PROCESS WATER REUSE FACILITY

ENGINEERING REPORT

Prepared for City of Pasco

July, 2022

22-0034

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City of Pasco

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Chapter 4 prepared by Valley Science and Engineering

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Note: This Engineering Report was completed under the direct supervision of the following Licensed Professional Engineers registered in the State of Washington.

Sincerely,

RH2 ENGINEERING, INC. & VALLEY SCIENCE AND ENGINEERING

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City of Pasco

Process Water Reuse Facility Engineering Report

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List of Abbreviations

Abbreviation	Definition
°C	degrees Celsius
°F	degrees Fahrenheit
AA	average annual
amsl	above mean sea level
Bgs	Below ground surface
BOD	Biochemical Oxygen Demand
BPA	Bonneville Power Administration
BVF	Bulk Volume Fermenter
CAF	cavitation air flotation
CELS	Columbia East Lift Station
CFR	continuous flow reactors
City	City of Pasco
COW	condensate of whey
CRBG	Columbia River Basalt Group
ft^3/day	cubic feet per day
DAF	dissolved air flotation device
Dam Safety	Ecology's Dam Safety Office
DMRs	discharge monitoring reports
Ecology	Washington State Department of Ecology
EQ	equalization
ESP	exchangeable sodium percentages
ET	evapotranspiration
FDS	fixed dissolved solids
FTE	full-time employee
FWLS	Foster Wells Lift Station
gpd	gallons per day
gpm	gallons per minute
hp	horsepower
lb/ac/day	pounds per acre per day
IPS	Intake Pump Station

Abbreviation	Definition
LRAD	low-rate anaerobic digesters
LTS	land treatment system
MG	million gallons
MGD	million gallons per day
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MM	maximum month
mmhos/cm	millimhos per centimeter
NRCS	National Resources Conservation Service
OM	organic matter
PACE	Pace Engineers, Inc.
Permit	State Waste Discharge Permit Number ST0005369
ppd	pounds per day
PVC	polyvinyl chloride
PWRF	Process Water Reuse Facility
RAS	Return Activated Sludge
Reclamation	US Bureau of Reclamation
RNG	renewable natural gas
RWW	Raw Wastewater
sf	square feet
s.u.	standard units
SAR	sodium adsorption ratio
SBR	sequencing batch reactors
SCBID	South Columbia Basin Irrigation District
SEPA	State Environmental Policy Act
TDS	total dissolved solids
TN	Nitrogen
TSS	total suspended solids
UASB	Upflow Anaerobic Sludge Blanket
µmhos/cm	micromhos per centimeter
Valley	Valley Science AND Engineering

Abbreviation	Definition
VFD	Variable frequency drive
WAC	Washington Administrative Code
WAS	Waste Activated Sludge
Water Quality	Ecology’s Water Quality Office
WWTF	wastewater treatment facility

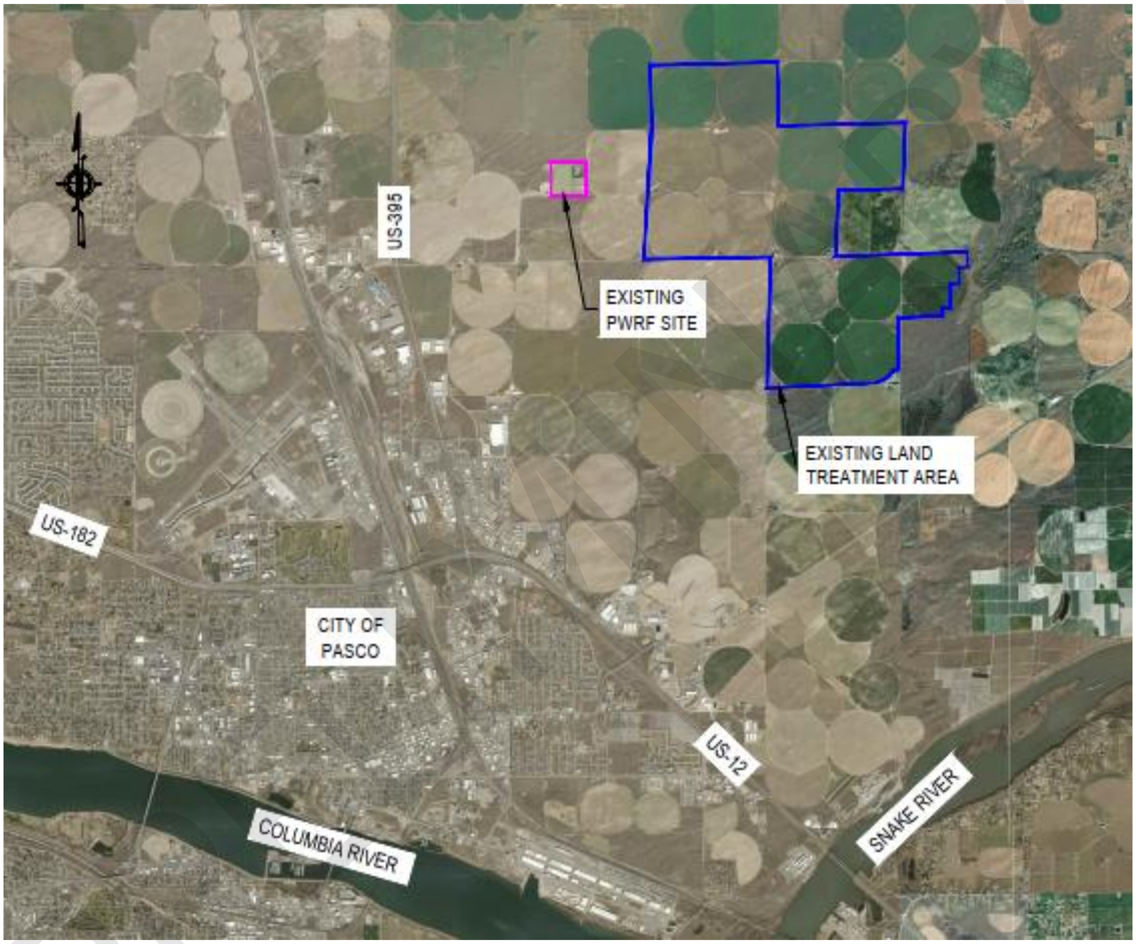
Executive Summary

To be completed last.

Chapter 1.0 Introduction and Background

The City of Pasco (City) owns and operates a facility for the treatment of industrial wastewater collected from vegetable processors. The Process Water Reuse Facility (PWRF) consists of a pretreatment and storage facility, as well as a land treatment system (LTS). These areas are located east of US-395 and north of the City limits as shown in **Figure 1-A**.

Figure 1-A – Vicinity Map



In recent years, a study was completed to evaluate future improvements to the PWRF: the 2019 *Process Water Reuse Facility Capital Facilities Plan/Engineering Report* (2019 Facility Plan) from PACE Engineers, Inc., and Jacobs Engineering Group, Inc. The 2019 Facility Plan was approved by the Washington State Department of Ecology (Ecology). However, flow and load projections have increased recently beyond those previously evaluated in the 2019 Facility Plan, and as such, an Engineering Report inclusive of the current projections must be completed to properly plan improvements. This report will meet the requirements of an "Engineering Report" for an industrial wastewater facility in accordance with Washington Administrative Code (WAC) 173-240-130.

1.1 PWRF Overview

1.1.1 Existing Facility

The PWRF currently provides preliminary and primary treatment of influent process wastewater followed by land treatment via crop irrigation during the growing season. During the non-growing season, the pre-treated influent is stored in large lined lagoons at the PWRF, referred to as winter storage lagoons. **Figure 1-B** shows a map of the existing site, and **Figure 1-C** shows a process schematic of the existing facility.

Figure 1-B – Existing Site Layout

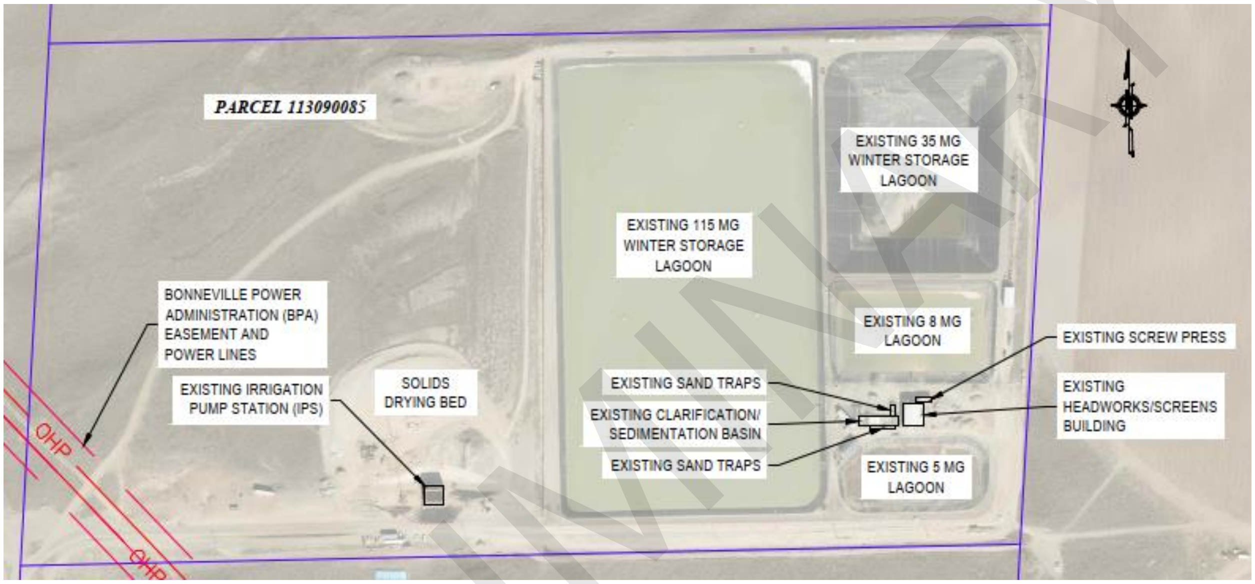
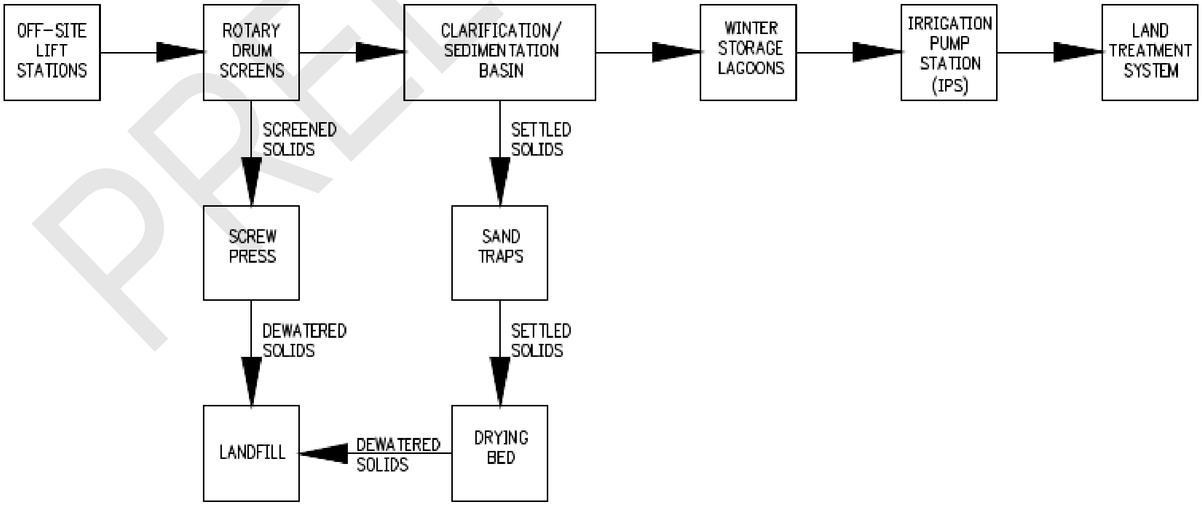


Figure 1-C – Existing PWRF Process Schematic



1.1.1.1 Conveyance

Processors currently convey their wastewater to the facility via lift stations and force mains. The Foster Wells Lift Station (FWLS) pumps combined flows from Pasco Processing, Baker Produce, Reser's, and Twin City Foods. Simplot's process water is conveyed via its own private lift station and force main. A new lift station, the Columbia East Lift Station (CELS) is not yet operational but will be used to connect freeze Pack and Grimmway to the PWRF.

Processors' discharges to the collection system are required by permit to meet a pH limit of 5 to 11 standard units (s.u.). Some processors add magnesium hydroxide or sodium hydroxide to meet this requirement.

1.1.1.1.1 Evaluation

The conveyance system provides adequate capacity for processor flows (**Table 1-A**). Simplot plans to eventually decommission its private lift station and instead connect to the CELS, which will require upgrades to the CELS capacity.

Table 1-A – Existing Lift Station Capacities

Lift Station	Capacity (gpm)
Foster Wells Lift Station (FWLS)	4,300
Columbia East Lift Station (CELS)	2,170
Simplot Lift Station (SLS)	1,200

The pH of process water at the PWRF is low, averaging below 6 s.u. at the influent and below 5 s.u. at the effluent to the irrigation system. The low pH conditions contribute to corrosion of the components at the PWRF and irrigation system and to the generation of odor problems at the PWRF and land application sites.

1.1.1.2 Preliminary Treatment

The combined influent process water enters the screenings building, where it passes through two above-grade and enclosed rotary drum screens. These screens provide very fine screenings (0.02 inches) and are intended to substantially reduce particulate biochemical oxygen demand (BOD).

1.1.1.2.1 Evaluation

The two existing screens are needed in operation to pass peak hydraulic flows; therefore, there is no additional screening redundancy during peak conditions. Further, the screens plug frequently. There is insufficient water pressure to clean the screens, and operators expect warm water may be necessary to adequately clean the screens with such a small aperture size.

1.1.1.3 Primary Treatment

The screened influent process water next enters a single rectangular clarification and sedimentation basin intended to remove settleable solids. However, the rectangular clarification and sedimentation basin sludge collection mechanism failed due to the large volume of inert solids (sand and grit) that accumulated in the basin. The City has since added a series of pre-cast concrete tanks (sand traps) to collect inert solids, which is further discussed in **Section 1.1.1.4 – Solids Handling**.

1.1.1.3.1 Evaluation

The lack of a dedicated automatic grit removal system led to the failure of the rectangular sedimentation basin sludge collection mechanism and has prompted the need for the manual removal of settled solids. Although processors provide some level of sand and grit removal, the processor systems still allow a substantial amount of inert solids to be conveyed to the PWRF. A dedicated influent grit removal system is necessary to protect any future downstream treatment systems, and the system should be automated to substantially reduce the City's labor associated with the current process. Removal of inert solids by the industries should also be regulated and enforced through the individual processor permits.

1.1.1.4 Solids Handling

Solids screened by the rotary drum screens are removed via an auger and sent to the screw press for dewatering. Dry solids exit the screw press at the discharge and fall into a discharge box. These dewatered, screened solids are hauled offsite for livestock feed during the corn processing season or taken to a landfill during other processing seasons.

Solids settled in the clarification and sedimentation basin are removed via a wasting pump and further settled out in a parallel series of 12 sand traps. Settled sand from the sand traps is removed manually via vactoring and air dried on a paved drying bed prior to landfill disposal.

1.1.1.4.1 Evaluation

The screw press handling the solids removed from the screens is in a temporary configuration and is labor intensive. Solids removal is manual and expensive.

1.1.1.5 Land Treatment System

Process water outfalls to lined storage lagoons after primary treatment. During the irrigation season, an Irrigation Pump Station (IPS), newly constructed after the 2019 Facility Plan, draws from the storage lagoons and discharges to the land treatment system. The City owns 1,856 acres of agricultural land consisting of 14 center-pivot irrigated fields. Process water from the PWRF is land applied at this site, and supplemental irrigation is provided by separate City-owned irrigation wells located nearby.

Overall, the PWRF and land treatment system have two distinct periods – the non-growing season of December 1st to February 28th, and the growing season from March 1st through November 30th; however, the actual land application window is limited by weather. All pre-treated process wastewater received from the industries during the non-growing season is stored in on-site lined lagoons until the irrigation season. The new storage described in this report will plan for an extended non-growing season, as discussed in **Chapter 6**.

1.1.1.5.1 Evaluation

Fixed dissolved solids applied to the fields currently exceed performance-based limits prescribed under the State Waste Discharge Permit (SWDP). Fixed dissolved solids are not removed in the PWRF.

Total nitrogen is not reduced before land application, which leads to more restrictive cropping choices and may result in exceedances of the agronomic rates for nitrogen application to the spray field.

High BOD contributes to odor problems at the land application sites. Additionally, operators at the PWRF have noted that fouling of the irrigation nozzles occurs frequently due to starches and substances within the effluent. The proposed pretreatment system should reduce the BOD, starches, and other substances substantially.

The open storage lagoons can collect tumbleweeds and other debris, causing plugging of the irrigation system. Coarse screening, as typically used for irrigation systems, should be provided prior to distribution.

1.1.1.6 Winter Storage

The site has four lagoons, two of which, the 115 million gallons (MG) and 35 MG lagoons, are used for storage. Water first fills the 115 MG lagoon and then overflows to the 35 MG lagoon. A third 8 MG equalization lagoon can be used to buffer influent flow surges. According to operators, this lagoon is rarely used since its relatively flat, incorrectly sloped bottom makes it difficult to clean. A fourth 5 MG lagoon is used to capture drain water from the screen building and screw press, which is then pumped back to the headworks.

1.1.1.6.1 Evaluation

The storage volume is insufficient for newly projected flows.

Odors at the site are significant due to the lack of BOD reduction ahead of the storage lagoons.

1.1.2 Review Previous Facility Plan Recommendations

The 2019 Facility Plan recommended the following near-term PWRF improvements:

1. Install a third, identical rotary drum screen in the existing headworks building to increase capacity and redundancy.

   Current Evaluation: The third rotary drum screen was intended to provide additional hydraulic capacity for the screening system. However, the increased flow and loading projections prompt renewed analysis of influent screening to support additional pretreatment improvements as discussed in this report.

   The existing very fine screens are intended to provide significant BOD reduction. However, most of the influent BOD is soluble and will not be removed through screening. If BOD reduction is desired, it must be provided through some form of secondary treatment. The type and configuration of a future screening system should be selected to provide sufficient screening and protection of any proposed secondary treatment system.

2. Provide a chemical pH adjustment system for control of pH downstream of the rotary drum screens.

   Current Evaluation: Chemical pH adjustment was intended to reduce odors and corrosion of components at the facility. Chemical pH adjustment needs to be considered relative to the other necessary treatment system improvements. The addition of chemicals should be used in a supporting role to other treatment processes and should be limited due to the operational cost and chemical cost. Chemical additional also increases the fixed dissolved solids (FDS) loading to the land treatment system, which is undesirable.

3. Provide a 90-foot-diameter circular primary clarifier, intended to provide solids and grit removal as well as BOD reduction.

   Current Evaluation: A new clarifier was intended to replace the failed rectangular clarification and sedimentation basin, as well as to replace the temporary sand traps installed as an interim measure for removing inert solids. However, without independent grit removal prior to primary clarification, the main concern would be with mechanism “binding” in dense settled sludge consisting of large quantities of inert solids, similar to the occurrence with the rectangular mechanism.

   Further, since a significant portion of the BOD loading is soluble, fine screens and primary clarification would not be expected to provide sufficient BOD reduction.

4. Provide flow equalization using the existing 35 MG lagoon.

   Current Evaluation: An equalization lagoon is intended to reduce peak flows into the pretreatment system. However, a renewed look at equalization is needed in the context of the currently projected flows and the equalization needs of future treatment processes.

5. Install surface aerators in the 35 MG equalization lagoon for stabilization.

   Current Evaluation: The 2019 Facility Plan proposed to install approximately 1,500 horsepower (hp) of surface aerators in the 35 MG lagoon to create an aerated stabilization basin. The intent was to provide some level of stabilization resulting in BOD reduction and reduced odors. Based on the current BOD loading projections, the total horsepower required to provide sufficient stabilization is much higher than that proposed by the 2019 Facility Plan. It is unlikely that the planned improvements will provide substantial stabilization or reduction in BOD. Further, it would be necessary to add nitrogen and phosphorus to the influent wastewater to achieve significant BOD reduction in the aerated stabilization basin. Additionally, some biomass would accumulate within the aerated stabilization basin, requiring periodic sludge removal. The 2019 Facility Plan notes that solids handling pumps would be added for this purpose, but the method for removal, conveyance, dewatering, and off-site disposal is unclear. This would create a new solids handling waste stream for operators to manage.

The 2019 Facility Plan noted that biological treatment would be needed for future flow and loading conditions for BOD reduction. This report will analyze various methods for BOD reduction by the PWRF relative to the current loading projections.

6. Replace the lost 35 MG in storage (from converting the 35 MG storage lagoon to equalization) and provide an additional 86 MG of winter storage.

   Current Evaluation: Current flow projections will require more additional storage than projected in the 2019 Facility Plan and projected storage will be thoroughly analyzed in this report.

The City has not made pretreatment improvements to the PWRF since the 2019 Facility Plan was completed; suggested improvements should be reevaluated based on new flow and loading projections.

1.1.3 Changes Since Previous Facility Plan

1.1.3.1 Flow and Loading Changes

Since the 2019 Facility Plan, the City has received interest from new and existing industrial users to discharge additional flow and loading to the PWRF. The City's recent data collection at processors' facilities also shows higher loading than previously projected. **Exhibit 1-A** shows the PWRF, existing and proposed processors, and available land treatment area.

The 2019 Facility Plan analyzed near-term flow and loading for the following conditions:

- Phase 1 – The existing flow and load (from Pasco Processing, Freeze Pack, Twin City Foods, and Reser's) plus the addition of Simplot (at the original CRF Frozen Foods facility).
- Phase 2 – Phase 1 plus 30-percent growth by Reser's and the addition of Grimmway, which currently pretreats process water and discharges it to the municipal wastewater treatment facility (WWTF).

This report analyzes the following conditions:

- Existing – All Phase 1 processors from the 2019 Facility Plan using 2018 through 2021 data showing higher loading rates than previously predicted.
- Proposed – Increases to existing processors and the addition of Grimmway, a new Reser's facility, Darigold condensate of whey (COW), and Darigold dairy process wastewater (WW).

Table 1-B compares the flow and loading conditions finrom the 2019 Facility Plan from those measured in 2021. The previous report analyzed the seasonal periods of "summer" and "winter." This report will use the nomenclature of average annual day and maximum month average day, as discussed in more depth in **Chapter 3**.

Table 1-B – Comparison of 2019 Facility Plan Projections to Existing Conditions

	2019 Facility Plan Existing	2019 Facility Plan Phase 2	2021 Existing Data
PWRF Pretreatment Influent Parameter	Summer Average Day	Summer Average Day	Maximum Month Average Day
Hydraulic Loading (MGD)	3.0	5.83	3.86
BOD Loading (ppd)	18,800	43,274	220,000
TN Loading (ppd)	1,900	2,486	6,600

1. *The 2019 Facility Plan did not evaluate monthly maximum flows and loads, but instead separated flows and loads into winter and summer seasons for analysis.*

As shown in the table, 2021 BOD and nitrogen (TN) measurements at the PWRF influent are already above those projected in the 2019 Facility Plan's Phase 2 scenario. As will be evaluated in **Chapter 3**, the planned processor additions will bring PWRF loading even further above the 2019 Facility Plan's projections.

The 2019 Facility Plan pretreatment recommendations were intended to address existing plant deficiencies and support Phase 2 flow and loading but were not intended to support further flow and loading increases. The 2019 Facility Plan stated that biological treatment would be necessary for BOD and nitrogen reduction prior to storage and land application at flow and loading beyond Phase 2. As such, the 2019 Facility Plan's recommended improvements are no longer expected to be appropriate or effective.

1.1.3.2 Planned Improvements

Near-term improvements to the PWRF are currently planned in three construction phases.

Construction Phase 1 extends and relocates water, power, and fiber utilities to existing PWRF facilities. City water for both drinking supplies and fire protection will extend from the East Foster Wells Road and Capital Avenue intersection to the IPS, screens building and office trailer. Power and fiber will be relocated and transitioned from overhead to underground starting at the entrance to the PWRF at E Foster Wells Road to a transformer adjacent to the screens building. Two of the E. Foster Wells force mains will be relocated from the start of the PWRF access road at E. Foster Wells Rd. to the IPS to be better aligned with existing force mains and provide a more uniform utility corridor for future utilities. Construction Phase 1 is scheduled to begin in summer 2022. This phase is not further evaluated in this report.

Construction Phases 2 and 3 will construct the improvements identified in **Chapter 6** of this report. Phase 2 will be constructed on the United States Bureau of Reclamation's (Reclamation) 80-acre parcel north of the existing PWRF site. Phase 3 will be constructed on the west 40 acres of the parcel containing the existing PWRF site. Phase 2 provides additional winter storage through proposed lagoons and establishes a construction site for pretreatment. Phase 3 will construct the pretreatment improvements. Phases 2 and 3 construction are scheduled to begin in winter 2022.

Future expansion of the PWRF would occur on Reclamation's 80-acre parcel to the south of the existing PWRF site. The City is in the process of obtaining fee title for this parcel and anticipates transfer of ownership by the end of September 2022. The City could use the land to construct additional lagoons for winter storage. There currently is no schedule for the future expansion as the additional winter storage is not necessary based on current processor demands. Future expansion is not further evaluated in this report.

1.2 Summary

Improvements to the PWRF will need to address existing facility deficiencies and accommodate newly projected growth. The 2019 Facility Plan pretreatment recommendations are no longer sufficient, so biologic pretreatment will be necessary prior to storage and land application. The following chapters will further evaluate improvements to pretreatment, winter storage, and land treatment.

Chapter 2.0 Regulatory and Planning Requirements

2.1 Discharge Permits

2.1.1 PWRF Permit

The PWRF is regulated by State Waste Discharge Permit ST0005369 issued by Ecology. The most recent permit was issued in May 2015, expired in June 2019, and is currently being updated. The permit specifies the following influent design criteria for the facility (**Table 2-A**).

Table 2-A – Existing PWRF Influent Permit Limits

Flow Max Month (MGD)	Flow Total Annual (MG)	BOD Max Month (ppd)	Total Nitrogen Total Annual (lbs)
10.6	1,003.4	355,600	866,246

Additionally, the permit regulates the water discharged to the LTS measured at the outfall of the PWRF. Land application rates cannot exceed the agronomic demand of the LTS for water and total nitrogen as determined in the annual Farm Operations Report. The application season is limited to March 1st through November 31st, and BOD application is limited to 100 pounds per acre per day (lb/ac/day).

Land application also must not cause a violation of the groundwater standards (Chapter 173-200 WAC) or the surface water quality standards (Chapter 173-201A WAC). To protect groundwater, the 2015 permit established interim limits for nitrate and FDS (**Table 2-B**). FDS is measured at the PWRF outfall prior to land treatment, and nitrate and pH are measured at groundwater monitoring wells in the land treatment area.

Table 2-B – Existing PWRF Effluent Interim Permit Limits

Effluent Limits		Groundwater Limits	
FDS Max Month (mg/L)	FDS Max Daily (mg/L)	Nitrate (mg/L)	pH (s.u.)
794	957	38.6	6.5-8.5

The permit also requires the PWRF to monitor influent and effluent flow and loading constituents and report results to Ecology in monthly Discharge Monitoring Reports (DMRs). At the influent, the PWRF continuously monitors flow, samples for pH weekly, and takes 24-hour composite samples for total nitrogen and BOD twice per month. At the effluent to land treatment, the PWRF continuously monitors flow, samples for pH weekly, takes 24-hour composite samples for total nitrogen, nitrogen species, BOD, and FDS twice per month, and takes 24-hour composite samples for sodium, calcium, magnesium, sulfate, chloride, alkalinity, and total phosphate twice per year.

2.1.2 Individual Processor Permits

Processors' discharges to the PWRF are regulated by Industrial Waste Discharge Permits issued by the City. Ecology delegated the responsibility to manage processors' permits to the City in 2015, before which Ecology issued the permits. **Table 2-C** shows a summary of current processor permit limits. Existing permits require the processors to continuously monitor flow, sample for pH daily, and take 24-hour composite samples for total nitrogen, BOD, total suspended solids (TSS), and FDS twice per month, and report their results to the City in monthly DMRs. Existing permits do not limit FDS discharges, but the City is expecting to establish FDS limits based on monitoring data and the capacity of the land treatment area as discussed in **Chapter 4**.

Table 2-C – Existing Processor Permit Limits

			Flow			BOD			TN	pH
Processor	Permit No.	Expiration Date	Max Month (MGD)	Total Annual (MG)	Winter Storage (MG)[a]	Max Month (ppd)	Max Day (ppd)	Max Day (mg/L)	Total Annual (lbs)	Min-Max (s.u.)
Current Dischargers to PWRF										
Pasco Processing	IWDP-000601	12/31/2023	2.5	384	80	-	127,000	-	270,000	5.0-11.0
Freeze Pack	IWDP-000700	6/30/2024	0.1	30	-[b]	200	250	-	15,000	5.0-12.0
Twin City Foods	IWDP-000101	9/30/2023	2.4	225	5	140,000	160,000	-	225,000	5.0-12.0
Simplot	IWDP-000201	12/31/2024	1.25	205	25	70,000	80,000	-	150,000	5.0-12.0
Reser's (Existing)	IWDP-000300	6/30/2020	0.3	115	-	7,200	-	-	72,000	5.0-12.0
TOTAL	**-**	**-**	**6.55**	**959**	**-**	**344,400[c]**	**-**	**-**	**732,000**	**-**
Other Processors										
Grimmway (Pretreated)[d]	IWDP-000500	6/30/2021	1.2	-	-	-	-	300	-	5.5-9.0

[a] *Existing permits define winter storage as discharges from December 1st to February 29th.*

[b] *Freeze Pack's winter storage allowance is included in Pasco Processing's limit.*

[c] *To estimate the total of maximum month BOD permit limits, 127,000 ppd BOD was used for Pasco Processing since the permit only has a maximum day limit.*

[d] *Grimmway currently pretreats its wastewater before discharge to the municipal WWTF but is requesting to minimize pretreatment once it switches to discharging to the PWRF.*

2.1.2.1 Processor Permit Change Recommendations

New permits should be issued for all processors that will discharge to the PWRF. As seen in **Table 2-C**, not all processors are regulated by consistent criteria. When new permits are issued, it is recommended that all permits have consistent criteria, including maximum month, average annual, and winter storage limits for flow; maximum month limit for BOD; and average annual limit for total nitrogen. Sampling frequency for loading should also be increased, likely to two times per week, to provide more representative data. Permit limits should also be evaluated based on existing data and processor requests, as discussed in **Chapter 3**, as well as with regard to any future PWRF improvements that may necessitate updating permit conditions.

2.2 Other Permits

The following permits are anticipated for construction of the recommended improvements:

- Ecology Dam Safety Permit
- Ecology Air Quality Permit
- Ecology Water Quality Permit
- Ecology Biosolids Management Permit
- Bonneville Power Administration (BPA) Easement
- State Environmental Policy Act (SEPA) evaluation
- Local Permits:
    - Franklin County Building Permit
    - Franklin County Plumbing Permit
    - Franklin County Mechanical Permit
    - Franklin County Electrical Permit
    - Franklin County Conditional Use Permit
    - City of Pasco Building Permit
- Other Permits??

Chapter 3.0 Evaluation of Processor Flow and Load

3.1 Introduction

The total influent to the PWRF consists of discharges from six industrial processors, including Pasco Processing, Baker Produce, Freeze Pack, Twin City Foods, Simplot, and Reser's. New discharges will include increased discharges from existing users, a new Reser's facility, transferring Grimmway's plant that currently discharges to the municipal WWTP, and a new Darigold facility. **Exhibit 1-A** shows the processors, PWRF, and land treatment area.

3.2 Summary of Existing Processors Discharging to PWRF

3.2.1 Pasco Processing

Pasco Processing is located at 5815 Industrial Way. The facility operates year-round to process assorted fruits and vegetables, including apples, cherries, beets, broccoli, carrots, cauliflower, corn, edamame, onions, parsnips, peas, peppers, potatoes, and squash. The fruits and vegetables processed vary seasonally and based on market demand. Vegetable processing includes cleaning/husking, sorting, cutting, blanching, freezing, and storing. Roasted vegetables and fruits are preprocessed by outside sources before arriving at the facility where they are roasted, frozen, and stored.

Pasco Processing's pretreatment consists of two rotary drum screens and a dissolved air flotation device (DAF). The rotary drum screens remove solids greater than 0.02-inch diameter. A polymer is injected into the wastewater prior to the DAF, and then dissolved air is injected at the DAF, causing lighter solids to float to the top and heavier solids to sink to the bottom for removal. Magnesium hydroxide is added as needed to meet pH limits. The facility also has an oil/water separator for use in the event of an oil spill. The facility recycles water for washing vegetables using a separate system of settling channels and a rotary drum screen. The facility discharges pretreated wastewater via a gravity line to the FWLS, which then pumps to the PWRF.

Pasco Processing is owned by the Oregon Potato Company, the same parent company that owns Baker Produce and Freeze Pack.

3.2.2 Baker Produce

Baker Produce is located at 1505 E Foster Wells Road. The facility operates seasonally to process potatoes and onions. Potato processing includes washing, sorting, and packaging; and onion processing includes sorting and packaging. The facility recycles its wash water using a treatment system of screening, coagulation and flocculation, and hydrodynamic separators.

Baker Produce currently discharges wastewater to Pasco Processing's pretreatment system. Baker Produce currently does not have its own discharge permit, but the City is working on a new permit for it. For analysis in this chapter, Baker Produce's flow and loading are included in Pasco Processing's flow and loading projections.

3.2.3 Freeze Pack

Freeze Pack is located at 302 Venture Road. The facility has historically operated year-round to process onions, but in 2021 it only operated in June and July to process blueberries. Onion processing includes washing, cutting, slicing, blanching, and freezing; and blueberry processing includes washing and freezing.

Freeze Pack's pretreatment consist of two cisterns and a rotating drum screen. The facility also has a DAF unit downstream of the screen, but it is currently bypassed and not used for wastewater treatment. Sodium hydroxide can be added before the screen to raise the wastewater pH if needed, but it is not regularly used.

From 2015 until October 2020, Freeze Pack discharged to Simplot's discharge pit, combining its flow with Simplot's to the PWRF; however, this agreement ended, and Freeze Pack currently hauls its wastewater by truck to Pasco Processing. Freeze Pack plans to connect into the CELS once the lift station starts operation. Freeze Pack has asked to have capacity built into the PWRF improvements based on its historical onion processing flow and load, but in 2022 it plans to only process blueberries from July through August. Once the CELS is operational, Freeze Pack may process other fruits and vegetables in addition to onions, but this has not been decided yet.

3.2.4 Twin City Foods

Twin City Foods is located at 5405 Industrial Way and primarily processes peas and corn. Corn processing involves steaming, husking, washing, cutting, sizing, blanching, and freezing; pea processing involves cleaning, blanching, freezing, sorting, sizing, and storing. Both processes have a cold storage warehouse. Processing of peas generally runs from early June to late July, and the corn season runs from late July to mid-October. Cob packaging and electronic product inspection runs generally from November through May. Twin City Foods also operates a repack operation year-round.

Twin City Food's pretreatment consist of three double-drum screens, also called dewatering reels, that remove particles larger than 0.02 inches. Liquid magnesium hydroxide is added to the wastewater stream for pH adjustment. Pretreated wastewater is then discharged via a gravity line to the FWLS, which then pumps to the PWRF.

3.2.5 Simplot

Simplot is located at 1825 N Commercial Avenue. The facility has historically processed assorted vegetables, including corn, peas, carrots, onions, and green beans. Processing involves cleaning, husking, cutting, blanching, and quick freezing the vegetables. The facility is planning to process potatoes year-round with other vegetables seasonally.

For pretreatment, wastewater passes through two drum screens followed by a discharge basin. The facility also has a DAF/ cavitation air flotation (CAF) system and pH adjustment system, but these are not currently in use. Simplot currently discharges to its own private lift station and force main that pumps wastewater approximately 3.8 miles to the PWRF. The facility plans to eventually connect into the CELS once the CELS capacity is upgraded.

3.2.6 Reser's Existing Facility

Reser's existing facility is located at 5310 Industrial Way. Once its new facility (discussed in the following section) is operational, Reser's plans to shut down the existing plant for sale or reconfiguration. Since the future of the existing plant is unknown, if it restarts operations with discharge to the PWRF, its allowable flow and loading will be proportioned from the new permit limits established for the new plant.

The existing facility operates 24 hours per day, 5 days a week year-round to produce potato products and side dishes comprised of vegetables and pasta blends. The facility receives raw potatoes and then washes, steams, peels, cooks, chills, and packages them. Some potatoes are further processed into shredded or mashed potatoes. The facility also cooks and packages vegetables and pasta with seasonings for the side dishes.

The existing facility uses a rotary screen for pretreatment. The wastewater regularly meets pH limits without adjustment. Wastewater is pumped to the FWLS, which then pumps to the PWRF.

3.3 Summary of Future Processors Discharging to PWRF

3.3.1 Reser's New Facility

Reser's is constructing a new facility at 5526 N Capital Avenue. The new facility will process potato products and side dishes year-round, like the existing facility. Reser's plans to begin operating the new facility in summer of 2022 and gradually increase operations until reaching its typical operations in 2026.

The new facility may use a DAF for pretreatment if needed to meet permit limits. Otherwise, pretreatment is expected to be similar to the existing plant, with screening and pH adjustment as needed. The new facility will discharge to the FWLS for conveyance to the PWRF.

3.3.2 Grimmway

Grimmway is located at 1315 Dietrich Road. The facility processes carrots annually from July through November with facility cleaning occurring in June and December. From July through November, the facility operates 24 hours per day, 5 to 6 days per week. The facility cuts, peels, chills, and packages the carrots.

The facility currently treats process water to meet limits for discharge to the City's municipal WWTF but is requesting to reduce treatment once it switches to discharging to the PWRF. The facility also recycles process water in some processes. Grimmway's treatment system consists of screens, separators, filters, and an aerated equalization pond.

Grimmway currently discharges wastewater to the Kahlotus Pump Station, which pumps to the City's WWTF. Grimmway plans to discharge via a gravity line to the CELS and then to the PWRF once the new lift station is operational, which is anticipated in July of 2022.

This facility is expected to begin discharging to the PWRF as soon as a new permit is established.

3.3.3 Darigold

Darigold is proposing a new facility at 8201 N Railroad Avenue that will process dairy to produce protein powder and butter. These processes will produce two separate waste streams: COW water is the water produced when milk is evaporated; and dairy WW is the water produced from other dairy processing. The waste streams will be kept separate because COW water is expected to have minimal suspended solids in comparison to what is currently entering the PWRF system; therefore, it will not require treatment before land application. Darigold plans to provide screening and pH adjustment as needed to meet permit limits.

The facility is expected to start discharging minor low strength flows to the PWRF in fall of 2023 and come fully online in spring of 2024. Darigold will provide its own lift station and conveyance to the PWRF, with COW process water conveyed separately from WW process water.

3.4 Historical Flow and Loading

3.4.1 Data Collection

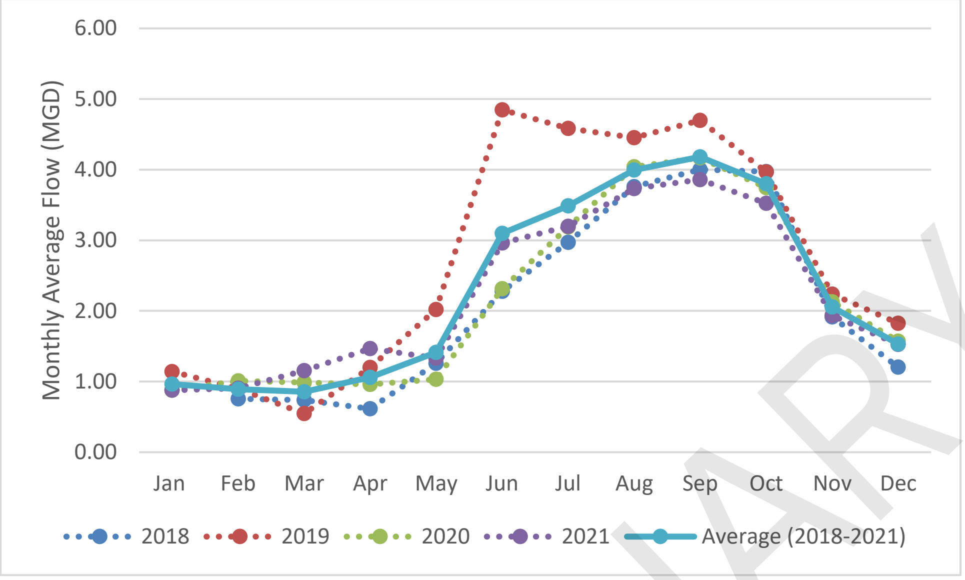
The historical data evaluated in this report includes data from the individual processors' DMRs, the PWRF's DMRs measuring the combined loading, and additional data from recent City sampling. Processors submit DMRs monthly to the City, and the PWRF submits DMRs monthly to Ecology as required by the City's permit. Starting in late July of 2021, the City began sampling at each processor and reporting these sampling results back to the processors to be used for their DMRs. The City's sampling data is considered to be the most reliable data available.

Some issues have been identified with the data provided in the processors' DMRs. First, sampling was relatively infrequent (currently twice per month by permit) and may not have been fully representative of load. As discussed in **Chapter 2**, it is recommended that processors' sampling frequency for loading be increased. Sampling procedures also may need to be improved by the processors. Further, variability was found between various labs used for testing, so now the City sends all samples to the TestAmerica lab for consistency.

3.4.2 Historical Flow

Flow data is available from continuous monitoring at each processor's effluent and the PWRF influent. The historical 2018 through 2021 PWRF influent flow is graphed in **Chart 3-A**.

Chart 3-A – Historical PWRF Monthly Average Influent Flow (2018 to 2021)



Flows have historically peaked in summer or early fall and been lowest throughout the winter. The highest average monthly flow since 2018 was 4.85 million gallons per day (MGD) experienced in June of 2019. For other years, the maximum month flow occurred in September. In most months, 2019 had higher flows than 2018, 2020, and 2021, but there is not a clear trend between years. **Table 3-A** breaks down the monthly flow from each processor.

Table 3-A – Historical Average Month Flows (2018 to 2021) (MGD)

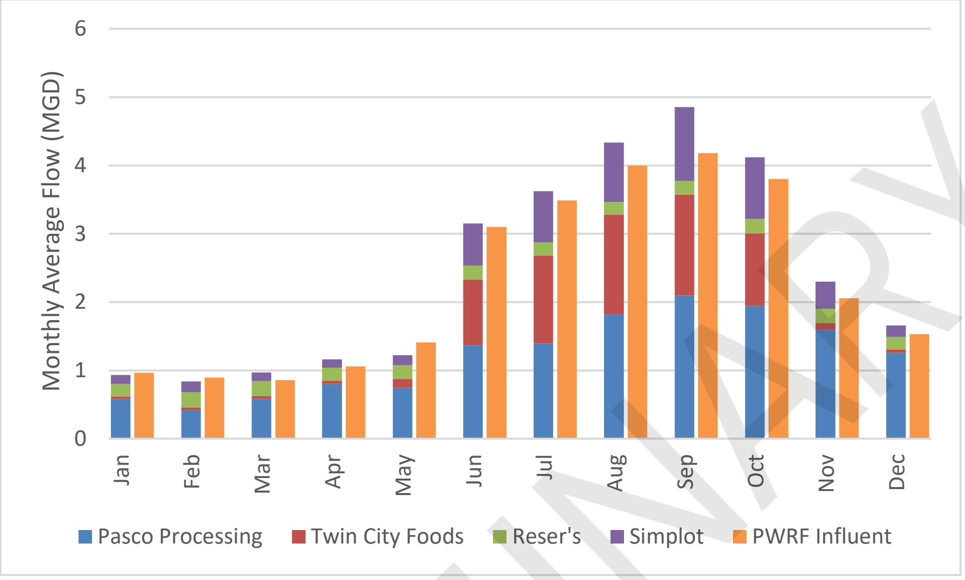
Month	Process DMR Data					PWRF Influent Data
	Pasco Processing[a]	Twin City Foods	Reser's	Simplot[b]	Cumulative	
Jan	0.58	0.04	0.18	0.13	**0.93**	**0.97**
Feb	0.41	0.04	0.22	0.16	**0.84**	**0.89**
Mar	0.58	0.04	0.22	0.12	**0.97**	**0.86**
Apr	0.80	0.05	0.19	0.12	**1.16**	**1.06**
May	0.75	0.13	0.20	0.15	**1.22**	**1.41**
Jun	1.36	0.96	0.20	0.62	**3.15**	**3.10**
Jul	1.40	1.28	0.20	0.75	**3.62**	**3.49**
Aug	1.82	1.46	0.19	0.87	**4.33**	**4.00**
Sep	2.10	1.47	0.20	1.08	**4.85**	**4.18**
Oct	1.94	1.06	0.21	0.90	**4.12**	**3.80**
Nov	1.59	0.10	0.21	0.40	**2.30**	**2.06**
Dec	1.26	0.05	0.18	0.17	**1.66**	**1.53**

[a] *Pasco Processing's flow and loading includes all discharges from Baker Produce and 2021 discharges from Freeze Pack.*

[b] *Simplot's flow and loading includes 2018 to 2020 discharges from Freeze Pack.*

Pasco Processing is the largest discharger to the PWRF year-round. Twin City Foods is the second largest discharger during summer months but the smallest discharger during winter months. Pasco Processing, Twin City Foods, and Simplot all have seasonal flow patterns that peak in September and remain low throughout the winter. Reser’s discharges consistently year-round. **Chart 3-B** compares the sum of the processors’ data to the PWRF’s influent data.

Chart 3-B – Historical Monthly Average Processor Flow Data vs PWRF Influent Flow Data (2018 to 2021)



Based on **Chart 3-B**, in summer months the PWRF has recorded slightly lower influent flows than the processors report, and in some spring and winter months the PWRF has recorded slightly higher flows than the processors report. This discrepancy is likely due to variation between the PWRF’s and processors’ flow meters.

Table 3-B shows the average annual (AA) and maximum month (MM) flows for 2018 through 2021.

Table 3-B – Historical Average Annual and Maximum Month Flows

	Flow (MGD)							
	2018		2019		2020		2021	
Processor	AA	MM	AA	MM	AA	MM	AA	MM
Pasco Processing[a]	-	-	1.10	1.99	1.21	2.19	1.34	2.11
Twin City Foods	0.56	1.44	0.65	2.10	0.51	1.33	0.52	1.39
Reser's	0.26	0.29	0.24	0.28	0.19	0.22	0.12	0.17
Simplot[b]	0.47	1.29	0.58	1.59	0.44	1.00	0.34	0.76
Total Processor Data	**-**	**-**	**2.56**	**5.96**	**2.34**	**4.73**	**2.32**	**4.42**
PWRF Influent Data	**2.13**	**4.00**	**2.70**	**4.85**	**2.17**	**4.17**	**2.21**	**3.86**

[a] *Pasco Processing’s flow and loading includes all discharges from Baker Produce and 2021 discharges from Freeze Pack.*

[b] *Simplot’s flow and loading includes 2018 to 2020 discharges from Freeze Pack.*

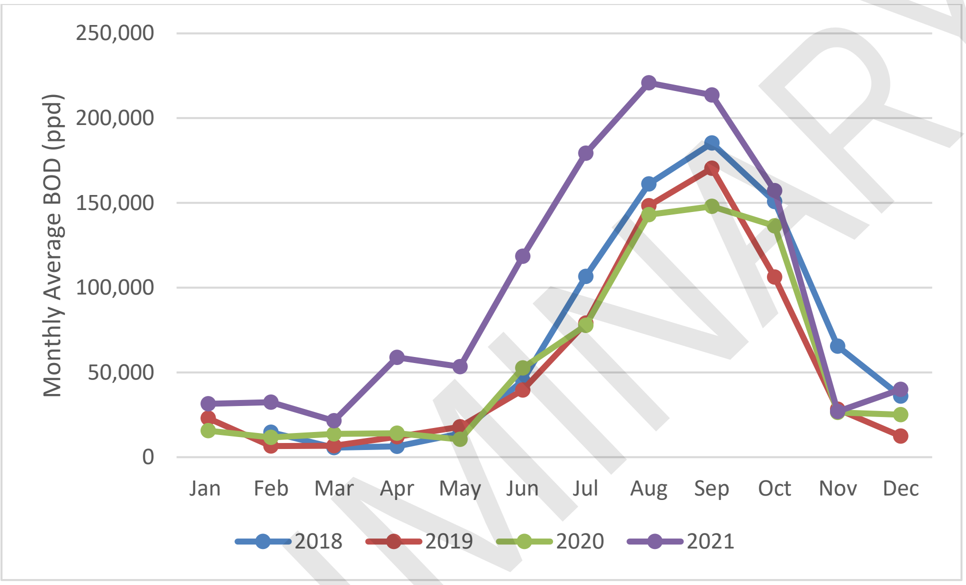
Pasco Processing’s highest average annual flow of 1.34 MGD occurred in 2021; however, according to plant operators, this was a higher than normal production year since one of the company’s other plants was temporarily out of service. The other processors’ highest average annual flows occurred in 2019 with 0.65 MGD for Twin City Foods, 0.24 MGD for Reser’s, and

0.58 MGD for Simplot. Based on information from the Reser's plant operators, Reser's 2021 flow was lower than normal since the company is preparing to start up a new facility. The sum of the processors' maximum month flows are greater than that measured at the PWRF since not all processors' peak operating months coincide.

3.4.3 Historical BOD Loading

BOD data is available from sampling at each processor's effluent and the PWRF influent. Historical PWRF influent BOD loading is graphed in **Chart 3-C**.

Chart 3-C – Historical PWRF Influent BOD (2018 to 2021)



The BOD loading historically follows the same pattern as the flow, with loads peaking in summer or early fall and low loads throughout the winter. The historical maximum month BOD loading measured at the PWRF influent is approximately 222,000 pounds per day (ppd) experienced in August 2021.

Table 3-C breaks down the BOD loading reported by the processors compared to the cumulative PWRF influent measurement, and **Chart 3-D** shows the monthly distribution in 2021.

Table 3-C – Historical BOD Loading (2018 to 2021)

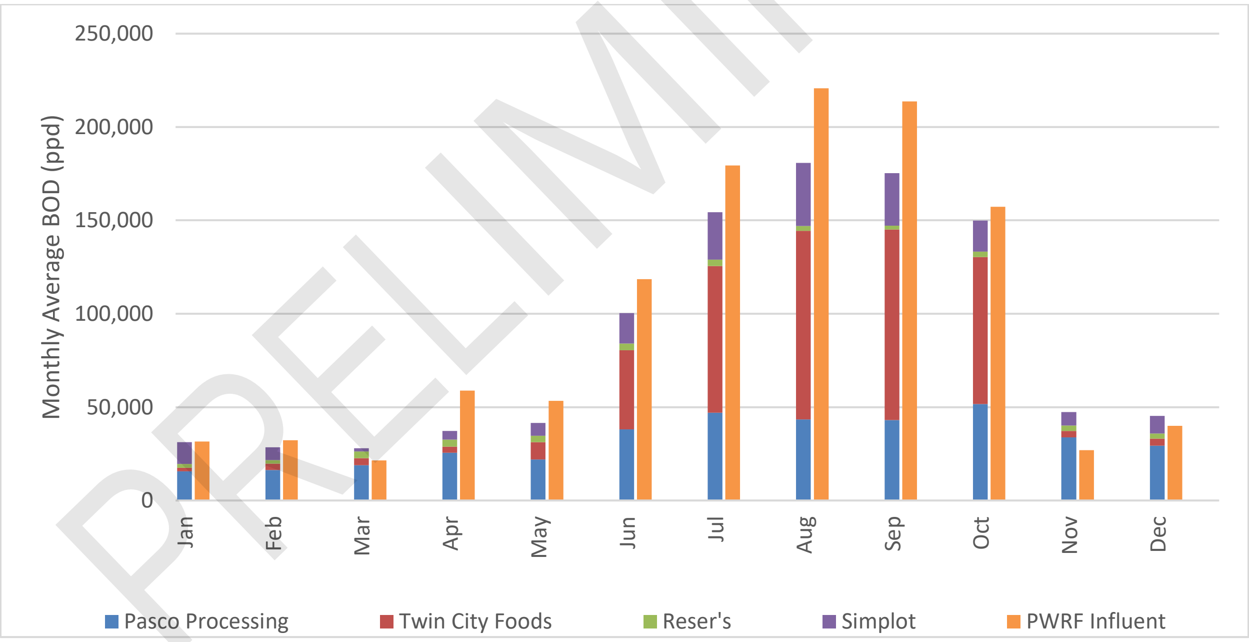
	BOD Loading (ppd)							
	Data Prior to City Sampling						Data Includes City Sampling	
	2018		2019		2020		2021[c]	
Processor	**AA**	**MM**	**AA**	**MM**	**AA**	**MM**	**AA**	**MM**
Pasco Processing [a]	-	-	2,900	8,100	2,200	5,500	25,300	51,800
Twin City Foods	3,000	10,500	2,600	12,100	1,000	3,300	36,900	102,500
Reser's	3,900	6,000	4,200	4,900	3,700	5,200	3,200	7,100
Simplot[b]	1,200	3,200	2,400	9,600	1,100	2,400	10,400	33,600
Total Processor Data	**8,100**	**19,700**	**12,100**	**34,700**	**8,100**	**16,300**	**75,800**	**195,100**
PWRF Influent Data	**71,900**	**185,200**	**54,200**	**170,400**	**56,200**	**148,000**	**80,500**	**221,900**

[a] *Pasco Processing's flow and loading includes all discharges from Baker Produce and 2021 discharges from Freeze Pack.*

[b] *Simplot's flow and loading includes 2018 to 2020 discharges from Freeze Pack.*

[c] *City sampling began in July of 2021; this table's data for July through December 2021 includes both processor DMRs and City samples.*

Chart 3-D – Historical Monthly Average Processor BOD Data vs PWRF Influent BOD Data (2021)



In **Table 3-C,** prior to 2021, the sum of processors' BOD loading data is much lower than the BOD loading measured at the PWRF influent. The sampling and laboratory changes in 2021 are believed to have closed this gap significantly. In 2021, there is still a difference in the maximum month of about 25,000 ppd BOD, but prior to 2021 this difference was greater than 130,000 ppd BOD. The remaining difference between processor and PWRF measurements may be due to solids breaking down during conveyance from the processors to the PWRF. It should also be noted that processors' operations do not all peak in the same month, so the individual maximum month loadings would be expected to add up to more than the maximum month experienced at the PWRF. For example, the 2021 cumulative monthly processor load in **Chart 3-D** peaks at around 180,000 ppd in August, approximately 15,000 ppd less than the sum of all processors' 2021 maximum months. **Chart 3-D** also shows that in high flow months the PWRF has recorded higher influent BOD loading than the processors report, and in some low flow months the PWRF has recorded slightly lower loading than the processors report. As will be discussed in **Section 3.5 – Projected Flow and Loading**, a correction factor was applied to projected BOD loads for existing processors to account for the increase in loading measurements between the processors' facilities and the PWRF.

Table 3-D calculates the average BOD concentration during each processor's historic max month loading.

Table 3-D – Historical Maximum Month BOD Loading (2018 to 2021)

	BOD Load	Corresponding Month Flow [b]	Calculated BOD Concentration [c]		
Processor	ppd	MGD	mg/L	Month	Data Source
Pasco Processing [a]	51,800	2.03	3,100	Oct-21	Processor DMR
Twin City Foods	102,500	1.39	8,900	Sep-21	Processor DMR
Reser's	7,100	0.13	6,700	May-21	Processor DMR
Simplot	33,600	0.76	5,300	Aug-21	City Sampling

[a] *Pasco Processing's flow and loading includes all discharges from Baker Produce and 2021 discharges from Freeze Pack.*

[b] *Corresponding Month Flow is the average daily flow over the month when the maximum month BOD loading occurred. This is not necessarily the same as the maximum month flow experienced from 2018 to 2021.*

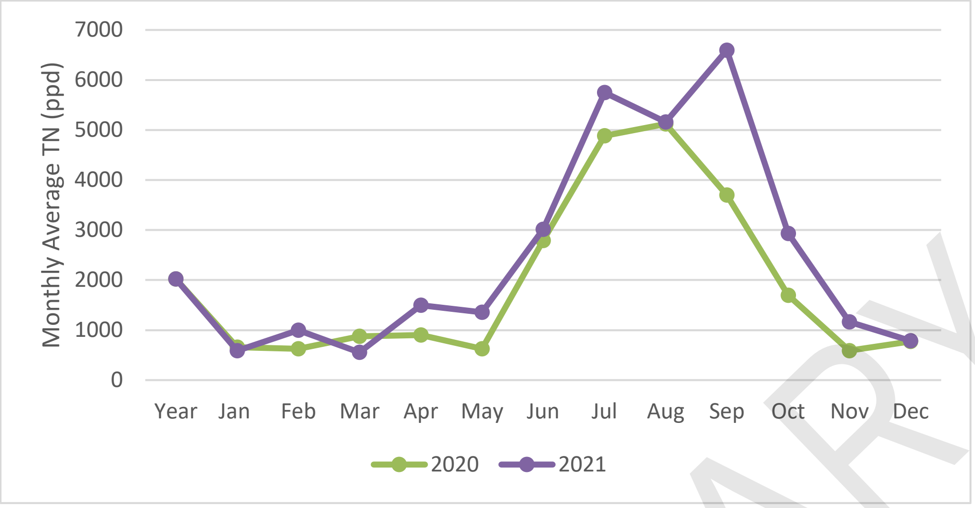
[c] *BOD concentration was calculated from BOD load and corresponding month flow and rounded up to the next 100 mg/L.*

The calculated historical maximum month BOD concentrations vary by processor, ranging from 3,100 milligrams per liter (mg/L) to 8,900 mg/L, with the lowest concentration for Pasco Processing and the highest concentration for Twin City Foods.

3.4.4 Historical Nitrogen Loading

TN data is available from sampling at each processor's effluent and the PWRF influent. Historical PWRF influent TN loading is graphed in **Chart 3-E**.

Chart 3-E – Historical PWRF Influent TN (2020 to 2021)



The TN loading historically follows the same pattern as flow and BOD, with loads peaking in summer or early fall and low loads throughout the winter. The historical maximum month TN loading measured at the PWRF influent is approximately 6,600 ppd, experienced in September 2021. **Table 3-E** breaks down the TN loading reported by the processors compared to the cumulative PWRF influent measurement, and **Chart 3-F** shows the monthly distribution in 2021.

Table 3-E – Historical TN Loading (2020 to 2021)

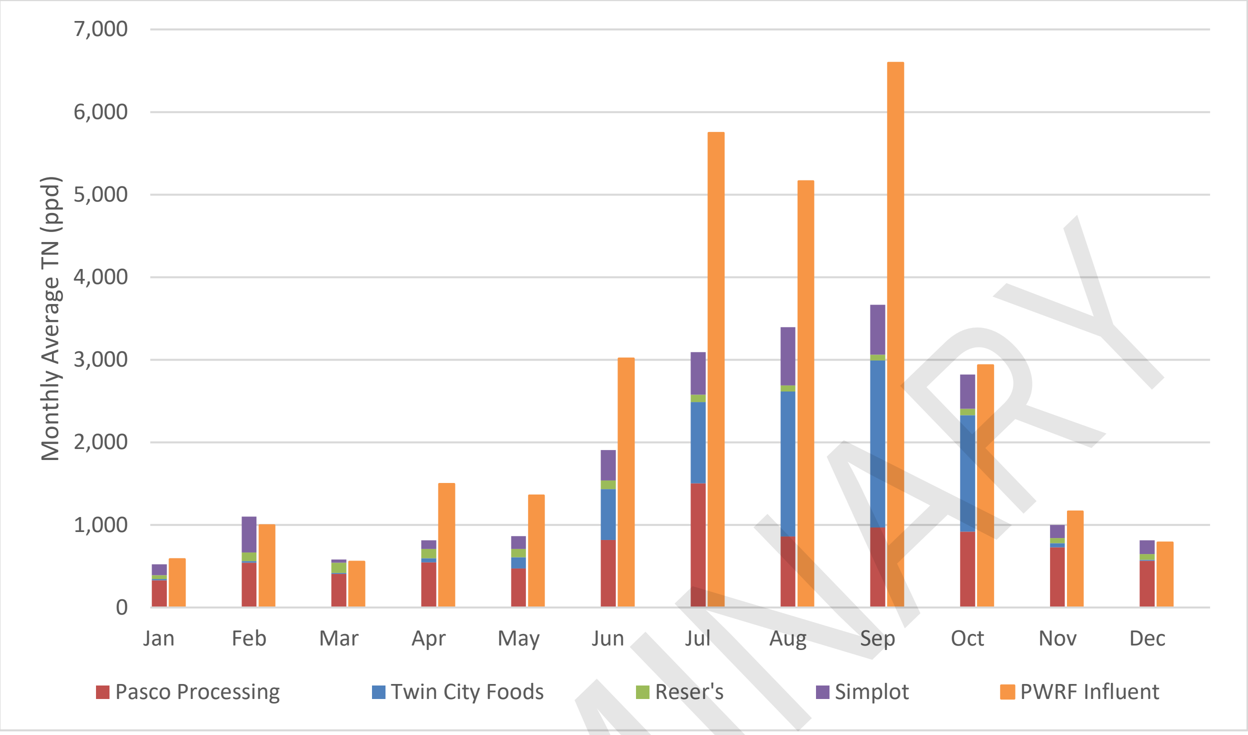
	Historical TN Loading (ppd)			
	Data Prior to City Sampling		Data Includes City Sampling	
	2020		2021[c]	
Processor	AA	MM	AA	MM
Pasco Processing [a]	320	610	720	1,500
Twin City Foods	110	280	590	2,020
Reser's	170	300	90	120
Simplot[b]	140	290	320	710
Total Processor Data	**800**	**1,500**	**1,700**	**4,400**
PWRF Influent Data	**1,900**	**5,100**	**2,500**	**6,600**

[a] Pasco Processing's flow and loading includes all discharges from Baker Produce and 2021 discharges from Freeze Pack.

[b] Simplot's flow and loading includes 2020 discharges from Freeze Pack.

[c] City sampling began in July of 2021; this table's data for July through December 2021 includes both processor DMRs and City samples.

Chart 3-F – Historical Monthly Average Processor TN Data vs PWRF Influent TN Data (2021)



Like BOD loading, the sum of processors' TN loading data is lower than the loading measured at the PWRF influent, and the largest difference is in peak processing months. As will be discussed in **Section 3.5 – Projected Flow and Loading**, a correction factor was applied to projected TN loads for existing processors to account for the increase between processors' facilities and the PWRF.

Table 3-F calculates the average TN concentration during each processor's historic maximum month loading.

Table 3-F – Historical Maximum Month TN Loading (2020 to 2021)

Processor	TN Load ppd	Corresponding Month Flow [c] MGD	Calculated TN Concentration [d] mg/L	Month	Data Source
Pasco Processing [a]	1,505	1.64	110	Jul-21	City Sampling
Twin City Foods	2,024	1.39	180	Sep-21	City Sampling
Reser's	300	0.22	170	Nov-20	Processor DMR
Simplot[b]	707	0.76	120	Aug-21	City Sampling

[a] Pasco Processing's flow and loading includes all discharges from Baker Produce and 2021 discharges from Freeze Pack.

[b] Simplot's flow and loading includes 2018 to 2020 discharges from Freeze Pack.

[c] Corresponding Month Flow is the average daily flow over the month when the maximum month TN loading occurred. This is not necessarily the same as the maximum month flow experienced from 2020 to 2021.

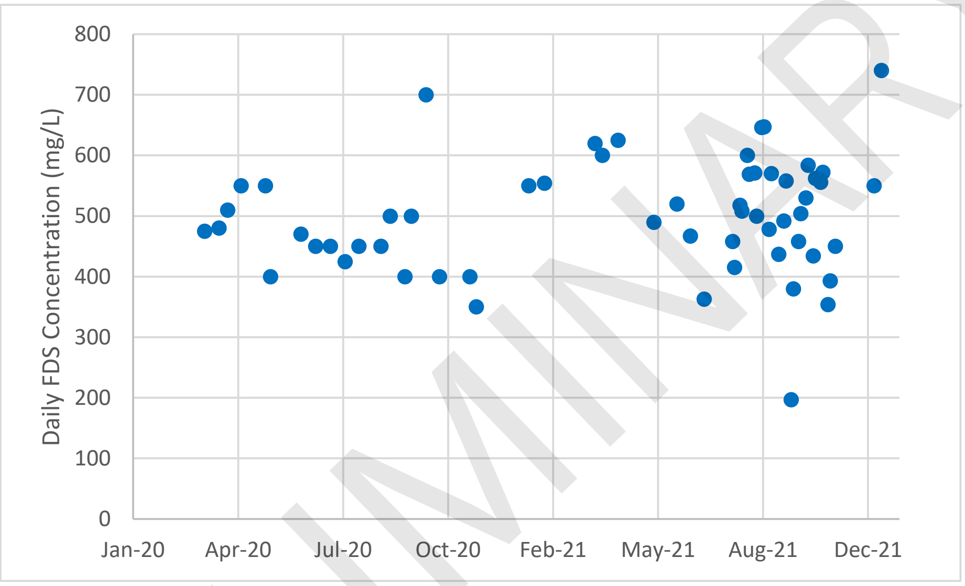
[d] TN concentration was calculated from TN load and corresponding month flow and rounded up to the next 10 mg/L.

The historical maximum month TN concentrations vary by processor, ranging from 110 mg/L to 180 mg/L, with the lowest concentration for Pasco Processing and the highest concentration for Twin City Foods.

3.4.5 Historical FDS Loading

Historical FDS data is limited. Data from City sampling is available for all processors from July through December 2021 but was not sampled for earlier DMRs. At the PWRF, FDS is sampled at the effluent prior to land treatment (**Chart 3-G**), which has similar FDS content as the influent since the existing pretreatment has minimal impact on FDS.

Chart 3-G – Historical PWRF Effluent FDS Concentration Single Sample Values (2020 to 2021)



There is not a clear monthly pattern of FDS concentration variation, but the concentration averages around 500 mg/L, and most samples are between 400 and 600 mg/L. **Table 3-G** breaks down the FDS loading by processor.

Table 3-G – Historical FDS Loading (2021)

	Data Includes City Sampling		
	2021[b]		
Processor	Average Concentration	AA Flow	Calculated AA Load
	mg/L	MGD	ppd
Pasco Processing [a]	475	1.34	5,310
Twin City Foods	515	0.52	2,220
Reser's	730	0.12	730
Simplot	525	0.34	1,510
Total Processors	**505**	**2.32**	**9,800**
PWRF Effluent	**515**	**2.21**	**9,500**

[a] Pasco Processing's flow and loading includes discharges from Freeze Pack and Baker Produce.

[b] This table uses City sampling data for July through December 2021.

Since FDS was only measured at the processors during part of 2021, the average annual FDS loading could not be directly evaluated. Instead, the measured concentrations were averaged to estimate an average annual concentration, and then used to estimate the average annual load. Unlike BOD and TN, the weighted average FDS concentration from each processor is close to that measured at the PWRF, and the difference may be explained by variation in sampling equipment and sampling times.

3.4.6 Summary of Existing Flow and Loading

The existing (2021) flow and loading conditions to the PWRF are summarized in **Table 3-H**.

Table 3-H – Summary of Existing (2021) PWRF Flow and Loading

	Existing (2021)
Flow	
Annual Average Day (MGD)	2.21
Maximum Month Average Day (MGD)	3.86
Total Annual (MG)	807
BOD	
Annual Average Day (lb/d)	80,500
Concentration (mg/L)	*4,368*
Maximum Month Average Day (lb/d)	221,900
Concentration (mg/L)	*6,859*
TN	
Annual Average Day (lb/d)	2,500
Concentration (mg/L)	*136*
Maximum Month Average Day (lb/d)	6,600
Concentration (mg/L)	*205*
FDS	
Annual Average Day (lb/d)	9,500
Concentration (mg/L)	*515*

3.5 Projected Flow and Loading

3.5.1 Introduction

Flow projections were made based on the processors' requests for growth and compared to the historical flow data. Loading projections were made based on the City's sampling data at existing processors, processors' requests for growth, and sampling data at facilities similar to new processors. To represent typical operating patterns, monthly distributions were developed for flow, BOD loading, and TN loading. Since historic data showed an increase in BOD and TN loading measured at the PWRF influent compared to that measured at existing processors, an influent correction factor was added to the monthly projections. The peak month shown in the typical operating patterns is representative of the maximum month expected at the PWRF, even though processors have requested maximum month permit limits above their typical operations.

