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Yakima Valley Dairies

Quarterly Groundwater Monitoring Data Report

Fourth Quarter 2014

Administrative Order on Consent
SDWA-10-2013-0080

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Tables

Figures

Appendices

Acronyms and Abbreviations

AOC	Administrative Order on Consent
CAFOs	Confined Animal Feeding Operations
CSM	conceptual site model
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
HSP	Health and Safety Plan
LHG	Licensed Hydrogeologist
LG	Licensed Geologist
MCL	maximum contaminant level
µS/cm	microsiemens per centimeter
meq/L	milliequivalents per liter
mg/L	milligrams per liter
mV	millivolts
NTU	nephelometric turbidity units
NPDES	National Pollution Discharge Elimination System
NRCS	Natural Resources Conservation Service
PARCC	Precision, Accuracy, Representativeness, Comparability, and Completeness
PC	Project Coordinator
QAM	Quality Assurance Manager

QAPP	Quality Assurance Project Plan
QC	quality control
SDG	Sample Delivery Group
SOP	standard operating procedure
SOW	Statement of Work
SWDA	Safe Water Drinking Act

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Executive Summary

The (1) Cow Palace Dairy, LLC; (2) D & A Dairy, LLC (also known as D&A Dairy L.L.C.), George DeRuyter & Son Dairy, L.L.C., and George & Margaret, L.L.C; and (3) Liberty Dairy LLC and its associated dairy facility H&S Bosma Dairy ("Dairies") present this Quarterly Groundwater Monitoring Data Report (the "Report") for the Yakima Valley Dairies (the "Dairies"). The Report is prepared in accordance with requirements identified in Section III.E of the Statement of Work (SOW) (Appendix B of Administrative Order on Consent [AOC] SDWA-10-2013-0080). Groundwater monitoring at the Dairies is required by the AOC in accordance with the Groundwater Monitoring Quality Assurance Project Plan (QAPP) dated June 21, 2013.

Pursuant to Section III.E of the AOC SOW, the objectives of groundwater monitoring are to establish a baseline of groundwater quality information at the Dairies to evaluate whether actions taken to reduce nitrogen loading are effective over time, and to collect information to supplement and verify existing information on the environmental setting at the Dairies, including further clarification of the hydraulic gradient of the aquifer beneath the Dairies. After eight years of quarterly groundwater monitoring (32 quarters), the nitrate levels in the monitoring wells that are downgradient of the dairy nitrogen sources will be evaluated. For any individual monitoring well where the nitrate level is not trending downward, additional source control actions will be required in accordance with Section III.G of the AOC.

A network of 26 groundwater monitoring wells is in place at the Dairies. In addition to seven groundwater monitoring wells that were installed by EPA in 2012, the Dairies installed 19 groundwater monitoring wells as part of the AOC in 2013. Twenty-three of the monitoring wells were completed at the top of the "shallow" surficial aquifer (at the water table), and three of the monitoring wells were completed deeper in the surficial aquifer. All of the wells were installed in the surficial aquifer which is used as a source of drinking water. All of the wells were designed and installed according to Washington State regulations and an EPA-approved QAPP.

This is the sixth quarterly groundwater monitoring report prepared under the AOC. From December 14 to 17, 2014, the Dairies sampled 26 of 26 wells at the site, in accordance with the sampling procedures outlined below and in the Groundwater Monitoring QAPP (ARCADIS 2013b). The nitrate results are shown spatially on a map in Figure 17. The monitoring well network includes wells that are located upgradient and downgradient of the dairies. There are four groundwater monitoring wells located upgradient of the Dairy facilities' footprint. All four wells were screened at the top of the

aquifer. In the upgradient monitoring wells nitrate concentrations [reported in milligrams per liter (mg/L)] at the time the Dairies sampled the wells were:

Well	Nitrate (mg/L)
DC-01	18.9
YVD-02	0.22
YVD-03	4.27
YVD-04	3.81

The nitrate concentrations in these upgradient groundwater monitoring wells ranged from less than 0.22 mg/L to 18.9 mg/L. The drinking water standard, or maximum contaminant level (MCL), for nitrate is 10 mg/L. Nitrate concentrations in the upgradient monitoring wells were less than the MCL except as detected in well DC-01.

In the downgradient monitoring wells that were screened at the top of the aquifer (water table wells), nitrate concentrations (reported in mg/L) were:

Well	Nitrate (mg/L)
DC-03	193
DC-04	40.8
DC-05	33.4
DC-07	2.92
DC-09	5.94
DC-14	10.4
YVD-05	2.65
YVD-06	0.45
YVD-07	2.92
YVD-08	14.0
YVD-09	53.9
YVD-10	78.7
YVD-11	49.1
YVD-12	15.1
YVD-13	27.3
YVD-14	96.1

Well	Nitrate (mg/L)
YVD-15	66.9
YVD-16	22.4
YVD-17	0.66

Nitrate concentrations in the downgradient water table groundwater monitoring wells ranged from 0.45 mg/L to 193 mg/L. Nitrate concentrations in six of the downgradient water table wells were less than the MCL; nitrate concentrations in 18 of the downgradient water table wells exceeded the MCL. The higher nitrate concentrations in the downgradient groundwater monitoring wells compared to the upgradient wells indicate that significant nitrate loading from Dairy sources has occurred.

The Dairies installed three additional downgradient groundwater monitoring wells at screen depths that were estimated by EPA to approximate the depth of a typical residential drinking water well in the area. Each of these deeper wells was paired with a well that was installed at the water table at the same location. These were the results (in mg/L) for each well pair, with the water table well listed above its deeper counterpart:

Well	Nitrate (mg/L)	Well	Nitrate (mg/L)	Well	Nitrate (mg/L)
YVD-13	27.3	DC-03	193	DC-05	33.4
YVD-18	16.5	DC-03D	38.6	DC-05D	7.90

The results show higher nitrate concentrations at the top of the water table, and lower concentrations at depth. This is consistent with a scenario of nitrate loading occurring at the top of the aquifer, and the nitrate becoming increasingly diluted as it mixes with cleaner water below.

In addition to nitrate, groundwater samples were also analyzed for:

- Ammonia
- Total phosphorus
- Total Kjeldahl nitrogen
- Inorganic anions (chloride, fluoride, sulfate)
- Metals (calcium, potassium, magnesium, sodium)
- Alkalinity (total and bicarbonate)

Some of these results are summarized in Figures 16, 24, 25, and 26.

Sulfate was detected in two wells, DC-01 and YVD-17, at a concentration greater than the secondary contaminant level of 250 mg/L.

Site geology observed in most of the monitoring well borings typically consisted of finer-grained materials in the upper portion of borings and coarser-grained material in lower portions of borings. The surficial aquifer was typically encountered in the gravelly sand or sandy gravel that dominated most of the subsurface throughout the site. Depth to groundwater from the land surface ranged from 21 to 220 feet. Groundwater was deepest in borings located in areas of the site that were topographically higher. Comparatively, groundwater was shallowest in borings located in areas of the site that were topographically lower.

The groundwater gradient at the site is generally to the southwest at an average hydraulic gradient of 0.02 ft/ft. Hydraulic gradients are steeper in wells completed in the upslope areas with an average of 0.04 ft/ft. As groundwater flows to the southwest, hydraulic gradients flatten to about 0.015 ft/ft in the central portion of the site and then to 0.006 ft/ft in the south portion of the site. The calculated average linear groundwater flow velocities for the area under the Dairies range from 3 to 19 feet per day.

Site groundwater is primarily classified as calcium-bicarbonate type water. Calcium bicarbonate type waters were present in groundwater samples collected from 15 monitoring wells. Calcium-sulfate type waters were present in groundwater samples collected from six monitoring wells and sodium-bicarbonate type waters were present in groundwater samples collected from five monitoring wells.

Total dissolved ions show a significant increase in concentration along with nitrate as the groundwater moves downgradient beneath the Dairies (Figure 23). Figure 28 confirms that ion concentrations are generally more elevated in the downgradient monitoring wells toward the southwest.

1. Report Organization

This Report includes the following sections: Executive Summary, Introduction, Location and Setting, Site Investigation Activities, Site Soil and Groundwater Characteristics, Analytical Program, and Analytical Results.

