



# **Comox Sewer Conveyance Project**

## **Groundwater Monitoring Program Results**

**Prepared for:**

Comox Valley Regional District

**Prepared by:**

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## Executive Summary

The Comox Valley Regional District is implementing upgrades and improvements to their sewage conveyance infrastructure through Comox and CVRD Electoral Area 'B'. The sewer pipe, extending from the Courtenay pump station, through to the Comox Valley Water Pollution Control Centre (CVWPCC) was constructed using a cut and cover method, in which the pipe was installed in a shallow 2.5 m deep trench, oriented along existing road networks.

A groundwater monitoring network was established to monitor conditions before, during and after installation of the new sewer force main, within in the CVRD Electoral Area 'B', Lazo Hill area where water supply is obtained primarily from private domestic wells.

Beginning in May 2021, a complete inventory of wells and water sources was completed of properties within the subject area. From the initial inventory, a sub-group of wells were selected to monitor groundwater quality and quantity, including both shallow, excavated wells which intercept groundwater within shallow gravel seams and layers within shallow till deposits, and deeper, drilled wells constructed in Aquifer 408, an unconsolidated, sand and gravel aquifer which extends from Comox to Black Creek.

Equipment was installed to continuously monitor groundwater levels, temperature and electrical conductivity, an indicator of water salinity or mineral content. Samples were collected from each source to measure field-based water quality parameters, and for laboratory analysis of drinking water quality. The network wells were monitored for a two-year period to establish baseline conditions prior to installation of the sewer pipe. Monitoring continued through the installation period and water quality sampling was completed after installation of the trench and pipe.

This study summarizes the results of the groundwater monitoring program, including comparison of groundwater conditions in the shallow and deep aquifer zones. Groundwater levels exhibit a seasonal pattern reflecting aquifer recharge from precipitation. Groundwater levels are closest to the ground surface in the winter period (December-February) and the deepest levels are observed in late summer to autumn (August-October). Shallow dug wells show a greater range in water level fluctuations (up to 4 m) compared to deeper, drilled wells which typically vary by 1 to 2 m annually. No changes in groundwater levels were observed during the pipe trench construction period.

Groundwater quality in the study area is generally good, with few exceedances of drinking water guidelines. Concentrations of iron and manganese exceeded drinking water guidelines (aesthetic objectives) in some sources. Concentrations of chloride and nitrate, which can indicate impacts of pollution from sewage sources such as septic systems, were low and below drinking water limits. Bacteria, including total coliforms and *E.coli* were present in some wells, likely related to well construction and maintenance concerns. No significant differences in groundwater quality were observed before or after the sewer pipe construction. The monitoring program provided useful information for private well owners to manage their water supplies, and to understand groundwater conditions in the subject area.

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## 1 BACKGROUND

The Comox Valley Regional District (CVRD) operates the Comox Valley Sewerage Service that treats wastewater collection from the communities of Courtenay, Comox, the Department of National Defence, and the K'ómoks First Nation (Comox Valley Regional District, 2026a). In 2018 CVRD initiated a Liquid Waste Management Plan process, which evaluated alternatives and costs for improvements to sewage waste management in the region, including upgrades to the Comox Valley Water Pollution Control Centre (CVWPCC) sewage treatment plant and outfall (Comox Valley Regional District, 2021; WSP, 2022). As a part of this process, options were considered to reroute a section of the Courtenay-Comox sewer force main which passed along the marine foreshore at the base of Willemar Bluffs, previously identified as vulnerable to hazards associated with bank instability, and coastal erosion (CH2MHILL, 2005; EBA Engineering Consultants Ltd., 2005; Comox Valley Regional District, 2023).

In 2021 the CVRD Board approved a design plan and funding to install an upgraded sewer main from the Courtenay Pump Station through the Comox area to the Comox Valley Water Pollution Control Centre (CVWPCC) sewage treatment plant on Brent Road (Comox Valley Regional District, 2021, 2026b). Over the next two years, various options for the sewer main route and construction design were evaluated, including an intensive process of public consultation and input.

In July 2021 GW Solutions was engaged by CVRD to undertake a baseline assessment of groundwater resources in an area of the proposed sewage infrastructure upgrades in the Lazo Hill, where properties rely primarily on water supply from private wells. The study area is shown in Figure 1. Monitoring of groundwater conditions (quantity and quality) within a network of domestic wells began in 2021 and continued through 2025 to the present.

In 2023, an option being considered, to install the new sewer force main by horizontal directional drilling (HDD) through the Lazo Hill, was excluded. Instead, the CVRD opted to install the new sewer main using a cut and cover method, routing the pipe in a shallow trench primarily along existing roads and transportation corridors (Comox Valley Regional District, 2023). Consequently, the Lazo area groundwater monitoring network was modified to include two additional sites in proximity to the cut and cover route, to augment monitoring being conducted at existing locations and placing greater emphasis on the shallow groundwater system.

Construction of the new sewer conveyance began in May 2024, and the majority of work was completed by July 2025 (Comox Valley Regional District, 2026b). Repaving and boulevard/easement restoration in some sections, and additional construction in the area of the CVWPCC were ongoing in spring and summer 2026. The new sewage conveyance is intended to be fully commissioned and operational by fall 2026 (Comox Valley Regional District, 2025).

### 1.1 Previous work

GW Solutions completed several assessments during phased CVRD project planning and implementation, including evaluations of potential impacts on existing domestic wells of the proposed sewage pipeline, and an assessment of groundwater conditions and impacts of

pipeline route options on sensitive wetland ecosystems in Lazo Marsh (GW Solutions Inc., 2021a, 2021b, 2022). Baseline groundwater monitoring of groundwater quality and quality conditions prior to construction of the new sewer main were previously reported in GW Solutions (2023).

This (current) report summarizes the results of both the baseline assessment and results of monitoring during subsequent periods during and after the force main pipe installation along Lazo Road from using the cut and cover method.

## 2 SCOPE & OBJECTIVES

The scope of the Comox sewer conveyance groundwater assessment project included the following phases:

- Phase 1: Hydrogeologic data inventory and compilation, including field-based observations and information gathering, and development of a hydrogeologic model of the study area.
- Phase 2: Baseline resource characterization and pre-construction monitoring.
- Phase 3: Monitoring during sewer conveyance construction phase.
- Phase 4: Post-construction sampling and monitoring.
- Reporting: Preparation of a report on monitoring and sample results, and assessment of potential impacts.

The objectives of GW Solutions' work were to:

- Develop and update a three-dimensional hydrogeologic model of the Comox aquifer in the area of the proposed sewer conveyance in the Lazo Hill area.
- Complete a field inventory to identify wells and water sources on properties along the initial and revised the pipeline route (Lazo Road and the area between Torrence Road and Brent Road).
- Develop and implement a groundwater monitoring program, including identifying appropriate locations for monitoring based on site access, property owner permissions, and location (well depth and horizontal distance relative to the pipeline construction area).
- Monitor groundwater conditions before, during, and after the pipeline construction.
- Analyze and report on the monitoring results, and assessment of potential impacts of the project on groundwater resources in the study area.
- Provide recommendations for future work, including continuation of the monitoring program and other activities.

During the initial phase of the project existing information on geology and hydrogeology of the island was reviewed and compiled. The primary data sets and sources compiled for the study are summarized in Table 1. Additional sources and references are listed in the report sections below.

**Table 1: Data sources and application within the study.**

| Source                                                  | Category                                             | Data processing and application within the study                                                                                                                                                                                                                                                 |
|---------------------------------------------------------|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Province of BC                                          | Groundwater Wells and Aquifers Database (GWELLS)     | Data from GWELLS (Province of BC, 2025a) provided information on the locations and depths of registered wells, aquifer materials, depths of water bearing zones, groundwater levels, and relative aquifer productivity (estimated yield).                                                        |
| Province of BC and geospatial analysis                  | Mapped aquifers and lithological strata              | Aquifer boundaries and characteristics were obtained from the Provincial database. Groundwater characteristics in the Comox area were further refined based on data from registered wells (above) and wells identified through the field inventory.                                              |
| Province of BC                                          | Water licenses                                       | The provincial Water Rights Database contained information on the locations and licensed volumes for surface water Points of Diversion (POD's), including licensed springs, and groundwater Points of Well Diversion (PWD's) (Water Management, 2025a, 2025b).                                   |
| Province of BC and water systems                        | Groundwater monitoring data                          | There is one active Provincial Observation Well in the Comox Area. Data from this monitoring location was obtained for comparison to monitoring data at the study properties.                                                                                                                    |
| Province of BC                                          | Surficial, Quaternary and bedrock geology            | Surficial geology of the area was based primarily on (Guthrie, 2005). In addition, terrain resource information mapping and soil mapping for the study area was also reviewed to interpret surficial material types and thickness. Bedrock geology mapping was obtained from (Cui et al., 2019). |
| Province of BC                                          | Digital Elevation Model                              | Detailed topographic elevation of the study was obtained as digital elevation model (DEM) layer from BC Lidar Data Portal (GeoBC Branch, 2025). The elevation data were used to calculate the elevation of monitoring locations, and to map groundwater elevation and flow direction.            |
| Province of BC and local authorities                    | Water quality                                        | Existing data on groundwater quality was compiled from the Provincial Environmental Management System (EMS) database, for comparison to the study results.                                                                                                                                       |
| Comox Valley Regional District (CVRD) and Town of Comox | Municipal service areas (water, sewer)               | Spatial mapping of municipal service areas was obtained from Comox Valley Regional District and Town of Comox.                                                                                                                                                                                   |
| Province and local authorities, CVRD                    | Cadastral mapping (lot boundaries) and land use      | Current cadastral lot boundaries and BC Assessment actual land use were obtained from Comox Valley Regional District and used to determine the locations and purpose of water use.                                                                                                               |
| Environment and Climate Change Canada                   | Historic climate data                                | Statistical analysis of historic records on temperature and precipitation were completed based on compiled data from appropriately located climate monitoring stations (Environment and Climate Change Canada, 2026).                                                                            |
| Various                                                 | Existing hydrogeologic and environmental assessments | A detailed literature search was completed to gather and review information from previously prepared hydrogeologic and environmental studies.                                                                                                                                                    |
| Well operators, property owners and field survey        | Local water resource inventory                       | A field inventory of wells, including locations and status of use, was completed in the study area to validate information in the GWELLS database, and identify additional unregistered water sources.                                                                                           |



Figure 1: Comox Lazo Road study area.

### 3 COMOX WATER SOURCES & MONITORING METHODS

#### 3.1 Wells

Water supply for residential and non-residential use in the Town of Comox comes from the Comox Valley Water System. In the Lazo Hill area of CVRD Electoral Area 'B', water supply is obtained from privately operated groundwater wells, mainly domestic supplies providing water for household use, gardens and pets. The field inventory of wells completed in summer 2021 found many wells that were not registered in the provincial Groundwater Wells and Aquifers (GWELLS) database. Two primary well types were observed in the field: large diameter (~1 m) dug wells excavated in shallow, unconsolidated sediments, and smaller diameter (0.15 m, 6") drilled wells constructed in deeper sand and gravel deposits. Locations of field verified wells and wells selected for the monitoring network are shown in Figure 2. Properties where no groundwater source was present were also noted. The average and maximum reported well depth in each well category are summarized in Table 2.

**Table 2: Maximum and average depth of shallow (excavated) and deep (drilled) wells identified in Lazo Road field inventory.**

| Item       | Well depth (mbgs) |      |         |                        |
|------------|-------------------|------|---------|------------------------|
|            | Shallow           | Deep | Unknown | All (shallow and deep) |
| Average    | 3.4               | 37.8 | 0       | 23.38                  |
| Maximum    | 9.1               | 80.8 | 0       | 80.77                  |
| Count (N=) | 36                | 53   | 3       | 92                     |

#### 3.2 Aquifers

The primary groundwater source in the study area is Aquifer 408 (AQ408), a sand and gravel aquifer made up of glacial outwash and pre-glacial sediments (aquifer subtype 4a). AQ408 is a large aquifer with a total mapped area of 155 km<sup>2</sup>, extending from Comox to Black Creek (Hinnel and Lengyel, 2020). The main lithostratigraphic unit associated with AQ408 is the Quadra Sand, characterized by relatively thick layers of well sorted sand and gravel (Humphrey, 2000; Hinnel et al., 2020). Fine-grained materials such as clay, silt or till (compacted sandy clay and silt)—referred to as confining sediments—protect an aquifer by slowing the rate of infiltration of contaminants introduced at the land surface. AQ408 is considered partially confined. In some areas till and fine-grained sediments overly the aquifer but these vary in thickness and extent. While in other areas permeable sand layers in the unsaturated zone overlying the aquifer are exposed at the land surface or below thin soils. For this reason the vulnerability to contamination is considered moderate. Productivity of wells in AQ408 is variable with a median reported well yield of 0.63 Litres/second (10 gallons per minute), considered within a low range (Province of BC, 2025b). A representative cross-section of AQ408 in the study area is shown in Figure 3.

Dug or excavated wells in the study area obtain water from shallower sediments, where water is present in thinner permeable sand or gravel lenses within overall lower permeability deposits such as till that overlie AQ408, associated with the Vashon Drift

lithostratigraphic unit. While most dug wells were constructed historically and before the more widespread installation and use of drilled wells, they are still actively used water sources on some lots. Excavated wells in this area are typically less than 10 m deep and considered highly vulnerable to contaminants introduced at the land surface both because the groundwater source is from shallow sedimentary layers, and due to the characteristics of well construction and maintenance, discussed further in section 6.3.

### 3.3 Lazo Road area groundwater monitoring network

A network of existing wells was established to monitor groundwater conditions in the Lazo Road area. Wells were selected from a short-list of potential locations identified during the field well inventory, based on location and distance from the proposed sewer conveyance route, well depth and construction characteristics (selecting both shallow and deep wells), site access and suitability for monitoring equipment installation, and permission obtained from property owners to participate in the study. All monitoring sites selected were domestic wells in active use for drinking water supply on the subject properties.

When the sewer conveyance design was altered from HDD to a cut and cover approach, the initial monitoring site selection in 2022 was further modified in 2023 to include two additional wells near the planned shallow trench installation. The groundwater monitoring network sites are shown in Figure 2 and listed in Table 3.

At each site in the domestic well monitoring network, the following work was completed:

|                           |                                                                                                                                                                                 |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Site documentation</b> | Well construction characteristics were documented, including well co-ordinates, diameter, measured well depth, and a downhole camera inspection was conducted (where possible). |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Water level monitoring</b> | <p>A PVC drop-pipe conduit was installed to enable installation of monitoring equipment without causing damage to the pump or well equipment.</p> <p>A submersible pressure transducer datalogger (Solinst LTC Levelogger) was installed to measure groundwater level, temperature and electrical conductivity (a water quality parameter related to the concentration of minerals in the water). The loggers were programmed to collect hourly readings (continuous throughout the monitoring period). The Leveloggers were connected via a direct-read cable to a telemetry interface--Solinst LevelSender with external antenna to communicate daily real-time data from each well via a cellular connection and email server.</p> |
|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Each site was visited periodically during the project to download the logger data, collect manual groundwater level measurements, and calibrate or repair equipment.

Groundwater level monitoring data were compensated for barometric pressure and corrected in using manual measurements.

**Water quality monitoring**

Water was pumped from each source using existing pump equipment. Samples were collected for analysis of field parameters, and laboratory testing, from a location in the water system as close as possible to the well and prior to any treatment system, for example at hose bib in the pumphouse or adjacent to the well. Each sample location was disinfected using 10% chlorine bleach solutions prior to connecting a sample hose apparatus constructed of material CSA certified for potable water use.

Water quality field parameters were measured in groundwater from each well using a hand-held YSI meter connected to an enclosed flow cell. The YSI measured water temperature, dissolved oxygen, electrical conductivity, total dissolved solids, pH and oxidation reduction potential (ORP). Field parameters were collected during the initial field visit and subsequently during collection of samples for laboratory analysis.

Samples were collected of untreated water from each well for laboratory analysis. Multiple samples were collected from each site to evaluate seasonal water quality variability and assess baseline conditions prior to, during, and after installation of the sewer pipe.

All samples were collected using aseptic technique following standard methods and provincial standards (Province of BC, 2013a, 2013b, 2020, 2021, 2022). Prior to sampling, water was purged from the source for a period of 5 or more minutes, until measured field parameters had stabilized to within 10% for 3 successive readings. The wells are in active use and therefore as short purging duration is sufficient to obtain a representative sample.

### 3.4 Additional monitoring sites

In addition to the domestic well monitoring, the CVRD monitors groundwater quality in monitoring wells located downgradient of the Pollution Control Centre (CVWPCC). Analysis of the data from these sites was not included in this report.

Groundwater levels were monitored in a manually installed shallow 2" monitoring well in the Lazo Marsh (BH22-01). However water quality samples were not collected at that location.

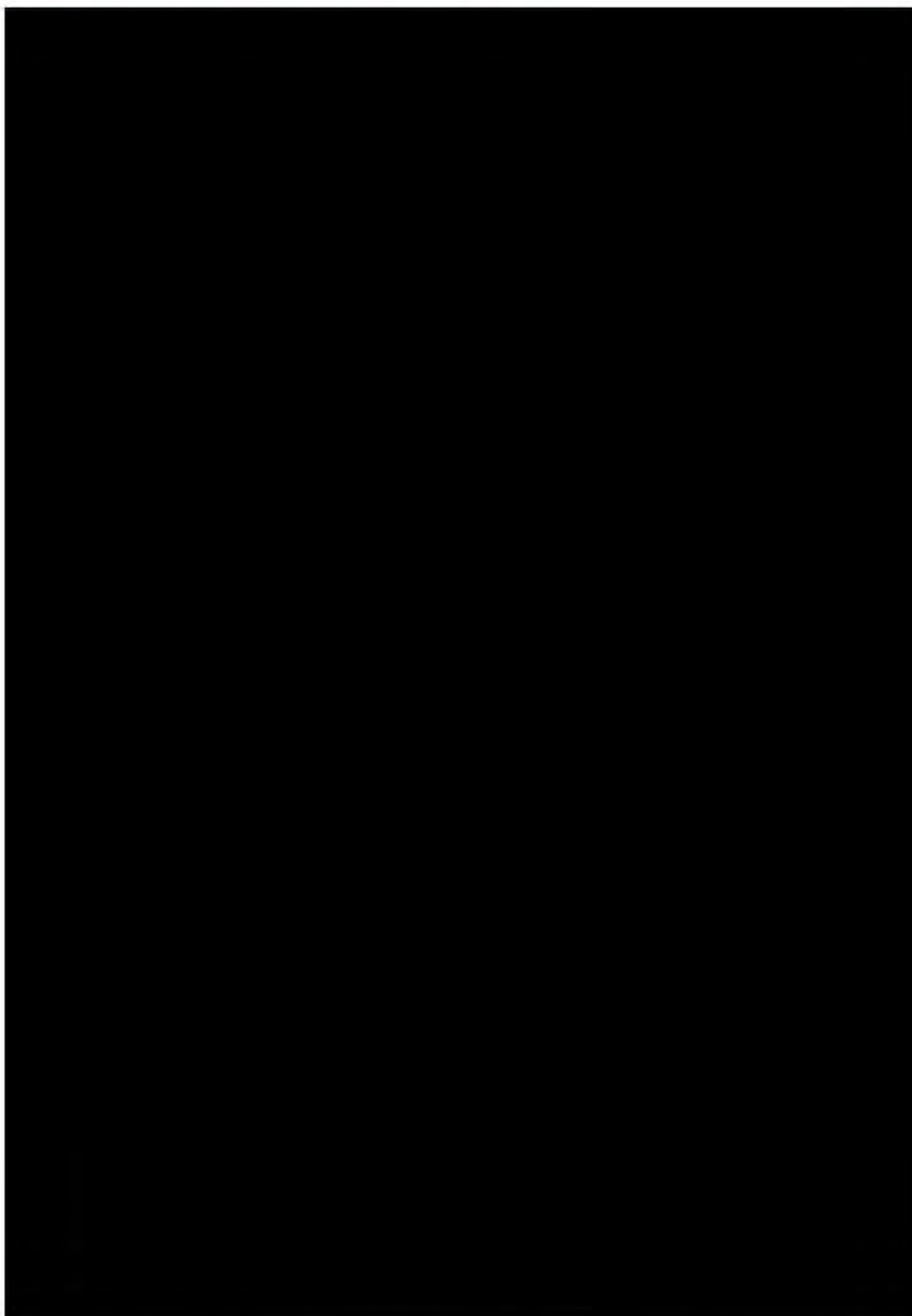


**Figure 2: Comox Lazo Road well inventory and groundwater monitoring network sites.**

**Table 3: Lazo Hill study area groundwater monitoring network sites.**

| Site name | Well name | Well Tag No. | Well ID Plate | Well type | Well diameter (m) | Well diameter (inches) | Well depth (ft) | Well depth (m) | Monitoring status (April 2026) | Date added to network | Groundwater level data to         |
|-----------|-----------|--------------|---------------|-----------|-------------------|------------------------|-----------------|----------------|--------------------------------|-----------------------|-----------------------------------|
|           | Well 22   |              |               | Dug       | 1.40              | 55                     | 23              | 6.86           | Active                         | 2021-Nov-01           | 2024-Aug-08                       |
|           | Well 24   |              |               | Dug       | 1.10              | 43                     | 20              | 6.14           | Active                         | 2023-Aug-14           | 2025-Sep-03                       |
|           | Well 23   |              |               | Dug       | 1.40              | 55                     | 16              | 4.92           | Inactive                       | 2023-Jan-19           | 2025-Sep-03                       |
|           | Well 5    |              |               | Dug       | 1.40              | 55                     | 13              | 3.89           | Active                         | 2021-Nov-03           | 2025-Sep-03                       |
|           | Well 20   |              |               | Drilled   | 0.152             | 6                      | 75              | 22.9           | Inactive                       | 2021-Nov-02           | 2023-Aug-14                       |
|           | Well 13   |              |               | Drilled   | 0.152             | 6                      | 102             | 31.04          | Inactive                       | 2021-Nov-02           | 2024-Aug-07                       |
|           | Well 12   |              |               | Drilled   | 0.152             | 6                      | 170             | 51.81          | Active                         | 2021-Nov-02           | 2025-Sep-03                       |
|           | Well 14   |              |               | Drilled   | 0.152             | 6                      | 163             | 49.59          | Active                         | 2021-Nov-02           | 2025-Sep-03                       |
|           | Well 21   |              |               | Drilled   | 0.152             | 6                      | 151             | 46.02          | Inactive                       | 2021-Nov-01           | 2023-Aug-14                       |
|           | Well 25   |              |               | Drilled   | 0.152             | 6                      | 59              | 18.00          | Active                         | 2023-Aug-14           | 2025-Sep-03                       |
| BH 22-01  | 22-01     | nr           |               | Dug       |                   | 2                      | 2               | 0.58           | Active                         | 2022-Jul-21           | 2025-Sep-25                       |
| BH19-01   | 19-01     | nr           | na            | Drilled   | 0.051             | 2                      | 40              | 12.20          | Active                         | 2022-Sep-15           | Periodic manual measurements only |
| BH19-02   | 19-02     | nr           | na            | Drilled   | 0.051             | 2                      | 16              | 4.90           | Active                         | 2022-Sep-15           | Periodic manual measurements only |

Well Tag No. =Unique registration number in GWELLS database. Well ID Plate=Metal identification plate attached to well to identify it in the field.  
nr=not registered in GWELLS database.

BH22-01 is located in Lazo Marsh.

BH 19-01 and BH-19-02 are located and Comox Valley Water Pollution Control Centre.



**Figure 3: Cross-section A-A' oriented along the initially planned Horizontal Directional Drilling (HDD) pipeline route.**

## 4 SEWER CONVEYANCE INSTALLATION

Construction of the new sewer pipe began in April 2024 and was completed by September 2025. Within the Lazo Road area the main periods of construction occurred from October to December 2024, and from mid-May to early June 2025 (Zoe Berkey, personal communication, January 22, 2026). The construction schedule in the Lazo Road monitoring area is shown in

Table 4, and the pipeline route and control points are shown in Figure 2.