3.5.2 Projected Flow

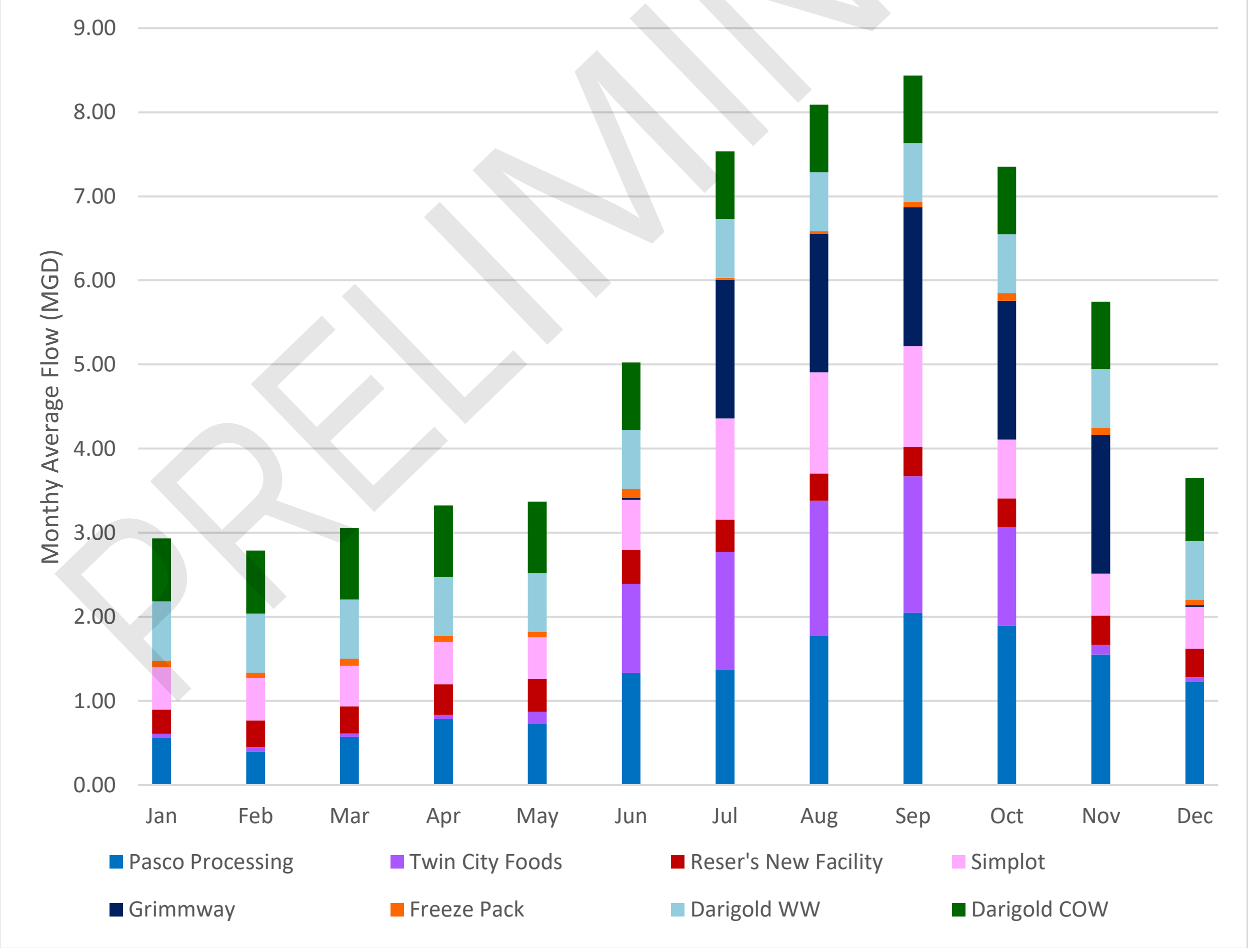
Each processor requested a total annual and maximum month flow limit to be accommodated with the PWRF improvements (**Table 3-I**). Flows were distributed by month to represent typical operating patterns (**Chart 3-H**). Darigold's COW process water is tabulated separately from other processors' flows since it is low strength and will not require biologic treatment prior to land application.

Table 3-I – Projected Flow

	Total Annual Flow (MG)	Average Annual Daily Flow (MGD)	Max Month Daily Flow (MGD)[a]
Pasco Processing	435	1.19	2.50
Freeze Pack	25	0.07	0.11
Twin City Foods	225	0.62	1.80
Reser's New Plant	127	0.35	0.41
Simplot	255	0.70	1.25
Grimmway	254	0.70	1.65
Darigold WW	256	0.70	0.84
Total (no COW)	**1,577**	**4.33**	**8.56**
Darigold COW	292	.80	0.95
Total (with COW)	**1,869**	**5.13**	**9.51**

[a] *Conservative maximum month permit limit request by industry.*

Chart 3-H – Projected Monthly Flow Distribution Based on Typical Patterns



Pasco Processing requested an increase from its current permit flow limit to increase its processing capacity. For the monthly estimates, this flow was distributed proportionally to the average flow pattern in its 2018 to 2021 DMRs. Pasco Processing's projected flow peaks in September and remains lower throughout the winter.

Freeze Pack requested to have capacity for its historical onion processing, so its allowance and distribution was based on flow from its 2019 DMR, the most recent year of onion processing. Freeze Pack makes up a very small portion of the flow and loading to the PWRF year-round.

Twin City Foods requested no changes, so its current permit flow limit will be planned for. Like Pasco Processing, the monthly estimates were achieved by distributing the annual flow proportionally to the average flow pattern in its 2018 to 2021 DMRs. Twin City Foods' projected flow peaks in August and September, with very low flows over the winter.

Simplot requested an increase from its current permit flow limit, and the processor provided an estimated monthly flow distribution. Simplot's projected flow peaks in July through September and remains lower in winter months. With the new flow distribution, Simplot expects to operate more over the winter than it has historically, so its seasonal variation is reduced.

For its new facility, Reser's requested an increase from its existing facility's current permit limit and expects consistent year-round flows. Reser's existing facility is not planned for separately, but if it restarts operations with discharge to the PWRF, its allowable flow and loading will be proportioned from the new permit limits established for the new plant.

Grimmway plans to follow a specific operating pattern. From January through May, the facility will produce no flows to the PWRF. Then in June, the facility will start-up with minor flows for cleaning. The facility will process produce from July through August with consistent flows, and then in December produce only minor flows for cleaning and winterizing.

Darigold plans to operate its dairy (WW) process consistently year-round with slight seasonal variation in its COW process.

Overall, **Chart 3-H** shows projected flow to the PWRF peaking in September at an average monthly flow of 7.6 MGD (8.4 MGD including Darigold COW) with lower flows throughout the winter.

Chapter 6 evaluates the winter storage needed based on the projected flow distribution.

3.5.3 Projected BOD Loading

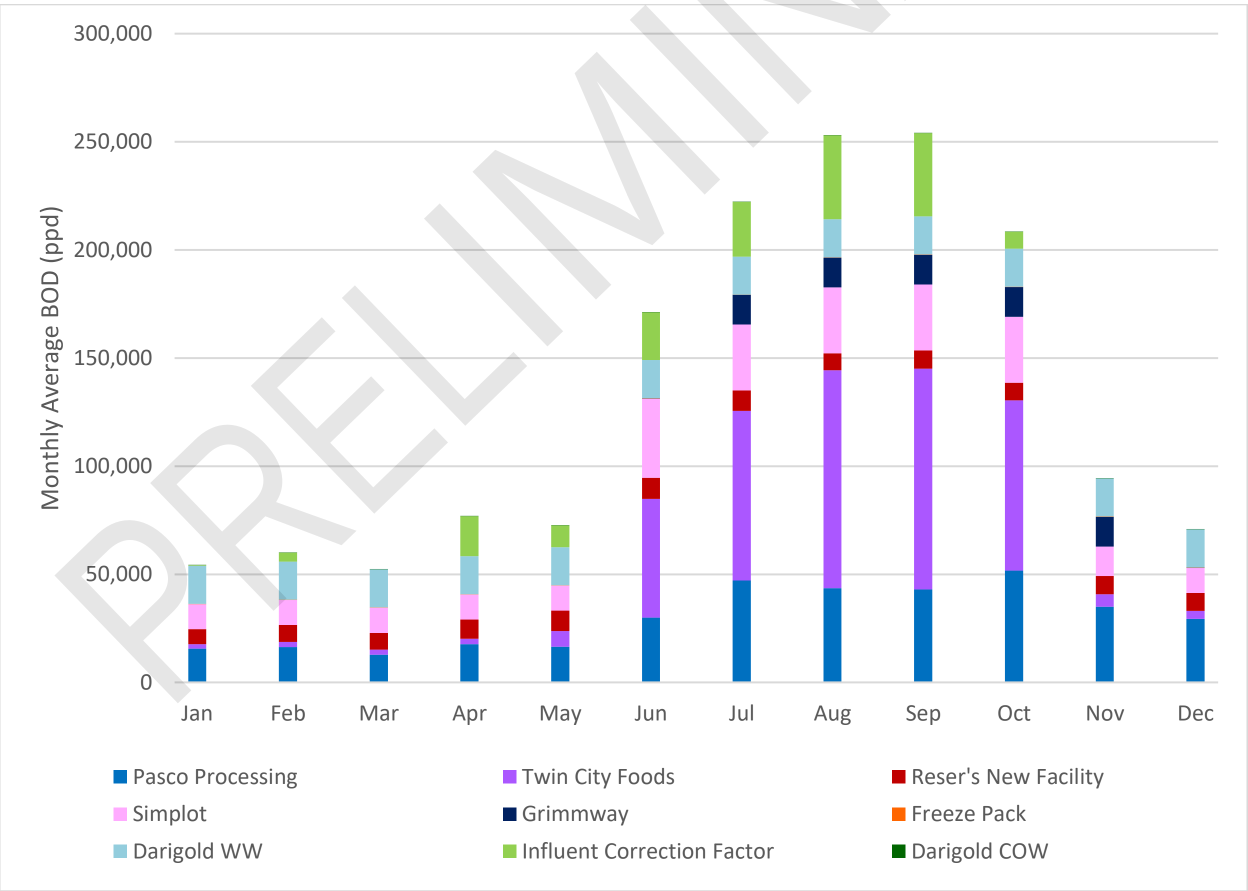
The projected average annual, maximum month, and typical monthly BOD loading distribution were estimated for each processor (**Table 3-J** and **Chart 3-I**).

Table 3-J – Projected BOD Loading

Processor	Average Annual Daily Load (ppd)	Max Month Daily Load (ppd)[a]
Pasco Processing	30,000	65,000
Freeze Pack	135	225
Twin City Foods	37,000	105,000
Reser's New Plant	8,400	10,200
Simplot	20,200	70,000
Grimmway	5,800	13,800
Darigold WW	17,600	24,600
Influent Correction Factor	13,000	40,000
Total (No COW)	**133,000**	**329,000**
Darigold COW	33	40

[a] *Conservative maximum month permit limit request by industry.*

Chart 3-I – Projected Monthly BOD Distribution Based on Typical Patterns



Loading projections for existing processors were made based on City-collected data at the existing facilities and processors' requests for growth. Since historical data showed higher BOD loading measured at the PWRF than at the processors, an influent correction factor was added for each month proportionally to the difference in historical data. For months where data reported higher loading at the processors than the PWRF, no influent correction factor was added.

At Grimmway, samples of raw process water were collected before the facility's pretreatment system. These measurements were used to estimate the process water quality when the facility switches to discharging to the PWRF.

The process water quality of Darigold's two streams was estimated based on sampling data collected at one of Darigold's similar facilities.

Overall, **Chart 3-I** shows projected BOD loading to the PWRF peaking in September at an average monthly load of 254,000 ppd (without Darigold COW) with lower loading throughout the winter. Twin City foods is the largest BOD contributor with most of its loading occurring from June through October. In order, the next highest BOD contributors are Pasco Processing, Simplot, Darigold WW, Reser's, and Grimmway. Darigold COW and Freeze Pack contribute very low BOD compared to the other processors.

From the typical loading distribution, the flow-weighted average BOD concentration to the PWRF pretreatment system each month was estimated (**Table 3-K**). The combined concentration to the PWRF varies each month as the ratio of flow between processors changes.

Table 3-K – Projected Monthly Average PWRF Pretreatment Influent BOD Concentration

Month	Average PWRF Influent Concentration (No COW) (mg/L)
January	2,983
February	3,536
March	2,844
April	3,722
May	3,454
June	4,857
July	3,957
August	4,163
September	3,989
October	3,817
November	2,288
December	2,924
Annual Average (Flow-Weighted)	**3,650**

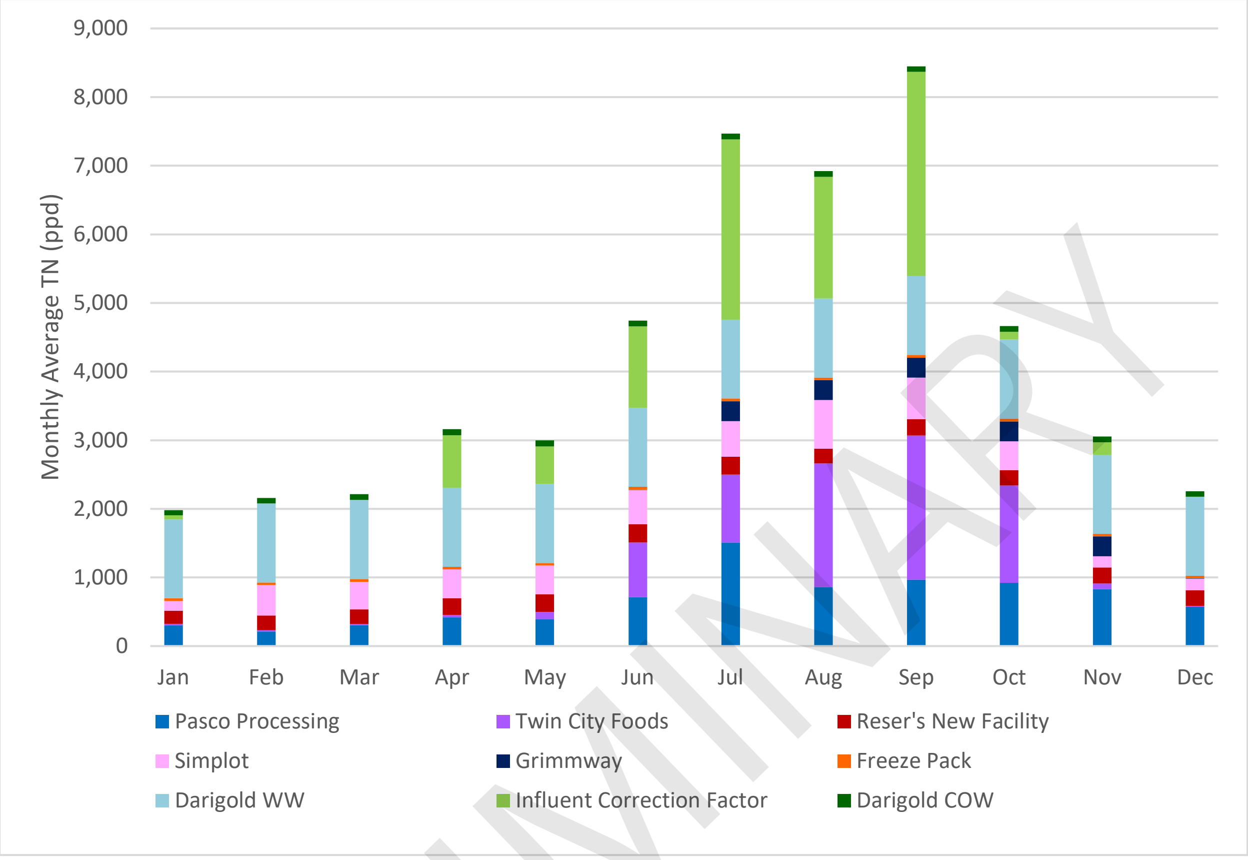
3.5.4 Projected TN Loading

Like BOD, average annual and typical monthly TN loading distribution were estimated for each processor (**Table 3-L** and **Chart 3-J**). Projections were based on the same data sources and processor requests described for the BOD projections.

Table 3-L – Projected TN Loading

Processor	Average Annual Daily Load (ppd)
Pasco Processing	670
Freeze Pack	40
Twin City Foods	620
Reser's New Plant	230
Simplot	410
Grimmway	120
Darigold WW	1,150
Influent Correction Factor	820
Total (No COW)	**4,100**
Darigold COW	85

Chart 3-J – Projected Monthly TN Distribution Based on Typical Patterns



Overall, **Chart 3-J** shows projected TN loading to the PWRF peaking in September at an average monthly load of 8,400 ppd (without Darigold COW), with lower loading throughout the winter. The largest TN contributor is Darigold WW, followed by Pasco Processing, Twin City Foods, and Simplot.

From the typical loading distribution, the flow-weighted average TN concentration to the PWRF pretreatment system each month was estimated (**Table 3-M**). Like BOD, the combined concentration to the PWRF varies each month as the ratio of flow between processors changes.

Table 3-M – Projected Monthly Average PWRF Pretreatment Influent TN Concentration

Month	Average PWRF Influent Concentration (No COW) (mg/L)
January	105
February	122
March	116
April	149
May	138
June	133
July	132
August	113
September	131
October	84
November	72
December	90
Annual Average (Flow-Weighted)	**114**

3.5.5 Projected FDS Loading

To predict FDS loading, an average concentration was determined for each processor, and the average annual load was calculated from the average concentrations and projected flows (**Table 3-N**). Average concentration for existing processors was determined from the City's sampling data at the existing facilities. An average concentration for Darigold's process water streams was estimated from sampling data collected at one of Darigold's similar facilities. Since historical data showed similar FDS measurements at processors compared to the PWRF, an influent correction factor was not added.

Table 3-N – Projected FDS Loading

Processor	Average Concentration (mg/L)	Average Annual Daily Load (ppd)
Pasco Processing	475	4,700
Freeze Pack	515	300
Twin City Foods	515	2,600
Reser's New Plant	730	2,500
Simplot	530	3,100
Grimmway	360	2,100
Darigold WW	1,655	9,700
Average (Flow-Weighted)	**684**	**-**
Total (No COW)	**-**	**25,000**
Darigold COW	105	710
Total (with COW)	**-**	**25,710**

From the typical concentrations and flow distribution, the flow-weighted average FDS concentration to the PWRF each month was estimated (**Table 3-O**). The combined FDS concentration to the PWRF varies each month as the ratio of flow between processors changes. The concentration is highest in winter months since more of the flow comes from Darigold WW, which has the highest concentration of FDS.

Table 3-O – Projected Average PWRF Influent FDS Concentration by Month

Month	Average PWRF Pretreatment Influent Concentration (No COW) (mg/L)	Average Concentration (All Processors) (mg/L)
January	896	693
February	935	709
March	897	673
April	858	662
May	852	661
June	710	613
July	602	548
August	607	557
September	586	540
October	608	552
November	625	552
December	797	653

3.5.6 Projected TSS Loading

Table 3-P summarizes the projected TSS loading. A monthly distribution was not evaluated since TSS is not a controlling factor for treatment.

Table 3-P – Projected TSS Loading

Processor	Average Annual Daily Load (ppd)	Max Month Daily Load (ppd)
Pasco Processing	15,910	42,500
Freeze Pack	140	225
Twin City Foods	13,580	50,800
Reser's New Plant	7,310	10,800
Simplot	12,360	20,000
Grimmway	1,690	13,770
Darigold WW	2,330	2,790
Influent Correction Factor	25,000	87,000
Total (No COW)	**78,320**	**228,000**
Darigold COW	170	200

3.5.7 Summary of Projected Flow and Loading

Projected flow and loading to the PWRF is summarized in **Table 3-Q**. These summarized values are based on the monthly typical flow and loading distributions described in this chapter.

Table 3-Q – Projected Typical PWRF Influent Summary

	Projected Pretreatment Influent (no COW)	Darigold COW
Flow		
Annual Average Day (MGD)	4.33	0.8
Total Annual (MG)	1577	292
Maximum Month Average Day (MGD)	7.6	0.85
BOD		
Annual Average Day (ppd)	133,000	33
Average Annual Concentration (mg/L)	*3,650*	*5*
Maximum Month Average Day (ppd)	254,000	35
TN		
Annual Average Day (ppd)	4,100	85
Average Annual Concentration (mg/L)	*114*	*13*
Maximum Month Average Day (ppd)	8,400	88
FDS		
Annual Average Day (ppd)	25,000	710
Calculated Average Concentration (mg/L)	*684*	*105*

1. *These projections are based on the typical monthly flow and loading distributions.*

The values in **Table 3-Q** are expected to represent the realistic average and maximum month projected conditions and are used for the purposes of analyzing the land treatment system. The design criteria for any biological pretreatment systems are conservatively estimated above the values shown in **Table 3-Q** as detailed in **Chapter 5.**

Other loading constituents will be discussed in **Chapter 4** as they relate to land treatment.

Chapter 4.0 Evaluation of Land Treatment System

4.1 Project Description

4.1.1 Introduction and Purpose

The City of Pasco (City) treats and reuses process wastewater (process water) from a variety of vegetable processing facilities (Food Processors) by irrigation to agricultural crops in a City-owned land treatment system (Site). The process water is currently applied to a total of 1,856 acres of agricultural land. The Site is operated within the terms of State Waste Discharge Permit Number ST0005369 (Permit), effective July 1, 2015 (Washington Department of Ecology 2015). An additional 514 irrigated acres are proposed for expansion of the land treatment system.

The purpose of this engineering report chapter is to describe, characterize, and clarify the technical and environmental aspects of the proposed expansion. This chapter does not provide final design plans that can be used for construction of improvements, but rather outlines the design parameters to meet the stated objectives. The proposed expansion fields are not yet connected to the land treatment system. This chapter is specifically designed to provide sufficient information to allow the addition of the proposed fields to the Permit for the expressed purpose of using process water irrigation as a water supplement and partial fertilizer nutrient supply.

Except for items addressed in other chapters, this chapter has been prepared to comply with the requirements for an Engineering Report in “Guidelines for Preparation of Engineering Reports for Industrial Wastewater Land Application Systems” (Washington State Department of Ecology, Water Quality Program 1993) and the Washington Administrative Code (WAC) Chapter 173 Section 240 (Submission of Plans and Reports for Construction of Wastewater Facilities, 173 WAC § 240 2000).

4.1.2 Food Processors

Currently, there are 5 Food Processors including Reser’s Fine Foods, Pasco Processing, Twin City Foods, Freeze Pack, and Simplot RDO (**Exhibit 4-A**). The City anticipates several additional processors in the near future including Grimmway Enterprises and Darigold (**Exhibit 4-B**). The City plans to phase in new Food Processors and provide sufficient, additional process water treatment capacity with additional pretreatment components and the proposed expansion.

4.1.3 Land Treatment Site

The existing Site consists of 14 center-pivot irrigated fields (Circles 1 – 13 and 15) (**Exhibits 4-A** and **4-C**). Crops typically include alfalfa, potato, wheat, and grain corn. Little Circles 2 and 7 are operated as part of Circles 2 and 7, respectively. Process water and/or fresh water flow to Little Circles 2 and 7 is possible only as part of the flow to Circles 2 and 7, respectively; flow monitoring to each of the large circles includes the flow to their respective little circle. All aspects of operation and management (e.g., irrigation, tillage, planting, harvesting, etc.) are identical on the respective circles. All reporting related to Circles 2 and 7 includes their respective little circle.

During the irrigation period, March through November, the process water is land applied to the circles for final treatment. The process water is conveyed from the storage ponds into the Irrigation Pump Station (IPS) and pumped to the circles for crop irrigation.

4.1.4 Land Treatment Site Expansion Circles

The City plans to expand the land treatment site by 514 acres (**Exhibit 4-A**). The City will own 408 acres within Circles V16, V17, Little V17 (collectively considered Circle V17), and V18 (**Exhibit 4-C**). Circle B19, comprising of 111 acres, will receive process water and be managed by the City via a long-term lease with the property owner.

4.1.5 Fresh Water

Fresh water is provided from groundwater wells on the Site to help meet the supplemental irrigation needs (crop water requirements) of the crops. Fresh water, with the exception of expansion Circle B19, can be blended with process water at each circle or applied independently depending on the requirements of irrigation operations. Expansion Circles V16, V17, and V18 receive fresh water from the South Columbia Basin Irrigation District (SCBID) via canal. Circles V16, V17, and V18 receive an additional irrigation water contribution from an underdrain network installed in Circles V17 and V18.

4.1.6 Process Water

Process water is conveyed from the Food Processors to the Process Water Reuse Facility (PWRF) via underground pipelines (**Exhibits 4-A** and **4-B**). Process water from Reser's Fine Foods, Twin City Foods, and Pasco Processing flows via gravity to the Foster Wells pump station from which it is then pumped approximately 2.5 miles. Process water from Simplot RDO is pumped approximately 4 miles to the PWRF from the Simplot RDO pump station, while the combined process water from Freeze Pack and Grimmway will be pumped approximately 6 miles from the Columbia East pump Station. Darigold process water will be pumped approximately 2 miles from the Darigold pump station.

4.1.7 Projected Treatment and Storage

The City evaluated the Site capacity (**Section 4.4.3**) compared to the projected untreated process water loads (**Table 3-Q**) and determined pretreatment is required. In summary, the process water will be pretreated for liquid-solid separation via screening, biochemical oxygen demand reduction via low rate anaerobic digester, and nitrogen reduction via sequencing batch reactor (**Exhibit 4-B**).

The process water will be stored in lined storage ponds during the non-irrigation period (December through February). Total storage capacity will be approximately 467 MG, of which, approximately 100 MG will be separate and dedicated to the Darigold COW water, which will not receive pretreatment (**Exhibit 4-B**).

4.1.8 Flow Measurement

Flow meters are used to monitor incoming and outgoing process water flow, process water load by circle, and supplemental fresh water load by circle. Incoming flow is monitored ahead of the pretreatment system, while the outgoing flow is monitored at the irrigation pump station before discharge to the land treatment site (**Exhibit 4-B**). In addition, each circle is equipped with flow meters to independently measure the process water and supplemental fresh water loads to each circle. The circle-specific flows are used to determine circle-specific constituent loads and water balances.

4.1.9 Domestic Wastewater

Domestic wastewater produced at the PWRF is discharged to a septic system and leach field for final treatment and disposal. No domestic sanitary wastewater is discharged to the Site.

4.1.10 Stormwater

Stormwater discharge from the PWRF infiltrates into the surrounding ground surface or is directed into the PWRF treatment system. A Stormwater Pollution Prevention Plan is located on file at the PWRF.

4.2 Site Use And Considerations

The existing Site is located approximately 5 miles north of the City, 1 mile east of U.S. Highway 395, and north of East Foster Wells Road (**Exhibits 4-A** and **B**) and includes:

- Sections 3, 11, and 2 (N ½ and SW ¼), Township 9 North, Range 30 East of the Willamette Meridian
- Section 34 (S ½), Township 10 North, Range 30 East of the Willamette Meridian

All existing acreage is owned and operated by the City.

The expansion Circles V16, V17, V18 are located adjacent to the north end of the existing Site and expansion Circle B19 is located about 1 mile west of the existing Site at the following locations:

- Circles V16, V17, and V18: Section 27 (S ½ of the NE ¼, and SE ¼; Section 34 (NE ¼, and E ½ of the NW ¼) Township 10 North, Range 30 East of the Willamette Meridian
- Circle B19: Section 32 (SE ¼) Township 10 North, Range 30 East of the Willamette Meridian

4.2.1 Historical Land Use, Land Ownership, and Neighboring Land Uses

Land use in the area of the Site ranges from irrigated agriculture to urban development approximately 2 miles away. The area immediately surrounding the Site is agricultural land and farm residences. A confined animal feeding operation is located approximately 0.3 miles from the northwestern corner (Circle 13) of the land treatment fields (**Exhibit 4-C**). The Snake River is approximately 3 miles south and the Columbia River is approximately 5 miles southwest (**Exhibit 4-A**).

4.2.2 Climate

Climate conditions including precipitation and crop evapotranspiration (ET) are important considerations of a land treatment system. Precipitation and ET rates are used in the circle-specific hydraulic budgets.

The Site is located in South central Washington State about 20 miles north of the Oregon border. The Pasco area is within the rain shadow of the Cascade Mountains. The climate consists of a relatively cool, moist fall and winter, with a relatively hot, dry spring and summer. The average monthly and annual precipitation for the Site was determined using data from the

Washington State University AgWeatherNet CBC Pasco weather station, which is located about 5 miles west of the Site at an elevation of 404 feet above mean sea level (ft amsl) (Washington State University n.d.). The elevation of the Site is slightly higher at about 500 ft amsl. The long-term (2001-2021) average precipitation is 5.7 inches. The 10-year return frequency high precipitation (highest precipitation expected every 10 years) is 8.3 inches, which is derived from the second highest precipitation year in the last 20 years of recorded data (**Table 4-A**, **Appendix A**).

4.2.3 Topography and Surface Hydrology

The Site is located in an area that is nearly level to gently sloping to the east. The elevation of the existing Site is in the range of 450- to 550-ft amsl and generally slopes to the east and southeast. The northern and western parts of the Site drain south and east toward the central and eastern circles. Drainage to the east is blocked by Piekaraski Road, and Circle 1 would drain to the southeast toward Lower Smith Canyon.

4.2.4 Expansion Circles

Circles V16, V17, and V18 range in elevation between 510- to 570-ft amsl. Circle V16 has a maximum slope of approximately 3.8% and an average slope of 1.3% generally to the southeast. Circle V17, including Little Circle V17, and has a maximum slope of approximately 2.2% with an average slope of less than 1.0% generally to the southeast. Circle V18 has a maximum slope of approximately 2.5% with an average slope of less than 1.0% generally to the southeast.

Circle B19 ranges in elevation between 525- to 555- ft amsl. Circle B19 has maximum slope of approximately 2.7% with an average slope of less than 1% generally to the north and east.

4.2.5 Soil Characterization

The existing Site and expansion circles are included in the Soil Survey of Franklin County, Washington (U.S. Department of Agriculture - Soil Conservation Service 2006) and the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Web Soil Survey (Soil Survey Staff, Natural Resources Conservation Service n.d.). The soils of the existing Site were characterized by direct observation during a field evaluation in November 2017 by a Valley soil scientist. Soils for the “V” circles and “B” circle were investigated by a Valley soil scientist in October 2021 and June 2022, respectively.

The purpose of the soil characterization was to understand the extent of the soils and to quantify their properties, especially those relevant to the capacity of the Site for process water. Field work commenced with reconnaissance across the Site to identify areas with soil that were expected to be the major soil types compared to the soil survey mapping. Soil pits were excavated in locations specifically selected to observe the soil profiles for comparison to the available soil survey information and to collect soil samples. Soil investigation also occurred using auger borings to 60 inches, in addition to excavated soil pits. The physical and chemical properties of the soil samples were determined through laboratory analysis. The field observations and laboratory analysis results generally confirm that the published soil survey information is accurate. Therefore, the soil survey information can be used to determine the extent of the soil types across each circle and calculate their estimated soil water capacity.

The soils predominantly consist of mixed eolian sands, with minor portions of underlying glaciofluvial deposits. Additional soils consisting of sandy alluvium and loess over layered lacustrine deposits make up approximately 10% of the remaining soils. The soil textures across the Site are predominantly loamy fine sand or sandy loam surface soils underlain by fine sand or loamy fine sand. There are 11 soil map units identified across the Site (**Table 4-B, Exhibit 4-D**, and **Appendix B**). The soil units and key characteristics are summarized here.

- **Soil Map Unit 29** – Hezel loamy fine sand, 0- to 15-% slopes (approximately 7.9% of the irrigated area). Hezel soils consist of very deep, somewhat excessively drained, typically consisting of soils with a loamy find sand surface over fine sandy loam subsoil. Hezel soils occur on dissected terraces and terrace escarpments. This soil is limited to the central and eastern portion of V17, eastern portion of V18, central and northeast part of Circle 1, a portion of the north half of Little Circle 2, and is the predominant soil of Circle 12.
- **Soil Map Unit 43** – Kennewick silt loam, 0- to 2-% slopes (approximately 6.3% of the irrigated area). Kennewick soils consist of very deep, well drained, silt loams. Kennewick soils occur on dissected terraces and terrace escarpments of remnant fans. This soil is limited to the eastern portion of V18.
- **Soil Map Unit 89** – Quincy loamy fine sand, 0- to 15-% slopes (approximately 61.1% of the irrigated area). Quincy soils consist of very deep, excessively drained soils formed in sands on dunes and terraces. Quincy soils occur on uplands, fan piedmonts and terraces, some having a ridged, hummocky, or dune micro-relief. This is the predominant soil of Circles 3, 4, 6, 8, 9, 10, 11, 13, 15, V16, V17, V18, and B19. Quincy soils are also located in the southeastern part of Circle 1, northeastern part of Circle 2, portions of Little Circle 2, southern part of Circle 5, western part of Circle 7, northern part of Circle 12.
- **Soil Map Unit 92** – Quincy loamy fine sand, loamy substratum, 0- to 10-% slopes (approximately 7.1% of the irrigated area). Quincy soils are excessively drained and occur on dunes and terraces. This soil consists of approximately 85% Quincy and similar soils with 15% contrasting inclusions of very fine sandy loam in the upper 52 inches and calcareous soils throughout the profile. These soils occur in the southeast half of Little Circle 2, the northwestern part of Circle 6, northeastern part of Circle 7 and all of Little Circle 7, western and southeastern parts of Circle 8, northeast part of Circle 13, portions of V16, V17, V18, and the northern part of B19.
- **Soil Map Unit 97** – Quincy-Hezel complex, 0- to 15-% slopes (approximately 9.6% of the irrigated area). This complex consists of approximately 50% Quincy and similar soils, 25% Hezel and similar soils, and 25% contrasting inclusions. The Quincy-Hezel complex is somewhat excessively to excessively drained and occur on convex areas of dunes and terraces (Quincy soils) as well as concave areas of terraces (Hezel soils). The Quincy-Hezel complex occur in the central parts of Circle 11, northern and southern parts of Circle 15, eastern part of Circle 1, western part of Circle 2, northeastern and southern parts of Circle 4, and the majority of Circle 5.

- **Soil Map Unit 126** – Royal loamy fine sand, 0- to 10-% slopes (approximately 0.1% of the irrigated area). This soil consists of approximately 85% Royal and similar soils with 15% contrasting inclusions of Sagehill soils. Royal soils are well drained and occur on terraces. This soil is located in the northeastern part of Circle 11.
- **Soil Map Unit 128** – Royal loamy fine sand, 0- to 2-% slopes (approximately 5.1% of the irrigated area). Royal soils are well drained with a fine sandy loam surface over very fine sandy loam subsoil and occur on terraces. This soil is located in the western part of Circle 6, western and southern parts of Circle 8, northeastern part of Circle 10, is the predominant soil of Circle 7, and a major soil type for B19.
- **Soil Map Unit 129** – Royal loamy fine sand, 2- to 5-% slopes (approximately 0.3% of the irrigated area). Royal soils are well drained with a fine sandy loam surface over very fine sandy loam subsoil and occur on terraces. This soil is located in the southern and eastern portion of V17.
- **Soil Map Unit 144** – Sagemoor very fine sandy loam, 0- to 2-% slopes (approximately 5.1% of the irrigated area). Sagemoor soils are very deep, well-drained soils on gently sloping to steeply dissected terraces. This soil is located in the northwestern part of Circle 1, northeastern part of Circle 3, eastern part of Circle 12, central part of Circle 15, and is the predominate soil in Circle 2.
- **Soil Map Unit 145** – Sagemoor very fine sandy loam, 2- to 5-% slopes (approximately 2.9% of the irrigated area). Sagemoor soils are very deep, well-drained soils occurring on gently sloping to steeply dissected terraces. These soils have a very fine sandy loam surface over silt loam subsoil. This soil is located in the southern part of Circle 1, northeastern part of Circle 2, northern and eastern parts of Circle 3, south and central part parts of Circle 5, northeastern part of Circle 12, and central part of Circle 15.
- **Soil Map Unit 146** – Sagemoor very fine sandy loam, 5- to 10-% slopes (approximately 0.5% of the irrigated area). Sagemoor soils are very deep, well-drained soils occurring on gently sloping to steeply dissected terraces. These soils have a very fine sandy loam surface over silt loam subsoil. This soil is limited the southeastern part of Circle 12.

The majority of the Site (68.2%) is mapped in the Web Soil Survey as Quincy Loamy Fine Sand (soil map units 89 and 92, combined). All soils at the Site are deep (> 60 inches), provide adequate drainage, and are suited to a wide variety of commercial crops, if irrigated, including, for example, grass (for seed, pasture, or hay), alfalfa, wheat, potatoes, and corn.

4.2.6 Water Holding Capacity

Soil water holding capacity (field capacity) is the water content of the soil after the drainage of excess water, by gravity, has ceased. In other words, field capacity is the amount of water the soil can hold. Available soil water holding capacity is the amount of water available to plants between field capacity and the permanent wilting point. At permanent wilting point, remaining water in the soil is held too tightly to be available to most plants.

Table 4-B presents the water holding capacity of a 60-inch deep soil profile for each soil map unit. Field capacity ranges from 6.3 inches (soil map unit 89) to 15.1 inches soil (map units 144,

145, and 146). Available water content ranges from 4.9 inches (soil map units 43 and 89) to 11.5 inches (soil map units 144, 145, and 146). These soil water holding capacity values will be used as the basis to compute circle-specific soil water hydraulic budgets. The acreage of each soil type within each circle, as measured using the Web Soil Survey, was used in conjunction with the soil water holding capacity values published in the web soil survey to estimate the average soil profile water capacity characteristics for each circle (**Table 4-C**).

Average field capacity ranges from 6.3- to 12.0-inches (**Table 4-C**). These values will be used in the soil water hydraulic budgets to help determine the hydraulic capacity of the Site for precipitation, process water, and supplemental fresh well water irrigation.

4.2.7 Expected Infiltration Rates and Permeability

The soil map units found at the Site are described as being well drained to excessively drained. The saturated hydraulic conductivity of the most limiting soil horizon for each soil map unit (surface) ranges from moderately high to very high (0.2 to 20 inches per hour), Soil Survey (U.S. Department of Agriculture - Soil Conservation Service 2006), and is not a design limiting parameter. The risk of erosion by water is low.

4.2.8 Soil Fertility

Soil fertility is important in maintaining soil and crop growth conditions favorable for land treatment system use and uptake (treatment) of the process water hydraulic and nutrient loadings. The information presented is based on the soil conditions in 2021 and 2022. Soils data from the existing Site is as reported in the 2022 Farm Operations Report (Valley Science and Engineering 2022). Soils data for the “V” and “B” circles was collected by Valley in October 2021 and June 2022, respectively. **Table 4-D** presents the soil analytical results.

The Oregon State University Extension Service has published a Soil Test Interpretation Guide (Horneck, et al. 2011) that provides a consistent reference for evaluating soil test results and guiding general fertility recommendations in Oregon and Washington. This document was used to evaluate the soil test results presented in the following paragraphs.

Soil pH is important to soil nutrient availability and crop growth. Soil pH ranged from 7.4 to 8.1 standard units (s.u.) in the surface one-foot of soil. Soils at the Site have pH values that are in an acceptable range. A pH of 8.5 s.u. or more would be considered strongly alkaline and likely reduce soil nutrient availability and crop growth. Soil pH should continue to be monitored at the Site to identify any significant trends in pH that indicate the need for operations adjustment. The pH observed for all expansion circles will be compatible for land treatment needs.

The exchangeable sodium percentages (ESP) ranged from 1.2- to 3.9-%. When ESP values are greater than 15%, water infiltration in the soil is likely to decrease substantially, although this threshold value will vary for different soil types and is dependent on other soil properties such as saturation paste extract electrical conductivity (ECe) and soil texture (clay content). Since these values are below 15% and the soil clay content is low, soil ESP is not a limiting concern for water infiltration and drainage at the Site. The ESP observed for all expansion circles will be compatible for land treatment needs.

Soil organic matter (OM) is important in soil chemical reactions and soil-water relations. Maintaining or increasing soil OM is beneficial in sandy soils, such as those found at the Site. Soil OM in the surface one-foot of soil across the Site ranged from 0.5- to 1.5-% across all existing and expansion circles and averaged 1.2% in the fall of 2021 on the existing circles. The OM levels at the existing Site have remained generally stable in comparison to fall 2011, which ranged from 0.7- to 1.6-% and averaged 1.1% (Cascade Earth Sciences 2012). Soil OM levels are likely to remain relatively stable, being maintained by the inclusion of perennial and annual forage crops (alfalfa and grasses) within the overall crop rotation. OM ranges from 0.5- to 0.9-% on the expansion circles which will likely increase with process water irrigation and inclusion of perennial forage crop rotations such as alfalfa. The OM ranges observed for all expansion circles will be compatible for land treatment needs.

Test results indicate that some available soil nitrogen is present for crop growth on all circles. The available soil nitrogen (ammonium-nitrogen plus nitrate-nitrogen (NO_3-N)) ranged from 3.1- to 24.9- milligrams per kilogram (mg/kg) in the surface one-foot of soil of all circles. The other primary plant nutrients (phosphorus and potassium) appear to be at levels that do not require addition from commercial fertilizers. Of the secondary nutrients, magnesium, sulfate-sulfur, and calcium concentrations are considered sufficient. These nutrient ranges observed for all expansion circles will be compatible for land treatment needs.

Soluble salts (electrical conductivity, EC) in the surface one-foot of soil are within acceptable levels. The EC in the surface one-foot during ranged from 0.2- to 1.7- millimhos per centimeter (mmhos/cm) across all fields, with an average of 0.4 millimhos per centimeter (mmhos/cm). The soil EC levels are not a limiting factor for process water irrigation at this Site, but should continue to be monitored. The EC ranges observed for all expansion circles will be compatible for land treatment needs.

4.2.9 Conclusions and Recommendations

According to this soil characterization analysis, the soils at the Site are suitable for receiving the process water for land treatment purposes. Irrigation management practices, including soil moisture monitoring and irrigation scheduling, are important considerations for these soils with relatively low water holding capacities across the Site. Irrigation amount (depth of water applied per pass or per set) should be managed to supply enough irrigation to meet the crop water use requirements, avoid runoff, and limit deep percolation to the estimated leaching requirement to maintain soluble salts at acceptable levels in the root zone.

4.3 Geology and Hydrogeology

The land treatment site lies within the Columbia Plateau physiographic province. The Columbia Plateau occupies most of Eastern Washington, Northeastern Oregon, and Western Idaho, occupying approximately 70,000 square miles. The Columbia Plateau is bounded to the west by the Cascade Range, bounded to the east by the Rocky Mountains, bounded to the north by the Okanogan Highlands, and bounded to the south by the Blue Mountains (Lane and Whiteman 1989).

4.3.1 Regional Geology

The Columbia Plateau hosts is an extensive volcanic plateau consisting of Columbia River Basalt Group (CRBG) basalt flows (Alt and Hyndman 1984). The CBRG basalts flows are Miocene in age, created 6 to 17 million years ago. The thick sequence of basalt flows are overlain by sedimentary deposits from the ancestral floods that blanketed the Columbia Basin near the end of the most recent ice age (Schuster 2005). Recent and smaller deposits of windblown loess mantle the higher slopes and sand dunes throughout the plateau. Alluvium and mass-wasting deposits are present near streams and river margins.

The Site lies within the Palouse sub-province, which is east of the Yakima Fold Belt. The Palouse sub-province is characterized by structurally simple basalt flows of the CBRG that dip shallowly to the southwest (Bauer and Hansen 2000). The CBRG basalt flows are more than 15,000 feet (ft) thick and sub-divided into 4 formations, starting from oldest to youngest, the Imnaha Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt. (Drost, Whiteman and Gonthier 1990). Sediment deposits of sand, silt, and gravel overlie basaltic bedrock associated with Miocene Age CRBG.

A generalized description of geologic units is described below from youngest to oldest (Reidel, Fecht and Washington State 1994):

- **Dune Sand** (Holocene) – Eolian medium to fine sand and silt; grains composed of quartz, basalt, and or feldspar includes Mazama tephra at numerous places; active and stabilized dunes occur through-out the low terrain, mostly in the northeastern part of the map area; age inferred from geomorphology, ages of parent materials, and presence of Mazama tephra.
- **Outburst-Flood deposits** – Consist of (Pleistocene) outburst flood gravels with beds of fine sediment that have normal polarity; contains Mount St. Helens set as (13 thousand years ago).
- **Ringold Formation** – The (Pliocene to Miocene) aged Ringold Formation consists of the upper and lower unit.
    - The upper unit contains continental sand, silt, and clay beds - interbedded fluvial and lacustrine facies, local pebble lenses, and stringers; silt clay units are horizontally laminated and generally lack current-generated sedimentary structures; silt and sand units display horizontal, ripple and cross-bedding; sand chiefly quartz and feldspar, locally micaceous; commonly capped by pedogenic carbonate or silcrete; contains diatomite beds, ash beds, and fossils; white, gray, green, red, and tan. Exposed along the east side of the Columbia River, eastern Rattlesnake Hills, and as isolated outcrops between Richland and Kennewick.
    - The lower unit consists of continental (Pliocene to Miocene) aged conglomerate-varicolored pebble to cobble conglomerate with sand matrix; clasts well rounded and chiefly composed of quartzite, granite, basalt, metamorphic rocks, and volcanic porphyries; generally well-sorted, massively bedded; locally imbricated; included lenses of course to medium quartz-feldspathic sand that are cress bedded or foreset bedded in places; commonly uncemented, but in places

moderately to poorly indurated with silica, iron oxide, and calcite. Exposed along the White Bluffs and along the flank basaltic ridge west of Richland.

- **Volcanic Rocks, CRBG** – The (upper Miocene) aged Ice Harbor Member of the Columbia River Basalt Group consist of flows, vents, northwest-trending feeder dikes, and minor tephra between flows; plagioclase phenocrysts commonly more tabular (needlelike in cross-section) than in other Saddle Mountains Basalt flows; less than 30 meters thick in most places; about 8.5 million years ago, based on Potassium-Argon age estimates.

4.3.2 Regional Hydrogeology

The geological units described above host groundwater in the regions. The Columbia Plateau aquifer system underlies about 50,600 square miles of the Columbia Plateau of central and Eastern Washington, North-central and Eastern Oregon, and a small part of Northwestern Idaho (Bauer and Hansen 2000).

Two groundwater systems are present in the Columbia Plateau region. A lower confined aquifer is associated with basalt flows of the CRBG. Due to the mostly impermeable nature of this aquifer, groundwater is recharged through localized cracks and fissures, whereas the majoirity of the aquifer is confined beneath and aquiclude of unfractured basalt. A shallow unconfined aquifer is hosted by sedimentary units that overly the CRBG basalts, mainly glacial outwash deposit permits the unconfined aquifer to be rapidly recharged by precipitation and surface water seepage (PACE Engineers, Inc.; Jacobs; Cascade Earth Sciences; FCS Group 2019).

Groundwater is recharged north of the Site by surface water infiltration in the Smith Canyon area and the Esquatzel Coulee. Groundwater flows to the south/southwest following the natural topography of the region and southwesterly dip of the CRBG lava flows. Groundwater ultimately discharges into the Snake and Columbia Rivers south of the Site (PACE Engineers, Inc.; Jacobs; Cascade Earth Sciences; FCS Group 2019).

Groundwater hydraulic conductivities in the unconfined aquifer range from approximately 100-to 1,000-ft/day, with an approximate value of 400 ft/day used as a representative at the regional scale (Bauer and Hansen 2000). The water table elevation decreases from approximately 550- to 350-ft over 18 miles, for a hydraulic gradient of 0.003 ft/ft. The groundwater flow velocity, based on a literature value of 0.25 effective porosity, is calculated to range from 1.2- to 12-ft/day with an approximate velocity of 5ft/day (PACE Engineers, Inc.; Jacobs; Cascade Earth Sciences; FCS Group 2019)

4.3.3 Local Hydrogeology

The following narrative was prepared for the expansion circles based upon previous work at the Site (PACE Engineers, Inc.; Jacobs; Cascade Earth Sciences; FCS Group 2019).

4.3.3.1 Surface Geology

The surface geology for expansion Circles V16, V17, and V18, located immediately adjacent to the north of the existing Site are primarily Holocene-eolian stabilized sand dune deposits composed of medium to fine sand and silt, with mineralogical compositions of quartz, basalt, and feldspars. Expansion Circle B19 located west on the current land treatment site comes in contact with younger Pleistocene alluvial outburst flood gravels with fine-grained interbeds (Bauer and Hansen 2000).

4.3.3.2 Well Log Review

Well logs were obtained from the Washington State Department of Ecology. The well logs confirm the presence of the unconfined sediment-hosted aquifer and the lower confined basalt aquifer (**Appendices C1** and **C2**).

Water well reports identified 52 wells within one-mile of the land treatment site drilled between 1963 and 2018 (**Exhibit 4-E**). Of the 52 wells, 12 are irrigation wells; 4 are monitoring wells; 7 are test wells; 19 are domestic wells; 1 production well; 1 abandoned well; and 8 wells that do not have a recorded use. Wells completed in unconfined sediment are 94- to 229-ft deep with static water levels of 8- to 186-ft. Wells completed in basalt are 157- to 571-ft deep with static water levels of 36- to 240-ft.

Of the 52 well logs reviewed, 36 wells near the expansion circles (excludes well reports that are abandoned, no record of use, geotechnical, or are testing wells). Of these wells, 16 are completed in basalt and 20 are completed in sediment.

4.3.3.3 Local Unconfined Aquifer

Drilling records of 9 monitoring wells and irrigation wells from the existing Site show the subsurface consists of brown silt approximately 25- to 50-ft below ground surface (bgs), silty sand and gravel between 60- to 100-ft bgs, and a discontinuous silt/clay unit that can range from 5- to 10-ft thick at 100- to 140-ft bgs.

The existing monitoring wells are installed in the unconfined aquifer. Groundwater elevation data from these wells indicate groundwater flow is northeast to southwest (**Exhibit 4-E**). The water table gradient is similar to the topographic gradient in the Pasco area with groundwater elevation decreasing from approximately 550- to 350-ft over 18 miles, for a hydraulic gradient of 0.002 ft/ft, sloping from the higher elevation areas located northeast of the land treatment site towards the Columbia and Snake Rivers. Because groundwater gradients could differ between the upper (unconfined aquifer) and lower (confined aquifer), the direction of groundwater flow in both units might not be perpendicular to the contours for all areas.

Unconfined perched groundwater conditions occur seasonally above a discontinuous semi-impermeable silt/clay layer at MW-1. Monitoring well MW-1 is installed southeast of Circle V16 and northwest of Circle 13 (**Exhibit 4-E**).

Transmissivity values determined from well yield data obtained from driller's logs for the current land treatment site ranged from 50,000- to 500,000-gallons per day (gpd) per foot. Using the transmissivity values from these adjacent land treatment areas and the average aquifer thickness of 70ft, projected calculated hydraulic conductivity estimates for the existing Site ranges from 700- to 7,000-gpd per square foot (ft^2). This converts to approximately 90- to 900-ft/day, which is comparable to the range for the regional range of 100- to 1,000-ft/day. The groundwater flow has not changed dramatically over time, and there does not appear to be a seasonal shift in flow patterns for direction. Since expansion circles are adjacent to the existing Site and overlie the same regional unconfined aquifer, previous work conducted to characterize the aquifer at the Site is applicable to the aquifer beneath the expansion circles.

4.3.4 Proposed Groundwater Monitoring Network

The monitoring network will be expanded to add 4 groundwater monitoring wells surrounding the expansion circles to be completed in the uppermost portion of the unconfined aquifers.

The proposed well locations are shown on **Exhibit 4-F**. Locations are approximate and may vary laterally by 100 ft, depending on encountered Site conditions (i.e., utilities, surface topography, obstructions, etc.). The hydrogeologic positions and potential well depths are presented in **Appendix D**. All monitoring wells will be constructed to allow monitoring of the upper 10- to 15-ft of the uppermost-saturated zone.

4.3.4.1 Monitoring Well Design and Installation Plan

All drilling and well construction will be performed in accordance with WAC 173-160 (Minimum Standards for Construction and Maintenance of Wells, 173 WAC § 160 2008).

A Washington-licensed well driller will drill 6-inch diameter boreholes and construct monitoring wells in the boreholes. The drilling, logging, and construction of the monitoring wells will be conducted under the guidance of a Washington-licensed hydrogeologist (LHG). Based on the construction and monitoring records from the existing wells at the Site, monitoring well completion depths are expected to range from about 60- to 180-ft bgs. All monitoring wells will be constructed to allow monitoring of the upper 10- to 15-ft of the saturated zone.

The well construction specifications will generally conform with the following description, with any minor deviations for comparable materials or methods to be approved by the LHG. The well casing (blank and screen) will consist of threaded nominal 2-inch diameter Schedule 40 polyvinyl chloride (PVC). The screen will be machine-slotted with 0.010-inch apertures. The filter pack will consist of Colorado Silica Sand that is 20/40 (420- to 840-micron) size to match the 0.010-inch screen. The filter pack will be filled from the bottom of the borehole to approximately 2- to 3-ft above the screen. The filter pack will be placed in the borehole as the temporary steel casing is slowly removed from the ground. Care will be taken to prevent bridging of well materials during well construction.

Each well will be sealed using 3/8-inch bentonite chips from the top of the filter pack to approximately 2 ft bgs. Concrete will be poured over the bentonite and into a 3-ft square or round, 4-inch thick pad that slopes away from the well casing. An aboveground monument will be set over the PVC casing and into the base of the concrete pad. The aboveground monument will consist of a steel casing with a locking cap. A PVC slip cap or expandable well cap with a small hole will be installed on the top of the PVC casing. To protect the well from collisions by vehicles and equipment, 3 protective posts will be set in concrete in an array around each well.

All drilling equipment placed in the borehole will be washed before use and again between boreholes. Washing methods will include high-pressure steam cleaning followed by rinsing with potable water.

4.3.4.2 Well Development

Prior to the installation of sampling pumps or inertial lift tubing, the well screen intervals will be developed by the well drilling company by surging and pumping or bailing to remove fine sediment and reduce turbidity for groundwater sampling. The goal of well development will be to achieve a turbidity of 50 nephelometric turbidity units or less.

Groundwater levels and groundwater quality parameters will be monitored in the field during development with portable meter(s) and recorded on a form or notebook.

Groundwater samples will be collected as each casing volume is purged for field parameter measurements, including turbidity, temperature, pH, and EC. Groundwater levels will be used to assess drawdown and adjust pumping rates to the extent practicable. If the well goes dry during development at a minimum purging rate of 0.5 gallons per minute (gpm), the well will be allowed to recharge to within 90% of the static water column and purged once more before development is terminated. If the well does not go dry during development, well development will proceed until field parameter readings have stabilized or at least 60 gallons have been purged (2 hours at a minimum flow rate of 0.5 gpm), whichever occurs first. Water quality stabilization criteria are listed below:

- turbidity < 50 nephelometric turbidity units
- temperature +/- 0.5 °C
- pH +/- 0.2 s.u.
- EC +/- 50 microSiemens per centimeter

4.3.4.3 Wellhead Survey

The wellheads will be surveyed to calculate groundwater elevations and prepare potentiometric groundwater maps. The location, elevation of the land surface, and the elevation of the top of the casing (reference point) of each well will be surveyed. The survey reference point will be a permanent ink mark or notch filed at the top of each PVC well casing on the north side. The location survey will have a horizontal accuracy of ±1.0 ft, the land surface elevation will have a vertical accuracy of ±0.1 ft, and the top of well casing elevation will have a vertical accuracy of ±0.01 ft. A Washington Registered Land Surveyor or Professional Engineer will perform the survey.

4.4 Land Treatment System Management

Irrigation of agricultural land with process water conserves water and plant nutrients. The success of a process water land treatment system depends on the process water hydraulic and constituent loads, cropping, climate conditions, and management. Cropping, soils, and climate determine the nutrient and hydraulic capacities of the Site. The crop rotation tolerance to salinity influences the leaching requirement.

This section presents:

- process water design considerations
- crop rotation information
- agronomic constituent and hydraulic capacities
- constituent management
- irrigation management of the Site

4.4.1 Design Considerations

This section discusses the quantity and quality of process water and quality of supplemental fresh water. Irrigation of process water and/or supplemental fresh water is practiced during March through November, whereas process water is received year round from Food Processors and must be stored during non-irrigation months. Irrigation is not practiced during December, January, or February.

4.4.1.1 Projected Process Water Quantity

The operational year is ordered from November of the previous year through October of the subsequent year to match the cropping cycles of planting and harvest. The average monthly process water flow values are important in consideration of the irrigation hydraulic loads for land treatment management projections. The projected monthly process water flow ranges from 78 MG in February to 253 MG in September (**Table 4-E**). The projected annual process water hydraulic load is 1,869 MG.

4.4.1.2 Projected Process Water Quality

The City evaluated the Site capacity (**Section 4.4.3**) compared to the projected untreated process water loads (**Table 3-Q**) and determined pretreatment is required. **Table 4-F** presents the projected annual flow weighted average process water quality for select constituents. The process water quality presented in **Table 4-F** represents the projected combined quality of existing Food Processors, additions from Grimmway and Darigold, and includes estimates of pretreatment effects from screening, low rate anaerobic digestion with pH adjustment using magnesium hydroxide, and sequencing batch reactors.

4.4.1.3 Sodium Adsorption Ratio

The sodium adsorption ratio (SAR) must be considered for land treatment. Too much sodium in a soil can cause the soil particles to disperse, sealing the surface of the soil, and limiting the ability of water to penetrate into the soil resulting in runoff and poor crop growth. The average process water SAR (computed from the calcium, magnesium, and sodium concentrations) is projected to be 1.5 (**Table 4-F**). If SAR is less than 6, there should be no problem with soil sealing (Canessa and Hermanson 1994). This is especially true of the soils at the Site with very little clay. As such, the SAR of the process water should not limit process water application at the Site.

4.4.1.4 pH

The process water pH must be considered for land treatment. A pH range of 3 to 11 s.u. has been applied successfully to land treatment systems (U.S. Environmental Protection Agency 2006). Irrigated process water quality at the Site has historically averaged at the low end of this range. Process water pH is projected to be 7.3 s.u. (**Table 4-F**), which is within the acceptable range for land treatment and should not limit process water application at the Site.

4.4.1.5 Supplemental Fresh Water Quality

Supplemental fresh water is provided to help meet the crop water requirements at the Site. It is important to account for the supplemental fresh water quality in land treatment system management. There are several wells (IW-6 through IW-15) that supply supplemental fresh well water to specific existing circles (**Table 4-G**). Historically, more than 1,000 MG (not shown) of supplemental fresh well water has been typically applied to the Site to meet the crop water demand not met by the process water. Fresh water quality is summarized below for the fresh water from the wells and the SCBID, which includes the underdrain water and is therefore not characterized separately.

Supplemental fresh water quality is as follows:

- TDS ranges from 181-(SCBID) to 625-milligrams per liter (mg/L) (IW-6 through IW-15), with an average of 518 mg/L.
- NO_3-N ranges from 0.8- (SCBID) to 32.6-mg/L (IW-6 through IW-15), with an average of 17.6 mg/L.
- EC ranges from 283- to 977-micromhos per centimeter (µmhos/cm) (IW-6 through IW-15).

4.4.1.5.1 Underdrain Water

An underdrain system consisting of a network of buried corrugated plastic drainage pipe is located in expansion Circles V17 and V18. The drain lines vary in buried depth, but are generally deeper than the extent of the soils investigation (60-inches bgs) conducted by Valley.

All buried drain lines gravity flow to a 20-ft deep sump, from which a 20-horsepower pump delivers the drainage water through a return line connected to the SCBID canal water mainline that serves Circles V16, V17, and V18 (**Exhibit 4-C**). When the SCBID water pump station is in operation (servicing SCBID canal water irrigation to Circles V16, V17, and V18), the drainage water is combined with SCBID canal irrigation water and delivered as irrigation water to the circles that are receiving irrigation. When the SCBID pump station that serves the “V” circles is not in operation, but the 20-horsepower pump is running, the drainage water is then discharged to the SCBID canal.

Based on the drain system design, it should not serve as a limitation for land treatment. The underdrain water TDS concentration is lower compared to the existing Site fresh water wells, but is higher in NO_3-N (**Table 4-G**). An inline valve is available for routine sampling of underdrain water quality. A flow meter is installed to track underdrain water flow, and the resulting hydraulic and constituent loads can be attributed to each of the "V" circles based on circle-specific flow meters at each pivot.

The underdrain flow is estimated at 0.3 million gallons per day (based on 200 gpm). This projected daily hydraulic load estimate and associated nitrogen and TDS load has been accounted for on Circles V16, V17, and V18. All projected fresh water loads for the "V" circles beyond what can be supplied by underdrain water is met with SCBID fresh water quality.

4.4.2 Cropping

Crop management plays a critical role in using process water on farmland. Beneficial use of process water nutrients is achieved by harvest and removal of plant material. Higher crop yields increase Site capacity for process water loads. The crops chosen for the Site must grow well in the local area and under the process water and soil conditions at the Site. Perennial crops such as alfalfa have been successfully grown at the Site. Perennial crops consume water and nutrients throughout the extent of the growing season, from early spring to late fall, which coincides with early and late season process water application as needed.

The perennial crops may be maintained in place for several years until productivity begins to decline. They are re-established after rotation to another crop for one or more crop growing seasons. Rotation to another crop before re-establishment is an agronomic best management practice. As a system best management practice, an established crop or cover crop should be maintained on all circles in the fall to take up nutrients and increase ET. Maintaining a crop or cover crop helps to remove nitrogen that may be available in the soil profile ahead of the winter precipitation period. This practice limits the potential for migration of nitrogen beyond the root zone during winter precipitation events. The established crops also provide soil protection against wind and water erosion during winter and early spring.

4.4.2.1 Crop Rotation

Table 4-H presents the circles, acres, and crops grown at the Site during 2018 through 2021 (Cascade Earth Sciences 2019, 2020, Valley Science and Engineering 2021, 2022) as well as the design basis limiting crop rotation used to calculate the Site hydraulic, nitrogen, and BOD capacities. The design basis crop rotation represents the minimum nitrogen capacity of any planned future crop mix with the expansion circles.

The typical rotation has been to maintain alfalfa in a majority of the circles, grow potatoes in 3 circles, and double-crop 3 other circles. Double-cropping examples include triticale followed by corn or one cutting of alfalfa followed by corn. Lower nutrient removal rates may be expected during rotation periods compared to when a perennial crop is fully established and maintained. Keeping a majority of the fields in a perennial crop maintains nitrogen capacity. Established cover crops help maintain hydraulic capacity during late fall and winter months.

For example in 2018, the potato crop in Circle 5 was harvested in September and the circle was planted to alfalfa, which is shown as potato/alfalfa (**Table 4-H**). The potato crop consumed water and nutrients until September, while the alfalfa did so through the remainder of the season. The alfalfa has since been maintained. In 2020, the alfalfa in Circle 6 was harvested in May and the circle was planted to corn, which is shown as alfalfa/corn. The alfalfa consumed water and nutrients through May, while the corn did so through late September when it was harvested. In this case, the circle remained in corn residue (stalks and leaves) after harvest and was planted to potato the following spring. The corn residues controlled wind erosion, but the nitrogen capacity was limited the following spring because a limited amount of process water was applied to potato compared to a perennial forage crop, such as alfalfa.

4.4.2.2 Planting, Cultivation, Harvest, and Crop Nitrogen Capacity

Table 4-I presents example planting and harvest months, crop yields, crop nitrogen removal, and nitrogen capacity by crop type. The expected yields and crop nitrogen capacities are based on historical Site data.

Crops will be planted using accepted agronomic seeding rates and methods, and those circles with established crops (alfalfa, for example) will not require planting until they are rotated, as discussed above. Where two or more crops are listed for one circle, the second crop will be planted following harvest of the first crop and after any necessary cultivation for seedbed preparation.

Alfalfa will be harvested for hay (cut, cured, baled, or green-chopped for haylage). Any other crops that may be grown at the Site will be harvested according to local and industry standard means. Harvest periods for each circle will be coordinated to improve crop removal management flexibility, but managed to allow process water application at all times in consideration of individual circle harvest schedules. The actual schedule will vary depending on weather and crop growth.

Crop nitrogen capacity shown in **Table 4-I** is historical average crop nitrogen removal increased to account for volatilization and denitrification losses of nitrogen. Process water nitrogen availability has been estimated to be 89% based on recommendations in (Meisinger and Randall 1991) using the average process water nitrogen concentration (**Table 4-F**).

$$\text{Available Process Water Nitrogen} = [((\text{TKN} - \text{ammonia-nitrogen } NH_3\text{-N}) + (NH_3\text{-N} \times 0.80) + (NO_3\text{-N})) \times 0.96] \div (\text{TKN} + NO_3\text{-N}).$$

4.4.2.3 Fertilizer, Herbicide, and Pesticides Application

Commercial fertilizer will be applied, as needed, for the specific circle and crop to maintain healthy, viable land treatment system crops for maximum nutrient uptake under process water treatment conditions. The term viable may be defined as capable of living, developing, or germinating under maximum favorable conditions. Process water nitrogen availability will be considered in any decision to apply fertilizer. Fertilizer application will be according to soil test results, tissue test results, and recommended nutrient levels from state and local extension service and consultants. Nitrogen may be applied at recommended starter rates for legume crops (i.e., alfalfa). Once established, nitrogen fertilizer will not be required because legume crops are able to harness their own nitrogen in addition to utilizing the nitrogen supplied by the process water. Nitrogen may also be applied to non-legume crops (e.g., corn) if a deficiency is identified between the recommended amount and the amount that will be applied in the process water.

Pesticides, including herbicides, insecticides, and fungicides, will be used, as necessary, under the advice of a professional crop consultant. Herbicides for weed control are planned for use.

Insecticides or fungicides will be used only if needed to treat specific problems. Herbicides are generally applied to alfalfa at the end of February and in mid-March. Actual herbicide use will vary depending on the weed problem, crop, time of year, and product availability from year to year. Aerial application or ground sprayer can apply pesticides with dependence on time, weather, soil wetness, price, suitability, and availability. All pesticides will be used and applied according to product labels.

4.4.3 Design Basis Capacity

The capacity of a land treatment site for nutrient and hydraulic loading is an important consideration for good management and design of a system that is protective of groundwater. Proper design and good management of process water application and nutrients encompasses the requirements of all known, available, and reasonable methods of prevention, control, and treatment (AKART) farming for land treatment.

The term agronomic capacity is defined in the Implementation Guidance for the Ground Water Quality Standards (Washington State Department of Ecology 2005) as the "rate at which a viable crop can be maintained and there is minimal leaching of chemical downwards below the root zone. Crops should be managed for maximum nutrient uptake when used for wastewater treatment." Therefore, agronomic rates can be used in combination with the design basis crop rotation to establish the design basis capacity of the land treatment site for both irrigation and nutrients.

The purpose of this section is to define the nutrient and hydraulic load capacities of the Site and evaluate the nutrient and hydraulic balances. This section also defines the capacities of other important parameters for land treatment design. The design basis for the land treatment capacity defined in this Engineering Report is the most limiting projected crop rotation presented in **Table 4-H**. The design basis crop rotation (**Table 4-H**) will be used to determine the minimum nutrient and hydraulic capacities of the Site. The design basis crop rotation has the minimum number of acres that would be in perennial and high yielding crops such as alfalfa and more acres of other crops (i.e., potato), which use the least amount of process water nitrogen. It will represent the lower limit of crop nitrogen removal from the Site in future operational years. As the perennial and high yield crop acreage changes, hydraulic and nutrient capacities also change at the Site and may be greater than the limiting rotation in some years.

The agronomic capacities, within which the Site must be managed by the City, will be established and reported each year in the annual Farm Operations Report, as required by the Permit. The Permit states that the total nitrogen and water applied to the Site must not exceed the crop requirements as determined by the Farm Operations Report. The design basis capacity defined in this Engineering Report can be considered the potential minimum agronomic capacity for the Site.

4.4.3.1 Hydraulic Capacity

The hydraulic capacity of the Site depends on the crop water needs (ET), precipitation, soil water holding capacity, leaching requirements, and nitrogen capacity. Soil hydraulic budgets were developed to determine the hydraulic capacity of the Site using these variables (**Appendix E**).

The capacity for process water and fresh water is dependent on the crop nitrogen capacity. The soil hydraulic budgets were constructed as examples using the design basis (limiting) crop rotation (**Table 4-C**) to demonstrate the minimum potential nitrogen capacity rotational year. Total process water and freshwater nitrogen loads to each circle cannot exceed the crop nitrogen capacity.

The budgets take into account the normalized 10-year return precipitation and ET (**Table 4-A**) and total water content at field capacity (**Table 4-C**). They were constructed with the initial soil water content of 85% of field capacity. Budgets were prepared with example process water and supplemental fresh well water irrigation loads that result in estimated percolate loss (leaching fraction) at or less than the salts leaching requirement. The gross irrigation inputs into the soil hydraulic budgets illustrate an example of the potential hydraulic capacity of the Site, and thus, the agronomic capacity of the Site.

A leaching requirement was determined based on the average EC of the process water and supplemental fresh water with the desired equilibrium soil salinity of 2 mmhos/cm. The process water has an EC of 1,166 µmhos/cm and the supplemental fresh water has an EC that ranges from 283- to 977-µmhos/cm (**Tables 4-F** and **4-G**, respectively). The calculated leaching requirement for the combined process water and supplemental fresh well water averages 9.5% of the average hydraulic load to the Site (**Table 4-J** and **Appendix E**). Additional supplemental fresh well water loading may be scheduled during the late fall or early months of the season to achieve a leaching fraction equivalent to the leaching requirement (**Table 4-J** and **Appendix E**). The actual practice of irrigating extra supplemental fresh water for leaching will depend on the need to decrease soil salts if indicated by the annual soil test results.

The leaching fractions shown in **Table 4-J** are less than the leaching requirements for all circles. Leaching is typically preferred in the winter when trying to meet a leaching requirement. Example hydraulic loads have been projected to limit leaching, with none scheduled during the growing season when process water is being applied. The leaching requirement for the Site is often partially met by natural precipitation during the winter storage period, which corresponds to a low consumptive water use period for the crops.

The sum of the gross process water and supplemental fresh water inputs represent the total irrigation capacity of the Site since they were balanced with the precipitation, ET, soil water holding capacity, and leaching fractions. Monthly total process water loads were scheduled based on historical monthly loads and increased until the maximum capacity was achieved without excess leaching. Process water irrigation was not scheduled during the storage season of December, January, and February.

Table 4-J presents a summary of the annual totals from the soil hydraulic budgets for each circle including precipitation, gross process water and supplemental fresh water irrigation, ET, and leaching. Gross process water irrigation ranges from 11.3- to 56.2-inches, while gross supplemental fresh water irrigation ranges from 12.5- to 28.6-inches, with the exception of no fresh water projected for Circle B19. A supplemental fresh water connection is not planned for Circle B19. The potential ET ranges from 38.4- to 56.4-inches.

In this example, the Site design basis capacity for gross process water irrigation ranges from 92- to 253-MG per month (**Table 4-K**). Supplemental fresh water loads, based on supplementing the process water to meet crop water requirements, range from 9 MG in November, March, September, and October, to 427 MG in July. The total irrigation capacity in this example is 3,136 MG per year during the irrigation season (i.e., November, and March through October).

The annual example hydraulic capacities in **Table 4-K** were used with the process water quality (**Table 4-F**) and supplemental fresh water quality (**Table 4-G**) to calculate constituent mass loads from the process water and supplemental fresh water irrigation for comparison to the Site capacities discussed in the following section.

4.4.3.2 Nitrogen Capacity

There are two mechanisms of nitrogen treatment in a land treatment system. The first and largest is uptake by the crops growing and removal in the harvested portion of the crop. **Table 4-L** shows the past performance of the crops grown at the Site to remove nitrogen applied in process water, supplemental fresh water, and commercial fertilizer.