2. Introduction

The (1) Cow Palace Dairy, LLC; (2) D & A Dairy, LLC (also known as D&A Dairy L.L.C.), George DeRuyter & Son Dairy, L.L.C., and George & Margaret, L.L.C; and (3) Liberty Dairy LLC and its associated dairy facility H&S Bosma Dairy (“Dairies”), present this Quarterly Groundwater Monitoring Data Report (the “Report”). The Report is prepared in accordance with requirements identified in Section III.E of the Statement of Work (SOW) (Appendix B of Administrative Order on Consent [AOC] SDWA-10-2013-0080). Groundwater monitoring at the Dairies is required by the AOC in accordance with the Groundwater Monitoring Quality Assurance Project Plan (QAPP) dated June 21, 2013.

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2.1. Location and Setting

The Dairies include the George DeRuyter & Son Dairy, D & A Dairy, Cow Palace 1 and 2, Liberty Dairy, and H&S Bosma Dairy. The Dairies are located in an area that occupies both the easternmost portion of the Toppenish Basin and the westernmost portion of the Benton Basin within the south-central part of the Yakima Basin just south of the Rattlesnake Hills in Yakima County, Washington.

The Dairies are located approximately 10 road miles northwest of Sunnyside, Washington. The Dairies occupy portions or all of Sections 25, 26, 27, 35, and 36 of

Township 11 North, Range 21 East; Sections 19, 30, 31, and 32 of Township 11 North, Range 22 East; Section 1 of Township 10 North, Range 21 East; and Sections 6 and 7 of Township 10 North, Range 22 East, Willamette Meridian. Figure 1 shows the location of the Dairies, the installed monitoring wells, and general topography of the area. Figure 2 shows an aerial photograph of the Dairies. A figure showing the Facility Plan, which includes land use information within the Dairies boundary is included as Figure 3.

Figures 3A, 3B and 3C depict the Facility Plan for each individual Dairy, and include facility specific features including: dairy production, irrigation and domestic water wells, pipelines, and outfalls. One outfall is located within the footprint of the Liberty Dairy, as shown on Figure 3C. Discharge from the outfall is non-contact process water related to milk plate cooler. Cooling water from the plate cooler is discharged to Sunnyside Valley Irrigation District Joint Drain 26-6. This outfall is not covered by a NPDES permit. There are no outfalls within the footprint of Cow Palace. One outfall is located within the footprint of the George DeRuyter and Sons owned property, as shown on Figure 3b. Discharge from the outfall is non-contact process water related to milk plate cooler. Cooling water from the plate cooler is discharged to SVID Joint Drain 26-6. This outfall is not covered by a NPDES permit. There are no French drains, sewer pipes, stormwater drains, or tile drains within the footprint of the Dairies.

Topography of the area containing the Dairies consists of gently rolling hills. Land use is predominantly large dairy farms, which are concentrated animal feeding operations (CAFOs), and irrigated cropland including corn fields, apple and cherry orchards and grape vineyards. Residences are interspersed throughout the area and are serviced by private water wells for drinking water.

2.2. Regional Geology and Hydrogeology

The information presented below is summarized from the U.S. Geological Survey (USGS) publication *Hydrogeologic Framework of the Yakima River Basin Aquifer System, Washington* (USGS 2009) and the U.S. Environmental Protection Agency (EPA) publication *Relation Between Nitrate in Water Wells and Potential Sources in the Lower Yakima Valley, Washington* (EPA 2012). Surface soils and drainage classification, as mapped by NRCS, within the footprint of the Respondents' dairy facilities are illustrated in Appendix A.

The Toppenish and Benton Basins consist of fine- and coarse-grained sediments overlying a sequence of three major basalt flows. The structural setting is created by bounding ridges such as the Rattlesnake Mountains, Ahtanum Ridge, Toppenish Ridge, and Horse Heaven Hills. The uppermost basalts of the Saddle Mountain Unit of the Columbia River Basalt Group are typically exposed in these upland ridges. This unit averages more than 500 feet thick. The underlying Wanapum unit averages 600 feet thick. These units are separated by the Mabton Interbed, with an average thickness of 70 feet.

The valley is filled with a variety of sediments that pinch out along the flanks of the ridges. These sediments include Touchet Beds, loess and thick alluvial sands and gravels, and significant thickness of Ellensburg Formation. The thickness of these sedimentary units decreases from an average of more than 500 feet in the Toppenish Basin to less than 200 feet in the lower Benton Basin.

Groundwater is found in fractures and interbeds formed of clinkers, permeable lava, lake deposits or paleosols and may occur at significant depths in the upland ridges, such as Horse Heaven Hills, and especially in the basalts. The water table is found at shallower depths as the valley is approached from these ridges. Near the Yakima River, depth to water may be less than 10 feet, especially during the irrigation season.

There are two main aquifer types underlying the Dairies. They include a surficial unconfined to semi-confined alluvial aquifer and an extensive basalt aquifer of great thickness underlying the sedimentary deposits. The basalt aquifer is believed to be semi-isolated from the surficial aquifer and stream systems. Groundwater flow within the surficial aquifer generally follows topography, with natural recharge occurring within the headlands and on the sides of the valley and discharge occurring to the Yakima River. Flow within the uppermost portions of the underlying deep surficial basaltic aquifer also generally follows this pattern.

Because the basalts extend to great depths, the deeper basaltic layers may convey waters across local flow divides to more regionally significant discharge locations such as the Columbia River. This pattern produces a major flow direction from northwest to southeast as water moves down the valley parallel to the course of the Yakima River. Other, more localized directions of flow, typically at shallower depths in the uppermost sediments, tend to flow toward the Yakima River. Locally, the flow direction may be modified by geologic structures and by irrigation practices, drains, ditches, canals, and other hydrologic features.

The Lower Yakima Valley is filled with sediments shed by the ridges at the margins of the study area and those deposited in the valley bottom by the Yakima River. These sediments have an internal structure that strongly controls groundwater movement. As the water moves through these sediments, it tends to follow preferential flow paths composed of coarser sediments.

3. Investigation Activities

Investigation efforts were initiated as a result of the September 21, 2013 Administrative Order on Consent. As discussed in Section 1.0, the objectives of Groundwater Monitoring task are to establish a baseline of groundwater quality information at the Dairies to evaluate whether actions taken to reduce nitrogen loading are effective over time, and to collect information to supplement and verify existing information on the environmental setting at the Dairies, including further clarification of the hydraulic gradient of the aquifer beneath the Dairies. As part of the ongoing activities a conceptual site model (CSM) was developed and will be updated and modified as necessary (Figure 4 and Figure 5).

The Groundwater Monitoring QAPP dated June 21, 2013 was conditionally approved with modification by EPA June 19, 2013. Field investigation activities pursuant to the EPA-approved QAPP were initiated in June 27, 2013. Drilling and monitoring well construction activities began on June 27, 2013 and concluded on August 23, 2013. Well development activities began on August 26, 2013 and concluded September 4, 2013. A Quarterly Groundwater monitoring program was initiated in September 2013.

3.1. Groundwater Monitoring Well Installation

A total of 19 groundwater monitoring wells were located, drilled and installed as part of the AOC at the Dairies. Sixteen monitoring wells were completed in the “shallow” surficial aquifer, and three monitoring wells were completed in the “deep” surficial aquifer. Cascade Drilling, L.P. (Cascade Drilling) of Woodinville, Washington was subcontracted to drill and develop the monitoring wells.

The exact location of each well was jointly agreed upon in the field by representatives of the Dairies and EPA. Well locations were marked with an annotated lathe stake. Details of drilling, installation and completion of monitoring wells is provided in the Groundwater Monitoring Well Installation Report (ARCADIS, 2013).

3.2. December 2014 Groundwater Sampling Event

ARCADIS and IES personnel performed monitoring and sampling of the 19 wells installed as part of the AOC SOW (the "YVD" wells) and the seven wells previously installed by EPA wells (the "DC" wells) from December 14 through 17, 2014. The locations of the monitoring wells are depicted in Figures 1 and 2. The location and construction information for each well is presented in Table 1. The monitoring and sampling was performed in accordance with the sampling procedures documented in the Groundwater Monitoring QAPP (IES, 2015). Data validation reports were submitted to EPA on February 9, 2015.

3.2.1. Measurement of Static Water Levels

Prior to purging water from a monitoring well, an electronic water level meter was used to measure the depth to groundwater. A set of synoptic (concurrent) water level measurements was collected from all 26 monitored wells on December 14, 2014. Static water level measurements were recorded to the nearest 0.01-foot at the indicated reference point on the well casing. The static water level measurement was recorded on the Groundwater Sampling Forms presented in Appendix B. The recorded groundwater measurements for Fourth Quarter 2014 are summarized in Table 2.