### 4.1 Construction and design

The sewer pipes are installed by excavating a longitudinal trench approximately 2.5 m deep and approximately 1 m wide at its base. The sewer pipe segments comprised of 0.9 m (36") diameter High Density Polyethylene (HDPE) are laid along the base of the trench prepared with granular bedding material (AECOM, 2025). The trench is backfilled to a minimum depth of 0.3 m above the pipe with granular material. The remaining hole is then backfilled with native sediments and soil and reseeded in boulevard areas or with granular road base, compacted to a standard density and prepared for repaving. An example diagram of trench installation design is shown in Figure 4, and example photos of the installation are provided in Figure 5.

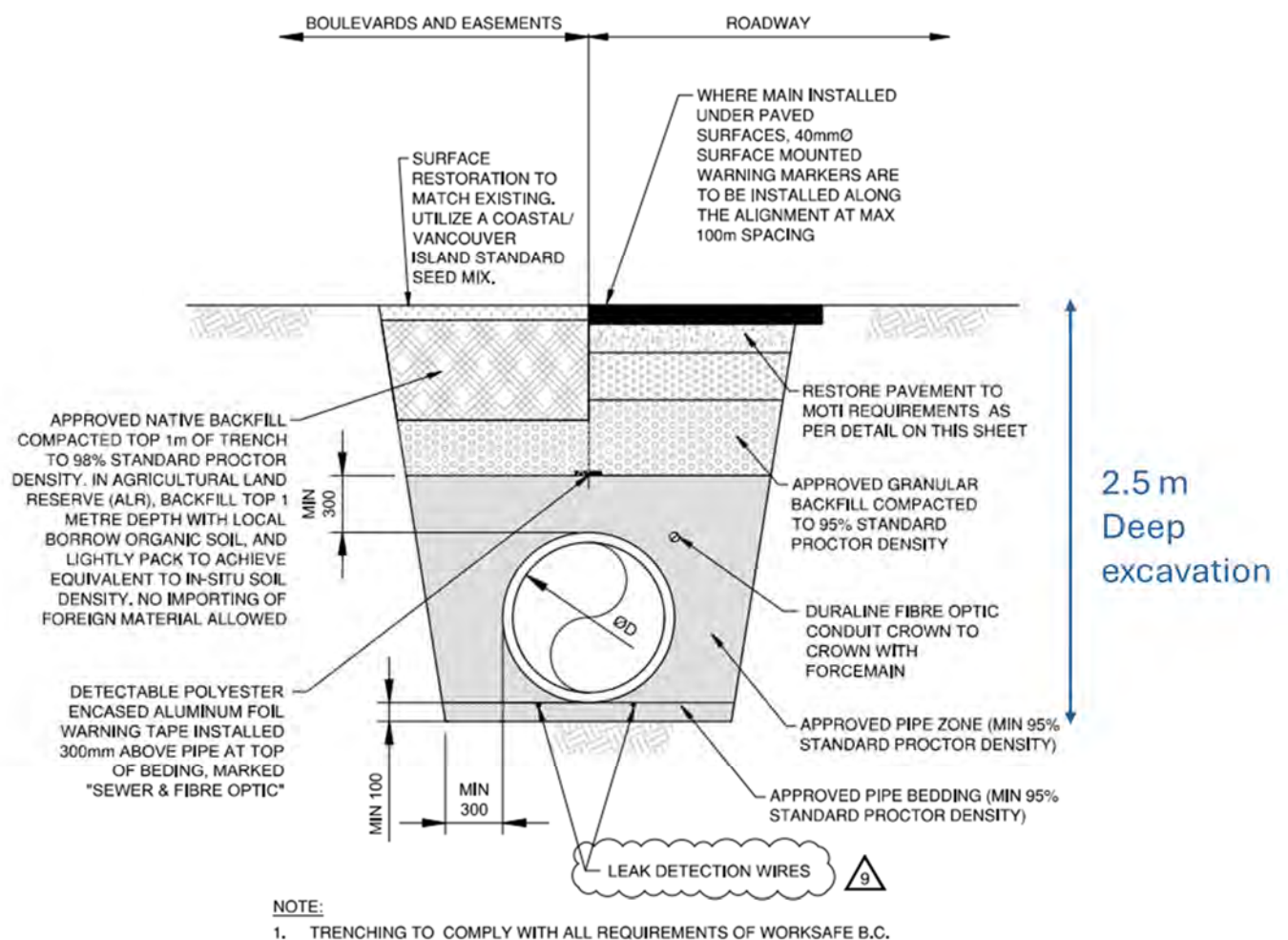
Various design measures were included to avoid impacts to groundwater sources during construction, and to prevent contaminant release from the pipe and detect if damage to the sewer force main occurs once the pipe is commissioned and put into use (Comox Valley Regional District, 2023; Charlie Gore, Manager Capital Projects, 2023; AECOM, 2025).

- The sewer pipe has a large diameter and is installed along generally low to moderately sloped road grade to help manage entrained gases and ensure steady flow rates.
- The effluent flows under gravity and the pipe is not under pressure.
- The pipe is constructed of large diameter, fully-fused HDPE several centimeters thick.
- Leak detection wire sensors are installed beneath the sewer pipe within the trench.
- Line shut-off and isolation valves enable the sewage pumps to be shut off at any time.
- Trench dams are installed within the excavations to prevent groundwater movement along the pipeline route.
- In the Lazo Road area, and along most the pipeline route, the trench was installed in public property along existing roadways.
- Due to the shallow depth of the trench, the pipe was mainly installed above the water table with minimal dewatering required.
- Monitoring was conducted of wells adjacent to the pipeline route before, during and after installation of the trench and pipeline.

The groundwater monitoring program was in place to evaluate and manage potential impacts to nearby groundwater wells during the pipeline construction phase, such as:

- Trench dewatering causing temporary lowering of groundwater levels;
- Vibration and disturbance during excavation or compaction causing temporary changes in water quality, such as water cloudiness (turbidity).

These impacts were anticipated to impact primarily dug or excavated wells, in which groundwater levels are shallower and closer to the ground surface. Within drilled wells, groundwater levels were deeper (6 m or more below ground) and therefore these wells were considered unlikely to be impacted by activities associated with the trench and pipe installation. Once installed, the force main is sealed and not anticipated to allow release of sewage or contaminants into the environment.



### TRENCH DETAIL

Figure 4: Force main installation detail, reproduced from AECOM (2025).



**Figure 5: Example photos of trench and pipe installation. Photos from CVRD.**

**Table 4: Comox Lazo Road area trench excavation and backfill schedule October 2024 to June 2025 (route and station control points shown in Figure 2).**

| Date Range             | Excavation Progress (station) | Backfill Progress (Station) |
|------------------------|-------------------------------|-----------------------------|
| October 3 – 11, 2024   | 19+510 to 19+610              | Backfilled to 19+595        |
| October 23 – 31, 2024  | 18+310 to 18+160              | Backfilled to 18+260        |
| November 4 – 15, 2024  | 18+070 to 17+670              | Backfilled to 17+840        |
| November 25 – 28, 2024 | 17+550 to 17+420              | Backfilled to 17+480        |
| December 3 – 11, 2024  | 17+390 to 17+290              | Backfilled to 17+285        |
| May 12 – 15, 2025      | 17+240 to 17+200              | Backfilled to 17+285        |
| May 20 – 23, 2025      | 17+240 to 17+200              | Backfilled to 17+235        |
| June 2 – 4, 2025       | 17+200 to 16+880              | Backfilled to 16+860        |

## 5 GROUNDWATER LEVEL MONITORING RESULTS

The Comox-Lazo Road area groundwater monitoring program enabled collection of information on groundwater quantity and quality in the area of the planned sewer conveyance.

The results of groundwater level monitoring within four shallow, dug well sites are plotted in Figure 6. Short gaps in data collection occurred in some cases, due to problems with the datalogger equipment. One site [REDACTED] was added to the network in 2023. The observed range in seasonal groundwater level fluctuation in dug wells is less than 5 m between winter maximum (shallowest) groundwater levels and fall minimum (deepest) water levels, and the median groundwater level ranges from 0.7 to 2.8 m. Due to the shallow well depth (6.5 m or less) groundwater levels respond rapidly to daily and seasonal precipitation events. No observable changes or differences were noted in either groundwater levels or the patterns of daily or seasonal hydrograph response during the pipe installation period (shade in grey).

The results of groundwater level monitoring within six drilled domestic wells in AQ408, are plotted in Figure 7. The drilled wells range in depth from 18 to 61.6 m. Monitoring in two sites [REDACTED] was discontinued after two years on owner request. One site [REDACTED] was added to the network in 2023. Some data gaps are noted, due to malfunctions of the logger equipment. Annually, groundwater levels in the drilled wells range from 6.5 to 41.3 m below ground (non pumping conditions), and exhibit responses to seasonal precipitation and groundwater recharge. The drilled wells show a smaller seasonal variability compared to the shallow wells, and groundwater levels typically range within 1 m between winter (high) and autumn (low) levels. No observable changes or differences were noted in either groundwater levels or the patterns of daily or seasonal hydrograph response during the pipe installation period (shade in grey).

Monitoring was also conducted in BH22-01, a shallow 2" piezometer installed in the Lazo Marsh wetland, data from July 2022 to September 2025 shown in Figure 8. Monitoring in the swamp also showed a typical seasonal response to precipitation with water levels rising in the fall due to rainfall events. No changes were noted when the pipeline was being constructed in the area (grey shaded period).

Appendix A, Table A-1 lists the monitoring period, observations regarding pumping effects, seasonal water level fluctuation, and identified data gaps for each monitoring site.

### 5.1 Findings and recommendations from monitoring methods and equipment

The Comox Lazo Hill groundwater monitoring network collected useful data to understand well and aquifer conditions including seasonal variation in groundwater levels, and responses to pumping within AQ408 and within the shallower groundwater flow system overlying the regional aquifer.

The program also provides a potential model for establishment of a more long-term monitoring network, that could be operated by CVRD or other community groups in this or other groundwater dependent areas. For example, the Regional District of Nanaimo operate

a Volunteer Observation Well Network, utilizing dataloggers installed in domestic wells to augment data collected in dedicated wells in the Provincial Observation Well Network (PGOWN), that provides valuable information on groundwater levels and long-term trends in target aquifers (Regional District of Nanaimo, 2025, 2026; Ministry of Environment and Parks, 2026).

Based on the results of the Comox monitoring program, the following findings and recommendations are noted:

- The technology used for monitoring of the wells including installed dataloggers was generally reliable. Some problems occurred from failure of the datalogger itself (e.g. drainage of the internal battery, or failure of electronic components). Other problems including data losses and communication errors occurred with LevelSender telemetry equipment (e.g. drainage of sender batteries, moisture accumulation within the direct-read cable).
- Cellular communication service was limited in many parts of the monitoring area which caused problems with remote connection and data transmission.
- Sites were visited more frequently during the start of the monitoring program (approximately three times annually) and subsequently reduced (one to two times per year). A minimum frequency of 3 visits per year is generally recommended to conduct site and equipment maintenance and calibration, to prevent data loss and to ensure effective operation of the monitoring network.
- For monitoring networks with the objective to collect information on seasonal variability and long-term trends in aquifer levels and conditions (temperature, salinity) in domestic wells, real-time monitoring and communication via telemetry is not essential. Real-time monitoring may be more appropriate or necessary for monitoring on non-domestic wells, such as for water supply systems where daily, weekly or monthly updates are needed. A field visit schedule could be developed to ensure that sites are visited to collect observations and document seasonal conditions during key times of the year, such as during mid-late spring for drought prediction prior to the summer season, or autumn to document levels during periods of deeper water level, prior to the start of the fall rainy season.

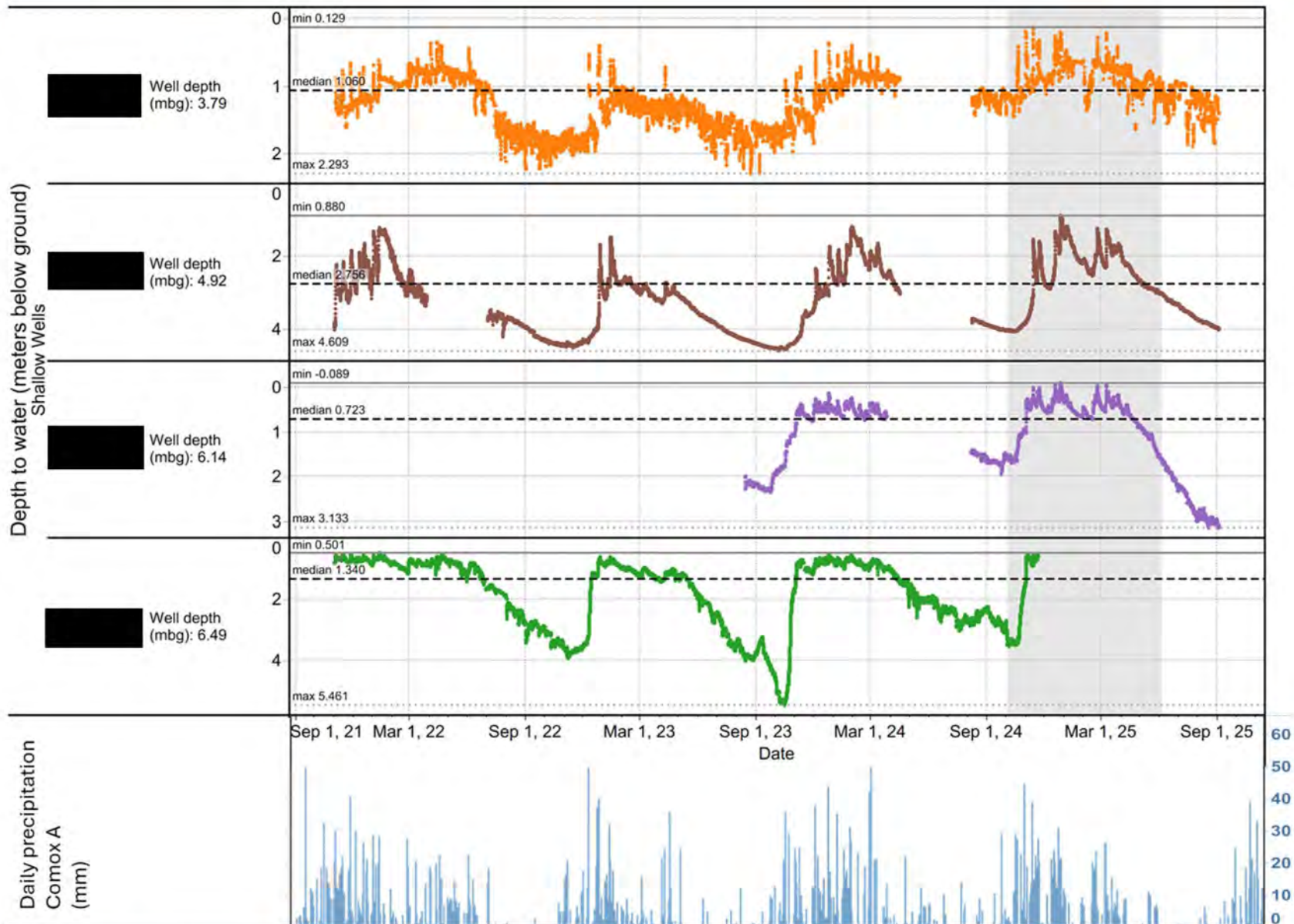


**Figure 6: Shallow well hydrographs, illustrating groundwater level vs time compared to precipitation (2021-2025). Trench construction period shaded (grey).**

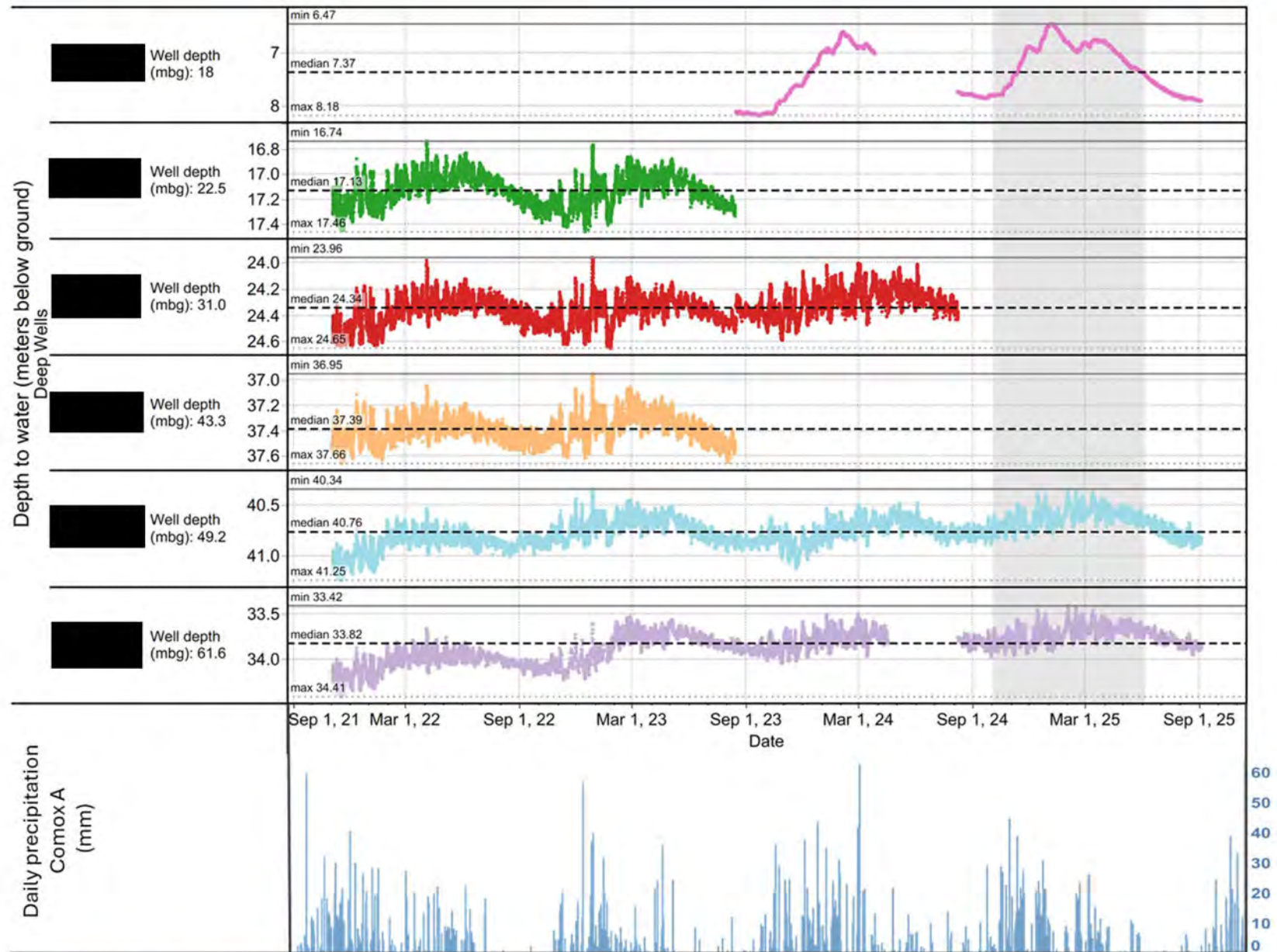


Figure 7: Deep well hydrographs illustrating groundwater level vs time compared to precipitation (2021-2025).

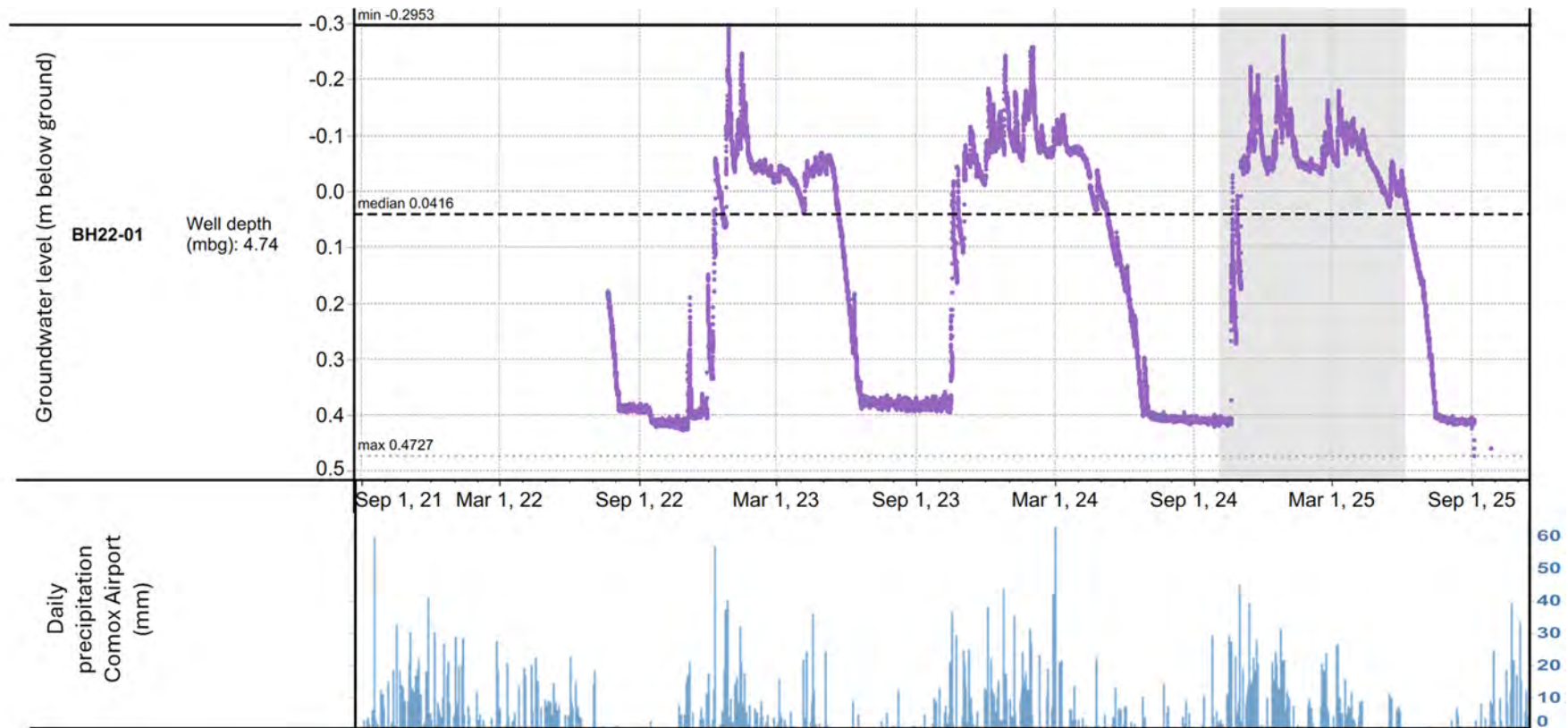


Figure 8: Shallow groundwater levels in BH22-01 Lazo Marsh compared to precipitation.

## 6 GROUNDWATER QUALITY MONITORING RESULTS

An objective of the groundwater monitoring network was to assess and characterize water quality in the study area. Water quality monitoring including collection of field parameters using a hand-held YSI meter, and collection of water samples for laboratory analysis. Samples were sent to Bureau Veritas Laboratory in Burnaby, BC, and analyzed for general chemistry parameters, major ions, nutrients, total and dissolved metals and microbiology (bacteria).

Laboratory results were compared to the Canadian Drinking Water Quality Guidelines, which include: Maximum Acceptable Concentration (MAC) for water quality parameters associated with health-related impacts, Aesthetic Objectives (AO) for water quality parameters associated with water taste, odour and appearance, and Operational Guidance (OG) values for water quality parameters that influence the effectiveness of water disinfection and treatment (Health Canada, 2025). The full list of analytical parameters and associated Canadian Drinking Water Quality guidelines is included in Appendix A, Table A-2.

### 6.1 Quality Assurance and Quality Control

BV Labs provided documented lab QA/QC results for each sample date (group of samples); lab QA/QC included replicates, method blanks, matrix spike, and spiked blanks. For the field program, Quality Assurance and Quality Control (QA/QC) included collection of replicate samples (two sample dates). The relative percent difference (RPD%) was calculated for all replicate samples. The RPD for all parameters above detection limits was less than 5% for most parameters, and less than 20% in all instances. The Province of BC recommends the Relative Percent Difference shall not exceed 20% (Province of BC, 2013a). The results of QA/QC samples are included in Appendix A, Table A-3.