As the crop mix acreage changes, nutrient capacities also change. The projected crop nitrogen removal by the design basis crop rotation (**Table 4-H**) is presented in **Table 4-L** to show the most limiting projected Site nitrogen capacity. Note that the crop nitrogen removal of the design basis crop rotation is significantly larger compared to previous years (2017-2021) due to the inclusion of the expansion circles.

The second nitrogen treatment mechanism in land treatment systems is denitrification and volatilization (i.e., gaseous losses), which must be considered as part of the treatment and removal process for estimating nitrogen capacity. The applied process water nitrogen will be mostly in inorganic forms (nitrate and ammonia) following pretreatment before it is land applied.

Denitrification of the nitrate is typically promoted by the dose and rest cycles of the irrigation systems in conjunction with the labile carbon content represented by the BOD_5 load (U.S. Environmental Protection Agency 2006, Smith, J.H., J.R. Peterson 1982). However, the BOD_5 concentration of the process water will not drive significant amounts of denitrification. In addition, not all of the organic nitrogen is considered available because it will not easily mineralize following irrigation (Overcash and Pal 1979). The slightly to moderately alkaline pH of the soils and broadcast nature of sprinkler irrigation promotes a limited amount of volatilization of NH_3-N. These considerations have been accounted for in the equation below.

Based on the following equation, accounting for gaseous nitrogen losses, the available nitrogen load from process water is conservatively expected to be 89% of the total nitrogen applied (Meisinger and Randall 1991):

Equation:

$$\text{Available Nitrogen \%} = [((\text{TKN} - \text{NH}_3\text{-N}) + (\text{NH}_3\text{-N} \times 0.80) + (\text{NO}_3\text{-N})) \times 0.96] \div (\text{TKN} + \text{NO}_3\text{-N}) \times 100\%$$

Calculation:

Available Nitrogen % = [((30 mg/L - 15 mg/L) + (15 mg/L × 0.80) + (12 mg/L)) × 0.96] ÷ (30 mg/L + 12 mg/L) × 100%

= 89%

Accounting for the 89% nitrogen availability, the Site gross nitrogen capacity is 12% greater than the crop nitrogen removal (same as an 11% loss of gross nitrogen load). Therefore, Site nitrogen capacity can be calculated by increasing the crop nitrogen removal rates by 12% to account for the gaseous losses expected with process water application.

Example Calculation:

Nitrogen Removal Increase Factor = (1,034,800 nitrogen capacity - 921,000 pounds (lb) nitrogen removal) ÷ 921,000 lb nitrogen removal = 12% increase from crop nitrogen removal

4.4.3.3 Untreated Process Water Nitrogen Load

The untreated influent nitrogen load to the PWRF is estimated at 1,527,525 lb per year based on the projections presented in **Table 3-Q**. The untreated nitrogen load will be significantly greater than the site nitrogen capacity of 1,034,800 lb per year. Therefore, nitrogen is a limiting constituent of concern. The City determined that pretreatment of the influent for nitrogen reduction was required to meet the site nitrogen capacity as part of the land treatment system design.

4.4.3.4 Design Basis Nitrogen Load

Table 4-M presents the design basis nitrogen capacity and operational analysis across the Site with an example operational year nitrogen load scenario. The example operational load represents the gross nitrogen loads from process water and supplemental fresh water for each circle based on the hydraulic capacity analysis above. The example operational nitrogen loads were calculated from the process water and supplemental fresh water nitrogen concentrations (**Tables 4-F** and **4-G**, respectively) and respective irrigation amounts projected in the soil hydraulic budgets. Nitrogen load from the supplemental fresh water will be significant with limited gaseous losses. The available nitrogen load from the supplemental fresh water is conservatively estimated to be 96% of the nitrogen concentration with an assumed gaseous loss of 4% from denitrification.

Table 4-M presents an example process water nitrogen contribution of 646,936 lb and a supplemental fresh water nitrogen contribution of 178,997 lb. The total operational load of 825,933 lb is within the Site nitrogen capacity of 1,034,791 lb. **Table 4-M** also shows that the example operational circle-specific nitrogen loads (process water plus supplemental fresh water nitrogen) do not exceed their respective circle-specific nitrogen capacities.

4.4.3.5 Biochemical Oxygen Demand Capacity

The treatment capacity for BOD_5 depends on soil, temperature, and irrigation practices. The soil needs to allow sufficient oxygen transfer, the temperature affects the rate of microbial digestion of the organic components, and the irrigation practices provide sufficient water to maintain microbial function without extended soil saturation that would prevent sufficient oxygen. The BOD_5 capacity is most influenced by the soil texture and drainage rate because that affects the rate of oxygen diffusion into the soil. Sandier soils, such as those described for the Site, have larger soil pores with better oxygen diffusion potential, and thus, have a higher capacity for BOD_5 treatment than finer textured soils such as silt loams.

Crops also require an oxygenated soil. If the BOD_5 load is too great, the soil will become anaerobic and the crops will suffer stress that reduces performance, nutrient uptake, and yield. **Table 4-N** presents a potential annual BOD_5 load of 2,360,000 lb based on a projected BOD_5 concentration of 151 mg/L and process water flow of 1,869 MG. Based on 2,370 acres, 275 growing season days during the operational year, and process water loads applied to meet nitrogen capacities, the maximum annual loading rate averages approximately 4 pounds per acre per day (lb/ac/day) BOD_5. This BOD_5 load is below the commonly referenced 45- to 450-lb/ac/day BOD_5 range given for land treatment of wastewater by the Environmental Protection Agency (U.S. Environmental Protection Agency, 2006) and also below the existing permit limit of 100 lb/ac/day. The daily BOD_5 design load by field by month will range up to a maximum of 11 lb/ac/day; well below the 100 lb/ac/day Permit irrigation land application best management practice (**Table 4-O**).

4.4.3.6 Mineral Salts and Salinity Management

The FDS is a measure of the mineral salts present in the process water and supplemental fresh water and used to evaluate the salinity and mass of salts discharged to the Site (**Table 4-N**). The FDS that make up the process water and supplemental fresh water salinity include calcium, magnesium, sodium, potassium, sulfate, chloride, and bicarbonate ions. The annual process water plus supplemental fresh water FDS load of 15,190,000 lb, results in an average FDS load rate of 6,409 pounds per acre across the Site. The FDS load monitoring and management is important to manage accumulation of salts in the soil profile to prevent reductions in crop yields. The FDS load from process water and supplemental fresh water will determine the leaching requirements for each circle. The Site soil and crop FDS capacity is the calculated leaching requirement for each circle (**Table 4-J**, **Appendix E**). The EC of the water irrigated onto the Site is an indirect measure of the FDS (salinity) of the water. Therefore, irrigation water EC is used for computing the leaching requirement. Annual leaching fractions will not exceed calculated leaching requirements to limit the impact on groundwater quality. Soil salts will be monitored through annual soil sampling to determine effectiveness of scheduled leaching.

4.4.3.7 Leaching Requirement

The leaching requirement is the fraction of the total crop water supply from all sources that should percolate through the soil to control salt build-up in the soil profile. Leaching is required to prevent excessive amounts of salts from accumulating in the root zone. If not leached regularly, salts from both process water and supplemental fresh well water can build up in the soil profile to levels that could inhibit crop production. The salinity in the root zone should be maintained at or below the point of yield decline. A soil ECe of 2 mmhos/cm or less, which is suitable for most irrigated crops, was used to generate the leaching requirements. Given the limited precipitation in the region, it may be necessary to irrigate some supplemental fresh well water in the late fall to meet the leaching requirement. At the same time, irrigation should minimize deep percolation losses so that FDS losses from the soil are managed to control impacts to groundwater. The deep percolation rate (leaching fraction) should be equal to or less than the leaching requirement.

The leaching requirement, presented as a percentage of total irrigation, depends on the average electrical conductivity of the total water supply to the crop for the year. A leaching requirement is as follows (Canessa and Hermanson 1994):

$$LR = \frac{ECiw}{((5 \times ECe) - ECiw)}$$

Where:

LR = Fraction of the applied irrigation water that should become deep percolation

ECiw = EC of the irrigation water

ECe = Desired ECe of a soil saturated paste extract

Leaching requirements can be computed each year in the hydraulic budget calculations in the annual Farm Operations Report based on the actual water quality and hydraulic loads. The soil hydraulic budget calculations can also be used each year to compare the leaching requirement to the calculated leaching fraction as a check on agronomic irrigation management.

During the winter when leaching may occur from rainfall, there is low potential for nitrate to be leached if it has been adequately consumed by the crops. Cropping and loading rates can be managed to maintain a healthy crop to consume the available soil NO_3-N and maintain low nitrate concentrations in the soil before the time that winter leaching is more likely to occur.

4.4.4 Irrigation System Operation

Proper irrigation system operation is important for optimum process water treatment and agronomic capacity. The irrigation systems are operated to distribute the water across the circles for optimum control on irrigation depth and timing. Standard best management practices will include:

- visual observations of circles for runoff or ponding,
- routine soil profile moisture, salts, and nutrient monitoring,
- application rate monitoring, and
- leak and mechanical repair.

4.5 Summary

The soils at the proposed expansion circles are suitable for receiving the pretreated process water for land treatment purposes and the design crop rotation load scenario across the existing Site and expansion circles indicates that the nitrogen and hydraulic loads are within the agronomic capacity of the proposed Site expansion. The agronomic capacity will vary from year to year depending on the crop mix. The agronomic capacities, within which the Site must be managed by the City, will be established and reported each year in the annual Farm Operations Report, as required by the Permit.

Chapter 5.0 Evaluation of Pretreatment Alternatives

5.1 Introduction

As discussed in **Chapter 1**, the PWRF has historically provided basic pretreatment (screening and grit removal) and relied on the LTS for treatment and beneficial use of the process water. As detailed in **Chapter 4**, the projected loading from raw process water will significantly exceed the capacity of the existing LTS, as well as that provided by the land available for LTS expansion (Beus and Voss properties), so pretreatment is needed.

Significant expansion of the LTS area, in lieu of pretreatment improvements, is not feasible since sufficient additional nearby land area is not available. Also, land treatment alone would not remedy the odors from the high BOD water from the PWRF nor would it alleviate the low pH causing corrosion of the irrigation system components. Any additional LTS area also would require supplemental irrigation water due to the high load to flow ratio of the raw process water.

Further pretreatment of the process water will be necessary to allow the projected process water volume to be discharged to the expanded LTS. Alternatives for pretreatment are reviewed in this chapter.

5.2 Flow and Loading Criteria

Table 5-A provides the recommended basic design criteria for sizing of biological pretreatment systems at the PWRF. The values in **Table 5-A** exceed the typical projected flow and loading from **Table 3-Q** because the processors requested conservative permit limits in excess of their typical projected flow and loadings to avoid permit violations.

Table 5-A – Influent Design Criteria for Biological Pretreatment

	Influent Design Criteria[a]
Flow	
Annual Average Day (MGD)	4.38
Total Annual (MG)	1,600
Maximum Month Average Day (MGD)	8.56
BOD	
Maximum Month Average Day (ppd)	300,000[b]
TN	
Annual Average Day (ppd)	4,200

[a] Pretreatment design flow and loading excludes Darigold COW water since COW water will be stored separately from other process water and will not be pre-treated.

[b] See discussion for selection of BOD loading design criteria in subsequent paragraphs

The design criteria in **Table 5-A** were determined as follows.

Chapter 4 defined nitrogen loading as the limiting factor for the capacity of the LTS, which makes nitrogen reduction the primary goal of biologic pretreatment. Biological pretreatment will be sized to reduce the process water total nitrogen load to within the capacity of the LTS, based on the projected nitrogen load in **Chapter 3**.

Flow to the LTS can be managed by providing sufficient winter storage to allow for all water to be disposed of during the growing season, as analyzed in **Chapter 6**. Biological pretreatment will primarily be sized and configured as necessary to maintain nitrogen loading within the capacity of the land treatment.

The projected total annual BOD loading would be within the permitted LTS capacity of 100 lb/acre/day. However, nitrogen cannot be reduced without also reducing BOD. Reducing BOD will also provide the advantages of mitigating the current aesthetic and operational issues created by the high BOD loading by reducing odors at the site and stabilizing the process water pH. Depending on the biological pretreatment system chosen, the chemical addition necessary for pH adjustment can be significantly reduced compared to other alternatives. From **Table 3-J**, the PWRF may experience max month BOD loading up to 330,000 ppd. The biological pretreatment system will be sized to receive a max month BOD load of only 300,000 ppd since it is not necessary that all flows receive biological pretreatment as long as nitrogen is sufficiently reduced. For the majority of the year the biological pretreatment system will treat all flows.

FDS can be managed through operation of the LTS as shown in **Chapter 4**. Therefore, FDS reduction via pretreatment is not warranted at this time. This may be revisited in the future if additional processors with additional FDS loading are considered for connection to the PWRF.

5.3 Preliminary Screening of Alternatives

The general categories of treatment options for process wastewater similar to the PWRF influent consist of the following:

- Physical – which includes the physical separation of particulates from the waste stream via equipment such as screening, dissolved air floatation (DAF), clarification, etc.
- Chemical – which can include various techniques such as coagulation-processes, pH adjustment, etc.
- Biological – which generally consists of microbial organisms breaking down organic constituents under aerobic or anaerobic conditions.

Currently, both the individual processors and the PWRF facility provide physical and chemical treatment systems as discussed in **Chapter 1**. These systems do not significantly reduce total nitrogen or BOD, both of which are largely present in soluble form in the influent. As described in **Chapter 4**, a significant reduction in total nitrogen will be necessary through pretreatment for the expanded LTS to provide sufficient capacity for the disposal of the projected process water. Biological treatment via aerobic activated sludge is the proven and common approach for reduction of total nitrogen in wastewater and is recommended for nitrogen reduction at the PWRF. Pretreatment alternatives that do not include biological treatment are not considered viable for the projected PWRF loading and LTS configuration and are not analyzed further.

Due to the significant component of soluble BOD in the influent, another common and proven approach to biological treatment includes first anaerobic treatment for BOD reduction followed by aerobic treatment for nitrogen reduction. The initial anaerobic treatment significantly reduces BOD with low energy consumption (no aeration) and high solids destruction, and produces biogas that provides a renewable energy source. This allows for the sizing of the aerobic treatment system to be substantially reduced.

As described in **Chapter 1**, the 2019 Facility Plan recommended an aerated stabilization basin to support near-term flow and loading, which has now been exceeded. For future flow and loading increases, the 2019 Facility Plan recommended biological pretreatment for TN and BOD reduction in the form of an anaerobic followed by aerobic treatment, similar to that described above. The preferred form of anaerobic treatment identified in the 2019 Facility Plan consisted of Upflow Anaerobic Sludge Blanket (UASB) reactors, a type of high-rate anaerobic system. However, a renewed evaluation of anaerobic treatment options, to be discussed in **Alternative 2 – Anaerobic Treatment Followed by Aerobic Treatment**, will explain why a low-rate anaerobic treatment would be better for this application.

Based on this initial screening of options, the two leading alternatives for pre-treatment at the PWRF are analyzed in this chapter:

- Alternative 1 – Aerobic activated sludge treatment for reduction of nitrogen and BOD; and
- Alternative 2 – Anaerobic treatment for reduction of BOD followed by aerobic activated sludge treatment for reduction of nitrogen.

Items that would be identical in cost and configuration to both alternatives, such as preliminary treatment to protect the secondary treatment systems, are not included in this alternatives analysis. Ancillary treatment processes to support these systems are identified with each analysis herein.

5.4 Alternatives Analyses

5.4.1 Alternative 1 – Aerobic Activated Sludge Process

5.4.1.1 Overview

In an aerobic activated sludge treatment process, bacteria break down organic matter as they grow biomass. An aeration system of diffusers and blowers supply oxygen to aerate the biomass, and the required aeration demand is generally dependent on the influent BOD and nitrogen loading. Unaerated zones, or cycles, must be provided to achieve total nitrogen reduction as these provide anoxic conditions in which nitrate (produced from oxidation of ammonia under aerobic conditions) is converted to nitrogen gas and released from the process.

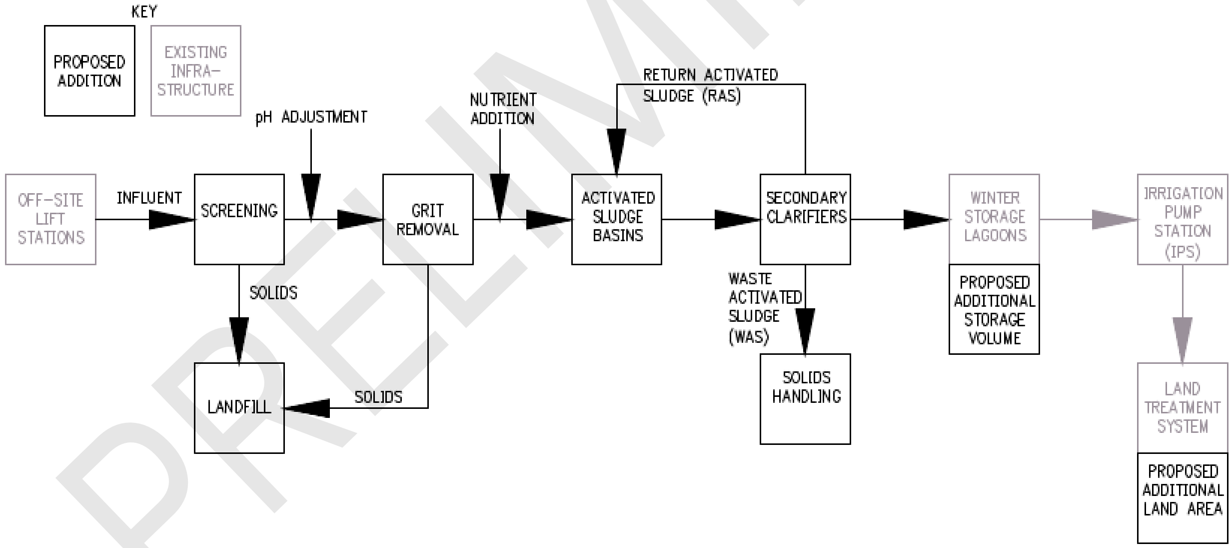
There are various configurations of aerobic activated sludge treatment processes that could be employed at the PWRF. Common configurations include continuous flow reactors (CFR), in which basins are compartmentalized into anoxic or aerobic zones and followed by clarifiers, and sequencing batch reactors (SBR) in which anoxic and aerobic conditions, as well as biomass settling, all occur via cycles within a tank. These processes provide a high level of treatment relative to footprint and could fit within the available space for treatment at the site without impacting the footprint needed for winter storage. Larger low-rate processes, such as aerated lagoons, are not considered due to the necessary footprint for such processes.

An SBR configuration, compared to a CFR, avoids compartmentalized tanks, secondary clarifiers, and associated equipment, and is likely to have a similar, though potentially lower capital cost to a CFR for this facility. For the purposes of comparing Alternative 2 to Alternative 1, an aerobic activated sludge treatment process in a CFR configuration is assumed, as this is likely to provide a slightly more conservative estimate of capital costs for the system.

A CFR configuration is assumed to include two identical basins, each compartmentalized to create anoxic and aerobic zones. Diffused aeration would be provided in the aerobic zones. Mixers are provided for each anoxic zone to homogenize the mixed liquor, a combination of wastewater and biomass. Mixed liquor is internally recycled, with some effluent from the final basin returning to the first basin and the rest continuing to a secondary clarifier where sludge settles to the bottom. Some settled sludge is returned to the activated sludge basins, called return activated sludge (RAS), while the rest is sent to solids handling, called waste activated sludge (WAS).

Figure 5-A provides a diagrammatic overview of the Alternative 1 treatment system.

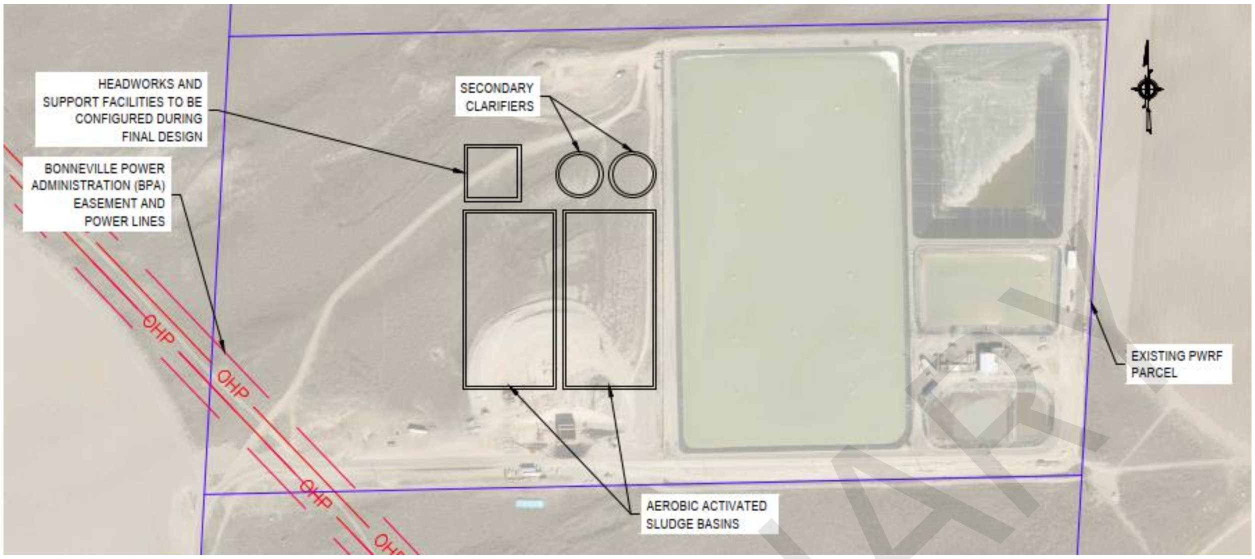
Figure 5-A – Alternative 1 Process Schematic (CFR Option Shown)



As shown in the figure, the activated sludge process would be preceded by preliminary treatment consisting of screening and grit removal. A solids handling system would be necessary to process the waste sludge from the system.

Figure 5-B provides a preliminary basic layout of the treatment system footprint at the proposed PWRF site.

Figure 5-B – Alternative 1 Conceptual Site Plan



The major considerations for this system are provided in the following section.

5.4.1.2 Major Considerations

5.4.1.2.1 Secondary Treatment (Basins and Clarifiers)

In this alternative, an aerobic activated sludge system would biologically remove organic matter and suspended solids from the wastewater, and then sludge would settle in secondary clarifiers.

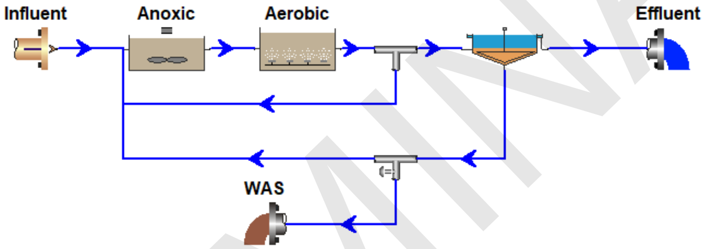
The 2019 Facility Plan recommended primary treatment prior to secondary treatment to reduce BOD. As previously stated, most of the influent BOD is soluble and is unlikely to be removed by conventional primary treatment methods, such as gravity separation. Some manufacturers promote DAF equipment as a form of primary treatment for BOD reduction in industrial wastewater, but this equipment would be expected to reduce the particulate fraction of BOD and not the soluble portion. Some of the existing processors already pretreat with DAF equipment, and the process water discharged from these facilities remains high in soluble BOD. For comparing secondary treatment alternatives, assuming no primary treatment is the most conservative approach and is recommended.

Screened and de-gritted influent would flow by gravity to the aerobic activated sludge system. The basins likely would be earthen impoundments with synthetic liners and concrete floors. Two basins are recommended; both basins would be operated in tandem to treat peak loading, and a single basin could be operated during the winter months. Configuration of the basin walls and berm construction would be analyzed in detail during final design. The basins likely would have an approximate volume of 20 MG each, with a side water depth of approximately 20 feet pending further analysis during final design. To maximize oxygen transfer within the basin volumes proposed, dense grids of fine bubble membrane aeration diffusers would be mounted to the concrete floor of the basins. Each basin would need to be periodically drained to perform maintenance on the diffusers; however, the basins could be sequentially taken offline for maintenance during the low loading season. The aeration system would need to be sized to meet the very large oxygen demands that would result from the high BOD loading. Based on preliminary modeling, the system is expected to require aeration blowers capacity in excess of 5,000 hp. Due to this large size, it is expected that these aeration blowers would be housed on exterior concrete pads near the basins.

Two circular secondary clarifiers in concrete tanks, each approximately 120 feet in diameter, would be installed downstream of the activated sludge aeration basins. Full redundancy in the secondary clarifier system is not necessarily required, and as such, each clarifier is assumed to be sized to handle approximately 75 percent of the loading for this analysis. Each clarifier would include a RAS pump station consisting of a wet well with submersible sewage pumps for returning RAS to the influent upstream of the basins.

Figure 5-C shows the basic process configuration used in the BioWin® modeling of this alternative.

Figure 5-C – Alternative 1 BioWin® Schematic



5.4.1.2.2 Solids Handling System

WAS would be pumped from the bottom of the clarifiers to a solids handling process. The activated sludge system likely will create approximately 0.75 to 1 pound of biomass per pound of influent BOD, resulting in large quantities of solids that must be wasted continually for processing prior to disposal. Based on this ratio, the average annual solids generated are expected to be on the order of 100,000 to 130,000 dry pounds per day. Due to this quantity, on-site stabilization through digestion, air drying, or other processes is likely not practical or economically feasible. Instead, it is likely that the solids will need to be dewatered onsite via permanent dewatering equipment. The most cost-effective disposal method for the dewatered sludge would be land application near the PWRF. However, the solids will not be stabilized through digestion; therefore, they will have a high volatile content. The content will make immediate tilling into fields or other measures to reduce odor and vector attraction necessary. In the winter months, lime addition or other methods for stabilization may need to be considered prior to storage of the dewatered sludge if fields are not accessible for application and tilling.

For the purposes of comparing alternatives, the solids handling system is configured to include sufficient dewatering and conveyance equipment to handle the projected WAS loading, with all sludge disposal occurring offsite via land application.

5.4.1.2.3 pH Adjustment

Magnesium hydroxide would need to be continually added to boost alkalinity prior to the activated sludge process since the low pH of influent process water would adversely affect an aerobic process. This addition would create significant ongoing chemical costs as well as increase the FDS loading to the land application sites. Preliminary calculations estimate that greater that 1600 gallons per day of a 60% magnesium hydroxide solution would be needed for Alternative 1, more than 7 times that estimated for Alternative 2.

5.4.1.2.4 Nutrient Addition

Per **Table 3-Q**, the typical maximum month loading of 254,000 ppd BOD and 8,400 ppd TN equates to a BOD:TN ratio of 100:3.3, whereas the typical ratio for nutrient-limited waters for biological treatment is 100:5 BOD:TN. Based on preliminary BioWin® modeling, it appears likely that an aerobic activated sludge system would require addition of both nitrogen and phosphorus. Feed systems for nutrients, in addition to the influent pH adjustment, would be provided upstream of the aerobic process. This represents a substantial ongoing chemical cost as described in the sections that follow. The uptake of nitrogen through assimilation into the activated sludge bacteria will remove most of the nitrogen with the influent BOD from the liquid stream. However, most of the influent nitrogen and the added nitrogen will be incorporated into the WAS. If all of the waste solids were to be disposed of by land application on the City-owned sprayfield, the nitrogen loading would be significantly higher than it is currently. Therefore, the waste solids would have to be transported elsewhere.

5.4.1.3 Expected Effluent Quality

Table 5-B provides the expected effluent water quality for the improvements proposed in Alternative 1.

Table 5-B – Alternative 1 Expected Effluent Water Quality

Parameter		Units
pH	6.0 - 7.5	s.u.
BOD	< 300	mg/L
TSS	< 300	mg/L
TN	< 50	mg/L

5.4.1.4 Design Summary

Table 5-C provides the basic design criteria for the major components of the Alternative 1 pretreatment system.

Table 5-C – Alternative 1 Basic Design Criteria

Parameter	
Influent Screening	
Screen Type	Rotary Drum
Screen Opening	1/4 in
Screen Quantity	3
Peak Hydraulic Capacity (per screen)	4600 gpm
Grit Removal and Handling	
System Configuration	Vortex
System Peak Hydraulic Capacity	9200 gpm
Pump Type	Recessed impeller
Grit Washing System	Cyclone/classifier
pH adjustment	
60% $Mg(OH)_2$ Solution	>1600 gpd
Solids Handling	
Mechanical Dewatering Equipment	
Solids Generation	100k-130k ppd
Activated Sludge Basins	
Basin Quantity	2
Basin Size	20 MG
Aeration Blowers	>5,000 hp
Clarifiers	
Clarifier Quantity	2
Clarifier Diameter	120 ft

5.4.1.5 Capital Cost Estimate

Table 5-D provides the estimated capital costs for the Alternative 1 pretreatment system. These costs assume that the project is completed as a single, standalone project. This table excludes costs that are identical between the systems. Total costs for the recommended improvements are provided in **Chapter 6**.

Table 5-D – Alternative 1 Capital Costs

Item	Cost
Secondary Treatment (Activated Sludge)	$62,500,000
Solids Handling System	$25,100,000
PROJECT TOTAL	**$87,600,000**

1. *Costs rounded to nearest $100,000*
2. *Costs includes tax and indirect costs*
3. *Continency omitted for alternatives comparison*

5.4.1.6 Estimated Operating and Maintenance Costs

The improvements for Alternative 1 are estimated to require four full-time operators, which represents approximately a two full-time employee (FTE) increase over the current PWRF staffing. This increase is prompted by the significant sludge dewatering operation required for this alternative. The major electrical loads are primarily associated with the large aeration system. Chemical costs include pH adjustment, influent nitrogen and phosphorus adjustment, and substantial polymer usage by the new system for processing WAS. The aerobic process will generate large quantities of solids, requiring hauling and disposal on a continual basis. Maintenance and equipment replacement costs are calculated as a portion of equipment that will require replacement within 20 to 30 years, including blowers and pumps.

Table 5-E provides the estimated annualized total operating costs for the processes presented in Alternative 1. The costs do not include operating costs for existing processes (i.e. the IPS) that will be maintained in all alternatives.

Table 5-E – Alternative 1 Annual Costs

Item	Cost
Labor	$400,000
Electrical (Major Loads)	$1,500,000
Chemical	$2,800,000
Sludge Hauling and Disposal	$1,500,000
Equipment Maintenance and Replacement	$900,000
Total Annual	**$7,100,000**

5.4.2 Alternative 2 – Anaerobic Treatment Followed by Aerobic Treatment

5.4.2.1 Overview

This alternative would consist of an anaerobic treatment system, which reduces the majority of the influent BOD, followed by an aerobic treatment system to reduce nitrogen. By substantially reducing BOD with the anaerobic system, a much smaller aerobic system is necessary than proposed in Alternative 1.

In an anaerobic treatment system, bacteria grow in the absence of oxygen and break down organic matter in wastewater. The bacteria remove over 90 percent of the organic matter (BOD) and suspended solids from the wastewater. There are high rate and low rate anaerobic treatment systems. High rate systems, such as an UASB digester, allow for high loading relative to footprint and are applicable for treating high strength wastewater with low suspended solids concentrations. However, the suspended solids in the mixed process water to the PWRF likely would be problematic for a UASB, so a high rate treatment system is not recommended. Low rate anaerobic digesters (LRAD), often constructed in earthen impoundments, are a common approach to treatment for process water similar to that discharged to the PWRF. An LRAD operates with a long hydraulic retention time, long solids retention time, and low biomass growth rate. This is the recommended approach to anaerobic treatment at the PWRF.

LRADs are typically engineered, turnkey systems for which there are multiple experienced designers, as well as vendors with packaged systems. The configuration of each system varies between designers, but generally includes the fundamental elements discussed in this report. For the purposes of analyzing these systems, Evoqua Water Technologies (Evoqua) was engaged to provide a basic design scope and quotation of an LRAD system, which they refer to under the trade name of Bulk Volume Fermenter (BVF). The BVF reactor was invented by ADI Systems, which is now a part of Evoqua. A summary of Evoqua's preliminary design is provided in **Appendix F**.

Figure 5-D provides a diagrammatic overview of the Alternative 2 treatment system.

Figure 5-D – Alternative 2 Process Schematic

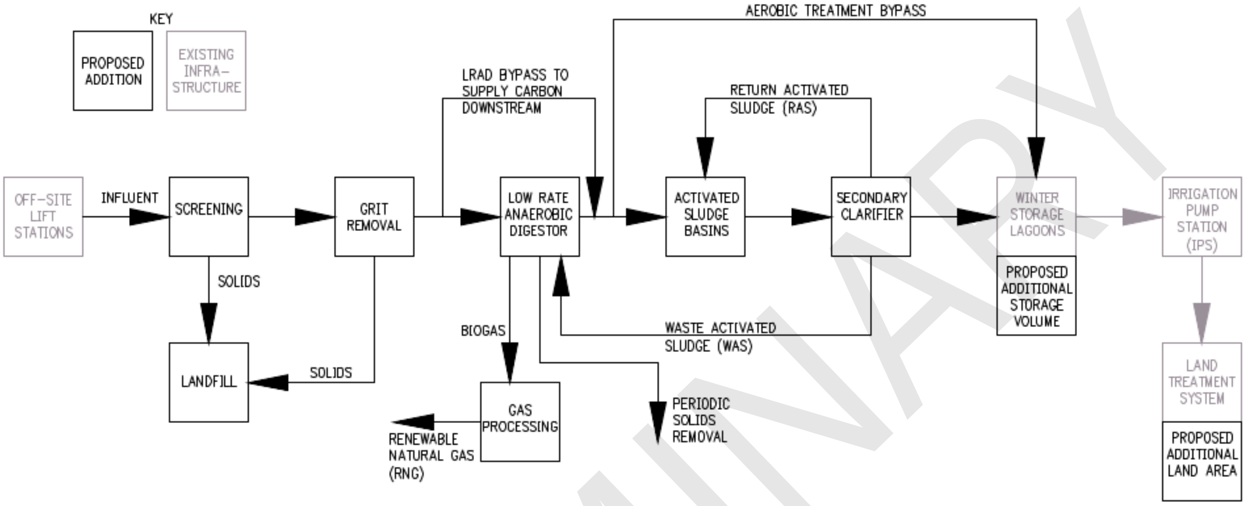
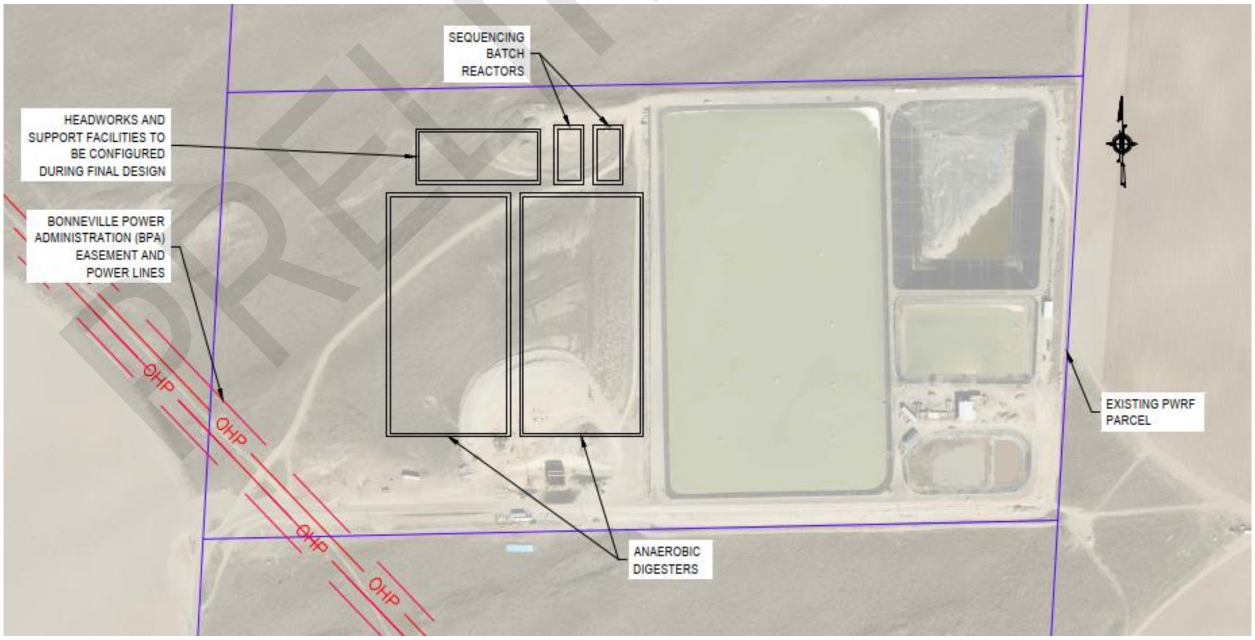


Figure 5-E provides a preliminary basic layout of the treatment system footprint at the proposed PWRF site.

Figure 5-E – Alternative 2 Conceptual Site Plan



The major considerations for this system are provided in the following section.

5.4.2.2 Major Considerations

5.4.2.2.1 Influent Equalization

Depending on the specific configuration of the LRAD system, some tankage for influent storage may be necessary to equalize peak flows to the LRAD system. For the basis of comparing treatment alternatives, 1.5 MG of covered, above-grade influent equalization (EQ) tankage is assumed, as well as a pump station to lift influent from preliminary treatment to the EQ tank. Alternatively, below-grade EQ tankage could be considered during final design.

5.4.2.2.2 Secondary Treatment (Anaerobic Treatment for BOD Reduction)

Downstream of the headworks, influent is discharged to LRAD reactors. Sludge from the reactors is recycled to the influent portion of the reactor to facilitate biomass contact and provide mixing in this area. The LRAD reactors are configured in a rectangular design with influent distributed across the short sides. The LRAD system consists of lagoons constructed within earth impoundments with a synthetic liner and upper concrete parapet walls. Based on the loading projected for the PWRF, two identical LRADs of approximately 34.5 MG each would provide sufficient capacity for the maximum month BOD load. Effluent flows by gravity from the opposite end of the LRAD reactor to the influent. Sludge settles within the LRAD and is wasted infrequently, as discussed in **Section 5.4.2.2.4 – Solids Handling**.

5.4.2.2.3 Secondary Treatment (Aerobic Treatment for Nitrogen Reduction)

Following the LRAD, a portion of wastewater would be sent to an aerobic activated sludge treatment process for nitrogen removal. Only partial treatment would be needed since reducing nitrogen loading below the acceptable rate for land application is not beneficial.

In principle, an aerobic treatment system for nitrogen reduction following an anaerobic system will function as discussed for Alternative 1 and could use various configurations, such as CFR or SBR. Some screened and de-gritted influent will bypass the LRAD to provide carbon for denitrification in the aerobic system. As previously noted, the anaerobic system greatly reduces the organic influent load, which allows the aerobic system to be sized significantly smaller with lower aeration demand than that shown in Alternative 1. WAS from the aerobic system could be returned to the LRAD, reducing solids handling costs. For the purposes of this alternatives analyses, Evoqua provided a preliminary scope and quotation for an SBR system to follow anaerobic treatment. An SBR system consists of a minimum of two identical tanks, each of which will perform cycles via a control system to provide treatment. Cycles generally include: Fill (influent feed to tank); Mix (anoxic period); React (aerated period); Settle (sludge settles to bottom of tank and a portion is wasted); and Decant (effluent is removed from top of tank). Similar to LRADs, SBRs are typically engineered, turnkey systems and Evoqua is one of many manufacturers with a patented SBR process. Based on the necessary nitrogen reduction at the projected flow and loading, Evoqua estimates two identical SBRs constructed in rectangular concrete tanks, each providing approximately 2 MG in operating volume, would be required.

The effluent from the SBR will combine with any bypassed LRAD effluent at the storage lagoons and flow to the IPS.

5.4.2.2.4 Solids Handling

A continual stream of WAS will be wasted from the aerobic process. The WAS will be discharged to the LRAD. A major advantage of anaerobic treatment of high strength wastewater is the limited sludge production relative to aerobic treatment as the digester destroys a large fraction of the volatile solids. Sludge generated by the anaerobic treatment of wastewater settles and is stored in the sludge storage zone of the digester, allowing wasting to occur only periodically. Evoqua's preliminary design proposal estimated that sludge will be wasted from the LRADs at a rate of 23.4 MG/year at 4% solids content. When solids processing is needed, it is expected that a temporary rental dewatering system will be set up at the PWRF to dewater the sludge. The dewatered solids should meet the requirements for Class B biosolids, allowing for land application for agricultural purposes. Due to the nitrogen limitation of the City's land treatment area, it is assumed that the solids will need to be transported offsite to a permitted biosolids disposal area.

5.4.2.2.5 Gas Handling

The bacteria in the LRAD produce biogas as a byproduct, which consists primarily of methane, carbon dioxide, ammonia, and hydrogen sulfide. The biogas is captured and collected by a floating geomembrane cover over the basin. The membrane also serves to insulate the basin and help maintain an LRAD operating temperature of 85 to 98 degrees Fahrenheit. The biogas is conveyed from the LRAD by blowers, which apply negative pressure beneath the membrane cover. The collected biogas has multiple potential uses:

- Fuel source for firing on-site boilers to heat the LRAD influent;
- Flaring of excess gas; and
- Processing and discharge as a renewable natural gas.

For the purposes of comparing treatment alternatives, it is assumed that the excess biogas will be used for LRAD heating and/or flared onsite.

Hydrogen sulfide (H_2S) is present in biogas from anaerobic digestion and may necessitate scrubbing from the biogas prior to flaring or reuse in on-site boilers. For the purposes of analyzing alternatives, no H_2S scrubbing is assumed but will require consideration as part of final design and air emissions permitting.

5.4.2.2.6 LRAD Heating

In order to maintain the desired operating temperature of the LRAD system, supplemental heat is required. Hot water boilers are used to provide hot water to heat exchangers for heating process water. Typically, LRAD contents are looped through heat exchangers continuously for this purpose.

Natural gas is typically used for initial heating and startup of the LRAD system. As previously noted, biogas can be used to fire the boilers once the LRAD system is operable.

5.4.2.2.7 Chemical Addition

Per Evoqua's preliminary design proposal, magnesium hydroxide will be added as needed upstream of the LRAD to raise the influent pH. Evoqua estimated that 207 gpd of a 60% magnesium hydroxide solution would be needed for pH adjustment. It is expected that the chemical addition can be decreased after start-up since the large LRAD volume will act as a buffer for the influent pH. The pH of SBR influent should be maintained above approximately 6.5 to allow for stable nitrification and denitrification. A chemical feed system will be provided as part of pretreatment improvements.

5.4.2.3 Expected Effluent Quality

Table 5-F provides the expected effluent water quality from Evoqua's preliminary design proposal for the improvements proposed in Alternative 2.

Table 5-F – Alternative 2 Expected Effluent Water Quality

Parameter	LRAD Effluent	SBR Effluent	Units
pH	6.5 – 7.5	6.0 – 9.0	s.u.
BOD	360	< 100	mg/L
TSS	460	< 100	mg/L
TN	100	28	mg/L

5.4.2.4 Design Summary

Table 5-G provides the basic design criteria for major components of the Alternative 2 pretreatment system.

Table 5-G – Alternative 2 Basic Design Criteria

Parameter	
Influent Screening	
Screen Type	Rotary drum
Screen Opening	1/4 in
Screen Quantity	3
Peak Hydraulic Capacity (per screen)	4600 gpm
Grit Removal and Handling	
System Configuration	Vortex
System Peak Hydraulic Capacity	9200 gpm
Pump Type	Recessed impeller
Grit Washing System	Cyclone/classifier
pH Adjustment	
60% $Mg(OH)_2$ Solution	207 gpd
LRAD	
Basin Quantity	2
Basin Volume (per LRAD)	34.5 MG
SBR	
Basin Quantity	2
Basin Volume (per SBR)	2 MG

5.4.2.5 Capital Cost Estimate

Table 5-H provides the estimated capital costs for the Alternative 2 pretreatment system. These costs assume that the project is completed as a single, standalone project. This table excludes costs that are identical between alternatives. Total costs for the recommended improvements are provided in **Chapter 6**.

Table 5-H – Alternative 2 Capital Costs

Item	Cost
Secondary Treatment (Anaerobic System)	$40,000,000
Secondary Treatment (Aerobic System)	$20,000,000
Additional Costs	$6,500,000
PROJECT TOTAL	**$66,500,000**

1. *Costs rounded to nearest $100,000*
2. *Costs includes tax and indirect costs*
3. *Continency omitted for alternatives comparison*

5.4.2.6 Estimated Operating and Maintenance Costs

Burnham (the contractor discussed in **Section 6.6 – Project Schedule and Delivery Method**) developed an estimate for the annualized total operating costs for the processes presented in Alternative 2 based on Evoqua's preliminary design proposal (**Table 5-I**).

Per Evoqua's proposal, the improvements are estimated to require three operators working at 12 hours per day, 7 days per week, as well as one FTE for maintenance. Labor costs include costs for operations, maintenance, and an asset fee. The major electrical loads are primarily associated with the aeration equipment for the aerobic treatment system. The annualized solids handling costs will cover the periodic removal of sludge from the LRAD. Consumables costs include chemical addition for pH adjustment as needed and minor equipment replacement. Per discussion with Burnham's team, their capital costs estimate (**Table 5-H**) also includes costs for pre-purchase of spare equipment, so costs for equipment replacement typical of this type of estimate are captured between the capital and operating and maintenance costs. Costs assume that biogas can be used to heat the LRADs.

Table 5-I – Alternative 2 Annual Costs

Item	Cost
Labor	$1,600,000
Electricity	$650,000
Sludge Hauling and Disposal	$1,100,000
Consumables	$475,000
Total Annual	**$3,850,000**

1. *Estimate developed by Burnham based on Evoqua's preliminary design proposal.*

5.4.3 Comparison of Alternatives and Recommendation

Both systems will be configured in a manner that alleviates the deficiencies of the current PWRF pretreatment system. Further, both secondary treatment alternatives can be configured to provide sufficient capacity for the proposed flow and loading and both systems will provide sufficient treatment to allow effluent to be discharged within the capacity of the LTS as described in **Chapter 4**. For the purposes of analyzing the two alternatives, the capital costs are assumed to funded over 25 years with an interest rate of 5 percent in order to establish annual debt service costs. The primary difference between the two alternatives is the life-cycle costs. The estimated life-cycle costs for the two alternatives are summarized in **Table 5-J**.

Table 5-J – Comparison of Alternatives 1 and 2 Life-Cycle Costs over 25 years

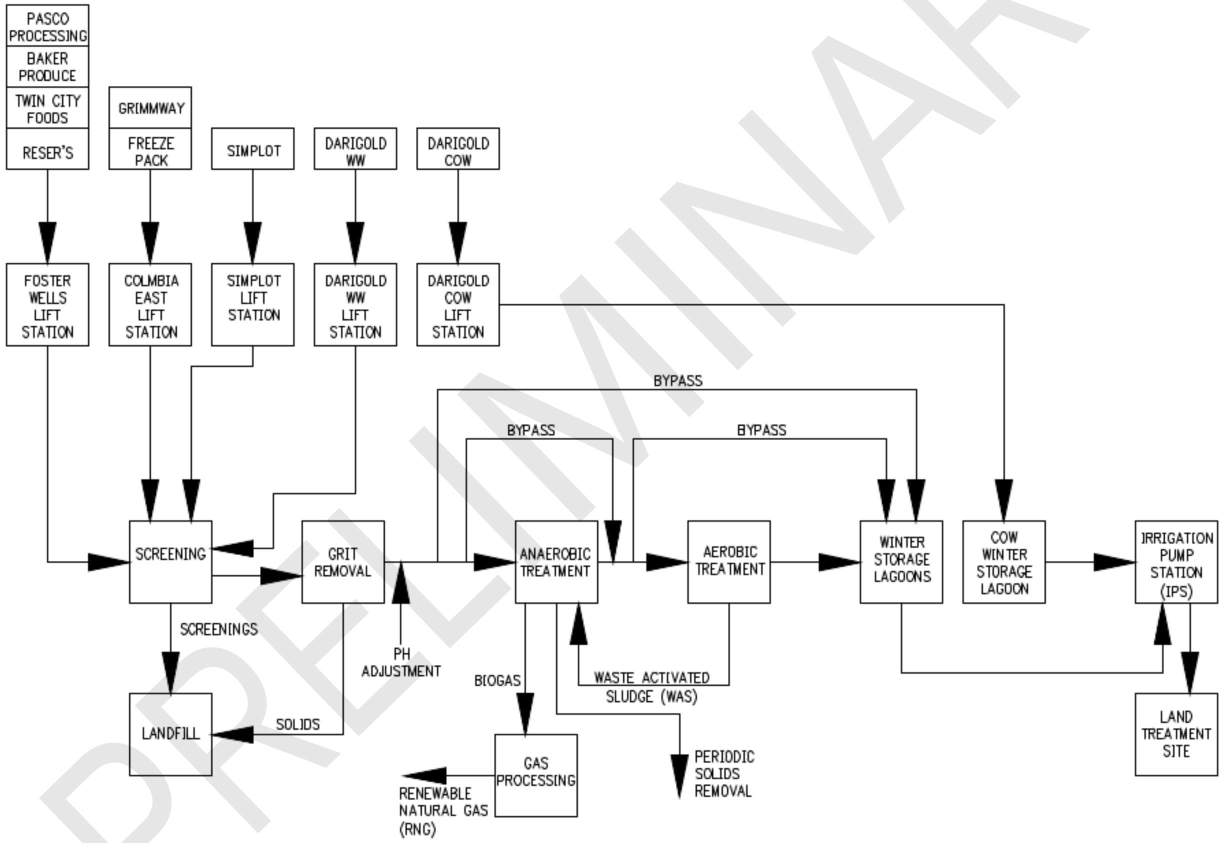
	Alternative 1 (Aerobic Only)	Alternative 2 (Anaerobic + Aerobic)
Capital Cost		
Capital Cost	$87,600,000	$66,500,000
Annualized Costs		
Annual Debt Service (5%, 25-yr)	$6,300,000	$4,800,000
Operations & Maintenance Costs	$7,100,000	$3,850,000
Total Annual Cost Estimate	**$13,400,000**	**$8,650,000**
Percent above lowest option	55%	0%

Alternative 2, consisting of an LRAD system followed by aerobic activated sludge treatment for nitrogen reduction, is the preferred alternative due to lower lifecycle costs. This alternative has lower operating costs for aeration, chemical addition, and solids handling. Preliminary sizing and additional details for the recommended alternative are discussed in **Chapter 6**.

Chapter 6.0 Implementation of Recommended Improvements

Based on the analyses of the previous chapters, the PWRF will be reconfigured to include biological treatment, including anaerobic followed by aerobic treatment, prior to discharge of effluent to the expanded LTS. Additional winter storage lagoons also will be constructed. This chapter intends to provide a sufficiently detailed description of the proposed improvements such that the design of the system can commence upon approval of this report in accordance with WAC 173-240-130. **Figure 6-A** provides a basic schematic of the proposed system.

Figure 6-A – Proposed Process Schematic



As shown in the figure, the existing and new processors will convey their process water to one of five lift stations. The Darigold COW water stream will bypass treatment and go directly to a designated storage lagoon. All other process water streams will combine to enter the proposed headworks for screening and grit removal. The screened and de-gritted influent will enter the anaerobic treatment system, which will substantially reduce BOD. The effluent from the anaerobic treatment system, or a portion of it depending on flow and loading, will flow to the aerobic treatment system for nitrogen reduction. Some screened and de-gritted influent will bypass anaerobic treatment and flow directly to aerobic treatment; this bypass will be used to supply the necessary carbon for denitrification. An additional bypass of all biological treatment also is recommended to provide operational flexibility. Treated effluent will enter the lagoons and either discharge to the irrigation pump station for distribution to the land treatment system or remain in the lagoons for storage during non-irrigation months.

As discussed in **Section 1.1.3.2 – Planned Improvements**, improvements are proposed to be constructed in three distinct phases. Construction Phase 1 extends and relocates water, power, and fiber utilities to existing PWRF facilities and relocates a portion of two of the FWLS force mains. Construction Phase 2 provides additional winter storage through proposed lagoons and begins grading a construction site for pretreatment. Construction Phase 3 will construct the pretreatment improvements. The project delivery method is further discussed in **Section 6.6 – Project Schedule and Delivery Method**.

6.1 Site Layout

The proposed overall site layout is summarized in **Exhibit 6-A**. Storage lagoons will be placed on the 80-acre Reclamation parcel north of the existing PWRF, and pretreatment improvements will be placed on the west 40 acres of the City's parcel with the existing PWRF. A preliminary layout of pretreatment improvements in the allocated area is included in Appendix C of Evoqua's preliminary design proposal (**Appendix F**). This pretreatment improvements layout will be refined during final design.

The overall site layout, which was chosen through an analysis of multiple alternatives, most cost effectively balances the hydraulic profile needs with excavation, grading, and utility extension costs. This layout efficiently provides the necessary footprint for the required pretreatment and storage areas discussed in this chapter.

6.2 Utilities and Other Improvements

6.2.1 Site Access

The only established access to the PWRF site is through a 60-foot access and utility easement on neighboring parcels. There is a 20-foot-wide access road that traverses through the easement. Utilities within the easement include five process water force mains, a proposed water main, and proposed power/fiber conduits. The recorded easement language precludes any additional utilities from being installed. **Figure 6-B** shows the off-site utility routing to the PWRF.

The proposed site layout places the pretreatment site in the west half of the existing City parcel. This would provide easy access for the Phase 3 contractor from the existing access easement, as only a short access road would need to be constructed. This also would limit the amount of access by the Phase 3 contractor through the City and northern Reclamation parcels, allowing the City to secure its site.

Figure 6-B – Off-Site Utility Routing

6.2.2 Process Water Conveyance

The existing lift station and force main capacities (FWLS, CELS, and SLS) are sufficient for conveying the proposed flows from Pasco Processing, Baker Produce, Freeze Pack, Twin City Foods, Simplot, Reser's, and Grimmway (**Table 6-A**). Simplot plans to eventually decommission its private lift station and instead connect into the CELS, which will require upgrades to the CELS capacity at that time. Darigold will construct two private lift stations and force mains to separately convey its wastewater and COW water streams to the PWRF. Darigold will be responsible for constructing its lift stations and force mains to the PWRF.

Table 6-A – Lift Station Capacities

Lift Station	Initial Capacity (gpm)	Future Capacity (gpm)	Force Main Diameters
Foster Wells Lift Station (FWLS)	4,300	4,300	(1) 8” (1) 16” (1) 20”
Columbia East Lift Station (CELS)	2,174	4,171	(2) 20”
Simplot Lift Station (SLS)	1,200	Shutdown	(1) 10”
Darigold WW Lift Station	700	700	TBD
Total (No COW)	**8,400**	**9,200**	**-**
Darigold COW Lift Station	700	700	TBD

The six force mains from the existing lift stations currently extend to the existing screenings building. As part of Phase 1 construction, two of the FWLS force mains will be relocated from the start of the PWRF access road at E Foster Wells Road to the IPS to be better aligned with existing force mains and provide a more uniform utility corridor for future utilities. All force mains will need to be extended to the proposed headworks building located on the pretreatment site.

6.2.3 On-Site COW Water

Darigold’s COW process water is expected to be relatively clean compared to other processors’ water streams; therefore, it has flexible uses. The COW process water may be used for direct land application, mixed with other treated process water, or used onsite for lagoon washdown. A lift station and force main is proposed for conveying COW process water within the PWRF site to give flexibility for the process water’s on-site use.

6.2.4 Natural Gas

Natural gas will need to be supplied to the site for heating the LRAD. It is proposed that a 12-inch natural gas main be extended to the site along the existing 60-foot access and utility easement from E Foster Wells Road; however, the existing easement is explicit in its language regarding the number and type of utilities. Natural gas is not a listed utility. The Phase 3 contractor will bear the responsibility for obtaining a new easement and all costs for extending the natural gas pipeline. Alternatively, if an easement cannot be acquired from E Foster Wells Road, the natural gas main may come from north of the site.

6.2.5 Domestic Water

The City is installing a 20-inch high-density polyethylene (HDPE) water service from the E Foster Wells Road and Capital Avenue intersection to the IPS, screens building, and office trailer as part of the Phase 1 PWRF improvements to provide fire protection and potable water. This service will need to be extended to the pretreatment site to provide fire protection and potable water there as well.

6.2.6 Power and Fiber

The City is extending underground power and fiber infrastructure to existing facilities as part of the PWRF Phase 1 improvements. Franklin Public Utility District will install cables, conductors, and switch gear, and energize the power system as they are the utility purveyor. Power and fiber infrastructure for existing and proposed demands, including pretreatment, will be extended from E Foster Wells Road to the existing screens building as part of the Phase 1 improvements. Power and fiber infrastructure will then need to be extended to the pretreatment site.

6.2.7 Domestic Wastewater

Currently, domestic wastewater produced at the PWRF is discharged to a septic system. No domestic sanitary wastewater is discharged to the PWRF treatment system. A new small septic system to support the proposed pretreatment facilities will be evaluated during final design.

6.2.8 Stormwater

Stormwater discharge from the PWRF currently infiltrates into the surrounding ground surface or is directed into the PWRF treatment system. A Stormwater Pollution Prevention Plan (SWPPP) is located on file at the PWRF. The proposed improvements are intended to retain and infiltrate stormwater onsite. The detailed stormwater improvements design and permitting will be completed during final design. The SWPPP will be updated to address new construction.

6.3 Pretreatment System Improvements

The recommended pretreatment alternative is low rate anaerobic treatment followed by aerobic treatment, as described in Alternative 2 in **Chapter 5**, and summarized in the following sections.

As previously noted, multiple designers and vendors provide fully engineered, turnkey systems for both the anaerobic and aerobic treatment systems recommended for this application. For the purposes of detailing the recommended improvements, establishing design criteria, compiling a site layout, and estimating costs, the City consulted with Evoqua to provide a detailed scope and quotation for the entirety of the PWRF pretreatment systems, including preliminary treatment, and anaerobic and aerobic secondary treatment. Evoqua's preliminary design proposal is included in **Appendix F**. As previously noted, Evoqua uses BVF to denote the low rate anaerobic system. The proposal is preliminary and will be refined with final design. It is recommended that a competitive process occur for the selection of the system designer pending approval of this report and the general approach to pretreatment described herein.

6.3.1 Flow and Loading Criteria

The pretreatment system design criteria previously established in **Table 5-A** is reproduced in **Table 6-B**. Darigold's COW process water stream is shown separately in the table as it will not be discharged to the pretreatment system.

Table 6-B – Pretreatment System Flow and Loading Criteria

	Process Water to Pretreatment	Darigold COW
Flow		
Annual Average Day (MGD)	4.38	0.80
Total Annual (MG)	1,600	292
Maximum Month Average Day (MGD)	8.56	0.95
Peak Hour (Cumulative Lift Station Capacities) (gpm)	9,200	700
BOD		
Maximum Month Average Day (ppd)	300,000	40
TN		
Annual Average Day (ppd)	4,200	85

Note: Darigold's COW process water stream will not be discharged to the pretreatment system.

6.3.2 Raw Wastewater Pump Station

Evoqua's proposal includes a Raw Wastewater (RWW) Pump Station to which all forcemains discharge. The RWW is intended to lift the combined influent to a new above-grade headworks facility as discussed in **6.3.3 Preliminary Treatment**. The existing headworks is also above grade, and as such, it may be feasible to reroute the existing force mains to the proposed headworks without adding a new RWW Pump Station. However, the exact elevation of the new headworks equipment will be determined during final design through coordination with the proposed hydraulic profile and the available head from the existing lift station pumps. For conservative planning, the RWW Pump Station is included for budgeting. The pump station would be designed with multiple pumps with 100 percent redundancy in the largest pump. The pumps will operate on variable frequency drives (VFDs) for flow control. The pumps will be installed within a wet well.

6.3.3 Preliminary Treatment

A secondary treatment system for this application should be preceded by preliminary treatment consisting of screening to ¼ inch or less, as well as grit removal to protect downstream processes. The existing screens have much finer openings at 0.02-inch and are intended to provide BOD reduction as previously discussed. However, coarser ¼-inch screening is recommended as it should sufficiently protect downstream equipment and minimize the plugging issues noted with the existing fine screens. The proposed screens also will have much higher hydraulic throughput than the existing screens. Three above-grade internally fed rotary drum screens are recommended: two screens would be sized to provide capacity for the projected peak flow with the third screen providing redundancy. The screens will include automated screen washing equipment.

It is recommended that a new screening system be installed in conjunction with an automated grit removal system, both co-located at a new headworks facility. Construction of a new headworks will avoid disturbing the existing preliminary treatment system during construction and will allow the new headworks to be located near the other recommended pretreatment system improvements.

The grit system is assumed to consist of above-grade packaged vortex grit removal equipment and a classifier. The dewatered grit will be discharged to a dumpster for off-site disposal, likely via landfill. Complete redundancy likely is not be necessary for the grit removal system as short outages of this equipment would not be detrimental to downstream processes.

The headworks should be sized to accommodate the peak hour flow of 9,200 gpm. The basic design criteria for the preliminary treatment system is provided in **Table 6-C.**

Table 6-C – Preliminary Treatment Design Criteria

Parameter	
Influent Screening	
Screen Type	Rotary Drum
Screen Opening	1/4 in
Screen Quantity	3
Peak Hydraulic Capacity (per screen)	4,600 gpm
Grit Removal and Handling	
System Configuration	Vortex
System Peak Hydraulic Capacity	9,200 gpm
Pump Type	Recessed Impeller
Grit Washing System	Cyclone/Classifier

The headworks equipment will be enclosed in a building for weather protection and to confine influent odors.

6.3.4 Influent Equalization

Following preliminary treatment, Evoqua's preliminary design proposes 1.5 MG of covered, above-grade tankage for the equalization of screened and degritted influent. The vendor recommends providing this tankage to allow attenuation and homogenization of influent. The tank is intended to be completely mixed with mechanical mixers. Downstream of the tank, the influent pumps convey flow to secondary treatment.

During final design, the influent equalization system will be thoroughly reviewed. Some of the significant considerations related to this system include the following:

- Gravity flow between the proposed headworks, EQ tank, and influent pump station is intended, so the EQ storage elevations must be designed to fit within the hydraulic profile between the headworks and the influent pump station.
- Tank materials and construction must be appropriately chosen to ensure longevity under low pH influent conditions.
- The tank must be insulated if intended for use during winter months.
- Tank level, mixing, and downstream pumping control must be coordinated.
- The ability to bypass the tank for maintenance or other purposes should be considered

6.3.5 Influent Pump Station

The Evoqua design includes an influent pump station to convey equalized process water to secondary treatment. The pump station will be designed with multiple pumps with 100 percent redundancy in the largest pump. The pumps will operate on VFDs for flow control. The pumps will be installed in a dry pit.

The pump station will be configured to allow flow to be diverted and metered between the normal discharge to the anaerobic system, as well as alternate options, such as bypass, to the aerobic system and effluent system.

6.3.6 Influent Odor Control

Odor control likely will be necessary for portions of the influent system. Odor control should be considered for the RWW and influent pump stations, headworks, and EQ tankage. Various options for odor control will be evaluated during final design.

6.3.7 Low Rate Anaerobic Digestion for BOD Reduction

Evoqua's preliminary design proposal includes two 34.5 MG LRADs, each with approximately 181,000 square feet (sf) of internal floor area and 32 feet of wall height. The LRADs were sized to provide 90 percent BOD reduction for the maximum month BOD loading of 300,000 ppd. It is expected that the LRADs can accept BOD loading above this rate for up to one week, but provisions for bypass to the storage lagoons should be provided in case of longer sustained high loading. The LRADs also are expected to minimally reduce TN, which necessitates the downstream aerobic treatment system for the majority of the TN reduction.

Evoqua's design includes two sets of pumps and conveyance within each LRAD. The supernatant recycle (SREC) system, intended to buffer the effects of loading variation, conveys supernatant from the influent surface of each LRAD to the influent sludge bed of each LRAD. The SREC system also includes heat exchangers to be used with boilers to heat the LRADs to their design operating temperature of 85 degrees Fahrenheit. The return anaerobic sludge (RANS) system, intended to improve biomass-substrate contact, recycles sludge from the floor of the effluent end to the influent of each LRAD. The RANS system also can be used to waste sludge from the LRADs as needed.

Evoqua's proposal also includes effluent pumps from the LRADs to either the SBRs or the storage lagoons, depending on flow conditions.

6.3.8 Aerobic Activated Sludge for Nitrogen Reduction

Evoqua's preliminary design proposal uses two 2 MG SBRs, each with approximately 13,800 sf of internal floor area and 24 feet of wall height, for aerobic activated sludge treatment, but a CFR could be selected for the final design. Some influent bypasses the LRAD directly to the SBR to provide carbon. The SBRs are expected to reduce TN to below 30 mg/L. Since nitrogen reduction is only needed to stay below the land application capacity, flows above 4 MGD will bypass the SBR to the storage ponds.

Each SBR will perform cycles via a control system to provide treatment. Cycles generally include: Fill (influent feed to tank); Mix (anoxic period); React (aerated period); Settle (sludge settles to bottom of tank and a portion is wasted); and Decant (effluent is removed from top of tank). Per Evoqua's proposal, aeration diffusers provide the required oxygen for aerobic digestion and provide mixing in combination with floating mixers. WAS from the floor of the SBRs is recycled to the LRADs via a pipeline.

6.3.9 Solids Handling

A continual stream of WAS will be wasted from the aerobic process and discharged to the LRAD. Wasting of sludge from the LRAD is only required periodically. Evoqua's design currently proposes hauling the WAS off-site without dewatering when wasting is needed; however the final design will evaluate options for further solids processing such as permanent or temporary rental dewatering equipment on site. It is expected that the dewatered solids can be transported offsite for land application. Locations for land application are still being evaluated; the City will provide updated information as part of the permitting process for land application.

6.3.10 Gas Handling and Renewable Natural Gas

A floating geomembrane covers the LRAD basins and retains the biogas produced by the anaerobic process. Currently, a third party is interested in the financial opportunity of processing biogas produced by the LRADs into renewable natural gas (RNG) for resale, as discussed in **Section 6.8 – Project Schedule and Delivery Method**. Per Evoqua's preliminary design proposal, biogas production from the LRAD is estimated at an average annual rate of 1,830,000 cubic feet per day (ft^3/day) and a maximum month rate of 4,190,000 ft^3/day. Since biogas production trends with BOD loading, the maximum month biogas production will far exceed the average annual production. It is not expected to be financially advantageous to design the biogas processing for the maximum month production, so biogas in excess of the processing capacity will be flared or used to heat the LRADs. When biogas is being processed for resale, external natural gas is expected to be used in the boilers to heat the LRADs to their optimal operating temperature.

For flaring biogas, Ecology's air quality permitting requirements will need to be reviewed during final design. Scrubbing of biogas may be required prior to flaring.

6.3.11 Chemical Addition

Per Evoqua's preliminary design proposal, magnesium hydroxide will be added as needed upstream of the LRAD to raise the influent pH. Evoqua estimated that 207 gpd of a 60-percent magnesium hydroxide solution would be needed for pH adjustment. It is expected that the chemical addition can be decreased after startup since the large LRAD volume will act as a buffer for the influent pH. The pH of SBR influent should be maintained above approximately 6.5 s.u. to allow for stable nitrification and denitrification. Chemical addition prior to the SBR will be considered during final design.

A chemical feed system will be provided as part of the pretreatment improvements. For planning, approximately a 10,000-gallon tank and dual metering pumps are assumed for this system.

6.3.12 Effluent Screening

Operators at the PWRF have noted that fouling of the irrigation nozzles occurs frequently. The new LRAD system will substantially reduce the starches and other substances that may cause fouling in the existing system. However, the open storage lagoons can collect tumbleweeds and other debris that should be screened prior to distribution. Coarse filtration, as typically used for irrigation systems, is recommended. Automatic self-cleaning filters with a coarse filter likely would be appropriate for this application. Due to limited space in the wet well on the influent side of the existing IPS, the only option is to provide pressurized filtration downstream of the IPS. Multiple filters installed in parallel would be required to treat peak flow rates while providing at least one filter as a standby for redundancy. The filters would be installed above grade on a concrete slab; freeze protection will not be required as these will not operate during winter months. However, the manifold would be configured to allow for complete draining and isolation of each filter. The filters would automatically backflush to discharge the screenings based on increased pressure across the filters.

6.3.13 Other Considerations

6.3.13.1 Sampling

Flow-proportionate composite sampling will be required for both the raw influent and the effluent to the LTS for permit reporting. Intermediate sampling locations for process control sampling may require additional samplers and will be considered during final design.

6.3.13.2 Fire Protection Requirements

The Construction Phase 1 improvements will provide a sufficiently sized domestic water pipe to the proposed pretreatment site for fire flow. During final design, additional fire protection measures shall be evaluated in accordance with the appropriate National Fire Protection Association (NFPA) codes and standards, especially for wastewater process areas and gas handling areas.

6.3.13.3 Electrical Classification

The National Electrical Code and NFPA must be thoroughly reviewed during the final design to determine the electrical system requirements for each area of the pretreatment process. The extents and requirements for classified spaces, such as those where the hazard of flammable gas ignition is present, must be identified and the electrical system appropriately designed for these applications. In addition to providing suitable climate and odor control, building ventilation must be designed to meet NFPA requirements if air exchanges are used to reduce electrical classification.

6.3.13.4 Building Construction and Materials Selection

The final design will review the occupancy and classification of the buildings proposed for the site and will determine the appropriate materials of construction for each building to meet the intended use, classification, and fire protection requirements. The Washington State Energy Code will be reviewed to determine the specific construction requirements for each structure.

6.3.13.5 Back-up Power

The requirements for back-up power for the PWRF system will be determined during final design. The primary loads requiring back-up power will be identified for the purposes of sizing the back-up power system. It is assumed that a standby diesel generator will be provided onsite with an automatic transfer switch to automatically backup the critical facility loads in the event of an outage of the primary service.

6.3.13.6 Administration and Maintenance Facilities

The existing PWRF pretreatment facilities will be abandoned after the construction of the new pretreatment improvements. As such, the proposed improvements will require consideration of restrooms, offices, kitchen, breakroom, storage areas, maintenance shop or garage, and other items to be determined and configured in the final design. A small on-site laboratory is recommended for performing process control testing and potentially may be expanded to complete all permit testing if desired by the City. Proper separation of the administration and maintenance areas from process areas is critical to a suitable work environment for the operators and should be thoroughly reviewed during final design.