3.2.2. Measure Total Depth of the Well and Water Column

The total depth of each well was measured by lowering the water level tape to the bottom of the well and reading the depth at the well casing's reference point. The total well depth of the well was recorded on the Groundwater Sampling Form. The recorded monitoring well depth was compared to the original completion depth of the well to assess the accumulation of sediment in the well.

Using the static water level and the known depth to the bottom of the well measurements, the volume of standing water in the well was calculated. This volume, multiplied by the gallons per linear foot of the casing, equals the volume of water in the well casing. For example, a 2-inch-diameter well has 0.17 gallon per linear foot of casing. To calculate one casing volume with 10 feet of water in the casing, multiply 10 feet by 0.17 gallon per linear foot to equal 1.7 gallons.

3.2.3. Sample Collection

Groundwater samples were collected using low-flow sample collection procedures described in the Standard Operation Procedure (SOP) entitled *Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells* (IES, 2015; Appendix E). Low-flow sample collection is a method that minimizes the impact of the purging process on groundwater chemistry and results in a smaller volume of purge water generated.

The low-flow sample collection method requires water quality indicator parameters and water levels to be measured during purging, prior to sample collection. Stabilization of the water quality indicator parameters, and monitoring water levels, is a prerequisite to sample collection. The water quality indicator parameters to be measured include dissolved oxygen, oxidation-reduction potential, pH, specific conductance, temperature, and turbidity. Analyte specifications for field parameters and stabilization criteria are presented in Table 4 of the Groundwater Monitoring QAPP (IES, 2015).

The purging and sampling of the monitoring wells was performed by installing a QED Sample Pro® Portable Micropurge Pump. The low-flow bladder pump was fitted with disposable Teflon bladders for each well. The pump was connected to dedicated, twin-bonded, ¼-inch-outside-diameter polyethylene discharge line with a ¼-inch-outside-diameter polyethylene air line complete with a stainless steel inlet screen. The polyethylene tubing was cut to length and left in each well following sampling activities.

Groundwater field parameters collected during well purging included pH, temperature, specific conductance, turbidity, dissolved oxygen, and oxidation-reduction potential. Water quality parameters were measured using a Horiba™ U-52 multi-parameter water quality meter utilizing a flow through cell. Parameters were measured every 3 to 5 minutes during well purging until the parameters stabilized to within ±10 percent. Observations regarding odors present, the color and amount of sediment/turbidity, or foreign matter present, were noted in the comments section of the Groundwater Sampling Form. Field data measurements recorded are presented in Table 3.

Sample collection was performed after all field measurements were taken and recorded via the low-flow method. Sample collection was conducted using the correct type and number of sample containers and the correct preservatives (if needed). Samples were not filtered in the field. Samples were transported and analyzed in accordance with the Groundwater Monitoring QAPP (IES, 2015).

3.2.4. Sample Handling and Custody

All samples were accompanied by a chain-of-custody record. When custody of samples was transferred, the individuals relinquishing and receiving the samples signed and dated the chain-of-custody record. The chain-of-custody record documents the custody transfer from the sampler, often through another agent (shipping/transport company), to the laboratory sample custodian.

Prior to shipment, samples were packaged properly and a chain-of-custody record accompanied each shipping container. All shipping containers were sealed with custody seals for shipment/transport to the laboratory unless the sample containers were hand-delivered to the laboratory. Custody seals were placed in a manner that indicated if the container has been opened during shipment. Courier names and other pertinent information were documented on the chain-of-custody record. All shipments were accompanied by the chain-of-custody record that identifies the contents of the shipment. The original and one copy was included in the shipment, an additional copy was retained by the sampler and provided to the ARCADIS Project Coordinator (PC). All shipping documentation (e.g., freight bills) was retained as part of the chain-of-custody documentation by the ARCADIS PC.

All samples collected for laboratory analyses were received at TestAmerica Laboratory, Inc. (TestAmerica) located at 11922 E 1st Avenue, Spokane, Washington. Upon arrival at the laboratory, the TestAmerica sample custodian accepted custody of the samples from the carrier and entered information about the shipment into a sample receipt log that included the initials of the person delivering the package and the status of custody seals on the containers. The sample custodian logged in the samples following the laboratory standard operating procedure (SOP). Following sample analysis, the unused portions of all samples were disposed of by TestAmerica in accordance with their laboratory SOP. A total of three sample delivery groups (SDGs) were submitted to the analytical laboratory; the delivery groups and collection dates are as follows:

Sample Delivery Group	Samples Collected	Date Received by Lab
SXL0103	December 15, 2014	December 16, 2014
SXL0108	December 15 & 16, 2014	December 17, 2014
SXL0121	December 16 & 17, 2014	December 18, 2014
SXL0144	December 17, 2014	December 19, 2014

In addition to the chain-of-custody documentation described above, Groundwater Sampling Forms were completed at each well and indicated samples collected, sample numbers, duplicate samples, and other pertinent information including significant events and observations that occurred during sampling activities. Sufficient information was noted on field sampling forms to enable participants to reconstruct events that occurred and to refresh the memory of field personnel, if needed (Appendix B). Original copies of all field forms and chain-of-custody documents were retained by the PC in the project files.

3.2.4.1. Sample Containers, Preservatives, and Hold Times

Field personnel in coordination with the analytical laboratory determined the number and type of sample containers needed for a given sampling event, including enough sample containers for the QC/QA samples in addition to the containers required for the actual well sampling. Preservatives were required for EPA Method 350.1, 365.1, 351.2, and 200.7 analyses. TestAmerica provided the appropriate containers for the analytes, including required container sizes. The laboratory did not provide laboratory-prepared trip blanks.

3.2.5. Measurement of Final Water Level

Immediately after pumping ceased and after samples were collected, the final water level from the TOC for each well was measured and recorded on the Groundwater Sampling Form.

3.2.6. Equipment Decontamination

Water level and water quality meters were decontaminated to prevent cross-contamination between sampling sites. All other equipment/materials were either dedicated to a particular well, or were disposable. The following procedures were followed for the water level and water quality meters:

- The equipment was cleaned with a phosphate-free detergent such as Alconox™.

- The equipment was rinsed three successive times with deionized water.

Water used for decontamination was disposed in the immediate vicinity away from the nearest monitoring well. All disposable items such as paper towels, disposable gloves and wash cloths were deposited into garbage bags and disposed in a solid waste container located at the staging area.

3.2.7. Health and Safety

ARCADIS prepared a Project Health & Safety Plan (ARCADIS 2013a). Work activities referenced in this Report were conducted in accordance with applicable OSHA rules and regulations, as well as those specifically established in the Project Health and Safety Plan. All personnel involved in the work were current with respect to required OSHA training and refresher requirements of 29 CFR Part 1920.120. The work was conducted in Level D personal protective equipment.

3.3. Temporal Groundwater Level Monitoring

Temporal groundwater levels were monitored using Solinst® Levelogger® Junior Edge pressure transducers in six monitoring wells to evaluate seasonal fluctuations and trends in groundwater elevations. Two pressure transducers were installed in one of the shallow/deep monitoring well pairs to evaluate differences in head between the shallow and deep portions of the surficial aquifer. Wells included DC-03, DC-05/DC-05D well pair, YVD-03, YVD-08, and YVD-11. Additionally, a Solinst® Barologger® Edge barometric pressure transducer was deployed in YVD-08 to provide the basis to compensate water levels for barometric pressure changes. Water levels often exhibit a response to barometric pressure, i.e. a rise in barometric pressure will often result in a drop in water levels. The sensitivity of the water level response to pressure is termed barometric efficiency. Although barometric pressure compensation is calculated for each transducer, some fluctuation will be present due to the barometric efficiency of the aquifer.

Levelogger® transducers were suspended in the well screen intervals below the water table to the extent that water level fluctuations will not expose the transducers to air. Further, the transducers will be appropriately rated for the respective anticipated head in each well. Transducers were secured within the steel surface casing to prevent vandalism and/or tampering. The Barologger® was suspended in YVD-08 approximately five feet below the top of the PVC casing.

Transducers were programmed to record water levels every hour beginning at 12 noon on October 15, 2013. Data was collected from the transducers during the groundwater sampling event conducted December 14 through 17, 2014. Prior to deploying transducers and downloading data, water levels in wells were manually gauged using an electronic water level meter. Following the data download, water level data was compensated for changes in barometric pressure. The resulting groundwater hydrographs are presented in Figures 6A to 6F.