### 6.2 Groundwater quality summary

Groundwater quality samples were collected at domestic well monitoring network sites shown in Figure 2. The results of water quality sampling are provided below. The analysis is focused on parameters important to drinking water potability and human health, and parameters considered useful to understand aquifer conditions, and environmental quality, including the potential impacts of pollution.

#### 6.2.1 Water type

A Piper diagram showing the relative proportion of major ions in water samples from the Comox domestic well monitoring network is shown in Figure 9. Samples from shallow, dug wells are shown in orange, while samples from deep, drilled wells are shown in blue. The water type indicates the relative proportion of major elements in the water sample, based on the position of the sample point in a representative quadrant of the diagram. The composition of the water samples identifies water originating from different sources, or that has undergone different geochemical processes, such as mixing and interactions between groundwater and the aquifer materials (e.g. dissolution or cation exchange)(Freeze and Cherry, 1979).

The groundwater type varies according to the location and well type. Both shallow and drilled wells are mainly calcium-magnesium-bicarbonate ( $\text{Ca-Mg-HCO}_3$ ) water type indicative of a fresh, recently recharged source. The shallow dug well samples plot toward the centre right of the plot indicating that they have a greater proportion of sodium and chloride, potentially reflecting less dilution within the source (limited flow through shallow gravel and sand lenses within overall lower permeability confining layers) or reflecting the influence of contaminant sources such as private septic system discharges.

Table 5 includes the median concentrations of key drinking water parameters in samples from shallow (dug) and deep (drilled) wells, before and after the pipeline construction (a supplementary table that also shows the maximum and minimum concentrations is included in Appendix A, Table A-4). Metals are reported as both a total concentration, which includes metals concentrated in mineral particles suspended in the water, and a dissolved concentration for samples that have been passed through a  $0.45\ \mu\text{m}$  filter to remove particulate matter. Table 6 lists the number of samples that met or exceeded drinking water quality guidelines from shallow and deep wells before and after construction. While some differences were observed in groundwater from shallow and deep wells, water quality from both types of wells is generally fresh and of very good quality. Parameters which exceeded drinking water quality guidelines in some samples and sources included iron, manganese, true colour, and bacteria, discussed further below.

Minor differences in water quality parameters were observed for samples collected after construction; it was noted that both post-construction sample events were during the dry season, when water levels are deeper, and the concentrations of some parameters become more concentrated. The water quality results are discussed further below, with consideration given to natural minerals and to parameters that can indicate impacts from land use, depending on the vulnerability of the wells and aquifer to contamination.

### 6.2.2 Natural minerals

**Iron and manganese** are two metals that are often naturally present in groundwater, that can affect the aesthetic quality or pleasantness of water for drinking. The Health Canada Aesthetic Objective (AO) for iron is  $100\ \mu\text{g/L}$ . If the concentration of iron is above this level, the water may have a red colour, cause staining of plumbing or fixtures, and may be unpalatable for use (Health Canada, 2024). Manganese is also commonly present in groundwater found on its own or in water that also has a high iron concentration (Health Canada, 2025). There are two Canadian guidelines for drinking water quality for manganese. The lower Aesthetic Objective (AO) is  $20\ \mu\text{g/L}$ ; above this concentration the water may have a noticeable colour (e.g. visible black flecks or particulate), unpleasant taste and be less palatable for drinking, and can cause staining of household plumbing fixtures and laundry. A higher Maximum Allowable Concentration (MAC) for manganese of  $120\ \mu\text{g/L}$  has also been established; drinking water with manganese above this concentration may be associated with adverse health impacts including effects on neurological development in children. Both manganese and iron concentration can be reduced by water treatment using oxidation, adsorption with specialized granular media, and filtration (Health Canada, 2024).

### 6.2.2.1 *Comox groundwater monitoring network observations – natural minerals*

**Iron and manganese:** Water from deeper groundwater sources may have higher mineral concentrations, as the water is generally older, and has had more time for weathering and dissolution of minerals from rock in contact with groundwater (McGuigan et al., 2010). In the Comox study area, the median concentration of iron was slightly higher in groundwater samples from deep (drilled) wells compared to shallow (dug) wells; For example, the median concentration of total iron in groundwater from deep wells was 337 µg/L (higher than the 100 µg/L drinking water guideline) compared to the median concentration of total iron of 237 µg/L in groundwater from shallow wells. In comparison, the concentration of manganese was in a similar range in both shallow and deep sources, with a median concentration of total manganese of 49.8 µg/L in groundwater from shallow wells, compared to a median total manganese of 46.1 µg/L in groundwater from deep wells, higher than the 20 µg/L Aesthetic Objective limit but lower than the 120 µg/L Maximum Allowable Concentration.

The concentration of elements such as arsenic, boron and fluoride were low and below drinking water guidelines in samples from both sources.

### 6.2.3 **Water quality indicators of aquifer processes and land-use impacts**

The concentration and distribution of water quality parameters such as chloride, conductivity, nitrate and sodium can provide information about the vulnerability of a well or aquifer source to contamination, and the potential impacts of land use on water quality.

**Chloride** (Cl) is a natural element abundant in rocks, soil and natural waters, and most abundant in the world's oceans (Health Canada, 1987). Chloride concentration is generally low in rain, surface water (rivers and lakes), and variable in groundwater depending on the processes occurring in the aquifer. For example, the chloride concentration may be higher in water influenced by or mixed with water from marine sources. Other sources of chloride in groundwater include salt applications on roadways, leachate from industry, and discharge of sewage effluent, such as from septic systems. The drinking water guideline for chloride is an Aesthetic Objective of 250 mg/L. Water above this concentration water has a noticeable salty taste and can corrode water fixtures and distribution pipes (Health Canada, 1987).

**Nitrate** (NO<sub>3</sub>) is a water quality parameter that varies in concentration in water impacted by human activities and land use. Nitrate contamination from point and non-point sources is a significant environmental problem impacting both surface and groundwater quality in Canada and worldwide (Rivett et al., 2008; Rudolph et al., 2015). The ambient concentration of nitrate within groundwater in B.C. and on Vancouver Island is typically very low, less than 0.1 mg/L (Wei et al., 2010; Barroso and Ormand, 2016; Barroso and Melnechenko, 2019). Nitrate concentrations greater than 1 mg/L in surface or groundwater are considered indicative of human impacts associated with industry, agriculture and urban development (Dubrovsky and et al, 2010). Elevated nitrate concentrations (above 2 mg/L) in groundwater can often be attributed to pollution sources, such as infiltration of surface water or run-off containing residues of chemical fertilizers or animal manure, or from human waste discharges from septic tanks or sewage systems (Health Canada, 2013).

In water, nitrate has no colour, taste, or smell and it can only be measured by a laboratory or chemical test. The drinking water guideline for nitrate in drinking water is a Maximum Acceptable Concentration (MAC) of 10 mg/L (when measured as nitrate-nitrogen) (Health Canada, 2025). Nitrate is a health concern as it can affect oxygen metabolism in the bloodstream, associated with adverse effects in young children, causing methaemoglobinaemia also called “blue baby syndrome” (Health Canada, 2013). Drinking water with nitrate at concentrations below current drinking water guidelines has also been linked to impacts on normal thyroid function, elevated risk of some cancers (colorectal, ovarian, thyroid, kidney and bladder), and adverse birth outcomes such as low birth rate and preterm birth (Schullehner et al., 2018; Temkin et al., 2019; Ward et al., 2018). Water treatment methods for the removal of nitrate include anion exchange, reverse osmosis, biological denitrification, and distillation. However, boiling water can increase nitrate concentration (Health Canada, 2013).

**Turbidity** is a measure of how clear or cloudy water is based on how it absorbs or scatters light passing through it (Health Canada, 2012). Turbidity is higher in water with a higher concentration of suspended particles, including fine silt, clay or mineral particulates, or microscopic organisms such as algae or protozoa e.g. in groundwater sources hydraulically connected to surface water. Water treatment processes such as disinfection may be less effective in water that has a higher turbidity; therefore turbidity <1 Nephelometric Turbidity Units (NTU) is recommended for untreated water entering a water distribution system. Water with higher turbidity may require pre-filtration to ensure disinfection is effective. Surface water generally has a higher turbidity compared to groundwater which can undergo natural filtration as water circulates through the aquifer materials. Changes in water turbidity can occur seasonally, for example increasing in shallow sources following heavy rains. Disturbances within a well or aquifer, such as during well or pump maintenance, or from nearby construction can also result in changes in groundwater turbidity (Health Canada, 2012).

**Bacteria** including total coliforms and *Escherichia coli* are analyzed to indicate the vulnerability of a water source to potential pathogens (Health Canada, 2020a). **Total coliform bacteria** are found naturally in shallow soil and surface water sources such as lakes and ponds. The presence of total coliforms in a groundwater sample may indicate that surface water or water from a shallow source has entered a well, for example, via recharge through shallow soils and sediments, or runoff or floodwater entering the well. Surface water and shallow groundwater may contain harmful pathogens that can affect the health of people using the water for drinking, therefore total coliforms in untreated groundwater is a general indication of the vulnerability of a water source to contamination (Health Canada, 2025).

***Escherichia coli (E. coli)*** are a type of fecal coliform bacteria present in the digestive systems of animals and humans; therefore if these bacteria are found, it indicates that the sample or the groundwater source has been contaminated with fecal matter, in which pathogens such as viruses or harmful bacteria may also be present (Health Canada, 2020b).

Groundwater from a well, and water from a surface or groundwater source that is disinfected e.g. using chlorine or ultraviolet disinfection, should not contain any total or fecal coliforms, therefore the Drinking Water Quality Guideline is zero Colony Forming Units per hundred millilitres of water (0 CFU/100 mL) (Health Canada, 2020a, 2020b).

The presence of total or fecal coliform bacteria in an untreated groundwater sample is often associated with problems related to well construction and maintenance. Observations with respect to well maintenance in the study wells is discussed further in section 6.3.

#### 6.2.3.1 *Comox groundwater monitoring network observations – Water quality indicators of aquifer processes and land use impacts*

**Chloride:** The concentration of chloride was low in samples from both shallow and deep groundwater sources, with a median chloride of 20.5 mg/L in groundwater from drilled wells compared to median chloride 16.5 mg/L in groundwater sampled from dug wells, as summarized in Table 5. The chloride concentration over time by site for shallow well sources is shown in Figure 10 and for deep wells is shown in Figure 11. Although there is some variability between sites, the concentration is relatively consistent over time at each location, and all water quality is considered fresh with no drinking water guideline exceedances for chloride.

**Nitrate:** Nitrate is higher in groundwater from shallow, dug wells, with a median concentration 0.89 mg/L, ranging from less than the laboratory detection limit (<0.02 mg/L) up to a maximum of 7.92 mg/L. In Figure 12, the nitrate concentration over time is shown for samples from four shallow well sites. The well at [REDACTED] has much higher nitrate concentration compared to other locations. The difference is potentially due to the influence of leachate from nearby septic systems; the area upgradient from this site has a higher lot density compared to the areas upgradient of the other sites. Figure 13 shows concentration over time of nitrate in groundwater sampled from drilled wells. The concentration was less than the reportable detection limit for three locations, and in a range of 1 mg/L at two other sites. In general, shallower groundwater sources may be more vulnerable to contamination from nitrates, to the proximity to nitrate sources such as septic sewage disposal and fertilizer applications in agricultural areas (Ward et al., 2018; Rayne et al., 2019). Nitrate concentrations are also often higher in winter, as the nitrate is flushed from shallow soil and sediment layers into deeper aquifer zones.

**Turbidity** was generally lower in groundwater from shallow wells (median 0.7 NTU) compared to deep wells (median from all samples, 2.5 NTU), as shown in Table 5. The turbidity over time is shown for groundwater samples from shallow wells (Figure 14) and deep wells (Figure 15). Minor seasonal trends were observed in two wells, where higher turbidity occurred in winter, likely due to entry of fine sediments from shallow recharge, increasing water cloudiness. Deep (drilled) wells had higher turbidity overall, with slightly higher concentrations in summer: in those cases the turbidity may be associated with mineral particulate which may be higher during dry periods when groundwater is less diluted.

From Table 5, it is noted that approximately half of the samples from shallow wells exceeded guidelines for pH, an operational parameter that is assessed due to its influence

on the effectiveness of water treatment processes. Rainwater is naturally more acidic, with lower pH, and therefore lower pH in groundwater from shallow wells reflects water from more recent recharge.

In terms of bacteria, as shown in Table 5, Table 6 and Table 7, total coliforms were present in samples from both deep and shallow wells, indicating the influences of recharge from shallow soil layers. However, the total coliform concentrations were much higher in samples from shallow wells. None of the samples from deep (drilled) wells had *E. coli* present, while *E. coli* was detected in samples from three of the shallow well sites, indicating that the well water had been contaminated by fecal material. Many of the shallow well owners, and some drilled well owners, had disinfection systems such as ultraviolet disinfection to remove bacteria and help ensure water was safe for potable use. The presence of total coliform and *E. coli* were considered related to aspects of well construction and maintenance, discussed further in section 6.3 below.

The water quality results in all cases were believed to be associated with ambient conditions and natural variability within the aquifer source and wells. No observations appeared to be associated with changes introduced due to construction of the sewer main.

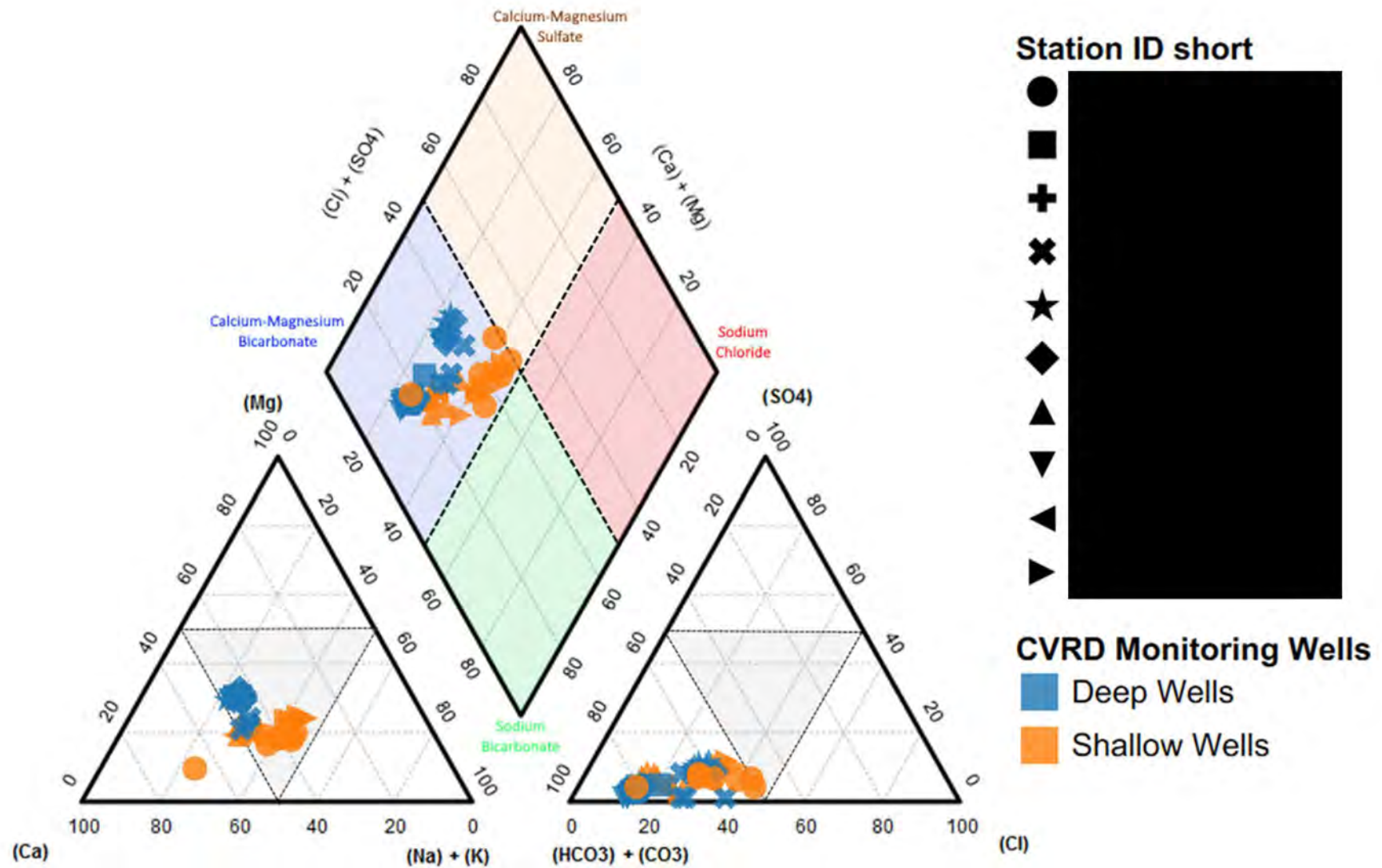


**Table 5: Groundwater quality results, median concentration in shallow and deep wells before and after pipeline construction.**

|                                 |             | Number of tests |       |            |       | Median Concentration |        |             |            |       |             | Drinking Water Quality Guideline |      |     |
|---------------------------------|-------------|-----------------|-------|------------|-------|----------------------|--------|-------------|------------|-------|-------------|----------------------------------|------|-----|
|                                 |             | Shallow Wells   |       | Deep Wells |       | Shallow Wells        |        |             | Deep Wells |       |             |                                  |      |     |
| Parameter                       | Result Unit | Before          | After | Before     | After | Before               | After  | All samples | Before     | After | All samples | MAC                              | AO   | OG  |
| General Chemistry & Nutrients   |             |                 |       |            |       |                      |        |             |            |       |             |                                  |      |     |
| Chloride (Cl)                   | mg/L        | 21              | 4     | 31         | 4     | 16                   | 17     | 16.5        | 16         | 25    | 20.5        | -                                | 250  | -   |
| Dissolved Fluoride (F)          | mg/L        | 21              |       | 31         |       | 0.05                 |        | 0.05        | 0.05       |       | 0.05        | 1.5                              | -    | -   |
| Nitrate (N)                     | mg/L        | 21              | 4     | 31         | 4     | 1.33                 | 0.4575 | 0.8938      | 0.023      | 0.11  | 0.0665      | 10                               | -    | -   |
| Nitrite (N)                     | mg/L        | 21              | 4     | 31         | 4     | 0.005                | 0.005  | 0.005       | 0.005      | 0.005 | 0.005       | 1                                | -    | -   |
| pH                              | pH          | 21              | 4     | 31         | 4     | 7.01                 | 6.94   | 6.975       | 7.76       | 7.505 | 7.63        | 7.0:<br>10.5                     | -    | -   |
| Sulphate (SO4)                  | mg/L        | 21              | 4     | 31         | 4     | 5.4                  | 6.45   | 5.925       | 5.4        | 2.8   | 4.1         | -                                | 500  | -   |
| Total Dissolved Solids          | mg/L        | 21              | 4     | 31         | 4     | 100                  | 130    | 115         | 170        | 155   | 162.5       | -                                | -    | -   |
| Total Sulphide                  | mg/L        | 18              |       | 26         |       | 0.0018               |        | 0.0018      | 0.0028     |       | 0.0028      | -                                | 0.05 | -   |
| Turbidity                       | NTU         | 21              | 4     | 31         | 4     | 0.67                 | 0.77   | 0.72        | 1.1        | 3.84  | 2.47        |                                  |      |     |
| True Colour                     | Col. unit   | 21              |       | 31         |       | 5                    |        | 5           | 5          |       | 5           | -                                | 15   | -   |
| Elements by Atomic Spectroscopy |             |                 |       |            |       |                      |        |             |            |       |             |                                  |      |     |
| Dissolved Aluminum (Al)         | µg/L        | 18              | 4     | 26         | 4     | 3.5                  | 3.25   | 3.375       | 3          | 3     | 3           | 2900                             | -    | 100 |
| Dissolved Antimony (Sb)         | µg/L        | 18              | 4     | 26         | 4     | 0.5                  | 0.5    | 0.5         | 0.5        | 0.5   | 0.5         | 6                                | -    | -   |
| Dissolved Arsenic (As)          | µg/L        | 18              | 4     | 26         | 4     | 0.15                 | 0.115  | 0.1325      | 0.1        | 0.105 | 0.1025      | 10                               | -    | -   |
| Dissolved Barium (Ba)           | µg/L        | 18              | 4     | 26         | 4     | 1.55                 | 2      | 1.775       | 11.8       | 8.75  | 10.275      | 2000                             | -    | -   |
| Dissolved Boron (B)             | µg/L        | 18              | 4     | 26         | 4     | 50                   | 50     | 50          | 50         | 50    | 50          | 5000                             | -    | -   |
| Dissolved Cadmium (Cd)          | µg/L        | 18              | 4     | 26         | 4     | 0.01                 | 0.01   | 0.01        | 0.01       | 0.01  | 0.01        | 7                                | -    | -   |
| Dissolved Chromium (Cr)         | µg/L        | 18              | 4     | 26         | 4     | 1                    | 1      | 1           | 1          | 1     | 1           | 50                               | -    | -   |
| Dissolved Copper (Cu)           | µg/L        | 18              | 4     | 26         | 4     | 2.455                | 2.185  | 2.32        | 0.495      | 0.2   | 0.3475      | 2000                             | -    | -   |
| Dissolved Iron (Fe)             | µg/L        | 18              | 4     | 26         | 4     | 35.85                | 108.5  | 72.175      | 21.65      | 413.3 | 217.48      | -                                | 100  | -   |
| Dissolved Lead (Pb)             | µg/L        | 18              | 4     | 26         | 4     | 0.2                  | 0.23   | 0.215       | 0.2        | 0.2   | 0.2         | 5                                | -    | -   |

| Parameter                    | Result Unit | Number of tests |       |            |       | Median Concentration |        |             |            |        |             | Drinking Water Quality Guideline |      |     |
|------------------------------|-------------|-----------------|-------|------------|-------|----------------------|--------|-------------|------------|--------|-------------|----------------------------------|------|-----|
|                              |             | Shallow Wells   |       | Deep Wells |       | Shallow Wells        |        |             | Deep Wells |        |             | MAC                              | AO   | OG  |
|                              |             | Before          | After | Before     | After | Before               | After  | All samples | Before     | After  | All samples |                                  |      |     |
| Dissolved Manganese (Mn)     | µg/L        | 18              | 4     | 26         | 4     | 23.1                 | 70.15  | 46.625      | 37.95      | 50.5   | 44.225      | 120                              | 20   | -   |
| Dissolved Selenium (Se)      | µg/L        | 18              | 4     | 26         | 4     | 0.1                  | 0.1    | 0.1         | 0.1        | 0.145  | 0.1225      | 50                               | -    | -   |
| Dissolved Sodium (Na)        | mg/L        | 18              | 4     | 26         | 4     | 14.35                | 15.75  | 15.05       | 15.15      | 15.3   | 15.225      | -                                | 200  | -   |
| Dissolved Uranium (U)        | µg/L        | 18              | 4     | 26         | 4     | 0.1                  | 0.1    | 0.1         | 0.1        | 0.1    | 0.1         | 20                               | -    | -   |
| Dissolved Zinc (Zn)          | µg/L        | 18              | 4     | 26         | 4     | 10.85                | 9.8    | 10.325      | 9          | 5.9    | 7.45        | -                                | 5000 | -   |
| Total Aluminum (Al)          | µg/L        | 21              | 4     | 31         | 4     | 13.4                 | 8.8    | 11.1        | 3          | 9      | 6           | 2900                             | -    | 100 |
| Total Antimony (Sb)          | µg/L        | 21              | 4     | 31         | 4     | 0.5                  | 0.5    | 0.5         | 0.5        | 0.5    | 0.5         | 6                                | -    | -   |
| Total Arsenic (As)           | µg/L        | 21              | 4     | 31         | 4     | 0.16                 | 0.145  | 0.1525      | 0.1        | 0.105  | 0.1025      | 10                               | -    | -   |
| Total Barium (Ba)            | µg/L        | 21              | 4     | 31         | 4     | 2.3                  | 2.2    | 2.25        | 12.7       | 9      | 10.85       | 2000                             | -    | -   |
| Total Boron (B)              | µg/L        | 21              | 4     | 31         | 4     | 50                   | 50     | 50          | 50         | 50     | 50          | 5000                             | -    | -   |
| Total Cadmium (Cd)           | µg/L        | 21              | 4     | 31         | 4     | 0.01                 | 0.01   | 0.01        | 0.01       | 0.01   | 0.01        | 7                                | -    | -   |
| Total Chromium (Cr)          | µg/L        | 21              | 4     | 31         | 4     | 1                    | 1      | 1           | 1          | 1      | 1           | 50                               | -    | -   |
| Total Copper (Cu)            | µg/L        | 21              | 4     | 31         | 4     | 4.04                 | 3.05   | 3.545       | 2.76       | 0.675  | 1.7175      | 2000                             | 1000 | -   |
| Total Iron (Fe)              | µg/L        | 21              | 4     | 31         | 4     | 166                  | 307.5  | 236.75      | 213        | 461    | 337         | -                                | 100  | -   |
| Total Lead (Pb)              | µg/L        | 21              | 4     | 31         | 4     | 0.2                  | 0.31   | 0.255       | 0.2        | 0.2    | 0.2         | 5                                | -    | -   |
| Total Manganese (Mn)         | µg/L        | 21              | 4     | 31         | 4     | 22.1                 | 77.5   | 49.8        | 39.6       | 52.55  | 46.075      | 120                              | 20   | -   |
| Total Selenium (Se)          | µg/L        | 21              | 4     | 31         | 4     | 0.1                  | 0.1    | 0.1         | 0.1        | 0.1    | 0.1         | 50                               | -    | -   |
| Total Sodium (Na)            | mg/L        | 21              | 4     | 31         | 4     | 14                   | 16.45  | 15.225      | 14.5       | 15.25  | 14.875      | -                                | 200  | -   |
| Total Uranium (U)            | µg/L        | 21              | 4     | 31         | 4     | 0.1                  | 0.1    | 0.1         | 0.1        | 0.1    | 0.1         | 20                               | -    | -   |
| Total Zinc (Zn)              | µg/L        | 21              | 4     | 31         | 4     | 12.4                 | 13.15  | 12.775      | 10.8       | 7.7    | 9.25        | -                                | 5000 | -   |
| <b>Mercury by Cold Vapor</b> |             |                 |       |            |       |                      |        |             |            |        |             |                                  |      |     |
| Dissolved Mercury (Hg)       | ug/L        | 11              | 4     | 16         | 4     | 0.0019               | 0.0019 | 0.0019      | 0.0019     | 0.0019 | 0.0019      | 1                                | -    | -   |
| Total Mercury (Hg)           | ug/L        | 21              |       | 31         |       | 0.0019               |        | 0.0019      | 0.0019     |        | 0.0019      | 1                                | -    | -   |
| <b>Microbiology</b>          |             |                 |       |            |       |                      |        |             |            |        |             |                                  |      |     |
| Total Coliforms              | CFU/100mL   | 21              | 4     | 31         | 4     | 38                   | 4950   | 2494        | 2          | 2      | 2           | -                                | -    | -   |

|           |             | Number of tests |       |            |       | Median Concentration |       |             |            |       |             | Drinking Water Quality Guideline |    |    |
|-----------|-------------|-----------------|-------|------------|-------|----------------------|-------|-------------|------------|-------|-------------|----------------------------------|----|----|
|           |             | Shallow Wells   |       | Deep Wells |       | Shallow Wells        |       |             | Deep Wells |       |             |                                  |    |    |
| Parameter | Result Unit | Before          | After | Before     | After | Before               | After | All samples | Before     | After | All samples | MAC                              | AO | OG |
| E. coli   | CFU/100mL   | 21              | 4     | 31         | 4     | 0                    | 2     | 1           | 0          | 0     | 0           | -                                | -  | -  |