6.3.13.7 Site Security

Currently, the PWRF site is unsecured. Securing critical components of the new treatment facility and gas processing equipment will need to be evaluated during final design. At a minimum, this likely will include perimeter fencing and access gates.

6.3.14 Summary of Design Criteria for Recommended Pretreatment Improvements

The pretreatment flow and loading design criteria from **Table 6-B** is reproduced in **Table 6-D**, and a summary of the pretreatment design criteria is provided in **Table 6-E**.

Table 6-D – Pretreatment System Flow and Loading Criteria

	Process Water to Pretreatment
Flow	
Annual Average Day (MGD)	4.38
Total Annual (MG)	1,600
Maximum Month Average Day (MGD)	8.56
Peak Hour (Cumulative Lift Station Capacities) (gpm)	9,200
BOD	
Maximum Month Average Day (ppd)	300,000
TN	
Annual Average Day (ppd)	4,200

Table 6-E – Pretreatment Basic Design Criteria

Parameter	
Influent Screening	
Screen Type	Rotary Drum
Screen Opening	1/4 in
Screen Quantity	3
Peak Hydraulic Capacity (per screen)	4,600 gpm
Grit Removal and Handling	
System Configuration	Vortex
System Peak Hydraulic Capacity	9,200 gpm
Pump Type	Recessed Impeller
Grit Washing System	Cyclone/Classifier
pH Adjustment	
60% $Mg(OH)_2$ Solution	207 gpd
LRAD	
Basin Quantity	2
Basin Volume (per LRAD)	34.5 MG
SBR	
Basin Quantity	2
Basin Volume (per SBR)	2 MG

6.4 Storage System Improvements

6.4.1 Storage Projections

Process water produced outside of the irrigation season is stored in storage lagoons until the spring. By permit, land application is not allowed from December 1st through February 28th; however, the land application window is further limited by weather and crop demand, so storage should be planned for parts of November and March as well.

Projected winter storage needs can be estimated from the typical monthly flow distribution to the PWRF established in **Section 3.5.2 – Projected Flow** and the irrigation demand to the fields. As an initial estimate, RH2 Engineering, Inc., calculated the storage volume needed for each processor using a storage season of November 15th through March 15th (**Table 6-F**). This estimate assumes all process water produced outside of the storage season can be promptly applied to the fields, and all process water produced within the storage season must be stored through March 15th. A more detailed analysis of the storage requirement was completed using the difference between processors' typical monthly flow distribution and Valley's monthly design basis hydraulic capacity (**Table 4-K**), which yielded a storage requirement of 430 MG, slightly more than the initial estimate. Adding 8-percent contingency, the minimum recommended storage is approximately 465 MG. The existing PWRF site already provides 150 MG of winter storage (from the 115 and 35 MG storage lagoons), so at least 315 MG of additional winter storage is necessary.

Table 6-F – Projected Winter Storage

<table>
<tr><th></th><th>Nov. 15 - Mar. 15 Winter Storage Estimate (MG)</th><th></th></tr>
<tr><td>Pasco Processing</td><td>99</td><td></td></tr>
<tr><td>Twin City Foods</td><td>7</td><td></td></tr>
<tr><td>Reser's</td><td>39</td><td></td></tr>
<tr><td>Simplot</td><td>60</td><td></td></tr>
<tr><td>Grimmway</td><td>25</td><td></td></tr>
<tr><td>Freeze Pack</td><td>9</td><td rowspan="4">LTS Design Basis Hydraulic Capacity Winter Storage Estimate (MG)</td></tr>
<tr><td>Darigold WW</td><td>85</td></tr>
<tr><td>Total (no COW)</td><td>323</td></tr>
<tr><td>Darigold COW</td><td>93</td></tr>
<tr><td>Total (with COW)</td><td>416</td><td>430</td></tr>
</table>

1. *March 1st-15th and November 15th-30th storage are estimated as half of each monthly flow volume.*

6.4.2 Storage Lagoons

The proposed winter storage lagoons will be constructed on the Reclamation parcel north of the existing PWRF as shown in **Exhibit 6-A**. The preliminary site layout in **Exhibit 6-A** proposes approximately 329 MG of new storage, including a designated approximately 100 MG lagoon for Darigold's COW process water stream. Changes to grading in the final design may adjust the proposed storage volume, although it will remain above the required 315 MG. The incremental cost to add additional storage beyond the required 315 MG is very low compared to the cost of separately constructing that storage capacity in the future, so storage should be constructed to utilize the full parcel.

The embankments for the storage lagoons will be constructed with a maximum crest height of 14 feet, as measured from the lowest outside toe to the top of the embankment, to remain within Ecology's size classification as a small dam (below 15 feet). The embankments will be a minimum of 30 feet wide, with the final width to be determined by a structural analysis during the final design. The analysis will include seepage analysis, multiple breach analysis, drawdown analysis, and hazard classification. A geologic investigation with borings at the site will be conducted prior to the structural analysis, and findings will be submitted to Ecology in a separate geological report.

Based on discussions with Ecology, since the stored water is suitable for land application, Ecology's Water Quality Office (Water Quality) will defer to Ecology's Dam Safety Office (Dam Safety) for liner requirements. Based on previous geological investigations, groundwater is expected approximately 80 feet below the site. The structural analysis of the embankments will include a seepage analysis as if no liner were installed, so Dam Safety will not require a liner for structural purposes. However, a single layer of synthetic membrane liner is still proposed to accommodate utility terrain vehicles (UTVs) traveling along the bottom of the lagoons for maintenance. It is expected that the liner will be a reinforced HDPE material to prevent tearing, with ballast bags to keep the liner from lifting, and vents at the top of the liner to allow trapped gases to escape.

As shown in **Exhibit 6-A**, overflow pipes will be installed between the storage lagoons, with a final emergency overflow structure and spillway provided from the east proposed storage lagoon. The size and type of overflow will be determined with final design.

Additionally, the existing 5 MG lagoon will be decommissioned once all proposed PWRF improvements are operational. The lagoon will be filled in and all pipes routed to it will be capped.

6.5 Land Treatment System Improvements

The proposed LTS improvements are evaluated and described in **Chapter 4**. Approximately 514 acres of land treatment area will be added from the addition of the Beus Farms (Circle B19 in **Exhibit 4-F**) and Voss Farms land (Circles V6, V17, and V18 in **Exhibit 4-F**), making the total land treatment area 2,370 acres. Groundwater monitoring wells will be installed adjacent to the new fields (**Exhibit 4-F**).

Conveyance will be installed from the existing IPS to the proposed land treatment areas. PACE Engineers, Inc., (PACE) completed a separate study, the 2022 *Process Water Reuse Facility Land Treatment Evaluation* (2022 LTE), which evaluated the improvements needed to incorporate the proposed Voss Farms land, including the proposed conveyance.

The existing IPS was constructed to replace the previous IPS following recommendations from the 2019 Facility Plan. It conveys process water to the LTS via a 24-inch diameter irrigation force main. PACE's 2022 LTE recommended that the existing 24-inch-diameter force main be dedicated to convey process water to the Voss Farm circles and 2 existing north circles, and a new parallel 30-inch-diameter force main be installed to convey to the rest of the existing LTS circles.

The routing and sizing of conveyance to the proposed Beus Farms land will be determined with final design. For the purpose of estimating costs, it is assumed that conveyance to the Beus property will tee off of the existing 24 inch IPS discharge at the southeast corner of the existing PWRF parcel, run north to the north boundary of the north Reclamation parcel, and then turn west to the Beus property and route to its center irrigation pivot.

The Voss Farm circles are already equipped with pivots for irrigation. The Beus Farm circle will need to be equipped with an irrigation pivot and prepared for planting crops. The respective landowners will be responsible for improvements within their irrigation circles.

6.6 Project Schedule and Delivery Method

Near-term improvements to the PWRF are currently planned in three construction phases:

- Construction Phase 1 – Off-site Utilities – Begin Summer 2022
- Construction Phase 2 – Winter Storage Expansion – Begin Winter 2023
- Construction Phase 3 – Pretreatment System – Begin Winter 2023

Construction Phase 1 extends and relocates water, power, and fiber utilities to existing PWRF facilities and relocates a portion of two of the E Foster Wells Road force mains. Construction Phase 2 then constructs the proposed storage lagoons, begins site grading, and extends utilities constructed in Phase 1 to the proposed pretreatment site. In conjunction with Phase 2 construction, Darigold's WW and COW lift stations and force mains will be constructed, which will be Darigold's responsibility up to connection into the pretreatment facility. Construction Phases 1 and 2 will be implemented with a traditional design-bid-build project delivery method.

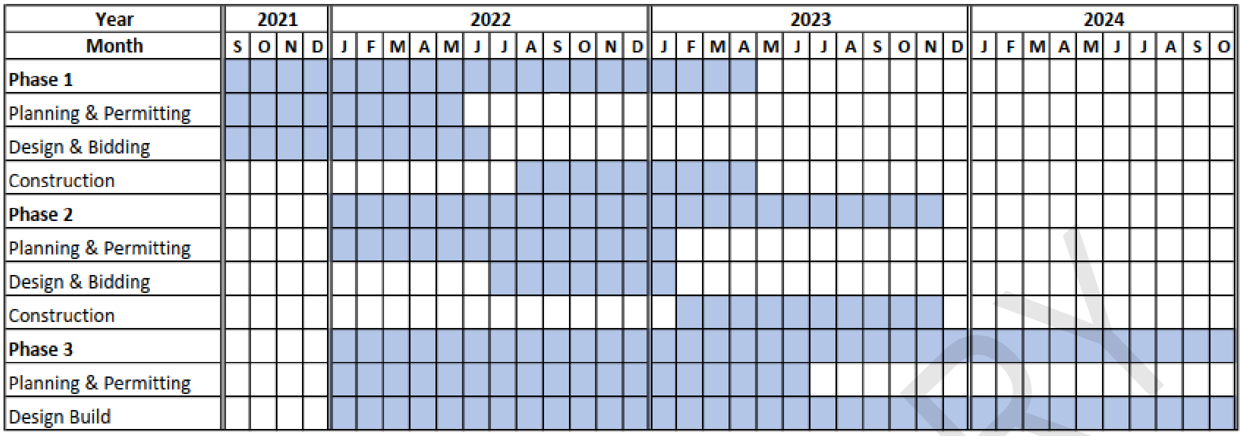
Construction Phase 3 will construct the pretreatment improvements on the designated area of the PWRF site. The City is pursing completing Construction Phase 3 through a design-build-own-operate project delivery method. This method was selected due to a third party's interest in the financial opportunity of reselling processed biogas from the LRAD as RNG. Through a public bid process, the City selected Burnham SEV Pasco LLC (Burnham) for the design, construction, operation, maintenance, and financing of the proposed pretreatment system, including the gas processing facility. Burnham will select subcontractors to design and construct the pretreatment improvements through a design-build contract.

Burnham not only intends to develop and build but also will provide operational services through a long-term 30 year agreement (the Water Treatment Agreement) with the City. Burhman will own the pretreatment improvements and lease the land from the City. The City will own and operate the conveyance lift stations, force mains, storage lagoons, and influent pump station. The City is currently working with Burnham and Ecology on the extent to which Burnham will be responsible under the revised updated permits to meet water quality discharge requirements.

The LTS improvements, including installing conveyance from the PWRF to the LTS and equipping the LTS for irrigation, will be complete in conjunction with Phase 3 improvements, separate from Burnham's contract.

Table 6-G shows the schedule for improvements. All improvements are planned to be completed by winter of 2024.

Table 6-G – Project Schedule



Year	2021				2022												2023												2024									
Month	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Phase 1	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																		
Planning & Permitting	▨	▨	▨	▨	▨	▨	▨	▨	▨																													
Design & Bidding	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																												
Construction												▨	▨	▨	▨	▨	▨	▨	▨	▨																		
Phase 2					▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨											
Planning & Permitting					▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																					
Design & Bidding											▨	▨	▨	▨	▨	▨	▨																					
Construction																		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨											
Phase 3					▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Planning & Permitting					▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																
Design Build					▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨

1. *LTS improvements will occur with the same overall schedule as the Phase 3 improvements, but under a separate contract.*

6.7 Estimated Capital Costs

The capital costs are summarized in the following Engineer's Opinion of Probable Construction Costs (OPCC) for Phase 1 (**Table 6-H**), Phase 2 (**Table 6-I**), Phase 3 (**Table 6-J**), and the LTS improvements (**Table 6-K**). The costs are planning-level estimates and have not yet been developed in detail.

Table 6-H – Phase 1 OPCC

Item Description	Total Amount
Preparation	$719,000
Water	$1,151,000
Sewer	$678,000
Electrical	$664,000
Surfacing/Paving	$1,132,000
Grading	$93,000
Erosion Control and Planting	$39,000
Traffic	$47,000
Other Items	$146,000
Subtotal	**$4,669,000**
Sales Tax - 8.1%	$374,000
Net Total, Including Sales Tax	**$5,043,000**

1. *Costs rounded to nearest $1,000*

Table 6-I – Phase 2 OPCC

Item Description	Total Amount
Preparation	$882,000
COW Water Lift Station and Force Main	$915,000
Potable Water	$73,000
Process Water	$2,529,000
Electrical	$26,000
Darigold Utilities	$612,000
Surfacing/Paving	$588,000
Grading	$14,583,000
Erosion Control and Planting	$79,000
Other Items	$832,000
Subtotal	**$21,117,000**
Contingency - 35%	$7,391,000
Sales Tax - 8.1%	$2,452,000
Net Total, Including Sales Tax	**$30,960,000**

1. *The "Darigold Utilities" item includes cost to construction lift stations and conveyance from Darigold's facility up to connection into the PWRF, which will be Darigold's responsibility.*
2. *Costs rounded to nearest $1,000.*

Table 6-J – Phase 3 OPCC

Item Description	Total Amount
Preliminary Treatment	$6,500,000
LRADs for BOD Reduction	$40,000,000
SBRs for Nitrogen Removal	$20,000,000
Additional Costs	$6,500,000
Total	**$73,000,000**

1. *Costs rounded to nearest $100,000.*
2. *Costs includes tax and indirect costs.*

Table 6-K – Land Treatment System Improvements OPCC

Item Description	Total Amount
Voss Farms and Existing LTS Conveyance	$3,401,000
Beus Farms Conveyance	$1,500,000
Subtotal	**$4,901,000**
Contingency - 40%	$1,960,000
Sales Tax - 8.1%	$590,000
Net Total, Including Sales Tax	**$7,451,000**

1. *The "Voss Farms and Exiting LTS Conveyance" item is the rough order of magnitude cost estimates from 2022 PACE 2022 LTE.*
2. *Costs rounded to neared $1,000.*

The total estimated capital cost of the proposed improvements is $117 M.

6.8 Estimated Operating and Maintenance Costs

Burnham (the Phase 3 Contractor discussed in **Section 6.6 – Project Schedule and Delivery Method**) developed an estimate for the annualized total operating costs for the proposed pretreatment improvements based on Evoqua's preliminary design proposal (**Table 6-L**).This estimate does not include costs for RNG processing.

Per Evoqua's proposal, the improvements are estimated to require 3 operators working 12 hours per day, 7 days per week, as well as one FTE for maintenance. Labor costs include costs for operations, maintenance, and an asset fee. The major electrical loads are primarily associated with the aeration equipment for the aerobic treatment system. The annualized solids handling costs will cover the periodic removal of sludge from the LRAD. Consumables costs include chemical addition for pH adjustment as needed and minor equipment replacement. Per discussion with Burnham's team, their capital costs estimate (**Table 6-J**) also includes costs for pre-purchase of spare equipment, so costs for equipment replacement typical of this type of estimate are captured between the capital and operating and maintenance costs. Costs assume that biogas can be used to heat the LRADs.

Table 6-L – Annual Operating and Maintenance Costs

Item	Cost
Labor	$1,600,000
Electricity	$650,000
Sludge Hauling and Disposal	$1,100,000
Consumables	$475,000
Total Annual	**$3,850,000**

1. *Estimate developed by Burnham based on Evoqua's preliminary design proposal.*

6.9 SEPA Compliance Statement

State Environmental Policy Act (SEPA) Checklist will be completed after Ecology's review of this report.

No other state or local water quality monitoring plans will limit the project.

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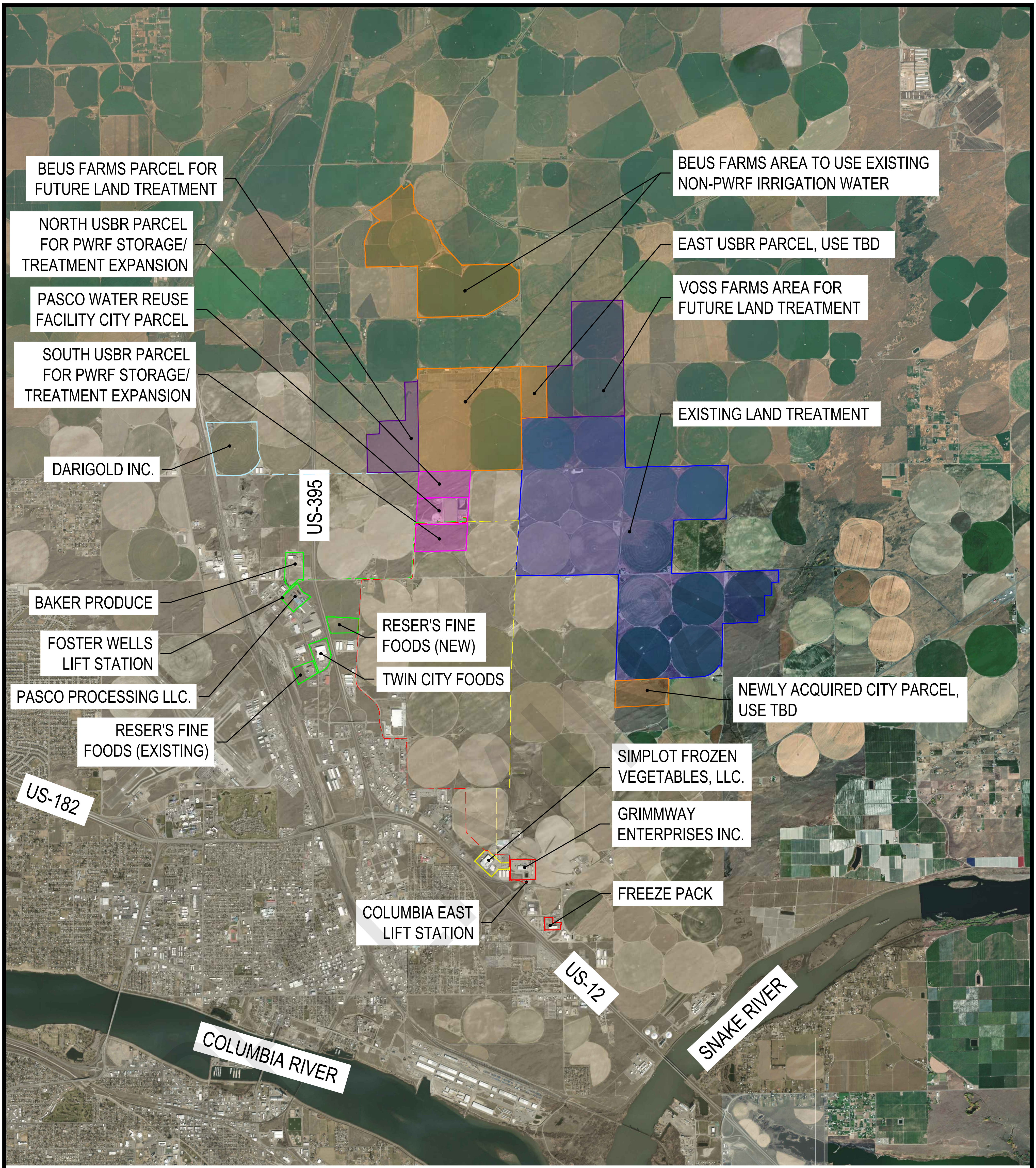
Exhibits



LEGEND

🟦	EXISTING LAND TREATMENT
🟪	PROPOSED LAND TREATMENT
🟪	PWRF PROPERTY
🟧	OTHER PROPERTY (LABELED)
– – – – –	COLUMBIA EAST LIFT STATION (CELS) CONVEYANCE (APPROX. 6 MI)
– – – – –	FOSTER WELLS LIFT STATION (FWLS) CONVEYANCE (APPROX 2.5 MI)
– – – – –	DARIGOLD CONVEYANCE (APPROX. 2 MI)
– – – – –	SIMPLOT CONVEYANCE (APPROX. 4 MI)
——	PROCESSOR DISCHARGING TO CELS
——	PROCESSOR DISCHARGING TO FWLS
——	DARIGOLD
——	SIMPLOT

NOTES

LIFT STATION PEAK FLOW CAPACITIES
CELS = 2,174 GPM CURRENT; 4,171 GPM FUTURE
FWLS = 4,300 GPM
DARIGOLD WASTEWATER = 700 GPM
DARIGOLD COW = 700 GPM
SIMPLOT LIFT STATION = 1,200 GPM CURRENT; FUTURE SHUTDOWN

EXHIBIT 1-A OVERVIEW

PASCO PROCESS WATER REUSE FACILITY

SCALE: 1"=5000'
0" 1/2" 1"
DRAWING IS FULL SCALE WHEN BAR MEASURES 1"

PLOT DATE: 7/13/2022
FILE PATH: \\corp.rh2.com\dfs\projects\Data\PSC\22-0034\CAD\pwrf-e-overview.dwg

(SOURCE: Google Earth Pro Image April 2021, ©2022 Google™)

0 4500'

1" = 4500'

(SCALE AND LOCATIONS ARE APPROXIMATE)

N

Exhibit 4-A. Area Map

PROJECT NUMBER: 2022230003	Land Treatment System Engineering Report RH2 Engineers, Inc.
DATE: 6/15/2022	
DWG NO: 2022230003 EXHIBITS.DWG	City of Pasco Pasco, Washington
DWG BY: 6NSG PROJECT MANAGER: 6SLV	
REVISED:	VALLEY SCIENCE AND ENGINEERING

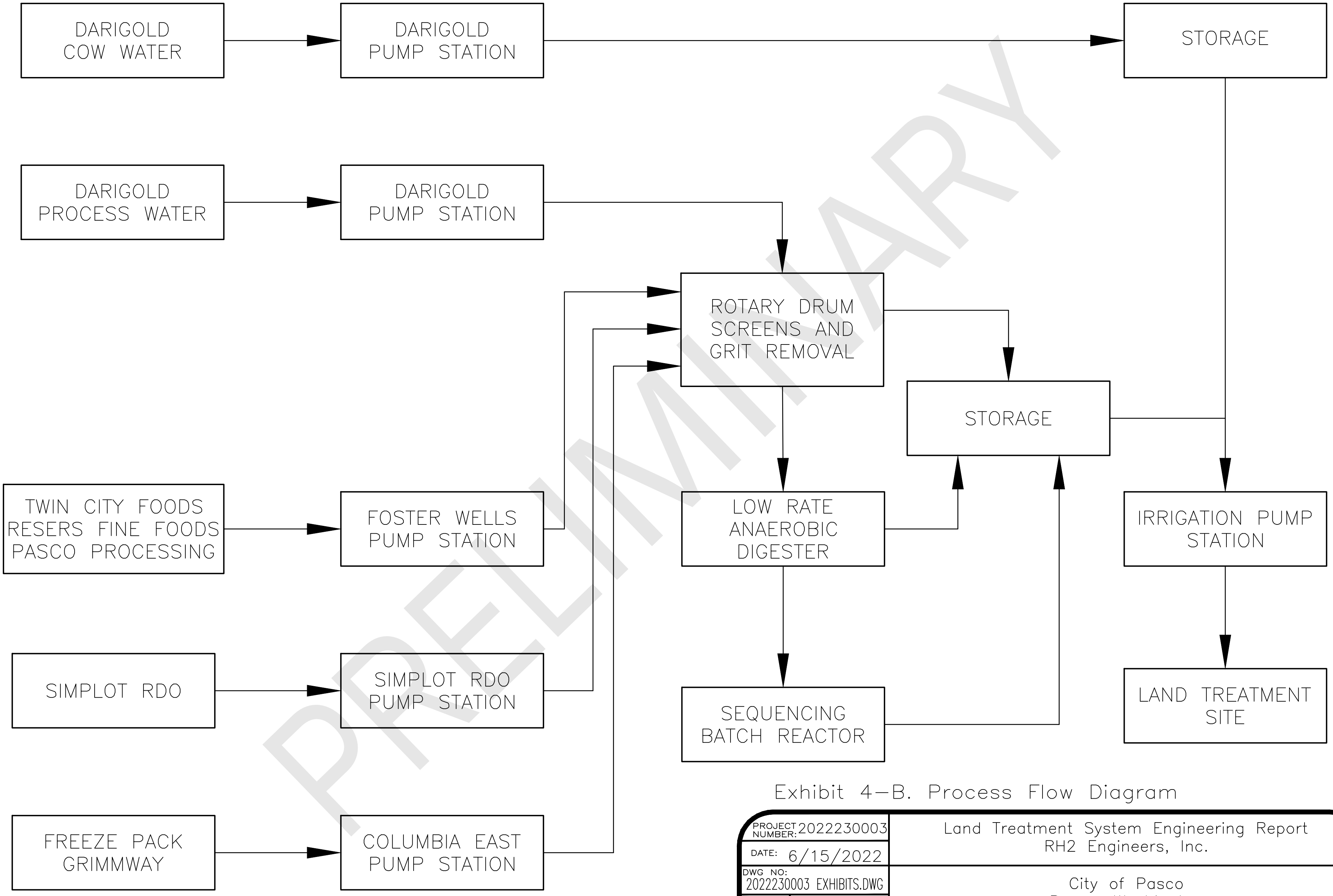


Exhibit 4–B. Process Flow Diagram

PROJECT NUMBER: 2022230003
DATE: 6/15/2022
DWG NO: 2022230003 EXHIBITS.DWG
DWG BY: 6NSG
PROJECT MANAGER: 6SLV
REVISED:

Land Treatment System Engineering Report
RH2 Engineers, Inc.

City of Pasco
Pasco, Washington

VALLEY SCIENCE AND ENGINEERING

EXPLANATION

01 EXISTING LAND TREATMENT CIRCLE

B19 EXPANSION LAND TREATMENT CIRCLE

(SOURCE: Google Earth Pro Image April 2021, ©2022 Google™)

Exhibit 4–C. Land Treatment Site Map

PROJECT NUMBER: 2022230003	Land Treatment System Engineering Report RH2 Engineers, Inc.
DATE: 6/15/2022	
DWG NO: 2022230003_EXHIBITS.DWG	City of Pasco Pasco, Washington
DWG BY: 6NSG PROJECT MANAGER: 6SLV	
REVISED:	VALLEY SCIENCE AND ENGINEERING

EXPLANATION

(01) EXISTING LAND TREATMENT CIRCLE

(B19) EXPANSION LAND TREATMENT CIRCLE

(89) SOIL MAP UNITS AND BOUNDARIES

0 2000'

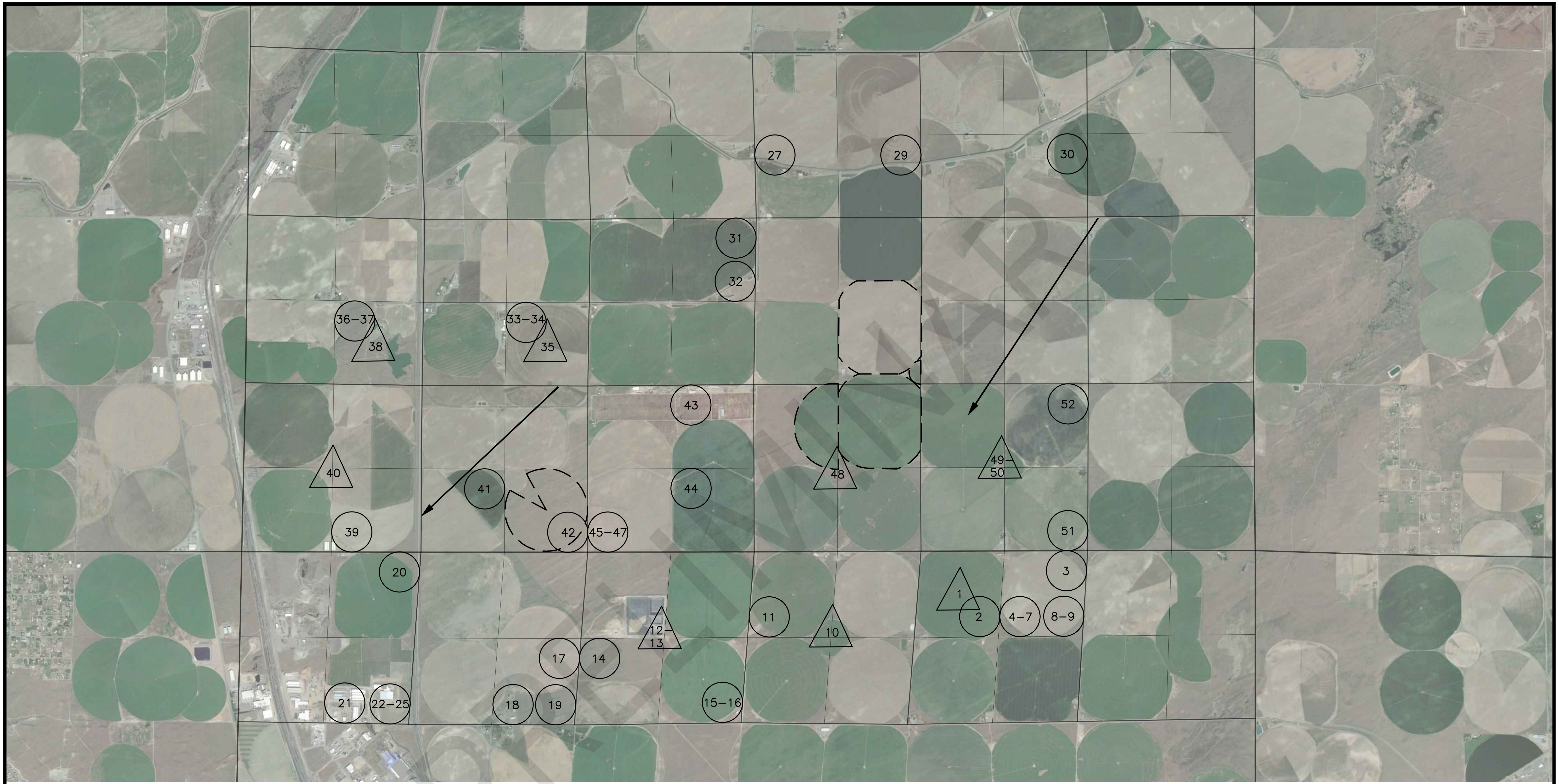
1" = 2000'

(SCALE AND LOCATIONS ARE APPROXIMATE)

(SOURCE: Google Earth Pro Image April 2021, ©2022 Google™)

Exhibit 4–D. Soil Map

PROJECT NUMBER: 2022230003	Land Treatment System Engineering Report RH2 Engineers, Inc.
DATE: 6/15/2022	
DWG NO: 2022230003_EXHIBITS.DWG	City of Pasco Pasco, Washington
DWG BY: 6NSG PROJECT MANAGER: 6SLV	
REVISED:	VALLEY SCIENCE AND ENGINEERING



EXPLANATION

△ 1 WELL LOCATION IDENTIFICATION
QUARTER OF SECTION OR NOT RECORDED

② WELL LOCATION IDENTIFICATION
QUARTER QUARTER OF SECTION

◌ EXPANSION LAND TREATMENT CIRCLE

→ ESTIMATED DIRECTION OF GROUNDWATER FLOW

(SOURCE: Google Earth Pro Image April 2021, ©2022 Google™)

SECTION KEY:

T10N R30E					
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36
06	05	04	03	02	01

T09N R30E

0 3000'

1" = 3000'

(SCALE AND LOCATIONS ARE APPROXIMATE)

N

Exhibit 4–E. Wells Within 1–Mile of the Expansion Sites

PROJECT NUMBER: 2022230003

DATE: 6/15/2022

DWG NO: 2022230003_EXHIBITS.DWG

DWG BY: 6NSG

PROJECT MANAGER: 6SLV

REVISED:

Land Treatment System Engineering Report
RH2 Engineers, Inc.

City of Pasco
Pasco, Washington

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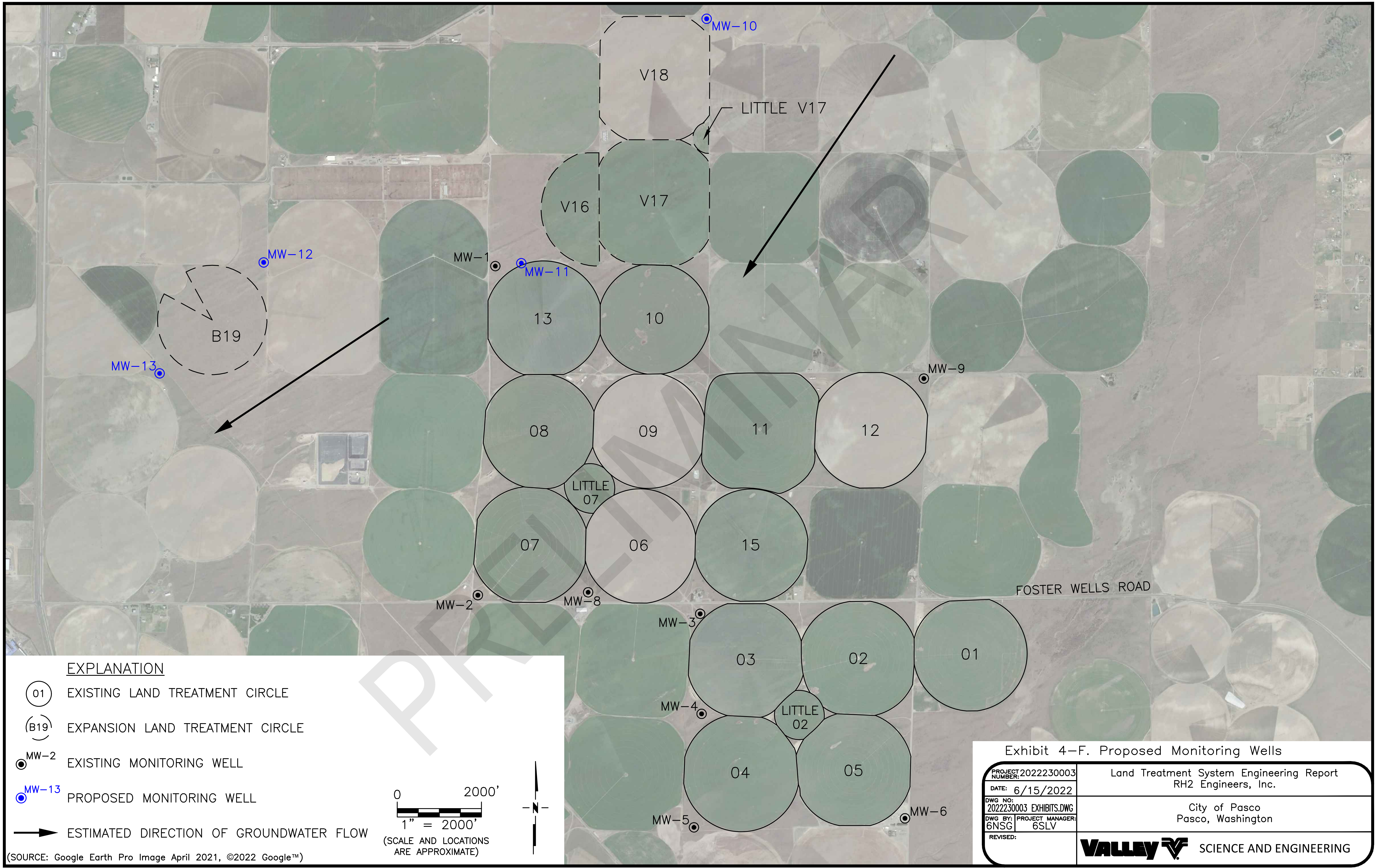
Exhibit 4–F. Proposed Monitoring Wells



(SOURCE: Google Earth Pro Image April 2021, ©2022 Google™)

PROJECT NUMBER: 2022230003
DATE: 6/15/2022
DWG NO: 2022230003 EXHIBITS.DWG
DWG BY: 6NSG
PROJECT MANAGER: 6SLV
REVISED:

Land Treatment System Engineering Report
RH2 Engineers, Inc.

City of Pasco
Pasco, Washington

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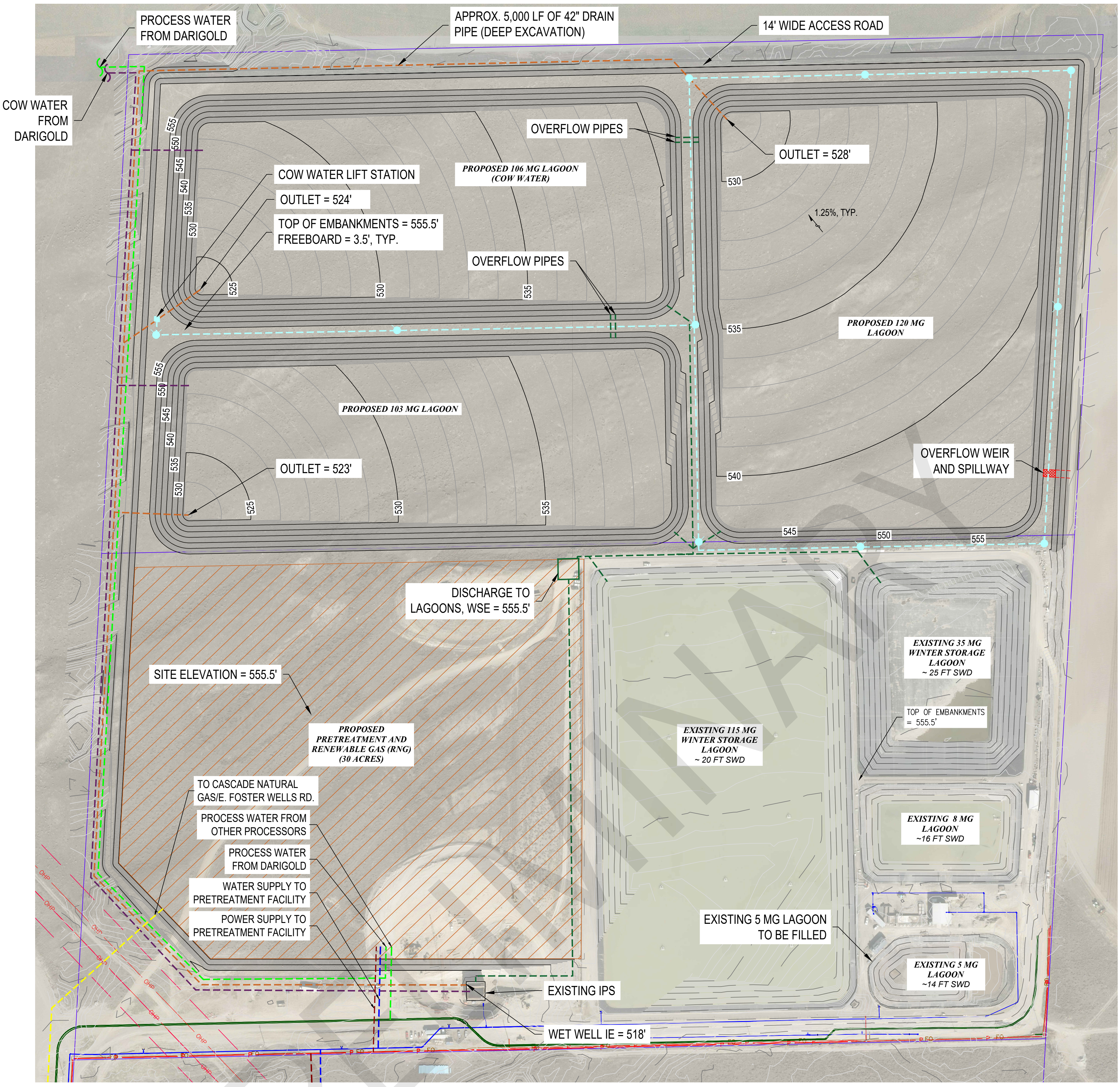


PRELIMINARY PWRF STORAGE LAYOUT
NTS

LAGOON STORAGE

Lagoon	Winter Storage (MG)
PROPOSED 106 MG LAGOON	106
PROPOSED 103 MG LAGOON	103
PROPOSED 120 MG LAGOON	120
Total	**329**

LEGEND

- - - - - - - -	PROCESS WASTEWATER
- - - - - - - -	COW WATER FORCE MAIN
- - - - - - - -	TREATED WASTEWATER (TO LAGOONS/IPS)
- - - - - - - -	GRAVITY DRAINS (TO IPS)
- - - - - - - -	TREATED WASTEWATER FORCE MAIN (FROM LAGOONS)
- - - - - - - -	POWER LINE
- - - - - - - -	NATURAL GAS LINE
- - - - - - - -	WATER LINE

EXHIBIT 6-A

PRELIMINARY STORAGE LAYOUT
PROCESS WATER REUSE FACILITY

RH2
Pasco

SCALE: NTS

Tables

Table 4-A. Climate Summary

Month	Precipitation [1]		Potential Crops and Evapotranspiration [2]							
	Average	Normalized 10-Year Return	Alfalfa	Potato / Alfalfa	Alfalfa / Corn	Timothy / Corn	Corn	Potato	Triticale / Corn	Bare Soil
	inches									
Nov	0.6	0.8	1.3	0.8	1.3	1.0	0.8	0.8	1.0	0.8
Dec	1.0	1.4	0.8	0.6	0.8	0.6	0.6	0.6	0.6	0.6
Jan	0.8	1.2	0.9	0.7	0.9	0.7	0.7	0.7	0.7	0.7
Feb	0.5	0.7	1.6	0.8	1.6	1.1	0.8	0.8	1.1	0.8
Mar	0.5	0.7	3.4	1.3	3.4	2.6	1.3	1.3	2.6	1.3
Apr	0.4	0.6	5.4	1.4	5.4	4.1	1.0	1.4	4.1	1.6
May	0.5	0.8	7.4	4.5	7.4	5.6	3.8	4.5	5.6	1.9
Jun	0.5	0.7	9.0	9.0	6.6	5.5	8.4	9.0	5.5	2.0
Jul	0.1	0.2	10.2	10.3	8.1	8.1	10.8	10.3	8.1	2.1
Aug	0.2	0.2	8.3	4.9	7.7	7.7	7.7	4.9	7.7	1.9
Sep	0.3	0.4	5.1	2.6	0.8	0.8	0.8	1.6	0.8	1.6
Oct	0.5	0.7	2.9	2.9	0.8	0.8	0.8	1.2	0.8	1.2
Total	**5.7**	**8.3**	**56.4**	**39.9**	**44.7**	**38.4**	**37.6**	**37.2**	**38.4**	**16.5**

NOTES:

All data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

[1] Average precipitation is based on actual monthly precipitation from 2001 through 2021. The normalized 10-year return is the 2nd highest total annual precipitation out of 20 years (8.3 inches from 2015-2016) normalized in relation to the long-term average for each month for design purposes.

[2] Evapotranspiration is the average of actual monthly data from 2001-2021 for crops typically grown at the land treatment site. Bare soil evaporation is calculated using the 10-year return precipitation and average reference evapotraspiration data (Snyder, Orang, Matyac, & Eching, 2007). Bare soil evapotranspiration is used when AgWeatherNet evapotranspiration is less than fallow evapotranspiration or when crops are not in place.

Table 4-B. Published Soil Type and Physical Properties

Soil Map Unit	Soil Unit Name	Soil Name	Proportion of Land Treatment Site	Texture	Depth	Bulk Density	Perm [1]	Average Available Soil Water Holding Capacity [2]			Water Content at Permanent Wilting Point [3]	Field Capacity [4]	Organic Matter
					inches	g/cc	in/hr	in/in	Thickness				%
									inches				
29	Hezel loamy fine sand, 0 to 15% slopes	Hezel	7.9%	loamy fine sand	0-7	1.25-1.45	1.3	0.09-0.13	7	0.77	0.31	1.08	0.0-0.5
				loamy fine sand, loamy sand, fine sand	7-18	1.40-1.60	1.3	0.08-0.12	11	1.10	0.12	1.22	0.0-0.5
				fine sandy loam, very fine sandy loam, silt loam	18-27	1.30-1.50	1.3	0.13-0.21	9	1.53	0.35	1.88	0.0-0.5
				stratified fine sandy loam to silt loam	27-60	1.30-1.50	1.3	0.13-0.21	33	5.61	1.46	7.07	0.0-0.5
								Total	**60**	**9.01**	**2.24**	**11.25**	
43	Kennewick silt loam, 0 to 2% slopes	Kennewick	0.2%	silt loam	0-8	1.15-1.35	9.2	0.19-0.21	8	1.60	0.45	2.05	0.5-1.0
				silt loam	8-60	1.30-1.50	2.8	0.18-0.20	52	9.88	3.64	13.52	0.0-0.5
								Total	**60**	**11.48**	**4.08**	**15.56**	
89	Quincy loamy fine sand, 0 to 15% slopes	Quincy	61.1%	loamy fine sand	0-4	1.50-1.65	13.0	0.09-0.11	4	0.40	0.09	0.49	0.5-1.0
				loamy fine sand, fine sand	4-60	1.50-1.65	13.0	0.05-0.11	56	4.48	1.35	5.83	0.0-0.5
								Total	**60**	**4.88**	**1.44**	**6.32**	
92	Quincy loamy fine sand, loamy substratum, 0 to 10% slopes	Quincy	7.1%	loamy fine sand	0-3	1.25-1.45	13.0	0.08-0.11	3	0.29	0.10	0.39	1.0-2.0
				loamy fine sand	3-52	1.30-1.50	13.0	0.08-0.11	49	4.66	1.18	5.83	0.0-0.5
				silt loam, very fine sandy loam, fine sandy loam	52-60	1.50-1.70	1.3	0.16-0.18	8	1.36	0.41	1.77	0.0-0.5
								Total	**60**	**6.30**	**1.69**	**7.99**	
97	Quincy-Hezel complex, 0 to 15% slopes	Quincy	9.6%	loamy fine sand	0-7	1.50-1.65	13.0	0.09-0.11	7	0.70	0.16	0.86	0.5-1.0
				loamy fine sand, fine sand	7-18	1.50-1.65	13.0	0.05-0.11	11	0.88	0.26	1.14	0.0-0.5
		Hezel		loamy fine sand	0-7	1.25-1.45	13.0	0.09-0.13	7	0.77	0.31	1.08	0.0-0.5
				loamy fine sand, loamy sand, fine sand	7-18	1.40-1.60	13.0	0.08-0.12	11	1.10	0.12	1.22	0.0-0.5
				fine sandy loam, very fine sandy loam, silt loam	18-27	1.30-1.50	1.3	0.13-0.21	9	1.53	0.35	1.88	0.0-0.5
				stratified fine sandy loam to silt loam	27-60	1.30-1.50	0.4	0.13-0.21	33	5.61	1.69	7.30	0.0-0.5
Quincy (7-18 inches) + Hezel (18-60 inches)								**Total**	**60**	**8.72**	**2.46**	**11.18**	
Hezel								**Total**	**60**	**9.01**	**2.89**	**13.48**	
126	Royal loamy fine sand, 0 to 10% slopes	Royal	0.1%	loamy fine sand	0-6	1.35-1.45	13.0	0.09-0.11	6	0.60	0.21	0.81	0.5-1.0
				fine sandy loam, very fine sandy loam	6-19	1.30-1.50	4.0	0.13-0.17	13	1.95	0.66	2.61	0.0-0.5
				stratified fine sand to very fine sandy loam	19-60	1.40-1.60	4.0	0.10-0.14	41	4.92	1.36	6.28	0.0-0.5
								Total	**60**	**7.47**	**2.24**	**9.71**	

Table 4-B. Published Soil Type and Physical Properties

Soil Map Unit	Soil Unit Name	Soil Name	Proportion of Land Treatment Site	Texture	Depth	Bulk Density	Perm [1]	Average Available Soil Water Holding Capacity [2]			Water Content at Permanent Wilting Point [3]	Field Capacity [4]	Organic Matter
									Thickness				
					inches	g/cc	in/hr	in/in	inches				%
128	Royal fine sandy loam, 0 to 2% slopes	Royal	5.1%	fine sandy loam	0-5	1.30-1.40	4.0	0.13-0.15	5	0.70	0.27	0.97	0.5-1.0
				fine sandy loam, very fine sandy loam	5-15	1.30-1.50	4.0	0.13-0.17	10	1.50	0.51	2.01	0.0-0.5
				stratified fine sand to very fine sandy loam	15-60	1.40-1.60	4.0	0.10-0.14	45	5.40	2.30	7.70	0.0-0.5
								Total	**60**	**7.60**	**3.08**	**10.68**	
129	Royal fine sandy loam, 2 to 5% slopes	Royal	0.3%	fine sandy loam	0-5	1.30-1.40	28.2	0.13-0.15	5	0.70	0.35	1.05	0.5-1.0
				fine sandy loam	5-15	1.30-1.50	28.2	0.13-0.17	10	1.50	0.51	2.01	0.0-0.5
				fine sand, very fine sandy loam	15-60	1.40-1.60	28.2	0.10-0.14	45	5.40	1.50	6.90	0.0-0.5
								Total	**60**	**7.60**	**2.35**	**9.95**	
144	Sagemoor very fine sandy loam, 0 to 2% slopes	Sagemoor	5.1%	very fine sandy loam	0-4	1.20-1.35	1.3	0.16-0.20	4	0.72	0.26	0.98	1.0-2.0
				silt loam	4-9	1.20-1.35	1.3	0.16-0.20	5	0.90	0.31	1.21	1.0-2.0
				silt loam, very fine sandy loam	9-18	1.30-1.40	1.3	0.18-0.20	9	1.71	0.53	2.24	0.0-0.5
				silt loam, very fine sandy loam	18-60	1.30-1.45	0.4	0.18-0.21	42	8.19	2.48	10.67	0.0-0.5
								Total	**60**	**11.52**	**3.59**	**15.11**	
145	Sagemoor very fine sandy loam, 2 to 5% slopes	Sagemoor	2.9%	very fine sandy loam	0-4	1.20-1.35	1.3	0.16-0.20	4	0.72	0.26	0.98	1.0-2.0
				silt loam	4-9	1.20-1.35	1.3	0.16-0.20	5	0.90	0.31	1.21	1.0-2.0
				silt loam, very fine sandy loam	9-18	1.30-1.40	1.3	0.18-0.20	9	1.71	0.53	2.24	0.0-0.5
				silt loam, very fine sandy loam	18-60	1.30-1.45	0.4	0.18-0.21	42	8.19	2.48	10.67	0.0-0.5
								Total	**60**	**11.52**	**3.59**	**15.11**	
146	Sagemoor very fine sandy loam, 5 to 10% slopes	Sagemoor	0.5%	very fine sandy loam	0-4	1.20-1.35	1.3	0.16-0.20	4	0.72	0.26	0.98	1.0-2.0
				silt loam	4-9	1.20-1.35	1.3	0.16-0.20	5	0.90	0.31	1.21	1.0-2.0
				silt loam, very fine sandy loam	9-18	1.30-1.40	1.3	0.18-0.20	9	1.71	0.53	2.24	0.0-0.5
				silt loam, very fine sandy loam	18-60	1.30-1.45	0.4	0.18-0.21	42	8.19	2.48	10.67	0.0-0.5
								Total	**60**	**11.52**	**3.59**	**15.11**	

NOTES:

Summary of Natural Resource Conservation Service Web Soil Survey of area of interest (Soil Survey Staff, Natural Resources Conservation Service, n.d.).

Abbreviations: g/cc = grams per cubic centimeter, in/hr = inches per hour, in/in = inches per inch, Perm = permeability.

1 The permeability range values are from the Web Soil Survey for Franklin County. Permeability is the same as saturated hydraulic conductivity (Ksat), which is substantially lower than infiltration.

2 Available soil water holding capacity is the amount of water available to plants between field capacity and the permanent wilting point. The average available soil water holding capacity (inches) was calculated using the average of the range of the in/in values multiplied by the thickness of the horizon.

3 Estimated using estimates of sand, silt, organic matter, and gravel content to match the average soil available water holding capacity for each horizon using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

4 Field capacity is the water content of the soil after the drainage of excess water by gravity has ceased.

Table 4-C. Circle-Specific Soil Water Capacity

Soil Map Unit[1]		29	43	89	92	97	126	128	129	144	145	146	Average Field Capacity[7]	Average Available Capacity[7]
Depth	inches	60	60	60	60	60	60	60	60	60	60	60		
Field Capacity[2]		11.2	6.3	6.3	8.0	13.5	9.7	10.7	10.0	15.1	15.1	15.1		
Available Capacity[3]		9.0	4.9	4.9	6.3	9.0	7.5	7.6	7.6	11.5	11.5	11.5		
Wilting Point[4]		2.2	1.4	1.4	1.7	2.9	2.2	3.1	2.4	3.6	3.6	3.6		
Circle[5]	acres	Percentage[6]											inches	
1	122	25.4	--	27.6	--	16.0	--	--	--	19.5	11.5	--	11.4	8.6
2	152	4.4	--	28.7	--	24.2	--	--	--	39.5	3.2	--	12.0	8.9
3	128	--	--	81.3	--	--	--	--	--	5.7	13.0	--	8.0	6.1
4	128	--	--	65.5	--	34.5	--	--	--	--	--	--	8.8	6.3
5	128	--	--	30.9	--	55.2	--	--	--	--	13.9	--	11.5	8.1
6	128	--	--	81.1	12.5	--	--	6.4	--	--	--	--	6.8	5.2
7	152	--	--	28.5	42.0	--	--	29.5	--	--	--	--	8.3	6.3
8	128	--	--	85.3	10.3	--	--	4.4	--	--	--	--	6.7	5.1
9	128	--	--	99.8	0.2	--	--	--	--	--	--	--	6.3	4.9
10	128	--	--	83.3	--	--	--	16.7	--	--	--	--	7.0	5.3
11	150	--	--	75.0	--	22.1	0.7	--	--	2.2	--	--	8.1	6.0
12	128	61.5	--	16.4	--	--	--	--	--	4.5	7.5	10.1	11.3	8.9
13	128	--	--	98.5	1.5	--	--	--	--	--	--	--	6.3	4.9
15	128	--	--	59.3	--	19.0	--	--	--	16.3	5.4	--	9.6	7.1
V16	70	--	--	89.2	10.4	--	--	--	0.4	--	--	--	6.5	5.0
V17	169	38.6	--	49.7	6.4	--	--	1.8	3.4	--	--	--	8.5	6.7
V18	164	2.7	2.3	68.5	26.5	--	--	--	--	--	--	--	6.9	5.4
B19	111	--	--	52.8	10.8	--	2.1	34.4	--	--	--	--	8.1	6.0

NOTES:

Summary of information from the Natural Resource Conservation Service Web Soil Survey of area of interest (Soil Survey Staff, Natural Resources Conservation Service, n.d.).

Abbreviation: -- = soil map unit not found.

[1] The soil map unit is used to represent the soil unit on the soil survey map.

[2] Field capacity is the maximum amount of water the soil can hold against gravitational forces.

[3] Available water is the amount of water available to the crop. It is the difference between field capacity and the water content at wilting point.

[4] Wilting point is the water content remaining in the soil that is too difficult for the crop to uptake.

[5] Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7. Circle V17 is Circle V17 plus Little Circle V17.

[6] The percentage of each soil unit by circle is based on the Web Soil Survey mapping.

[7] Averages are weighted by soil-type (soil map unit) percentages. Average field capacity = the sum of products of circle-specific field capacity and soil map unit percentages, divided by the sum of the soil map unit percentages (100). Average available capacity is calculated in the same way as field capacity, except using available capacity instead of field capacity.

Table 4-D. Soil Analytical Results

Circle [1]	Depth	ESP	CEC	OM	TKN	NO_3-N	NH_4-N	Total P	EC	Na	Ca	Mg	K	SO_4-S	pH
	ft bgs	%	meq/100g	%	mg/kg				mmhos/cm	meq/100g			mg/kg		s.u.
1	1	3.1	9.3	1.2	770	13.3	7.5	911	0.39	0.36	8.5	2.4	404	16	7.7
	2	2.2	8.3	0.4	307	5.3	1.1	699	0.22	0.25	9.4	3.0	234	10	7.9
	3	1.7	9.4	0.5	368	6.7	1.6	698	0.27	0.31	14.5	3.1	163	17	8.2
	4	1.9	10.6	0.3	285	1.5	1.0	395	0.18	0.39	15.4	3.4	100	8	8.4
	5	2.5	11.2	0.3	235	3.0	1.0	694	0.19	0.48	14.4	3.7	157	7	8.5
2	1	2.2	12.3	1.3	1,021	11.2	4.6	915	0.40	0.31	9.2	3.4	470	16	7.5
	2	2.3	12.7	0.6	539	5.0	1.1	761	0.29	0.43	15.2	4.1	194	13	8.1
	3	2.4	15.4	0.5	525	5.9	2.4	753	0.29	0.56	16.8	5.6	229	14	8.2
	4	2.3	15.5	0.4	378	3.4	1.1	736	0.29	0.55	17.6	5.8	241	14	8.5
	5	2.8	17.5	0.4	340	7.7	1.0	706	0.39	0.73	18.1	6.7	283	26	8.5
3	1	2.4	10.9	1.1	1,188	3.3	13.7	1,115	0.22	0.29	7.6	3.3	425	5	7.7
	2	2.8	12.5	0.4	560	1.2	1.4	900	0.26	0.52	14.3	3.9	200	24	8.3
	3	2.3	12.4	0.3	471	1.3	2.1	887	0.31	0.42	14.8	3.9	145	28	8.2
	4	2.2	12.5	0.2	381	4.4	1.6	843	0.24	0.43	14.4	4.3	143	16	8.3
	5	2.3	11.7	0.2	364	6.5	1.5	888	0.25	0.41	12.7	4.2	190	13	8.2
4	1	2.4	8.5	1.0	1,047	4.7	11.6	1,113	0.21	0.20	4.7	2.3	377	4	7.4
	2	3.0	6.5	0.3	363	1.0	1.0	864	0.15	0.27	6.7	2.4	255	5	8.0
	3	2.2	7.2	0.3	379	1.8	1.7	851	0.18	0.28	10.1	2.6	222	7	8.0
	4	2.3	7.0	0.2	338	4.1	1.0	825	0.19	0.30	10.6	2.3	169	8	8.0
	5	1.8	7.8	0.2	320	7.1	1.1	783	0.25	0.28	12.8	2.1	176	12	8.2
5	1	2.0	9.5	1.2	1,158	7.5	15.0	1,150	0.28	0.23	8.0	2.3	458	5	7.7
	2	2.8	7.8	0.3	386	2.7	1.1	860	0.23	0.35	9.9	2.5	175	11	8.2
	3	2.6	7.1	0.3	380	2.5	1.5	866	0.26	0.28	7.8	2.2	154	13	8.1
	4	2.9	7.1	0.2	360	3.6	1.0	875	0.24	0.28	7.8	1.9	135	10	8.1
	5	2.6	10.4	0.2	348	6.3	1.0	852	0.28	0.37	11.3	2.7	148	12	8.2
6	1	3.2	9.9	1.3	1,168	8.8	9.7	1,175	0.39	0.34	6.4	2.7	542	12	7.5
	2	2.0	11.6	0.4	567	19.5	1.3	1,021	0.50	0.33	12.6	4.2	384	30	7.8
	3	1.8	11.5	0.3	515	10.9	2.1	1,033	0.32	0.35	14.9	3.4	198	14	8.0
	4	2.2	10.6	0.2	425	16.8	1.2	1,048	0.34	0.39	13.6	3.4	130	11	8.2
	5	2.4	10.8	0.1	296	4.2	1.2	1,118	0.20	0.35	11.2	3.0	150	4	8.3
7	1	2.1	11.4	1.5	1207	4.4	17.3	1,240	0.25	0.27	8.4	3.1	376	5	7.6
	2	2.5	10.5	0.5	497	2.7	1.5	1,055	0.25	0.43	14.8	3.7	205	15	8.2
	3	3.3	10.2	0.4	455	8.8	1.8	948	0.40	0.58	15.1	3.8	128	25	8.2
	4	2.4	10.9	0.3	422	3.7	2.1	926	0.39	0.51	16.2	3.7	103	25	8.2
	5	2.1	11.3	0.3	366	2.9	1.3	931	0.28	0.42	16.3	3.2	134	17	8.2

Table 4-D. Soil Analytical Results

Circle[1]	Depth	ESP	CEC	OM	TKN	NO_3-N	NH_4-N	Total P	EC	Na	Ca	Mg	K	SO_4-S	pH
	ft bgs	%	meq/100g	%	mg/kg				mmhos/cm	meq/100g			mg/kg		s.u.
8	1	2.0	9.8	1.3	1,117	5.0	8.2	1,142	0.22	0.22	6.8	2.7	378	6	7.5
	2	2.1	9.6	0.5	547	2.5	1.1	976	0.28	0.31	12.1	3.7	237	10	7.8
	3	1.7	10.7	0.5	553	4.7	1.7	958	0.26	0.34	17.8	3.4	163	10	8.1
	4	1.8	10.3	0.3	402	4.0	1.0	996	0.21	0.32	16.2	3.2	117	8	8.2
	5	1.2	11.9	0.3	361	3.4	1.0	930	0.19	0.29	19.3	3.4	148	8	8.3
9	1	2.5	11.1	1.2	1,044	7.8	8.0	1,207	0.38	0.31	9.1	2.9	403	14	7.6
	2	2.5	10.8	0.3	378	30.3	1.4	995	0.52	0.42	13.4	3.5	261	15	7.8
	3	2.1	11.2	0.3	375	12.8	2.3	905	0.35	0.35	12.9	3.8	204	13	8.0
	4	2.1	11.1	0.2	237	12.7	1.2	990	0.29	0.37	14.1	3.2	119	8	8.1
	5	2.3	11.3	0.2	239	16.3	1.1	1,033	0.29	0.39	13.2	3.3	127	7	8.3
10	1	1.7	11.7	1.3	1133	7.5	7.9	1,260	0.27	0.23	10.9	2.9	437	6	7.5
	2	1.4	11.3	0.5	527	1.8	1.0	1,087	0.21	0.29	16.7	3.7	245	11	8.0
	3	1.7	11.5	0.4	572	9.1	2.9	1,107	0.36	0.39	19.2	4.0	161	20	8.1
	4	1.9	11.2	0.3	434	8.9	1.0	1,124	0.27	0.38	16.9	3.5	118	11	8.3
	5	1.6	11.8	0.4	451	2.9	1.2	1,178	0.20	0.31	14.6	4.3	193	9	8.3
11	1	3.2	9.7	1.2	1,074	5.0	9.5	1,152	0.24	0.31	5.6	3.0	301	6	7.5
	2	3.9	9.3	0.4	466	3.6	1.0	1,091	0.24	0.36	5.6	3.2	126	7	7.9
	3	2.4	9.9	0.4	514	3.4	1.7	1,175	0.22	0.34	10.7	2.9	130	6	8.0
	4	1.6	10.7	0.4	434	4.4	1.5	1,199	0.24	0.33	16.9	3.1	112	14	8.2
	5	1.5	10.6	0.2	385	4.5	1.3	1,174	0.27	0.30	16.4	3.1	124	13	8.2
12	1	3.0	10.0	1.1	874	5.7	4.9	1,075	0.28	0.31	6.6	3.0	275	12	7.6
	2	2.1	11.6	0.4	406	20.6	1.5	897	0.51	0.36	14.1	4.1	163	34	7.8
	3	2.3	14.5	0.4	382	20.1	3.1	852	0.44	0.51	16.9	5.7	125	24	8.1
	4	2.3	16.5	0.3	248	13.8	1.4	782	0.34	0.61	19.8	6.1	119	16	8.3
	5	3.0	19.4	0.2	217	11.1	1.1	851	0.40	0.85	19.5	7.5	229	20	8.4
13	1	2.2	9.2	1.1	1,068	1.6	13.6	1,047	0.21	0.19	5.4	2.5	253	4	7.5
	2	3.2	8.4	0.3	363	1.0	1.1	861	0.17	0.30	7.1	2.8	187	3	8.0
	3	2.2	10.3	0.3	461	1.1	3.6	917	0.21	0.35	12.8	3.2	128	7	8.1
	4	1.5	11.8	0.2	277	2.7	1.0	969	0.22	0.29	15.5	3.3	96	13	8.3
	5	1.7	11.6	0.2	230	6.9	1.2	894	0.30	0.31	14.6	2.9	119	17	8.3
15	1	3.2	9.6	1.1	941	2.4	12.4	1,078	0.25	0.30	5.6	2.6	345	4	7.5
	2	2.9	8.3	0.3	271	1.3	1.2	935	0.22	0.33	9.6	2.7	195	12	8.0
	3	2.2	9.0	0.4	317	2.3	2.5	972	0.28	0.31	12.4	2.7	132	20	8.0
	4	1.6	8.6	0.2	177	3.8	1.2	949	0.25	0.28	13.9	2.6	89	12	8.2
	5	1.9	9.9	0.2	195	12.1	1.2	923	0.27	0.34	13.7	2.9	118	13	8.2

Table 4-D. Soil Analytical Results

Circle [1]	Depth	ESP	CEC	OM	TKN	NO_3-N	NH_4-N	Total P	EC	Na	Ca	Mg	K	SO_4-S	pH
	ft bgs	%	meq/100g	%	mg/kg				mmhos/cm	meq/100g			mg/kg		s.u.
V16	1	2.1	9.1	0.6	--	1.9	1.2	15	0.26	0.19	5.7	2.5	72	6	7.6
	2	--	--	--	--	1.5	0.5	--	0.26	--	--	--	--	--	--
	3	--	--	--	--	1.9	0.0	--	0.22	--	--	--	--	--	--
	4	--	--	--	--	1.9	0.3	--	0.31	--	--	--	--	--	--
	5	--	--	--	--	1.9	0.2	--	0.21	--	--	--	--	--	--
V17	1	2.6	7.8	0.8	--	1.8	2.4	27	0.28	0.20	4.7	2.0	87	6	7.6
	2	--	--	--	--	1.6	1.5	--	0.30	--	--	--	--	--	--
	3	--	--	--	--	5.0	1.0	--	0.56	--	--	--	--	--	--
	4	--	--	--	--	7.3	1.0	--	0.59	--	--	--	--	--	--
	5	--	--	--	--	4.5	0.6	--	0.78	--	--	--	--	--	--
V18	1	2.3	9.4	0.9	--	23.1	1.8	33	1.71	0.22	8.5	2.3	168	14	8.1
	2	--	--	--	--	3.6	0.7	--	0.35	--	--	--	--	--	--
	3	--	--	--	--	4.7	0.7	--	0.26	--	--	--	--	--	--
	4	--	--	--	--	4.9	0.7	--	0.06	--	--	--	--	--	--
	5	--	--	--	--	4.2	0.7	--	0.72	--	--	--	--	--	--
B19	1	1.2	7.5	0.5	--	2.1	1.8	9	0.36	0.09	7.3	1.4	302	2	7.8
	2	--	--	--	--	1.1	1.7	--	0.27	--	--	--	--	--	--
	3	--	--	--	--	1.4	1.6	--	0.27	--	--	--	--	--	--
	4	--	--	--	--	1.5	1.4	--	0.39	--	--	--	--	--	--
	5	--	--	--	--	1.8	1.3	--	0.64	--	--	--	--	--	--

NOTES:

Soil samples were collected from Circles 1-12 November 18, 2021; Circles V16, V17, and V18 October 19, 2021; and Circle B19 June 9, 2022.

Abbreviations: Ca = calcium, CEC = cation exchange capacity, EC = electrical conductivity, ESP = exchangeable sodium percentage, ft bgs = feet below ground surface, K = potassium, meq/100g = milliequivalents per 100 grams of soil, Mg = magnesium, mg/kg = milligrams per kilogram, mmhos/cm = millimhos per centimeter, Na = sodium, NH_4-N = ammonia-nitrogen, NO_3-N = nitrate-nitrogen, OM = organic matter, P = phosphorus, s.u. = standard units, SO_4-S = sulfate-sulfur, TKN = total Kjeldahl nitrogen.

[1] Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7.

Table 4-E. Projected Process Water Flow

Month [1]	Process Water Flow
	million gallons
November	173
December	113
January	91
February	78
March	95
April	100
May	104
June	151
July	233
August	251
September	253
October	228
Total	**1,869**

NOTES:

Projected process water flow represents estimates of incoming flow to the City of Pasco Process Water Reuse Facility based on food processor forecasts. Flow data compiled by the City of Pasco.

[1] The operational year runs from November through October, which corresponds with the approximate beginning of the reduced crop growing period through the completion of crop harvest.

Table 4-F. Projected Process Water Quality

pH	EC[1]	Total N	TKN	NO_3 + NO_2-N	NH_3-N	BOD_5	FDS	Na	Ca	Mg	SO_4	Cl	Total P	SAR
s.u.	µmhos/cm	mg/L												
7.3	1,167	42	30	12	15	151	622	41	26	18	54	34	52	1.5

NOTES:

Projected annual flow-weighted process water quality for land treatment from the City of Pasco Process Water Reuse Facility (PWRF). Data for nitrogen, pH, FDS, and BOD_5 are estimates based on food processor forecasts and analytical results from City of Pasco sampling of existing processor influent during 2021. Nitrogen, pH, FDS, and BOD_5 quality include estimated pretreatment effects from screening, low rate anaerobic digester, and sequencing batch reactor. Data for Na, Ca, Mg, SO_4, Cl, and total P are weighted averages of process water analytical data reported in the 2022 Farm Operations Report (Valley Science and Engineering, 2022).

Abbreviations: BOD_5 = five-day biochemical oxygen demand, Ca = calcium, Cl = chloride, EC = electrical conductivity, FDS = fixed dissolved solids, Mg = magnesium, mg/L = milligrams per liter, Na = sodium, NH_3-N = ammonia-nitrogen, NO_3 + NO_2-N = nitrate + nitrite-nitrogen, P = phosphorus, s.u. = standard units, SAR = sodium adsorption ratio, SO_4 = sulfate, TKN = total Kjeldahl nitrogen, total N = total nitrogen (TKN + nitrite-nitrogen + nitrate-nitrogen), µmhos/cm = micromhos per centimeter.