Groundwater levels in DC-03 (Figure 6B) during this period showed an increasing trend into late October 2014, reaching a maximum elevation of approximately 838.5 feet amsl, then beginning to decrease into December. Groundwater levels in DC-05 increased into November 2014 (Figure 6C), then began to fluctuate by 0.5-foot into December. Comparatively, water levels in DC-05D (Figure 6D) followed the same trend but with greater daily fluctuation. Monitoring well pair DC-05/DC-05D showed an overall increasing trend into November, with water level elevations increasing approximately 1-foot during the Fourth Quarter 2014. Groundwater levels were generally lower in DC-05D compared to water levels in DC-05, thus indicating a slight downward hydraulic gradient.

Groundwater levels in monitoring wells YVD-03 and YVD-08 showed daily fluctuations of about 0.5-foot to 1-foot (Figures 6E and 6F). Groundwater levels in YVD-11 showed daily fluctuations from 0.1-foot (Figure 6G). During the Fourth Quarter 2014 groundwater levels showed an overall stable trend with less than 0.5-foot of decreased elevation throughout the quarter.

4. Soil and Groundwater Characteristics

The following section summarizes soil and groundwater conditions encountered during subsurface soil boring and well installation efforts conducted at the Dairies. Specific information for each soil boring is provided in the Groundwater Monitoring Well Installation Report (ARCADIS 2013).

4.1. Subsurface Soil Characteristics

Soil boring and groundwater monitoring well drilling efforts were conducted during June through August 2013. Borehole field observations are provided in geologic borehole logs provided in Appendix A of the Groundwater Monitoring Well Installation Report (ARCADIS 2013). Figure 7 illustrates the locations of geologic cross-sections across the Site. Figures 8 to 14 present geologic cross-sections.

Lithology and depths of borings varied throughout most of the site. Site geology in most borings typically consisted of encountering finer-grained materials in the upper portion of borings and coarser-grained material in lower portions of borings. A silt loam, likely equivalent to Warden silt loam soils, was typically encountered in most borings at the surface or within 20 feet of the surface. Silt loam thickness was greatest in the areas containing YVD-13 and YVD-18 (Figure 8, 9, and 14) and in the upland areas where YVD-04 and DC-01 (Figures 9, 10, 11, 12, and 14) are located. Silt loam in these areas ranged from 23 to 57 feet thick. The silt loam typically pinched out with distance from the upland borings towards lower-elevation borings. In areas where the silt loam layer was deeper, such as in DC-01, the silt loam interbeds with the sand and gravelly sand sediments that typically dominate the lithology of borings located further downslope (Figures 10, 11 and 13).

Several borings encountered a partially cemented layer of sand and gravel (e.g., YVD-08, YVD-12, YVD-13/18, and YVD-15) located either beneath or interbedded with the silt loam. This partially cemented layer was slow to drill and was generally five to ten feet thick. Lithology beneath the cemented layer varied from 10 to 20 feet of silt loam in some borings (e.g., YVD-13) and sand in other borings (e.g., YVD-12).

Various layers of sand, gravelly sand, and sandy gravel dominated most of the borings completed at the Dairies. Sand and gravel were typically poorly graded. Lenses of silty sand and clayey sand were encountered in some of the borings. These lenses typically were present in the deeper portion of borings.

Three borings, DC-01, YVD-02 and YVD-03, penetrated into weathered basalt. Weathered basalt was encountered in borings YVD-02 and YVD-03 at 12 and 184 feet below ground surface respectively. The surface of the weathered basalt greatly decreased in a short distance from these two wells in the down slope direction. Basalt was not encountered in the nearest down slope wells including YVD-04, YVD-06, or YVD-07. Total depths of these wells ranged from 168 to 245 feet bgs, thus indicating that basalt is deeper.

4.2. Groundwater Characteristics

The unconfined surficial aquifer is situated in gravelly sand or sandy gravel. Depth to water in the 26 wells ranged from 26 to 220 feet deep. Groundwater was deepest in borings located in areas of the site that were topographically higher (e.g., YVD-04, YVD-05, YVD-06, YVD-07, YVD-08, and YVD-09). Depths to water in these borings ranged from 108 to 220 feet below ground surface. Comparatively, groundwater was shallowest in borings located in areas of the site that were topographically lower (e.g., YVD-14, YVD-15, YVD-17, DC-03D, and DC-04). Depths to water in these borings ranged from 73 to 88 feet below ground surface. Depths to water in borings completed in the weathered basalt or basalt ranged from 26 feet in YVD-02 to 190 feet below ground surface in YVD-03.

Groundwater elevations in the surficial aquifer gauged on December 14, 2014 range from 1,255.96 feet amsl in YVD-02 to 824.66 feet amsl in YVD-12. A summary of cumulative water level measurements and groundwater elevations are presented in Table 4. Figure 8 presents interpretive groundwater potentiometric contours developed from the synoptic water level gauging event on December 12, 2014. Groundwater generally flows through the site to the southwest at an average hydraulic gradient of 0.02 foot per foot (ft/ft). Hydraulic gradients are steeper in wells completed in the upslope areas with an average of 0.04 ft/ft. As groundwater flows to the southwest, hydraulic gradients flatten to about 0.015 ft/ft in the central portion of the site and then to 0.006 ft/ft in the southern portion of the site.

Groundwater elevations in wells DC-09 and YVD-06 appear anomalous when compared to groundwater elevations in nearby wells. During the drilling of both these wells, groundwater was initially encountered at depths of 187 and 148 feet bgs, respectively. Following the completion of the monitoring wells, water levels stabilized at 144 and 108 feet bgs, respectively. The encountered lithology in the well borings suggests that groundwater may be under semi-confined to confined conditions due to the presence of a 16-foot thick sandy silt layer in DC-09 and a 34-foot thick silt layer in YVD-06. Groundwater elevations for these two wells were not used in the development of the groundwater potentiometric contours in Figure 15.

Comparison of groundwater elevations in the three shallow/deep monitoring well pairs (YVD-13/YVD-18, DC-03/DC-03D, and DC-05/DC-05D), indicates a slight to no downward vertical hydraulic gradient present in the surficial unconfined aquifer as measured during the sampling event. The vertical gradients are approximately equivalent; ranging from 0.001 ft/ft at well pair YVD-13/YVD-18 and 0.006 ft/ft at well pair DC-05/DC-05D.

Although most of the monitoring wells are completed in sandy gravel or gravelly sand formations, recharge of groundwater was typically slow in most borings. In most cases, water levels took 30 minutes or more to stabilize in the borehole. Water levels in YVD-04 and YVD-06 took several hours to stabilize. Part of the slow recovery can be attributed to the relatively small saturated layer thicknesses in which the well screens were competed in (e.g., less than 15 feet).

4.3. Human Influences on Groundwater Flow

Human influences in the Yakima Valley may affect the hydrology and hydrogeology on and around the Dairies. These human influences include but are not limited to; water extraction wells, large septic systems, storm water basins/structures, irrigation ditches/pipelines, surface water structures such as ponds, and field irrigation methods; a number of these structures are depicted in Figures 3A, 3B, and 3C.

Supply wells and regional wells withdraw water for irrigation, residential use, and other farming uses. These wells may withdraw consistent volumes of water year round or large volumes of water seasonally. Supply wells will likely effect the local hydraulic regime of the underlying aquifer, particularly within the area of well influence. Leakage of irrigation water from the Roza and Sunnyside Irrigation Canals is a source of recharge to the upper surficial aquifer during months when flow is present in the canals.

4.4. Average Linear Groundwater Flow Velocity

A potential average linear groundwater flow velocity for the surficial alluvial aquifer can be estimated based on the measured groundwater gradient and the observed characteristics of the aquifer material. The average linear velocity of groundwater flow (V_x) is determined according to the equation:

$$V_x = \frac{K}{n_e} \times I$$

Where: K = Hydraulic conductivity of the aquifer material
I = Hydraulic gradient of the aquifer
n_e = effective porosity of the aquifer material

No direct testing or analysis of hydraulic conductivity or effective porosity was performed for the surficial alluvial aquifer. Measurements of hydraulic conductivity and effective porosity are typically made using methods such as aquifer tests (i.e. pumping tests or slug tests) or physical analysis of aquifer material (e.g. permeameter testing, grain-size analysis). However, an estimate of the average linear groundwater velocity can be made using data (developed by others) for hydraulic conductivities and effective porosities of materials similar to that composing the surficial alluvial aquifer.