**Notes:**

MAC Maximum Acceptable Concentration  
 AO Aesthetic Objective  
 OG Operational guideline for water systems.

**Table 6: Sample drinking water quality exceedances for deep (drilled) and shallow (dug) wells.**

|                                 |             | Shallow Wells   |       | Deep Wells |       | Shallow Wells                                                                     |                                                                     |                                                                     |                                                                     | Deep Wells                                                          |                                    |                                    |                                    | Shallow Wells       |                    | Deep Wells          |                    |
|---------------------------------|-------------|-----------------|-------|------------|-------|-----------------------------------------------------------------------------------|---------------------------------------------------------------------|---------------------------------------------------------------------|---------------------------------------------------------------------|---------------------------------------------------------------------|------------------------------------|------------------------------------|------------------------------------|---------------------|--------------------|---------------------|--------------------|
|                                 |             | Before          | After | Before     | After | Before Construction                                                               |                                                                     | After Construction                                                  |                                                                     | Before Construction                                                 |                                    | After Construction                 |                                    | Before Construction | After Construction | Before Construction | After Construction |
| Parameter                       | Result Unit | Number of tests |       |            |       | Exceeds AO<br>Exceeds AO and MAC<br>Exceeds MAC<br>Exceeds OG<br>Within guideline | Exceeds AO<br>Exceeds AO and MAC<br>Exceeds MAC<br>Within guideline | Exceeds AO<br>Exceeds AO and MAC<br>Exceeds MAC<br>Within guideline | Exceeds AO<br>Exceeds AO and MAC<br>Exceeds MAC<br>Within guideline | Exceeds AO<br>Exceeds AO and MAC<br>Exceeds MAC<br>Within guideline | Turbidity >1NTU<br>Turbidity >1NTU | Turbidity >1NTU<br>Turbidity >1NTU | Turbidity >1NTU<br>Turbidity >1NTU |                     |                    |                     |                    |
| General Chemistry & Nutrients   |             |                 |       |            |       |                                                                                   |                                                                     |                                                                     |                                                                     |                                                                     |                                    |                                    |                                    |                     |                    |                     |                    |
| Chloride (Cl)                   | mg/L        | 21              | 4     | 31         | 4     | 21                                                                                |                                                                     | 4                                                                   |                                                                     | 31                                                                  |                                    | 4                                  |                                    |                     |                    |                     |                    |
| Dissolved Fluoride (F)          | mg/L        | 21              |       | 31         |       | 21                                                                                |                                                                     |                                                                     |                                                                     | 31                                                                  |                                    |                                    |                                    |                     |                    |                     |                    |
| Nitrate (N)                     | mg/L        | 21              | 4     | 31         | 4     | 21                                                                                |                                                                     | 4                                                                   |                                                                     | 31                                                                  |                                    | 4                                  |                                    |                     |                    |                     |                    |
| Nitrite (N)                     | mg/L        | 21              | 4     | 31         | 4     | 21                                                                                |                                                                     | 4                                                                   |                                                                     | 31                                                                  |                                    | 4                                  |                                    |                     |                    |                     |                    |
| pH                              | pH          | 21              | 4     | 31         | 4     | 10                                                                                | 11                                                                  | 2                                                                   | 2                                                                   | 2                                                                   | 29                                 | 4                                  |                                    |                     |                    |                     |                    |
| Sulphate (SO4)                  | mg/L        | 21              | 4     | 31         | 4     | 21                                                                                |                                                                     | 4                                                                   |                                                                     | 31                                                                  |                                    | 4                                  |                                    |                     |                    |                     |                    |
| Total Dissolved Solids (TDS)    | mg/L        | 21              | 4     | 31         | 4     | 21                                                                                |                                                                     | 4                                                                   |                                                                     | 31                                                                  |                                    | 4                                  |                                    |                     |                    |                     |                    |
| Total Sulphide (S2)             | mg/L        | 18              |       | 26         |       | 1                                                                                 | 17                                                                  |                                                                     |                                                                     | 3                                                                   | 23                                 |                                    |                                    |                     |                    |                     |                    |
| True Colour                     | Col. Unit   | 21              |       | 31         |       | 2                                                                                 | 19                                                                  |                                                                     |                                                                     | 5                                                                   | 26                                 |                                    |                                    |                     |                    |                     |                    |
| Turbidity                       | NTU         | 21              | 4     | 31         | 4     |                                                                                   |                                                                     |                                                                     |                                                                     |                                                                     |                                    |                                    |                                    | 7                   | 1                  | 21                  | 2                  |
| Elements by Atomic Spectroscopy |             |                 |       |            |       |                                                                                   |                                                                     |                                                                     |                                                                     |                                                                     |                                    |                                    |                                    |                     |                    |                     |                    |
| Dissolved Metals                |             |                 |       |            |       |                                                                                   |                                                                     |                                                                     |                                                                     |                                                                     |                                    |                                    |                                    |                     |                    |                     |                    |
| Aluminum (Al)                   | µg/L        | 18              | 4     | 26         | 4     | 18                                                                                |                                                                     | 4                                                                   |                                                                     | 26                                                                  |                                    | 4                                  |                                    |                     |                    |                     |                    |
| Antimony (Sb)                   | µg/L        | 18              | 4     | 26         | 4     | 18                                                                                |                                                                     | 4                                                                   |                                                                     | 26                                                                  |                                    | 4                                  |                                    |                     |                    |                     |                    |
| Arsenic (As)                    | µg/L        | 18              | 4     | 26         | 4     | 18                                                                                |                                                                     | 4                                                                   |                                                                     | 26                                                                  |                                    | 4                                  |                                    |                     |                    |                     |                    |
| Barium (Ba)                     | µg/L        | 18              | 4     | 26         | 4     | 18                                                                                |                                                                     | 4                                                                   |                                                                     | 26                                                                  |                                    | 4                                  |                                    |                     |                    |                     |                    |
| Boron (B)                       | µg/L        | 18              | 4     | 26         | 4     | 18                                                                                |                                                                     | 4                                                                   |                                                                     | 26                                                                  |                                    | 4                                  |                                    |                     |                    |                     |                    |
| Cadmium (Cd)                    | µg/L        | 18              | 4     | 26         | 4     | 18                                                                                |                                                                     | 4                                                                   |                                                                     | 26                                                                  |                                    | 4                                  |                                    |                     |                    |                     |                    |

|                |             | Shallow Wells   |       | Deep Wells |       | Shallow Wells       |   |                    |  | Deep Wells          |   |                    |   | Shallow Wells       |                    | Deep Wells          |                    |                  |  |                    |    |             |  |                  |   |                 |  |                 |  |                 |  |                 |  |
|----------------|-------------|-----------------|-------|------------|-------|---------------------|---|--------------------|--|---------------------|---|--------------------|---|---------------------|--------------------|---------------------|--------------------|------------------|--|--------------------|----|-------------|--|------------------|---|-----------------|--|-----------------|--|-----------------|--|-----------------|--|
|                |             | Before          | After | Before     | After | Before Construction |   | After Construction |  | Before Construction |   | After Construction |   | Before Construction | After Construction | Before Construction | After Construction |                  |  |                    |    |             |  |                  |   |                 |  |                 |  |                 |  |                 |  |
| Parameter      | Result Unit | Number of tests |       |            |       | Exceeds AO and MAC  |   | Exceeds MAC        |  | Exceeds OG          |   | Within guideline   |   | Exceeds AO and MAC  |                    | Exceeds MAC         |                    | Within guideline |  | Exceeds AO and MAC |    | Exceeds MAC |  | Within guideline |   | Turbidity >1NTU |  | Turbidity >1NTU |  | Turbidity >1NTU |  | Turbidity >1NTU |  |
| Chromium (Cr)  | µg/L        | 18              | 4     | 26         | 4     |                     |   |                    |  |                     |   | 18                 |   |                     |                    |                     |                    |                  |  | 26                 |    |             |  |                  |   | 4               |  |                 |  |                 |  |                 |  |
| Copper (Cu)    | µg/L        | 18              | 4     | 26         | 4     |                     |   |                    |  |                     |   | 18                 |   |                     |                    |                     |                    |                  |  | 26                 |    |             |  |                  |   | 4               |  |                 |  |                 |  |                 |  |
| Iron (Fe)      | µg/L        | 18              | 4     | 26         | 4     | 1                   |   |                    |  | 17                  | 1 |                    | 3 | 4                   |                    | 22                  | 2                  |                  |  |                    | 26 |             |  |                  | 2 |                 |  |                 |  |                 |  |                 |  |
| Lead (Pb)      | µg/L        | 18              | 4     | 26         | 4     |                     |   |                    |  |                     |   | 18                 |   |                     |                    |                     |                    |                  |  | 26                 |    |             |  |                  |   | 4               |  |                 |  |                 |  |                 |  |
| Manganese (Mn) | µg/L        | 18              | 4     | 26         | 4     | 7                   | 3 |                    |  | 8                   | 2 | 1                  | 1 | 14                  | 3                  | 9                   | 2                  | 1                |  |                    | 26 |             |  |                  | 1 |                 |  |                 |  |                 |  |                 |  |
| Selenium (Se)  | µg/L        | 18              | 4     | 26         | 4     |                     |   |                    |  |                     |   | 18                 |   |                     |                    |                     |                    |                  |  | 26                 |    |             |  |                  |   | 4               |  |                 |  |                 |  |                 |  |
| Sodium (Na)    | mg/L        | 18              | 4     | 26         | 4     |                     |   |                    |  |                     |   | 18                 |   |                     |                    |                     |                    |                  |  | 26                 |    |             |  |                  |   | 4               |  |                 |  |                 |  |                 |  |
| Uranium (U)    | µg/L        | 18              | 4     | 26         | 4     |                     |   |                    |  |                     |   | 18                 |   |                     |                    |                     |                    |                  |  | 26                 |    |             |  |                  |   | 4               |  |                 |  |                 |  |                 |  |
| Zinc (Zn)      | µg/L        | 18              | 4     | 26         | 4     |                     |   |                    |  |                     |   | 18                 |   |                     |                    |                     |                    |                  |  | 26                 |    |             |  |                  |   | 4               |  |                 |  |                 |  |                 |  |
| Total Metals   |             |                 |       |            |       |                     |   |                    |  |                     |   |                    |   |                     |                    |                     |                    |                  |  |                    |    |             |  |                  |   |                 |  |                 |  |                 |  |                 |  |
| Aluminum (Al)  | µg/L        | 21              | 4     | 31         | 4     |                     |   |                    |  | 1                   |   | 20                 |   |                     |                    |                     |                    |                  |  | 31                 |    |             |  |                  |   | 4               |  |                 |  |                 |  |                 |  |
| Antimony (Sb)  | µg/L        | 21              | 4     | 31         | 4     |                     |   |                    |  |                     |   | 21                 |   |                     |                    |                     |                    |                  |  | 31                 |    |             |  |                  |   | 4               |  |                 |  |                 |  |                 |  |
| Arsenic (As)   | µg/L        | 21              | 4     | 31         | 4     |                     |   |                    |  |                     |   | 21                 |   |                     |                    |                     |                    |                  |  | 31                 |    |             |  |                  |   | 4               |  |                 |  |                 |  |                 |  |
| Barium (Ba)    | µg/L        | 21              | 4     | 31         | 4     |                     |   |                    |  |                     |   | 21                 |   |                     |                    |                     |                    |                  |  | 31                 |    |             |  |                  |   | 4               |  |                 |  |                 |  |                 |  |
| Boron (B)      | µg/L        | 21              | 4     | 31         | 4     |                     |   |                    |  |                     |   | 21                 |   |                     |                    |                     |                    |                  |  | 31                 |    |             |  |                  |   | 4               |  |                 |  |                 |  |                 |  |
| Cadmium (Cd)   | µg/L        | 21              | 4     | 31         | 4     |                     |   |                    |  |                     |   | 21                 |   |                     |                    |                     |                    |                  |  | 31                 |    |             |  |                  |   | 4               |  |                 |  |                 |  |                 |  |
| Chromium (Cr)  | µg/L        | 21              | 4     | 31         | 4     |                     |   |                    |  |                     |   | 21                 |   |                     |                    |                     |                    |                  |  | 31                 |    |             |  |                  |   | 4               |  |                 |  |                 |  |                 |  |
| Copper (Cu)    | µg/L        | 21              | 4     | 31         | 4     |                     |   |                    |  |                     |   | 21                 |   |                     |                    |                     |                    |                  |  | 31                 |    |             |  |                  |   | 4               |  |                 |  |                 |  |                 |  |
| Iron (Fe)      | µg/L        | 21              | 4     | 31         | 4     | 6                   |   |                    |  | 15                  | 2 |                    | 2 | 14                  |                    | 17                  | 2                  |                  |  |                    | 26 |             |  |                  | 2 |                 |  |                 |  |                 |  |                 |  |
| Lead (Pb)      | µg/L        | 21              | 4     | 31         | 4     |                     |   |                    |  |                     |   | 21                 |   |                     |                    |                     |                    |                  |  | 31                 |    |             |  |                  |   | 4               |  |                 |  |                 |  |                 |  |

|                        |               | Shallow Wells   |                 | Deep Wells                                                                        |                                                                     | Shallow Wells                                                       |                                                                     |                                                                     |                                    | Deep Wells                         |    |                        |                       | Shallow Wells          |                       | Deep Wells |   |    |   |
|------------------------|---------------|-----------------|-----------------|-----------------------------------------------------------------------------------|---------------------------------------------------------------------|---------------------------------------------------------------------|---------------------------------------------------------------------|---------------------------------------------------------------------|------------------------------------|------------------------------------|----|------------------------|-----------------------|------------------------|-----------------------|------------|---|----|---|
|                        |               | Before<br>After | Before<br>After | Before<br>Construction                                                            |                                                                     | After<br>Construction                                               |                                                                     | Before<br>Construction                                              |                                    | After<br>Construction              |    | Before<br>Construction | After<br>Construction | Before<br>Construction | After<br>Construction |            |   |    |   |
| Parameter              | Result Unit   | Number of tests |                 | Exceeds AO<br>Exceeds AO and MAC<br>Exceeds MAC<br>Exceeds OG<br>Within guideline | Exceeds AO<br>Exceeds AO and MAC<br>Exceeds MAC<br>Within guideline | Exceeds AO<br>Exceeds AO and MAC<br>Exceeds MAC<br>Within guideline | Exceeds AO<br>Exceeds AO and MAC<br>Exceeds MAC<br>Within guideline | Exceeds AO<br>Exceeds AO and MAC<br>Exceeds MAC<br>Within guideline | Turbidity >1NTU<br>Turbidity >1NTU | Turbidity >1NTU<br>Turbidity >1NTU |    |                        |                       |                        |                       |            |   |    |   |
| Manganese (Mn)         | µg/L          | 21              | 4               | 31                                                                                | 4                                                                   | 9                                                                   | 3                                                                   | 9                                                                   | 2                                  | 1                                  | 1  | 18                     | 2                     | 11                     | 2                     | 1          | 1 |    |   |
| Selenium (Se)          | µg/L          | 21              | 4               | 31                                                                                | 4                                                                   |                                                                     |                                                                     | 21                                                                  |                                    |                                    | 4  |                        |                       | 31                     |                       |            | 4 |    |   |
| Sodium (Na)            | mg/L          | 21              | 4               | 31                                                                                | 4                                                                   |                                                                     |                                                                     | 21                                                                  |                                    |                                    | 4  |                        |                       | 31                     |                       |            | 4 |    |   |
| Uranium (U)            | µg/L          | 21              | 4               | 31                                                                                | 4                                                                   |                                                                     |                                                                     | 21                                                                  |                                    |                                    | 4  |                        |                       | 31                     |                       |            | 4 |    |   |
| Zinc (Zn)              | µg/L          | 21              | 4               | 31                                                                                | 4                                                                   |                                                                     |                                                                     | 21                                                                  |                                    |                                    | 4  |                        |                       | 31                     |                       |            | 4 |    |   |
| Mercury by Cold Vapor  |               |                 |                 |                                                                                   |                                                                     |                                                                     |                                                                     |                                                                     |                                    |                                    |    |                        |                       |                        |                       |            |   |    |   |
| Dissolved Mercury (Hg) | µg/L          | 11              | 4               | 16                                                                                | 4                                                                   |                                                                     |                                                                     | 11                                                                  |                                    |                                    | 4  |                        |                       | 16                     |                       |            | 4 |    |   |
| Total Mercury (Hg)     | µg/L          | 21              |                 | 31                                                                                |                                                                     |                                                                     |                                                                     | 21                                                                  |                                    |                                    |    |                        |                       | 31                     |                       |            |   |    |   |
| Microbiology           |               |                 |                 |                                                                                   |                                                                     |                                                                     |                                                                     |                                                                     |                                    |                                    |    |                        |                       |                        |                       |            |   |    |   |
| E. coli                | CFU/<br>100mL | 21              | 4               | 31                                                                                | 4                                                                   |                                                                     |                                                                     | 2                                                                   |                                    |                                    | 19 |                        |                       | 3                      | 1                     |            |   | 31 | 4 |
| Total Coliforms        | CFU/<br>100mL | 21              | 4               | 31                                                                                | 4                                                                   |                                                                     |                                                                     | 18                                                                  |                                    |                                    | 3  |                        |                       | 3                      | 1                     |            |   | 24 | 7 |

Table 7: Drinking water quality exceedances over time in groundwater from deep and shallow wells.