[1] EC is estimated as follows: EC = FDS × 1.20 ÷ 0.64 assuming FDS is 80% of total dissolved solids and the standard relationship of EC = total dissolved solids ÷ 0.64 (U.S. Salinity Laboratory Staff, 1954).

Table 4-G. Irrigation Fresh Water Quality

Water Source	Circle [1]	TDS [2]	NO_3-N	EC [3]
		mg/L		µmhos/cm
IW-1	1	466	11.7	728
IW-2	2	466	12.2	728
IW-3	3	466	13.5	728
IW-4	4	535	12.1	836
IW-5	5	625	11.0	977
IW-6, 9	6-15	625	23.2	977
IW-7	6-15	625	23.2	977
IW-8, 10	6-15	625	23.2	977
IW-11, 13	6-15	625	23.2	977
IW-12	6-15	625	23.2	977
IW-15	6-15	625	23.2	977
V18, V19 Underdrain	V16-V18	426	32.6	666
SCBID	V16-V18	181	0.8	283
Flow Weighted Average		**519**	**17.6**	**811**

NOTES:

Supplemental irrigation water (fresh water) was sampled by City of Pasco in August 2021 from the individual City of Pasco wells (labeled "IW"). Underdrain water from Circles V18 and V19 was sampled by City of Pasco in December 2021. SCBID water was sampled by SCBID during 7 events between April and October 2021, and values shown are averages.

Abbreviations: EC = electrical conductivity, IW = irrigation well, mg/L = milligrams per liter, NO_3-N = nitrate-nitrogen, SCBID = South Columbia Basin Irrigation District, TDS = total dissolved solids, µmhos/cm = micromhos per centimeter.

1 Circles served from corresponding fresh water sources. Flow from IW-6 through IW-15 is commingled and quality is not tracked separately.

2 The SCBID TDS concentration was estimated using the relationship of TDS = EC × 0.64 (U.S. Salinity Laboratory Staff, 1954).

3 Electrical conductivity calculated for City of Pasco wells and the V18, V19 underdrain using the relationship of EC = TDS ÷ 0.64 (U.S. Salinity Laboratory Staff, 1954).

Table 4-H. Crop Rotations

Circle [1]	Acres	2018	2019	2020	2021	Design Basis Crop Rotation [2]
1	122	Alfalfa	Alfalfa	Alfalfa	Alfalfa / Corn	Alfalfa
2	152	Alfalfa / Corn	Potato / Alfalfa	Alfalfa	Alfalfa	Potato / Alfalfa
3	128	Alfalfa	Alfalfa	Potato / Sudangrass	Triticale / Alfalfa	Alfalfa / Corn
4	128	Corn	Potato / Alfalfa	Alfalfa	Alfalfa	Alfalfa
5	128	Potato / Alfalfa	Alfalfa	Alfalfa	Alfalfa	Alfalfa
6	128	Alfalfa	Alfalfa	Alfalfa / Corn	Potato / Alfalfa	Alfalfa
7	152	Potato / Alfalfa	Alfalfa	Alfalfa	Alfalfa	Potato / Alfalfa
8	128	Alfalfa	Potato / Alfalfa	Alfalfa	Alfalfa	Alfalfa / Corn
9	128	Alfalfa	Alfalfa	Alfalfa / Corn	Potato / Alfalfa	Alfalfa
10	128	Potato / Alfalfa	Alfalfa	Alfalfa	Alfalfa	Alfalfa
11	150	Alfalfa	Potato / Alfalfa	Alfalfa	Alfalfa	Triticale / Corn
12	128	Alfalfa	Alfalfa	Alfalfa	Potato / Alfalfa	Alfalfa / Corn
13	128	Alfalfa	Alfalfa	Potato / Sudangrass	Triticale / Alfalfa	Alfalfa
15	128	Alfalfa	Alfalfa / Corn	Potato / Corn	Triticale / Alfalfa	Alfalfa
V16	70	--	--	--	--	Alfalfa
V17	169	--	--	--	--	Triticale / Corn
V18	164	--	--	--	--	Alfalfa / Corn
B19	111	--	--	--	--	Alfalfa
Total	**2,370**					
Summary by Crop (acres)						
Alfalfa		1,168	1,170	1,216	966	1,199
Alfalfa / Corn		152	128	256	122	548
Triticale / Corn		0	0	0	0	319
Potato / Alfalfa		408	558	0	384	304
Other		128	0	384	384	0

NOTES:

Cropping information obtained from the Annual Farm Operations Reports (Cascade Earth Sciences, 2019, 2020; Valley Science and Engineering, 2021, 2022). Where two crops are listed together, the first crop is grown and harvested followed by planting and harvest of the second crop, except for the crop after potatoes, which is planted but not harvested until the following growing season.

[1] Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7. Circle V17 is Circle 17 plus Little Circle 17.

[2] Design basis crop rotation is the most limiting projected crop mixture used to calculate the limiting design basis capacity for the land treatment site.

Table 4-I. Crop Planting, Harvest, and Nitrogen Management

Crop	Planting Month	Number of Harvest(s) - Harvest Month(s)	Expected Yield	Crop Nitrogen	
				Removal [1]	Capacity [2]
			tons/ac/yr	lb/ac/yr	
Alfalfa	September to Early October	3 to 4 harvests - May, June / July, July / August, September	7.7	484	540
Alfalfa / Corn	Established / May	May / October	13.8	337	380
Corn	March or April	October	8.6	216	240
Potato	April	September	29.5	228	260
Triticale / Silage Corn	September / May	May / October	22.6	271	300
Wheat	March	August	4.0	228	260

NOTES:

Planting and harvest months, expected yield, and crop nitrogen are based on City of Pasco records.

Abbreviations: lb/ac/yr = pounds per acre per year, mg/L = milligrams per liter, TKN = total Kjeldahl nitrogen, tons/ac/yr = tons per acre per year.

1 Crop nitrogen removal represents the average removal rate expected based on historical land treatment site crop removal records.

2 Nitrogen capacity is the crop nitrogen need increased to account for net available process water nitrogen after volatilization and denitrification losses.
Nitrogen need = crop nitrogen removal ÷ 0.89. Available nitrogen of 89% is calculated using rates based on recommendations in (Meisinger, J.J., & Randall, G.W., 1991).
Formula: [((TKN - ammonia-nitrogen) + (ammonia-nitrogen × 0.80) + (nitrate-nitrogen)) × 0.96] ÷ (TKN + nitrate-nitrogen)
Calculation: [((30 mg/L - 16 mg/L) + (16 mg/L × 0.80) + (12 mg/L)) × 0.96] ÷ (30 mg/L + 12 mg/L)

Table 4-J. Summary of Circle-Specific Monthly Soil Hydraulic Budgets - Annual Totals

Circle [1]	Acres	Crop [2]	Gross Precip [3]	Gross Irrigation [4]			Net Irrigation [5]	Evapotranspiration [6]		Leaching	
				Process	Fresh	Total		Potential	Estimated	LF [7]	LR [8]
			inches			MG	inches			%	
1	122	Alfalfa	8.3	40.3	13.0	176	49.2	56.4	48.6	1.1	10.1
2	152	Potato / Alfalfa	8.3	13.0	26.7	164	37.6	39.9	37.6	0.0	7.8
3	128	Alfalfa / Corn	8.3	17.2	25.0	147	40.4	44.7	39.4	1.8	8.2
4	128	Alfalfa	8.3	39.1	21.0	209	54.0	56.4	52.9	1.4	10.2
5	128	Alfalfa	8.3	39.7	18.2	201	52.2	56.4	51.4	1.0	10.7
6	128	Alfalfa	8.3	38.3	19.0	199	51.7	56.4	50.8	1.5	10.7
7	152	Potato / Alfalfa	8.3	11.3	26.5	156	36.1	39.9	34.7	2.8	9.3
8	128	Alfalfa / Corn	8.3	17.1	27.0	153	41.6	44.7	40.4	1.9	9.7
9	128	Alfalfa	8.3	38.2	16.0	188	49.4	56.4	48.3	1.6	10.7
10	128	Alfalfa	8.3	38.5	19.0	200	51.9	56.4	50.8	1.5	10.7
11	150	Triticale / Corn	8.3	24.8	12.5	152	36.5	38.4	35.1	2.9	9.9
12	128	Alfalfa / Corn	8.3	19.3	26.0	157	43.0	44.7	41.9	1.8	9.8
13	128	Alfalfa	8.3	38.2	18.9	198	51.7	56.4	50.3	2.0	10.7
15	128	Alfalfa	8.3	39.9	14.0	187	49.5	56.4	48.5	1.5	10.7
V16	70	Alfalfa	8.3	36.0	20.7	108	51.2	56.4	50.2	1.5	8.4
V17	169	Triticale / Corn	8.3	21.8	17.0	178	37.3	38.4	35.8	3.1	7.4
V18	164	Alfalfa / Corn	8.3	14.8	28.6	193	41.3	44.7	40.3	1.9	5.9
B19	111	Alfalfa	8.3	56.2	0.0	169	51.0	56.4	50.0	1.5	11.3
Average			**8.3**	**29.0**	**19.7**	**176**	**45.2**	**49.2**	**44.2**	**1.8**	**9.5**
Total (MG) [9]			**531**	**1,869**	**1,267**	**3,136**	**2,910**	**3,163**	**2,842**		

NOTES:

Abbreviations: LF = leaching fraction, LR = leaching requirement, MG = million gallons, Precip = precipitation.

[1] Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7. Circle V17 is Circle 17 plus Little Circle V17.

[2] Design basis crop rotation.

[3] Gross precipitation is based on monthly precipitation from the years with sufficient data from 2001-2021 from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.) and represents a 10-year return. The 2nd highest total annual precipitation out of 20 years (8.25 inches from 2015-2016) were normalized in relation to the long-term average for each month to create the 10-year return precipitation data for design purposes.

[4] Gross irrigation = inches of process and fresh water delivered at the irrigation system discharge point (i.e., sprinkler heads). No connection to fresh irrigation water is planned for Circle B19, so no fresh water irrigation is projected for Circle B19 in this scenario.

[5] Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

[6] Potential evapotranspiration is from the average of available data from 1995-2016 for crops that are grown at the land treatment site from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.). Estimated evapotranspiration calculated from potential evapotranspiration and soil moisture content.

[7] Leaching fraction = percent of gross input estimated to percolate beyond the root zone (total percolate loss ÷ [precipitation + gross irrigation]).

[8] Leaching requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

[9] Total MG = acres × 27,154 gallons per acre-inch ÷ 1,000,000.

Table 4-K. Design Basis Hydraulic Capacity

Month	Process Water	Fresh Water	Total
	million gallons		
Nov	92	9	101
Dec	0	0	0
Jan	0	0	0
Feb	0	0	0
Mar	138	9	147
Apr	210	63	274
May	315	150	465
Jun	216	381	598
Jul	233	427	660
Aug	251	210	461
Sep	253	9	262
Oct	160	9	169
Total	**1,869**	**1,267**	**3,136**

NOTES:

Million gallons calculated from inches of process and fresh water scheduled to all fields within the monthly soil hydraulic budgets based on the design basis crop rotation. Hydraulic capacity was developed considering crop irrigation and nitrogen requirements.

Table 4-L. Crop Nitrogen Removal and Capacity

Year	2017	2018	2019	2020	2021	Design Basis Crop Rotation [1]
	pounds per year					
Crop Nitrogen Removal [2]						
Crop Removal	541,952	658,880	759,104	796,224	647,744	921,000
Site Gross Nitrogen Capacity [3]						
Gross Capacity						1,034,800

NOTES:

Abbreviations: lb/ac = pounds per acre, mg/L = milligrams per liter, TKN = total Kjeldahl nitrogen.

[1] Design basis crop rotation is the most limiting projected crop mixture resulting in the limiting design basis capacity for the land treatment site. Values rounded to the nearest hundred.

[2] Crop nitrogen removal calculated from historical crop yield and crop tissue nitrogen concentration data from the City of Pasco records.

[3] Site gross nitrogen capacity is crop nitrogen removal increased to account for net available process water nitrogen after volatilization and denitrification losses. Site gross nitrogen capacity = crop nitrogen removal ÷ 0.89. Available nitrogen of 89% is calculated using rates based on recommendations in (Meisinger, J.J., & Randall, G.W., 1991).
Formula: [((TKN - ammonia-nitrogen) + (ammonia-nitrogen × 0.80) + (nitrate-nitrogen)) × 0.96] ÷ (TKN + nitrate-nitrogen)
Calculation: [((30 mg/L - 16 mg/L) + (16 mg/L × 0.80) + (12 mg/L)) × 0.96] ÷ (30 mg/L + 12 mg/L)

Table 4-M. Design Basis Nitrogen Capacity and Operational Analysis

Circle [1]	Process Water	Fresh Water [2]	Total Load [3]	Capacity [4]
	pounds nitrogen			
1	46,172	4,044	50,216	66,380
2	18,575	10,790	29,364	38,992
3	20,695	9,414	30,110	48,431
4	46,999	7,088	54,087	69,645
5	47,721	5,584	53,305	69,645
6	46,036	12,296	58,332	69,645
7	16,146	20,326	36,472	38,992
8	20,575	17,473	38,048	48,431
9	45,916	10,354	56,270	69,645
10	46,277	12,296	58,573	69,645
11	34,969	9,480	44,448	45,651
12	23,222	16,826	40,048	48,431
13	45,904	12,231	58,135	69,645
15	48,042	9,060	57,102	69,645
V16	23,663	3,491	27,154	38,087
V17	34,568	6,914	41,482	51,434
V18	22,816	11,333	34,149	62,053
B19	58,640	0	58,640	60,395
Total	**646,936**	**178,997**	**825,933**	**1,034,791**

NOTES:

Pounds of nitrogen calculated from the inches of process and fresh water scheduled to each field within monthly soil hydraulic budgets based on the projected nitrogen concentration of the process water and supplemental fresh irrigation water.

Abbreviations: mg/L = milligrams per liter, TKN = total Kjeldahl nitrogen.

1 Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7. Circle V17 is Circle 17 plus Little Circle V17.

2 Fresh water nitrogen load accounts for assumed gaseous losses of 4% due to denitrification. No connection to fresh irrigation water is planned for Circle B19, so fresh water irrigation is not projected for Circle B19.

3 Example total operational load is less than capacity due to crop-dependent agronomic irrigation management considerations such as crop dry-down and harvest periods.

4 Capacity is the field by field design basis crop rotation nitrogen removal increased to account for net available process water nitrogen after volatilization and denitrification losses. Nitrogen capacity = crop nitrogen removal ÷ 0.89. Available nitrogen of 89% is calculated using rates based on recommendations in (Meisinger, J.J., & Randall, G.W., 1991).
Formula: [((TKN - ammonia-nitrogen) + (ammonia-nitrogen × 0.80) + (nitrate-nitrogen)) × 0.96] ÷ (TKN + nitrate-nitrogen)
Calculation: [((30 mg/L - 16 mg/L) + (16 mg/L × 0.80) + (12 mg/L)) × 0.96] ÷ (30 mg/L + 12 mg/L)

Table 4-N. Design Basis Annual Mass Loads

Source	Flow	Total N	BOD_5	FDS
	million gallons	pounds		
Process Water [1]	1,869	646,936	2,360,000	9,700,000
Fresh Water [2]	1,267	178,997	--	5,490,000
Total	3,136	825,933	2,360,000	15,190,000

NOTES:

BOD_5 and FDS rounded to the nearest 10,000 pounds.

Abbreviations: -- = not calculated, BOD_5 = five-day biochemical oxygen demand, FDS = fixed dissolved solids, mg/L = milligrams per liter, SCBID = South Columbia Basin Irrigation District, TDS = total dissolved solids, TKN = total Kjeldahl nitrogen, total N = total nitrogen (TKN + nitrite-nitrogen + nitrate-nitrogen).

1 Process water mass loads calculated using the annual flow weighted process water constitutent concentrations for total N (42 mg/L), BOD_5 (151 mg/L), FDS (622 mg/L), and flow scheduled to each field within the monthly soil hydraulic budgets.

2 Fresh water mass loads calculated using the 2021 constituent concentrations of total N and TDS from the City of Pasco fresh water wells, SCBID irrigation water, and V-circles underdrain system and flow scheduled to each field within the monthly soil hydraulic budgets. BOD_5 data not available.

Table 4-O. Design Five-Day Biochemical Oxygen Demand Daily Loads

Circle [1]	Month											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	pounds BOD_5 per acre per day											
1	2	0	0	0	3	5	7	6	6	6	7	5
2	0	0	0	0	0	2	4	1	1	1	3	3
3	2	0	0	0	3	3	4	1	1	1	2	2
4	2	0	0	0	3	5	7	6	6	6	7	4
5	2	0	0	0	3	5	7	6	6	6	7	4
6	2	0	0	0	3	5	7	6	6	6	7	3
7	1	0	0	0	0	1	2	1	1	1	3	3
8	2	0	0	0	3	3	4	1	1	1	2	2
9	2	0	0	0	3	5	7	6	6	6	7	3
10	2	0	0	0	3	5	7	6	6	6	7	4
11	1	0	0	0	3	3	4	1	5	7	3	1
12	3	0	0	0	3	3	4	1	1	1	2	3
13	2	0	0	0	3	5	7	6	6	6	7	3
15	2	0	0	0	3	5	7	6	6	6	7	5
V16	1	0	0	0	3	5	7	6	6	6	7	2
V17	1	0	0	0	2	3	4	1	6	7	2	0
V18	1	0	0	0	3	3	4	1	1	1	2	0
B19	2	0	0	0	3	6	9	11	11	11	6	4

NOTES

Projected BOD_5 loads based on monthly process water design flow and an estimated BOD_5 concentration of 151.3 mg/L as follows: million gallons × 8.34 million pounds per million gallons × 151.3 mg/L BOD_5 ÷ acres ÷ days per month.

Abbeviations: BOD_5 = five-day biochemical oxygen demand, mg/L - milligrams per liter.

[1] Circle 2 is Circle 2 plus Little Circle 2. Circle 7 is Circle 7 plus Little Circle 7. Circle V17 is Circle V17 plus Little Circle V17.

Appendices

Appendix A1

Historical and Design Precipitation – 2001 through 2021

Appendix A1. Historical and Design Precipitation – 2001 through 2021

Month	Average [1]	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	Normalized [2]	
																						Factor	Return Precipitation (Design)
	inches																						inches
Nov	0.57	1.08	0.29	0.14	0.54	0.91	1.00	1.13	0.76	0.36	0.54	0.14	0.71	0.30	0.37	0.46	0.37	0.76	0.52	0.12	0.94	10%	0.8
Dec	0.96	0.59	2.16	1.34	0.71	1.77	1.51	0.69	0.64	0.74	2.21	0.07	0.80	0.28	1.18	1.66	0.40	0.78	0.66	0.33	0.63	17%	1.4
Jan	0.84	0.26	1.85	1.36	0.63	1.38	0.29	0.99	1.08	1.47	0.64	0.47	0.24	0.47	0.94	1.36	0.42	0.76	1.16	0.65	0.41	15%	1.2
Feb	0.47	0.74	0.84	0.64	0.05	0.24	0.35	0.41	0.68	0.41	0.35	0.32	0.03	0.48	0.55	0.27	1.20	0.22	0.90	0.16	0.54	8%	0.7
Mar	0.46	0.31	0.21	0.15	0.11	0.30	0.70	0.42	1.27	0.30	1.11	0.68	0.12	0.42	0.30	0.79	0.98	0.31	0.35	0.33	0.06	8%	0.7
Apr	0.38	0.23	0.77	0.16	0.18	0.86	0.24	0.12	0.27	0.63	0.41	0.77	0.33	0.21	0.14	0.21	0.60	0.83	0.49	0.11	0.04	7%	0.6
May	0.53	0.18	0.52	0.80	0.00	0.62	0.60	0.31	0.06	1.19	1.32	0.16	0.36	0.19	1.35	1.18	0.16	0.52	0.33	0.67	0.12	9%	0.8
Jun	0.45	0.91	0.00	1.15	0.00	1.25	0.60	0.48	0.05	1.14	0.17	1.12	0.78	0.12	0.00	0.31	0.36	0.06	0.12	0.31	0.16	8%	0.7
Jul	0.12	0.29	0.00	0.00	0.25	0.00	0.60	0.00	0.01	0.28	0.00	0.55	0.00	0.00	0.00	0.22	0.00	0.00	0.03	0.06	0.01	2%	0.2
Aug	0.17	0.20	0.00	0.47	0.05	0.00	0.48	0.80	0.04	0.25	0.01	0.15	0.19	0.46	0.00	0.02	0.03	0.00	0.12	0.11	0.00	3%	0.2
Sep	0.25	0.00	0.23	0.13	0.56	0.24	0.79	0.02	0.11	1.17	0.00	0.00	0.50	0.04	0.02	0.17	0.11	0.00	0.56	0.01	0.38	4%	0.4
Oct	0.45	0.14	0.07	0.00	0.45	0.39	0.30	0.03	1.01	1.28	0.47	0.75	0.01	0.63	0.02	1.60	0.42	0.30	0.24	0.20	0.78	8%	0.7
Winter [3]	2.27	1.59	4.85	3.34	1.39	3.39	2.15	2.09	2.40	2.62	3.20	0.86	1.07	1.23	2.67	3.29	2.02	1.76	2.72	1.14	1.58		3.3
Annual [4]	**5.65**	**4.93**	**6.94**	**6.34**	**3.53**	**7.96**	**7.46**	**5.40**	**5.98**	**9.22**	**7.23**	**5.18**	**4.07**	**3.60**	**4.87**	**8.25**	**5.05**	**4.54**	**5.48**	**3.06**	**4.07**	100%	8.3
Statistics [5]																							
Rank (m)		13	6	7	19	3	4	10	8	1	5	11	16	18	14	2	12	15	9	20	17		
Exceedance Probability		62%	29%	33%	90%	14%	19%	48%	38%	5%	24%	52%	76%	86%	67%	10%	57%	71%	43%	95%	81%		
Recurrance Interval (T)		1.6	3.5	3.0	1.1	7.0	5.3	2.1	2.6	21.0	4.2	1.9	1.3	1.2	1.5	10.5	1.8	1.4	2.3	1.1	1.2		

NOTES:

All data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 The average precipitation is based on actual monthly precipitation from 2001 through 2021.

2 The 2nd highest total annual precipitation out of 20 years (8.25 inches from 2015-16 [shaded]) were normalized in relation to the long term average for each month to create the 10-year return precipitation data for design purposes.

3 Winter period is December through February.

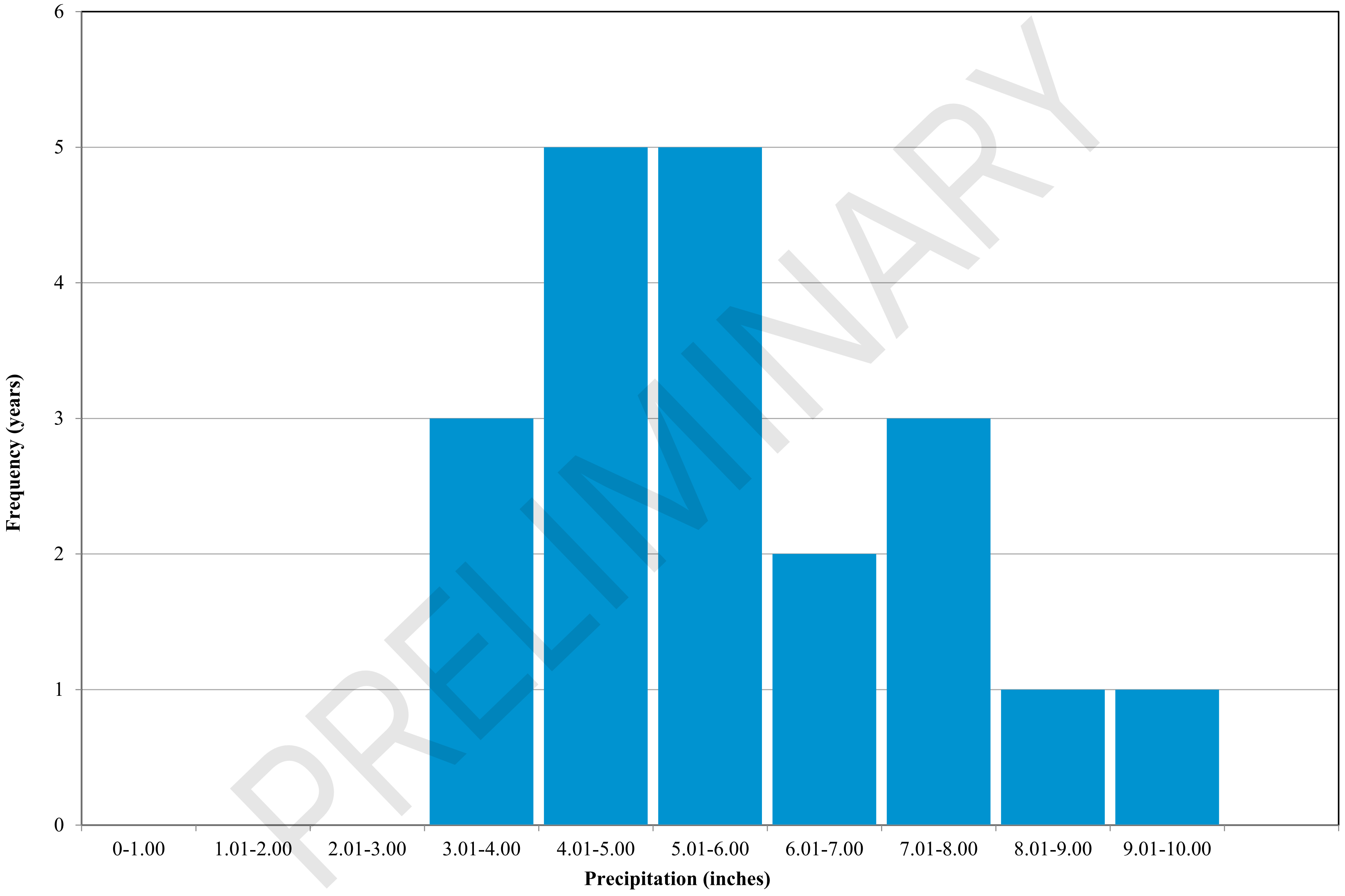
4 Annual precipitation is based on the land treatment system operating year November through October.

5 Rank (m) = rank of annual precipitation, where 1 is given to the highest precipitation and 20 is given to the lowest precipitation.
Exceedance Probability (p) = probability of precipitation equal to or higher in any given year. Calculated as p = m ÷ (n + 1), where n = number of years in data set.
Recurrance Interval (T) = average number of years between precipitation events equal to or higher than any given year. Calculated as T = 1 ÷ p = (n + 1) ÷ m, where n = number of years in data set.

Appendix A2

20-Year Precipitation Histogram

Appendix A2. 20-Year Precipitation Histogram



0-1.00	0
1.01-2.00	0
2.01-3.00	0
3.01-4.00	3
4.01-5.00	5
5.01-6.00	5
6.01-7.00	2
7.01-8.00	3
8.01-9.00	1
9.01-10.00	1

Appendix B

Web Soil Survey Results

Appendix B. Web Soil Survey Results

United States
Department of
Agriculture

NRCS

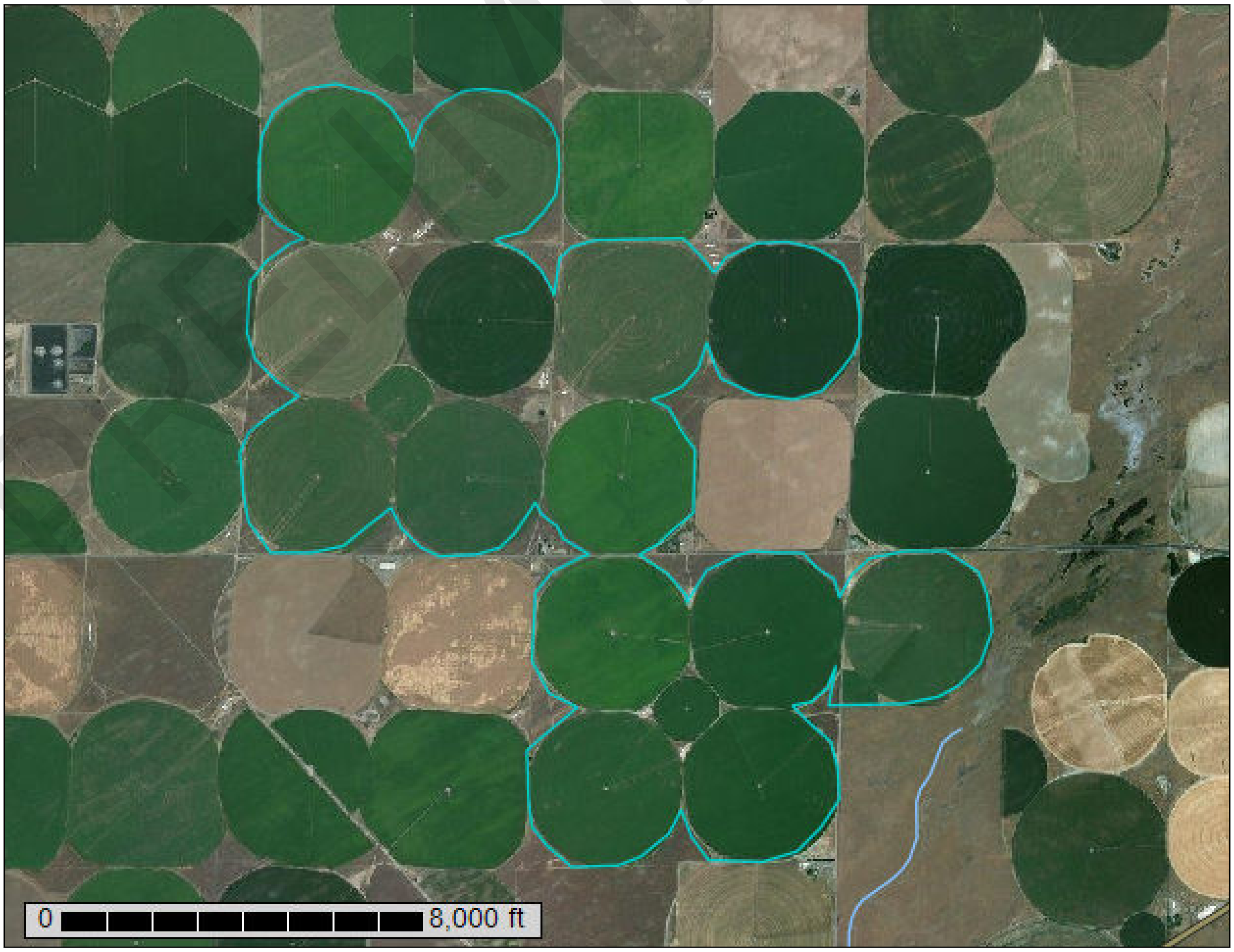
Natural
Resources
Conservation
Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Franklin County, Washington

City of Pasco Land Application Site



October 16, 2017

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

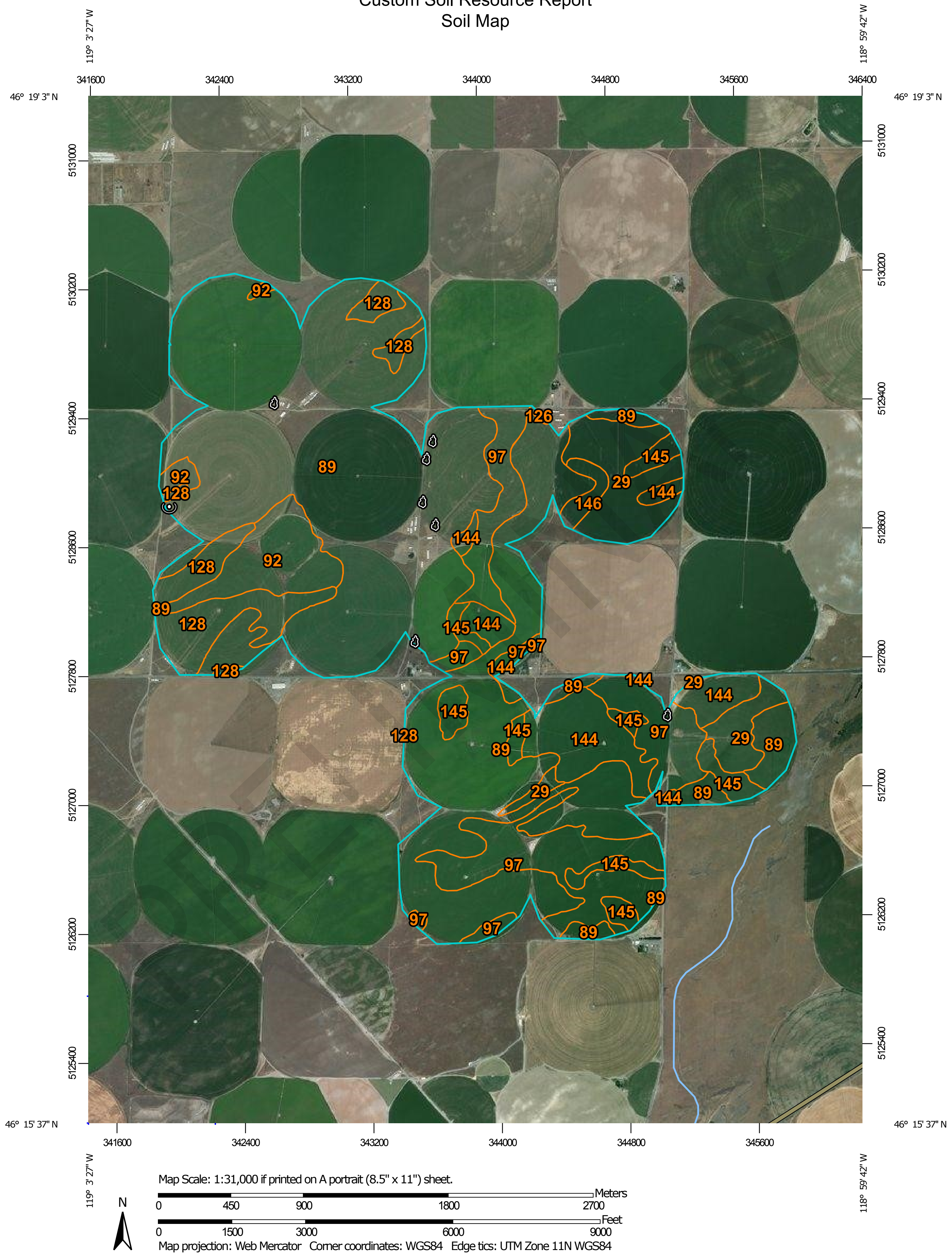
identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Appendix B. Web Soil Survey Results

Soil Map



Map Scale: 1:31,000 if printed on A portrait (8.5" x 11") sheet.

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Franklin County, Washington
Survey Area Data: Version 14, Sep 8, 2016

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 28, 2014—Sep 11, 2016

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
29	Hezel loamy fine sand, 0 to 15 percent slopes	125.2	6.1%
89	Quincy loamy fine sand, 0 to 15 percent slopes	1,255.1	60.7%
92	Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes	92.7	4.5%
97	Quincy-Hezel complex, 0 to 15 percent slopes	255.4	12.4%
126	Royal loamy fine sand, 0 to 10 percent slopes	1.0	0.0%
128	Royal fine sandy loam, 0 to 2 percent slopes	111.8	5.4%
144	Sagemoor very fine sandy loam, 0 to 2 percent slopes	135.9	6.6%
145	Sagemoor very fine sandy loam, 2 to 5 percent slopes	74.3	3.6%
146	Sagemoor very fine sandy loam, 5 to 10 percent slopes	14.7	0.7%
Totals for Area of Interest		**2,066.1**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Franklin County, Washington

29—Hezel loamy fine sand, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2dm1
Elevation: 400 to 2,500 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Hezel and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hezel

Setting

Landform: Terraces
Parent material: Glaciofluvial deposits with a mantle of eolian sands

Typical profile

H1 - 0 to 7 inches: loamy fine sand
H2 - 7 to 18 inches: loamy sand
H3 - 18 to 27 inches: fine sandy loam
H4 - 27 to 60 inches: stratified fine sandy loam to silt loam

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

Minor Components

Quincy

Percent of map unit: 10 percent
Landform: Terraces
Hydric soil rating: No

Sagehill

Percent of map unit: 5 percent
Landform: Terraces
Hydric soil rating: No

89—Quincy loamy fine sand, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2dtt
Elevation: 350 to 1,200 feet
Mean annual precipitation: 6 to 12 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 4 inches: loamy fine sand
H2 - 4 to 60 inches: fine sand

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 3 percent
Available water storage in profile: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Dunes, terraces
Hydric soil rating: No

92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2dv6
Elevation: 350 to 1,000 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 3 inches: loamy fine sand
H2 - 3 to 52 inches: loamy fine sand
H3 - 52 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 10 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 5.0
Available water storage in profile: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e

Hydrologic Soil Group: A
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

97—Quincy-Hezel complex, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2dvt
Elevation: 350 to 2,500 feet
Mean annual precipitation: 6 to 12 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 50 percent
Hezel and similar soils: 25 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 4 inches: loamy fine sand
H2 - 4 to 60 inches: fine sand

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 3 percent
Available water storage in profile: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

Description of Hezel

Setting

Landform: Terraces

Parent material: Glaciofluvial deposits with a mantle of eolian sands

Typical profile

H1 - 0 to 7 inches: loamy fine sand
H2 - 7 to 18 inches: loamy sand
H3 - 18 to 27 inches: fine sandy loam
H4 - 27 to 60 inches: stratified fine sandy loam to silt loam

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 5 percent
Landform: Dunes, terraces
Hydric soil rating: No

Kennewick

Percent of map unit: 5 percent
Landform: Terraces
Hydric soil rating: No

Warden

Percent of map unit: 5 percent
Landform: Terraces, dunes
Hydric soil rating: No

126—Royal loamy fine sand, 0 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2df7
Elevation: 400 to 1,400 feet

Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Royal and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Royal

Setting

Landform: Terraces
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 6 inches: loamy fine sand
H2 - 6 to 19 inches: fine sandy loam
H3 - 19 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 0 to 10 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 7.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: SANDS 6-10 PZ (R007XY502WA)
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Terraces
Hydric soil rating: No

128—Royal fine sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2dfc
Elevation: 400 to 1,400 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Royal and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Royal

Setting

Landform: Terraces
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 5 inches: fine sandy loam
H2 - 5 to 15 inches: fine sandy loam
H3 - 15 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: A
Ecological site: SANDY 6-10 PZ (R007XY501WA)
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Terraces
Hydric soil rating: No

144—Sagemoor very fine sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2dgj
Elevation: 400 to 1,000 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Sagemoor and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sagemoor

Setting

Landform: Terraces
Parent material: Loess over layered lacustrine deposits

Typical profile

H1 - 0 to 4 inches: very fine sandy loam
H2 - 4 to 9 inches: silt loam
H3 - 9 to 18 inches: silt loam
H4 - 18 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 11.7 inches)

Interpretive groups

Land capability classification (irrigated): 1

Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: C
Ecological site: LOAMY 6-10 PZ (R007XY102WA)
Hydric soil rating: No

Minor Components

Kennewick

Percent of map unit: 10 percent
Landform: Terraces
Hydric soil rating: No

145—Sagemoor very fine sandy loam, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: 2dgl
Elevation: 400 to 1,000 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Sagemoor and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sagemoor

Setting

Landform: Terraces
Parent material: Loess over layered lacustrine deposits

Typical profile

H1 - 0 to 4 inches: very fine sandy loam
H2 - 4 to 9 inches: silt loam
H3 - 9 to 18 inches: silt loam
H4 - 18 to 60 inches: silt loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water storage in profile: High (about 11.7 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: LOAMY 6-10 PZ (R007XY102WA)
Hydric soil rating: No

Minor Components

Kennewick

Percent of map unit: 10 percent
Landform: Terraces
Hydric soil rating: No

146—Sagemoor very fine sandy loam, 5 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2dgn
Elevation: 400 to 1,000 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Sagemoor and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sagemoor

Setting

Landform: Terraces
Parent material: Loess over layered lacustrine deposits

Typical profile

H1 - 0 to 4 inches: very fine sandy loam
H2 - 4 to 9 inches: silt loam
H3 - 9 to 18 inches: silt loam
H4 - 18 to 60 inches: silt loam

Properties and qualities

Slope: 5 to 10 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None

Frequency of ponding: None
Calcium carbonate, maximum in profile: 15 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 11.7 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: LOAMY 6-10 PZ (R007XY102WA)
Hydric soil rating: No

Minor Components

Kennewick

Percent of map unit: 10 percent
Landform: Terraces
Hydric soil rating: No

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United States
Department of
Agriculture

NRCS

Natural
Resources
Conservation
Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for
Franklin County, Washington

June 2, 2022

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

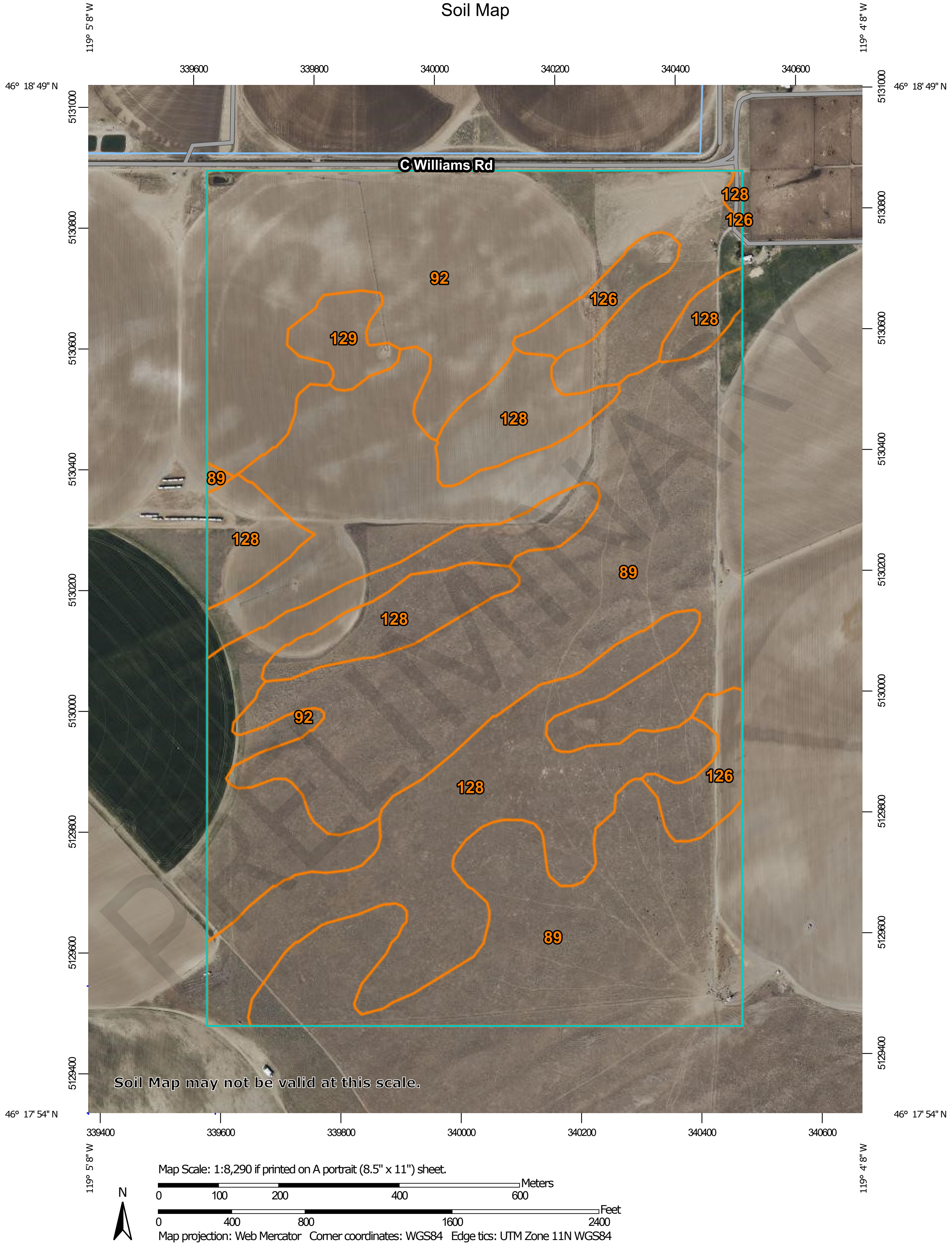
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map



Map Scale: 1:8,290 if printed on A portrait (8.5" x 11") sheet.

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Franklin County, Washington
Survey Area Data: Version 19, Aug 23, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 16, 2021—Apr 17, 2021

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
89	Quincy loamy fine sand, 0 to 15 percent slopes	141.7	45.3%
92	Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes	90.6	29.0%
126	Royal loamy fine sand, 0 to 10 percent slopes	9.7	3.1%
128	Royal fine sandy loam, 0 to 2 percent slopes	65.9	21.1%
129	Royal fine sandy loam, 2 to 5 percent slopes	4.5	1.4%
Totals for Area of Interest		**312.5**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Franklin County, Washington

89—Quincy loamy fine sand, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2dtt
Elevation: 350 to 1,200 feet
Mean annual precipitation: 6 to 12 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 4 inches: loamy fine sand
H2 - 4 to 60 inches: fine sand

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 3 percent
Available water supply, 0 to 60 inches: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R007XY502WA - SANDS 6-10 PZ
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Dunes, terraces
Hydric soil rating: No

92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2dv6
Elevation: 350 to 1,000 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 3 inches: loamy fine sand
H2 - 3 to 52 inches: loamy fine sand
H3 - 52 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 10 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 5.0
Available water supply, 0 to 60 inches: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R007XY502WA - SANDS 6-10 PZ
Hydric soil rating: No

126—Royal loamy fine sand, 0 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2df7
Elevation: 400 to 1,400 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Royal and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Royal

Setting

Landform: Terraces
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 6 inches: loamy fine sand
H2 - 6 to 19 inches: fine sandy loam
H3 - 19 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 0 to 10 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: R007XY502WA - SANDS 6-10 PZ
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Terraces
Hydric soil rating: No

128—Royal fine sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2dfc
Elevation: 400 to 1,400 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Royal and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Royal

Setting

Landform: Terraces
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 5 inches: fine sandy loam
H2 - 5 to 15 inches: fine sandy loam
H3 - 15 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: A
Ecological site: R007XY501WA - SANDY 6-10 PZ
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent

Landform: Terraces
Hydric soil rating: No

129—Royal fine sandy loam, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: 2dff
Elevation: 400 to 1,400 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Royal and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Royal

Setting

Landform: Terraces
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 5 inches: fine sandy loam
H2 - 5 to 15 inches: fine sandy loam
H3 - 15 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: R007XY501WA - SANDY 6-10 PZ
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Terraces
Hydric soil rating: No

Soil Information for All Uses

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Physical Soil Properties

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Physical Soil Properties–Franklin County, Washington														
Map symbol and soil name	**Depth**	**Sand**	**Silt**	**Clay**	**Moist bulk density**	**Saturated hydraulic conductivity**	**Available water capacity**	**Linear extensibility**	**Organic matter**	**Erosion factors**			**Wind erodibility group**	**Wind erodibility index**
										Kw	**Kf**	**T**		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
89—Quincy loamy fine sand, 0 to 15 percent slopes														
Quincy	0-4	-80-	-17-	1- 4- 6	1.50-1.58-1.65	42.34-92.00-141.14	0.09-0.10-0.11	0.0- 1.5- 2.9	0.5- 0.8-1.0	.24	.24	5	2	134
	4-60	-79-	-17-	1- 4- 7	1.50-1.58-1.65	42.34-92.00-141.14	0.05-0.08-0.11	0.0- 1.5- 2.9	0.0- 0.3-0.5	.20	.20			
92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes														
Quincy	0-3	-80-	-17-	0- 4- 7	1.25-1.35-1.45	42.34-92.00-141.14	0.08-0.10-0.11	0.0- 1.5- 2.9	1.0- 1.5-2.0	.24	.24	5	2	134
	3-52	-79-	-17-	1- 4- 7	1.30-1.40-1.50	42.34-92.00-141.14	0.08-0.10-0.11	0.0- 1.5- 2.9	0.0- 0.3-0.5	.32	.32			
	52-60	-34-	-59-	5- 8- 10	1.50-1.60-1.70	4.23-9.00-14.11	0.16-0.17-0.18	0.0- 1.5- 2.9	0.0- 0.3-0.5	.64	.64			

Physical Soil Properties–Franklin County, Washington														
Map symbol and soil name	**Depth**	**Sand**	**Silt**	**Clay**	**Moist bulk density**	**Saturated hydraulic conductivity**	**Available water capacity**	**Linear extensibility**	**Organic matter**	**Erosion factors**			**Wind erodibility group**	**Wind erodibility index**
										Kw	**Kf**	**T**		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
126—Royal loamy fine sand, 0 to 10 percent slopes														
Royal	0-6	-79-	-16-	2- 5- 8	1.35-1.40-1.45	42.34-92.00-141.14	0.09-0.10-0.11	0.0- 1.5- 2.9	0.5- 0.8- 1.0	.28	.28	5	2	134
	6-19	-65-	-27-	5- 8- 10	1.30-1.40-1.50	14.00-28.00-42.34	0.13-0.15-0.17	0.0- 1.5- 2.9	0.0- 0.3- 0.5	.37	.37			
	19-60	-92-	- 1-	3- 7- 10	1.40-1.50-1.60	14.00-28.00-42.34	0.10-0.12-0.14	0.0- 1.5- 2.9	0.0- 0.3- 0.5	.15	.15			
128—Royal fine sandy loam, 0 to 2 percent slopes														
Royal	0-5	-65-	-27-	5- 8- 10	1.30-1.35-1.40	14.00-28.00-42.34	0.13-0.14-0.15	0.0- 1.5- 2.9	0.5- 0.8- 1.0	.28	.28	5	3	86
	5-15	-65-	-27-	5- 8- 10	1.30-1.40-1.50	14.00-28.00-42.34	0.13-0.15-0.17	0.0- 1.5- 2.9	0.0- 0.3- 0.5	.37	.37			
	15-60	-66-	-27-	3- 7- 10	1.40-1.50-1.60	14.00-28.00-42.34	0.10-0.12-0.14	0.0- 1.5- 2.9	0.0- 0.3- 0.5	.55	.55			
129—Royal fine sandy loam, 2 to 5 percent slopes														
Royal	0-5	-65-	-27-	5- 8- 10	1.30-1.35-1.40	14.00-28.00-42.34	0.13-0.14-0.15	0.0- 1.5- 2.9	0.5- 0.8- 1.0	.28	.28	5	3	86
	5-15	-65-	-27-	5- 8- 10	1.30-1.40-1.50	14.00-28.00-42.34	0.13-0.15-0.17	0.0- 1.5- 2.9	0.0- 0.3- 0.5	.37	.37			
	15-60	-92-	- 1-	3- 7- 10	1.40-1.50-1.60	14.00-28.00-42.34	0.10-0.12-0.14	0.0- 1.5- 2.9	0.0- 0.3- 0.5	.15	.15			

Particle Size and Coarse Fragments

This table shows estimates of particle size distribution and coarse fragment content of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Total fragments is the content of fragments of rock and other materials larger than 2 millimeters in diameter on volumetric basis of the whole soil.

Fragments 2-74 mm refers to the content of coarse fragments in the 2 to 74 millimeter size fraction.

Fragments 75-249 mm refers to the content of coarse fragments in teh 75 to 249 millimeter size fraction.

Fragments 250-599 mm refers to the content of coarse fragments in the 250 to 599 millimeter size fraction.

Fragments >=600 mm refers to the content of coarse fragments in the greater than or equal to 600 millimeter size fraction.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Particle Size and Coarse Fragments–Franklin County, Washington										
Map symbol and soil name	**Horizon**	**Depth**	**Sand**	**Silt**	**Clay**	**Total fragments**	**Fragments 2-74 mm**	**Fragments 75-249 mm**	**Fragments 250-599 mm**	**Fragments >=600 mm**
		In	*L-RV-H Pct*	*L-RV-H Pct*	*L-RV-H Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*
89—Quincy loamy fine sand, 0 to 15 percent slopes										
Quincy	H1	0-4	-80-	-17-	1- 4- 6	—	—	—	—	—
	H2	4-60	-79-	-17-	1- 4- 7	—	—	—	—	—
92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes										
Quincy	H1	0-3	-80-	-17-	0- 4- 7	4	4	—	—	—
	H2	3-52	-79-	-17-	1- 4- 7	4	4	—	—	—
	H3	52-60	-34-	-59-	5- 8- 10	4	4	—	—	—
126—Royal loamy fine sand, 0 to 10 percent slopes										
Royal	H1	0-6	-79-	-16-	2- 5- 8	6	4	2	—	—
	H2	6-19	-65-	-27-	5- 8- 10	6	4	2	—	—
	H3	19-60	-92-	- 1-	3- 7- 10	6	4	2	—	—
128—Royal fine sandy loam, 0 to 2 percent slopes										
Royal	H1	0-5	-65-	-27-	5- 8- 10	6	4	2	—	—
	H2	5-15	-65-	-27-	5- 8- 10	6	4	2	—	—
	H3	15-60	-66-	-27-	3- 7- 10	6	4	2	—	—

Particle Size and Coarse Fragments–Franklin County, Washington										
Map symbol and soil name	**Horizon**	**Depth**	**Sand**	**Silt**	**Clay**	**Total fragments**	**Fragments 2-74 mm**	**Fragments 75-249 mm**	**Fragments 250-599 mm**	**Fragments >=600 mm**
		In	*L-RV-H Pct*	*L-RV-H Pct*	*L-RV-H Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*
129—Royal fine sandy loam, 2 to 5 percent slopes										
Royal	H1	0-5	-65-	-27-	5- 8- 10	6	4	2	—	—
	H2	5-15	-65-	-27-	5- 8- 10	6	4	2	—	—
	H3	15-60	-92-	- 1-	3- 7- 10	6	4	2	—	—

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United States
Department of
Agriculture

NRCS

Natural
Resources
Conservation
Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Franklin County, Washington

September 8, 2021

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

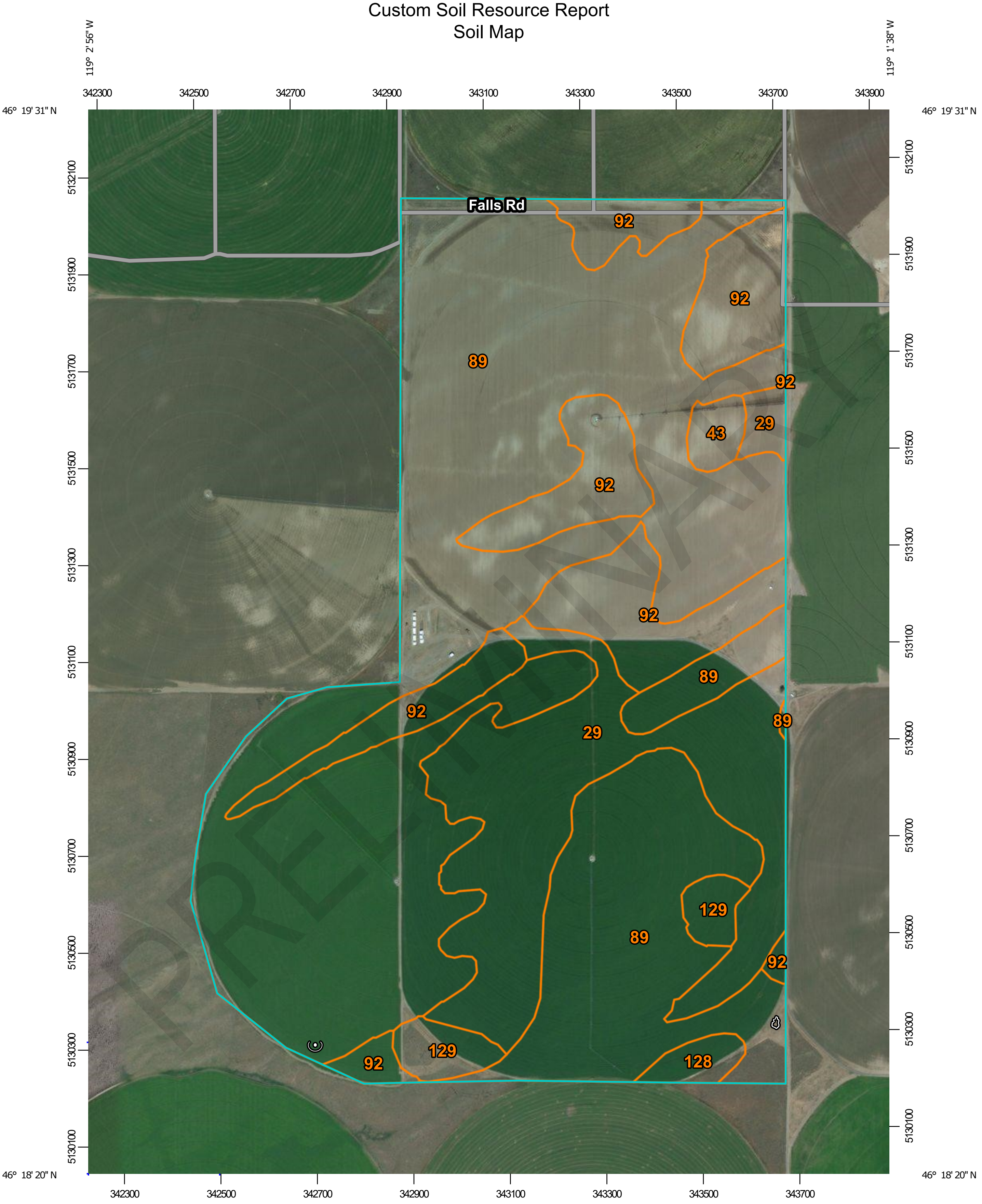
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map



Map Scale: 1:10,700 if printed on A portrait (8.5" x 11") sheet.

0	150	300	600	900	Meters
0	500	1000	2000	3000	Feet

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Franklin County, Washington
Survey Area Data: Version 18, Jun 4, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 28, 2014—Jul 2, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
29	Hezel loamy fine sand, 0 to 15 percent slopes	70.3	16.3%
43	Kennewick silt loam, 0 to 2 percent slopes	3.8	0.9%
89	Quincy loamy fine sand, 0 to 15 percent slopes	279.3	64.6%
92	Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes	65.9	15.3%
128	Royal fine sandy loam, 0 to 2 percent slopes	3.7	0.9%
129	Royal fine sandy loam, 2 to 5 percent slopes	9.0	2.1%
Totals for Area of Interest		**432.1**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Franklin County, Washington

29—Hezel loamy fine sand, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2dm1
Elevation: 400 to 2,500 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Hezel and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hezel

Setting

Landform: Terraces
Parent material: Glaciofluvial deposits with a mantle of eolian sands

Typical profile

H1 - 0 to 7 inches: loamy fine sand
H2 - 7 to 18 inches: loamy sand
H3 - 18 to 27 inches: fine sandy loam
H4 - 27 to 60 inches: stratified fine sandy loam to silt loam

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: R007XY502WA - SANDS 6-10 PZ
Hydric soil rating: No

Minor Components

Quincy

Percent of map unit: 10 percent
Landform: Terraces
Hydric soil rating: No

Sagehill

Percent of map unit: 5 percent
Landform: Terraces
Hydric soil rating: No

43—Kennewick silt loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2dnf
Elevation: 300 to 1,500 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 130 to 210 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Kennewick and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kennewick

Setting

Landform: Terraces
Parent material: Lacustrine deposits

Typical profile

H1 - 0 to 8 inches: silt loam
H2 - 8 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 12.0 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: C
Ecological site: R007XY701WA - CALCAREOUS LOAM 6-10 PZ
Hydric soil rating: No

Minor Components

Warden

Percent of map unit: 3 percent
Landform: Terraces
Hydric soil rating: No

Royal

Percent of map unit: 2 percent
Landform: Terraces
Hydric soil rating: No

89—Quincy loamy fine sand, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2dtt
Elevation: 350 to 1,200 feet
Mean annual precipitation: 6 to 12 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 4 inches: loamy fine sand
H2 - 4 to 60 inches: fine sand

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 3 percent
Available water supply, 0 to 60 inches: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): 3e

Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R007XY502WA - SANDS 6-10 PZ
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Dunes, terraces
Hydric soil rating: No

92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes

Map Unit Setting

National map unit symbol: 2dv6
Elevation: 350 to 1,000 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Quincy and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Quincy

Setting

Landform: Terraces
Parent material: Mixed eolian sands

Typical profile

H1 - 0 to 3 inches: loamy fine sand
H2 - 3 to 52 inches: loamy fine sand
H3 - 52 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 10 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 5.0
Available water supply, 0 to 60 inches: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R007XY502WA - SANDS 6-10 PZ
Hydric soil rating: No

128—Royal fine sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2dfc
Elevation: 400 to 1,400 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Royal and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Royal

Setting

Landform: Terraces
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 5 inches: fine sandy loam
H2 - 5 to 15 inches: fine sandy loam
H3 - 15 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 6c
Hydrologic Soil Group: A
Ecological site: R007XY501WA - SANDY 6-10 PZ
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Terraces
Hydric soil rating: No

129—Royal fine sandy loam, 2 to 5 percent slopes

Map Unit Setting

National map unit symbol: 2dff
Elevation: 400 to 1,400 feet
Mean annual precipitation: 6 to 9 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 180 to 200 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Royal and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Royal

Setting

Landform: Terraces
Parent material: Sandy alluvium

Typical profile

H1 - 0 to 5 inches: fine sandy loam
H2 - 5 to 15 inches: fine sandy loam
H3 - 15 to 60 inches: stratified fine sand to very fine sandy loam

Properties and qualities

Slope: 2 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A

Ecological site: R007XY501WA - SANDY 6-10 PZ
Hydric soil rating: No

Minor Components

Sagehill

Percent of map unit: 15 percent
Landform: Terraces
Hydric soil rating: No

Soil Information for All Uses

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

AOI Inventory

This folder contains a collection of tabular reports that present a variety of soil information. Included are various map unit description reports, special soil interpretation reports, and data summary reports.

Component Text Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the selected area. The component descriptions in this report, along with the maps, can be used to determine the composition and properties of a unit. A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the associated soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas (components) for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

The "Map Unit Component Nontechnical Descriptions" report gives a brief, general description of the soil components that occur in a map unit. Descriptions of nonsoil (miscellaneous areas) and minor map unit components may or may not be included. This description is written by the local soil scientists responsible for the respective soil survey area data. A more detailed description can be generated by the "Map Unit Description" report.

Additional information about the map units described in this report is available in other Soil Data Mart reports, which give properties of the soils and the limitations, capabilities, and potentials for many uses. Also, the narratives that accompany the Soil Data Mart reports define some of the properties included in the map unit descriptions.

Report—Component Text Descriptions

Franklin County, Washington

Map Unit: 29—Hezel loamy fine sand, 0 to 15 percent slopes

Description Category: GENSOIL

Hezel: 85 percent

The Hezel component makes up 85 percent of the map unit. Slopes are 0 to 15 percent. This component is on dissected terraces. The parent material consists of glaciofluvial deposits with a mantle of eolian sands. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is somewhat excessively drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches (or restricted depth) is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 0 percent. This component is in the R007XY502WA Sands 6-10 Pz ecological site. Nonirrigated land capability classification is 6e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 10 percent. There are no saline horizons within 30 inches of the soil surface.

Description Category: GENSOIL

Quincy: 10 percent

Generated brief soil descriptions are created for major soil components. The Quincy soil is a minor component.

Description Category: GENSOIL

Sagehill: 5 percent

Generated brief soil descriptions are created for major soil components. The Sagehill soil is a minor component.

Map Unit: 43—Kennewick silt loam, 0 to 2 percent slopes

Description Category: GENSOIL

Kennewick: 95 percent

The Kennewick component makes up 95 percent of the map unit. Slopes are 0 to 2 percent. This component is on terraces. The parent material consists of lacustrine deposits. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches (or restricted depth) is very high. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R007XY701WA Calcareous Loam 6-10 Pz ecological site. Nonirrigated land capability classification is 6c. Irrigated land capability classification is 2e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 8 percent. There are no saline horizons within 30 inches of the soil surface.

Description Category: GENSOIL

Warden: 3 percent

Generated brief soil descriptions are created for major soil components. The Warden soil is a minor component.

Description Category: GENSOIL

Royal: 2 percent

Generated brief soil descriptions are created for major soil components. The Royal soil is a minor component.

Map Unit: 89—Quincy loamy fine sand, 0 to 15 percent slopes

Description Category: GENSOIL

Quincy: 85 percent

The Quincy component makes up 85 percent of the map unit. Slopes are 0 to 15 percent. This component is on terraces. The parent material consists of mixed eolian sands. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is excessively drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches (or restricted depth) is low. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R007XY502WA Sands 6-10 Pz ecological site. Nonirrigated land capability classification is 7e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 2 percent.

Description Category: GENSOIL

Sagehill: 15 percent

Generated brief soil descriptions are created for major soil components. The Sagehill soil is a minor component.

Map Unit: 92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes

Description Category: GENSOIL

Quincy: 85 percent

The Quincy component makes up 85 percent of the map unit. Slopes are 0 to 10 percent. This component is on terraces. The parent material consists of mixed eolian sands. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is excessively drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches (or restricted depth) is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 2 percent. This component is in the R007XY502WA Sands 6-10 Pz ecological site. Nonirrigated land capability classification is 7e. Irrigated land capability classification is 3e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 3 percent.

Map Unit: 128—Royal fine sandy loam, 0 to 2 percent slopes

Description Category: GENSOIL

Royal: 85 percent

The Royal component makes up 85 percent of the map unit. Slopes are 0 to 2 percent. This component is on terraces. The parent material consists of sandy alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches (or restricted depth) is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R007XY501WA Sandy 6-10 Pz ecological site. Nonirrigated land capability classification is 6c. Irrigated land capability classification is 1 This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 10 percent. There are no saline horizons within 30 inches of the soil surface.

Description Category: GENSOIL

Sagehill: 15 percent

Generated brief soil descriptions are created for major soil components. The Sagehill soil is a minor component.

Map Unit: 129—Royal fine sandy loam, 2 to 5 percent slopes

Description Category: GENSOIL

Royal: 85 percent

The Royal component makes up 85 percent of the map unit. Slopes are 2 to 5 percent. This component is on terraces. The parent material consists of sandy alluvium. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Water movement in the most restrictive layer is high. Available water to a depth of 60 inches (or restricted depth) is moderate. Shrink-swell potential is low. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 1 percent. This component is in the R007XY501WA Sandy 6-10 Pz ecological site. Nonirrigated land capability classification is 6e. Irrigated land capability classification is 2e. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 10 percent. There are no saline horizons within 30 inches of the soil surface.

Description Category: GENSOIL

Sagehill: 15 percent

Generated brief soil descriptions are created for major soil components. The Sagehill soil is a minor component.

Selected Soil Interpretations

This report allows the customer to produce a report showing the results of the soil interpretation(s) of his or her choice. It is useful when a standard report that displays the results of the selected interpretation(s) is not available.

When customers select this report, they are presented with a list of interpretations with results for the selected map units. The customer may select up to three interpretations to be presented in table format.

For a description of the particular interpretations and their criteria, use the "Selected Survey Area Interpretation Descriptions" report.

Report—Selected Soil Interpretations

Selected Soil Interpretations–Franklin County, Washington			
Map symbol and soil name	Pct. of map unit	AWM - Irrigation Disposal of Wastewater	
		Rating class and limiting features	Value
29—Hezel loamy fine sand, 0 to 15 percent slopes			
Hezel	85	Very limited	
		Filtering capacity	1.00
		Too steep for surface application	1.00
		Slow water movement	0.22
		Too steep for sprinkler application	0.10
43—Kennewick silt loam, 0 to 2 percent slopes			
Kennewick	95	Somewhat limited	
		Slow water movement	0.22

Selected Soil Interpretations–Franklin County, Washington			
Map symbol and soil name	Pct. of map unit	AWM - Irrigation Disposal of Wastewater	
		Rating class and limiting features	Value
89—Quincy loamy fine sand, 0 to 15 percent slopes			
Quincy	85	Very limited	
		Filtering capacity	1.00
		Too steep for surface application	1.00
		Droughty	0.25
		Too steep for sprinkler application	0.10
92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes			
Quincy	85	Very limited	
		Filtering capacity	1.00
		Too steep for surface application	0.32
128—Royal fine sandy loam, 0 to 2 percent slopes			
Royal	85	Not limited	
129—Royal fine sandy loam, 2 to 5 percent slopes			
Royal	85	Somewhat limited	
		Too steep for surface application	0.08

Land Classifications

This folder contains a collection of tabular reports that present a variety of soil groupings. The reports (tables) include all selected map units and components for each map unit. Land classifications are specified land use and management groupings that are assigned to soil areas because combinations of soil have similar behavior for specified practices. Most are based on soil properties and other factors that directly influence the specific use of the soil. Example classifications include ecological site classification, farmland classification, irrigated and nonirrigated land capability classification, and hydric rating.

Hydric Soil List - All Components

This table lists the map unit components and their hydric status in the survey area. This list can help in planning land uses; however, onsite investigation is recommended to determine the hydric soils on a specific site (National Research Council, 1995; Hurt and others, 2002).

The three essential characteristics of wetlands are hydrophytic vegetation, hydric soils, and wetland hydrology (Cowardin and others, 1979; U.S. Army Corps of Engineers, 1987; National Research Council, 1995; Tiner, 1985). Criteria for all of the characteristics must be met for areas to be identified as wetlands. Undrained hydric soils that have natural vegetation should support a dominant population of ecological wetland plant species. Hydric soils that have been converted to other uses should be capable of being restored to wetlands.

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). These soils, under natural conditions, are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation.

The NTCHS definition identifies general soil properties that are associated with wetness. In order to determine whether a specific soil is a hydric soil or nonhydric soil, however, more specific information, such as information about the depth and duration of the water table, is needed. Thus, criteria that identify those estimated soil properties unique to hydric soils have been established (Federal Register, 2002). These criteria are used to identify map unit components that normally are associated with wetlands. The criteria used are selected estimated soil properties that are described in "Soil Taxonomy" (Soil Survey Staff, 1999) and "Keys to Soil Taxonomy" (Soil Survey Staff, 2006) and in the "Soil Survey Manual" (Soil Survey Division Staff, 1993).

If soils are wet enough for a long enough period of time to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. The indicators used to make onsite determinations of hydric soils are specified in "Field Indicators of Hydric Soils in the United States" (Hurt and Vasilas, 2006).