Review of the ARCADIS and EPA boring logs for wells completed at the Dairies indicate that the shallow surficial aquifer is chiefly composed of the following materials:

- Sands (SM) of fine grain size;
- Sands (SP) of medium grain size with fine gravels;
- Gravelly Sands (SP) of medium to coarse grain size with fine to coarse gravels, and;
- Sandy Gravels (GM) of fine grain size with fine to coarse sands.

Estimated values for hydraulic conductivity and effective porosity of the shallow surficial aquifer material are obtained from Method 9100, *Saturated Hydraulic Conductivity, Saturated Leachate Conductivity, and Intrinsic Permeability* (EPA, 1986) and *Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil* (Yu et al, 1993), respectively. Values of hydraulic conductivity (K) and effective porosity (n_e) for materials similar to the shallow surficial aquifer were selected from the above-referenced literature. The selected values are presented in Table 5.

The hydraulic gradient (*I*) as measured during December 2014 in the vicinity of the Dairies averages 0.02 ft/ft. Hydraulic gradients in the upslope areas average of 0.04 ft/ft. Hydraulic gradients flatten to approximately 0.015 ft/ft in the central portion of the Dairies and further flattening to 0.006 ft/ft in the south portion of the Dairies. A calculated range of average linear groundwater flow velocities in feet/day is presented in Table 5 based on the average and specific gradients. The calculated average linear groundwater flow velocities for the area under the Dairies range from 3 to 19 feet per day.

The average linear groundwater flow velocities presented in Table 5 are a range of estimated possible values only; they are calculated using data elements (hydraulic conductivity and effective porosity) that are not site-specific and may not reflect the actual conditions present at the Dairies. However, this range of calculated groundwater velocity, based on values of material properties and hydraulic conductivity presented in literature together with the measured site-specific hydraulic gradients is the best estimate of groundwater velocity that can be determined at this time.

5. Analytical Program

5.1. Analytical Methods

Groundwater samples were analyzed for the following analytes:

- Nitrate (as Nitrogen) by EPA Method 300.0
- Nitrite (as Nitrogen) by EPA Method 300.0
- Ammonia by EPA Method 350.1
- Total phosphorus by EPA Method 365.1
- Total Kjeldahl nitrogen by EPA Method 351.2
- Inorganic anions (chloride, fluoride, sulfate) by EPA Method 300.0
- Metals (calcium, potassium, magnesium, sodium) by EPA Method 200.7
- Alkalinity (total and bicarbonate) by Standard Method 2320B

The Groundwater Monitoring QAPP (IES, 2015; Table 3) presents the analytes, method, container, preservation method, and holding times for the groundwater samples collected during the Groundwater Monitoring. Because of the 48-hour holding time for nitrate analysis by EPA Method 300.0, samples were either hand delivered or shipped using an overnight delivery service each day (Sunday through Thursday). TestAmerica analyzed the samples immediately upon receipt to ensure holding time compliance. Analytical laboratory reports are presented in Appendix C.

5.2. Quality Control

This section presents the field and laboratory quality control (QC) requirements for Groundwater Monitoring Sampling.

5.2.1. Field Quality Control Samples

The Groundwater Monitoring Sampling included the collection of field QC samples including field duplicates and field blanks. Field QC samples were collected at the required frequency as specified in the QAPP except for the following instances:

5.2.2. Laboratory Quality Control Procedures

Laboratory QC procedures included the following:

- Nitrate analysis of water samples according to EPA Method 300.0
- Instrument calibration and standards as defined in the associated EPA method or Standard Method
- Laboratory blank measurements at a minimum 5 percent or one per batch frequency
- Accuracy and precision measurements at a minimum of one in 20 or one per set
- Data reduction and reporting according to laboratory SOP requirements
- Laboratory documentation according to laboratory SOP requirements.

5.3. Data Validation and Usability

All data underwent review and validation as described in Section 4 of the Groundwater Monitoring QAPP. Data validation for the Project is performed by Haley & Aldrich, Inc. of Phoenix, Arizona. The Data Usability Summary Report is presented in Appendix D.

5.4. Data Management

All field data collected during the Groundwater Monitoring Sampling was recorded on Groundwater Sampling Forms (Appendix B). Pertinent information, such as field parameter measurements, was transferred to an Excel spreadsheet.

The analytical data obtained from the laboratory is maintained in an electronic data management tool. Additionally, the data are provided to the EPA in accordance with the procedures presented in “EPA Region 10 Monitoring and Analytical Data Deliverables Data Submission Process for Water Quality Exchange (WQX) Compatible Deliverables for Yakima Dairies (Docket No. SDWA-10-2013-0080), and “EPA Region 10 Geographic Information System Data Deliverable Guidance for Yakima Dairies (Docket No. SDWA-10-2013-0080). Data submitted to the EPA is provided in the requested format which is consistent with the examples provided by the EPA to the Dairies.

5.5. Corrective Actions

No corrective actions were required for the Fourth Quarter 2014 Groundwater Monitoring event.

6. Data Validation and Usability

6.1. Data Review, Verification, and Validation

All data underwent a Stage 2 validation, which included a data package completeness review. Data were validated in accordance with the latest EPA National Functional Guidelines. The data validation report is presented in Appendix D. Any deviation from the approved QAPP were either documented within the body of this report or in the data validation report. All analyses met project data quality goals and criteria and are usable for all purposes except as noted below:

- Nitrate (as N) and Nitrite (as N) were rejected for YVD-F4-141217 due to holding time exceedance (SXL0144).

- TKN was rejected for DC-03-141217, YVD-10-141217, and YVD-D4-141217 due to a low matrix spike recovery (SXL0144).

7. Groundwater Sampling Results

Groundwater field parameter measurements for the December 2014 sampling event are presented in Table 3. Groundwater analytical results are presented in Table 6 for Fourth Quarter 2014. A summary of cumulative groundwater sampling results is presented in Table 7. Additionally, a summary of the cation/anion balance is presented in Appendix E. These results establish current groundwater quality conditions in the surficial alluvial aquifer that underlies the Dairies. Further, analytical results will be compared to subsequent quarterly events to identify spatial and temporal water quality trends. During the Fourth Quarter 2014 groundwater sampling event, all 26 wells were sampled.

7.1. Field Parameters

Groundwater field parameters collected during well purging included dissolved oxygen, pH, oxidation-reduction potential, specific conductance, temperature, and turbidity. Parameters were measured every 3 to 5 minutes during well purging until the parameters stabilized to within ±10 percent. A summary of the final measurements recorded during the purging of each well are presented in Table 3.

Dissolved oxygen measures the concentration of molecular oxygen dissolved in groundwater. Oxygen's limited solubility, as described by Henry's law, is directly related to atmospheric pressure and inversely related to water temperature and salinity. The solubility of oxygen increases proportionately with hydrostatic pressure, hence depth. In dilute solutions at sea level, the solubility of oxygen ranges between 7.0 and 10.0 mg/L, at temperatures ranging between 15 to 31°C (APHA 1981).

The primary chemical characteristic of molecular oxygen is its ability to accept electrons from (oxidize) other species in water. Aerobic bacteria utilize dissolved oxygen as part of their metabolism. This results in the oxidation of organic carbon, hydrogen sulfide, ammonium, molecular nitrogen and other reductants. An important aspect of these biochemical reactions is their irreversibility; dissolved oxygen is always consumed and never produced as a result of bacterial metabolism. Groundwater sources usually contain a low level of dissolved oxygen compared to surface waters. A dissolved oxygen level less than 1.0 mg/L is considered indicative of anaerobic conditions.

Dissolved oxygen as measured in the wells ranged from 0.0 in monitoring wells DC-03D, DC-07, YVD-02, and YVD-14 to 20.98 mg/L in monitoring well YVD-18. The measured pH ranged from 5.98 to 7.56 standard units (SU) with the lowest reading measured in monitoring well DC-07 and the highest reading measured in well YVD-03.

Oxidation-reduction potential (ORP) is a measure of the intensity or activity of an aqueous environment or soil to mediate reactions of important elements in biological systems (e.g., O, N, Mn, Fe, S, and C) and other metallic elements (EPA, 2013). The ORP is the tendency of a chemical species to acquire electrons and thereby be reduced. Each species has its own intrinsic reduction potential; the more positive the potential, the greater the species' affinity for electrons and tendency to be reduced.