|                |                |                  |                   | Analyte / ResultUnit_Unit    |                      |                          |                         |                         |                         | Exceedance label |                           |  |
|----------------|----------------|------------------|-------------------|------------------------------|----------------------|--------------------------|-------------------------|-------------------------|-------------------------|------------------|---------------------------|--|
| CVRD Monit..   | Well Depht ..  | Station ID short | Month of Sampli.. | Total Coliforms<br>CFU/100mL | E. coli<br>CFU/100mL | True Colour<br>Col. Unit | Total Iron (Fe)<br>ug/L | Total Mangane..<br>ug/L | Dissolved Man..<br>ug/L |                  | Dissolved Iron ..<br>ug/L |  |
| Deep Wells     | Depth 18 m     |                  | August 2023       | 1                            | 0                    | 221                      | 8370                    | 118                     | 135                     | 7570             | Within guideline          |  |
|                |                |                  | March 2024        | <2                           | <2                   | 202                      | 11600                   | 134                     | 151                     | 11600            | Exceeds MAC               |  |
|                |                |                  | August 2024       | <2                           | <2                   | 228                      | 12400                   | 153                     | 167                     | 13400            | Exceeds AO                |  |
|                |                |                  | September 2025    | <2                           | <2                   |                          | 16400                   | 184                     | 150                     | 11800            | Exceeds AO and MAC        |  |
|                | Depth 23 m     |                  | March 2022        | 70                           | 0                    | <5.0                     | 26.3                    | 1.4                     |                         |                  |                           |  |
|                |                |                  | June 2022         | 1                            | 0                    | <5.0                     | 15.5                    | <1.0                    | <1.0                    | <5.0             |                           |  |
|                |                |                  | September 2022    | 0                            | 0                    | <5.0                     | 8                       | <1.0                    | <1.0                    | <5.0             |                           |  |
|                |                |                  | December 2022     | 61                           | 0                    | <5.0                     | 70.9                    | <1.0                    | <1.0                    | <5.0             |                           |  |
|                | Depth 31 m     |                  | April 2023        | 5                            | 0                    | <5.0                     | 41.7                    | 1.4                     | 1.8                     | 13.8             |                           |  |
|                |                |                  | March 2022        | 2                            | 0                    | <5.0                     | 28.8                    | 1.3                     |                         |                  |                           |  |
|                |                |                  | June 2022         | 1                            | 0                    | <5.0                     | 18.4                    | 1.7                     | 1.3                     | <5.0             |                           |  |
|                |                |                  | September 2022    | 2                            | 0                    | <5.0                     | 108                     | 1.6                     | <1.0                    | <5.0             |                           |  |
|                |                |                  | December 2022     | 0                            | 0                    | <5.0                     | 13.3                    | <1.0                    | <1.0                    | <5.0             |                           |  |
|                |                |                  | April 2023        | 6                            | 0                    | <5.0                     | 110                     | 2.6                     | 1.2                     | 5.8              |                           |  |
|                |                |                  | August 2024       | 1                            | 0                    | <2.0                     | 36.9                    | 1.8                     | <1.0                    | <5.0             |                           |  |
|                |                |                  | September 2025    | 2                            | 0                    |                          | 52                      | 2.1                     | <1.0                    | <5.0             |                           |  |
|                | Depth 43 m     |                  | March 2022        | 15                           | 0                    | 44.9                     | 658                     | 38                      |                         |                  |                           |  |
|                |                |                  | June 2022         | 58                           | 0                    | <5.0                     | 669                     | 43                      | 39.9                    | 56.6             |                           |  |
|                |                |                  | September 2022    | 17                           | 0                    | <5.0                     | 525                     | 35.9                    | 35.7                    | 13.1             |                           |  |
|                |                |                  | December 2022     | 4                            | 0                    | <5.0                     | 633                     | 39.6                    | 41.5                    | 41.4             |                           |  |
|                | Depth 50 m     |                  | April 2023        | 3                            | 0                    | <5.0                     | 646                     | 36.5                    | 36                      | 37.8             |                           |  |
|                |                |                  | March 2022        | 100                          | 0                    | 56.6                     | 1120                    | 64                      |                         |                  |                           |  |
|                |                |                  | June 2022         | 2                            | 0                    | <5.0                     | 751                     | 50.8                    | 48.2                    | 55.2             |                           |  |
|                |                |                  | September 2022    | 0                            | 0                    | <5.0                     | 806                     | 50.8                    | 47.4                    | 13.8             |                           |  |
|                |                |                  | December 2022     | 18                           | 0                    | <5.0                     | 817                     | 51.9                    | 50.9                    | 12.1             |                           |  |
|                |                |                  | April 2023        | 130                          | 0                    | <5.0                     | 751                     | 52.3                    | 50.7                    | 28.4             |                           |  |
|                |                |                  | August 2024       | 0                            | 0                    | 2.2                      | 806                     | 52.9                    | 51.9                    | 707              |                           |  |
|                |                |                  | September 2025    | 82                           | 0                    |                          | 842                     | 56                      | 52.9                    | 769              |                           |  |
|                | Depth 55 m     |                  | March 2022        | 1                            | 0                    | 9.1                      | 146                     | 41                      |                         |                  |                           |  |
|                |                |                  | June 2022         | 1                            | 0                    | <5.0                     | 218                     | 45.5                    | 42                      | 47.7             |                           |  |
| September 2022 |                |                  | 0                 | 0                            | <5.0                 | 135                      | 27.8                    | 27.1                    | 14.9                    |                  |                           |  |
| December 2022  |                |                  | 0                 | 0                            | 8.5                  | 150                      | 39.8                    | 36                      | 89.5                    |                  |                           |  |
|                | April 2023     |                  | 9                 | 0                            | 7                    | 136                      | 44.2                    | 40.9                    | 33.7                    |                  |                           |  |
|                | August 2024    |                  | 0                 | 0                            | 5.2                  | 213                      | 57.4                    | 56.2                    | 137                     |                  |                           |  |
|                | September 2025 |                  | 0                 | 0                            |                      | 80                       | 49.1                    | 48.1                    | 57.6                    |                  |                           |  |
|                | Shallow Wells  |                  | Depth 4 m         | March 2022                   | 260                  | 0                        | 19.4                    | 275                     | 18.7                    |                  |                           |  |
| June 2022      |                |                  |                   | 38                           | 0                    | <5.0                     | 534                     | 42.1                    | 43.5                    | 178              |                           |  |
| September 2022 |                |                  |                   | 48                           | 0                    | <5.0                     | 136                     | 25                      | 23.9                    | 25               |                           |  |
| December 2022  |                |                  |                   | 470                          | 0                    | 12.6                     | 308                     | 35.4                    | 33                      | 33.2             |                           |  |
|                |                |                  | April 2023        | 45                           | 0                    | <5.0                     | 261                     | 28                      | 27.4                    | 83               |                           |  |
|                |                |                  | August 2024       | 110                          | 83                   | 2.9                      | 227                     | 16.9                    | 14.5                    | 68.3             |                           |  |
|                |                |                  | September 2025    | 3400                         | 28                   |                          | 373                     | 16.1                    | 14.4                    | 108              |                           |  |
|                |                |                  | Depth 5 m         | March 2022                   | 36                   | 0                        | <5.0                    | 13.3                    | <1.0                    |                  |                           |  |
| June 2022      |                |                  |                   | 0                            | 0                    | <5.0                     | 9.5                     | 2.1                     | 2                       | <5.0             |                           |  |
| September 2022 |                |                  |                   | >2000                        | 0                    | 6.1                      | 25.1                    | 26                      | 22.3                    | 6.8              |                           |  |
| December 2022  |                |                  |                   | 9100                         | 0                    | 36.1                     | 2290                    | 142                     | 122                     | 258              |                           |  |
|                |                |                  | April 2023        | 65                           | 1                    | 5                        | 227                     | 2.9                     | 19.9                    | 148              |                           |  |
|                |                |                  | August 2024       | 18                           | 0                    | 4.9                      | 2610                    | 156                     | 154                     | 2130             |                           |  |
|                |                |                  | September 2025    | 14000                        | 2                    |                          | 655                     | 64.7                    | 58.2                    | 527              |                           |  |
|                |                |                  | Depth 6 m         | August 2023                  | 4000                 | 0                        | <5.0                    | 1140                    | 20.7                    | 4.4              | 13                        |  |
| March 2024     |                |                  |                   | 52                           | 0                    | 10.5                     | 166                     | 4.9                     | 5                       | 86.8             |                           |  |
| August 2024    |                |                  |                   | 36                           | 0                    | 3.1                      | 36.6                    | 17.2                    | 17.2                    | 33               |                           |  |
| September 2025 |                |                  |                   | 6500                         | 2                    |                          | 242                     | 90.3                    | 82.1                    | 109              |                           |  |
| Depth 7 m      |                |                  | March 2022        | 23                           | 0                    | 14.1                     | 127                     | 5.7                     |                         |                  |                           |  |
|                |                |                  | June 2022         | 1                            | 0                    | <5.0                     | 81.5                    | 113                     | 106                     | 38.5             |                           |  |
|                |                |                  | September 2022    | 5                            | 0                    | <5.0                     | 39.6                    | 22.1                    | 16.3                    | 16.4             |                           |  |
|                |                |                  | December 2022     | 16                           | 0                    | 5.3                      | 683                     | 49                      | 31.7                    | 52.2             |                           |  |
|                |                |                  | April 2023        | 0                            | 0                    | <5.0                     | 15.7                    | 10.2                    | 10.3                    | 9.5              |                           |  |
|                |                |                  | August 2024       | 0                            | 0                    | 2.3                      | 46.3                    | 254                     | 259                     | 14.4             |                           |  |
|                |                |                  | September 2025    | 0                            | 0                    |                          | 27.2                    | 336                     | 291                     | 11.2             |                           |  |

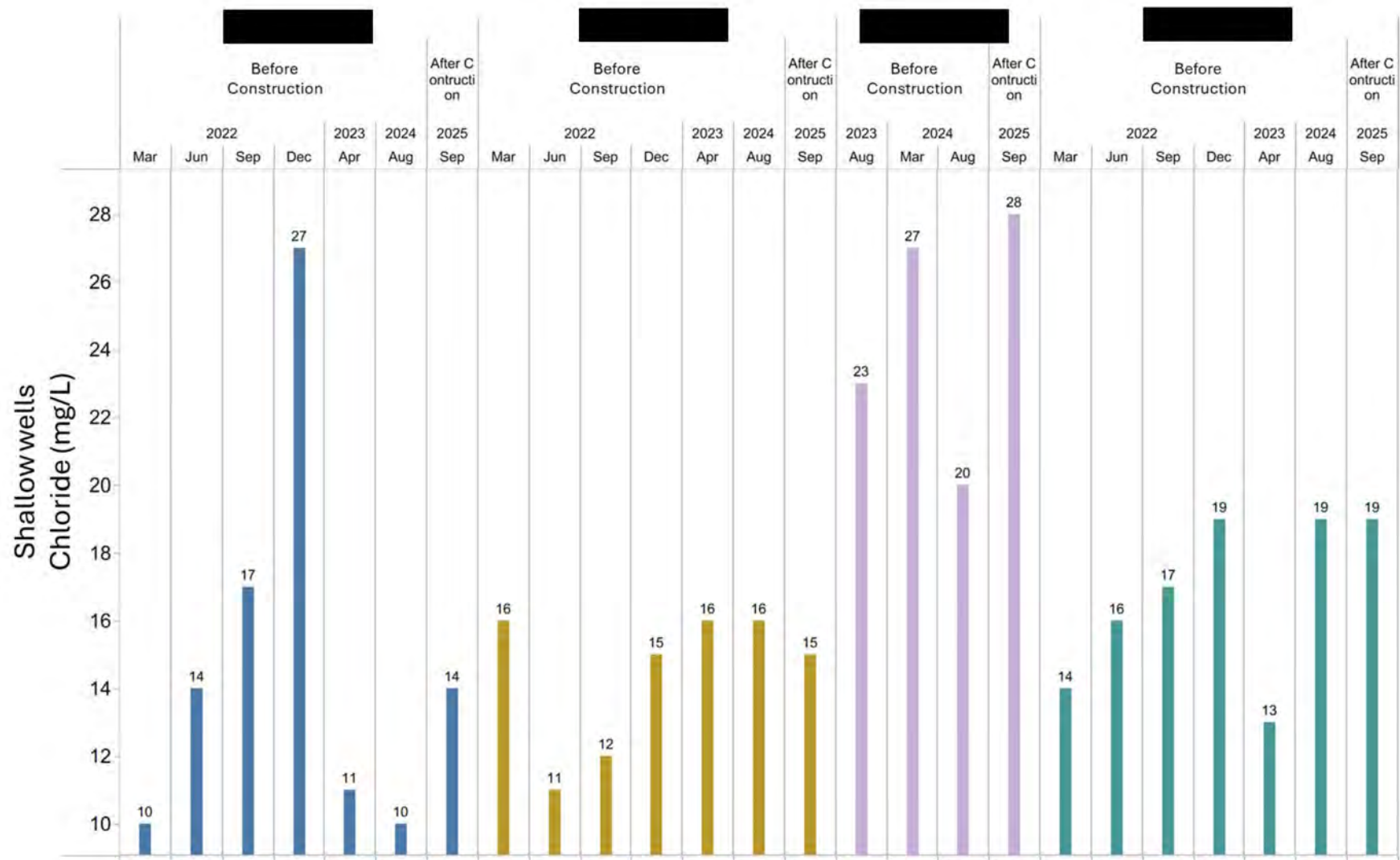


Figure 10: Chloride concentration over time in shallow wells.

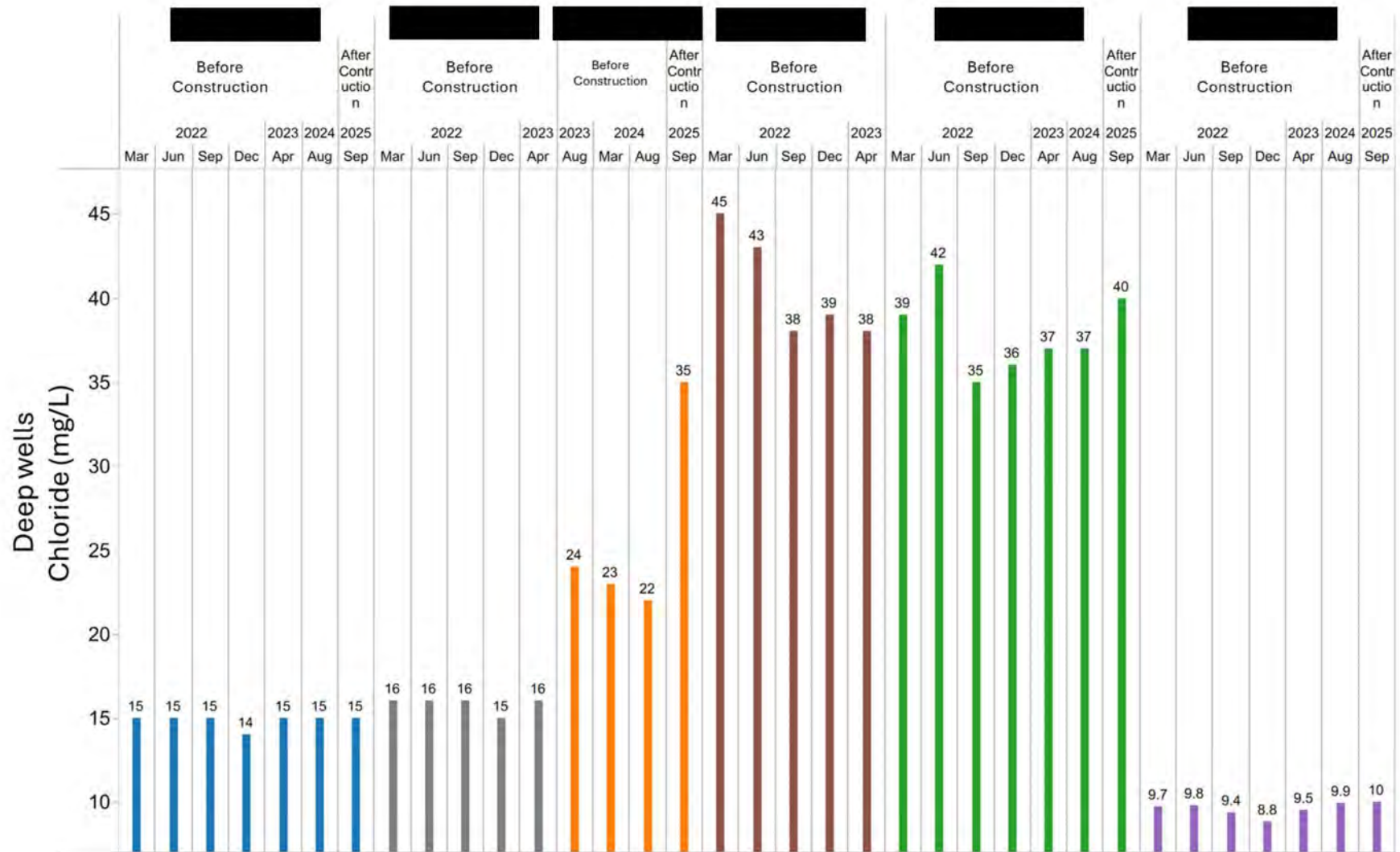


Figure 11: Chloride concentration over time in deep wells.

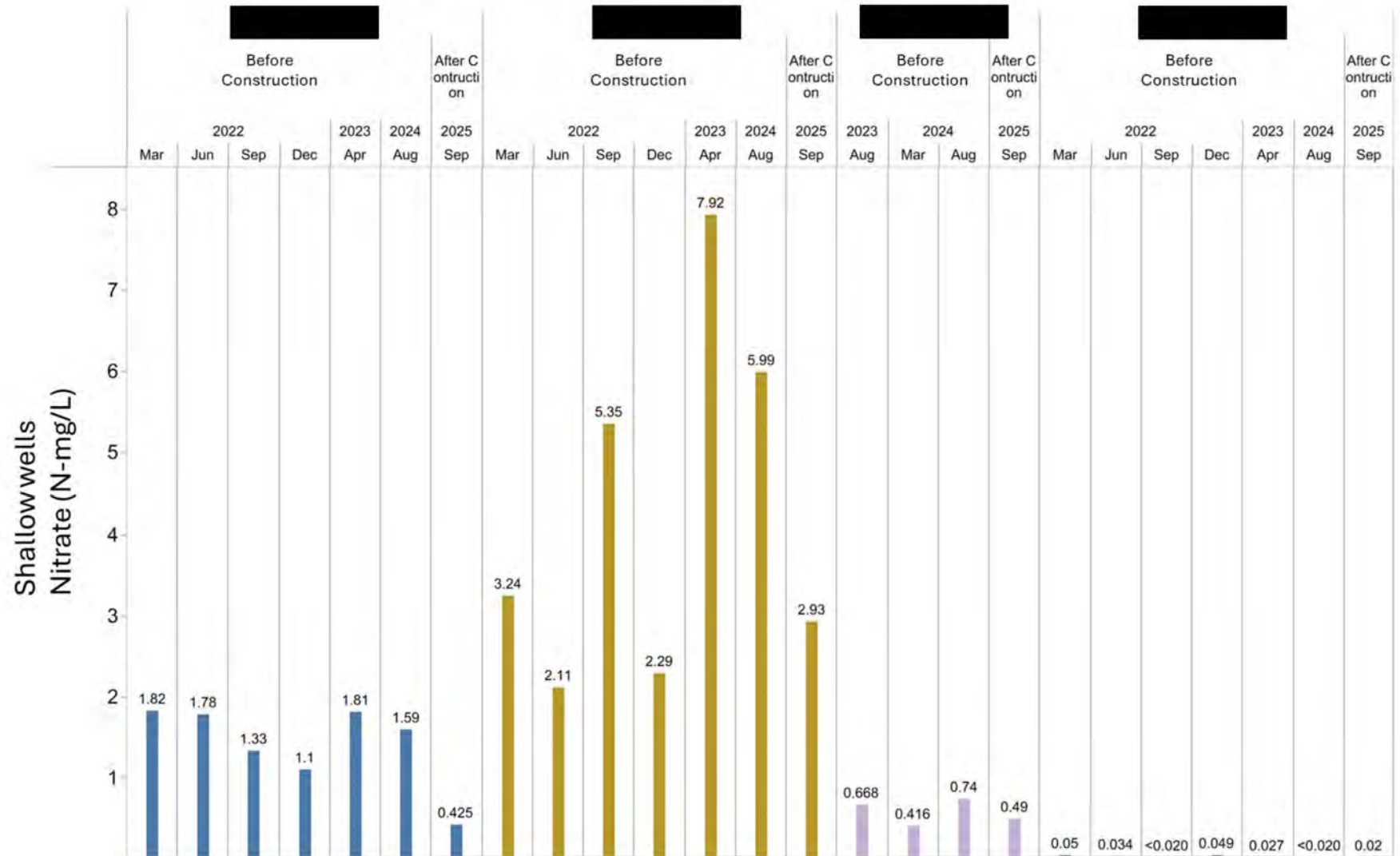


Figure 12: Nitrate concentration over time in shallow wells.

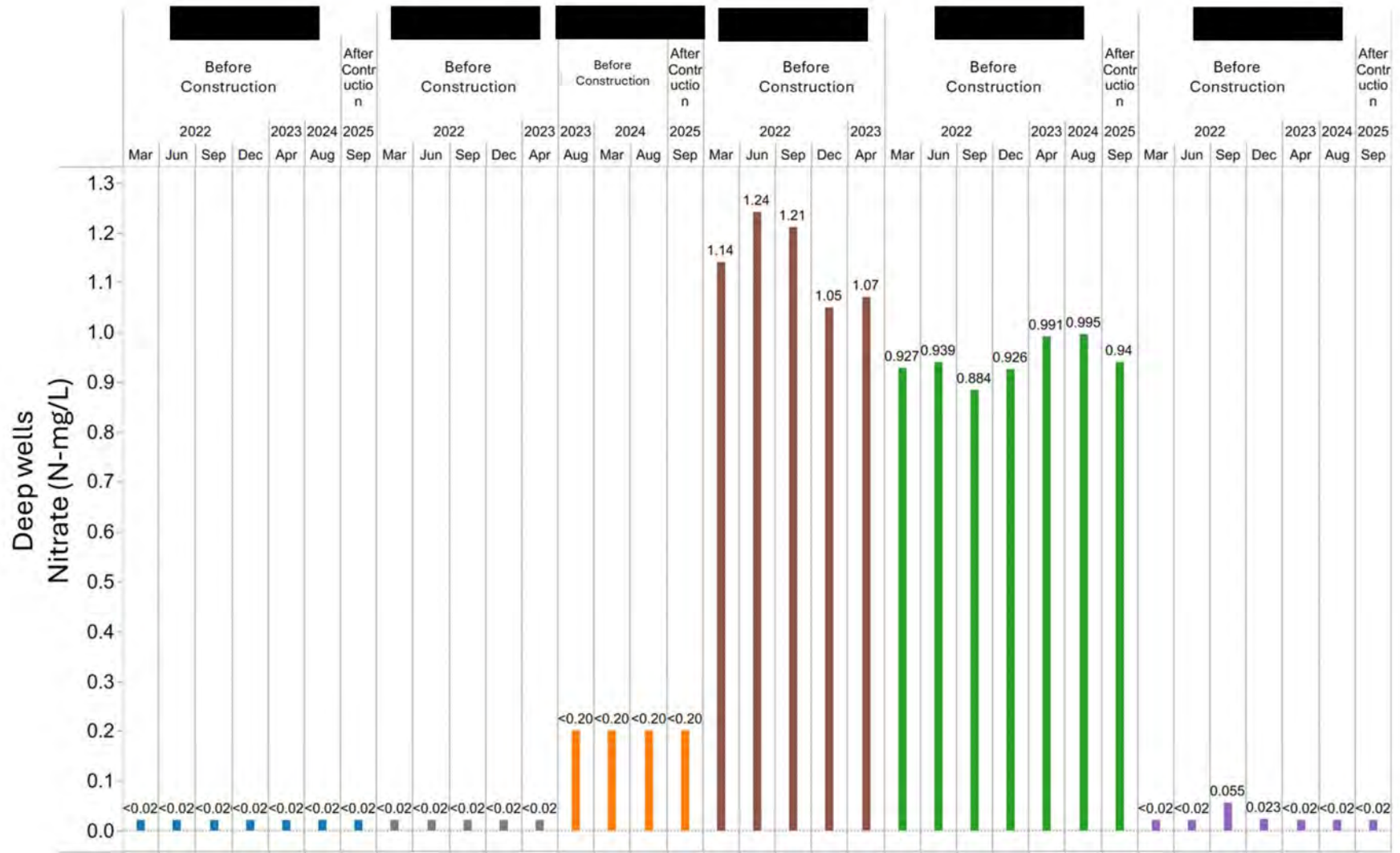


Figure 13: Nitrate concentration over time in deep wells.

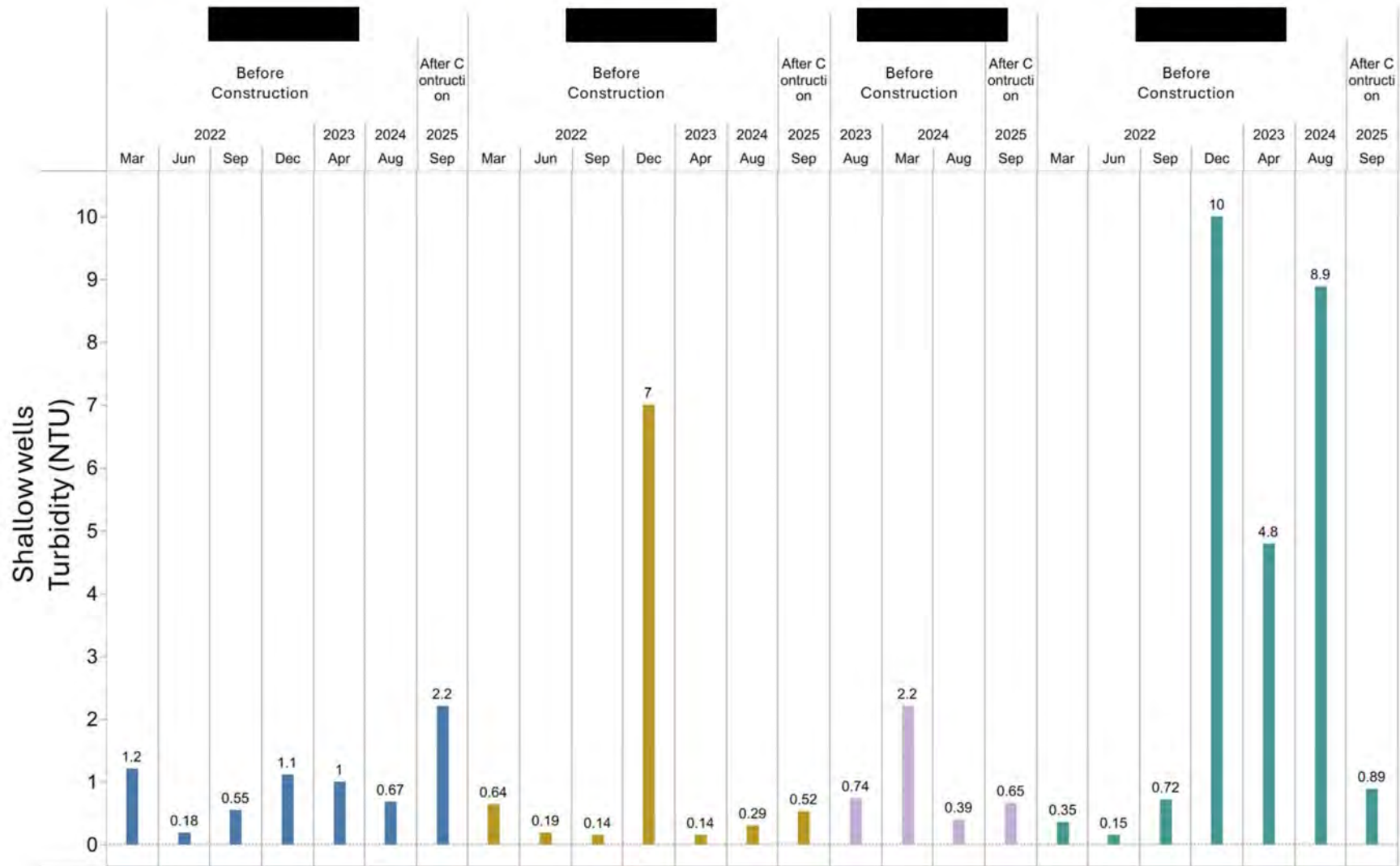


Figure 14: Turbidity concentration over time in shallow wells.