Hydric soils are identified by examining and describing the soil to a depth of about 20 inches. This depth may be greater if determination of an appropriate indicator so requires. It is always recommended that soils be excavated and described to the depth necessary for an understanding of the redoximorphic processes. Then, using the completed soil descriptions, soil scientists can compare the soil features required by each indicator and specify which indicators have been matched with the conditions observed in the soil. The soil can be identified as a hydric soil if at least one of the approved indicators is present.

Map units that are dominantly made up of hydric soils may have small areas, or inclusions, of nonhydric soils in the higher positions on the landform, and map units dominantly made up of nonhydric soils may have inclusions of hydric soils in the lower positions on the landform.

The criteria for hydric soils are represented by codes in the table (for example, 2). Definitions for the codes are as follows:

1. All Histels except for Folistels, and Histosols except for Folists.
2. Soils in Aquic suborders, great groups, or subgroups, Albolls suborder, Historthels great group, Histoturbels great group, Pachic subgroups, or Cumulic subgroups that:
    - A. Based on the range of characteristics for the soil series, will at least in part meet one or more Field Indicators of Hydric Soils in the United States, or
    - B. Show evidence that the soil meets the definition of a hydric soil;
3. Soils that are frequently ponded for long or very long duration during the growing season.
    - A. Based on the range of characteristics for the soil series, will at least in part meet one or more Field Indicators of Hydric Soils in the United States, or

   B. Show evidence that the soil meets the definition of a hydric soil;

4. Map unit components that are frequently flooded for long duration or very long duration during the growing season that:
   A. Based on the range of characteristics for the soil series, will at least in part meet one or more Field Indicators of Hydric Soils in the United States, or
   B. Show evidence that the soil meets the definition of a hydric soil;

Hydric Condition: Food Security Act information regarding the ability to grow a commodity crop without removing woody vegetation or manipulating hydrology.

References:

Federal Register. July 13, 1994. Changes in hydric soils of the United States.
Federal Register. Doc. 2012-4733 Filed 2-28-12. February, 28, 2012. Hydric soils of the United States.
Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18.
Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.
Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service.
Vasilas, L.M., G.W. Hurt, and C.V. Noble, editors. Version 7.0, 2010. Field indicators of hydric soils in the United States.

Report—Hydric Soil List - All Components

Hydric Soil List - All Components–WA021-Franklin County, Washington

Map symbol and map unit name	Component/Local Phase	Comp. pct.	Landform	Hydric status	Hydric criteria met (code)
29: Hezel loamy fine sand, 0 to 15 percent slopes	Hezel	85	Terraces	No	—
	Quincy	10	Terraces	No	—
	Sagehill	5	Terraces	No	—
43: Kennewick silt loam, 0 to 2 percent slopes	Kennewick	95	Terraces	No	—
	Warden	3	Terraces	No	—
	Royal	2	Terraces	No	—
89: Quincy loamy fine sand, 0 to 15 percent slopes	Quincy	85	Terraces	No	—
	Sagehill	15	Dunes,terraces	No	—
92: Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes	Quincy	85	Terraces	No	—
128: Royal fine sandy loam, 0 to 2 percent slopes	Royal	85	Terraces	No	—
	Sagehill	15	Terraces	No	—
129: Royal fine sandy loam, 2 to 5 percent slopes	Royal	85	Terraces	No	—
	Sagehill	15	Terraces	No	—

Taxonomic Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories (Soil Survey Staff, 1999 and 2003). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. This table shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Twelve soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol.* An example is Alfisols.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Udalfs (*Ud*, meaning humid, plus *alfs*, from Alfisols).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; type of saturation; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Hapludalfs (*Hapl*, meaning minimal horizonation, plus *udalfs*, the suborder of the Alfisols that has a udic moisture regime).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic subgroup is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other taxonomic class. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Typic* identifies the subgroup that typifies the great group. An example is Typic Hapludalfs.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineralogy class, cation-exchange activity class, soil temperature regime, soil depth, and reaction class. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is fine-loamy, mixed, active, mesic Typic Hapludalfs.

SERIES. The series consists of soils within a family that have horizons similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile.

References:

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.
Soil Survey Staff. 2006. Keys to soil taxonomy. 10th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. (The soils in a given survey area may have been classified according to earlier editions of this publication.)

Report—Taxonomic Classification of the Soils

[An asterisk by the soil name indicates a taxadjunct to the series]

Taxonomic Classification of the Soils–Franklin County, Washington	
Soil name	**Family or higher taxonomic classification**
Hezel	Sandy over loamy, mixed, superactive, nonacid, mesic Xeric Torriorthents
Kennewick	Coarse-silty, mixed, superactive, calcareous, mesic Xeric Torriorthents
Quincy	Mixed, mesic Xeric Torripsamments
Royal	Coarse-loamy, mixed, superactive, mesic Xeric Haplocambids

Soil Erosion

This folder contains a collection of tabular reports that present soil erosion factors and groupings. The reports (tables) include all selected map units and components for each map unit. Soil erosion factors are soil properties and interpretations used in evaluating the soil for potential erosion. Example soil erosion factors can include K factor for the whole soil or on a rock free basis, T factor, wind erodibility group and wind erodibility index.

Conservation Planning

This report provides those soil attributes for the conservation plan for the map units in the selected area. The report includes the map unit symbol, the component name, and the percent of the component in the map unit. It provides the soil description along with the slope, runoff, T Factor, WEI, WEG, Erosion class, Drainage class, Land Capability Classification, and the engineering Hydrologic Group and the erosion factors Kf, the representative percentage of fragments, sand, silt, and clay in the mineral surface horizon. Missing surface data may indicate the presence of an organic surface layer. Further information on these factors can be found in the National Soil Survey Handbook section 618 found at the url http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054223#00 .

Soil properties and interpretations for conservation planning. The surface mineral horizon properties are displayed. Organic surface horizons are not displayed.

Conservation Planning–Franklin County, Washington

Map symbol and soil name	Pct. of map unit	Slope RV	USLE Slope Length ft.	Runoff	T Factor	WEI	WEG	Erosion	Drainage	NIRR LCC	Hydrologic Group	Surface					
												Depths in.	Kf Factor	Frag-ments RV	Sand RV	Silt RV	Clay RV
29—Hezel loamy fine sand, 0 to 15 percent slopes																	
Hezel	85	8.0	—	—	5	134	2	—	Somewhat excessively drained	6e	C	0 - 7	.28	—	79	16	3
43—Kennewick silt loam, 0 to 2 percent slopes																	
Kennewick	95	1.0	—	—	5	56	5	—	Well drained	6c	C	0 - 7	.64	—	21	70	7
89—Quincy loamy fine sand, 0 to 15 percent slopes																	
Quincy	85	8.0	—	—	5	134	2	—	Excessively drained	7e	A	0 - 3	.24	—	79	16	3
92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes																	
Quincy	85	5.0	—	—	5	134	2	—	Excessively drained	7e	A	0 - 3	.24	4	79	16	3
128—Royal fine sandy loam, 0 to 2 percent slopes																	
Royal	85	1.0	—	—	5	86	3	—	Well drained	6c	A	0 - 5	.28	6	65	27	7
129—Royal fine sandy loam, 2 to 5 percent slopes																	
Royal	85	4.0	—	—	5	86	3	—	Well drained	6e	A	0 - 5	.28	6	65	27	7

RUSLE2 Related Attributes

This report summarizes those soil attributes used by the Revised Universal Soil Loss Equation Version 2 (RUSLE2) for the map units in the selected area. The report includes the map unit symbol, the component name, and the percent of the component in the map unit. Soil property data for each map unit component include the hydrologic soil group, erosion factor Kf for the surface horizon, erosion factor T, and the representative percentage of sand, silt, and clay in the mineral surface horizon. Missing surface data may indicate the presence of an organic layer.

Report—RUSLE2 Related Attributes

Soil properties and interpretations for erosion runoff calculations. The surface mineral horizon properties are displayed or the first mineral horizon below an organic surface horizon. Organic horizons are not displayed.

RUSLE2 Related Attributes–Franklin County, Washington

Map symbol and soil name	Pct. of map unit	Slope length (ft)	Hydrologic group	Kf	T factor	Representative value		
						% Sand	% Silt	% Clay
29—Hezel loamy fine sand, 0 to 15 percent slopes								
Hezel	85	—	C	.28	5	79.9	16.6	3.5
43—Kennewick silt loam, 0 to 2 percent slopes								
Kennewick	95	—	C	.64	5	21.7	70.8	7.5
89—Quincy loamy fine sand, 0 to 15 percent slopes								
Quincy	85	—	A	.24	5	79.9	16.6	3.5
92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes								
Quincy	85	—	A	.24	5	79.9	16.6	3.5
128—Royal fine sandy loam, 0 to 2 percent slopes								
Royal	85	—	A	.28	5	65.2	27.3	7.5
129—Royal fine sandy loam, 2 to 5 percent slopes								
Royal	85	—	A	.28	5	65.2	27.3	7.5

Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Particle Size and Coarse Fragments

This table shows estimates of particle size distribution and coarse fragment content of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Total fragments is the content of fragments of rock and other materials larger than 2 millimeters in diameter on volumetric basis of the whole soil.

Fragments 2-74 mm refers to the content of coarse fragments in the 2 to 74 millimeter size fraction.

Fragments 75-249 mm refers to the content of coarse fragments in teh 75 to 249 millimeter size fraction.

Fragments 250-599 mm refers to the content of coarse fragments in the 250 to 599 millimeter size fraction.

Fragments >=600 mm refers to the content of coarse fragments in the greater than or equal to 600 millimeter size fraction.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Particle Size and Coarse Fragments–Franklin County, Washington

Map symbol and soil name	Horizon	Depth	Sand	Silt	Clay	Total fragments	Fragments 2-74 mm	Fragments 75-249 mm	Fragments 250-599 mm	Fragments >=600 mm
		In	*L-RV-H Pct*	*L-RV-H Pct*	*L-RV-H Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*
29—Hezel loamy fine sand, 0 to 15 percent slopes										
Hezel	H1	0-7	-80-	-17-	2- 4- 5	—	—	—	—	—
	H2	7-18	-81-	-17-	0- 3- 5	—	—	—	—	—
	H3	18-27	-66-	-28-	5- 7- 8	—	—	—	—	—
	H4	27-60	-71-	-22-	5- 7- 8	—	—	—	—	—
43—Kennewick silt loam, 0 to 2 percent slopes										
Kennewick	H1	0-8	-22-	-71-	3- 8- 12	—	—	—	—	—
	H2	8-60	-21-	-69-	3-11- 18	—	—	—	—	—
89—Quincy loamy fine sand, 0 to 15 percent slopes										
Quincy	H1	0-4	-80-	-17-	1- 4- 6	—	—	—	—	—
	H2	4-60	-79-	-17-	1- 4- 7	—	—	—	—	—
92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes										
Quincy	H1	0-3	-80-	-17-	0- 4- 7	4	4	—	—	—
	H2	3-52	-79-	-17-	1- 4- 7	4	4	—	—	—
	H3	52-60	-34-	-59-	5- 8- 10	4	4	—	—	—

Particle Size and Coarse Fragments–Franklin County, Washington										
Map symbol and soil name	**Horizon**	**Depth**	**Sand**	**Silt**	**Clay**	**Total fragments**	**Fragments 2-74 mm**	**Fragments 75-249 mm**	**Fragments 250-599 mm**	**Fragments >=600 mm**
		In	*L-RV-H Pct*	*L-RV-H Pct*	*L-RV-H Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*	*RV Pct*
128—Royal fine sandy loam, 0 to 2 percent slopes										
Royal	H1	0-5	-65-	-27-	5- 8- 10	6	4	2	—	—
	H2	5-15	-65-	-27-	5- 8- 10	6	4	2	—	—
	H3	15-60	-66-	-27-	3- 7- 10	6	4	2	—	—
129—Royal fine sandy loam, 2 to 5 percent slopes										
Royal	H1	0-5	-65-	-27-	5- 8- 10	6	4	2	—	—
	H2	5-15	-65-	-27-	5- 8- 10	6	4	2	—	—
	H3	15-60	-92-	- 1-	3- 7- 10	6	4	2	—	—

Physical Soil Properties

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Physical Soil Properties–Franklin County, Washington

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
29—Hezel loamy fine sand, 0 to 15 percent slopes														
Hezel	0-7	-80-	-17-	2- 4- 5	1.25-1.35-1.45	42.34-92.00-141.14	0.09-0.11-0.13	0.0- 1.5- 2.9	0.0- 0.3-0.5	.28	.28	5	2	134
	7-18	-81-	-17-	0- 3- 5	1.40-1.50-1.60	42.34-92.00-141.14	0.08-0.10-0.12	0.0- 1.5- 2.9	0.0- 0.3-0.5	.32	.32			
	18-27	-66-	-28-	5- 7- 8	1.30-1.40-1.50	4.23-9.00-14.11	0.13-0.17-0.21	0.0- 1.5- 2.9	0.0- 0.3-0.5	.43	.43			
	27-60	-71-	-22-	5- 7- 8	1.30-1.40-1.50	1.40-3.00-4.23	0.13-0.17-0.21	0.0- 1.5- 2.9	0.0- 0.3-0.5	.37	.37			
43—Kennewick silt loam, 0 to 2 percent slopes														
Kennewick	0-8	-22-	-71-	3- 8- 12	1.15-1.25-1.35	4.23-9.00-14.11	0.19-0.20-0.21	0.0- 1.5- 2.9	0.5- 0.8-1.0	.64	.64	5	5	56
	8-60	-21-	-69-	3-11- 18	1.30-1.40-1.50	1.40-3.00-4.23	0.18-0.20-0.21	0.0- 1.5- 2.9	0.0- 0.3-0.5	.64	.64			
89—Quincy loamy fine sand, 0 to 15 percent slopes														
Quincy	0-4	-80-	-17-	1- 4- 6	1.50-1.58-1.65	42.34-92.00-141.14	0.09-0.10-0.11	0.0- 1.5- 2.9	0.5- 0.8-1.0	.24	.24	5	2	134
	4-60	-79-	-17-	1- 4- 7	1.50-1.58-1.65	42.34-92.00-141.14	0.05-0.08-0.11	0.0- 1.5- 2.9	0.0- 0.3-0.5	.20	.20			

Physical Soil Properties–Franklin County, Washington

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
92—Quincy loamy fine sand, loamy substratum, 0 to 10 percent slopes														
Quincy	0-3	-80-	-17-	0- 4- 7	1.25-1.35-1.45	42.34-92.00-141.14	0.08-0.10-0.11	0.0- 1.5- 2.9	1.0- 1.5-2.0	.24	.24	5	2	134
	3-52	-79-	-17-	1- 4- 7	1.30-1.40-1.50	42.34-92.00-141.14	0.08-0.10-0.11	0.0- 1.5- 2.9	0.0- 0.3-0.5	.32	.32			
	52-60	-34-	-59-	5- 8- 10	1.50-1.60-1.70	4.23-9.00-14.11	0.16-0.17-0.18	0.0- 1.5- 2.9	0.0- 0.3-0.5	.64	.64			
128—Royal fine sandy loam, 0 to 2 percent slopes														
Royal	0-5	-65-	-27-	5- 8- 10	1.30-1.35-1.40	14.00-28.00-42.34	0.13-0.14-0.15	0.0- 1.5- 2.9	0.5- 0.8-1.0	.28	.28	5	3	86
	5-15	-65-	-27-	5- 8- 10	1.30-1.40-1.50	14.00-28.00-42.34	0.13-0.15-0.17	0.0- 1.5- 2.9	0.0- 0.3-0.5	.37	.37			
	15-60	-66-	-27-	3- 7- 10	1.40-1.50-1.60	14.00-28.00-42.34	0.10-0.12-0.14	0.0- 1.5- 2.9	0.0- 0.3-0.5	.55	.55			
129—Royal fine sandy loam, 2 to 5 percent slopes														
Royal	0-5	-65-	-27-	5- 8- 10	1.30-1.35-1.40	14.00-28.00-42.34	0.13-0.14-0.15	0.0- 1.5- 2.9	0.5- 0.8-1.0	.28	.28	5	3	86
	5-15	-65-	-27-	5- 8- 10	1.30-1.40-1.50	14.00-28.00-42.34	0.13-0.15-0.17	0.0- 1.5- 2.9	0.0- 0.3-0.5	.37	.37			
	15-60	-92-	- 1-	3- 7- 10	1.40-1.50-1.60	14.00-28.00-42.34	0.10-0.12-0.14	0.0- 1.5- 2.9	0.0- 0.3-0.5	.15	.15			

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Appendix C1

Well Inventory Summary

Appendix C1. Well Inventory Summary

Well Inventory Number	Well ID	Owner	Well Completion Date	Well Location	Use [1]	Yield [2]	Well Depth	Casing Interval (diameter) [3]	Screened or Perforated Interval [4]	Aquifer [5]	Static Water Level [6]
						gpm	feet	feet below ground surface			feet
Township 9N, Range 30E, Section 2											
1	#3	Robert Tippet 3400 W Clearwater Kennewick, WA 99336	10/10/1974	NW	I, T	NR	159.0	0 to 158.6 (16)	None	BA	95
2	4	Robert Tippet 3400 W Clearwater Kennewick, WA 99336	6/2/1975	SE of NW	T	Not Tested	140.0	0 to 140 (6)	None	UA	68
3	MW-9 AFF 590	City of Pasco Pasco, WA	4/18/2001	NE of NE	NR	NR	125.0	3 to 95 (4)	95 to 125	UA	104
4	4A	Tippet Land and Morgage Franklin County	12/30/1988	SW of NE	I	NR	139.5	+6 to 120.5 (16)	120.5 to 138.5	UA	89
5	4	Tippet Land and Morgage Franklin County	12/9/1988	SW of NE	I, A	NR	NR	NR to 88 (16)	NR	NR	NR
6	5	Robert Tippet 3400 W Clearwater Kennewick, WA 99336	3/19/1975	SW of NE	I, T	NR	165.0	0 to 165 (16)	None	BA	98
7	#1 APJ 201	Carson Ay LLC 28 Pasco Kahlotus Rd Pasco, WA 99301	4/9/2008	SW of NE	MW	Not Tested	96.0	+2 to 96 (2)	76 to 96	UA	81.5
8	#3 APJ 203	Carson Ay LLC 28 Pasco Kahlotus Rd Pasco, WA 99301	5/9/2008	SE of NE	MW	Not Tested	94.0	1.5 to 94 (2)	74 to 94	UA	80
9	#1	Robert Tippet 3400 W Clearwater Kennewick, WA 99336	7/3/1974	SE of NE	I, T	2,451 4 hours 8-foot drawdown pump	127.0	0 to 127 (16)	None	UA	80
Township 9N, Range 30E, Section 3											
10	MW-03	City of Pasco Wastewater Treatment Facility Franklin County	1/26/1995	NR	NR	NR	139.0	+3.3 to 106.7 106.7 to 136.7 136.7 to 139.15 139.15 to 139.43	NR	UA	NR
11	NR	City of Pasco Pasco, WA	3/17/1995	SW of NW	MW	NR	NR	NR	NR	NR	NR
Township 9N, Range 30E, Section 4											
12	PW-1	City of Pasco Wastewater Treatment Facility	1/17/1975	NR	P	40-50	253.4	Not legible	Not legible	BA	175

Appendix C1. Well Inventory Summary

Well Inventory Number	Well ID	Owner	Well Completion Date	Well Location	Use [1]	Yield [2]	Well Depth	Casing Interval (diameter) [3]	Screened or Perforated Interval [4]	Aquifer [5]	Static Water Level [6]
						gpm	feet	feet below ground surface			feet
13	MW-02a	City of Pasco Wastewater Treatment Facility Franklin County	2/20/1975	NR	MW	NR	178.0	+3.5 to 145.27 145.27 to 175.29 175.29 to 177.68 177.68 to 178.0	Not legible	UA	NR
14	NR	Earl Blasdel 2001 E Foster Wells Rd Pasco, WA 99301	11/2/1993	NW of SW	I	1,860 12 hours 20-foot drawdown	220.0	+1 to 197	197 to 217	UA	175
15	NR	JE Lentz Franklin County	1/1/1978	SE of SE	I	NR	242.0	+1 to 216 (16)	216 to 237	BA	165
16	NR	Jim Minnehan Highway E 410 Pasco, WA 99301	7/31/1974	SE of SE	I	1,212 4 hours 16-foot drawdown	186.0	0 to 184 (12)	None	UA	146
Township 9N, Range 30E, Section 5											
17	29	NR	3/20/1973	NE of SE	I	NR	230.0	0 to 230 (16)	None	BA	166
18	AHK 268	Earl Blasdel E Foster Wells Rd and Commercial Rd Pasco, WA 99301	10/29/2002	SW of SE	D	50 Air 4 hours	203.5	+1.5 to 194 (8)	194 to 149	UA	162
19	NR	Herb Rode Collins	10/3/1992	SE of SE	D	NR	240.0	+1 to 217 (6)	None	BA	164
Township 9N, Range 30E, Section 6											
20	ACE 623	David Vooge 1532 North 14th Ave Pasco, WA 99301	8/20/1996	NE of NE	D	35 Air	124.0	+1 to 124 (6)	None	UA	87
21	NR	Robert Tippett 3400 W Clearwater Kennewick, WA 99336	3/4/1977 6/16/1977	SW of SE	D	15 estimated	101.0 154.0	0 to 154 (6)	40 slot	UA	78
22	NR	Gordon Bradshaw Franklin County	6/28/1993	SE of SE	D	35 Air 3 hours	245.0	+1 to 215 (6)	None	BA	155
23	BCF 552	Rogers Potato Railroad Ave Pasco, WA 99301	4/24/2012	SE of SE	D	50 Air 2 hours	144.0	+2 to 144 (8)	None	UA	87.5
24	ACX 249	Robertt Micheal McKee Benton	7/2/1998	SE of SE	D	50 Air 2 hours	225.0	+1 to 205 (6)	None	BA	161.0
25	NR	Robert Tippett 3400 W Clearwater Kennewick, WA 99336	9/5/1973	SE of SE	I	1,000 5 hours 25-foot drawdown	132.0	0 to 127 (16) 127 to 132 (12)	None	UA	97

Appendix C1. Well Inventory Summary

Well Inventory Number	Well ID	Owner	Well Completion Date	Well Location	Use [1]	Yield [2]	Well Depth	Casing Interval (diameter) [3]	Screened or Perforated Interval [4]	Aquifer [5]	Static Water Level [6]
						gpm	feet	feet below ground surface			feet
Township 10N, Range 30E, Section 21											
26	NR	USBR	4/16/1966	SE of SE	NR	NR	51.0	NR	NR	NR	NR
Township 10N, Range 30E, Section 22											
27	NR	Gary Pfisher Falls Rd Pasco, WA 99301	1/26/1977	NW of SW	D	NR	410.0	0 to 203 (6)	None	BA	218
28	AKW 941	Jerry Osswan 40 Falls Rd Pasco, WA 99301	8/31/2004	SW of SW	D	40 Air 1 hour	410.0	+1 to 192.5 (6) 192.5 to 410 (4.5)	None	BA	174
29	AKO 582	Mike McBee 33826 2181 PR SE Kennewick, WA 99336	9/29/2004	NE of SE	D	30 Air NR	157.0	+1 to 24 (6) -7 to 157 (4)	None	BA	36
Township 10N, Range 30E, Section 23											
30	BHW 074	Kerry Calaway 2160 Falls Rd Pasco, WA 99301	6/27/2014	NE of SE	D	30 Air 1 hour	200.0	+2 to 116 (6)	None	BA	78
Township 10N, Range 30E, Section 28											
31	BJA 054	Dennis Bens NKA E Vineyard Dr Pasco, WA 99301	12/9/2016	NE of NE	D	50+ Air 1 hour	400.0	+1.5 to 176 (6) -140 to 400 (4.5)	None	BA	176
32	NR	Tom Crigler Franklin County	5/28/1986	SE of NE	D	NR	140.6	+1 to 112.5 (6) 107 to 140.6 (4.5)	None	UA	41
Township 10N, Range 30E, Section 29											
33	BHT 030	Brent Preston 52 E Vineyard Pasco, WA 99301	11/1/2013	NW of SE	D	100 Air 2 hours	237.0	+1.5 to 177 (8) -7 to 237 (6)	None	BA	132
34	NR	Mike Franklin Franklin County	7/20/1994	NE of SE	D	15 Air 2 hours	160.0	+1 to 120 (6)	None	UA	8
35	ALC 743	Brent Preston 502 E Vineyard Pasco, WA 99301	5/5/2006	SW	D	75 Air 3 hours	363.0	+1 to 170.5 (8) 163 to 363 (6)	None	BA	151
Township 10N, Range 30E, Section 30											
36	ABX 793	Balcom + Moe Inc PO Box 968 Pasco, WA 99301	3/19/1996	NW of SE	D	None	120.0	0 to 199 (6)	None	UA	8.0

Appendix C1. Well Inventory Summary

Well Inventory Number	Well ID	Owner	Well Completion Date	Well Location	Use [1]	Yield [2]	Well Depth	Casing Interval (diameter) [3]	Screened or Perforated Interval [4]	Aquifer [5]	Static Water Level [6]
						gpm	feet	feet below ground surface			feet
37	ABX 801	Maury Balcom PO Box 968 Pasco, WA 99301	4/5/1996	NW of SE	D	NR	118.0	0 to 118 (6)	None	UA	80
38	NR	El Paso Natural Gas Company PO Box 1526 Salt Lake City, UT	11/14/1966	SE	NR	NR	285.0	0 to 163 (10)	NR	BA	NR
Township 10N, Range 30E, Section 31											
39	NR	Burlington Northern	1/4/1982	SW of SE¼	I	NR	170.0	+1 to 140 (16)	140 to 165	BA	109
40	NR	Duane Guenther 1524 W Howard Pasco, WA 99301	1/20/1965	NR	NR	20 1 hour 30-foot drawdown	218.0	0 to 158 (6)	NR	BA	NR
Township 10N, Range 30E, Section 32											
41	NR	Lentz Farms 1304 W Yakima St Pasco, WA 99301	3/11/1975	NW of SW	T	20 2 hours 2-foot drawdown	222.0	0 to 222 (6)	205 to 220 210 to 222	BA	167
42	NR	Lentz Franklin County	10/10/1975	SE of SW	I	1,557 4 hours 11-foot drawdown	192.0	+1 to 153 (16)	154 to 184	BA	138
Township 10N, Range 30E, Section 33											
43	NR	Northern Pacific Railway Company Seattle, Washington	7/13/1966	NW of NE	NR	NR	487.0	0 to 155 (6)	NR	BA	240
44	NR	Northern Pacific Railway Company Seattle, Washington	10/20/1966	SW of NE	NR	150 4 hours 188-foot drawdown	571.0	0 to 154 (10) 2 to 421 (8)	NR	BA	213
45	NR	Don Beus Franklin County	3/11/1978	SW of SW	I	NR	221.6	+1 to 197 (16)	197 to 218	UA	180
46	NR	Don Beus Franklin County	7/13/1977	SW of SW	I	NR	223.0	+1 to 197 (16)	197 to 223	UA	186
47	NR	Don Beus Franklin County	6/22/1977	SW of SW	T	NR	229.0	+1 to 218 (8)	219 to 224 223 to 228	UA	180
Township 10N, Range 30E, Section 34											
48	MW-04	City of Pasco Wastewater Treatment	2/6/1995	NR	NR	NR	145.0	+3 to 110.57 110.57 to 140.60 140.60 to 142.95 142.95 to 143.29	NR	UA	NR

Appendix C1. Well Inventory Summary

Well Inventory Number	Well ID	Owner	Well Completion Date	Well Location	Use [1]	Yield [2]	Well Depth	Casing Interval (diameter) [3]	Screened or Perforated Interval [4]	Aquifer [5]	Static Water Level [6]
						gpm	feet	feet below ground surface			feet
Township 10N, Range 30E, Section 35											
49	NR	Kenneth Piekarski State Route Box 205 Mesa, WA 99343	3/3/1975	SW	I	NR	122.5	0 to 105.5 (16)	104.5 to 117 117 to 122.5	UA	94
50	NR	Ray Voss State Route 1 Pasco, WA 99301	2/11/1975	SW	T	NR	152.5	Pulled	None	UA	NR
51	NR	Kenneth Piekarski State Route Box 205 Mesa, WA 99343	2/3/1975	SE of SE	I	NR	130.0	0 to 113 (16)	111 to NR NR to 130	UA	94
52	NR	Kenneth Piekarski State Route Box 205 Mesa, WA 99343	2/3/1975	NE of NE	D	18 1.5 hours 8-inch drawdown	147.0	0 to 122 (6)	126.6 to 122	UA	93

NOTES:

All information based on original Washington State Department of Ecology well log data (Washington State Department of Ecology, n.d.).

Abbreviations: E = east, gpm = gallons per minute, ID = identification, N = north, NE = northeast, NR = not reported, NW = northwest, SE = southeast, SW = southwest, USBR = United States Bureau of Reclamation, W = west.

1 A = abandoned, D = domestic, I = irrigation, MW = monitoring well, NR = not recorded, P = production well, T = test well.

2 Yield information is presented in sequence as follows: gallons per minute, test duration, drawdown, and test method (e.g., "Air").

3 Casing reported in feet below ground surface and diameter reported in inches.

4 Where no screen or perforations was reported, open borehole well construction was assumed.

5 BA = lower basalt bedrock aquifer, UA = uppermost unconfined sedimentary aquifer.

6 Static water level based on original well log data.

Appendix C2

Well Logs Within 1-Mile of Expansion Sites

The Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. TEST WEL G3 22491
Permit No. XXXXXXXXXXXX

(1) OWNER: Name ROBERT TIPPETT Address 3400 W. CLEARWATER, KENNEWICK, WN. 99336

(2) LOCATION OF WELL: County FRANKLIN 1300ft.N. & 1300ft.W.from center ¼ ¼ Sec. 2 T. 9 N., R. 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) #3

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 159 ft. Depth of completed well 159 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16 " Diam. from 0 ft. to 158.6 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☐ " Diam. from ft. to ft.

Perforations: Yes ☒ No ☐
Type of perforator used
SIZE of perforations in. by in.
perforations from 145 ft. to 157 ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name did not enstall
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level 502 ft.
Static level 95 ft. below top of well Date 9-11-74
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Green Valley
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" did do not give us a report " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
[illegible]ler test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Fine sand	0	20
Fine sand	20	30
Fine sand	30	50
Course sand	50	62
Small course gravel	62	75
Course sand and gravel	75	85
Course sand	85	95
Course gravel and sand	95	105
Course gravel and sand	105	118
Silt and sand	118	130
Silt and sand	130	145
Course gravel and sand	145	157
Water came in	145	
Basalt	157	
16 inch Lakewood Drive shoe		

2160 gal. ac. ft.
100 ac.

RECEIVED
DEC 6 1974
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 8-8, 19 74 Completed 10-10, 19 74

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC. 0554
(Person, firm, or corporation) (Type or print)

Address P.O. BOX 811, PASCO, WN. 99301

[Signed] Ed Gentz
(Well Driller)

License No. 0158 Date 10-10, 19 74

(USE ADDITIONAL SHEETS IF NECESSARY)

12/08/74

S. F. No. 7356—OS—(Rev. 4-71). 3

File Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

2

Application No. 23061 /
Permit No. TEST WELL

(1) OWNER: Name ROBERT TIPPET Address 3400 W. CLEARWATER, KENNEWICK, WN. 99336

(2) LOCATION OF WELL: County FRANKLIN — SE ¼ NW ¼ Sec 2 T. 9N N., R. 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 4
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 140 ft. Depth of completed well 140 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 140 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☒ No ☐
Type of perforator used MILLS
SIZE of perforations ¼ in. by 1 in.
perforations from 102 ft. to 108 ft.
x perforations from x ft. to x ft.
x perforations from x ft. to x ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
XXXXXXXXXXXXXXXXXXXXXXXXXX
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from XXXXXXXXXXXXXXXXXXXX ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? XX Depth of strata XXXX
Method of sealing strata off XXXX

(7) PUMP: Manufacturer's Name XXX
Type: XXXX H.P. XXX

(8) WATER LEVELS: Land-surface elevation above mean sea level.... xx 520 ft.
Static level xxx 68 ft. below top of well Date 6/21/75
Artesian pressure xxx lbs. per square inch Date xxx
Artesian water is controlled by XXXX (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? XXX
Yield: gal./min. with ft. drawdown after hrs.
" " "
XXXXXXXXXXXXXXXXXXXXXXXXXX
" "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
XXXXXXXXXXXXXXX					

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water XXXXXXXXX Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
~~Top Soil~~ Surface Seal	0	18
Top soil	0	42
Black gravel and course sand	42	105
Black gravel and course sand	105	140
6 inch drive shoe (Blue Crown)		
Perforated by Mills perforator from 102 ft. to 108 ft.		

Copied

Work started Jan. 24, 1975. Completed ~~May XX~~ JUNE 2, 1975.

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC.
(Person, firm, or corporation) (Type or print)

Address P.O. BOX 811, PASCO, WN. 99301

[Signed] David L. Whitehead
(Well Driller)

License No. 0554 Date July 7, 1975

11/20/75

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71)
ECY-070-28

93237

RESOURCE PROTECTION WELL REPORT

START CARD NO R43241

PROJECT NAME City of Pasco Process water reuse facility

COUNTY Franklin

WELL IDENTIFICATION NO MW-9 AFF590

LOCATION NE¼ NE¼ Sec 2 Twn 9N R 30E

DRILLING METHOD Air Rotary

STREET ADDRESS OF WELL

DRILLER Ronald Sink

FIRM Environmental West Exp

WATER LEVEL ELEVATION 104

SIGNATURE

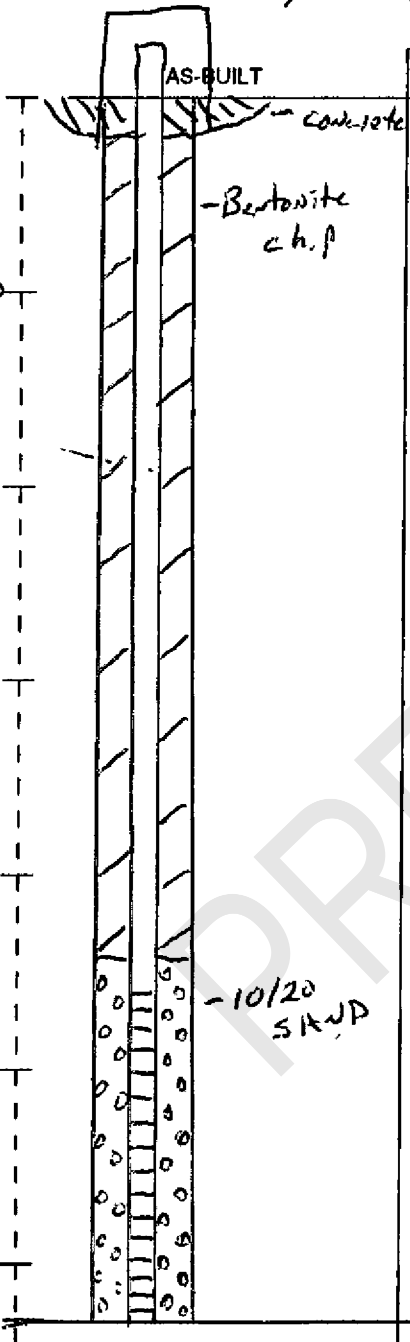
GROUND SURFACE ELEVATION

CONSULTING FIRM Landau

INSTALLED 4/16 - 4/18/01

REPRESENTATIVE Ryan Reich

DEVELOPED 4/18/01



WELL DATA

Use of Well: Monitor

Bore hole: 9"

Screen: .010 95' to 125' 4" PVC

Casing: +3' to 95' 4" PVC

Sand: 10/20 92' to 125'

Bentonite chps 2' to 92'

FORMATION DESCRIPTION

Fine Sand	30
Med. to Coarse Sand	55
Sandy gravels	63
Silty Sand	67
Gravels w/some sand	90
Gravely sand	120
	125

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APR 2001
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

SCALE 1" = 20'

PAGE 1 OF 1

ECY 050-12 (Rev 11/89)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

4

File Original and First Copy with
Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. [redacted]

Water Right Permit No. G3 22499

(1) **OWNER:** Name Tippel Land and Morgage Address

(2) **LOCATION OF WELL:** County Franklin SW ¼ NE ¼ Sec 2 T. 9 N., R. 30E W.M.

(2a) **STREET ADDDRESS OF WELL** (or nearest address) New well 12 feet East of old well

(3) **PROPOSED USE:** ☐ Domestic ☒ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) 4 A

Abandoned ☐ New well ☐ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 139'6" inches.
Drilled 16" feet. Depth of completed well 139'6" ft.

(6) **CONSTRUCTION DETAILS:** 375 Wall

Casing installed: 16 " Diam. from +6 ft. to 120'6" ft.
Welded ☒ " Diam. from ft. to ft.
Liner installed ☐
Threaded ☐ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type stainless Model No.
Diam. 16T Slot size 150 from 120'6" ft. to 138'6" ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 35 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name
Type: H.P.

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ft.
Static level 89 ft. below top of well Date 12-30-88
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.))

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand Tan	0	12
Silt Tan Sandy	12	20
Sand Blk Sandy silt	20	22
Silt Tan Sandy	22	43
Gravel 6" minus sand	43	
Black water @ 89'		100
Sand Black, gravel very	100	
silty		105
Gravel 6" minus sand Blk	105	114
Gravel, cobbles, boulders	114	
sand Blk		138'6"
Basalt Black	138'6	139'6

ECEIVE
JAN - 9 1989
DEPARTMENT OF
SPOKANE REG

Work started , 19. Completed 12-30, 1988

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Nelson Well Drilling Inc
(PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 10036 W Argent Pasco
(Signed) James Nelson License No. 361
(WELL DRILLER)
Contractor's Registration No. NELSOWD148CQ Date 12-30, 1988

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 3

5

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. [redacted]

Water Right Permit No. G3-22499

(1) **OWNER:** Name Tippel Land + Morgage Address

(2) **LOCATION OF WELL:** County Franklin SW ¼ NE ¼ Sec. 2 T. 9 N., R. 30E W.M.

(2a) **STREET ADDDRESS OF WELL** (or nearest address)

(3) **PROPOSED USE:** ☐ Domestic ☒ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) 4

Abandoned ☒ New well ☐ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 16 inches.
Drilled ___ feet. Depth of completed well ___ ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: ___ " Diam. from ___ ft. to ___ ft.
Welded ☐ ___ " Diam. from ___ ft. to ___ ft.
Liner installed ☐
Threaded ☐ ___ " Diam. from ___ ft. to ___ ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills
SIZE of perforations 3/8 in. by 6 in.
8 around perforations from 86 ft. to 10 ft.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.

Screens: Yes ☐ No ☐
Manufacturer's Name
Type ___ Model No.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.

Gravel packed: Yes ☐ No ☐ Size of gravel
Gravel placed from ___ ft. to ___ ft.

Surface seal: Yes ☐ No ☐ To what depth? ___ ft.
Material used in seal
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ___ Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name
Type: ___ H.P.

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ___ ft.
Static level ___ ft. below top of well Date
Artesian pressure ___ lbs. per square inch Date
Artesian water is controlled by ___ (Cap, valve, etc.))

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test

Bailer test ___ gal./min. with ___ ft. drawdown after ___ hrs.
Airtest ___ gal./min. with stem set at ___ ft. for ___ hrs.
Artesian flow ___ g.p.m. Date
Temperature of water ___ Was a chemical analysis made? Yes ☐ No ☐

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Screen broke while pulling		
from well - cased to 88		
feet with 16" casing		
Perforated Casing pumped		
bentonite ~~88~~ 88 feet to - 3 feet		
Cement - 3 feet to 0 feet		

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JAN - 9 1989
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 12-5, 19 . Completed 12-9, 1988

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Nelson Well Drilling, Inc
(PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 10036 W) Arrowhead Pasco
(Signed) James Nelson License No. 361
(WELL DRILLER)
Contractor's Registration No. NELSOWD198CQ Date 12-30, 1988

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 3

File Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

6

Application No. G322491
Permit No. Test Well

(1) OWNER: Name Robert Tippitt Address 3400 W. Clearwater, Kenmewick, wn. 99301

(2) LOCATION OF WELL: County Franklin — SW ¼ NE ¼ Sec. 2 T. 9 N., R. 30E W.M.

ng and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 5
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 165 ft. Depth of completed well 165 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16" Diam. from 0 ft. to 165 ft.
Threaded ☐ X" Diam. from X ft. to X ft.
Welded ☒ X" Diam. from X ft. to XX ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills
SIZE of perforations 3/8 in. by 2 in.
432 perforations from 98 ft. to 134 ft.
228 perforations from 144 ft. to 163 ft.
X perforations from X ft. to X ft.

Screens: Yes ☐ No ☒
Manufacturer's Name XXX
Type XXXX Model No.
Diam. XXX Slot size X from X ft. to XX ft.
Diam. X Slot size X from X ft. to XX ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: XXXX
Gravel placed from XXX ft. to XXX ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? XXX Depth of strata XXXXX
Method of sealing strata off XXXXX

(7) PUMP: Manufacturer's Name XX
Type: XX H.P. X

(8) WATER LEVELS: Land-surface elevation above mean sea level.... ~~500~~ 510 ft.
Static level 98 ft. below top of well Date 3/19/75
Artesian pressure X lbs. per square inch Date X
Artesian water is controlled by XXXXX (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

te of test
er test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface seal	0	18
Sandy loam	0	45
Sandy loam, sand	45	55
Course black gravel, 1½ minus	55	98
Course sand & gravel, all colors 1½ minus	98	110
Hit water		98
Pea gravel, black, white, brown	110	120
Course black sand and gravel	120	123
Course black & white gravel, peasize	123	132
Course gravel, sand all colors	132	135
Fine brown sand	135	140
Gravel, black, pea size	140	141
Sand and gravel	141	143
Mix sand and gravel	143	151
1½ minus rock and sand	151	163
Black basalt	163	165
16 inch Lakewood Drive shoe		

1 e 2160 gpm
Sou. ft.
1116 acres
240

Work started 2/20, 1975. Completed 3/19, 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Golden Autumn Const. Co., Inc.
(Person, firm, or corporation) (Type or print)

Address P.O. Box 811, PASCO, WN. 99301

[Signed] Gary Kelly
(Well Driller)

License No. 0606 Date 3/25/75, 1975

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71)
ECY-070-28

307574

7

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

Construction/Decommission (*"x" in circle*)
☒ Construction
○ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* #1

CURRENT Notice of Intent No. R035442
Unique Ecology Well ID Tag No. APJ 201
Water Right Permit No.
Property Owner Name Carson Ag LLC
Well Street Address 28 Pasco Kahlotus Rd
City Pasco County Franklin
Location SW 1/4-1/4 NE 1/4 Sec 2 Twn 9 R 30 [✓ EWM] or WWM (circle one)
Lat/Long (s, t, r Still **REQUIRED**) Lat Deg ______ Lat Min/Sec ______ Long Deg ______ Long Min/Sec ______
Tax Parcel No. 113 720 084

PROPOSED USE: ☐ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other Monitoring

TYPE OF WORK: Owner's number of well (if more than one) ______
☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6x2 inches, drilled 96 ft.
Depth of completed well 96 ft.

CONSTRUCTION DETAILS
Casing Installed: ☐ Welded ______" Diam. from ______ ft. to ______ ft.
☐ Liner installed ______" Diam. from ______ ft. to ______ ft.
☒ Threaded 2" Diam. from +2 ft. to 96 ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ______
SIZE of perfs ______ in. by ______ in. and no. of perfs ______ from ______ ft. to ______ ft.

Screens: ☒ Yes ☐ No ☐ K-Pac Location 76' to 96'
Manufacturer's Name ______
Type ______ Model No. ______
Diam. 2" Slot size ______ from 76' ft. to 96 ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel/Filter packed: ☒ Yes ☐ No ☐ Size of gravel/sand ______
Materials placed from 73 ft. to 96 ft.

Surface Seal: ☒ Yes ☐ No To what depth? 73 ft.
Material used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 81 ft. ft. below top of well Date 4/9/08
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☒ No If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
FINE TAN SAND	0	28
FINE BLACK SAND	28	35
COARSE BLACK SAND	35	42
FINE BLACK SAND	42	67
ABOVE WITH TRACE OF BROWN SILT	67	73
COARSE BLACK SAND	73	94
COARSE BLACK SAND & GRAVEL	94	96
TAN SAND & GRAVEL	96	

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Start Date 4/8/08 Completed Date 4/9/08

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Jim Nelson
Driller/Engineer/Trainee Signature Jim Nelson
Driller or trainee License No. 361

If TRAINEE,
Driller's Licensed No. ______
Driller's Signature ______

Drilling Company NELSON WELL DRILLING
Address 7505 W. COURT ST.
City, State, Zip PASCO WA 99301
Contractor's Registration No. NELSOWD 198CQ Date 5/11/08

Ecology is an Equal Opportunity Employer.

ECY 050-1-20 (Rev 3/05) **The Department of Ecology does NOT warranty the Data and/or Information on this Well Report.**

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

307573

8

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

Construction/Decommission *("x" in circle)*
● Construction
○ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* ____

CURRENT Notice of Intent No. R035441
Unique Ecology Well ID Tag No. APJ 203
Water Right Permit No. ____
Property Owner Name Carson Oe LK
Well Street Address 28 Pasco Kahlotus HWY
City Pasco County Franklin
Location SE 1/4-1/4 NE 1/4 Sec 2 Twn 9 R 30 [✓ EWM] or WWM circle one
Lat/Long (s, t, r Still **REQUIRED**) Lat Deg ____ Lat Min/Sec ____ Long Deg ____ Long Min/Sec ____
Tax Parcel No. 113 710 084

PROPOSED USE: ☐ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other Monitoring #3

TYPE OF WORK: Owner's number of well (if more than one) ____
☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6x2 inches, drilled 98 ft.
Depth of completed well 94 ft.

CONSTRUCTION DETAILS

Casing Installed: ☐ Welded ____" Diam. from ____ ft. to ____ ft.
☐ Liner installed ____" Diam. from ____ ft. to ____ ft.
☒ Threaded 2" Diam. from 1½ ft. to 94 ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ____
SIZE of perfs ____ in. by ____ in. and no. of perfs ____ from ____ ft. to ____ ft.

Screens: ☒ Yes ☐ No ☐ K-Pac Location 74' to 94'
Manufacturer's Name ____
Type PVC Model No. ____
Diam. 2" Slot size ____ from 74 ft. to 94 ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☒ Yes ☐ No ☐ Size of gravel/sand ____
Materials placed from 70 ft. to 94 ft.

Surface Seal: ☒ Yes ☐ No To what depth? 70 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 80 ft. below top of well Date 5/9/08
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☒ No If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
TAN SAND FINE	0	63
BLACK SAND FINE	63	84
BLACK SAND & GRAVEL	84	94
TAN SAND & GRAVEL FINE	94	98

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EASTERN REGIONAL OFFICE

Start Date 5/8/08 Completed Date 5/9/08

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Jim Nelson
Driller/Engineer/Trainee Signature ____
Driller or trainee License No. 361

If TRAINEE,
Driller's Licensed No. ____
Driller's Signature ____

Drilling Company NELSON WELL DRILLING
Address 7505 W. COURT ST. ~~PASCO~~
City, State, Zip PASCO WA. 99301
Contractor's Registration No. NELSOWD198CQ Date 5/11/08

Ecology is an Equal Opportunity Employer.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

9

Application No. G3-22491
Permit No. G3-22491 P

(1) OWNER: Name Robert Tippett #1 Address 3400 W. Clearwater Kennewick, Wn. 99336

(2) LOCATION OF WELL: County Franklin NW 1/4 of SE 1/4 NE 1/4 Sec 2 T. 9 N., R. 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one).... #1
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 16 inches.
Drilled 127 ft. Depth of completed well 127 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16" Diam. from 0 ft. to 127 ft.
Threaded ☐ ______" Diam. from ______ ft. to ______ ft.
Welded ☒ ______" Diam. from ______ ft. to ______ ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills
SIZE of perforations 3/8 in. by 1½ in.
616 perforations from 97 ft. to 125 ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 510 ft.
Static level 80 ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Green Valley
Yield: 2451 gal./min. with 8 ft. drawdown after 4 hrs.
" " " "
" did not "send us a report" "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Fine sand	0	38
Small gravel and sand	38	53
Course sand and gravel	53	68
Course sand and gravel	68	87
Water	90	
Course sand and gravel	87	90
Small gravel and black sand	90	110
Small gravel and black sand	110	125
16 inch Gopher Drive shoe		

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SPOKANE REGIONAL OFFICE

2160 gpm
1160 ac.ft.
240 ac.

Work started 6-3, 1974 Completed 7-3, 1974

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC. 0554
(Person, firm, or corporation) (Type or print)

Address P.O. BOX 811 PASCO, WN. 99301

[Signed] Ed ______ (Well Driller)

License No. 0158 Date 7-3-74, 19

12/07/74

(USE ADDITIONAL SHEETS IF NECESSARY)

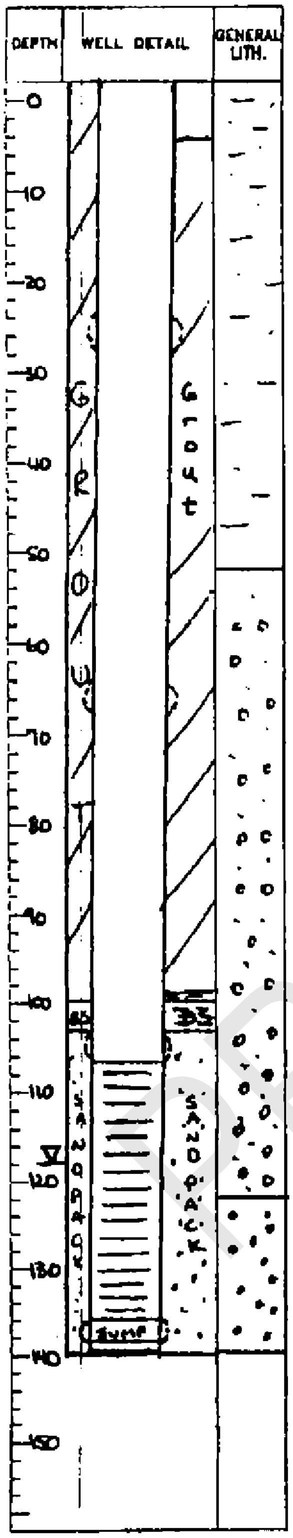
S. F. No. 7356—OS—(Rev. 4-71).

MONITORING WELL CONSTRUCTION SUMMARY

Project Name: City of Pasco / Wastewater Treatment
Project No.: 89534

Well No.: MW-03
Boring No.: MW-03
Start Card No.: R-02816

Horizontal Coords: ¹ ______
² ______
Ground Surface Elevation: ______
Top of PVC Well Casing: ______
Section 3 T.9N R.30 EWM Franklin Co.



DRILLING SUMMARY

Total Borehole Depth: 139.6 ft bgs
Borehole Diameter: 8.5 10 -inches
Drilling Contractor: Ponderosa Drilling - Spokane, WA
Driller(s): Roger Kelly
Rig(s): Reichdrill T625 Rotary / Circulation Medium: Air
Bit(s): Tricone Roller

TIME LOG

Task	Start Date	Start Time	Finish Date	Finish Time
Drilling Method:				
Air Rotary	1/20/95	1418	1/24/95	0930
Geophys. Logging	N/A			
Casing	1/24/95	0917	1/26/95	1109
Sand Pack	1/26	1130	1/26	1535
Grout	1/27	0824	1/27	1743
Bentonite Seal	1/26	1548	1/26	1610
Development (Start)				
Development (Finish)				

WELL INSTALLATION

Well Design and Specifications Basis:
Geologic Log: ✓ Geophysical Log: ___
Casing Material: Schedule 80, 4-inch PVC, flush-threaded
Casing(s): B = blank; S = screen; EC = end cap

Depth (ft)		Casing	Elevation ¹ (ft)
+3.3	106.7	B	
106.7	134.7	S	
134.7	139.15	B	
139.15	139.43	EC	

Screen Type/Size Factory slot / 0.030
Surface Seal (ft):
Mfr/Mtrl/Qty: 0
Grout Seal (ft): 98.95 - [illegible] bgs
60 bags [illegible] Mfr/Mtrl/Qty: Cement-Ash Grout [illegible] Baroid Aqua Gel 4% 1/27/95 [illegible] 45 bags
Bentonite Seal (ft): 103.5 ft to 100.0 ft
1.5 [illegible] Mfr/Mtrl/Qty: Enviroplug Tablets 3/8-inch (1/8) [illegible]
Sand Pack (ft): 139.6 ft to 103.5 ft bgs
25 bags Mfr/Mtrl/Qty: Colorado Silica Sand #8-12 (50# bags)
Bottom Seal (ft:) N/A
Mfr/Mtrl/Qty: ______

WELL DEVELOPMENT

Method:
Total Volume Purged:
Starting Level:
Finishing Level:
Stabilization Test Data

Date	Time	Volume	pH	Cond Spec.	Temp (°C)

Comments: ~~¹[illegible] Coordinate System. ²Oregon State Coordinate System~~
Stainless steel centralizers @ 24 ft, 64 ft, 104 ft, and 137 ft bgs.

See Wellhead Detail for surface construction information.

Generated by: Terry McPhetridge Date: 1/26/95
Checked by: ______ Date: ______

RUST ENVIRONMENT & INFRASTRUCTURE

11

File Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

4782

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. A0 33458
UNIQUE WELL I.D. # None
Water Right Permit No.

(1) **OWNER:** Name City of Pasco Address Pasco, WA

(2) **LOCATION OF WELL:** County Franklin - SW 1/4 NW 1/4 Sec 3 T. 9 N., R 30E W.M.

(2a) **STREET ADDRESS OF WELL** (or nearest address) E. Foster Wells Road

(3) **PROPOSED USE:** ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☒

(4) **TYPE OF WORK:** Owner's number of well (If more than one)
Abandoned ☒ New well ☐ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well inches.
Drilled feet. Depth of completed well ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: " Diam. from ft. to ft.
Welded ☐ " Diam. from ft. to ft.
Liner installed ☐ " Diam. from ft. to ft.
Threaded ☐

Perforations: Yes ☐ No ☐
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☐
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☐ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☐ No ☐ To what depth? ft.
Material used in seal
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name
Type: H.P.

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ft.
Static level ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Monitor well decommission:		
1. Pulled 4" PVC casing		
2. Tremmie grouted well with neat cement		
3. Pulled 10" steel conductor casing		
4. Poured concrete cap over well head		

Work Started 17 Mar, 1995 Completed 17 Mar, 19 95

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME PONDEROSA DRILLING & DEVELOPMENT INC.
(PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 6010 E. Broadway, Spokane, WA 99212
(Signed) License No. 0996
(WELL DRILLER)
Contractor's Registration No. PONDEI*248JE Date 26 Mar, 19 95

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

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~~MONITORING WELL~~ CONSTRUCTION SUMMARY

Production Well

Project Name: Wastewater Treatment - City of Pasco

Project No.:

Well No.: PW-1

Boring No.: —

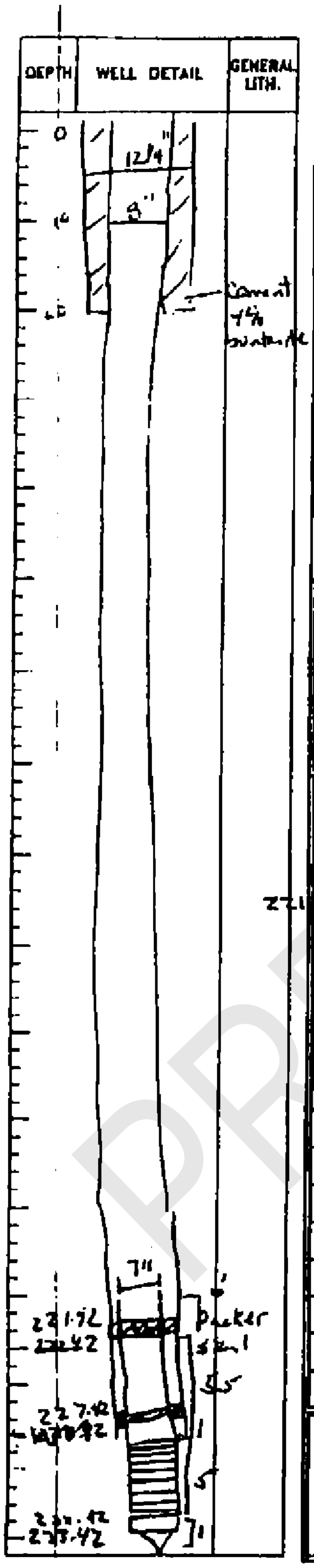
Start Card No.: W-044461

Horizontal Coords:

T 9N, R30E, Sect 4

Ground Surface Elevation:

Top of PVC Well Casing:



DRILLING SUMMARY

Total Borehole Depth: 233.42'

Borehole Diameter:

Drilling Contractor: Ponderosa

Driller(s): Roger Kelly

Rig(s): Bucy T625

Rotary/Circulating Med = Air

Bit(s): 12 ½" Tricone

~~7~~ 7 7/8" Tricone Roller

TIME LOG

	Start		Finish	
Task	**Date**	**Time**	**Date**	**Time**
Drilling Method:	1-12-95	0807	1-13-95	1420
Air Rotary - Casing				
Drive				
12" Surface Casing	1-12-95	0847	1-12-95	0915
Geophys. Logging	—	—	—	—
Casing 8" steel	1-12-95	0847	1-13-95	1420
Casing				
Sand Pack None	—	—	—	—
~~Grout~~ Surface Seal	1-17-95	1355	1-17-95	
Bentonite Seal				
Rubber				
Development (Start)	1-16-95	1543	1-16-95	1709
~~Development (Finish)~~				

WELL INSTALLATION

Well Design and Specifications Basis:

Geologic Log: ✓ Geophysical Log: —

Casing Material: 8" steel

casing welded every 20'

Casing(s): B = blank; S = screen; EC = end cap

Depth (ft)	Casing	Elevation ¹ (ft)
~~2.42~~ 0 - 227.42	B	-
224.92 - 222.92	Rub Seal	-
221.42 - 227.42	SB	-
227.42 - 232.42	S	-
233.42 - 232.42	EC	-

Screen Type/Size: 4" - 5' long Stainless Johnson Steel Slot 8" 20 slot

Surface Seal (ft): 0 to 20 Cement 4% bentonite

Mfr/Mtrl/Qty: Cement, Bentonite

Grout Seal (ft): No See above

Mfr/Mtrl/Qty:

Bentonite Seal (ft): 220.92 - 222.92 Rubber Packer

Mfr/Mtrl/Qty: Rubber Packer (Johnson) 8"

Sand Pack (ft): None

Mfr/Mtrl/Qty:

Bottom Seal (ft:) None

Mfr/Mtrl/Qty:

WELL DEVELOPMENT

Method: Air Lift Pneumatic Drop - Surge

Total Volume Purged: 3480 gal

Starting Level: 174.5 bgs

Finishing Level: 175.78 bgs

Stabilization Test Data

Date	Time	Volume	pH	Cond Spec	Temp (°C)	
1-16-95	1543	5	7.39	2.46 ms	17.1	V. sl. sediment
	1551	60	8.16	2.65 ms	15.5	MT
	1555	180	8.07	2.83 ms	15.4	ST
	1600	225	8.33	2.73 ms	16.4	ST
	1607	315	8.18	2.75	16.4	MT
	1618	495	8.11	2.60	15.8	clear some
	1624	270	8.44	2.70	16.5	"
	1634	450	8.28	2.70	16.4	"
	1645	495	8.21	2.69	16.5	"
	1701	720	8.23	2.70	16.5	"

Comments: ¹Tennison Coordinate System. ²Oregon State Coordinate System

measured flow through pipe to 5g bucket 10sec + 9sec = 30 g/min

losing 10-20 other places 40-50 gpm

See Wellhead Detail for surface construction information.

Checked by:

Date:

Generated by:

Date: 1/12 - 1/17

RUST ENVIRONMENT & INFRASTRUCTURE

cadforms\wellsum2.for

13

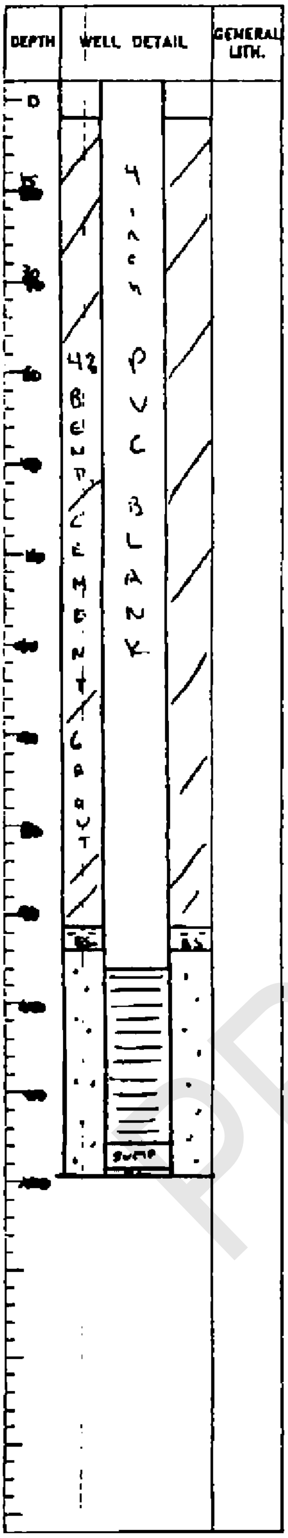
MONITORING WELL CONSTRUCTION SUMMARY

Project Name: City of Pasco - WWTP
Project No.: 89534

Well No.: MW-02a
Boring No.: MW-02a
Start Card No.: R-17349

Horizontal Coords: ¹ ______
² ______
Ground Surface Elevation: ______
Top of PVC Well Casing: ______

Section 4 T.9N R.30 EWM Franklin Co.



DRILLING SUMMARY

Total Borehole Depth: 178 ft bgs
Borehole Diameter: 8.6-inches
Drilling Contractor: Ponderosa Drilling - Spokane WA
Driller(s): Roger Kelly
Rig(s): Rockwell T625 Air-Rotary / casing drive
Bit(s): 7 7/8-inch tricone roller bit

TIME LOG

	Start		Finish	
Task	Date	Time	Date	Time
Drilling Method:				
Air Rotary	2-20	1220	2-21	1352
Geophys. Logging	NA			
Casing	2-22	0610	2-22	0848
Sand Pack	2-22	0857	2-22	1238
Grout	2-23	0719	2-23	1348
Bentonite Seal	2-22	1243	2-22	1313
Development (Start)				
Development (Finish)				

WELL INSTALLATION

Well Design and Specifications Basis:
Geologic Log: ✓ **Geophysical Log:** ___
Casing Material: Sched. 80, 4-inch Flush-threads, PVC
Casing(s): B = blank; S = screen; EC = end cap

Depth (ft)	Casing	Elevation ¹ (ft)
+3.5 - 145.27	B	-
145.27 - 175.21	S	-
175.28 - 177.68	B	-
177.68 - 178.0	EC	-
-		-

Screen Type/Size Well wire wrapped Factory 30 slot
Surface Seal (ft):
Mfr/Mtrl/Qty:
Grout Seal (ft): 139.2 to 3.0 ft
Mfr/Mtrl/Qty: Ash Grove PC (I&II) 39 bags w/ 6% ... bentonite (100#) 2 bags
Bentonite Seal (ft): 141.2 to 137.2 ft
Mfr/Mtrl/Qty: Enviroplug/3/8 inch chips/ 2 (50 lb) buckets
Sand Pack (ft): 178.0 to 141.2 ft
Mfr/Mtrl/Qty: CSSI/#6-12/12 bags (50#)
Bottom Seal (ft:) N/A
Mfr/Mtrl/Qty: ______

WELL DEVELOPMENT

Method:
Total Volume Purged:
Starting Level:
Finishing Level:
Stabilization Test Data

Date	Time	Volume	pH	Cond Spec.	Temp (°C)

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EASTERN REGIONAL OFFICE

Comments: ¹~~Yennison Coordinate System.~~ ²Oregon State Coordinate System
STAINLESS STEEL CENTRALIZERS PLACED @ 177 ft, 144 ft, 104 ft, 64 ft, + 24 ft bgs.

See Wellhead Detail for surface construction information.

Date: ______
Checked by: ______
Date: ______
Generated by: ______

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

14

File Original and First Copy with Department of Ecology
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Third Copy — Driller's Copy

195739

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W 22903
UNIQUE WELL I.D. #
Water Right Permit No. G3 28775 P

(1) OWNER: Name Earl Blasdel Address 2001 East Foster Wells Rd Pasco

(2) LOCATION OF WELL: County Franklin NW 1/4 SW 1/4 Sec 4 T. 9 N., R 30E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: ☐ Domestic ☒ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (If more than one)
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 220'6" feet. Depth of completed well 220 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from +1 ft. to 197 ft.
Welded ☒ " Diam. from ft. to ft.
Liner installed ☐ " Diam. from ft. to ft.
Threaded ☐

Perforations: Yes ☐ No ☑
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Huston
Type Stainless Steel Model No.
Diam. 16" Slot size 250 from 197 ft. to 217 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 175 ft. below top of well Date 11-2-93
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Layne Bowler
Yield: 1860 gal./min. with 20 ft. drawdown after 12 hrs.
" " " "
" " " "
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand Tan	8	9
Sand Tan Silty	9	104
Sand Tan	104	135
Sand Tan Silty	135	162
Sand Black Silty	162	173
Sand Black water at 175'	170	180
Gravel fine sand Tan	180	181
Gravel 6" minus sand Tan	181	217
Gravel 6" minus sand Tan silty water shut off	217	220'6"

RECEIVED
NOV 24 1993
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Work Started 10-11, 19. Completed 11-2, 1993

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Nelson Well Drilling Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 8200 W Argent Pasco
(Signed) Jim Nelson (WELL DRILLER) License No. 361
Contractor's Registration No. NELSOWD148CQ Date 11-2, 1993

(USE ADDITIONAL SHEETS IF NECESSARY)

ECL 050-1-20 (2/93)

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Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

15

Application No. G325178

Permit No. G3 25178P

(1) OWNER: Name J E Lentz Address

(2) LOCATION OF WELL: County FRANKlin NW4 - SE ¼ SE ¼ Sec 4 T. 9 N., R. 30E W.M.

Bearing and distance from section or subdivision corner 1200' N - 1200' W of SE Cor

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 242 ft. Depth of completed well 242 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16 " Diam. from +1 ft. to 216 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☐ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used.....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Low Carbon Shupd WIRE Model No.
Diam. 16" Telescope Slot size 250 from 216 ft. to 237 ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 35 ft.
Material used in seal Bentonite + Sand
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ..... Depth of strata.....
Method of sealing strata off.....

(7) PUMP: Manufacturer's Name.....
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 530 ft.
Static level 165 ft. below top of well Date
Artesian pressure ..... lbs. per square inch Date
Artesian water is controlled by..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?.....
Yield: ..... gal./min. with ..... ft. drawdown after ..... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....
Bailer test ..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Silt TAN Sandy	0	27
SAND Brown Fine Silty	27	145
SAND Black Fine Silty	145	147
SAND Black 4" Minus Gravel Silty	147	149
SAND Tan 1" minus gravel Silty	149	152
Silt TAN	152	164
SAND Black 2" minus gravel Silt Balls	164	168
SAND - Gravel 3" minus Brown Tan + Gray Water Barn	168	196
Gravel + Sand Ringold Slow Water	196	212
Gravel ½" Minus Sand TAN ~~Water Bearing~~ Ringold	212	237
Gravel Sand Cemented	237	242
Basalt	242	
1600 gpm		
333.8 AF/yr		
160 Ac		
Eltopia 15'		

Work started 1-18, 1978. Completed 1-10, 1978

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Nelson Well Drilling Inc (Person, firm, or corporation) (Type or print)

Address 10036 W Argent

[Signed] Dave Wellins (Well Driller)

License No. 0659 Date 3-13, 1978

4/5/78

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

16

Application No. G3 23408

Permit No. TEST WELL

(1) OWNER: Name Jim Minnehan Address Highway East 410 Pasco, Wn. 99301

(2) LOCATION OF WELL: County Franklin SE ¼ SE ¼ Sec 4 T. 9 N., R. 30E W.M.

Bearing and distance from section or subdivision corner

PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☒ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Bored ☐ Cable ☒ Driven ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 12 inches.

Drilled 186 ft. Depth of completed well 186 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 12 " Diam. from 0 ft. to 184 ft.

Threaded ☐ ....." Diam. from ..... ft. to ..... ft.

Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☒ No ☐

Type of perforator used Mills

SIZE of perforations 3/8 in. by 3 in.

182 perforations from 171 ft. to 184 ft.

..... perforations from ..... ft. to ..... ft.

..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒

Manufacturer's Name

Type ..... Model No. .....

Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:

Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.

Material used in seal Bentonite

Did any strata contain unusable water? Yes ☐ No ☐

Type of water? Soft Depth of strata 40

Method of sealing strata off

(7) PUMP: Manufacturer's Name

Type: did not install H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level. 540 520 ft.

Static level 146 ft. below top of well Date 7/31/74

Artesian pressure ..... lbs. per square inch Date .....

Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? Yes ☒ No ☐ If yes, by whom? Green Valley

Yield: 1212 gal./min. with 16 ft. drawdown after 4 hrs.

" " " "

" did not give us a report "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

of test 7/30/74

B st ..... gal./min. with ..... ft. drawdown after ..... hrs.

Artesian flow ..... g.p.m. Date .....

Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top soil, sandy and brown	0	16
Silt, light gray	16	26
Silt , light gray	26	93
Sand fine silty, brown	93	104
Silt, brown, sandy	104	160
Sand, fine, white (water bearing)	160	164
Gravel, course, sand	164	186
12 inch Gopher Drive shoe		

400 gp ft.
2/1 ac.
40 acres

RECEIVED
DEC 6 1974
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started JUNE 5, 1974 Completed July 31, 1974

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC. 0554
(Person, firm, or corporation) (Type or print)

Address P.O. BOX 811 PASCO, WN. 99301

[Signed] Frank A. Crane
(Well Driller)

License No. 0090 Date JULY 31, 1974 19

12/08/74

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

29

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

17

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....

Permit No. ....

(1) OWNER: Name ______ Address ______

(2) LOCATION OF WELL: County ______ NE ¼ SE ¼ Sec 5 T 1 N., R 32

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 29

New well ☒ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Bored ☐ Cable ☒ Driven ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16" inches.

