0 \text{m} \times 0.9] - (10.5 \text{ kPa/m} \times 1137.0\text{m}) + 200 \text{ kPa}
\]

\[
P_{\text{Wellhead}} = 25,582.5 - 11,938.5 + 200
\]

\[
P_{\text{Wellhead}} = 13,844 \text{ kPa}
\]

The maximum wellhead pressure will be 13,840 kPa.
Appendix B:
Colebrook–White Friction Pressure Loss

Frictional Pressure Gradient vs. Flow Rate of Various Tubing Diameters

Frictional Pressure Gradient (kPa/m)

Fluid Flow Rate (m^3/day)

D = 2 3/8"
D = 2 7/8"
D = 3 1/2 "

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Appendix C:
Well Testing Process Prior to Application

Recommended process to gather application data:

- Conduct a radial cement bond log displaying 3’ amplitude & 5’ VDL from the shoe to surface and then again with a 7000kPa pressure pass.
- If well is more than 10 years old, conduct casing inspection log (MIT/MTT tool).
- Conduct baseline temperature pass.
- Swab to 80% of depth to test for hydrocarbon production. Collect representative formation water samples, once load fluid volume recovered.
- Have water samples sent off for analysis and compatibility testing with disposal fluids.
- Run final string into the well, set packer as close as possible to the top of the open hole/casing shoe.
- Run recorders to obtain initial reservoir pressure and conduct the step-rate test or mini-frac to obtain formation fracture gradient.
- Rig out and come back after two weeks to pull the recorders
- Conduct concluding temperature logging following injection test to confirm zonal isolation of fluid.
Appendix D:
Summary Table

<table>
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<th>Well Type</th>
<th>Well Permit Req'd</th>
<th>Tenure or Consent Req'd</th>
<th>Target area applies?</th>
<th>Section 75 Approval Req'd</th>
<th>Applicable Spacing</th>
<th>Monthly Reporting</th>
<th>Links</th>
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<tbody>
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<td>N</td>
<td>N</td>
<td>N</td>
<td>none</td>
<td>S1</td>
<td>Well Permit Application Manual</td>
</tr>
<tr>
<td>Water Injection</td>
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<td>Y</td>
<td>N</td>
<td>Y</td>
<td>none</td>
<td>S18</td>
<td>Pressure Maintenance or Improved Recovery</td>
</tr>
<tr>
<td>Water Disposal</td>
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<td>Y</td>
<td>N</td>
<td>Y</td>
<td>none</td>
<td>S18</td>
<td>Deep Well Disposal of Produced Water</td>
</tr>
</tbody>
</table>

Consultation Considerations:

Consultation for subsurface projects is recommended but is not detailed in the Regulation. For a production project (such as waterflooding an oil pool) the area of consultation should include the owners of all wells completed in the pool.

For subsurface regional disposal aquifers, recommended consultation radius is 3 km. This area should be varied if there is a particular direction you expect the injected fluids to influence.

All reservoir engineering projects are posted on the Oil and Gas Commission website. If an objection to a project is expected, direct consultation with the potential objectors is recommended to demonstrate transparent, pro-active operating practices (‘head off’ any concerns). Consultation is recommended, but not required by regulation.