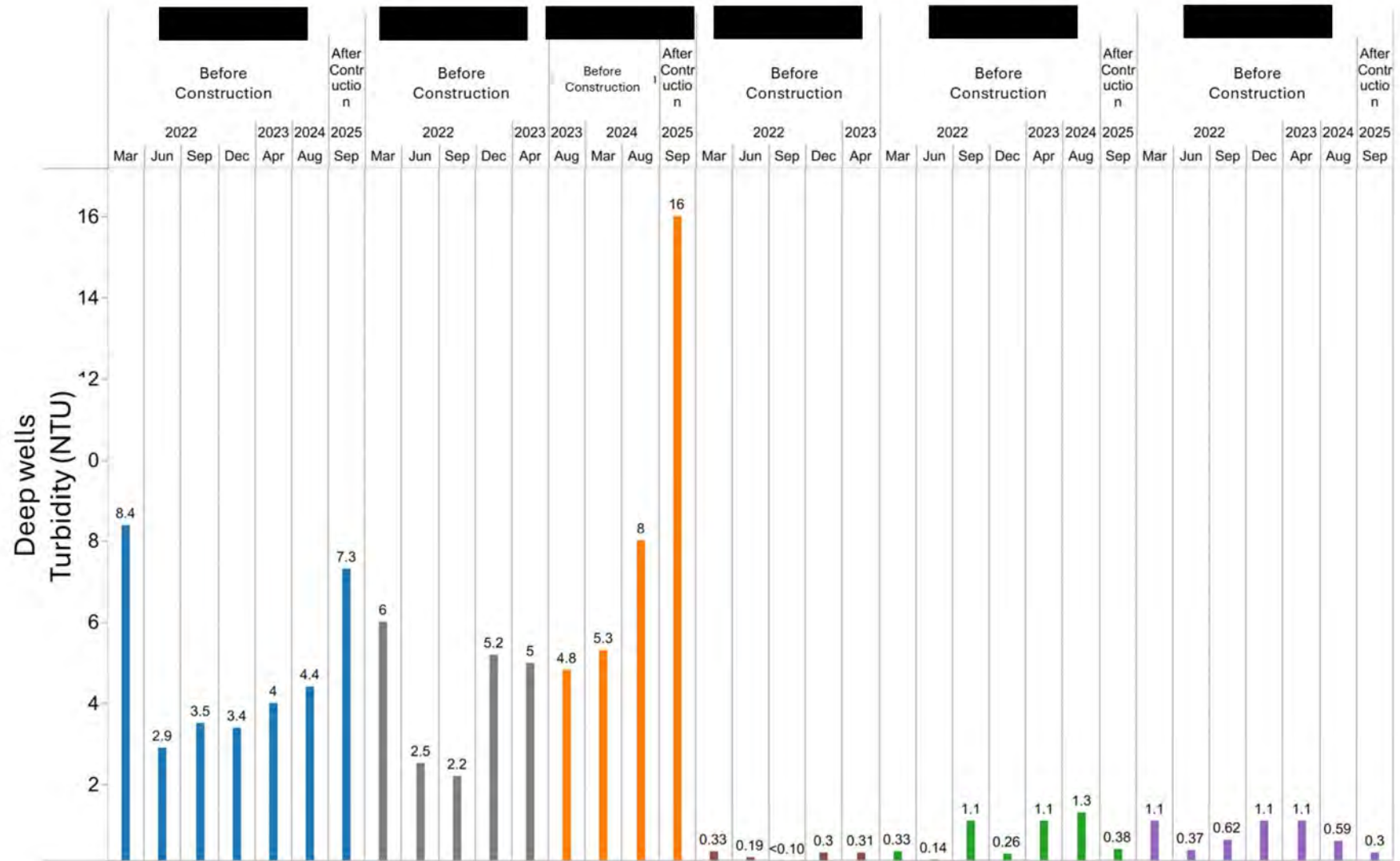
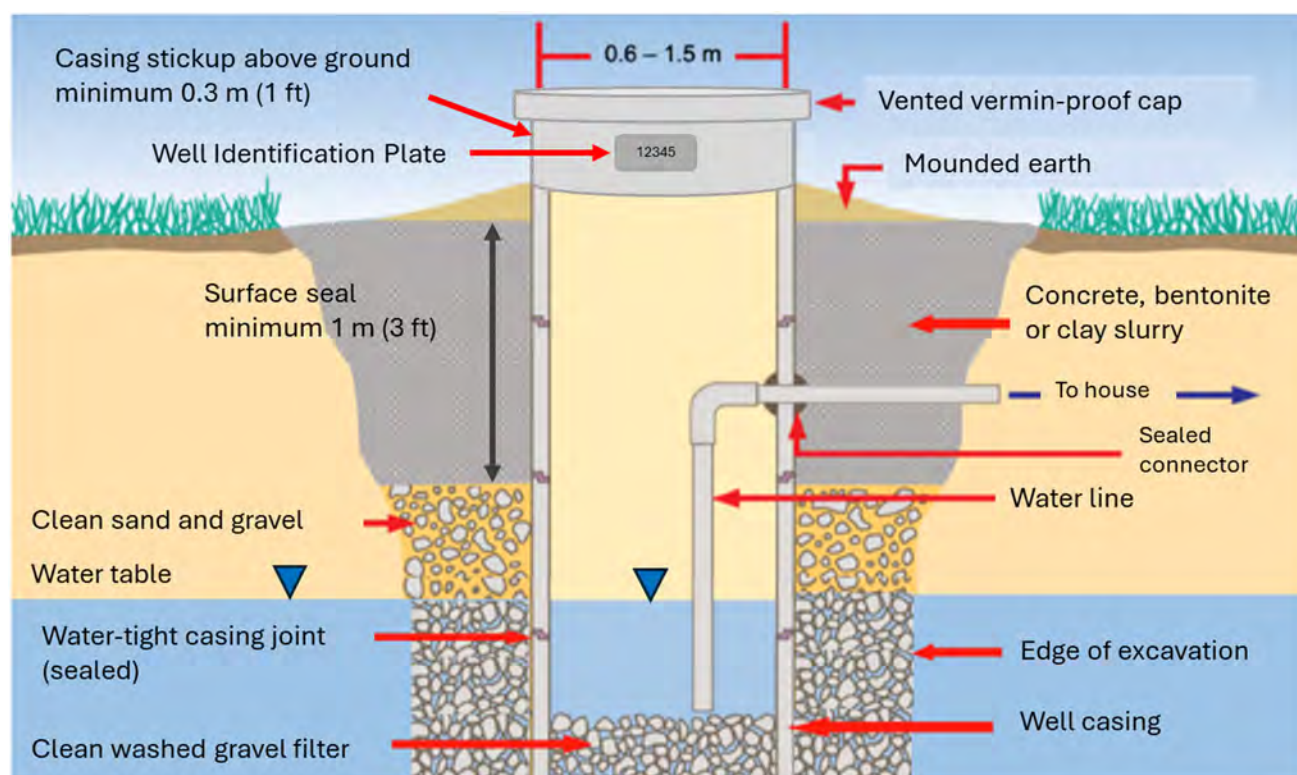


Figure 15: Turbidity concentration over time in deep wells.

### 6.3 Well construction and maintenance

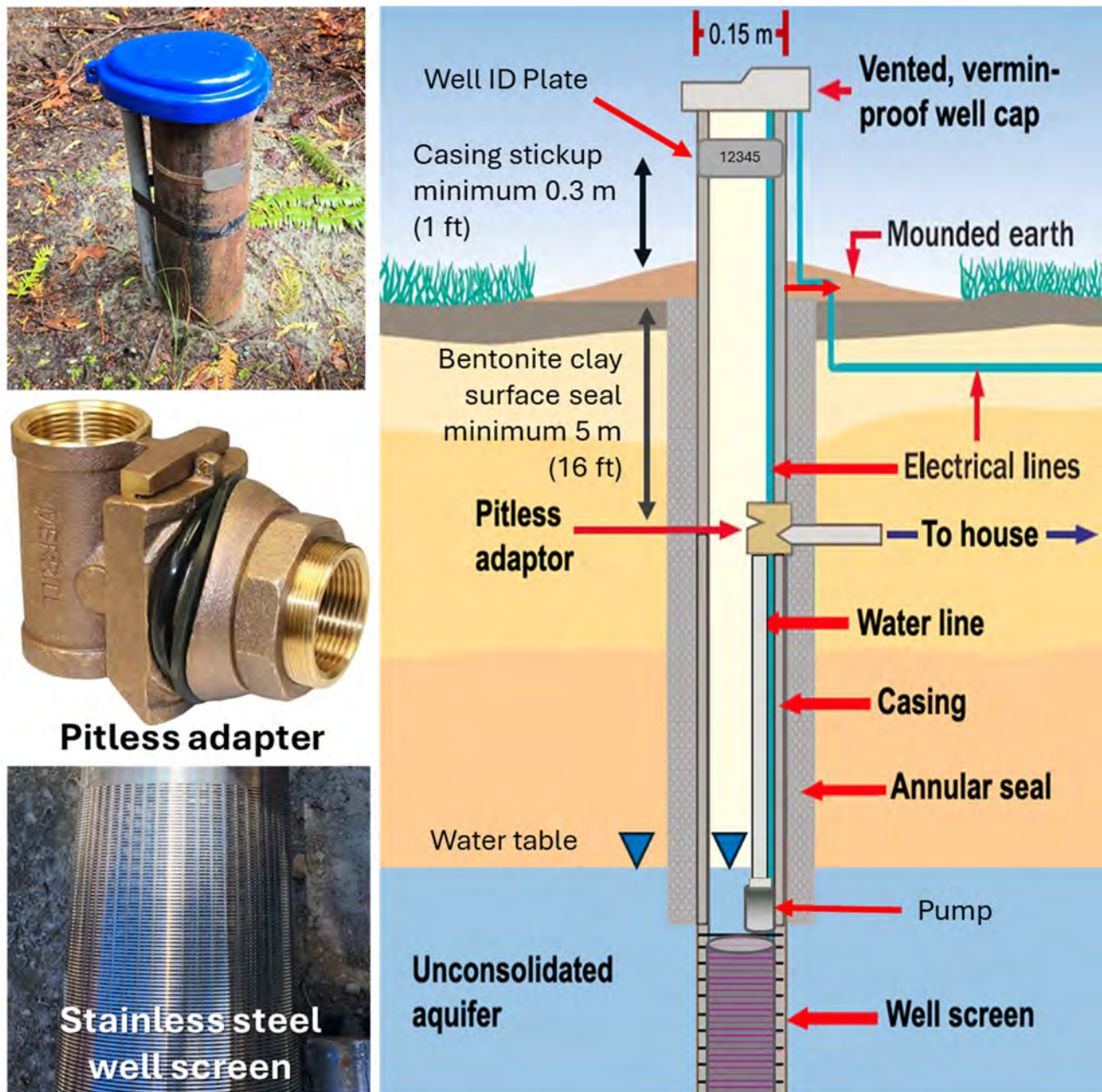
To help ensure that it is protected from contamination, a well must be properly constructed and maintained. The *Water Sustainability Act*, Groundwater Protection Regulation (GPR) outlines the minimum standards for well construction, maintenance, operation, and deactivation or closure (Province of BC, 2016; BC Ground Water Association, 2017). For example, all wells must have a properly attached well cap or cover that prevents the entry of vermin, water, including floodwater or contaminants into a well. Figure 16 illustrates minimum well construction standards for dug wells, and Figure 17 shows minimum well construction for drilled wells.

Wells must also be properly sited away from contamination sources. For example, the *Public Health Act*, Health Hazards Regulation, indicates that wells must be sited a minimum of 30 m from probable contamination sources such as septic fields and tanks, animal paddocks and manure piles. Additional setback requirements are included in Sewerage System Standard Practices Manual, and the Environmental Management Act, Municipal Wastewater Regulation ((Province of BC, 2012, 2004; Ministry of Health, Health Protection Branch, 2014). Example well setback requirements are shown in Figure 18.



**Excavated (dug) wells** are typically large diameter, shallow, with sides made of cement or wood cribbing. These types of wells are considered highly vulnerable to contamination and seasonal water supply may be limited.

**Figure 16: Well construction standards for dug (excavated) wells, adapted from (Drage, 2022).**



**Domestic drilled wells** in unconsolidated (sand and gravel) aquifers are often 0.15 m (6") in diameter with steel casing and stainless steel well screen (bottom left). Wells vary in depth, water production and vulnerability depending on the aquifer type.

Figure 17: Well construction standards for drilled wells, adapted from (Drage, 2022). Photos: S. Barroso except for pitless adapter from stock images.

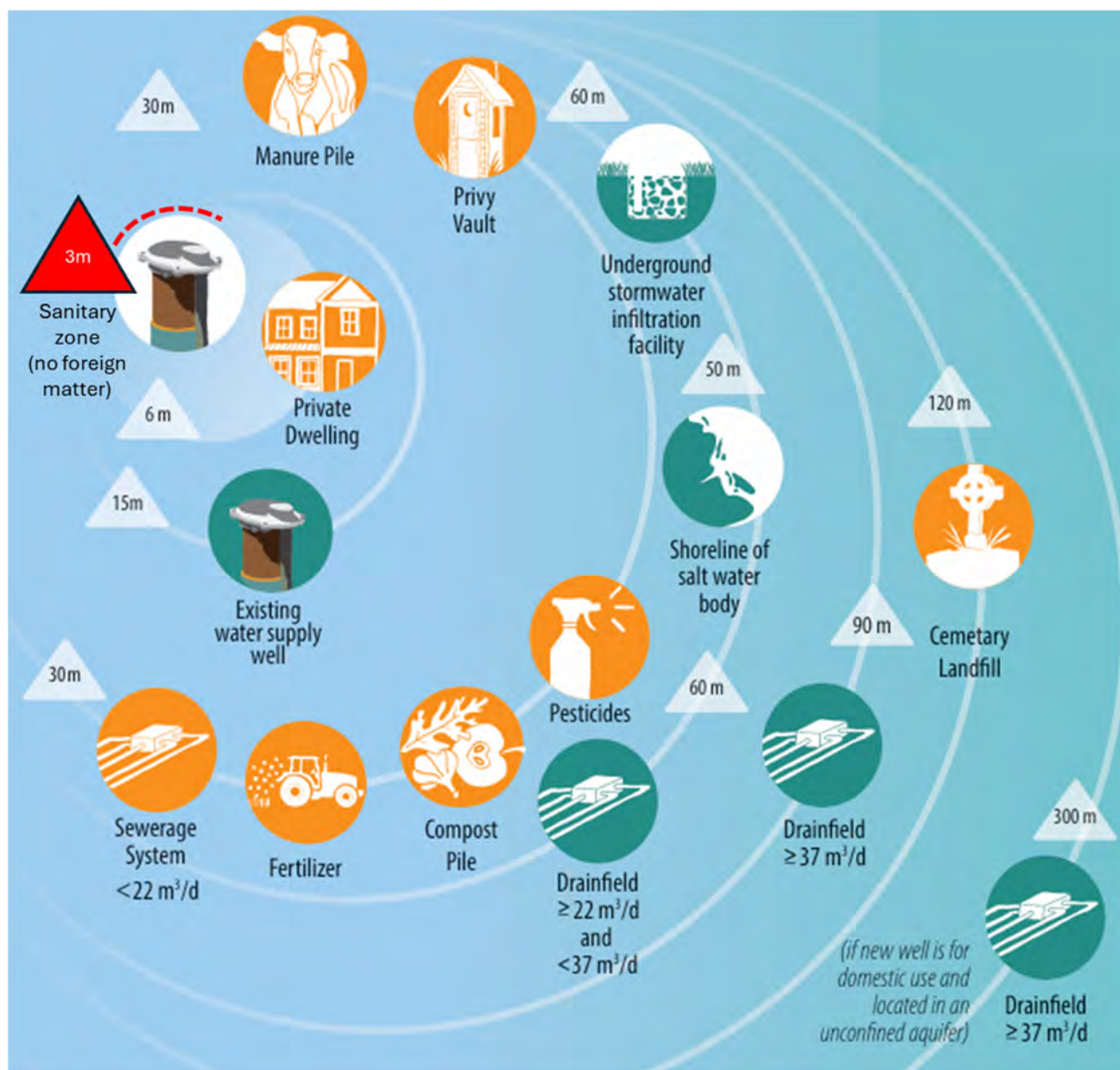


**Figure 18: Minimum well setbacks from sources of contamination. Adapted from Figure 1, Groundwater Protection Regulation Handbook (BC Ground Water Association, 2017).**

Since 2005, wells constructed in BC must have a bentonite clay surface seal that prevents water from leaking into the well through the gap between the outside casing and the surrounding soil or rock (Province of BC, 2016). If the surface seal material is eroded, removed, or is not present, such as in older wells, total coliforms or *E.coli* in a groundwater sample may indicate that surface water, or shallow drainage contaminated by sewage, is entering a well through the annular space around the casing. If this occurs, the well could be repaired to restore or install a new the surface seal.

Observations collected during the initial field inventory of wells and subsequent field visits showed that some well sources in the study area do not meet minimum construction

standards and therefore may be at higher risk of contamination. Some examples are provided in Figure 18, Figure 19, and Figure 20. Where needed, feedback was provided to well owners to improve aspects related to well maintenance.

Table 8 includes a well protection checklist for well owners to help identify aspects of well maintenance and construction that could be improved.



**Figure 19: Observations of shallow, dug wells. A. Dug well with  $>0.3$  m casing stickup above ground and sealed cap/cover is better protected from contaminants. B. Dug well with edge of casing at or below ground surface and gaps in the cover. When water from irrigation or rain runs off the site, muddy water and animal waste enter the well, causing bacterial contamination. C.-D. Sanitary area within 3 m radius around well must be kept free of foreign matter. Contaminants including septic fields/tanks, and fuel storage should be kept a minimum of 30 m from well.**

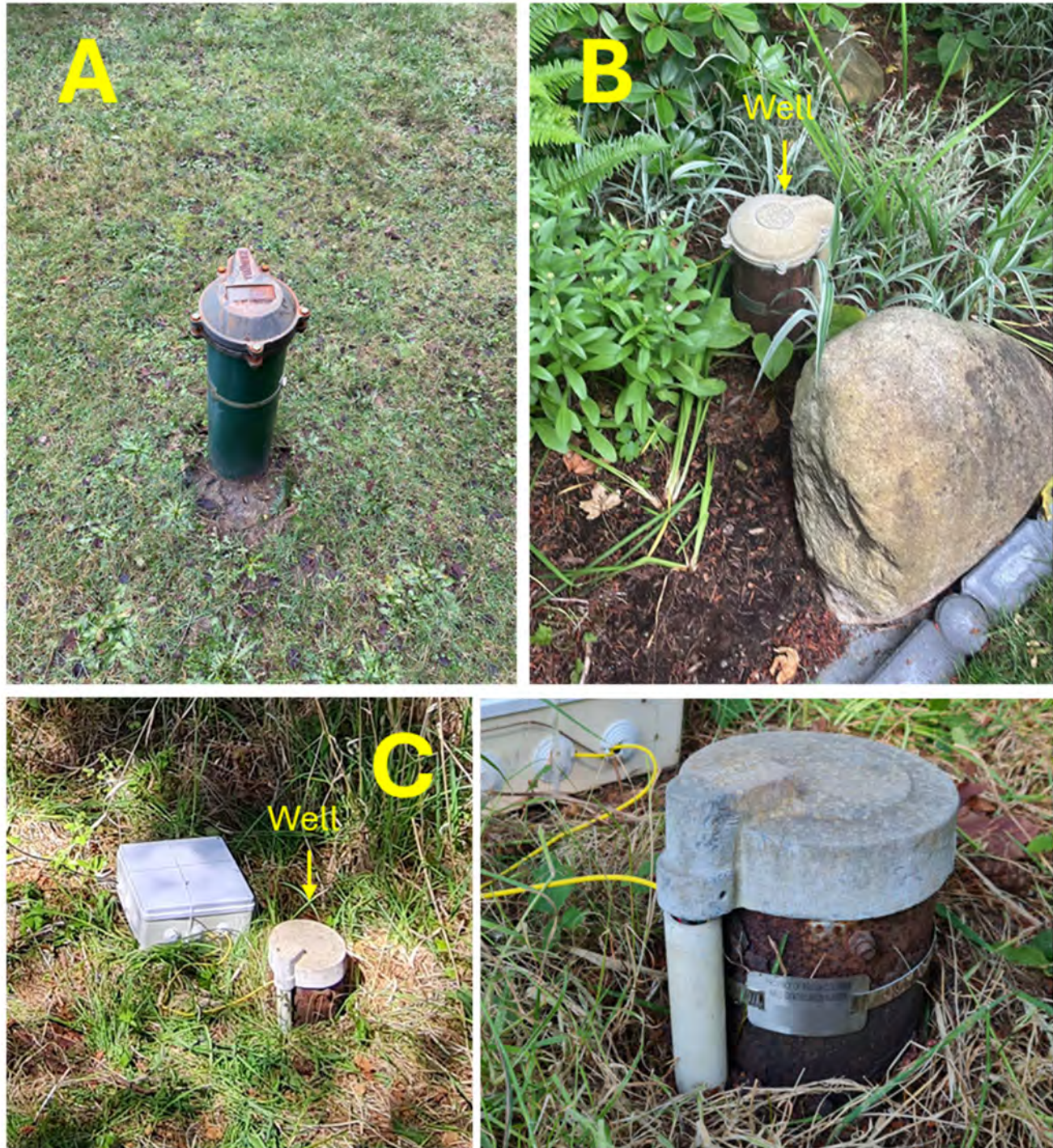


**Figure 20: Observations of deep (drilled) wells. A. Drilled well with good construction and maintenance. Casing minimum 30 cm above ground, and sanitary area within 3 m radius kept free of contaminants. B. A well in a garden space with adequate maintenance. Use caution to avoid well casing being buried or covered by vegetation. C. A well with a loose cap and low casing stickup in grassy field could be vulnerable to contamination or being lost or buried if overgrown by plants.**