Drilled 230 ft. Depth of completed well 230 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16" " Diam. from 0 ft. to 230 ft.
Threaded ☐ ______" Diam. from ______ ft. to ______ ft.
Welded ☐ ______" Diam. from ______ ft. to ______ ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills Knife
SIZE of perforations 3/8 in. by 3 in.
______ perforations from ______ ft. to ______ ft.
900 perforations from 195 ft. to 230 ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? ______ ft.
Material used in seal Puddled Clay/Bent.
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 520 ft.
Static level 116 ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure show thickness of aquifers and the kind and nature of the material in stratum penetrated, with at least one entry for each change of form

MATERIAL	FROM	T
SAND	0	19
WATER AT 155		
Sand Gravel Cobble	190	23
BedRock	230	—

Work started Dec 20, 1923. Completed MAR 20, 1924

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report i true to the best of my knowledge and belief.

NAME St George Drilling Co. (Person, firm, or corporation) (Type or print)

Address 701 So. 45th Ave

[Signed] ______ (Well Driller)

License No. 0482 Date 3-29-, 1974

WATER WELL REPORT

ECOLOGY Original & 1st copy Ecology 2nd copy owner 3rd copy driller

Construction/Decommission (x in circle) 125085

☒ Construction

○ Decommission *ORIGINAL CONSTRUCTION Notice of Intent Number* ____________

CURRENT Notice of Intent No W 160 4184

Unique Ecology Well ID Tag No AHK 278

Water Right Permit No ____________

Property Owner Name Earl Bluschel

Well Street Address E Foster Wells Rd + Commercial DR

City Pasco County Franklin

Location SW 1/4 1/4 SE 1/4 Sec 5 Twn 9N R 30 [✓ EWM] or WWM *circle one*

Lat/Long (s t r still REQUIRED) Lat Deg ______ Lat Min/Sec ______ Long Deg ______ Long Min/Sec ______

Tax Parcel No ____________

PROPOSED USE ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK Owner's number of well (if more than one) ______

☒ New Well ☐ Reconditioned *Method* ☐ Dug ☐ Bored ☐ Driven

☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS Diameter of well 8 inches, drilled 2036 ft

Depth of completed well 2036 ft

CONSTRUCTION DETAILS

Casing Installed ☒ Welded 8 Diam from +1½ ft to 194 ft

☐ Liner installed ______ Diam from ______ ft to ______ ft

☐ Threaded ______ Diam from ______ ft to ______ ft

Perforations ☐ Yes ☒ No

Type of perforator used ______

SIZE of perfs ______ in by ______ in and no of perfs ______ from ______ ft to ______ ft

Screens ☒ Yes ☐ No ☐ K Pac Location 193

Manufacturer's Name Cook

Type Stainless Model No ______

Diam 8T Slot Size 40 from 194 ft to 199 ft

Diam ______ Slot Size ______ from ______ ft to ______ ft

Gravel/Filter packed ☐ Yes ☒ No ☐ Size of gravel/sand ______

Materials placed from ______ ft to ______ ft

Surface Seal ☒ Yes ☐ No To what depth? 20 ft

Materials used in seal Bentonite

Did any strata contain unusable water? ☐ Yes ☐ No

Type of water? ______ Depth of strata ______

Method of sealing strata off ______

PUMP Manufacturer's Name ______

Type ______ H P ______

WATER LEVELS Land surface elevation above mean sea level ______ ft

Static level 162 ft below top of well Date 10-29-02

Artesian pressure ______ lbs per square inch Date ______

Artesian water is controlled by ______ (cap valve etc)

WELL TESTS Drawdown is amount water level is lowered below static level

Was a pump test made? ☐ Yes ☐ No If yes by whom? ______

Yield ______ gal /min with ______ ft drawdown after ______ hrs

Yield ______ gal /min with ______ ft drawdown after ______ hrs

Yield ______ gal /min with ______ ft drawdown after ______ hrs

Recovery data (time taken as zero when pump turned off)(water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______

Bailer test ______ gal /min with ______ ft drawdown after ______ hrs

Airtest 50 gal /min with stem set at 190 ft for 4 hrs

Artesian flow ______ g p m Date ______

Temperature of water ______ Was a chemical analysis made? ☐ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation Describe by color character size of material and structure and the kind and nature of the material in each stratum penetrated with at least one entry for each change of information Indicate all water encountered (USE ADDITIONAL SHEETS IF NECESSARY)

MATERIAL	FROM	TO
Sand Tan	0	8
Sand Tan silty	8	37
Sand Tan	37	153
Sand Black gravel	153	163
Gravel, sand Tan	163	
Water Bearing		200
Sand Tan Gravel	200	
silty		203½

RECEIVED DEC 23 2002

Start Date 10-18-02 Completed Date 10-29-02

WELL CONSTRUCTION CERTIFICATION I constructed and/or accept responsibility for construction of this well and its compliance with all Washington well construction standards Materials used and the information reported above are true to my best knowledge and belief

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Jim Nelson

Driller/Engineer/Trainee Signature Jim Nelson

Driller or Trainee License No 361

If trainee, licensed driller's Signature and License no ______

Drilling Company Nelson Well Drilling INC

Address 2505 W Court

City State Zip Pasco WA 99301

Contractor's Registration No NELSOWD 198CQ Date 11-7-02

Ecology is an Equal Opportunity Employer ECY 050 1 20 (Rev 4/01)

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

7916

19

STATE OF WASHINGTON

Start Card No. [redacted]

Water Right Permit No. R

(1) **OWNER:** Name HerB RODE Address COllins.

LOCATION OF WELL: County ~~Benton~~ Franklin SE ¼ SE ¼ Sec 5 T. 9 N., R 30 W.M.

(2a) **STREET ADDDRESS OF WELL** (or nearest address)

(3) **PROPOSED USE:** ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one)

Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.

Drilled 240 feet. Depth of completed well 240 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6 " Diam. from +1 ft. to 217 ft.
Welded ☒ " Diam. from ft. to ft.
Liner installed ☐
Threaded ☐ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 46 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name
Type: H.P.

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ft.
Static level 164 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.))

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 60 gal./min. with stem set at 220 ft. for 4 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
cement Gravel 2" to 7/8	0	47
Brown clay	47	163
Ash	163	174
Brown + Gray clay	174	217
Brocken Redsh Brown Basalt	217	221
Brocken Black Basalt Bearing water	221	240

RECEIVED
JAN 18 1995
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

RECEIVED
DEC 2 1992
DEPARTMENT OF ECOLOGY
CENTRAL REGION OFFICE

Work started 10/31/92, 19. Completed , 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME St George Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 701 So 45 AVE W. Richland
(Signed) (WELL DRILLER) License No. 0483
Contractor's Registration No. 601-048-715 Date 11-4-92., 19

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 18

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

20

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

31791

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W-28406
UNIQUE WELL I.D. # ACE-623
Water Right Permit No. ______

(OWNER: Name David Vooge. Address 1532 North 14th Ave, Pasco, WA 99301

(2) LOCATION OF WELL: County Franklin. NE 1/4 NE 1/4 Sec 6 T. 9 N., R 30 E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) ______

(3) PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (If more than one) ______
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 124 feet. Depth of completed well 124 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from +1 ft. to 124 ft.
Welded ☒ ______" Diam. from ______ ft. to ______ ft.
Liner installed ☐ ______" Diam. from ______ ft. to ______ ft.
Threaded ☐

Perforations: Yes ☐ No ☒
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 87 ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 35 gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown Sand	0	16
Brown Sand Gravel	16	26
Brown Sand	26	68
Brown Sand Gravel	68	87
Brown Sand Gravel/Moist	87	105
Brown Sand Gravel/Bearing Water	105	124

RECEIVED
MAR 17 1997
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

RECEIVED
JAN 22 1997
DEPARTMENT OF ECOLOGY
CENTRAL REGIONAL OFFICE

Work Started 8/20/96, 19. Completed 8/20/96, 19 ______

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME St George Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 701 S 45 AVE W, Richland
(Signed) ______ (WELL DRILLER) License No. 0483

Contractor's Registration No. 0GI C48-715 Date 8/20/96, 19 ______

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

ECY 050-1-20 (9/93)

File Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. DOMESTIC

(1) OWNER: Name ROBERT TIPPETT Address 3400 W. Clearwater, Kennewick, Wn. 99336

(2) LOCATION OF WELL: County Franklin SW ¼ SE ¼ Sec. 6 T. 9 N., R. 31E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 101 ft. Depth of completed well 101 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 101 ft.
Threaded ☐ ....” Diam. from .... ft. to .... ft.
Welded ☒ ....” Diam. from .... ft. to .... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations .... in. by .... in.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type .... Model No. ....
Diam. .... Slot size .... from .... ft. to .... ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ XX No ☒
Type of water? XXXX Depth of strata ....
Method of sealing strata off XXX

(7) PUMP: Manufacturer's Name XXXXXXXXXXXXX
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level .... ft.
Static level 78 ft. below top of well Date 3/3/77
Artesian pressure XXX lbs. per square inch Date XX
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ XXXXXXXXXXXXX
Yield: gal./min. with ft. drawdown after hrs.
ESTIMATED 15 GAL/ MIN. BY DRILLER

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Date of test ....
Bailer test .... gal./min. with .... ft. drawdown after .... hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☐

4/8/77

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Surface seal	0	20
Top Soil	0	2
Sand and Gravel	2	16
CEmented gravel	16	38
Fine heaving sand, some water	38	42
Sand, cemented	42	58
Sand and gravel	58	82
Sand, gravel and water	82	101
6 INCH BLUE CROWN DRIVE SHOE		

Copied

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MAR 31 1977
DEPT. OF ECOLOGY
CENTRAL REGIONAL OFFICE

RECEIVED
APR - 6 1977
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 3/1, 19 77 Completed 3/4, 1977

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONSTRUCTION CO., INC. (Person, firm, or corporation) (Type or print)

Address P.O. BOX 811, PASCO, WN. 99301

[Signed] .... (Well Driller)

License No. 0564 Date 3/6, 19 77

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

21 (Page 2 of 2)

File Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. ......

Permit No. .... Domestic

(1) OWNER: Name Robert Tippett Address 3400 W. Clearwater, Kennewick, Wa. 99336

(2) LOCATION OF WELL: County Franklin — SW ¼ SE ¼ Sec 6 T. 9 N., R 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ......

New well ☐ Method: Dug ☐ Bored ☐
Deepened xxxx Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 53 ft. Depth of completed well 154 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 154 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ......
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson 0ipx
Type 40 slot Model No. ......
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ...... Depth of strata ......
Method of sealing strata off ......

(7) PUMP: Manufacturer's Name XXXXX
Type: ...... H.P. ......

(8) WATER LEVELS: Land-surface elevation above mean sea level 445 ft.
Static level 78 ft. below top of well Date 6/17/77
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ......
Yield: ...... gal./min. with ...... ft. drawdown after ...... hrs.
" " "
XXXXXXXXXXXXXXXXXX "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
	XXXXXXXXXXXXXX				

Date of test ......
Bailer test ...... gal./min. with ...... ft. drawdown after ...... hrs.
Artesian flow ...... g.p.m. Date ......
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
CEMENTED SAND AND GRAVEL	1019	114
Cemented Sand and Gravel with Clay	114	118
Cemented sand & gravel	118	140
Sand, small gravel	140	152
White caay and sand	152	154
5 foot Johnson 40 slot screen		

Work started 6/6 19 77 Completed 6/16 19 77

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME GOLDEN AUTUMN CONST. CO., INC.
(Person, firm, or corporation) (Type or print)

Address P.O. BOX 611, PASCO, WASH. 99301

[Signed] HD Brown
(Well Driller)

License No. 0569 Date June 17, 19 77

1/24/77

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

22

9121
Start Card No. [redacted]

Water Right Permit No. ______

(1) OWNER: Name Gordon Bradshaw Address ______

(2) LOCATION OF WELL: County ~~Benton~~ Franklin SE ¼ SE ¼ Sec 6 T 9 N., R 30 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) ______

(3) PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ______

Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 245 feet. Depth of completed well 245 ft.

(6) CONSTRUCTION DETAILS:

Casing Installed: 6 " Diam. from +1 ft. to 215 ft.
Welded ☒ ______ " Diam. from ______ ft. to ______ ft.
Liner installed ☐
Threaded ☐ ______ " Diam. from ______ ft. to ______ ft.

Perforations: Yes ☐ No ☒
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 60 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 155 ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 35 gal./min. with stem set at 200 ft. for 3 hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown Sand Gravel	0	41
Brown clay	41	161
Brown Sand Gravel	161	174
Blue Gray clay	174	215
Brocken Redsh Brocken	215	245
Basalt Bearing water		

RECEIVED
JAN 18 1995

30

Work started 6-28-93, 19. Completed ______, 19__

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME St. George Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 208 So 45 AVE. W. Richland
(Signed) Pete E St George (WELL DRILLER) License No. 0483
Contractor's Registration No. 601-048-715 Date 6-28-93 19__

(USE ADDITIONAL SHEETS IF NECESSARY)

454131

ECOLOGY

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

Construction/Decommission *("x" in circle)*
☒ Construction
○ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* ______

CURRENT
Notice of Intent No. WE14443
Unique Ecology Well ID Tag No. BCF 552
Water Right Permit No. ______
Property Owner Name Rogers Potato
Well Street Address Railroad Ave
City Pasco County 11-Franklin
Location SE 1/4-1/4 SE 1/4 Sec 6 Twn 9N R 30 [✓ EWM] or WWM circle one
Lat/Long (s, t, r Still **REQUIRED**) Lat Deg ______ Lat Min/Sec ______
Long Deg ______ Long Min/Sec ______
Tax Parcel No. 113110357

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: *Owner's number of well (if more than one)* ______
☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☐ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 8 inches, drilled 148 ft.
Depth of completed well 144 ft.

CONSTRUCTION DETAILS
Casing Installed: ☒ Welded 8 " Diam. from +2 ft. to 144 ft.
☐ Liner installed ______ " Diam. from ______ ft. to ______ ft.
☐ Threaded ______ " Diam. from ______ ft. to ______ ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ______
SIZE of perfs ______ in. by ______ in. and no. of perfs ______ from ______ ft. to ______ ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ______
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand ______
Materials placed from ______ ft. to ______ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft.
Material used in seal Bentonite chips
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 87.5 ft. below top of well Date 4/24/12
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☒ No If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 50 gal./min. with stem set at 140 ft. for 2 hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water 65 Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Sand	0	24
Black course Sand, Gravel	24	55
Gravel, Sand	55	146
Tan clay	146	148

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MAY 22 2012
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Start Date 4/20/12 Completed Date 4/24/12

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Forest Hoopes
Driller/Engineer/Trainee Signature Forest Hoopes
Driller or trainee License No. 2910

If TRAINEE,
Driller's Licensed No. ______
Driller's Signature ______

Drilling Company Blue Star Enterprises
Address 2019 Butler Loop
City, State, Zip Richland WA 99354
Contractor's Registration No. Bluesen 942RM Date 4-26-12

Ecology is an Equal Opportunity Employer.

ECY 050-1-20 (Rev 3/05)

24

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

57787

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W-087946
UNIQUE WELL I.D. # ACX-249
Water Right Permit No.

(1) **OWNER:** Name Robert H Michael McKee Address

(2) **LOCATION OF WELL:** County Benton SE 1/4 SE 1/4 Sec 8 T. 9 N., R 30 W.M. R

(2a) **STREET ADDRESS OF WELL** (or nearest address)

(3) **PROPOSED USE:** ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (If more than one)
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 225 feet. Depth of completed well 225 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6 " Diam. from +1 ft. to 205 ft.
Welded ☒ " Diam. from ft. to ft.
Liner installed ☐ " Diam. from ft. to ft.
Threaded ☐

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name
Type: H.P.

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ft.
Static level 161 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 50 gal./min. with stem set at 220 ft. for 2 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown Sand Gravel	0	2
cemented Gravel	2	37
Brown clay	37	160
Ash with Gravel	160	175
Brown + Gray clay	175	205
Redish Brown Broken Porus	205	225
Basalt Bearing water		
Apx 50 Gpm		

RECEIVED
AUG - 7 [illegible]
DEPARTMENT OF ECOLOGY
CENTRAL REGION OFFICE

Work Started 7/2/98, 19. Completed 7/2/98, 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME St George Drilling
(PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address 701 So 45 AVE W Richland

(Signed) (WELL DRILLER) License No. 0483

Contractor's Registration No. 601048715 Date 7/8/98, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

25

Application No. 12306
Permit No. G3-00932

(1) **OWNER:** Name Robert H. Tippett Address 3411 W. Clearwater Kennewick Wash

(2) **LOCATION OF WELL:** County Franklin SE ~~[illegible]~~ ¼ SE ¼ Sec. 6 T. 9 N., R. 30 W.M.
Bearing and distance from section or subdivision corner 1240' West 1240' N of SE Corner Section

(3) **PROPOSED USE:** Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☒ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one)....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 16 inches.
Drilled 145 ft. Depth of completed well 132 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 16" Diam. from 0 ft. to 127 ft.
Threaded ☐ 12" Diam. from 127 ft. to 132 ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☒ No ☐
Type of perforator used Mills Knife
SIZE of perforations 3/8 in. by 3 in.
600 perforations from 105 ft. to 132 ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Puddle Clay
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name
Type: H.P.

(8) **WATER LEVELS:** Land-surface elevation above mean sea level 450 ft.
Static level 97 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Fosseen

Yield: gal./min.	with ft. drawdown	after hrs.
1000	24	5

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
	30 sec	~~recovery~~			

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water 51 Was a chemical analysis made? Yes ☐ No ☐

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Sand	0	50
Sand with ~~Sm~~ Small Gravel	50	97
Gravel with Sand	97	110
Heavey Gravel	110	132
Water 105		
Clay	132	145

1200 gpm
675 AF
135 A

Work started 8-15, 1973 Completed 9-5, 1973

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME St George Drilling Co. (Person, firm, or corporation) (Type or print)
Address 701 S045 W Richland Wash
[Signed] (Well Driller)
License No 223-02-6920 Date 9-12, 1973

OK
TMO
10-4-73

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

File Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

26

WATER WELL REPORT
STATE OF WASHINGTON

Application No.

Permit No.

(1) OWNER: Name USBR, Drainage Observation Well

LOCATION OF WELL: County .... SE ¼ SE ¼ Sec 21 T 10 N., R 30 W.M.

aring and distance from section or subdivision corner 29' W. - 200' N. of SE Cor.

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☐ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well .... inches.
Drilled .... ft. Depth of completed well .... ft.

(6) CONSTRUCTION DETAILS:

Casing installed: ...." Diam. from .... ft. to .... ft.
Threaded ☐ ...." Diam. from .... ft. to .... ft.
Welded ☐ ...." Diam. from .... ft. to .... ft.

Perforations: Yes ☐ No ☐
Type of perforator used ....
SIZE of perforations .... in. by .... in.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☐ No ☐
Manufacturer's Name ....
Type .... Model No. ....
Diam. .... Slot size .... from .... ft. to .... ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☐ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☐ No ☐ To what depth? .... ft.
Material used in seal ....
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level .... 604.9 ft.
Static level .... ft. below top of well Date ....
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ....
Yield: .... gal./min. with .... ft. drawdown after .... hrs.
" .... " .... " .... "
" .... " .... " .... "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test .... gal./min. with .... ft. drawdown after .... hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Sand, fine	0	20
Sand w/clay	20	51

Work started ...., 19 .... Completed 4/14 1966

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Henry Bach
(Person, firm, or corporation) (Type or print)

Address Yakima

[Signed] ....
(Well Driller)

License No. .... Date ...., 19 ....

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

27

Application No. ....

Permit No. ....

(1) OWNER: Name GARY [redacted] Pfister Address Falls Rd. Pasco, Wn.

(2) LOCATION OF WELL: County Franklin — NW ¼ SW ¼ Sec 22 T 10 N., R 30E W.M.

Bearing and distance from section or subdivision corner Eltopia

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 410 ft. Depth of completed well 410 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 203 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name ....
Type ...... Model No. ......
Diam. ...... Slot size ...... from ...... ft. to ...... ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ......
Gravel placed from ...... ft. to ...... ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal [illegible]-BENTONITE
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ...... Depth of strata ......
Method of sealing strata off ......

(7) PUMP: Manufacturer's Name ......
Type: ...... H.P. ......

(8) WATER LEVELS: Land-surface elevation above mean sea level 700 ft.
Static level 218 ft. below top of well Date 1/26/77
Artesian pressure ...... lbs. per square inch Date ......
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ......
Yield: ...... gal./min. with ...... ft. drawdown after ...... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ......
Bailer test ...... gal./min. with ...... ft. drawdown after ...... hrs.
Artesian flow ...... g.p.m. Date ......
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Sand& Clay	0	185
fractured basalt	185	203
black basalt 9	203	350
black porous basalt&clay seams water bearing 1-2 gpm	350	363
black basalt	363	375
decomposed basalt& sandstone waterbearing 18 to 20 gpm.	375	410

RECEIVED
FEB 11 1977
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Copy

Eltop

Work started ......, 19...... Completed ......, 19......

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME H&H DRILLING INC. (Person, firm, or corporation) (Type or print)

Address Rt 2 Box 13H Richland Wa.

[Signed] ...... (Well Driller)

License No. 196 Date 1/26, 1977

(USE ADDITIONAL SHEETS IF NECESSARY)

2/11/77

S. F. No. 7356—OS—(Rev. 4-71)
ECY 070-28

28

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

WATER WELL REPORT

ECOLOGY Original & 1st copy - Ecology, 2nd copy - owner, 3rd copy - driller

154583

Construction/Decommission *("x" in circle)*
☒ Construction
○ Decommission *ORIGINAL CONSTRUCTION Notice of Intent Number*____

CURRENT Notice of Intent No. W 179665

Unique Ecology Well ID Tag No. AKW 941

Water Right Permit No. ____

Property Owner Name Jerry Ossman

Well Street Address 40 Falls Rd

City Pasco County: Franklin

Location SW 1/4- 1/4 SW 1/4 Sec 22 Twn 10N R 30 [✓ EWM] or WWM *circle one*

Lat/Long: (s,t,r still REQUIRED) Lat Deg ____ Lat Min/Sec ____
Long Deg ____ Long Min/Sec ____

Tax Parcel No. ____

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other____

TYPE OF WORK: Owner's number of well (if more than one)____
☒ New Well ☐ Reconditioned ☐ Deepened
Method: ☐ Dug ☐ Bored ☐ Driven ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 410 ft.
Depth of completed well 410 ft.

CONSTRUCTION DETAILS

Casing Installed:
☒ Welded 6" Diam. from +1 ft. to 192¼ ft.
☒ Liner installed 4½" Diam. from 172 ft. to 410 ft.
☐ Threaded ____" Diam. from ____ ft. to ____ ft.

Perforations: ☒ Yes ☐ No
Type of perforator used SAW
SIZE of perfs 1/8 in. by 6 in. and no. of perfs 80 from 370 ft. to 410 ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location____
Manufacturer's Name____
Type____ Model No.____
Diam.____ Slot Size____ from____ ft. to____ ft.
Diam.____ Slot Size____ from____ ft. to____ ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand____
Materials placed from____ ft. to____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 19 ft
Materials used in seal BENTONITE
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water?____ Depth of strata____
Method of sealing strata off____

PUMP: Manufacturer's Name____
Type:____ H.P.____

WATER LEVELS: Land-surface elevation above mean sea level____ft.
Static level 174 ft. below top of well Date 8/31/04
Artesian pressure____ lbs. per square inch Date____
Artesian water is controlled by____ (cap,valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level.
Was a pump test made? ☐ Yes ☒ No If yes, by whom?____
Yield:____ gal./min. with____ ft. drawdown after____ hrs.
Yield:____ gal./min. with____ ft. drawdown after____ hrs.
Yield:____ gal./min. with____ ft. drawdown after____ hrs.

Recovery data (time taken as zero when pump turned off)(water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test____
Bailer test____ gal./min. with ____ ft. drawdown after____ hrs.
Airtest 40 gal./min. with stem set at 380 ft. for 1 hrs.
Artesian flow____ g.p.m. Date____
Temperature of water____ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Indicate all water encountered. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
SILT & BROWN SAND	0	6
BROWN SAND	6	51
SILTY TAN CLAY	51	76
FINE BROWN SAND	76	88
TAN CLAY	88	99
BROWN SAND	99	108
STICKY TAN CLAY	108	134
RED SILTSTONE	134	152
TAN CLAY	152	153
RED SILTSTONE	153	191
BLACK BASALT MED	191	234
PORICE BLACK BASALT	234	268
PORICE RED & BLACK BASALT	268	276
BLACK BASALT HARD	276	341
PORICE RED & BLACK	341	348
" BLACK BASALT	348	370
" BLACK BASALT &	370	
BLUE SILTSTONE W/H2O	3	404
HARD BLACK BASALT	404	410

RECEIVED
SEP 15 2004
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Start Date 8/26/04 Completed Date 8/31/04

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) JEREMY RUDE
Driller/Engineer/Trainee Signature____
Driller or Trainee License No. 2651

If trainee, licensed driller's Signature and License no.____

Drilling Company Nelson Well Drilling
Address 2505 W COURT
City, State, Zip PASCO WA 99301
Contractor's Registration No. NELSOWD198CQ Date 9-4-04

WATER WELL REPORT

ECOLOGY Original & 1st copy - Ecology, 2nd copy - owner, 3rd copy - driller

CURRENT Notice of Intent No. W179802

Unique Ecology Well ID Tag No. AKO-582

Water Right Permit No. ______

Construction/Decommission *("x" in circle)*
☒ Construction
○ Decommission *ORIGINAL CONSTRUCTION Notice of Intent Number* ______
156086

Property Owner Name MIKE MCBEE J

Well Street Address 33826 2181 PR SE

City KENNEWICK County: BENTON

Location NE 1/4- 1/4 SE 1/4 Sec 22 Twn 10N R 30 [✓ EWM] or WWM *circle one*

Lat/Long: (s,t,r still REQUIRED) Lat Deg ______ Lat Min/Sec ______
Long Deg ______ Long Min/Sec ______

Tax Parcel No. ______

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: Owner's number of well (if more than one) ______
☒ New Well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 157 ft.
Depth of completed well 157 ft.

CONSTRUCTION DETAILS

Casing Installed:
☒ Welded 6 " Diam. from +1 ft. to 24 ft.
☐ Liner installed 4 " Diam. from -7 ft. to 157 ft.
☐ Threaded ______ " Diam. from ______ ft. to ______ ft.

Perforations: ☒ Yes ☐ No
Type of perforator used SAW
SIZE of perfs 1/8 in. by 12 in. and no. of perfs 33 from 137 ft. to 157 ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ______
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot Size ______ from ______ ft. to ______ ft.
Diam. ______ Slot Size ______ from ______ ft. to ______ ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand ______
Materials placed from ______ ft. to ______ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft
Materials used in seal BENTONITE
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 36 ft. below top of well Date 9-29-04
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______
(cap,valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level.
Was a pump test made? ☐ Yes ☐ No If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Recovery data (time taken as zero when pump turned off)(water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 30 gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water 62° Was a chemical analysis made? ☐ Yes ☐ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Indicate all water encountered.
(USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
SAND + COBBLES	0	19
BLACK SAND	19	24
GRAY BASALT	24	106
BLACK BASALT SOFT	106	118
GRAY CLAYSTONE	118	129
BLACK BASALT SOFT	129	141
BROWN BASALT	141	145
GRAY BASALT	145	160

DEPT. OF ECOLOGY
Received
OCT 1 2004
CENTRAL REGION OFFICE

Start Date 9-28-04 Completed Date 9-29-04

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☐ Driller ☐ Engineer ☒ Trainee Name (Print) BILL McHAFFIE JR.
Driller/Engineer/Trainee Signature Bill McHaff
Driller or Trainee License No. 2724 T

If trainee, licensed driller's Signature and License no. 2094

Drilling Company FIVE STAR DRILLING
Address 36301 HWY 12
City, State, Zip DAYTON, WA 99328
Contractor's Registration No. FIVESDX077MB Date 9-30-04

Ecology is an Equal Opportunity Employer. ECY 050-1-20 (Rev 4/01)

DEPARTMENT OF ECOLOGY State of Washington

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

Construction/Decommission *("x" in circle)*

☒ Construction

☐ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* ______

CURRENT

Notice of Intent No. W355490

Unique Ecology Well ID Tag No. BHW 074

Water Right Permit No. NO

Property Owner Name Kerry Calaway

Well Street Address 2160 Falls Rd.

City Pasco County Franklin

Location NE 1/4-1/4 SE 1/4 Sec 23 Twn 10 R 30 EWM ☒ Or WWM ☐

(s, t, r Still REQUIRED)

Lat/Long Lat Deg ____ Lat Min/Sec ____

Long Deg ____ Long Min/Sec ____

Tax Parcel No. (Required) 124610096

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: Owner's number of well (if more than one) ____

☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven

☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 200 ft.

Depth of completed well 200 ft.

CONSTRUCTION DETAILS

Casing Installed:

☒ Welded 6 " Diam. from +2 ft. to 116 ft.

☐ Liner installed ____ " Diam. from ____ ft. to ____ ft.

☐ Threaded ____ " Diam. From ____ ft. to ____ ft.

Perforations: ☐ Yes ☒ No

Type of perforator used ______

SIZE of perfs ____ in. by ____ in. and no. of perfs ____ from ____ ft. to ____ ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ______

Manufacturer's Name ______

Type ______ Model No. ______

Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☐ Yes ☒ No Size of gravel/sand ____

Materials placed from ____ ft. to ____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18 ft.

Material used in seal Bentonite Dry

Did any strata contain unusable water? ☐ Yes ☒ No

Type of water? ______ Depth of strata ______

Method of sealing strata off ______

PUMP: Manufacturer's Name ______

Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.

Static level 78 ft. below top of well Date 10/27/14

Artesian pressure ____ lbs. per square inch Date ______

Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☐ Yes ☒ No If yes, by whom? ______

Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______

Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.

Airtest 30 gal./min. with stem set at 198 ft. for 1 hrs.

Artesian flow ____ g.p.m. Date 10/27/14

Temperature of water ____ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Brown Sand	0	38'
Brown Sticky Sand & Clay	38'	55'
Black Sand & Gravel	55'	67'
Brown Clay Soft	67	111'
Brown Clay & Sandstone		
Tough	111'	109'
Brown Clay & Broken		
Brown Basalt Soft	109'	113'
Brown Broken Basalt	113'	170'
Little H2O 1-2Gpm		
Hard Gray Basalt	170'	173'
Black Soft Basalt	173'	179'
Broken Brown Basalt		
Little water 5-6Gpm	179'	192'
Broken Brown & Red		
Basalt Good water 25Gpm	192'	198'
Broken Brown & Red Clay	198'	200'

Start Date 10/27/14 Completed Date 10/27/14

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☐ Driller ☐ Engineer ☒ Trainee Name (Print) Cole

Driller/Engineer/Trainee Signature D. Cole

Driller or trainee License No. 3165T

IF TRAINEE: Driller's License No: 1267

Driller's Signature: Mitch Markus

Drilling Company D C Drilling Inc

Address Po Box 1269

City, State, Zip Royal City WA 99357

Contractor's Registration No. DCDRICD875OF Date 10/27/14

ECY 050-1-20 (Rev 02/10) *If you need this document in an alternate format, please call the Water Resources Program at 360-407-6872. Persons with hearing loss can call 711 for Washington Relay Service. Persons with a speech disability can call 877-833-6341.*

31

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

DEPARTMENT OF ECOLOGY State of Washington

Construction/Decommission *("x" in circle)*

☒ Construction

☐ Decommission *ORIGINAL INSTALLATION*

Notice of Intent Number ______

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: Owner's number of well (if more than one) ______

☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven

☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 400 ft.

Depth of completed well 400 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 6" Diam: from +1½ ft. to 176 ft.

☒ Liner installed 4½" Diam. from -140 ft. to 400 ft.

☐ Threaded ______" Diam. From ______ ft. to ______ ft.

Perforations: ☒ Yes ☐ No

Type of perforator used SAW

SIZE of perfs 1/8 in. by 6 in. and no. of perfs 180 from 360 ft. to 400 ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ______

Manufacturer's Name ______

Type ______ Model No. ______

Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel/Filter packed: ☐ Yes ☒ No Size of gravel/sand ______

Materials placed from ______ ft. to ______ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 50 ft.

Material used in seal Bentonite

Did any strata contain unusable water? ☐ Yes ☒ No

Type of water? ______ Depth of strata ______

Method of sealing strata off ______

PUMP: Manufacturer's Name ______

Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ______ ft.

Static level 176 ft. below top of well Date 12-9-16

Artesian pressure ______ lbs. per square inch Date ______

Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☐ Yes ☐ No If yes, by whom? ______

Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______

Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.

Airtest 50+ gal./min. with stem set at 380 ft. for 1 hrs.

Artesian flow ______ g.p.m. Date ______

Temperature of water ______ Was a chemical analysis made? ☐ Yes ☐ No

RECEIVED
JAN 12 2017
Department of Ecology
Eastern Washington Office

CURRENT

Notice of Intent No. WE-26153

Unique Ecology Well ID Tag No. BJA-054

Water Right Permit No. –

Property Owner Name Dennis Bens

Well Street Address NKA E. Vineyard Dr.

City Pasco County Franklin

Location NE 1/4-1/4 NE 1/4 Sec 28 Twn 10 R 30 EWM ☒ Or WWM ☐

(s, t, r Still REQUIRED)

Lat/Long

Lat Deg ______ Lat Min/Sec ______

Long Deg ______ Long Min/Sec ______

Tax parcel No. (Required) 124650013

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Brown Sand + Silt	0	50
Brown + Tan Clay	50	73
Brown Silt	73	90
Tan Clay	90	115
Brown Silty Clay	115	172
Black Basalt Soft	172	212
Black Basalt Med	212	230
Black Porus + Green Clay	230	236
Black Basalt Hard	236	322
Red Basalt	322	328
Black Basalt Med	328	372
Red Porus Basalt	372	381
Black Porus Basalt w/ Blue Scoria	381	390
Black Basalt Soft w/fractures	390	400

RECEIVED
2017

Start Date 12-6-16 Completed Date 12-9-16

Department of Ecology
Eastern Washington Office

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

■ Driller ☐ Engineer ☐ Trainee Name Josh Burns

Driller/Engineer/Trainee Signature

Driller or trainee License No. 2866

IF TRAINEE: Driller's License No:

Driller's Signature:

Drilling Company **Nelson Drilling LLC**

Address **600 W. Vineyard Dr.**

City, State, Zip **Pasco Wa. 99301**

Contractor's Registration No. **NELSODL895WM** Date 12-9-16

ECY 050-1-20 (Rev 02-2010) To request ADA accommodation including materials in a format for the visually impaired, call Ecology Water Resources Program at 360-407-6872. Persons with impaired hearing may call Washington Relay Service at 711. Persons with speech disability may call TTY at 877-833-6341.

File Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

32

Application No. ....

Permit No. ....

(1) OWNER: Name Tom Crylez Address ....

(2) LOCATION OF WELL: County Franklin SE ¼ NE ¼ Sec 28 T 10 N., R 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☒ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.

Drilled 140 8" ft. Depth of completed well 140 8" ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from +1 ft. to 112-6 ft.

Threaded ☐ ...." Diam. from .... ft. to .... ft.

Welded ☒ 4½" Diam. from 107 ft. to 140 8 ft.

Perforations: Yes ☒ ~~No~~

Type of perforator used Saw

SIZE of perforations 1/8 in. by 6 in.

60 perforations from 118 ft. to 140 ft.

.... perforations from .... ft. to .... ft.

.... perforations from .... ft. to .... ft.

Screens: Yes ☐ No ☑

Manufacturer's Name ....

Type .... Model No ....

Diam. .... Slot size .... from .... ft. to .... ft.

Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....

Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☑ No ☐ To what depth? 25 ft.

Material used in seal Bentonite

Did any strata contain unusable water? Yes ☐ No ☐

Type of water? .... Depth of strata ....

Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....

Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level .... ft.

Static level 41 ft. below top of well Date ....

Artesian pressure .... lbs. per square inch Date ....

Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? Yes ☐ No ☐ If yes, by whom? ....

Yield:	gal./min. with	ft. drawdown after	hrs.
"	"	"	"
"	"	"	"

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....

Bailer test 25 gal./min. with 75 ft. drawdown after 2 hrs.

Artesian flow .... g.p.m. Date ....

Temperature of water .... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Sand Tan silty	0	14
Sand Black	14	17
Sand Tan silty wet	17	42
Sand Tan silty	42	66
Sand Brown	66	71
Clay Tan	71	115
Claystone Brown water Bearing	115	140

RECEIVED
JUN 23 1986
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 5-21, 1986. Completed 5-28, 1986

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Nelson Well Drilling Inc
(Person, firm, or corporation) (Type or print)

Address 10036 Wernett Pasco

[Signed] Jame Nelson
(Well Driller)

License No. 361 Date 5-29, 1986

6/24/86

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

DEPARTMENT OF ECOLOGY State of Washington

WATER WELL REPORT

506696

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

Construction/Decommission *("x" in circle)*

☒ Construction

☐ Decommission *ORIGINAL INSTALLATION*

Notice of Intent Number ______

CURRENT

Notice of Intent No. WE-17320

Unique Ecology Well ID Tag No. BHT-030

Water Right Permit No. ______

Property Owner Name Brent Preston

Well Street Address 52 E. Vineyard Dr.

City Pasco County Franklin

Location NW1/4-1/4 SE1/4 Sec 29 Twn 10 R 30 EWM ☒ Or WWM ☐

(s, t, r Still REQUIRED)

Lat/Long Lat Deg ____ Lat Min/Sec ____

Long Deg ____ Long Min/Sec ____

Tax Parcel No. (Required) 124660040

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: Owner's number of well (if more than one) ______

☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven

☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 8 inches, drilled 240 ft.

Depth of completed well 237 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 8" Diam. from +1.5 ft. to 177 ft.

☒ Liner installed 6" Diam. from -7 ft. to 237 ft.

☐ Threaded ____" Diam. From ____ ft. to ____ ft.

Perforations: ☒ Yes ☐ No

Type of perforator used SAW

SIZE of perfs 1/8 in. by 8 in. and no. of perfs 90 from 210 ft. to 234 ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ______

Manufacturer's Name ______

Type ______ Model No. ______

Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☐ Yes ☒ No Size of gravel/sand ____

Materials placed from ____ ft. to ____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 20 ft.

Material used in seal Bentonite

Did any strata contain unusable water? ☒ Yes ☐ No

Type of water? High Nitrate Depth of strata 120-160

Method of sealing strata off Drive Shoe + Casing

PUMP: Manufacturer's Name ______

Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ____ ft.

Static level 132 ft. below top of well Date 11-1-13

Artesian pressure ____ lbs. per square inch Date ______

Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☐ Yes ☒ No If yes, by whom? ______

Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______

Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.

Airtest 100 gal./min. with stem set at 230 ft. for 2 hrs.

Artesian flow ____ g.p.m. Date ______

Temperature of water ____ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Tan Silt + Clay	0	28
3/8" Gravel + Black Sand	28	63
3/8" Gravel + Tan Sand	63	78
Brown Sandstone 'Hard'	78	92
Tan Siltstone	92	115
Gravel + Tan Sand	115	140
1" Gravel + Sand	140	160
Cemented Sand + Gravel	160	175
Black Basalt	175	220
Porous Bslt + Green Clay	220	236
Airtest		
100gpm @ 230		
50gpm @ 200		

RECEIVED

MAR 14 2014

Department of Ecology
Eastern Regional Office

Start Date 10-29-13 Completed Date 11-1-13

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☒ Driller ☐ Engineer ☐ Trainee Name (Print) Jeff Burns

Driller/Engineer/Trainee Signature

Driller or trainee License No. 2866

IF TRAINEE: Driller's License No:

Driller's Signature:

Drilling Company Nelson Drilling, LLC

Address 600 W. Vineyard Dr.

City, State, Zip Pasco, WA., 99301

Contractor's Registration No. NELSODL895WA Date ______

ECY 050-1-20 (Rev 02/10) *If you need this document in an alternate format, please call the Water Resources Program at 360-407-6872. Persons with hearing loss can call 711 for Washington Relay Service. Persons with a speech disability can call 877-833-6341.*

34

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

186997

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 045196
UNIQUE WELL I.D. #
Water Right Permit No.

(1) **OWNER:** Name Mike Franklin Address

(2) **LOCATION OF WELL:** County Franklin - ne 1/4 se 1/4 Sec 29 T. 10 N., R 30 W.M.

(2a) **STREET ADDRESS OF WELL** (or nearest address)

(3) **PROPOSED USE:** ☒ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (If more than one)

Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Cable ☐ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 160 feet. Depth of completed well 160 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 6 " Diam. from +1 ft. to 120 ft.
Welded ☒ " Diam. from ft. to ft.
Liner installed ☐ " Diam. from ft. to ft.
Threaded ☐

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 75 ft.
Material used in seal Bentonite cement
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name
Type: H.P.

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ft.
Static level 8 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 15 gal./min. with stem set at 160 ft. for 2 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Ash	0	20
Brown sand Gravel Bearing water	20	65
Gray clay	65	120
Broken Black Basalt Bearing water	120	160

RECEIVED
SEP 12 1994
DEPARTMENT OF ECOLOGY
REGION OFFICE

RECEIVED
MAY 15 2000
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Work Started 7/20/94, 19. Completed , 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME St George Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 701 504S AVE W, Richland
(Signed) (WELL DRILLER) License No. 0483
Contractor's Registration No. 601-048-714 Date 8-30-94, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

Please print, sign and return to the Department of Ecology

Water Well Report

Original – Ecology, 1st copy – owner, 2nd copy – driller

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Construction/Decommission 200073

☒ Construction

☐ Decommission *ORIGINAL INSTALLATION Notice of Intent Number* ______

Current Notice of Intent No. W 224175

Unique Ecology Well ID Tag No. ALC 743

Water Right Permit No. ______

Property Owner Name Brent Preston

Well Street Address 502 E Vineyard

City Pasco County Franklin

Location ___1/4-1/4 SW 1/4 Sec 29 Twn 10N R 30 ☒ EWM or ☐ WWM circle one

Lat/Long (s, t, r still REQUIRED) Lat Deg ______ Lat Min/Sec ______ Long Deg ______ Long Min/Sec ______

Tax Parcel No. ______

PROPOSED USE: ☒ Domestic ☐ Industrial ☐ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ______

TYPE OF WORK: Owner's number of well (if more than one) ______

☒ New well ☐ Reconditioned *Method :* ☐ Dug ☐ Bored ☐ Driven

☐ Deepened ☐ Cable ☒ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 8 inches, drilled 363 ft.

Depth of completed well 363 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 8" Diam. from +1 ft. to 170± ft.

☒ Liner installed 6 PVC Diam. from 163 ft. to 363 ft.

☐ Threaded ______" Diam. from ______ ft. to ______ ft.

Perforations: ☒ Yes ☐ No

Type of perforator used SAW

SIZE of perfs 1/8 in. by 6 in. and no. of perfs 95 from 351 ft. to 363 ft.

Screens: ☐ Yes ☒ No ☐ K-Pac Location ______

Manufacturer's Name ______

Type ______ Model No. ______

Diam.______Slot size______from______ft. to______ft.

Diam.______Slot size______from______ft. to______ft.

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand ______

Materials placed from______ft. to______ft.

Surface Seal: ☒ Yes ☐ No To what depth? 170± ft.

Material used in seal BENTONITE & CASING

Did any strata contain unusable water? ☒ Yes ☐ No

Type of water? HIGH NITRATES Depth of strata 127 - 168

Method of sealing strata off CASING & BENTONITE

PUMP: Manufacturer's Name ______

Type: ______ H.P. ______

WATER LEVELS: Land-surface elevation above mean sea level ______ ft.

Static level 151 ft. below top of well Date 5/5/06

Artesian pressure ______ lbs. per square inch Date ______

Artesian water is controlled by ______ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☐ Yes ☒ No If yes, by whom? ______

Yield:______gal./min. with______ft. drawdown after______hrs.

Yield:______gal./min. with______ft. drawdown after______hrs.

Yield:______gal./min. with______ft. drawdown after______hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______

Bailer test______gal./min. with ______ft. drawdown after______hrs.

Airtest 75 gal./min. with stem set at 275 ft. for 3 hrs.

Artesian flow ______g.p.m. Date ______

Temperature of water ______ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information indicate all water encountered. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
TAN SAND & SILT	0	34
TAN CLAY	34	46
WHITE CLAY	46	49
WHITE CLAY & GRAVEL	49	57
TAN CLAY & GRAVEL	57	68
TAN SILT	68	73
TAN CLAY	73	96
CEMENTED BROWN SAND	96	106
BROWN SILTSTONE	106	109
BROWN SILTSTONE & ROCKS	109	127
GRAVEL TAN SAND [redacted]	127	168
PORICE BLK BASALT	168	169
BLACK BASALT	169	187
PORICE BLACK BASALT	187	198
BLACK BASALT HARD	198	231
PORICE BLACK BASALT	231	–
W/ BLUE SILTSTONE & CLAY	–	242
PORICE RED & BLACK BASALT	242	246
PORICE BLACK ← H2O * 13GPM	246	249
BLACK BASALT HARD	249	335
BLUE CLAY	335	351
GREENISH GREY SAND H2O	351	356
BLACK BASALT HARD	356	363

RECEIVED

JUL 19 2006

DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Start Date 5/1/06 Completed Date 5/5/06

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

Driller/Engineer/Trainee Name (Print) JEREMY L RUDE

Driller/Engineer/Trainee Signature ______

Driller or trainee License No. 2691

If TRAINEE,
Driller's Licensed No. ______
Driller's Signature ______

Drilling Company NELSON WELL DRILLING

Address 7505 W. COURT ST

City, State, Zip PASCO WA. 99301

Contractor's Registration No. NELSOWD 198 CQ Date 5/5/06

Ecology is an Equal Opportunity Employer. ECY 050-1-20 (Rev 2/03)

36

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

37745

WATER WELL REPORT
STATE OF WASHINGTON

Start Card No. 050068
UNIQUE WELL I.D. # ABX 793
Water Right Permit No.

(1) OWNER: Name BALCOM + MOE INC Address PO BOX 968 PASCO, WA. 99301

(2) LOCATION OF WELL: County FRANKLIN NW 1/4 SE 1/4 Sec 30 T. 10 N., R 30E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: ☑ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (If more than one)
Abandoned ☐ New well ☐ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6" inches.
Drilled 120 feet. Depth of completed well 120 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 199 ft.
Welded ☑ " Diam. from ft. to ft.
Liner installed ☐ " Diam. from ft. to ft.
Threaded ☐

Perforations: Yes ☑ No ☐
Type of perforator used
SIZE of perforations 1/4 in. by 1/2 in.
150 perforations from 105 ft. to 115 ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☐ No ☑
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☐ Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes ☑ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 75 ft. below top of well Date 3-18-96
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☑ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airtest 40 gal./min. with stem set at 100 ft. for 6 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand - Brown	0	8'
Gravel & Sand	8'	13'
Sand	13'	32'
Sand & Gravel	32'	50'
Sand	50'	54'
Sand & Gravel Trace of water	54'	93'
Clay, Brown	93'	96'
Sand & Gravel water Bearing 40 GPM	96'	120'

RECEIVED
APR - 3 1997
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Work Started 3-15-96, 19. Completed 3-19-96, 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Statewide Well Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 2839 W Kenn #330 Kenn WA 99336
(Signed) (WELL DRILLER) License No. 2343

Contractor's Registration No. STATEWD077DQ Date 4-96, 19

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

ECY 050-1-20 (9/93)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

37751

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W050074
UNIQUE WELL I.D. # ABY-801
Water Right Permit No. ______

(1) OWNER: Name Maury Balcom Address PO Box 968 Pasco WA 99301

(2) LOCATION OF WELL: County Franklin NW 1/4 SE 1/4 Sec 30 T 10 N R 30E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) ______

(3) PROPOSED USE: ☑ Domestic ☐ Irrigation ☐ DeWater ☐ Industrial ☐ Test Well ☐ Municipal ☐ Other

(4) TYPE OF WORK: Owner's number of well (if more than one) 2
☐ Abandoned ☑ New well ☐ Deepened ☐ Reconditioned
Method: ☐ Dug ☐ Cable ☑ Rotary ☐ Bored ☐ Driven ☐ Jetted

(5) DIMENSIONS: Diameter of well 6" inches.
Drilled 118 feet Depth of completed well 118 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 118 ft.
☑ Welded ______ Diam. from ______ ft. to ______ ft.
☐ Liner installed ______ Diam. from ______ ft. to ______ ft.
☐ Threaded

Perforations: Yes ☐ No ☑
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☐ No ☑
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☑ Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☑ No ☐ To what depth? 30' + ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 80' ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 40 gal./min. with stem set at 100 ft. for 3 hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☑

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand - Brown	0'	43'
Silt, Clay & Sand	43'	72'
Sand, Some Gravel - (Trace of water)	72'	97'
Sand & Gravel (water sand)	97'	103'
Cause Gravel (40 GPM)	103'	118'

Work started 4-3-96 Completed 4-5-96

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Stacie de well Drilling (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 2337 W 15th #30C Kenn WA 99336
(Signed) ______ License No. 2345

Contractor's Registration No. STALEWD017DG Date 4-96, 19__

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

File Original and First Copy with
the Division of Water Resources
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

38

UNRECORDED

Application No. ....

Permit No. ....

[illegible]) OWNER:

[illegible]ne El Paso Natural Gas Company

Address P.O. Box 1526
Salt Lake City 10, Utah

(2) LOCATION OF WELL:

County Franklin Owner's number, if any—

¼ SE ¼ Section 30 T. 10 R. 30 E W.M.

Bearing and distance from section or subdivision corner

Elev 508

Eltopia

(3) TYPE OF WORK (check):

New Well ☐ Deepening ☐ Reconditioning ☐ Abandon ☐

If abandonment, describe material and procedure in Item 11.

(4) PROPOSED USE (check):

Domestic ☐ Industrial ☐ Municipal ☐

Irrigation ☐ Test Well ☐ Other ☐

(5) TYPE OF WELL:

Rotary ☐ Driven ☐

Cable ☐ Jetted ☐

Dug ☐ Bored ☐

(6) CASING INSTALLED:

Threaded ☐ Welded ☒

10 " Diam. from 0 ft. to 163 ft. Gage .250

...... " Diam. from ...... ft. to ...... ft. Gage ......

...... " Diam. from ...... ft. to ...... ft. Gage ......

[illegible]PERFORATIONS:

Perforated? ☐ Yes ☐ No

Type of perforator used

SIZE of perforations in. by in.

...... perforations from ...... ft. to ...... ft.

...... perforations from ...... ft. to ...... ft.

...... perforations from ...... ft. to ...... ft.

...... perforations from ...... ft. to ...... ft.

...... perforations from ...... ft. to ...... ft.

(8) SCREENS:

Well screen installed ☐ Yes ☐ No

Manufacturer's Name ......

Type ...... Model No. ......

Diam. ...... Slot size ...... Set from ...... ft. to ...... ft.

Diam. ...... Slot size ...... Set from ...... ft. to ...... ft.

(9) CONSTRUCTION:

Was well gravel packed? ☐ Yes ☐ No Size of gravel: ......

Gravel placed from ...... ft. to ...... ft.

Was a surface seal provided? ☐ Yes ☐ No To what depth? ...... ft.

Material used in seal—

Did any strata contain unusable water? ☐ Yes ☐ No

Type of water? Depth of strata

Method of sealing strata off

(10) WATER LEVELS:

Static level ft. below land surface Date

[illegible]an pressure lbs. per square inch Date

[illegible]ater is controlled by ......
(Cap, valve, etc.)

(11) WELL TESTS:

Drawdown is amount water level is lowered below static level

Was a pump test made? ☐ Yes ☐ No If yes, by whom?

Yield: gal./min. with ft. drawdown after hrs.

" " " "

" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	*Water Level*	*Time*	*Water Level*

Date of test ......

Bailer test gal./min. with ft. drawdown after hrs.

Artesian flow g.p.m. Date

Temperature of water Was a chemical analysis made? ☐ Yes ☐ No

(12) WELL LOG:

Diameter of well ...... inches.

Depth drilled ft. Depth of completed well ft.

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Sandy soil	2	2
Sand & gravel	37	39
Sandy gray clay w/gravel	12	51
Light brown clay	7	58
Hard sandy clay	10	68
Light brown clay	15	83
Gravel w/some sand	8	91
Cement gravel	10	101
Washed gravel & sand	15	116
Gravel & sand	12	128
sand w/little gravel	36	164
Broken rock	3	167
Black broken basalt	42	209
Black basalt & blue clay	15	224
Dark gray rock (hard)	46	270
Light " " "	15	285

Work started 10-3 1966. Completed 11-14 1966

(13) PUMP:

Manufacturer's Name ......

Type: ...... H.P. ......

Well Driller's Statement:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Moore & Anderson
(Person, firm, or corporation) (Type or print)

Address P.O. Box 1228, Walla Walla, Wash.

[Signed] ......
(Well Driller)

License No. ...... Date 12-12, 1966

(USE ADDITIONAL SHEETS IF NECESSARY)

File Original and First Copy with Department of Ecology
Second Copy — Owner s Copy
Third Copy — Driller s Copy

(4) – 13

WATER WELL REPORT
STATE OF WASHINGTON

Application No

Permit No 63270-30P

(1) OWNER Name Burlington Northern Address

(2) LOCATION OF WELL County SW ¼ ~~SW~~ SE¼ ¼ Sec 31 T 10 N R 30 W M

Bearing and distance from section or subdivision corner

(3) PROPOSED USE Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK Owner s number of well (if more than one)

New well ☒ Method Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS Diameter of well 16 inches
Drilled 170 ft Depth of completed well 170 ft

(6) CONSTRUCTION DETAILS

Casing installed 16 Diam from +1 ft to 140 ft
Threaded ☐ Diam from ft to ft
Welded ☐ Diam from ft to ft

Perforations Yes ☐ No ☐
Type of perforator used
SIZE of perforations in by in
perforations from ft to ft
perforations from ft to ft
perforations from ft to ft

Screens Yes ☒ No ☐
Manufacturer s Name Johnson
Type Stainless Model No —
Diam 12"PS Slot size 60 from 140 ft to 165 ft
Diam Slot size from ft to ft

Gravel packed Yes ☒ No ☐ Size of gravel F-5
Gravel placed from 109 ft to 167 ft

Surface seal Yes ☐ No ☐ To what depth? ft
Material used in seal
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP Manufacturer s Name
Type H.P

(8) WATER LEVELS Land surface elevation above mean sea level 470 ft
Static level 109 ft below top of well Date
Artesian pressure lbs per square inch Date
Artesian water is controlled by (Cap valve etc)

(9) WELL TESTS Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes by whom?
Yield gal /min with ft drawdown after hrs

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal /min with ft drawdown after hrs
Artesian flow g p m Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG

Formation Describe by color character, size of material and structure and show thickness of aquifers and the kind and nature of the material in each stratum penetrated with at least one entry for each change of formation

MATERIAL	FROM	TO
Sand Tan Silty	0	7
Sand BlK 3" minus gravel	7	32
Boulders	32	34
Gravel 3" minus Sand Blk	34	52
Boulders	52	54
Sand Tan	54	83
Silt Tan Sandy	83	85
Sand Tan	85	87
Silt Tan Sandy	87	118
Sand Tan Silty	118	120
Gravel 6" minus Sand Med Water	120	131
Sand Tan Fine Gravel 6" minus Water	131	165
Basalt BlK	165	170

RECEIVED
MAR 19 1982
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

31 Feet 12 STD Well Pipe
26 Feet 12" 60 Slot SS Screen
5 Feet 12" STD Well Pipe

Work started 12-17 1981 Completed 1-4 1982

WELL DRILLER'S STATEMENT

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief

NAME Nelson Well Drilling Inc (Person firm or corporation) (Type or print)

Address 10036 W. Clargent Road

[Signed] James Nelson (Well Driller)

License No 361 Date 1-6 1982

(USE ADDITIONAL SHEETS IF NECESSARY)

Reg. # 3953

WELL LOG

NER:

NAME DUANE GUENTHER

ADDRESS 1524 W. HOWARD PASCO

DATE DRILLED: JAN. 4-20 1965

LOCATION OF WELL: Elev 480 (E1 top

COUNTY FRANKLIN **BLOCK** 17 **UNIT** 46

____ ¼ ____ ¼ **SECTION** 31 **T.** 10N **R.** 30E **W.M.**

TYPE OF WORK: NEW **USE:** DOM. & L.S

CASING: **DIAMETER:** 6 INCH **WEIGHT:** 18.97/FT. **DRIVE SHOE** B-C

TOTAL CASING: 160'-6" **CASED BELOW SURFACE** 158'-6"

TOTAL WELL DEPTH: 218 **OPEN END:** 59'-6" **SIZE:** 5-15/16"

ALL CASING JOINTS DOUBLE TAPERED AND TRIPLE WELDED.

SCREEN: ____ **SURFACE SEAL:** 2 SACKS BENTONITE

TEST: **STATIC WATER LEVEL:** 135FT. TOP CASING **BAILER TEST** ✓ **PUMP TEST** ____

YIELD: 20 **GAL./MIN. WITH** 30 **FT. DRAWDOWN AFTER** 1 **HRS.**

YIELD: ____ **GAL./MIN. WITH** ____ **FT. DRAWDOWN AFTER** ____ **HRS.**

TEMPERATURE: 63 DEGREES **WELL CHLORINATED:** YES

PUMP SETTING: FOR A YIELD OF 15-20 GPM WE SUGGEST SETTING PUMP INTAKE @ 180 FT. THIS WELL MAY YIELD 30-35 GPM. WITH PUMP INTAKE SET @ 210 TO 212 FT.

[redacted]

MATERIAL	S. W. L.	THICKNESS	DEPTH	CASING
SANDY SOIL		9	9	
FINE GR. & S.		12	21	
CEMENTED GR.		15	36	
CLAY & SOME FINE GR. & S.		13	49	
SILTY SAND		17	66	
SANDY CLAY		6	72	
SAND, SOME FINE GR. & CL.		8	80	
FINE GRAVEL & SAND		4	84	
FINE GRAVEL, S. & CL.		3	87	
CLAY - OCCASSIONAL LAYER F. GR. & S.		49	136	
CEMENTED GR.		9	145	
SANDY CLAY		8	153	
DEC. BAS.		2	155	
PARTIALLY DEC. BAS.		3	158	
MED. HARD BAS. - CL. SEDIMENT		20	178	(TRACE H_2O-17
MED. HARD BAS.		4	182	
VERY HARD BAS.		20	202	
FRAC. MED HARD BAS		4	206	(TRACE H_2O-2
POROUS BAS (WATER)		11	217	
MED. HARD BAS		1	218	

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

X

WATER WELL REPORT
STATE OF WASHINGTON

41

Application No. ....
Permit No. G3-24193

(1) OWNER: Name Lentz Farms Address 1304 W. Yakima St - Pasco, Wash 99301

(2) LOCATION OF WELL: County Franklin NE ¼ SW ¼ Sec. 32 T. 10 N., R. 30 W.M.
Bearing and distance from section or subdivision corner South Central Part

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Bored ☐ Cable ☒ Driven ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 222 ft. Depth of completed well 222 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 222 ft.
Threaded ☐ .... " Diam. from .... ft. to .... ft.
Welded ☒ .... " Diam. from .... ft. to .... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations .... in. by .... in.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Stainless Model No. ....
Diam. 6 Slot size 20 from 205 ft. to 220 ft.
Diam. 6 Slot size 40 from 210 ft. to 222 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 520 ft.
Static level 167 ft. below top of well Date 3/2/75
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ....
Yield: .... gal./min. with .... ft. drawdown after .... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test 20 gal./min. with 2 ft. drawdown after 2 hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Sand & Clay with Silt	0	162
1/16" Sand some 1/4" gravel - Water	162	168
Water	168	169
Coarse Sand 1/8" - Heaves in Casing More Water	169	180
Fine sand - some gravel - Still Heaves	180	190
Cemented Gravel - No Water	190	200
Fine Sand - some gravel 1/4"	200	205
Heaving Fine Sand - Traces of Gravel	205	212
Loose Gravel 1/4" to 2" - Some Sand	212	221
Bedrock	221	222

1500 gpm
744
160 Acres

Eltopia

Work started 2/24 1975 Completed 3/11 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME B & H Drilling (Person, firm, or corporation) (Type or print)
Address Rt. 3 Box 3365A - Kennewick, Wash. 99336
[Signed] Leonard Bulten (Well Driller)
License No. 0066 Date 3/11, 1975

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71). 3

Second Copy — Owner's Copy
Third Copy — Driller's Copy

STATE OF WASHINGTON

42

Permit No. G3 24143 D

(1) OWNER: Name Lentz Address

(2) LOCATION OF WELL: County Franklin — SE ¼ SW ¼ Sec 32 T. 10 N., R 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☑ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 197 ft. Depth of completed well 192 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16" Diam. from +1 ft. to 153 ft.
Threaded ☐ ......" Diam. from ...... ft. to ...... ft.
Welded ☒ ......" Diam. from ...... ft. to ...... ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations ...... in. by ...... in.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.
...... perforations from ...... ft. to ...... ft.

Screens: Yes ☒ No ☐ 16" TO 12" Slip Packer
Manufacturer's Name Johnson
Type Low Carbon Model No.
Diam. 12" Slot size .060 from 154 ft. to 184 ft.
Diam. ...... Slot size ...... from ...... ft. to ...... ft.

Gravel packed: Yes ☑ No ☐ Size of gravel F-5 Filter
Gravel placed from 150 ft. to 186 ft.

Surface seal: Yes ☒ No ☐ To what depth? 33 ft.
Material used in seal Cement - Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 540 ft.
Static level 138 ft. below top of well Date 10-9
Artesian pressure ...... lbs. per square inch Date
Artesian water is controlled by ...... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: 1557 gal./min. with 11 ft. drawdown after 4 hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test ...... gal./min. with ...... ft. drawdown after ...... hrs.
Artesian flow ...... g.p.m. Date
Temperature of water ...... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Soil - Sandy - TAN	0	4
Sand - Silty - TAN	4	84
Sand - Med - Gray	84	101
Silt - Sandy - TAN	101	145
Sand - Med - Gray	145	163
Sand - Gravel - Ringold Formation - Loose	163	184
Sand - Gravel - Ringold Formation Silty Tight	184	192
Basalt Broken - Black	192	197
Screen - Total Lenght 42-6" - 192-184 - 12" Casing - 184 - 154 30 FT 12" pipe size .060 Low Carbon Johnson screen - 154 150 - 4 FT 12" casing - Lead 16" To 12" Slip Packer on Top		

1550
744
160 A

Work started ......, 19...... Completed 10-10, 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Nelson Well Drilling
(Person, firm, or corporation) (Type or print)

Address P.O. Box 2814 Pasco

[Signed] James Nelson
(Well Driller)

License No. 0361 Date 10-14, 1975

12/4/14

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

#1

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
DIVISION OF WATER RESOURCES

[illegible]-8250
P-7664

WELL LOG

Record by: Driller

Source: Driller's Record

Location: State of WASHINGTON

County: Franklin

Area:

Map:

NW ¼ NE ¼ sec. 33 T. 10 N., R. 30 E. W.

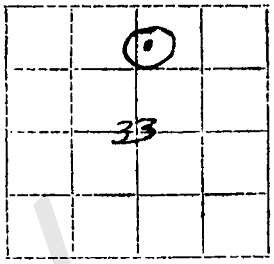

Diagram of Section

Drilling Co. Charles Jungmann Drilling Company

Address: 115 Rees Ave. Walla Walla, Washington

Method of Drilling: Cable Date ...., 19......

Owner: Northern Pacific Railway Company

Address: Seattle, Washington

Land surface, datum .... ft. above below

SWL: 240' Date July 13, 19 66 Dims. 8" x 487'

(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)

CORRELATION	MATERIAL	From (feet)	To (feet)
	Stock use		
	Sand	0	155
	Basalt	155	487
	Casing: 8" from 0 to 155'		
	Has permanent pump capacity of well 90 gpm		
	with 200' drawdown.		
	This well was previously drilled with no		
	records available. Formations and casing		
	are assumptions, after drilling well		
	nearby.		

Turn up

Sheet ...... of ...... sheets

#2

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
DIVISION OF WATER RESOURCES

A-8250
P-7664

WELL LOG

Record by: Driller

Source: Driller's Record

Location: State of WASHINGTON

County: Franklin

Area:

Map:

SW ¼ NE ¼ sec. 33 T. 10 N., R. 30 E.

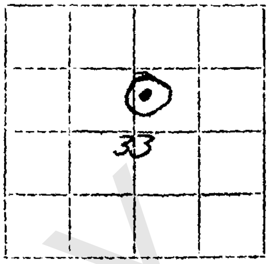

Diagram of Section

Drilling Co. Charles Jungmann Drilling Company

Address: 115 Rees Avenue, Walla Walla, Wash.

Method of Drilling: Cable Date: Oct. 24, 1966

Owner: Northern Pacific Railway Company

Address: Seattle, Washington

Land surface, datum ft. above below

SWL: 213' Date: Oct. 20, 1966 Dims: 10" and 8" x 471'

CORRELATION	MATERIAL	From (feet)	To (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)		
	Stock use		
	Sand	0	154
	Basalt, black	154	172
	Basalt, gray, very hard	172	245
	Basalt, broken, black, & clay	245	276
	Basalt, very hard, gray	276	367
	Basalt, soft, black	367	386
	Basalt, gray	386	394
	Conglomerate (rock, clay)	394	423
	Basalt, gray	423	432
	Basalt, black, soft	432	450
	Basalt, hard, black	450	571
	Casing: 10" from 0 to 154'		
	8" from 2 to 421'		
	Perforated from 390 to 400'		
	(over)		

Turn up Sheet of sheets

WELL LOG.—Continued No. 10/30-33R

Formation	Material	From (feet)	To (feet)
	Depth forward	→	
	Yield: 150 gpm with 188' dd after 4 hrs.		
	Complete recovery in 30 min.		
	Date: 10/20/66		

S. F. No. 7449—OS—12-65.

File Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. #3
Permit No. 63-25678

(1) OWNER: Name Dan Beus Address 63-25166

(2) LOCATION OF WELL: County Franklin SW SW SW ¼ Sec. 33 T. 10 N., R. 30 W.M.

Bearing and distance from section or subdivision corner 35' N - 60' E. of SW Corner

PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 221-6 ft. Depth of completed well 221-6 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16 " Diam. from +1 ft. to 197 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used.....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson Stainless
Type..... Model No.....
Diam. 16 Slot size .250 from 197-7 ft. to 218 ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

ravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 80 ft.
Material used in seal Bentonite & Sand
Did any strata contain unusable water? Yes ☐ No ☒
Type of water?..... Depth of strata.....
Method of sealing strata off.....

(7) PUMP: Manufacturer's Name.....
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level... 550 ft.
Static level 180 - ft. below top of well Date 3-11-78
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?.....
Yield: ..... gal./min. with ..... ft. drawdown after ..... hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

ate of test .....
test ..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water..... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Sand - Tan Silty	0	14
Silt	14	20
Sand - Tan - Silty	20	184
Sand - Grey & Black 2-3" gravel NC	184	189
Sand - Fine Tan & Black Coarse 2-4" Ringold gravel	189	218
Sand - Fine Tan - 2-3" gravel Ringold	218	221-6
Basalt Brown Firm	221-6	222
Prim [illegible] 3000 15 30		
Screen measurements		
1'4" Packer & Blank		
20'5 Screen		
3-6 Blank		

RECEIVED
[illegible] 1980
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 2-6, 1978. Completed 3-11, 1978.

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Nelson Well Drilling Inc.
(Person, firm, or corporation) (Type or print)

Address 10036 W. Argent Pasco WA

[Signed] Bruce Williams
(Well Driller)

License No. 0659 Date 3-17, 1978

11/19/80

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev 4-71)
ECY-070-28

#3

File Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

46

Application No. #2

Permit No. G3-25678

(1) OWNER: Name Don Bues Address G3-25166

(2) LOCATION OF WELL: County Franklin SW SW ¼ SW ¼ Sec 33 T 10 N., R 30 W.M.

and distance from section or subdivision corner 180'N + 360'E of SW Cor

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)

New well ☒ Method: Dug ☐ Bored ☐

Deepened ☐ Cable ☒ Driven ☐

Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.

Drilled [redacted] - 223 ft. Depth of completed well 223 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16" Diam. from +1 ft. to 197 ft.

Threaded ☐ " Diam. from ft. to ft.

Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒

Type of perforator used

SIZE of perforations in. by in.

perforations from ft. to ft.

perforations from ft. to ft.

perforations from ft. to ft.

Screens: Yes ☒ No ☐

Manufacturer's Name JOHNSON

Type STAINLESS Model No.

Diam. 14" Slot size .250 from 197 ft. to 223 ft.

Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:

Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 27 ft.

Material used in seal BenTonite

Did any strata contain unusable water? Yes ☐ No ☒

Type of water? Depth of strata

Method of sealing strata off

(7) PUMP: Manufacturer's Name

Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level 550 ft.

Static level 186 ft. below top of well Date 7-13-77

Artesian pressure lbs. per square inch Date

Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? Yes ☐ No ☐ If yes, by whom?

Yield: gal./min.	with	ft. drawdown after	hrs.
"	"	"	"
"	"	"	"

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test

Bailer test gal./min. with ft. drawdown after hrs.

Artesian flow g.p.m. Date

Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
SAND-TAN, Brown-SILTY	0	182
SAND-Grey + BLACK, 2-4" gravel H2O	182	216
SAND-Fine TAN, 2-6" gravel	216	223
Ringold —		

Permitted ~~1400~~ 3000 gpm 1500 300 Ac

RECEIVED

DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 6-22, 1977. Completed 7-13, 1977

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Nelson Well Drilling (Person, firm, or corporation) (Type or print)

Address 10036 W. ARGENT PASCO, WN

[Signed] Bruce Williams (Well Driller)

License No. 0659 Date 7-15, 1977

11/19/80

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev 4-71)
ECY-070-28

#2

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WATER WELL REPORT
STATE OF WASHINGTON

47

Application No. G3 25675
Permit No. G3-25166

#1

(1) OWNER: Name Don Bues Address

(2) LOCATION OF WELL: County Franklin SW ¼ SW ¼ Sec 33 T 10 N., R 30 W.M.
[illegible] and distance from section or subdivision corner 350' N - 550' E of SW Cor

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 8 inches.
Drilled 229 ft. Depth of completed well 229 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 8 " Diam. from +1 ft. to 218 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Stainless Model No.
Diam. 8 Slot size 035 from 218 ft. to 223 ft.
Diam. 8 Slot size 050 from 223 ft. to 228 ft.