In aqueous solutions, the ORP is the tendency of the solution to either gain or lose electrons when it is subject to change by introduction of a new species. A solution with a higher (more positive) ORP than the new species will have a tendency to gain electrons from the new species (i.e. to be reduced by oxidizing the new species) and a solution with a lower (more negative) ORP will have a tendency to lose electrons to the new species (i.e. to be oxidized by reducing the new species). The transfer of electrons between chemical species determines the ORP of an aqueous solution. It does not characterize the capacity of the system for oxidation or reduction, in much the same way that pH does not characterize the buffering capacity. A numerically positive ORP represents an environment conducive to the oxidation of an introduced substance by reduction of the original media.

Groundwater typically contains both reduced and oxidized species, however what is termed the redox buffer capacity of an aquifer is normally dominated by the chemistry of the aquifer matrix. In most natural groundwater systems iron is the dominant (by one to three orders of magnitude) buffering species involved in redox reactions.

The Denitrification (NO_3 to N_2) reaction [$3CH_2O + 4NO_3^- = 2N_2 + 3HCO_3^- + H^+ + 2H_2O$] consumes organic matter in groundwater (Vance, 1996). Denitrification can occur under ORP conditions in the range of +100mV to +250mV. Water in contact with air will have an ORP in the range of +350mV to +500mV.

Most work with oxidation/reduction reactions involves solutions in closed systems that are in an equilibrium state. In groundwater with more than one oxidation/reduction species, the ORP cannot be accurately measured unless the reactants are at thermodynamic equilibrium. Some redox reactions can take from 10 to 1,000 years to reach equilibrium. However, environmental processes are typically in disequilibrium, caused by:

- Flowing groundwater conditions.
- Biological activity.
- Reactions of light bioactive elements (C, H, O, and S) which most often involve the breaking of covalent bonds, a process that is normally slow.
- Electrochemical reactions of exposed active mineral surfaces.

Oxidation-reduction potential ranged from 170 to 248 millivolts (mV) in monitoring wells YVD-02 and DC-05, respectively.

Specific conductance is a measurement of the dissolved material in an aqueous solution, which relates to the ability of the media to conduct an electrical current. The greater the amount of dissolved material in a media, the higher the specific conductance value. Specific conductance in water depends on the concentration of ions, mobility, valence, relative concentrations, and the temperature of the solution. Natural waters have specific conductance that are usually much less than 1 micromho per centimeter (µmhos/cm). An estimate of total dissolved solids in mg/L can be made by multiplying specific conductance in µmhos/cm by a factor ranging from 0.55 to 0.9, depending on the concentration of soluble component. The presence of charged ionic species allows current to be conducted through the solution, but other undissociated species in the solution complicate the relationship between specific conductance and total dissolved solids. Specific conductance, as a field parameter, may best reflect major ion chemistry in groundwater as it is less affected by either volatilization or small-scale heterogeneity. Comparing temporal and spatial specific conductance measurements can provide an approximation of the mobility of the ionic species in the system.

Specific conductance ranged from 0.326 to 2.33 micro Siemens per centimeter (µS/cm) with the lowest reading measured in monitoring well YVD-06 and the highest reading measured in well YVD-14. Groundwater temperature measurements ranged from 3.35 to 14.08°C in monitoring wells YVD-04 and YVD-13, respectively. Groundwater temperature measurements are made at the surface and do not necessarily indicate the water temperature of the aquifer. The lowest turbidity readings were zero nephelometric turbidity units (NTU) in monitoring wells DC-05D, YVD-09, YVD-10, YVD-11, and YVD-14. The highest turbidity readings measured greater than the instrument detection limit of 800 NTUs in wells YVD-02.

7.2. Nitrate

Nitrate (as nitrogen) was detected in 25 monitoring wells (Figure 17). Concentrations ranged from 0.22 milligrams per liter (mg/L) in well YVD-02 to 193 mg/L in well DC-03 (Table 6).

Nitrate was detected in 10 wells at concentrations less than the maximum contaminant level (MCL) of 10 mg/L:

- DC-05D (7.90 mg/L)
- DC-09 (5.94 mg/L)
- YVD-03 (4.27mg/L)
- YVD-05 (2.65 mg/L)
- YVD-07 (2.92 mg/L)
- DC-07 (2.92 mg/L)
- YVD-02 (0.22 mg/L)
- YVD-04 (3.81mg/L)
- YVD-06 (0.45 mg/L)
- YVD-17 (0.66 mg/L)

Nitrate was detected in 16 wells at concentrations greater than 10 mg/L:

- DC-01 (18.9 mg/L)
- DC-03D (38.6 mg/L)
- DC-03 (193 mg/L)
- DC-04 (40.8 mg/L)

- DC-05 (33.4 mg/L)
- YVD-08 (14.0 mg/L)
- YVD-10 (78.7 mg/L)
- YVD-12 (15.1mg/L)
- YVD-14 (96.1 mg/L)
- YVD-16 (22.4 mg/L)
- DC-14 (10.4 mg/L)
- YVD-09 (53.9 mg/L)
- YVD-11 (49.1 mg/L)
- YVD-13 (27.3 mg/L)
- YVD-15 (66.9 mg/L)
- YVD-18 (16.5 mg/L)

Nitrate concentrations in well pairs showed lower detected concentrations in the deep well compared to the shallow well. Nitrate was detected in well pair YVD-13 (shallow) and YVD-18 (deep) at 27.3and 16.5 mg/L, respectively. Nitrate was detected in well pair DC-03 (shallow) and DC-03D (deep) at 190 and 38.6 mg/L, respectively. Nitrate was detected in well pair DC-05 (shallow) and DC-05D (deep) at 33.4 and 7.90 mg/L, respectively.

7.3. Nitrite

All 26 wells contained nitrite at concentrations less than the laboratory reporting limits of 0.200 mg/L, 0.400 mg/L, 0.800 mg/L, 1.00 mg/L or 2.00 mg/L (Figure 16).

7.4. Ammonia

Ammonia (as N) was detected in monitoring well DC-03 at 0.180 mg/L. Ammonia concentrations are summarized in Table 6 and depicted on Figure 16. The remaining 25 wells contained ammonia at concentrations less than the laboratory reporting limit.

7.5. Total Phosphorus

Total phosphorus was detected in 19 monitoring wells. Phosphorous concentrations are summarized in Table 6 and depicted on Figure 16. Detected phosphorus concentrations ranged from 0.1 mg/L in well YVD-16 to 1.3 mg/L in well YVD-09. The remaining two wells contained phosphorous at concentrations less than the laboratory reporting limit.

7.6. Total Kjeldahl Nitrogen

Total Kjeldahl Nitrogen (TKN) was detected in eight monitoring wells. TKN concentrations are summarized in Table 6 and depicted on Figure 16. Detected TKN concentrations ranged from 0.264 mg/L in well YVD-05 to 0.414 mg/L in YVD-15. The remaining wells contained TKN at concentrations less than the laboratory reporting limit of 0.250 mg/L.

7.7. Inorganic Anions

Inorganic anions included chloride, fluoride, and sulfate. A summary of the analytical results for the Fourth Quarter 2014 sampling event is presented in Figure 24 and discussed below.

7.7.1. Chloride

Chloride was detected in 26 monitoring wells. Concentrations ranged from 2.90 mg/L in well YVD-02 to 182 mg/L in well DC-03. Chloride concentrations were less than the secondary contaminant level of 250 mg/L.

7.7.2. Fluoride

Fluoride was detected in one monitoring well above the laboratory reporting limit. Fluoride was detected in well YVD-03 at 0.540 mg/L. Fluoride concentrations were less than the secondary contaminant level of 2.0 mg/L. The remaining 25 wells contained fluoride at concentrations less than the laboratory reporting limits of 0.500, 1.00, 2.00, 2.50, and 5.00.

7.7.3. Sulfate

Sulfate was detected in 26 monitoring wells. Concentrations ranged from 6.01 mg/L in well YVD-17 to 463 mg/L in well YVD-13. Sulfate was detected in two wells (DC-01 and YVD-17) at a concentration greater than the secondary contaminant level of 250 mg/L.

7.8. Metals

Metals included calcium, magnesium, potassium, and sodium. A summary of the analytical results for the December 2014 sampling event is presented in Figure 25 and discussed below.

7.8.1. Calcium

Calcium was detected in 26 monitoring wells. Concentrations ranged from 29.9 mg/L in well YVD-07 to 274 mg/L in well DC-03.