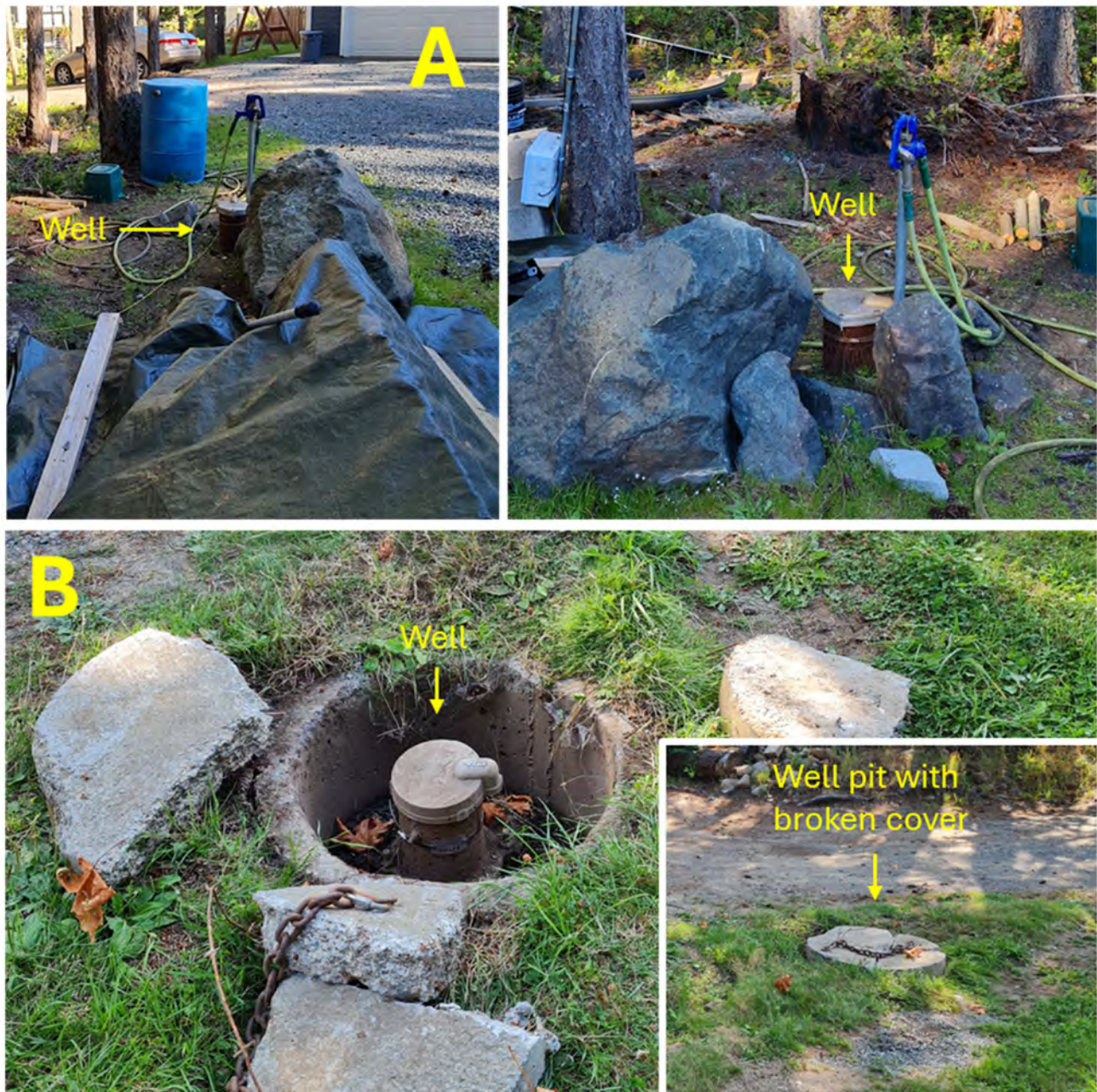


**Figure 21: Observations regarding wells near driveways. A. Drilled well beside driveway is protected by large rocks preventing damage from vehicle traffic. Always avoid parking near a well. B. Well in underground pit on driveway is vulnerable to damage and contamination from vehicles. Water can accumulate in the pit, and insects or rodents may be attracted to enclosure increasing hazard of well contamination.**

**Table 8: Well protection checklist for well owners<sup>1</sup>.**

| Yes                      | No                       | Not sure                 | Category                                  | Description                                                                                                                                                                |
|--------------------------|--------------------------|--------------------------|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>Location</b>                           | Well location is known (not buried or overgrown with vegetation)                                                                                                           |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>Well drilled by qualified person</b>   | Drilled well constructed by or under direct supervision of a registered qualified well driller (see Note 1)                                                                |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>Pump installed by qualified person</b> | Well pump installed by registered qualified well pump installer (see Note 1)                                                                                               |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>Well log</b>                           | A copy of the well construction report is available                                                                                                                        |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>Well siting</b>                        | Well is located a minimum distance from potential sources of contamination sources, including a minimum of 30 m from septic fields or animal paddocks (see Figure 18)      |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>Foreign matter</b>                     | Sanitary zone within 3 m of well head is kept free of vegetation and foreign matter (garbage, junk, fuel, contaminants, vehicle parking)                                   |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>Well ID plate</b>                      | Well has a metal identification plate number (required since 2005)                                                                                                         |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>Well cap and cover</b>                 | Well has a secure, vermin-proof and water-proof cap                                                                                                                        |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>Casing stickup</b>                     | Well casing has a minimum height of 0.3 m (1 ft) above ground to prevent entry of contaminants or floodwaters                                                              |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>Surface seal</b>                       | There is no visible gap between the well casing and the surrounding soil                                                                                                   |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>Surface seal</b>                       | Wells has a bentonite clay surface seal that fills the annular space between the casing and surrounding materials (required since 2005)                                    |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>Grading</b>                            | Ground around the well is mounded so that surface water will drain away it and there are no low spots, and no ponding or pooling of water around the well head             |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>Pump house</b>                         | Pump house containing well or water equipment is in good repair, not use for storage of foreign materials, and prevents entry of vermin such as rodents.                   |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>Well pit</b>                           | If well is in an underground vault or pit, the pit has a water-proof cover and drainage and does not allow entry of vermin.                                                |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>Artesian flow</b>                      | If a well is flowing artesian (groundwater level is higher than the ground surface), the flow is under control (Note 2)                                                    |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <b>Unused wells</b>                       | Wells that are in use for water supply, monitoring, or future backup supply are decommissioned by a qualified well driller (backfilled with layers clean fill and sealant) |

**If you checked no or not sure for any items above, action may be needed. For more information see (Ministry of Water, Land and Resource Stewardship, 2026).**

<sup>1</sup>Adapted from (Regional District of Nanaimo, n.d.). Notes: 1. Registry of qualified well drillers and well pump installers available at: <https://apps.nrs.gov.bc.ca/gwells/registries>. Dug wells can be installed by a non-driller but must meet all Groundwater Protection Regulation construction standards. 2: See Flowing Artesian Well Brief for the Well Owner: [https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-wells/flowing\\_artesian\\_wells.pdf](https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-wells/flowing_artesian_wells.pdf).

## 7 CONCLUSIONS

This study involved monitoring of groundwater conditions before, during and after construction of a pipeline for conveyance of municipal sewage through the Comox, Lazo Road area where water is supplied primarily from private domestic wells. The main objectives were to characterize groundwater resources in the area, and to assess any changes affecting domestic wells along the construction corridor during and after pipe installation.

**Well inventory:** An initial inventory of properties in the subject area was completed in summer to fall 2021, which identified the locations of wells and water sources for each parcel. Two primary water sources were observed in the field: shallow, excavated or dug wells, with large (~1.4 m) diameter casings, and depth generally less than 10 m which obtain water from shallow sand and gravel lenses in lower permeability till; and deep (drilled wells, 0.15 m or 6" diameter) wells up to 80 m deep, constructed in regional AQ408, a partially-confined, sand and gravel aquifer.

**Monitoring network:** A groundwater monitoring network was established in November 2021 within an initial selection of three shallow and six deep wells along the proposed route of the CVRD sewage conveyance. The monitoring network was further modified, adding two new sites in 2023 as plans for the sewage pipe construction changed to a shallow, cut and cover installation method. Two drilled well monitoring sites were discontinued on request of the property owners, after the initial period of baseline monitoring.

**Water quantity:** Groundwater level, temperature and electrical conductivity was monitored using dataloggers installed in each well. The long-term monitoring showed that groundwater levels in the wells respond hourly and daily to pumping, and seasonally in response to precipitation, aquifer recharge and groundwater use. Groundwater levels in shallow (dug) wells ranged from the ground surface up to 5.5 m below ground, with a 2 to 4 m seasonal variation in levels. Groundwater levels in deep, drilled wells were from 6.5 m up to 34.4 m below ground, with approximately 1 m range in levels seasonally. No change in water levels was observed during the period of sewer pipe installation in either shallow or deep wells.

**Water quality:** Groundwater quality was monitored in the field and samples were collected for laboratory analysis. Baseline monitoring was conducted for two years prior to the pipeline construction. An additional two sample events were completed after the pipe was installed. Groundwater in both shallow and deep wells was of generally very good quality. Drinking water guideline exceedances were observed for iron and manganese, pH, true colour, and bacteria. Groundwater from deeper, drilled wells had higher iron concentrations. Median concentrations of manganese were similar for both shallow and deep wells. The presence of total coliforms in groundwater from both deep and shallow wells indicated the presence of recharge from shallow sources, possibly associated with rapid infiltration of water down the annular space surrounding the well casing, as most wells were constructed historically, before installation of bentonite clay surface seal was required. Shallow, dug wells had both total coliform bacteria and *E.coli* bacteria in some cases, indicating the wells had been contaminated by fecal matter, mostly due to well maintenance concerns such as

a low casing stickup and gaps in the well cover. No notable changes in water quality were observed following the sewer pipe installation.

**Well construction:** Factors related to domestic well construction and maintenance were found to contribute to well vulnerability to contamination. Well owners were provided with feedback regarding improvements that could be made to protect their water source. Most properties also treat sewage using septic systems, which can contribute to contamination of the groundwater by nitrates, chloride, pharmaceuticals and personal care products, and pathogens including bacteria or viruses.

**Ongoing monitoring:** This project showed the value of collecting data on aquifer conditions in a groundwater dependent area using existing domestic wells. Continued monitoring of groundwater levels in representative network sites should continue for an additional two years to monitor groundwater conditions once the sewer pipe is fully commissioned and in active use.

## Study Limitations

This document was prepared for the exclusive use of the Comox Valley Regional District (CVRD). The inferences concerning the data, site and receiving environment conditions contained in this document are based on information obtained during investigations conducted at the site by GW Solutions and others and are based solely on the condition of the site at the time of the studies. Soil, surface water and groundwater conditions may vary with location, depth, time, sampling methodology, analytical techniques and other factors.

In evaluating the subject study area and water quality data, GW Solutions has relied in good faith on information provided. The factual data, interpretations and recommendations pertain to a specific project as described in this document, based on the information obtained during the assessment by GW Solutions on the dates cited in the document, and are not applicable to any other project or site location. GW Solutions accepts no responsibility for any deficiency or inaccuracy contained in this document as a result of reliance on the aforementioned information.

The findings and conclusions documented in this document have been prepared for the specific application to this project and have been developed in a manner consistent with that level of care normally exercised by hydrogeologists currently practicing under similar conditions in the jurisdiction.

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If new information is discovered during future work, including excavations, sampling, soil boring, predictive geochemistry or other investigations, GW Solutions should be requested to re-evaluate the conclusions of this document and to provide amendments, as required, prior to any reliance upon the information presented herein. The validity of this document is affected by any change of site conditions, purpose, development plans or significant delay from the date of this document in initiating or completing the project.

The produced graphs, images, and maps, have been generated to visualize results and assist in presenting information in a spatial and temporal context. The conclusions and recommendations presented in this document are based on the review of information available at the time the work was completed, and within the time and budget limitations of the scope of work.

CVRD may rely on the information contained in this memorandum subject to the above limitations.

## 8 CLOSURE

Conclusions and recommendations presented herein are based on available information at the time of the study. The work has been carried out in accordance with generally accepted engineering practice. No other warranty is made, either expressed or implied. Engineering judgement has been applied in producing this letter-report. This letter report was prepared by personnel with professional experience in the fields covered. Reference should be made to the General Conditions and Limitations attached in Appendix B.

GW Solutions was pleased to produce this document. If you have any questions, please contact the authors.

Respectfully submitted,

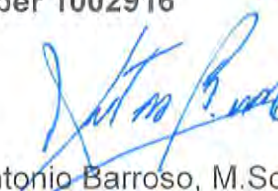
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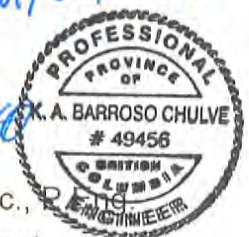
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## **APPENDIX A**

### **SUPPLEMENTARY DATA TABLES**

**Table A-1. Comox groundwater monitoring program dates, station status, and information on data gaps.**

| Site name | Well type | Well depth (ft) | Well depth (m) | Hydrograph observations                                                                       | Average drawdown from pumping                                                                                                                         | Observations during construction period       | Notes on data gaps or errors                                                                                                                      |
|-----------|-----------|-----------------|----------------|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
|           | Dug       | 23              | 6.86           | GWL range from 0.5 m to 5.5 m below ground. Shallowest level Nov-May, deepest levels Aug-Oct. | Avg 0.5 m drawdown from pumping.                                                                                                                      | NA (data not available due to logger failure) | Failed logger sent to manufacturer for data retrieval Sept 2025. No data were able to be obtained from November 2024 to date of last field visit. |
|           | Dug       | 20              | 6.14           | GWL range from 0 to 3 m below ground.                                                         | Avg 0.1 m to 0.5 m drawdown from pumping                                                                                                              | No change noted                               | Data missing from 2022-03-27 to 2022-07-02 and 2024-04-16 to 2024-08-07 due to failed logger                                                      |
|           | Dug       | 16              | 4.92           | GWL range from 0.9 m to 4.5 m below ground. Shallowest in Jan, deepest in Nov.                | Avg < 0.1 m drawdown from pumping                                                                                                                     | No change noted                               | Data missing from 2024-04-16 to 2024-08-08 due to failed logger                                                                                   |
|           | Dug       | 13              | 3.89           | GWL range from 0.1 to 2.9 m below ground. Shallowest in Dec, deepest in Oct.                  | Avg 0.2 to 1 m daily fluctuation. Frequent fluctuation from recharge (low stickup, water entering well directly from irrigation and rainfall runoff). | No change noted                               | Data missing from 2024-04-16 to 2024-08-08 due to failed logger                                                                                   |
|           | Drilled   | 75              | 22.9           | GWL range from 16.8 to 17.5 m.                                                                | Avg 2 to 4 m fluctuation in groundwater level from pumping                                                                                            | NA                                            | Station inactivated on owner request, prior to construction period.                                                                               |
|           | Drilled   | 102             | 31.04          | GWL range from 24 to 27 m below ground. Shallowest Dec-Apr, deepest Oct.                      | Average 0.5 m fluctuation from pumping                                                                                                                | NA (data not available due to logger failure) | Logger failure (Sept 2025). No data were able to be obtained.                                                                                     |

| Site name | Well type | Well depth (ft) | Well depth (m) | Hydrograph observations                                               | Average drawdown from pumping                                                                      | Observations during construction period | Notes on data gaps or errors                                        |
|-----------|-----------|-----------------|----------------|-----------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------------|---------------------------------------------------------------------|
|           | Drilled   | 170             | 51.81          | GWL range from 33.5 to 35.5 mbgs, highest in Mar-Apr, deepest in Nov. | Avg <0.5 m fluctuation from pumping.                                                               | No change noted                         | Data missing from 2024-04-16 to 2024-08-08 due to failed logger     |
|           | Drilled   | 163             | 49.59          | GWL range from 40.4 to 42.7 m, highest in Feb-Apr, lowest in Sep-Oct  | Avg 1 to 1.5 m fluctuation with pumping                                                            | No change noted                         | No missing data                                                     |
|           | Drilled   | 151             | 46.02          | GWL range from 37 to 40 m bgs, highest in Dec, lowest in Aug-Sep.     | Avg < 0.5 m drawdown from pumping effects, periodically up to 3 m difference (depending on demand) | NA                                      | Station inactivated on owner request, prior to construction period. |
|           | Drilled   | 59              | 18.00          | GWL range from 6.5 to 8.2 m bgs, highest in Jan-Feb, lowest in Sep.   | Avg < 0.1 m drawdown from pumping                                                                  | No change noted                         | Data missing from 2024-03-26 to 2024-08-07 due to failed logger     |
| BH 22-01  | Dug       | 2               | 0.58           | GWL range from 0.3 m above ground to 0.4 m below ground               | NA (no pump, ambient monitoring of wetland level)                                                  | No change noted                         | No missing data                                                     |

NA=Not applicable

**Table A-2. Laboratory water quality parameters, drinking water guidelines and detection limits**

| Category                        | Parameters                               | Unit      | MAC | AO   | OG       | RDL    |
|---------------------------------|------------------------------------------|-----------|-----|------|----------|--------|
| General Chemistry & Nutrients   | Alkalinity (PP as CaCO <sub>3</sub> )    | mg/L      |     |      |          | 1      |
|                                 | Alkalinity (Total as CaCO <sub>3</sub> ) | mg/L      |     |      |          | 1      |
|                                 | Bicarbonate (HCO <sub>3</sub> )          | mg/L      |     |      |          | 1      |
|                                 | Carbonate (CO <sub>3</sub> )             | mg/L      |     |      |          | 1      |
|                                 | Chloride (Cl)                            | mg/L      |     | 250  |          | 1      |
|                                 | Conductivity                             | µS/cm     |     |      |          | 2      |
|                                 | Dissolved Fluoride (F)                   | mg/L      | 1.5 |      |          | 0.05   |
|                                 | Dissolved Hardness (CaCO <sub>3</sub> )  | mg/L      |     |      |          | 0.5    |
|                                 | Hydroxide (OH)                           | mg/L      |     |      |          | 1      |
|                                 | Nitrate (N)                              | mg/L      | 10  |      |          | 0.02   |
|                                 | Nitrate plus Nitrite (N)                 | mg/L      |     |      |          | 0.02   |
|                                 | Nitrite (N)                              | mg/L      | 1   |      |          | 0.005  |
|                                 | pH                                       | pH        |     |      | 7.0:10.5 | NA     |
|                                 | Sulphate (SO <sub>4</sub> )              | mg/L      |     | 500  |          | 1      |
|                                 | Sulphide (as H <sub>2</sub> S)           | mg/L      |     |      |          | 0.0040 |
|                                 | Total Ammonia (N)                        | mg/L      |     |      |          | 0.015  |
|                                 | Total Dissolved Solids                   | mg/L      |     |      |          | 10     |
|                                 | Total Hardness (CaCO <sub>3</sub> )      | mg/L      |     |      |          | 0.5    |
|                                 | Total Nitrogen (N)                       | mg/L      |     |      |          | 0.1    |
|                                 | Total Organic Carbon (C)                 | mg/L      |     |      |          | 0.5    |
|                                 | Total Organic Nitrogen (N)               | mg/L      |     |      |          | 0.1    |
|                                 | Total Sulphide                           | mg/L      |     | 0.05 |          | 0.002  |
|                                 | Transmittance at 254nm                   | %T/cm     |     |      |          | NA     |
|                                 | True Colour                              | Col. Unit |     | 15   |          | 2      |
|                                 | Turbidity                                | NTU       |     |      |          | 0.1    |
| Elements by Atomic Spectroscopy | Dissolved Aluminum (Al)                  | ug/L      |     |      |          | 3      |
|                                 | Dissolved Antimony (Sb)                  | ug/L      |     |      |          | 0.5    |
|                                 | Dissolved Arsenic (As)                   | ug/L      |     |      |          | 0.1    |
|                                 | Dissolved Barium (Ba)                    | ug/L      |     |      |          | 1      |
|                                 | Dissolved Beryllium (Be)                 | ug/L      |     |      |          | 0.1    |
|                                 | Dissolved Bismuth (Bi)                   | ug/L      |     |      |          | 1      |
|                                 | Dissolved Boron (B)                      | ug/L      |     |      |          | 50     |
|                                 | Dissolved Cadmium (Cd)                   | ug/L      |     |      |          | 0.01   |
|                                 | Dissolved Calcium (Ca)                   | ug/L      |     |      |          | 0.05   |

| Category | Parameters                | Unit | MAC  | AO   | OG  | RDL  |
|----------|---------------------------|------|------|------|-----|------|
|          | Dissolved Chromium (Cr)   | ug/L |      |      |     | 1    |
|          | Dissolved Cobalt (Co)     | ug/L |      |      |     | 0.2  |
|          | Dissolved Copper (Cu)     | ug/L |      |      |     | 0.2  |
|          | Dissolved Iron (Fe)       | ug/L |      |      |     | 5    |
|          | Dissolved Lead (Pb)       | ug/L |      |      |     | 0.2  |
|          | Dissolved Lithium (Li)    | ug/L |      |      |     | 2    |
|          | Dissolved Magnesium (Mg)  | ug/L |      |      |     | 0.05 |
|          | Dissolved Manganese (Mn)  | ug/L |      |      |     | 1    |
|          | Dissolved Molybdenum (Mo) | ug/L |      |      |     | 1    |
|          | Dissolved Nickel (Ni)     | ug/L |      |      |     | 1    |
|          | Dissolved Phosphorus (P)  | ug/L |      |      |     | 0.05 |
|          | Dissolved Potassium (K)   | ug/L |      |      |     | 0.05 |
|          | Dissolved Selenium (Se)   | ug/L |      |      |     | 0.1  |
|          | Dissolved Silicon (Si)    | ug/L |      |      |     | 100  |
|          | Dissolved Silver (Ag)     | ug/L |      |      |     | 0.02 |
|          | Dissolved Sodium (Na)     | ug/L |      |      |     | 0.05 |
|          | Dissolved Strontium (Sr)  | ug/L |      |      |     | 1    |
|          | Dissolved Sulphur (S)     | ug/L |      |      |     | 3    |
|          | Dissolved Thallium (Tl)   | ug/L |      |      |     | 0.01 |
|          | Dissolved Tin (Sn)        | ug/L |      |      |     | 5    |
|          | Dissolved Titanium (Ti)   | ug/L |      |      |     | 5    |
|          | Dissolved Uranium (U)     | ug/L |      |      |     | 0.1  |
|          | Dissolved Vanadium (V)    | ug/L |      |      |     | 5    |
|          | Dissolved Zinc (Zn)       | ug/L |      |      |     | 5    |
|          | Dissolved Zirconium (Zr)  | ug/L |      |      |     | 0.1  |
|          | Total Aluminum (Al)       | ug/L | 2900 | -    | 100 | 3    |
|          | Total Antimony (Sb)       | ug/L | 6    | -    | -   | 0.5  |
|          | Total Arsenic (As)        | ug/L | 10   | -    | -   | 0.1  |
|          | Total Barium (Ba)         | ug/L | 2000 | -    | -   | 1    |
|          | Total Beryllium (Be)      | ug/L | -    | -    | -   | 0.1  |
|          | Total Bismuth (Bi)        | ug/L | -    | -    | -   | 1    |
|          | Total Boron (B)           | ug/L | 5000 | -    | -   | 50   |
|          | Total Cadmium (Cd)        | ug/L | 7    | -    | -   | 0.01 |
|          | Total Calcium (Ca)        | mg/L | -    | -    | -   | 0.05 |
|          | Total Chromium (Cr)       | ug/L | 50   | -    | -   | 1    |
|          | Total Cobalt (Co)         | ug/L | -    | -    | -   | 0.2  |
|          | Total Copper (Cu)         | ug/L | 2000 | 1000 | -   | 0.2  |

| Category              | Parameters                 | Unit      | MAC  | AO   | OG | RDL    |
|-----------------------|----------------------------|-----------|------|------|----|--------|
|                       | Total Iron (Fe)            | ug/L      | -    | 300  | -  | 5      |
|                       | Total Lead (Pb)            | ug/L      | 5    | -    | -  | 0.2    |
|                       | Total Lithium (Li)         | ug/L      | -    | -    | -  | 2      |
|                       | Total Magnesium (Mg)       | mg/L      | -    | -    | -  | 0.05   |
|                       | Total Manganese (Mn)       | ug/L      | 120  | 20   | -  | 1      |
|                       | Total Molybdenum (Mo)      | ug/L      | -    | -    | -  | 1      |
|                       | Total Nickel (Ni)          | ug/L      | -    | -    | -  | 1      |
|                       | Total Potassium (K)        | mg/L      | -    | -    | -  | 0.05   |
|                       | Total Selenium (Se)        | ug/L      | 50   | -    | -  | 0.1    |
|                       | Total Silicon (Si)         | ug/L      | -    | -    | -  | 100    |
|                       | Total Silver (Ag)          | ug/L      | -    | -    | -  | 0.02   |
|                       | Total Sodium (Na)          | mg/L      | -    | 200  | -  | 0.05   |
|                       | Total Strontium (Sr)       | ug/L      | 7000 | -    | -  | 1      |
|                       | Total Sulphur (S)          | mg/L      | -    | -    | -  | 3      |
|                       | Total Thallium (Tl)        | ug/L      | -    | -    | -  | 0.01   |
|                       | Total Tin (Sn)             | ug/L      | -    | -    | -  | 5      |
|                       | Total Titanium (Ti)        | ug/L      | -    | -    | -  | 5      |
|                       | Total Uranium (U)          | ug/L      | 20   | -    | -  | 0.1    |
|                       | Total Vanadium (V)         | ug/L      | -    | -    | -  | 5      |
|                       | Total Zinc (Zn)            | ug/L      | -    | 5000 | -  | 5      |
|                       | Total Zirconium (Zr)       | ug/L      | -    |      |    | 0.1    |
| Mercury by Cold Vapor | Dissolved Mercury (Hg)     | ug/L      | 1    |      |    | 0.0019 |
|                       | Total Mercury (Hg)         | ug/L      | 1    |      |    | 0.0019 |
| Microbiology          | E. coli                    | CFU/100mL |      |      |    | NA     |
|                       | Heterotrophic Plate Count  | CFU/mL    |      |      |    | 1      |
|                       | Iron Bacteria              | CFU/mL    |      |      |    | 25     |
|                       | Sulphate reducing bacteria | CFU/mL    |      |      |    | 75     |
|                       | Total Coliforms            | CFU/100mL |      |      |    | NA     |
| Calculated Parameters | Langelier Index (@ 4.4C)   | NA        | -    | -    | -  |        |
|                       | Langelier Index (@ 60C)    | NA        | -    | -    | -  |        |
|                       | Saturation pH (@ 4.4C)     | NA        | -    | -    | -  |        |
|                       | Saturation pH (@ 60C)      | NA        | -    | -    | -  |        |