7.8.2. Potassium

Potassium was detected in 25 monitoring wells. Concentrations ranged from 1.84 mg/L in well YVD-17 to 12.9 mg/L in well YVD-09. The sample collected from DC-07 was measured at concentrations less than the laboratory reporting limit of 1.00 mg/L.

7.8.3. Magnesium

Magnesium was detected in 26 monitoring wells. Concentrations ranged from 7.83 mg/L in well YVD-06 to 81.6 mg/L in well YVD-15.

7.8.4. Sodium

Sodium was detected in 26 monitoring wells. Concentrations ranged from 9.15 mg/L in well YVD-17 to 187 mg/L in well YVD-09.

7.9. Alkalinity

Alkalinity included bicarbonate alkalinity and total alkalinity. A summary of the analytical results for the Fourth Quarter 2014 sampling event is presented in Figure 26 and discussed below.

7.9.1. Bicarbonate Alkalinity

Bicarbonate alkalinity was detected in 26 monitoring wells. Concentrations ranged from 94.7 mg/L in well YVD-02 to 539 mg/L in well YVD-14.

7.9.2. Total Alkalinity

Total alkalinity was detected in 26 monitoring wells. Concentrations ranged from 95.0 mg/L in well YVD-02 to 540 mg/L in well YVD-14.

7.10. Water Type Classifications

Analytical results for cations and anions were used to construct Stiff patterns and Piper diagrams. These diagrams are used to evaluate the natural water chemistry of the shallow surficial aquifer, describe water type classifications, and map hydrochemical facies.

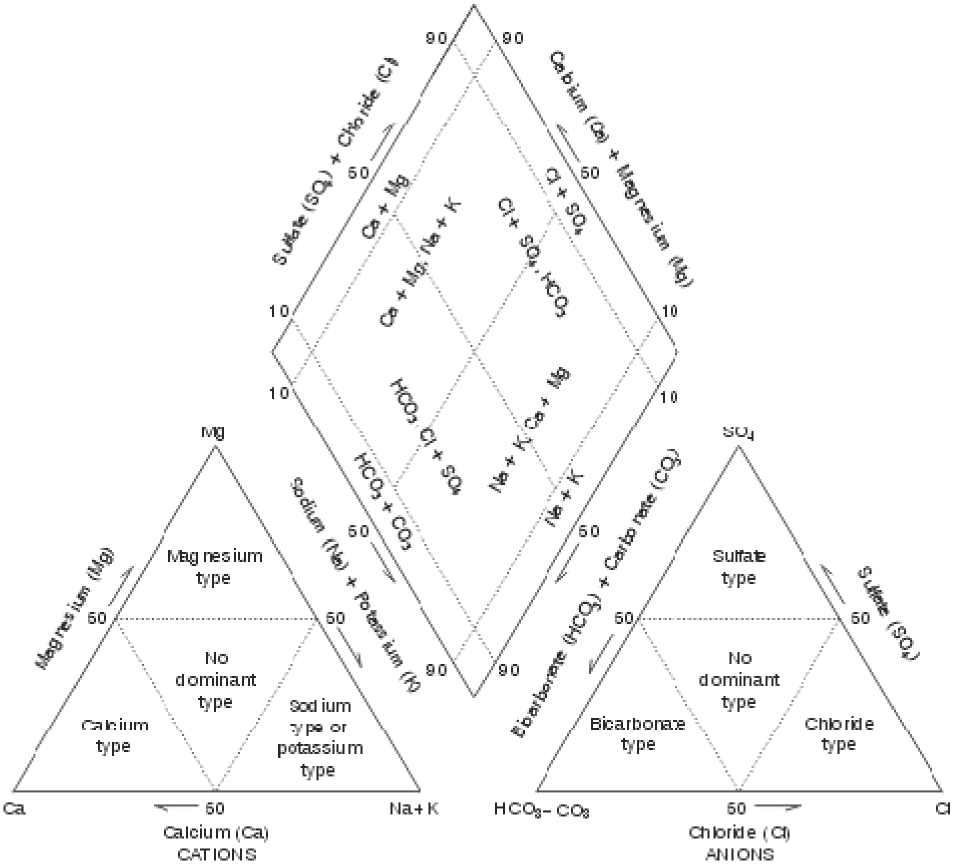
Anion/cation balances for several monitoring wells fluctuated over the sampling events and appeared elevated (i.e., greater than five percent). It should be noted that anion/cation balance is not a definitive result, meaning that is a calculated value rather than directly measured. Elevated anion/cation balances can suggest issues with analysis for anions (by USEPA Method 300.0, an ion chromatography technique) or due to sample heterogeneity issues (e.g., turbidity). Each of these analytical methods were evaluated for quality control outliers and were found to be acceptable. Piper diagrams, stiff patterns and concentration trends for these monitoring wells indicate that groundwater chemistry has remained relatively consistent between sampling events. A summary showing the calculated values of each of the ion concentrations is provided as Appendix E.

The total cation concentration was calculated as the sum of calcium, magnesium, sodium, and potassium. The total anion concentration was calculated as the sum of chloride, sulfate, and bicarbonate; and nitrate was also included because this negative ion was indicated to be at a relatively significant concentration in some samples. This information is summarized in a table with the calculated millequivalents per liter (meq/L, equivalent weight or equivalent mass) for the groundwater analytical results.

The ion balances for the groundwater samples were generally within +/- 5 percent, a general range used as one method for indicating that the major-ion laboratory analyses were of relatively good quality.

Exceptions include four samples (DC-01, YVD-02, YVD-05, and YVD-17). DC-01 and YVD-02 groundwater samples had ion balances calculated greater than +/- 20 percent. The ion balances for these samples suggests the analytical results may be unacceptable for one or more principal ions, or there were other constituents (perhaps such as organic anions, nutrients, and trace metals) contributing to higher ion balances and not accounted for in our calculations, or the groundwater chemistry was not in equilibrium (considered less likely based on the relatively neutral pH, etc).

Stiff patterns are used to graphically compare the cation and anion concentrations for wells throughout the site both spatially and over time. A polygonal shape is created from four parallel horizontal lines extending on either side of a vertical zero axis. Cations are plotted on the left of the zero axis, one to each horizontal axis, and anions are plotted to the right, extending along a given horizontal axis. Stiff patterns are useful in making rapid visual comparison between water of different sources; generally waters with the same polygonal shapes are derived from the same source. The larger the area of the polygonal shape, the greater the concentrations of the various ions associated with the depicted sample. Figure 27 presents Stiff patterns for the sampled wells. The attached Figure 28 shows the Stiff patterns next to the respective sample point on a facility base map. Concentrations in the Stiff diagrams are expressed in milliequivalents per liter (meq/L) and require a specific conversion for each individual ion concentration.



Example 1. Piper Diagram displaying relative ion composition (USGS 2002)

Piper diagrams illustrate the geochemical characteristics of each sample point within the lithological flow path by plotting dissolved ion concentrations (expressed in meq/L) on two-dimensional trilinear diagrams. Each trilinear diagram represents the relative percentages of three ions. Cations are represented in the left trilinear diagram, anions in the right. The apex of each of the triangles represents 100 percent of the ion shown at that corner. For example, water compositions with more than 50 percent relative calcium ions would plot in the bottom left corner of the cation diagram and would be considered calcium dominant. Compositions with less than 50 percent of each of the represented cations would plot in the center of the diagram and would therefore be considered to have no dominant type. Each of the data points from the cation and anion diagrams are then projected into the quadrilateral above. The quadrilateral represents the water composition as a whole, with respect to the six represented ions.

The Piper diagrams were constructed in general accordance with ASTM D5754-95 *Standard Guide for Displaying the Results of Chemical Analyses of Groundwater for Major Ions and Trace Elements – Trilinear Diagrams for Two or More Analyses*. The wells are divided into well groups, based on location and with respect to groundwater gradient, and shown on individual Piper diagrams as Figure 30 through Figure 32. Individual data points within each sample group demonstrate the changes in the hydrochemical facies throughout the flow path. Figure 29 presents a Piper diagram of general water quality for all 26 well samples.