**Notes:**

MAC Maximum Acceptable Concentration  
 AO Aesthetic Objective  
 OG Operational Guideline  
 RDL Reportable Detection Limit

**Table A-3. Quality Assurance/Quality Control Sample Parameters and Results**

| Site name | Aug 2024 QA/QC Sample | August 2024 QA/QC                             | RPD Results                                                                                                                                                             | Sep 2025 QAQC Sample       | RPD Results                                                                                                                            |
|-----------|-----------------------|-----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
|           | Y                     | Replicate General 250 ml                      | < $\pm 5$ (9 parameters), <RDL (5 parameters)                                                                                                                           | N                          |                                                                                                                                        |
|           | Y                     | Replicate (Total Ammonia, TC, <i>E.coli</i> ) | < $\pm 5\%$ (ammonia), < $\pm 8\%$ (tot coliform)                                                                                                                       | N                          |                                                                                                                                        |
|           | Y                     | Replicate Mercury-Dissolved                   | <RDL                                                                                                                                                                    | N                          |                                                                                                                                        |
|           | Y                     | Replicate Metals-Dissolved                    | <RDL (24 parameters), < $\pm 5\%$ (6 parameters), $\pm 6-11\%$ (6 parameters)                                                                                           | Replicate (all parameters) | <5% for all parameters except turbidity, TDS, Ca, Cu attributed to natural variability in quality for samples collected in succession. |
|           | Y                     | Replicate Metals-Total                        | < $\pm 5$ for 16 parameters (total metals), RDL 12% aluminum, RDL - 13% copper, (plumbing related, samples collected in succession, natural variability during pumping) | N                          |                                                                                                                                        |

Table A-4: Number of tests, median, minimum and maximum concentration of drinking water quality parameters in shallow (dug) and deep (drilled) wells in Comox study area.

|                                 |           | Number of tests |       |            |       | Median Concentration |       |             | Median Concentration |       |             | Minimum       |         |         |         | Maximum    |        |        |        | Drinking Water Quality Guideline |      |     |
|---------------------------------|-----------|-----------------|-------|------------|-------|----------------------|-------|-------------|----------------------|-------|-------------|---------------|---------|---------|---------|------------|--------|--------|--------|----------------------------------|------|-----|
|                                 |           | Shallow Wells   |       | Deep Wells |       | Shallow Wells        |       |             | Deep Wells           |       |             | Shallow Wells |         |         |         | Deep Wells |        |        |        |                                  |      |     |
|                                 |           | Before          | After | Before     | After | Before               | After | All samples | Before               | After | All samples | Before        | After   | Before  | After   | Before     | After  | Before | After  | MAC                              | AO   | OG  |
| General Chemistry & Nutrients   |           |                 |       |            |       |                      |       |             |                      |       |             |               |         |         |         |            |        |        |        |                                  |      |     |
| Chloride (Cl)                   | mg/L      | 21              | 4     | 31         | 4     | 16                   | 17    | 16.5        | 16                   | 25    | 20.5        | 10            | 14      | 14      | 10      | 27         | 28     | 9.9    | 40     | -                                | 250  | -   |
| Dissolved Fluoride (F)          | mg/L      | 21              |       | 31         |       | 0.05                 |       | 0.05        | 0.05                 |       | 0.05        | <0.050        |         | <0.050  |         | 0.053      |        | 0.084  |        | 1.5                              | -    | -   |
| Nitrate (N)                     | mg/L      | 21              | 4     | 31         | 4     | 1.33                 | 0.46  | 0.89        | 0.023                | 0.11  | 0.0665      | <0.020        | 0.02    | <0.020  | <0.020  | 7.92       | 2.93   | 1.24   | 0.94   | 10                               | -    | -   |
| Nitrite (N)                     | mg/L      | 21              | 4     | 31         | 4     | 0.005                | 0.005 | 0.005       | 0.005                | 0.005 | 0.005       | <0.0050       | <0.0050 | <0.0050 | <0.0050 | 0.0242     | 0.0298 | <0.050 | <0.050 | 1                                | -    | -   |
| pH                              | pH        | 21              | 4     | 31         | 4     | 7.01                 | 6.94  | 6.98        | 7.76                 | 7.51  | 7.63        | 6.48          | 6.72    | 6.63    | 7.13    | 7.88       | 7.56   | 8.14   | 7.92   | 7.0: 10.5                        | -    | -   |
| Sulphate (SO4)                  | mg/L      | 21              | 4     | 31         | 4     | 5.4                  | 6.5   | 5.9         | 5.4                  | 2.8   | 4.1         | 1.8           | 10.0    | <1.0    | <1.0    | 9.7        | 7.0    | 6.2    | 4.6    | -                                | 500  | -   |
| Total Dissolved Solids          | mg/L      | 21              | 4     | 31         | 4     | 100                  | 130   | 115         | 170                  | 155   | 163         | 100           | 180     | 130     | 110     | 98         | 80     | 96     | 220    | -                                | -    | -   |
| Total Sulphide                  | mg/L      | 18              |       | 26         |       | 0.0018               |       | 0.0018      | 0.0028               |       | 0.0028      | <0.0018       |         | <0.0018 |         | 0.17       |        | 0.086  |        | -                                | 0.05 | -   |
| Turbidity                       | NTU       | 21              | 4     | 31         | 4     | 0.67                 | 0.8   | 0.7         | 1.1                  | 3.8   | 2.5         | 0.14          | 0.52    | <0.10   | 0.3     | 8.9        | 2.2    | 8.4    | 7.3    |                                  |      |     |
| True Colour                     | Col. Unit | 21              |       | 31         |       | 5                    |       | 5           | 5                    |       | 5           | <5.0          |         | <2.0    |         | 6.1        |        | 9.1    |        | -                                | 15   | -   |
| Elements by Atomic Spectroscopy |           |                 |       |            |       |                      |       |             |                      |       |             |               |         |         |         |            |        |        |        |                                  |      |     |
| Dissolved Aluminum (Al)         | µg/L      | 18              | 4     | 26         | 4     | 3.50                 | 3.25  | 3.38        | 3.00                 | 3.00  | 3.00        | <3.0          | <3.0    | <3.0    | <3.0    | 9.40       | 4.20   | 9.70   | 14.00  | 2900                             | -    | 100 |
| Dissolved Antimony (Sb)         | µg/L      | 18              | 4     | 26         | 4     | 0.50                 | 0.50  | 0.50        | 0.50                 | 0.50  | 0.50        | <0.50         | <0.50   | <0.50   | <0.50   | 1.18       | 0.75   | <0.50  | <0.50  | 6                                | -    | -   |
| Dissolved Arsenic (As)          | µg/L      | 18              | 4     | 26         | 4     | 0.15                 | 0.12  | 0.13        | 0.10                 | 0.11  | 0.103       | <0.10         | <0.10   | <0.10   | <0.10   | 0.28       | 0.23   | 0.52   | 0.55   | 10                               | -    | -   |
| Dissolved Barium (Ba)           | µg/L      | 18              | 4     | 26         | 4     | 1.6                  | 2.0   | 1.8         | 11.8                 | 8.8   | 10.3        | <1.0          | <1.0    | 1.4     | 1.6     | 7.3        | 5.9    | 6      | 6      | 2000                             | -    | -   |
| Dissolved Boron (B)             | µg/L      | 18              | 4     | 26         | 4     | 50                   | 50    | 50          | 50                   | 50    | 50          | <50           | <50     | <50     | <50     | <50        | <50    | <50    | <50    | 5000                             | -    | -   |
| Dissolved Cadmium (Cd)          | µg/L      | 18              | 4     | 26         | 4     | 0.01                 | 0.01  | 0.01        | 0.01                 | 0.01  | 0.01        | <0.010        | <0.010  | <0.010  | <0.010  | <0.010     | 0.011  | 0.011  | 0.011  | 7                                | -    | -   |
| Dissolved Chromium (Cr)         | µg/L      | 18              | 4     | 26         | 4     | 1                    | 1     | 1           | 1                    | 1     | 1           | <1.0          | <1.0    | <1.0    | <1.0    | <1.0       | <1.0   | 2      | 1.7    | 50                               | -    | -   |
| Dissolved Copper (Cu)           | µg/L      | 18              | 4     | 26         | 4     | 2.46                 | 2.19  | 2.32        | 0.50                 | 0.20  | 0.3475      | 0.23          | 0.35    | <0.20   | <0.20   | 8.63       | 3.74   | 9.72   | 3.59   | 2000                             | -    | -   |
| Dissolved Iron (Fe)             | µg/L      | 18              | 4     | 26         | 4     | 35.9                 | 108.5 | 72.2        | 21.7                 | 413.3 | 217.48      | <5.0          | 108     | <5.0    | <5.0    | 9.5        | 527    | 89.5   | 769    | -                                | 100  | -   |
| Dissolved Lead (Pb)             | µg/L      | 18              | 4     | 26         | 4     | 0.20                 | 0.23  | 0.22        | 0.20                 | 0.20  | 0.2         | <0.20         | <0.20   | <0.20   | <0.20   | 0.47       | 0.37   | <0.20  | <0.20  | 5                                | -    | -   |
| Dissolved Manganese (Mn)        | µg/L      | 18              | 4     | 26         | 4     | 23.1                 | 70.2  | 46.6        | 38.0                 | 50.5  | 44.225      | 10.3          | 14.4    | <1.0    | <1.0    | 5          | 82.1   | 56.2   | 52.9   | 120                              | 20   | -   |
| Dissolved Selenium (Se)         | µg/L      | 18              | 4     | 26         | 4     | 0.10                 | 0.10  | 0.10        | 0.10                 | 0.15  | 0.1225      | <0.10         | <0.10   | <0.10   | <0.10   | 0.14       | <0.10  | 0.28   | 0.2    | 50                               | -    | -   |
| Dissolved Sodium (Na)           | mg/L      | 18              | 4     | 26         | 4     | 14.4                 | 15.8  | 15.1        | 15.2                 | 15.3  | 15.225      | 10.3          | 13.7    | 13.9    | 13.9    | 9.88       | 9.01   | 9.52   | 8.84   | -                                | 200  | -   |
| Dissolved Uranium (U)           | µg/L      | 18              | 4     | 26         | 4     | 0.1                  | 0.1   | 0.1         | 0.1                  | 0.1   | 0.1         | <0.10         | <0.10   | <0.10   | <0.10   | 0.1        | 0.17   | 1.43   | 1.37   | 20                               | -    | -   |
| Dissolved Zinc (Zn)             | µg/L      | 18              | 4     | 26         | 4     | 10.9                 | 9.8   | 10.3        | 9.0                  | 5.9   | 7.45        | <5.0          | 10.6    | <5.0    | <5.0    | 9.2        | 9      | 8      | 6.8    | -                                | 5000 | -   |
| Total Aluminum (Al)             | µg/L      | 21              | 4     | 31         | 4     | 13.4                 | 8.8   | 11.1        | 3                    | 9     | 6           | 11.1          | 11.3    | <3.0    | <3.0    | 9.4        | 6.3    | 8.1    | 17.1   | 2900                             | -    | 100 |
| Total Antimony (Sb)             | µg/L      | 21              | 4     | 31         | 4     | 0.5                  | 0.5   | 0.5         | 0.5                  | 0.5   | 0.5         | <0.50         | <0.50   | <0.50   | <0.50   | 1.12       | 0.86   | <0.50  | <0.50  | 6                                | -    | -   |
| Total Arsenic (As)              | µg/L      | 21              | 4     | 31         | 4     | 0.16                 | 0.145 | 0.1525      | 0.1                  | 0.105 | 0.1025      | <0.10         | 0.1     | <0.10   | <0.10   | 0.65       | 0.27   | 0.55   | 0.56   | 10                               | -    | -   |
| Total Barium (Ba)               | µg/L      | 21              | 4     | 31         | 4     | 2.3                  | 2.2   | 2.25        | 12.7                 | 9     | 10.85       | <1.0          | 1       | 1.3     | 1.6     | 7.1        | 6.4    | 6.6    | 6.1    | 2000                             | -    | -   |

|                        |             | Number of tests |       |            |       | Median Concentration |        |             | Median Concentration |        |             | Minimum       |         |         |         | Maximum    |         |         |         | Drinking Water Quality Guideline |      |    |
|------------------------|-------------|-----------------|-------|------------|-------|----------------------|--------|-------------|----------------------|--------|-------------|---------------|---------|---------|---------|------------|---------|---------|---------|----------------------------------|------|----|
|                        |             | Shallow Wells   |       | Deep Wells |       | Shallow Wells        |        |             | Deep Wells           |        |             | Shallow Wells |         |         |         | Deep Wells |         |         |         |                                  |      |    |
|                        |             |                 |       |            |       |                      |        |             |                      |        |             |               |         |         |         |            |         |         |         |                                  |      |    |
| Parameter              | Result Unit | Before          | After | Before     | After | Before               | After  | All samples | Before               | After  | All samples | Before        | After   | Before  | After   | Before     | After   | Before  | After   | MAC                              | AO   | OG |
| Total Boron (B)        | µg/L        | 21              | 4     | 31         | 4     | 50                   | 50     | 50          | 50                   | 50     | 50          | <50           | <50     | <50     | <50     | <50        | <50     | <50     | <50     | 5000                             | -    | -  |
| Total Cadmium (Cd)     | µg/L        | 21              | 4     | 31         | 4     | 0.01                 | 0.01   | 0.01        | 0.01                 | 0.01   | 0.01        | <0.010        | <0.010  | <0.010  | <0.010  | 0.026      | 0.011   | 0.349   | 0.015   | 7                                | -    | -  |
| Total Chromium (Cr)    | µg/L        | 21              | 4     | 31         | 4     | 1                    | 1      | 1           | 1                    | 1      | 1           | <1.0          | <1.0    | <1.0    | <1.0    | 1.5        | <1.0    | 2.2     | 2       | 50                               | -    | -  |
| Total Copper (Cu)      | µg/L        | 21              | 4     | 31         | 4     | 4.04                 | 3.1    | 3.5         | 2.8                  | 0.7    | 1.7         | 0.4           | 0.8     | <0.20   | <0.20   | 8.1        | 4.9     | 9.9     | 4.6     | 2000                             | 1000 | -  |
| Total Iron (Fe)        | µg/L        | 21              | 4     | 31         | 4     | 166                  | 308    | 237         | 213                  | 461    | 337         | 1140          | 242     | 108     | 16400   | 9.5        | 655     | 8370    | 842     | -                                | 100  | -  |
| Total Lead (Pb)        | µg/L        | 21              | 4     | 31         | 4     | 0.2                  | 0.31   | 0.26        | 0.20                 | 0.20   | 0.20        | <0.20         | <0.20   | <0.20   | <0.20   | 2.14       | 0.46    | 1.47    | 0.39    | 5                                | -    | -  |
| Total Manganese (Mn)   | µg/L        | 21              | 4     | 31         | 4     | 22.1                 | 77.5   | 49.8        | 39.6                 | 52.6   | 46.1        | <1.0          | 16.1    | <1.0    | 184     | 5.7        | 90.3    | 64      | 56      | 120                              | 20   | -  |
| Total Selenium (Se)    | µg/L        | 21              | 4     | 31         | 4     | 0.1                  | 0.1    | 0.1         | 0.1                  | 0.1    | 0.1         | <0.10         | <0.10   | <0.10   | <0.10   | <0.10      | <0.10   | 0.81    | 0.17    | 50                               | -    | -  |
| Total Sodium (Na)      | mg/L        | 21              | 4     | 31         | 4     | 14                   | 16.5   | 15.2        | 14.5                 | 15.3   | 14.9        | 10.30         | 14.20   | 13.40   | 14.20   | 9.53       | 9.21    | 9.06    | 9.19    | -                                | 200  | -  |
| Total Uranium (U)      | µg/L        | 21              | 4     | 31         | 4     | 0.1                  | 0.1    | 0.1         | 0.1                  | 0.1    | 0.1         | <0.10         | <0.10   | <0.10   | <0.10   | <0.10      | 0.21    | 1.59    | 1.49    | 20                               | -    | -  |
| Total Zinc (Zn)        | µg/L        | 21              | 4     | 31         | 4     | 12.4                 | 13.2   | 12.8        | 10.8                 | 7.7    | 9.3         | <5.0          | 12.6    | <5.0    | <5.0    | 81.8       | 7.2     | 7.1     | 9.4     | -                                | 5000 | -  |
| Mercury by Cold Vapor  |             |                 |       |            |       |                      |        |             |                      |        |             |               |         |         |         |            |         |         |         |                                  |      |    |
| Dissolved Mercury (Hg) | µg/L        | 11              | 4     | 16         | 4     | 0.0019               | 0.0019 | 0.0019      | 0.0019               | 0.0019 | 0.0019      | <0.0019       | <0.0019 | <0.0019 | <0.0019 | 0.0024     | <0.0019 | <0.0019 | <0.0019 | 1                                | -    | -  |
| Total Mercury (Hg)     | µg/L        | 21              |       | 31         |       | 0.0019               |        | 0.0019      | 0.0019               |        | 0.0019      | <0.0019       |         | <0.0019 |         | 0.003      |         | <0.0019 |         | 1                                | -    | -  |
| Microbiology           |             |                 |       |            |       |                      |        |             |                      |        |             |               |         |         |         |            |         |         |         |                                  |      |    |
| Total Coliforms        | CFU/100mL   | 21              | 4     | 31         | 4     | 38                   | 4950   | 2494        | 2                    | 2      | 2           | >2000         | 0       | <2      | <2      | 9100       | 6500    | 9       | 82      | -                                | -    | -  |
| E. coli                | CFU/100mL   | 21              | 4     | 31         | 4     | 0                    | 2      | 1           | 0                    | 0      | 0           | 0             | 0       | <2      | <2      | 83         | 28      | 0       | 0       | -                                | -    | -  |

**Notes:**  
MAC    Maximum Acceptable Concentration  
AO    Aesthetic Objective  
OG    Operational guideline for water systems.

## **APPENDIX B**

### **GW SOLUTIONS INC. GENERAL CONDITIONS AND LIMITATIONS**

This report incorporates and is subject to these "General Conditions and Limitations".

### 1.0 USE OF REPORT

This report pertains to a specific area, a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site or proposed development would necessitate a supplementary investigation and assessment. This report and the assessments and recommendations contained in it are intended for the sole use of GW SOLUTIONS's client. GW SOLUTIONS does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than GW SOLUTIONS's client unless otherwise authorized in writing by GW SOLUTIONS. Any unauthorized use of the report is at the sole risk of the user. This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of GW SOLUTIONS. Additional copies of the report, if required, may be obtained upon request.

### 2.0 LIMITATIONS OF REPORT

This report is based solely on the conditions which existed within the study area or on site at the time of GW SOLUTIONS's investigation. The client, and any other parties using this report with the express written consent of the client and GW SOLUTIONS, acknowledge that conditions affecting the environmental assessment of the site can vary with time and that the conclusions and recommendations set out in this report are time sensitive. The client, and any other party using this report with the express written consent of the client and GW SOLUTIONS, also acknowledge that the conclusions and recommendations set out in this report are based on limited observations and testing on the area or subject site and that conditions may vary across the site which, in turn, could affect the conclusions and recommendations made. The client acknowledges that GW SOLUTIONS is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the client.

### 2.1 INFORMATION PROVIDED TO GW SOLUTIONS BY OTHERS

During the performance of the work and the preparation of this report, GW SOLUTIONS may have relied on information provided by persons other than the client. While GW SOLUTIONS endeavours to verify the accuracy of such information when instructed to do so by the client, GW SOLUTIONS accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

### 3.0 LIMITATION OF LIABILITY

The client recognizes that property containing contaminants and hazardous wastes creates a high risk of claims brought by third parties arising out of the presence of those materials. In consideration of these risks, and in consideration of GW SOLUTIONS providing the services requested, the client agrees that GW SOLUTIONS's liability to the client, with respect to any issues relating to contaminants or other hazardous wastes located on the subject site shall be limited as follows:

(1) With respect to any claims brought against GW SOLUTIONS by the client arising out of the provision or failure to provide services hereunder shall be limited to the amount of fees paid by the client to GW SOLUTIONS under this Agreement, whether the action is based on breach of contract or tort;

(2) With respect to claims brought by third parties arising out of the presence of contaminants or hazardous wastes on the subject site, the client agrees to indemnify, defend and hold harmless GW SOLUTIONS from and against any and all claim or claims, action or actions, demands, damages, penalties, fines, losses, costs and expenses of every nature and kind whatsoever, including solicitor-client costs, arising or alleged to arise either in whole or part out of services provided by GW SOLUTIONS, whether the claim be brought against GW SOLUTIONS for breach of contract or tort.

### 4.0 JOB SITE SAFETY

GW SOLUTIONS is only responsible for the activities of its employees on the job site and is not responsible for the supervision

of any other persons whatsoever. The presence of GW SOLUTIONS personnel on site shall not be construed in any way to relieve the client or any other persons on site from their responsibility for job site safety.

### 5.0 DISCLOSURE OF INFORMATION BY CLIENT

The client agrees to fully cooperate with GW SOLUTIONS with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The client acknowledges that in order for GW SOLUTIONS to properly provide the service, GW SOLUTIONS is relying upon the full disclosure and accuracy of any such information.

#### **6.0 STANDARD OF CARE**

Services performed by GW SOLUTIONS for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

#### **7.0 EMERGENCY PROCEDURES**

The client undertakes to inform GW SOLUTIONS of all hazardous conditions, or possible hazardous conditions which are known to it. The client recognizes that the activities of GW SOLUTIONS may uncover previously unknown hazardous materials or conditions and that such discovery may result in the necessity to undertake emergency procedures to protect GW SOLUTIONS employees, other persons and the environment. These procedures may involve additional costs outside of any budgets previously agreed upon. The client agrees to pay GW SOLUTIONS for any expenses incurred as a result of such discoveries and to compensate GW SOLUTIONS through payment of additional fees and expenses for time spent by GW SOLUTIONS to deal with the consequences of such discoveries.

#### **8.0 NOTIFICATION OF AUTHORITIES**

The client acknowledges that in certain instances the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by GW SOLUTIONS in its reasonably exercised discretion.

#### **9.0 OWNERSHIP OF INSTRUMENTS OF SERVICE**

The client acknowledges that all reports, plans, and data generated by GW SOLUTIONS during the performance of the work and other documents prepared by GW SOLUTIONS are considered its professional work product and shall remain the copyright property of GW SOLUTIONS.

#### **10.0 ALTERNATE REPORT FORMAT**

Where GW SOLUTIONS submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed GW SOLUTIONS's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by GW SOLUTIONS shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancies, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by GW SOLUTIONS shall be deemed to be the overall original for the Project. The Client agrees that both electronic file and hard copy versions of GW SOLUTIONS's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except GW SOLUTIONS. The Client warrants that GW SOLUTIONS's instruments of professional service will be used only and exactly as submitted by GW SOLUTIONS. The Client recognizes and agrees that electronic files submitted by GW SOLUTIONS have been prepared and submitted using specific software and hardware systems. GW SOLUTIONS makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.