Group 1 consists of nine wells (DC-03, DC-03D, YVD-04, YVD-05, YVD-08, YVD-09, YVD-12, YVD-13, and YVD-18) located within the western portion of the Dairies. The wells in Group 1 display semi-equivalent concentrations of sodium and calcium with no dominant dissolved cation in the northern portion of the flowpath except DC-03D and YVD-04. Dissolved anion percentages in Group 1 varied from bicarbonate dominant in the northern portions of the site to sulfate dominant down gradient (YVD-13), and returning to bicarbonate anion dominated waters in the southernmost well (DC-03D). The analysis of the total major dissolved ion concentration of Group 1 indicates calcium bicarbonate water types with temporary hardness in the north, evolving to magnesium bicarbonate waters in the down-gradient areas.

Group 2 consists ten wells (DC-01, DC-04, DC-07, DC-14, YVD-03, YVD-06, YVD-10, YVD-14, YVD-15, and YVD-17) located within in the central portion of the Dairies. The wells in Group 2 vary from non- dominant concentrations of cations to slightly dissolved calcium cation dominant to magnesium cation dominant throughout the flow path. Dissolved anion percentages in group two varied from sulfate bicarbonate dominant in the northern portion of the Dairies, north of the Roza Canal, to bicarbonate dominant down gradient of the canal. The analysis of the total major dissolved ion concentration of Group 2 indicates mixing of calcium sulfate waters in the recharge area with increasingly bicarbonate waters down gradient resulting in a calcium bicarbonate water type with temporary hardness.

Group 3 consists of seven wells (DC-05, DC-05D, DC-09, YVD-02, YVD-07, YVD-11, and YVD-16) located within the eastern portion of the Dairies. The wells in Group 3 from are dissolved calcium and sodium cation dominant to waters throughout the flow path. Dissolved anion percentages in group one are bicarbonate dominant in the northern through the flow path. The analysis of the total major dissolved ion concentration of Group 3 indicates calcium-sodium bicarbonate water types with temporary hardness.

The results of analyses for major ions in the groundwater samples collected from Yakima Valley Dairies’ wells during Fourth Quarter 2014 were evaluated by comparing the activity of the principal cations in solution to the activity of the principal anions in solution; “ion balance” or “charge balance”.

The total cation concentration was calculated as the sum of calcium, magnesium, sodium, and potassium. The total anion concentration was calculated as the sum of chloride, sulfate, and bicarbonate; and nitrate was also included because this negative ion was indicated to be at a relatively significant concentration in some samples. This information is summarized in a table with the calculated millequivalents per liter (meq/L, equivalent weight or equivalent mass) for the groundwater analytical results.

The ion balances for the groundwater samples were generally within +/- 5 percent, a general range used as one method for indicating that the major-ion laboratory analyses were of relatively good quality.

Exceptions include samples collected from wells DC-01, YVD-02 and YVD-05. Groundwater samples collected from wells DC-01 and YVD-02 had ion balances calculated greater than +/- 20 percent. The ion balance was greater than 15 percent for groundwater from YVD-05. The ion balances for these samples suggests the analytical results may be unacceptable for one or more principal ions, or there were other constituents (perhaps such as organic anions, nutrients, and trace metals) contributing to higher ion balances and not accounted for in our calculations, or the groundwater chemistry was not in equilibrium (considered less likely based on the relatively neutral pH). The anion equivalent weight was notably higher in the results of analyses for the groundwater sample collected from DC-01, and the cation meq/L higher in the groundwater from YVD-02 and YVD-05.

8. References

American Public Health Association (APHA). 1981. Standard Methods for the Examination of Water and Wastewater, 15th ed. American Public Health Association. 1134pp

ARCADIS, 2013. Site Specific Health and Safety Plan. April 4.

ARCADIS. 2013. Groundwater Monitoring Well Installation Report. November 3.

ASTM International, 2006. Standard Guide for Displaying the Results of Chemical Analyses of Groundwater for Major Ions and Trace Elements – Trilinear Diagrams for Two or More Analyses, D5754-95.

U.S. Environmental Protection Agency (EPA). 2012. Relation Between Nitrate in Water Wells and Potential Sources in the Lower Yakima Valley, Washington: EPA 910-R-12-003. September.

U.S. EPA, Field Measurement of Oxidation-Reduction Potential (ORP), U.S. EPA Region 4 Science and Ecosystem Support Division, January 29, 2013

EPA, 1986. Method 9100, Saturated Hydraulic Conductivity, Saturated Leachate Conductivity, and Intrinsic Permeability, Chapter 6 – Properties, Publication SW-846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods.

IES, 2015. Groundwater Monitoring Quality Assurance Project Plan. August 28.

Natural Resources Conservation Service (NRCS), 2014. Web Soil Survey, Yakima County Area, Washington (WA677). Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed February 2014.

U.S. Geological Survey (USGS). 2009. Hydrogeologic Framework of the Yakima River Basin Aquifer System: Scientific Investigations Report (SIR) 2009-5152, Washington.

USGS, 2002. Water Quality and Environmental Isotopic Analyses of Ground-Water Samples Collected from the Wasatch and Fort Union Formations in Areas of Coalbed Methane Development- Implications to recharge and Ground-water Flow, Eastern Powder River Basin, Wyoming.

Vance, David B., Redox Reactions in Remediation, Environmental Technology, Vol. 6 No. 4 Pages 24-25, July/Aug. 1996

Yu et al, 1993. Yu, C., Loureiro, C., Cheng, J.J., Jones, L.G., Wang, Y.Y., Chia, Y.P., and Faillace, E. Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil. Environmental Assessment and Information Sciences Division, Argonne National Laboratory, Argonne, Illinois. April.

9. Certifications

9.1. Cow Palace Certification

I certify under the penalty of law that this document and all attachments were prepared by me or under my direction or supervision in accordance with a system designed to assure that qualified personnel gathered and evaluated the information submitted. Based on my inquiry of any and all persons directly responsible for gathering and analyzing the information obtained, I certify that the information contained in or accompanying this submittal is to the best of my knowledge and belief, true, accurate and complete. As to those identified portion(s) of this submittal for which I cannot personally verify the accuracy, I certify that this submittal and all attachments were prepared in accordance with procedures designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those directly responsible for gathering the information, or the immediate supervisor of such person(s), the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Cow Palace LLC

Signature:

Name: Adam Dolsen

Title: Member

Date: 1-13-16

9.2. D & A Dairy and George DeRuyter & Son Dairy Certification

I certify under the penalty of law that this document and all attachments were prepared by me or under my direction or supervision in accordance with a system designed to assure that qualified personnel gathered and evaluated the information submitted. Based on my inquiry of any and all persons directly responsible for gathering and analyzing the information obtained, I certify that the information contained in or accompanying this submittal is to the best of my knowledge and belief, true, accurate and complete. As to those identified portion(s) of this submittal for which I cannot personally verify the accuracy, I certify that this submittal and all attachments were prepared in accordance with procedures designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those directly responsible for gathering the information, or the immediate supervisor of such person(s), the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

D & A Dairy, LLC (also known as D and A Dairy L.L.C.),
George DeRuyter & Son Dairy, L.L.C

Signature: Dan DeRuyter

Name: Dan DeRuyter

Title: Member

Date: 1/13/15

9.3. George & Margaret Certification

I certify under the penalty of law that this document and all attachments were prepared by me or under my direction or supervision in accordance with a system designed to assure that qualified personnel gathered and evaluated the information submitted. Based on my inquiry of any and all persons directly responsible for gathering and analyzing the information obtained, I certify that the information contained in or accompanying this submittal is to the best of my knowledge and belief, true, accurate and complete. As to those identified portion(s) of this submittal for which I cannot personally verify the accuracy, I certify that this submittal and all attachments were prepared in accordance with procedures designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those directly responsible for gathering the information, or the immediate supervisor of such person(s), the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

George & Margaret, L.L.C.

Signature:
Name: Dan DeRuyter
Title: Member
Date: 1/13/15

9.4. Liberty Dairy Certification

I certify under the penalty of law that this document and all attachments were prepared by me or under my direction or supervision in accordance with a system designed to assure that qualified personnel gathered and evaluated the information submitted. Based on my inquiry of any and all persons directly responsible for gathering and analyzing the information obtained, I certify that the information contained in or accompanying this submittal is to the best of my knowledge and belief, true, accurate and complete. As to those identified portion(s) of this submittal for which I cannot personally verify the accuracy, I certify that this submittal and all attachments were prepared in accordance with procedures designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those directly responsible for gathering the information, or the immediate supervisor of such person(s), the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Liberty Dairy, LLC and its associated dairy facility
H & S Bosma Dairy

Signature: Henry W Bosma

Name: Henry Bosma

Title: Partner

Date: 1-12-16