Gravel packed: Yes ☐ No ☐ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? ft.
Material used in seal
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level 550 ft.
Static level 180 ft. below top of well Date
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Sand Silty Tan	0	92
Sand Blk Fine silty	92	93
Sand Silty Tan	93	121
Sand Tan Silty + Clkie	121	121.5
Sand tan Silty	121.5	145
Sand Blk Gray silty	145	160
Silt Tan	160	161
Sand Blk + Grey Fine Silty	161	178
Gravel Black Sand 4" minus	178	181
Gravel - Sand Tan Ringold Formation	181	229
Basalt Blk	229	
Screen		
Packer		
1 Ft Blank		
5 Ft 035 Slot		
5 Ft 050 Slot		
1 Ft Blank		
Bail Bottom		

RECEIVED
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

[illegible]

Work started 5-7, 1977. Completed 6-22, 1977

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Nelson Well Drilling Inc
(Person, firm, or corporation) (Type or print)

Address 10036 West Clygent

[Signed] Bruce Wellson
(Well Driller)

License No. 654 Date 6-22, 1977

11/19/80

(USE ADDITIONAL SHEETS IF NECESSARY)

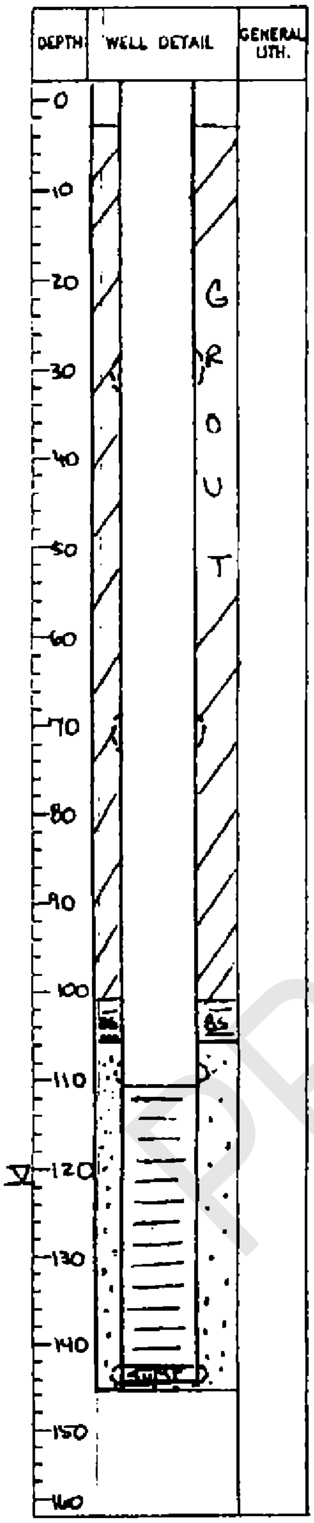
S. F. No. 7356—OS—(Rev. 4-71)
ECY-070-28

#1

MONITORING WELL CONSTRUCTION SUMMARY

Project Name: City of Pasco / Wastewater Treatment
Project No.: 89584
Well No.: MW-04
Boring No.: MW-04
Start Card No.: R-02815

Horizontal Coords: ¹ ________
² ________
Ground Surface Elevation: ________
Top of PVC Well Casing: ________
Section 34 T. 10N R. 30 EWM Franklin Co



DRILLING SUMMARY

Total Borehole Depth: 145 ft bgs
Borehole Diameter: 8.6-inches
Drilling Contractor: Ponderosa Drilling - Spokane, WA
Driller(s): Roger Kolk
Rig(s): Reichdrill T625 Rotary / Circulation Medium = Air
Bit(s): 7 7/8-inch Tri-cone Roller Bit.

TIME LOG

	Start		Finish	
Task	Date	Time	Date	Time
Drilling Method:				
Air Rotary	2/2/95	1332	2/3/95	1436
Geophys. Logging	N/A			
Casing	2/6	0950	2/6	1115
Sand Pack	2/6	1128	2/6	1616
Grout	2/7	0735	2/7	1256
Bentonite Seal	2/6	1624	2/6	1648
Development (Start)				
Development (Finish)				

WELL INSTALLATION

Well Design and Specifications Basis:
Geologic Log: ✓ Geophysical Log: ___
Casing Material: Sched. 80, 4-inch Flush-Threaded PVC.
Casing(s): B = blank; S = screen; EC = end cap

Depth (ft)	Casing	Elevation ¹ (ft)
+3.0 - 110.57	B	
110.57 - 140.60	S	
140.60 - 142.95	B	
142.95 - 143.29	EC	

Screen Type/Size: Lakeshore Fact. Slot / 30 slot
Surface Seal (ft):
Mfr/Mtrl/Qty:
Grout Seal (ft): 100.0 ft to 3.0 ft bgs
Mfr/Mtrl/Qty: Ash Grove TC I&II 47 bgs / 8% bentonite grout, [illegible] 173 lbs
Bentonite Seal (ft): 106.5 ft to 100.0 ft bgs
Mfr/Mtrl/Qty: Enviroplug / 3/8-inch / 2 bags
Sand Pack (ft): 145.0 ft to 106.5 ft bgs
Mfr/Mtrl/Qty: CSSI / #8-12 / 25 bags
Bottom Seal (ft:) N/A
Mfr/Mtrl/Qty: ——

WELL DEVELOPMENT

Method:
Total Volume Purged:
Starting Level:
Finishing Level:
Stabilization Test Data

Date	Time	Volume	pH	Cond Spec.	Temp (°C)

RECEIVED
DEC 15
DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

Comments: ~~¹Tennison Coordinate System~~ ~~²Oregon State Coordinate System~~ OR STATE
Stainless steel centralizers @ 30 ft, 70 ft, 110 ft, and 141 ft bgs.

See Wellhead Detail for surface construction information.

Generated by: Terry McPartland Date: 2-6-95
Checked by: ________ Date: ________

RUST ENVIRONMENT & INFRASTRUCTURE

c:\forms\wellsum2.for

Second Copy — Owner's Copy
Third Copy — Driller's Copy

STATE OF WASHINGTON

Permit No. G3-2386

(1) OWNER: Name KENNETH PIEKARSKI Address STAR ROUTE, BOX 205, MESA, WN.

(2) LOCATION OF WELL: County FRANKLIN — ¼ SW ¼ Sec 35 T 12 N., R 30E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)....

New well ☐ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 136 ft. Depth of completed well 122-6 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16" Diam. from 0 ft. to 105-6 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name JOHNSON
Type 304 STAINLESS Model No TELES
TELESCOPE Diam. 16 Slot size 070 from 104½ ft. to 117 ft.
Diam. Slot size 120 from 117 ft. to 122½ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 30 ft.
Material used in seal
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 520 ft.
Static level 94 ft. below top of well Date 3/3/75
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?

Yield:	gal./min. with	ft. drawdown after	hrs.
"	"	"	"
"	"	"	"

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water 63 Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
CLAYISH SOIL	0	34
SILTY BLACK S.	10	44
CLAYISH SOIL	10	54
SILTY S.	2	58
CLAYISH SOIL	10	68
F.GR. + S	9	77
F.S.	3	80
F.GR., C.S.	17	97
F.GR. S.	2	99
S. SOME F.GR.	3	102
C.S. & F.GR.	8	110
" " SOME F.GR.	4	114
" " TRACE " "	4	118
" " SOME " "	3	121
F.GR., C.S.	2	123
YELLOW CLAY	13	136

2300 gpm
1617 A/Ft
320 Acres

RECEIVED
APR 25 1975
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 2/14, 1975. Completed 3/3, 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME CASCADE DRILLING CO.
(Person, firm, or corporation) (Type or print)

Address P.O. DRAWER E, KENNEWICK

[Signed]
(Well Driller)

License No. 0466 Date 3/4, 1975

4/25/75

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

File ~~Original and~~ First Copy with Department of Ecology
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Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

50

Ap[illegible]on No. ....
Permit No. ....

(1) OWNER: Name RAY VOSS Address RT. 1 PASCO, WASH.

(2) LOCATION OF WELL: County FRANKLIN — ¼ SW ¼ Sec 35 T. 10 N., R. 30 W.M.

Bearing and distance from section or subdivision corner Eltopia

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test ~~Well~~ HOLE ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☐ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Bored ☐ Cable ☒ Driven ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 152½ ft. Depth of completed well 0 ft.

(6) CONSTRUCTION DETAILS: PULLED

Casing installed: ...." Diam. from .... ft. to .... ft.
Threaded ☐ ...." Diam. from .... ft. to .... ft.
Welded ☐ ...." Diam. from .... ft. to .... ft.

Perforations: Yes ☐ No ☐
Type of perforator used ....
SIZE of perforations .... in. by .... in.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☐ No ☐
Manufacturer's Name ....
Type .... Model No. ....
Diam. .... Slot size .... from .... ft. to .... ft.
Diam. .... Slot size .... from .... ft. to .... ft.

Gravel packed: Yes ☐ No ☐ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☐ No ☐ To what depth? .... ft.
Material used in seal ....
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level 520 ft.
Static level .... ft. below top of well Date ....
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ....
Yield: .... gal./min. with .... ft. drawdown after .... hrs.
" .... " .... " .... "
" .... " .... " .... "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	*Water Level*	*Time*	*Water Level*	*Time*	*Water Level*

Date of test ....
[illegible]ler test .... gal./min. with .... ft. drawdown after .... hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water 63 Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
SANDY SOIL	0	29
COMPACT GR	3	32
CLAYISH SOIL	19	57
BLK.S. & SED	7	58
CLAYISH SANDY SOIL	4	62
COMPACT F.S. TR. F.GR.	10	72
" SAND, F.GR. & SED.	3	75
LOOSE C. BLK S.	6	81
SANDY CLAY	13	94
C. BLK. S.	2	96
CLAY	5	101
SANDY CLAY	14	115
BLK S & SED.	2	117
SILTY SAND	2	119
C. S & F.GR.	3	122
" " " " TIGHT	2	124
" " " "	1	125
CLAY	12	137
CLAYISH SILTY S.	8	145
SILTY S., TR. F.GR.	1	146
F.GR. & S	3½	149½
GREY F.GR. & S	1½	151
" GREEN COMPACT GR - S	½	151½
BASALT	1	152½

Eltopia

RECEIVED
APR 25 1975
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 2/5, 1975. Completed 2/11, 1975.

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME CASCADE DRILLING CO. (Person, firm, or corporation) (Type or print)

Address P.O. DRAWER E, KENN.

[Signed] .... (Well Driller)

License No. 0406 Date 2/10, 1975

4/25/75

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

3

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WATER WELL REPORT
STATE OF WASHINGTON

3374
3860
3861

51 Application No. ....
Permit No. 63-23386

(1) **OWNER:** Name KENNETH PIEKARSKI Address STAR ROUTE, MESA, WASH

(2) **LOCATION OF WELL:** County FRANKLIN SE ¼ SE ¼ SE ¼ Sec 35 T 10 N., R 30 W.M.

..g and distance from section or subdivision corner

(3) **PROPOSED USE:** Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☑ Test Well ☐ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (if more than one) ....
New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 16 inches.
Drilled 131 ft. Depth of completed well 130 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 16 " Diam. from 0 ft. to 132 ft.
Threaded ☐ ______ " Diam. from ______ ft. to ______ ft.
Welded ☑ ______ " Diam. from ______ ft. to ______ ft.

Perforations: Yes ☐ No ☑
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☑ No ☐
Manufacturer's Name Johnson
Type TELES Model No. 304
Diam. 16 Slot size .025 from 114 ft. to ______ ft.
Diam. ______ Slot size .075 from ______ ft. to 130 ft.

Gravel packed: Yes ☐ No ☑ Size of gravel: ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☑ No ☐ To what depth? 30 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) **PUMP:** Manufacturer's Name ______
Type: ______ H.P. ______

(8) **WATER LEVELS:** Land-surface elevation above mean sea level.... 518 ft.
Static level 236 ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level))

Time	Water Level	Time	Water Level	Time	Water Level

..e of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water 53 Was a chemical analysis made? Yes ☐ No ☑

(10) **WELL LOG:**

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Soil	2	2
Clayish Soil	35	37
Comp Blk S & Sed	6	43
Brn S & Cl	5	48
Clayish Soil	12	60
Sandy Silty Tr F.Gr	5	65
Compact, Rocks & S	3	68
" Gr & S	10	78
S, 3/4 minus Gr	10	88
Compact F.Gr & S	4	92
C.S & F.Gr	2	94
F.Gr.	4	98
Silty S & Sed.	2	100
Sand & Gr.	21	121
C.Gr.	5	126
Comp Gr.	2	128
Coarse "	3	131
Clay		

RECEIVED
FEB 05 1975
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

Work started 1/21 19 75 Completed 2/3 19 75

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME CASCADE DRILLING Co. (Person, firm, or corporation) (Type or print)
Address P.O. DRAWER E, KENN
[Signed] (Well Driller)
License No. 0446 Date 2/3 1975

2/5/75

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).

Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

52

Application No. ______
Permit No. G3-2386

(1) OWNER: Name KENNETH PIEKARSKI Address STAR ROUTE, BOX 205, MESA

(2) LOCATION OF WELL: County FRANKLIN SE¼ SE¼ SE¼ Sec 35 T. 10 N., R 30 W

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☑ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☑ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ______

New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☑ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 147 ft. Depth of completed well [illegible] ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 122 ft.
Threaded ☐ ______ " Diam. from ______ ft. to ______ ft.
Welded ☑ ______ " Diam. from ______ ft. to ______ ft.

Perforations: Yes ☐ No ☑
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☑ No ☐
Manufacturer's Name JOHNSON
Type TELESCOPE Model No. 304
Diam. 5 Slot size .040 from 126 8 ft. to 122 ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☑ Size of gravel: ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☑ No ☐ To what depth? 40 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 518 ft.
Static level 93'-4 ft. below top of well Date 2/3/75
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☑ No ☐ If yes, by whom? Co
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" 18 " 8 INCHES " 1 ½ "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test 2/3/75
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water 63 Was a chemical analysis made? Yes ☐ No ☑

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
SOIL	1½	1½
CLAYISH SOIL	35½	37
COMPACT BLK S. & SED	6	43
BROWNISH S & CL	5	48
CLAYISH SOIL	12	60
SANDY & SILTY TR F GR	5	65
COMPACT GR & S	12	77
F GR & S	10	87
COMPACT F GR & S	8	95
SILTY S & SED	2	97
" " TR F GR & SED	4	101
BLK S & F GR	7	108
F GR & S	5	113
SAND	3	116
C S & F GR MUCH SED	3	119
" " " "	2	121
" " " "	4	125
F GR	4	129
YELLOW CLAY (CASED)	3	132
" "	5	138
SILTY S	4	142
CEM. GR & S	4	146
BAS. (??)	1	147

RECEIVED
FEB 05 1975
DEPARTMENT OF ECOLOGY
SPOKANE REGIONAL OFFICE

230
147
320

Work started Jan 9, 1975. Completed 2/3, 1975

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME CASCADE DRILLING Co. (Person, firm, or corporation) (Type or print)

Address P.O. DRAWER E, KENN.

[Signed] ______ (Well Driller)

License No. 0466 Date 2/3, 1975

(USE ADDITIONAL SHEETS IF NECESSARY)

2/5/75

S. F. No. 7356—OS—(Rev. 4-71).

Appendix D

Proposed Groundwater Monitoring Wells

Appendix D. Proposed Groundwater Monitoring Wells

Well	Hydrogeologic Position [1]	Surface Elevation [2]	Target Aquifer [3]	Potential Well Depth	Potential Well Bottom Elevation [4]
		ft amsl		feet	ft amsl
MW-10	Upgradient of Circles V16, V17, and V18	561	unconfined aquifer	141	420
MW-11	Downgradient of Circles V16, V17, and V18	541	unconfined aquifer	151	390
MW-12	Upgradient of Circles B16	540	unconfined aquifer	170	370
MW-13	Downgradient of Circle B16	544	unconfined aquifer	179	365

NOTES:

Abbreviation: ft amsl = feet above mean sea level.

1 Hydrogeologic position is professional judgement based upon review of well logs, published research and previous work at adjacent Site.

2 Surface elevations obtained from Google Earth.

3 Target aquifers and potenital well depths identified from existing water well logs.

4 Potential well bottom elevations were calculated by subtracting potential well depths from surface elevations.

Appendix E

Circle-Specific Monthly Soil Hydraulic Budgets

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 1 **Acres:** 122 **Soil Water Content at Field Capacity [7]:** 11.4

Crop: Alfalfa **Rooting Depth [3] (approximate):** 60 **Initial Soil Water Content [8]:** 9.7

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.8	2.0	0.0	1.8	0.0	2.6	1.3	1.2	11.1	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.8	0.8	11.4	0.3
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.9	0.9	11.4	0.3
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.6	1.6	10.6	0.0
Mar	0.7	2.5	0.0	2.3	0.0	2.9	3.4	3.2	10.2	0.0
Apr	0.6	4.0	1.0	3.2	0.8	4.6	5.4	5.1	9.6	0.0
May	0.8	6.1	2.0	4.9	1.6	7.2	7.4	6.8	10.1	0.0
Jun	0.7	5.4	3.0	3.8	2.1	6.5	9.0	8.4	8.2	0.0
Jul	0.2	4.8	4.0	3.4	2.8	6.4	10.2	8.7	5.9	0.0
Aug	0.2	5.0	3.0	3.5	2.1	5.8	8.3	5.9	5.7	0.0
Sep	0.4	5.9	0.0	4.7	0.0	5.1	5.1	3.6	7.2	0.0
Oct	0.7	4.6	0.0	4.1	0.0	4.8	2.9	2.3	9.7	0.0
Total	8.3	40.3	13.0	31.6	9.4	49.2	56.4	48.6		0.7

Leaching Fraction [11]	1.1%
Leaching Requirement [12]	10.1%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **2** **Acres:** 152 **Soil Water Content at Field Capacity** [7]**:** 12.0

Crop: Potato / Alfalfa **Rooting Depth** [3] **(approximate):** 48 **Initial Soil Water Content** [8]**:** 10.2

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.8	0.0	0.0	0.0	0.0	0.8	0.8	0.7	10.3	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.6	0.6	11.1	0.0
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.7	0.7	11.7	0.0
Feb	0.7	0.0	0.0	0.0	0.0	0.7	0.8	0.8	11.5	0.0
Mar	0.7	0.0	0.0	0.0	0.0	0.7	1.3	1.3	10.9	0.0
Apr	0.6	2.0	0.0	1.6	0.0	2.2	1.4	1.3	11.7	0.0
May	0.8	3.5	1.0	2.8	0.8	4.4	4.5	4.4	11.7	0.0
Jun	0.7	0.5	9.0	0.4	6.3	7.3	9.0	8.9	10.1	0.0
Jul	0.2	0.5	13.0	0.4	9.1	9.6	10.3	9.4	10.3	0.0
Aug	0.2	0.5	3.7	0.4	2.6	3.2	4.9	4.5	8.9	0.0
Sep	0.4	3.0	0.0	2.4	0.0	2.8	2.6	2.2	9.5	0.0
Oct	0.7	3.0	0.0	2.7	0.0	3.4	2.9	2.6	10.2	0.0
Total	8.3	13.0	26.7	10.6	18.8	37.6	39.9	37.6		0.0

Leaching Fraction [11]	0.0%
Leaching Requirement [12]	7.8%

NOTES:

Circle 2 includes circle 2 plus little circle 2.

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **3** | **Acres:** 128 | **Soil Water Content at Field Capacity** [7]**:** 8.0

Crop: Alfalfa / Corn | **Rooting Depth** [3] **(approximate):** 60 | **Initial Soil Water Content** [8]**:** 6.8

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.8	1.7	0.0	1.5	0.0	2.4	1.3	1.2	7.9	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.8	0.8	8.0	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.9	0.9	8.0	0.3
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.6	1.6	7.1	0.0
Mar	0.7	2.5	0.0	2.3	0.0	2.9	3.4	3.2	6.8	0.0
Apr	0.6	3.0	0.0	2.4	0.0	3.0	5.4	5.0	4.7	0.0
May	0.8	4.0	6.0	3.2	4.8	8.8	7.4	5.7	7.8	0.0
Jun	0.7	1.0	6.0	0.7	4.2	5.6	6.6	6.5	6.8	0.0
Jul	0.2	1.0	6.0	0.7	4.2	5.1	8.1	7.5	4.4	0.0
Aug	0.2	1.0	7.0	0.7	4.9	5.8	7.7	5.7	4.6	0.0
Sep	0.4	1.5	0.0	1.2	0.0	1.6	0.8	0.6	5.5	0.0
Oct	0.7	1.5	0.0	1.4	0.0	2.0	0.8	0.7	6.9	0.0
Total	8.3	17.2	25.0	14.0	18.1	40.4	44.7	39.4		0.9

Leaching Fraction [11]	1.8%
Leaching Requirement [12]	8.2%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **4** **Acres:** 128 **Soil Water Content at Field Capacity**[7]**:** 8.8

Crop: Alfalfa **Rooting Depth**[3] **(approximate):** 60 **Initial Soil Water Content**[8]**:** 7.5

Month	Precip[1]	Gross Irrigation[2]		Net Irrigation[4]		Total Input[5]	Evapotranspiration[6]		Soil Water Content[9]	Percolate Loss[10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.8	1.9	0.0	1.7	0.0	2.5	1.3	1.2	8.8	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.8	0.8	8.8	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.9	0.9	8.8	0.3
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.6	1.6	7.9	0.0
Mar	0.7	2.5	0.0	2.3	0.0	2.9	3.4	3.2	7.6	0.0
Apr	0.6	4.0	3.0	3.2	2.4	6.2	5.4	5.1	8.7	0.0
May	0.8	6.1	2.0	4.9	1.6	7.2	7.4	7.4	8.6	0.0
Jun	0.7	5.4	6.0	3.8	4.2	8.6	9.0	8.9	8.3	0.0
Jul	0.2	4.8	8.0	3.4	5.6	9.2	10.2	10.0	7.5	0.0
Aug	0.2	5.0	2.0	3.5	1.4	5.1	8.3	7.7	5.0	0.0
Sep	0.4	5.9	0.0	4.7	0.0	5.1	5.1	3.8	6.2	0.0
Oct	0.7	3.5	0.0	3.2	0.0	3.8	2.9	2.5	7.5	0.0
Total	8.3	39.1	21.0	30.5	15.2	54.0	56.4	52.9		1.0

Leaching Fraction[11]	1.4%
Leaching Requirement[12]	10.2%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **5** **Acres:** 128 **Soil Water Content at Field Capacity [7]:** 11.5

Crop: Alfalfa **Rooting Depth [3] (approximate):** 60 **Initial Soil Water Content [8]:** 9.8

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.8	2.0	0.0	1.8	0.0	2.6	1.3	1.2	11.2	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.8	0.8	11.5	0.3
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.9	0.9	11.5	0.3
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.6	1.6	10.6	0.0
Mar	0.7	2.5	0.0	2.3	0.0	2.9	3.4	3.2	10.3	0.0
Apr	0.6	4.0	0.0	3.2	0.0	3.8	5.4	5.2	8.9	0.0
May	0.8	6.1	2.0	4.9	1.6	7.2	7.4	6.5	9.6	0.0
Jun	0.7	5.4	7.0	3.8	4.9	9.3	9.0	8.2	10.7	0.0
Jul	0.2	4.8	7.0	3.4	4.9	8.5	10.2	9.9	9.3	0.0
Aug	0.2	5.0	2.2	3.5	1.5	5.3	8.3	7.5	7.1	0.0
Sep	0.4	5.9	0.0	4.7	0.0	5.1	5.1	4.0	8.2	0.0
Oct	0.7	4.0	0.0	3.6	0.0	4.3	2.9	2.5	9.9	0.0
Total	8.3	39.7	18.2	31.1	12.9	52.2	56.4	51.4		0.7

Leaching Fraction [11]	1.0%
Leaching Requirement [12]	10.7%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 6 **Acres:** 128 **Soil Water Content at Field Capacity [7]:** 6.8

Crop: Alfalfa **Rooting Depth [3] (approximate):** 60 **Initial Soil Water Content [8]:** 5.8

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.8	1.6	0.0	1.4	0.0	2.3	1.3	1.2	6.8	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.8	0.8	6.8	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.9	0.9	6.8	0.3
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.6	1.6	5.9	0.0
Mar	0.7	2.5	0.0	2.3	0.0	2.9	3.4	3.2	5.7	0.0
Apr	0.6	4.0	2.0	3.2	1.6	5.4	5.4	5.0	6.1	0.0
May	0.8	6.1	2.0	4.9	1.6	7.2	7.4	7.0	6.3	0.0
Jun	0.7	5.4	6.0	3.8	4.2	8.6	9.0	8.6	6.3	0.0
Jul	0.2	4.8	6.0	3.4	4.2	7.8	10.2	9.8	4.2	0.0
Aug	0.2	5.0	3.0	3.5	2.1	5.8	8.3	6.5	3.5	0.0
Sep	0.4	5.9	0.0	4.7	0.0	5.1	5.1	3.7	4.9	0.0
Oct	0.7	3.0	0.0	2.7	0.0	3.4	2.9	2.5	5.8	0.0
Total	8.3	38.3	19.0	29.8	13.7	51.7	56.4	50.8		1.0

Leaching Fraction [11]	1.5%
Leaching Requirement [12]	10.7%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 7 **Acres:** 152 **Soil Water Content at Field Capacity** [7]**:** 8.3

Crop: Potato / Alfalfa **Rooting Depth** [3] **(approximate):** 48 **Initial Soil Water Content** [8]**:** 7.1

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.8	1.3	0.0	1.2	0.0	2.0	0.8	0.7	8.3	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.6	0.6	8.3	0.8
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.7	0.7	8.3	0.5
Feb	0.7	0.0	0.0	0.0	0.0	0.7	0.8	0.8	8.2	0.0
Mar	0.7	0.0	0.0	0.0	0.0	0.7	1.3	1.3	7.5	0.0
Apr	0.6	1.0	0.0	0.8	0.0	1.4	1.4	1.3	7.5	0.0
May	0.8	2.0	0.5	1.6	0.4	2.7	4.5	4.3	6.0	0.0
Jun	0.7	0.5	9.5	0.4	6.7	7.7	9.0	7.7	6.0	0.0
Jul	0.2	0.5	10.0	0.4	7.0	7.5	10.3	8.7	4.8	0.0
Aug	0.2	0.5	6.5	0.4	4.6	5.1	4.9	3.7	6.2	0.0
Sep	0.4	2.5	0.0	2.0	0.0	2.4	2.6	2.2	6.4	0.0
Oct	0.7	3.0	0.0	2.7	0.0	3.4	2.9	2.6	7.1	0.0
Total	8.3	11.3	26.5	9.3	18.6	36.1	39.9	34.7		1.3

Leaching Fraction [11]	2.8%
Leaching Requirement [12]	9.3%

NOTES:

Circle 7 is circle 7 plus little circle 7.

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **8** **Acres:** 128 **Soil Water Content at Field Capacity** [7]**:** 6.7

Crop: Alfalfa / Corn **Rooting Depth** [3] **(approximate):** 60 **Initial Soil Water Content** [8]**:** 5.7

Month	**Precip** [1]	**Gross Irrigation** [2]		**Net Irrigation** [4]		**Total Input** [5]	**Evapotranspiration** [6]		**Soil Water Content** [9]	**Percolate Loss** [10]
		Process	**Fresh**	**Process**	**Fresh**		**Potential**	**Estimate**		
		inches								
Nov	0.8	1.6	0.0	1.4	0.0	2.3	1.3	1.2	6.7	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.8	0.8	6.7	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.9	0.9	6.7	0.3
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.6	1.6	5.8	0.0
Mar	0.7	2.5	0.0	2.3	0.0	2.9	3.4	3.1	5.6	0.0
Apr	0.6	3.0	2.0	2.4	1.6	4.6	5.4	5.0	5.2	0.0
May	0.8	4.0	3.0	3.2	2.4	6.4	7.4	6.5	5.0	0.0
Jun	0.7	1.0	8.0	0.7	5.6	7.0	6.6	5.7	6.3	0.0
Jul	0.2	1.0	8.0	0.7	5.6	6.5	8.1	7.8	4.9	0.0
Aug	0.2	1.0	6.0	0.7	4.2	5.1	7.7	6.6	3.5	0.0
Sep	0.4	1.5	0.0	1.2	0.0	1.6	0.8	0.6	4.5	0.0
Oct	0.7	1.5	0.0	1.4	0.0	2.0	0.8	0.6	5.8	0.0
Total	8.3	17.1	27.0	13.9	19.4	41.6	44.7	40.4		1.0

Leaching Fraction [11]	1.9%
Leaching Requirement [12]	9.7%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 9 **Acres:** 128 **Soil Water Content at Field Capacity** [7]**:** 6.3

Crop: Alfalfa **Rooting Depth** [3] **(approximate):** 60 **Initial Soil Water Content** [8]**:** 5.4

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.8	1.5	0.0	1.4	0.0	2.2	1.3	1.2	6.3	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.8	0.8	6.3	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.9	0.9	6.3	0.3
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.6	1.6	5.4	0.0
Mar	0.7	2.5	0.0	2.3	0.0	2.9	3.4	3.1	5.2	0.0
Apr	0.6	4.0	1.0	3.2	0.8	4.6	5.4	5.0	4.8	0.0
May	0.8	6.1	1.0	4.9	0.8	6.4	7.4	6.5	4.8	0.0
Jun	0.7	5.4	5.0	3.8	3.5	7.9	9.0	7.8	4.9	0.0
Jul	0.2	4.8	6.0	3.4	4.2	7.8	10.2	9.0	3.6	0.0
Aug	0.2	5.0	3.0	3.5	2.1	5.8	8.3	6.3	3.2	0.0
Sep	0.4	5.9	0.0	4.7	0.0	5.1	5.1	3.6	4.6	0.0
Oct	0.7	3.0	0.0	2.7	0.0	3.4	2.9	2.5	5.5	0.0
Total	8.3	38.2	16.0	29.7	11.4	49.4	56.4	48.3		1.0

Leaching Fraction [11]	1.6%
Leaching Requirement [12]	10.7%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **10** **Acres:** 128 **Soil Water Content at Field Capacity**[7]**:** 7.0

Crop: Alfalfa **Rooting Depth**[3] **(approximate):** 60 **Initial Soil Water Content**[8]**:** 6.0

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.8	1.6	0.0	1.4	0.0	2.3	1.3	1.2	7.0	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.8	0.8	7.0	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.9	0.9	7.0	0.3
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.6	1.6	6.2	0.0
Mar	0.7	2.5	0.0	2.3	0.0	2.9	3.4	3.2	5.9	0.0
Apr	0.6	4.0	2.0	3.2	1.6	5.4	5.4	5.0	6.3	0.0
May	0.8	6.1	2.0	4.9	1.6	7.2	7.4	7.0	6.5	0.0
Jun	0.7	5.4	5.0	3.8	3.5	7.9	9.0	8.6	5.8	0.0
Jul	0.2	4.8	7.0	3.4	4.9	8.5	10.2	9.3	5.0	0.0
Aug	0.2	5.0	3.0	3.5	2.1	5.8	8.3	7.0	3.8	0.0
Sep	0.4	5.9	0.0	4.7	0.0	5.1	5.1	3.8	5.1	0.0
Oct	0.7	3.2	0.0	2.9	0.0	3.5	2.9	2.5	6.2	0.0
Total	8.3	38.5	19.0	30.0	13.7	51.9	56.4	50.8		1.0

Leaching Fraction [11]	1.5%
Leaching Requirement [12]	10.7%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle:	11	**Acres:**	150	**Soil Water Content at Field Capacity [7]:** 8.1
Crop:	Triticale / Corn	**Rooting Depth [3] (approximate):**	60	**Initial Soil Water Content [8]:** 6.9

Month	**Precip [1]**	**Gross Irrigation [2]**		**Net Irrigation [4]**		**Total Input [5]**	**Evapotranspiration [6]**		**Soil Water Content [9]**	**Percolate Loss [10]**
		Process	**Fresh**	**Process**	**Fresh**		**Potential**	**Estimate**		
		inches								
Nov	0.8	1.3	0.0	1.2	0.0	2.0	1.0	0.9	8.0	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.6	0.5	8.1	0.8
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.7	0.7	8.1	0.6
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.1	1.1	7.7	0.0
Mar	0.7	2.5	0.0	2.3	0.0	2.9	2.6	2.5	8.1	0.0
Apr	0.6	2.3	0.0	1.8	0.0	2.4	4.1	4.1	6.4	0.0
May	0.8	3.3	4.0	2.6	3.2	6.6	5.6	5.0	8.0	0.0
Jun	0.7	0.9	4.0	0.6	2.8	4.1	5.5	5.4	6.7	0.0
Jul	0.2	4.5	4.0	3.2	2.8	6.1	8.1	7.4	5.5	0.0
Aug	0.2	6.3	0.5	4.4	0.4	5.0	7.7	6.3	4.2	0.0
Sep	0.4	3.0	0.0	2.4	0.0	2.8	0.8	0.6	6.4	0.0
Oct	0.7	0.7	0.0	0.6	0.0	1.3	0.8	0.7	7.0	0.0
Total	8.3	24.8	12.5	19.1	9.2	36.5	38.4	35.1		1.3

Leaching Fraction [11]	2.9%
Leaching Requirement [12]	9.9%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 12 **Acres:** 128 **Soil Water Content at Field Capacity**[7]**:** 11.3

Crop: Alfalfa / Corn **Rooting Depth**[3] **(approximate):** 60 **Initial Soil Water Content**[8]**:** 9.6

Month	**Precip**[1]	**Gross Irrigation**[2]		**Net Irrigation**[4]		**Total Input**[5]	**Evapotranspiration**[6]		**Soil Water Content**[9]	**Percolate Loss**[10]
		Process	**Fresh**	**Process**	**Fresh**		**Potential**	**Estimate**		
		inches								
Nov	0.8	2.3	0.0	2.1	0.0	2.9	1.3	1.2	11.3	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.8	0.8	11.3	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.9	0.9	11.3	0.3
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.6	1.6	10.4	0.0
Mar	0.7	2.5	0.0	2.3	0.0	2.9	3.4	3.2	10.1	0.0
Apr	0.6	3.0	0.0	2.4	0.0	3.0	5.4	5.1	7.9	0.0
May	0.8	4.0	6.0	3.2	4.8	8.8	7.4	6.2	10.5	0.0
Jun	0.7	1.0	8.0	0.7	5.6	7.0	6.6	6.3	11.1	0.0
Jul	0.2	1.0	9.0	0.7	6.3	7.2	8.1	8.0	10.2	0.0
Aug	0.2	1.0	3.0	0.7	2.1	3.0	7.7	7.3	6.0	0.0
Sep	0.4	1.5	0.0	1.2	0.0	1.6	0.8	0.6	7.0	0.0
Oct	0.7	3.0	0.0	2.7	0.0	3.4	0.8	0.6	9.7	0.0
Total	8.3	19.3	26.0	15.9	18.8	43.0	44.7	41.9		1.0

Leaching Fraction[11]	1.8%
Leaching Requirement[12]	9.8%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: 13 **Acres:** 128 **Soil Water Content at Field Capacity**[7]**:** 6.3

Crop: Alfalfa **Rooting Depth**[3] **(approximate):** 60 **Initial Soil Water Content**[8]**:** 5.4

Month	**Precip**[1]	**Gross Irrigation**[2]		**Net Irrigation**[4]		**Total Input**[5]	**Evapotranspiration**[6]		**Soil Water Content**[9]	**Percolate Loss**[10]
		Process	**Fresh**	**Process**	**Fresh**		**Potential**	**Estimate**		
		inches								
Nov	0.8	1.5	0.0	1.4	0.0	2.2	1.3	1.2	6.3	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.8	0.8	6.3	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.9	0.9	6.3	0.3
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.6	1.6	5.5	0.0
Mar	0.7	2.5	0.0	2.3	0.0	2.9	3.4	3.1	5.2	0.0
Apr	0.6	4.0	2.0	3.2	1.6	5.4	5.4	5.0	5.7	0.0
May	0.8	6.1	3.0	4.9	2.4	8.0	7.4	7.0	6.3	0.3
Jun	0.7	5.4	5.0	3.8	3.5	7.9	9.0	9.0	5.3	0.0
Jul	0.2	4.8	6.0	3.4	4.2	7.8	10.2	9.4	3.7	0.0
Aug	0.2	5.0	2.9	3.5	2.0	5.8	8.3	6.3	3.1	0.0
Sep	0.4	5.9	0.0	4.7	0.0	5.1	5.1	3.6	4.6	0.0
Oct	0.7	3.0	0.0	2.7	0.0	3.3	2.9	2.5	5.5	0.0
Total	8.3	38.2	18.9	29.7	13.7	51.7	56.4	50.3		1.3

Leaching Fraction[11]	2.0%
Leaching Requirement[12]	10.7%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **15** **Acres:** 128 **Soil Water Content at Field Capacity**[7]**:** 9.6

Crop: Alfalfa **Rooting Depth**[3] **(approximate):** 60 **Initial Soil Water Content**[8]**:** 8.1

Month	Precip[1]	Gross Irrigation[2]		Net Irrigation[4]		Total Input[5]	Evapotranspiration[6]		Soil Water Content[9]	Percolate Loss[10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.8	2.0	0.0	1.8	0.0	2.6	1.3	1.2	9.6	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.8	0.8	9.6	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.9	0.9	9.6	0.3
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.6	1.6	8.7	0.0
Mar	0.7	2.5	0.0	2.3	0.0	2.9	3.4	3.2	8.4	0.0
Apr	0.6	4.0	1.0	3.2	0.8	4.6	5.4	5.1	7.9	0.0
May	0.8	6.1	1.0	4.9	0.8	6.4	7.4	6.7	7.6	0.0
Jun	0.7	5.4	4.0	3.8	2.8	7.2	9.0	8.0	6.8	0.0
Jul	0.2	4.8	6.0	3.4	4.2	7.8	10.2	8.6	5.9	0.0
Aug	0.2	5.0	2.0	3.5	1.4	5.1	8.3	6.5	4.5	0.0
Sep	0.4	5.9	0.0	4.7	0.0	5.1	5.1	3.5	6.1	0.0
Oct	0.7	4.3	0.0	3.8	0.0	4.5	2.9	2.3	8.2	0.0
Total	8.3	39.9	14.0	31.3	10.0	49.5	56.4	48.5		0.9

Leaching Fraction[11]	1.5%
Leaching Requirement[12]	10.7%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: V16 **Acres:** 70 **Soil Water Content at Field Capacity** [7]**:** 6.5

Crop: Alfalfa **Rooting Depth** [3] **(approximate):** 60 **Initial Soil Water Content** [8]**:** 5.5

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.8	0.7	0.8	0.6	0.7	2.2	1.3	1.2	6.5	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.8	0.8	6.5	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.9	0.9	6.5	0.3
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.6	1.6	5.6	0.0
Mar	0.7	2.5	0.8	2.3	0.7	3.7	3.4	3.1	6.1	0.0
Apr	0.6	4.0	0.8	3.2	0.6	4.4	5.4	5.3	5.2	0.0
May	0.8	6.1	0.8	4.9	0.7	6.3	7.4	6.7	4.9	0.0
Jun	0.7	5.4	6.0	3.8	4.2	8.6	9.0	7.8	5.7	0.0
Jul	0.2	4.8	7.0	3.4	4.9	8.5	10.2	9.6	4.6	0.0
Aug	0.2	5.0	2.8	3.5	2.0	5.7	8.3	7.0	3.3	0.0
Sep	0.4	5.9	0.8	4.7	0.7	5.7	5.1	3.6	5.4	0.0
Oct	0.7	1.6	0.8	1.4	0.7	2.8	2.9	2.7	5.5	0.0
Total	8.3	36.0	20.7	27.7	15.2	51.2	56.4	50.2		1.0

Leaching Fraction [11]	1.5%
Leaching Requirement [12]	8.4%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: V17 **Acres:** 169 **Soil Water Content at Field Capacity**[7]**:** 8.5

Crop: Triticale / Corn **Rooting Depth**[3] **(approximate):** 60 **Initial Soil Water Content**[8]**:** 7.3

Month	**Precip**[1]	**Gross Irrigation**[2]		**Net Irrigation**[4]		**Total Input**[5]	**Evapotranspiration**[6]		**Soil Water Content**[9]	**Percolate Loss**[10]
		Process	**Fresh**	**Process**	**Fresh**		**Potential**	**Estimate**		
		inches								
Nov	0.8	0.7	0.8	0.6	0.7	2.2	1.0	0.9	8.5	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.6	0.6	8.5	0.8
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.7	0.7	8.5	0.6
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.1	1.1	8.1	0.0
Mar	0.7	1.7	0.8	1.5	0.7	2.9	2.6	2.5	8.5	0.0
Apr	0.6	2.3	1.0	1.8	0.8	3.2	4.1	4.1	7.6	0.0
May	0.8	3.3	1.0	2.6	0.8	4.2	5.6	5.3	6.5	0.0
Jun	0.7	0.9	7.0	0.6	4.9	6.2	5.5	4.8	8.0	0.0
Jul	0.2	5.1	3.9	3.6	2.7	6.5	8.1	7.8	6.6	0.0
Aug	0.2	6.3	0.8	4.4	0.6	5.2	7.7	6.8	5.1	0.0
Sep	0.4	1.5	0.8	1.2	0.6	2.2	0.8	0.6	6.6	0.0
Oct	0.7	0.0	0.8	0.0	0.7	1.4	0.8	0.7	7.3	0.0
Total	8.3	21.8	17.0	16.4	12.6	37.3	38.4	35.8		1.5

Leaching Fraction[11]	3.1%
Leaching Requirement[12]	7.4%

NOTES:

Circle V17 includes circle 17 plus little circle 17.

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **V18** **Acres:** 164 **Soil Water Content at Field Capacity** [7]**:** 6.9

Crop: Alfalfa / Corn **Rooting Depth** [3] **(approximate):** 60 **Initial Soil Water Content** [8]**:** 5.9

Month	**Precip** [1]	**Gross Irrigation** [2]		**Net Irrigation** [4]		**Total Input** [5]	**Evapotranspiration** [6]		**Soil Water Content** [9]	**Percolate Loss** [10]
		Process	**Fresh**	**Process**	**Fresh**		**Potential**	**Estimate**		
		inches								
Nov	0.8	0.8	0.8	0.7	0.7	2.3	1.3	1.2	6.9	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.8	0.8	6.9	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.9	0.9	6.9	0.3
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.6	1.6	6.0	0.0
Mar	0.7	2.5	0.8	2.3	0.7	3.7	3.4	3.2	6.5	0.0
Apr	0.6	3.0	2.0	2.4	1.6	4.6	5.4	5.3	5.8	0.0
May	0.8	4.0	4.0	3.2	3.2	7.2	7.4	6.8	6.2	0.0
Jun	0.7	1.0	6.0	0.7	4.2	5.6	6.6	6.2	5.5	0.0
Jul	0.2	1.0	7.0	0.7	4.9	5.8	8.1	7.2	4.0	0.0
Aug	0.2	1.0	6.4	0.7	4.5	5.4	7.7	5.9	3.6	0.0
Sep	0.4	1.5	0.8	1.2	0.6	2.2	0.8	0.6	5.2	0.0
Oct	0.7	0.0	0.8	0.0	0.7	1.4	0.8	0.7	5.9	0.0
Total	8.3	14.8	28.6	11.9	21.2	41.3	44.7	40.3		1.0

Leaching Fraction [11]	1.9%
Leaching Requirement [12]	5.9%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix E1. Circle-Specific Monthly Soil Hydraulic Budget

Circle: **B19** **Acres:** 111 **Soil Water Content at Field Capacity [7]:** 8.1

Crop: Alfalfa **Rooting Depth [3] (approximate):** 60 **Initial Soil Water Content [8]:** 6.9

Month	Precip [1]	Gross Irrigation [2]		Net Irrigation [4]		Total Input [5]	Evapotranspiration [6]		Soil Water Content [9]	Percolate Loss [10]
		Process	Fresh	Process	Fresh		Potential	Estimate		
		inches								
Nov	0.8	1.8	0.0	1.6	0.0	2.5	1.3	1.2	8.1	0.0
Dec	1.4	0.0	0.0	0.0	0.0	1.4	0.8	0.8	8.1	0.6
Jan	1.2	0.0	0.0	0.0	0.0	1.2	0.9	0.9	8.1	0.3
Feb	0.7	0.0	0.0	0.0	0.0	0.7	1.6	1.6	7.2	0.0
Mar	0.7	3.0	0.0	2.7	0.0	3.4	3.4	3.2	7.4	0.0
Apr	0.6	5.0	0.0	4.0	0.0	4.6	5.4	5.2	6.7	0.0
May	0.8	8.0	0.0	6.4	0.0	7.2	7.4	6.8	7.1	0.0
Jun	0.7	10.0	0.0	7.0	0.0	7.7	9.0	8.4	6.3	0.0
Jul	0.2	10.0	0.0	7.0	0.0	7.2	10.2	9.1	4.4	0.0
Aug	0.2	10.0	0.0	7.0	0.0	7.2	8.3	6.2	5.5	0.0
Sep	0.4	5.0	0.0	4.0	0.0	4.4	5.1	4.2	5.7	0.0
Oct	0.7	3.4	0.0	3.1	0.0	3.7	2.9	2.5	6.9	0.0
Total	8.3	56.2	0.0	42.8	0.0	51.0	56.4	50.0		1.0

Leaching Fraction [11]	1.5%
Leaching Requirement [12]	11.3%

NOTES:

Abbreviation: Precip = precipitation.

All weather data obtained from the Washington State University AgWeatherNet CBC Pasco weather station in Pasco, Washington (Washington State University, n.d.).

1 Precipitation is the normalized 10-year return values.

2 Gross Irrigation is inches of process and fresh water delivered at sprinkler heads.

3 Assumed minimum rooting depth from which soil water would be utilized during the crop rotational sequence.

4 Net irrigation = gross irrigation × irrigation efficiency (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

5 Total input = net process water + net fresh water + precipitation (assumes: 90% for November through March, 80% for April through May, 70% for June through August, 80% for September, and 90% for October).

6 Potential evapotranspiration is the average of available data from 1995-2016.
Estimated evapotranspiration = potential evapotranspiration × (previous month's soil water content ÷ soil water content at field capacity)$^{1/2}$.

7 Total soil water content at field capacity is based on the acreage-weighted average available water capacity plus the acreage-weighted estimate of the water content at permanent wilting point for the assumed rooting depth as determined using the Soil-Plant-Air-Water model (Saxton, K., Rawls, W., Ronberger, J., & and Papenlick, R., 2009).

8 Initial soil water content estimated at 90% of the total soil water holding capacity at field capacity.

9 Soil water content predicted = previous month's soil water content + total input - evapotranspiration estimate. Cannot exceed soil water content at field capacity.

10 Percolate loss estimate: soil water in excess of the soil water content at field capacity which percolates (drains) out of the root zone.
Percolate loss estimate = previous month's soil water content + total water input - evapotranspiration estimate - current month's soil water content.

11 Leaching Fraction = percent of gross input estimated to percolate beyond root zone (total percolate loss ÷ [precipitation + gross irrigation]).

12 Leaching Requirement = percolate loss as a percentage of gross input required to manage soil salts to levels that do not impede crop productivity.

Appendix F

Preliminary Evoqua Pretreatment Design Documentation

BURNHAM

Burnham RNG
1201 Wilson Blvd, 27th Floor
Arlington, VA 22209

July 14, 2022

Dan Mahlum
Director
RH2 Engineering, Inc.

Re: Preliminary Design Documentation for Wastewater Processing, Pasco PWRF, Pasco, WA Project

Dear Dan,

Per your request of the design documentation for the PWRF facility in Pasco, please find the attached preliminary design documentation to satisfy the Engineering Report requirement of the WAC.

If you need more information, I can be reached by email at mike@burnhamdev.com or by phone at 336-501-8860.

Sincerely,

Mike Carter

Mike Carter
VP, Engineering and Operations

ADI Systems
evoqua

July 13, 2022

Chris Tynan
Founder & CEO
Burnham
chris@burnhamdev.com

RE: Design Document for Pasco PWRF, Pasco, WA Project

Dear Chris:

Please find attached Evoqua's design document for the Pasco PWRF project. This document includes updated preliminary process flow diagrams and site layout drawings, as well as basis of design and unit process sizing calculations.

Yours very truly,

Shannon Grant

Shannon R. Grant, MScE, MBA, P.Eng.
Director of Business Development
Evoqua Water Technologies Canada Ltd.
(O): 1 (506) 452-7259
(C): 1 (506) 447-9487
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ADI-BVF® AND SBR WASTEWATER TREATMENT SYSTEM PROCESS DESIGN MANUAL

FOR: PASCO PWRF (PROCESS WATER FACILITY FOR RNG FOOD WASTE), PASCO, WA

Project: 6069000103

Revision: 02

Date: July 13, 2022

Evoqua Water Technologies Canada Ltd., 370 Wilsey Road, Fredericton, New Brunswick E3B 6E9 Canada
1 (800) 561-2831 (toll-free) (506) 452-7307 (toll)   www.evoqua.com

This design manual was prepared by Evoqua Water Technologies Canada Ltd. for Pasco PWRF

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ABBREVIATIONS

‘	Feet	MLSS	Mixed Liquor Suspended Solids
“	Inches	MLVSS	Mixed Liquor Volatile Suspended Solids
Ø	Diameter	MMBtu	Million British Thermal Units
Amp	Amperage	OLR	Organic Loading Rate
AOR	Actual Oxygen Requirement	PFD	Process Flow Diagram
BOD	Biochemical Oxygen Demand	P&ID	Process and Instrumentation Diagram
Cfm	Cubic Feet per Minute	PC	Process Control
COD	Chemical Oxygen Demand	PDM	Process Design Manual
DC	Direct Current	PLC	Programmable Logic Controller
DO	Dissolved Oxygen	PVC	Polyvinyl Chloride
EMT	Electrical Metallic Tubing	RANS	Return Anaerobic Sludge
EOF	Emergency overflow	SBR	Sequencing Batch Reactor
EQ	Equalization	SMT	Sediment/Moisture Trap
°F	Degrees Fahrenheit	SREC	Supernatant Recycle
FIT	Flow Indicating Transmitter	SRT	Solids Retention Time
F:M	Food to Microorganism Ratio	SS	Stainless Steel
FOG	Fat, Oil, and Grease	STP	Standard Temperature and Pressure
FVNR	Full Voltage - Non Reversing	STSTR	Soft Starter
Gal	Gallons	TEFC	Totally Enclosed Fan Cooled
Gpd	Gallons per day	TKN	Total Kjeldahl Nitrogen
Gpm	Gallons per minute	TN	Total Nitrogen
H	Hour	TOW	Top of Wall
HDPE	High Density Polyethylene	TP	Total Phosphorus
HGL	Hydraulic Grade Lines	TS	Total Solids
HMI	Human Machine Interface	TSS	Total Suspended Solids
HRT	Hydraulic Retention Time	V	Volts
LIT	Level Indicating Transmitter	VAC	Voltage Alternating Current
LWL	Low Water Level	VFD	Variable frequency drive
MCC	Motor Control Center	VSS	Volatile Suspended Solids
mg/l	Milligrams per Liter	WANS	Waste Anaerobic Sludge
MG	Million Gallons	WAS	Waste Activated Sludge
MGD	Million Gallons per Day	WC	Water Column
Min	Minute	WWTP	Wastewater Treatment Plant

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Evoqua Quality System Checks			
Project No.:	6069000103	Date:	July 13, 2022
Issue Status:	DRAFT	Revision No.:	02
Prepared By:	Scarlett Zelaya		
Reviewed By:	Daniel Bertoldo Shannon Grant Troy Dorcas Jamie Killam		

1 INTRODUCTION

This process design manual (PDM) has been prepared for the PWRF (Process Water Facility for RNG Food Waste) in Pasco, WA.

The wastewater treatment system consists of a 1.5 MG EQ tank, two 34.5 MG low-rate, anaerobic, Type L ADI-BVF® reactors, and two 2.0 MG SBR tanks and is designed to treat the combined industrial wastewater.

1.1 Objectives of the Process Design Manual

The primary objective of the process design manual is to allow the process designers to communicate the following information to the detailed design team, customer, and governing authorities:

- Overall process description/review and battery limits.
- Detailed unit-by-unit review of the treatment process (i.e., design criteria, how each unit is to be operated, interrelationship between units).
- Wastewater/sludge/effluent quantities (minimum, average and peak) and characteristics.
- Projected biogas generation rate and biogas system components.
- Instrumentation required (flow meters, level transmitters, pressure transmitters, etc.).
- Process controls.
- Details on equipment.
- Unique features of the system.

1.2 Using the Process Design Manual

The PDM represents the process engineer's concept of how the treatment plant (and its individual components) operates. The information presented in the PDM is not "irrevocable" and is subject to review during the detailed design phase.

2 PLANT HYDRAULICS AND PIPING

2.1 Hydraulic

The hydraulic grade lines (HGLs) for all gravity flows and pumped waste streams within the treatment plant, including any bypass system, should be prepared to ensure that adequate provision has been made for all flow situations and head losses, etc. A drawing showing the HGL at maximum flow is recommended. In calculating the HGLs, changes in head caused by all factors should be considered, including the following:

1) Head losses due to channel and pipe wall friction with allowance for sludge friction factors where necessary
2) Head losses due to sudden enlargement or sudden contraction in flow cross-section.
3) Head losses due to sudden changes in direction such as at bends, elbows, Y-branches, and tees
4) Head losses due to sudden changes in slopes, or drops
5) Head losses due to obstruction in conduit
6) Head required to allow flow over weirs, orifices and other measuring, controlling, or flow division devices
7) Head losses caused by flow through screens, tankage, filters, and other treatment units when applicable
8) Head losses caused by gas entrainment or gas binding (take care to prevent/overcome gas locks in lines carrying anaerobic fluid)
9) Head losses incurred due to flow splitting along the side of a channel or conduit.
10) Head increases caused by pumping
11) Head allowances for expansion requirements and/or process changes
12) Head allowances due to maximum water levels in tanks/sumps/etc

Designers are cautioned to consider the consequences of excessive or inadequate allowances for head losses through wastewater treatment works. If pumping is required, excessive head loss allowances result in energy wastage. If inadequate head loss allowances are made, operation will be difficult.

2.2 Piping

All piping used in this treatment plant should be manufactured in accordance with applicable standards. In the general piping arrangement, sufficient space should be provided for piping to be removed, and the pipe design should provide for the proper isolation of pipe sections through valves to enable them to be repaired or replaced.

The designer should allow for the possibility that piping could be installed when temperature conditions are different from the design conditions, and substantial differences in pipe lengths could occur. Where pipe is cast-in-place, due allowance should be made for differential expansion between the pipe material and structures. The piping designer must check with the geotechnical engineer for final settlement estimates.

Piping should be arranged so that all valves and other items which may require regular inspection or maintenance are conveniently accessible. All liquid piping should be provided with drains at low points and air release valves at all high points.

The design of the piping should allow for proper restraint under all anticipated conditions, particularly where surges may occur and high transient pressure could result, or where different temperatures occur seasonally.

Where piping connections are made between adjacent structures, at least one flexible coupling should be provided if there is any possibility that differential settlement may occur. Particular attention should be given to pipe bedding in areas adjacent to structures to avoid settlement damage.

In sizing and selecting the material and pressure requirements of piping for use here, the following factors must be considered:

- Likelihood of blockage and size of line required
- Line size required to produce scouring velocities (3 ft/s and higher) and thus minimize solids deposition
- Nature and temperature of material to be conveyed and suitable piping materials for the application
- Flow characteristics of material to be conveyed and head requirements of pumps, or differential head required for gravity flow
- Possible settlement and need for support
- Need for future repair
- Need for future removal of pipe sections

2.3 Emergency Overflows

The EOF is to protect the basin contents from spilling over the top of the tank wall and potentially damaging the cover of the tank.

Emergency overflows (EOF) are required:

- EOF for the covered EQ tank
- EOF for the SBR System

3 DESIGN WASTEWATER CHARACTERISTICS AND EFFLUENT OBJECTIVES

The design raw wastewater, ADI-BVF® effluent, and SBR effluent characteristics provided to Evoqua are listed in Table 3.1.

Table 3.1 - Design Raw Wastewater, ADI-BVF® Effluent, and SBR Effluent Characteristics

Parameter	Raw Wastewater	ADI-BVF® Reactor Effluent	SBR Effluent
Avg.Annual Day Design Flow (mgd)	4.38	4.38	4
Max. Month Day Flow (gpd)	8.56	8.56	---
COD, AVG (mg/l)*	7,180	720	<200
COD, Daily AVG. Load (lb/d)*	262,070	26,200	<6,670
COD, Daily Month Load (lb/d)*	600,000	60,000	---
BOD, AVG (mg/l)	3,590	360	<100
BOD, Daily AVG. Load (lb/d)	131,035	13,100	<3,340
BOD, Max. Month Load (lb/d)	300,000	30,000	---
TSS, AVG (mg/l)	2,140	460	<100
TSS, AVG. Load (lb/d)	78,170	16,070	<3,340
TSS, Max Month Load (lb/d)	227,885	41,680	---
TN, AVG (mg/l)	114	100	28**
TN, Daily AVG. Load (lb/d)	4,170	3,650	<900
TN, Max. Month Load (lb/d)	8,140	7,140	---
pH (s.u.)	---	6.5-7.5	6-9
Temperature (°F)	74*	85-98	---

*Assumed

** BVF reactor effluent flows >4 MGD to bypass SBR to storage laggons

3.1 System Components

The design of the anaerobic and aerobic wastewater treatment system for Pasco PWRF shall consist of the following major components:

1. Raw wastewater station complete with:
   - Three raw wastewater pumps (3 @ 4,600 gpm) with VFDs
   - Instrumentation

2. Three rotary drums screen (perforation of $^1/_4$")

3. One vortex grit system

4. One 1.5 MG covered bolted steel EQ tank complete with:
   - Fixed cover.
   - Three side entry mixers (3 @ 30 hp)
   - Three EQ pumps (3 @ 4,600 gpm) with VFDs
   - EQ tank odor control system
     - Offgas fan
     - Biofilter with hardwood chip media
     - Offgas piping

5. Two 34.5 MG in-ground Type 'L' ADI-BVF reactors, each complete with:
   - Floating, flexible, insulated geomembrane cover system
   - Two mixers (2 @ 6 hp)
   - Two recycle pumps (2 @ 1,900 gpm) with VFDs
   - Three BVF reactor effluent pumps (3 @ 4,340 gpm) with VFDs
   - Sludge loadout connection.
   - Heat exchanger and heat loop pump
   - One 700 hp boiler for heat addition on the recycle line

6. One 10,000 gal $Mg(OH)_2$ tank complete with:
   - Two metering pumps
   - One mixer
   - Instrumentation and controls

7. Biogas collection, transmission, and flare system complete with:
   - Emergency vents
   - Five biogas blowers (5 @ 1,070 scfm, four duty, one standby) with VFDs
   - Two enclosed flares with dedicated control panels

- Instrumentation and controls

8. SBR system complete with:
- Two 2.0 MG SBR concrete basins
- SBR internal influent distribution piping.
- Automatic influent flow control valves (1 per basin, 2 total)
- Floating mixers (75 hp each) in the SBR basins (one per basin, two total)
- Fine bubble diffused aeration systems complete with aeration manifold piping, air diffusers, and four aeration blowers total (250 hp per blower)
- Decanters (one per basin, 2 total)
- SBR internal waste activated sludge (WAS) withdrawal piping and automatic WAS flow control valves (one per basin, 2 total) and WAS pumps (2 @ 800 gpm)
- Instrumentation, including level and DO/temperature transmitters
- Automatic effluent flow control valves (1 per basin, 2 total)
- Effluent flow meter (one common to all SBR basins)
- Effluent discharge piping

4 PHYSICAL ASPECTS AND CONTROL OF THE WASTEWATER TREATMENT SYSTEM

4.1 Raw Wastewater Lift Station

The raw wastewater will be collected and pumped (by others) to the raw wastewater (RWW) lift station. The preliminary dimensions of the raw wastewater station are 15' ∅ x 15' TH. The pump station will be an in-ground, round concrete wet well.

A level transmitter will continuously monitor the liquid level in the RWW pump station. The level transmitter will be used to control the operation of the RWW pumps and will be trended on the HMI. Alarms will be implemented for high-high, high, and low-low conditions.

4.1.1 Raw Wastewater (RWW) Pumps

Three RWW submersible pumps, each with a capacity of 4,600 gpm will be used to pump the raw wastewater to the rotary screens for solids removal. The pumps will be configured in a two duty/one standby arrangement; designations will alternate after a fixed time period. Each RWW pump will be equipped with a VFD. The VFDs are required for these pumps such that they stay on their pump curve through the expected operating level changes (indicated by the raw wastewater level transmitter) in the RWW station.

At the HMI, the operator will enter the following setpoints:
- RWW lift station low level
- RWW lift station high level
- RWW lift station max level

4.2 Raw Wastewater Rotary Drum Screens

The raw wastewater will be pumped to the rotary screens before delivery to the EQ tank. The raw wastewater enters a headbox where the energy is dissipated, and the flow is evenly distributed onto the interior of the rotary screening drum (two duty and one standby) capable of handling a peak flow of 4,600 gpm. Solids particles (> ¼") are retained on the screen surface while the liquid flows radially out through the screen openings. Screened solids are transported axially, by internal flights, to the open end of the rotary drum screen. The entire screening surface is intermittently washed by a fixed external spray bar. The rotary drum screens use clean water for screen washing via a solenoid valve. Screened solids will be transferred and collected in a storage bin for final disposal.

4.3 Grit Vortex System

The screened raw wastewater will be delivered to a grit vortex system for grit removal. The raw wastewater is introduced into the grit system via a tangentially positioned inlet, causing a rotational flow path around the dip plate. The flow spirals down the wall of the chamber as solids settle out by gravitational forces and forces created by the rotating flow. The grit collects in the grit pot as the center cone directs flow away from the base, up and around the center shaft into the inside of the dip plate. The upward flow rotates at a slower velocity than the outer downward flow. The resulting "shear" zone scrubs out the finer particles. The concentrated grit underflow is discharged to a grit bin for disposal (by others).

4.4 Equalization (EQ) Tank

The wastewater will flow by gravity to the EQ tank. The EQ tank (preliminary dimensions of 93'Ø x 32' TOW, 30' maximum liquid depth, 1.5 MG liquid volume, aluminum dome roof). The EQ tank will attenuate changes in process wastewater flow, organic strength, alkalinity, pH, temperature, etc. prior to the biological treatment process. At design flow conditions, the covered EQ tank will provide approximately 8 hours of hydraulic retention time (HRT). The contents of the influent EQ tank will be pumped to either the anaerobic ADI-BVF® reactors (via the reactor feed pumps), the SBR tanks (via the bypass pumps) or the effluent structure (via the RWW bypass line).

4.4.1 EQ Tank Mixing

The EQ tank mixing is accomplished with three side-entry mechanical mixers operated by the soft starters. Each mixer will be equipped with a 30 hp motor. The mixers will operate using an operator-adjustable repeating cycle timer. The operation of the mixers will be interlocked with the EQ tank level transmitter reading; the mixers will not be permitted to operate if the low-low EQ tank level alarm is active.

4.4.2 EQ Tank Level

A pressure-transducer type level transmitter will be used to continuously measure the liquid level in the EQ tank. EQ Tank level will be trended at the HMI. Level alarm setpoints will be entered for high-high, high, low, and low-low levels.

A loadout connection (quick-connect with isolation valve) will be installed close to the EQ tank floor in order to discharge the contents of the EQ tank to a tanker truck for disposal.

4.4.3 EQ Tank Headspace Ventilation

The EQ tank odor control system consists of a fan (with suction-side piped to the headspace of the EQ tank and discharge side piped to distribution piping in the base of the biofilter) and a biofilter. The fan operates continuously and will transmit EQ tank headspace gas into the base of a biofilter. As the headspace gas rises through the biofilter, the odor is absorbed by the media.

The biofilter will consist of a partially buried concrete perimeter wall, limestone base, gas distribution piping, geotextile, a top layer of hardwood chip media to neutralize odors in the gas, and an automatic water spray system used to prevent the media from drying out during the summer.

4.4.4 Influent Pumps

The three influent pumps, each with a capacity of 4,600 gpm, convey screened, grit removal, and equalized wastewater from the EQ tank to either the anaerobic ADI-BVF® reactors, the SBR tanks (via the bypass line), or the storage lagoons (via the RWW bypass line).

The flow meter signals are used to control the speed of the variable-speed EQ pumps in order to maintain the BVF reactors, BVF bypass, and RWW bypass flow rate setpoints (operator-adjustable). The EQ pumps operate in a lead/lag configuration; lead and lag designations alternate with each pumping cycle. The operation of the EQ pumps will be interlocked with the influent level transmitter reading; the influent pumps will not be permitted to operate if the low-low influent level alarm is active.

At the HMI, the operator will enter the following setpoints for each day of the week:
- EQ tank target level
- EQ tank high level
- EQ tank max level
- Normal flow rate
- Max flow rate

When the EQ tank level reaches the high level, the lead influent pumps will be called to operate. The pump VFD will modulate the pump speed in order to maintain the normal flow rate, as measured by the flow meter. When the EQ tank level reaches the target level, the lead influent pumps will stop. In the event that EQ tank level reaches the max level, the lead influent pumps VFD will modulate the pumps speed in order to maintain the max flow rate, as measured by the flow meters. The max flow rate will be targeted by the lead influent pump until the target EQ tank level has been reached, at which point the reactor feed pumps will stop.

4.4.5 BVF Bypass Line to SBRs

Some influent wastewater (i.e., 1 to 10 percent; average of 5 percent of total flow) will be bypassed to the aerobic SBR system as carbon source to facilitate nitrogen removal.

A BVF bypass flow meter and modulating control valve is located on the influent pumps' forcemain directing wastewater to the SBR tanks. The instantaneous flow meter reading should be trended at the HMI. Totalized daily flow for the previous 7 days should be displayed at the HMI. Totalized daily flows for the current day and previous 7 days will be displayed at the HMI.

The signal from the bypass flow meter is used to control the automatic, modulating bypass control valve in order to maintain the bypass flow rate setpoint (operator-adjustable) during the SBR feed event time (operator-adjustable) in the cycle.

4.4.6 Raw Wastewater (RWW) Bypass Line to Effluent Structure

A raw wastewater bypass line to the effluent structure is provided to allow flow of wastewater to go direct to the storage lagoons, if and when necessary. This would only be used on very high peak day flow conditions when an operator deems it necessary.

A RWW bypass flow meter and modulating control valve is located on the influent pumps' forcemain directing wastewater to the storage lagoons. The instantaneous flow meter reading should be trended at the HMI. Totalized daily flow for the previous 7 days should be displayed at the HMI. Totalized daily flows for the current day and previous 7 days will be displayed at the HMI.

The signal from the bypass flow meter is used to control the automatic, modulating bypass control valve in order to maintain the raw bypass flow rate setpoint (operator-adjustable).

4.4.7 Influent Sampler

An automatic influent sampling system is to be located on the common forcemain from the influent pumps. The flow-paced composite sampler is installed to collect flow-proportioned composite raw wastewater samples. The automatic sampler is to be controlled by a signal from the PLC based on measured flow (automatic sampler works in conjunction with the influent flow meters).

The PLC will signal an air actuated solenoid valve, connected to the pressurized influent forcemain, to collect flow-paced samples of raw wastewater. A sample line will flow to a container for sample collection located inside a small refrigerated unit. The sample line from the forcemain to the container should be as short as possible, and flow downward to the container.

The operator should be able to adjust how frequently an automatic sample is taken by adjusting the volumetric flow interval on the HMI.

4.5 Magnesium Hydroxide Metering System

The magnesium hydroxide (MagOx) dosing station serves to supply MagOx (i.e., supplemental alkalinity) to the BVF reactors. The MagOx dosing station consists of injection quills to the influent piping for each BVF reactor, a chemical storage tank (10,000 gal), two dosing pumps, pump flow and back-pressure calibration equipment, and water backflush ports.

The operator may set the dosing pump in Program mode, where the pump operates on an operator-adjustable cycle timer at an operator-adjustable pump speed. Alternatively, the operator may operate the chemical dosing pump in Operator mode at an operator-adjustable pump speed.

At design conditions, 207 gpd of 60% MagOx is required to satisfy the supplemental alkalinity requirements for the biomass in the BVF reactors. The alkalinity dosing pumps should be sized for 500 gpd (to account for a safety factor).

The 10,000 gal, FRP, well-mixed MagOx storage tank consists of a truck loadout connection, a top-mounted mixer (7.5 hp with VFD), and a top-down LIT:

- The truck loadout connection may be used to pump a truckload of MagOx into the tank, as necessary.
- The level transmitter will monitor the MagOx tank Low-Low, Low, High, and High-High alarms and level setpoints. The level transmitter readings are displayed and trended at the HMI, and alarms will register at the HMI.
- The mixer is used to continuously mix the contents of the MagOx tank (to prevent settling and hardening of the MagOx). The operator may operator it on an operator-adjustable cycle timer.

Note: On a regular basis, operators should use the water backflush ports to keep the MagOx dosing system piping clean.

4.6 The ADI-BVF® Reactors

The ADI-BVF® anaerobic reactors are designed to biologically digest the organic load in the wastewater in the absence of oxygen. A long solids retention time (SRT) allows a large mass of slow-growing anaerobic microorganisms to be held in the reactor. Effective contact between the bios and the organic matter in the wastewater is achieved with the design of the influent distribution system and recycle flows.

Two 34.5 MG type ‘L’ ADI-BVF® reactors (with interior dimensions of’ 602 x’ 301’ x 32’ TOW, 30’ LD) will anaerobically digest solids and organic matter in the wastewater and convert the organics to biogas. The design criteria for the BVF reactors are presented in Table 4.1. Influent flows and concentrations in Table 4.1 are from PWRF design basis tables. To accommodate switching the type of wastewater a reactor receives, both reactors shall have the same design and be able to handle the design conditions herein. Further BVF reactor process design and sizing calculations are provided in Section 8.

Table 4.1 - Design Criteria for ADI-BVF® Reactors

Parameter	Design Conditions
Number of BVF Reactors	2
Total reactive volume per reactor (MG)	34.5
Avg. Annual Day Design Flow (mgd)	4.38
Max. Month Day Flow (mgd)	8.56
COD, Avg. (mg/l)*	7,180
COD, Daily Avg.. Load (lb/d)*	262,070
COD, Load Max. Month (lb/d)*	600,000
BOD, AVG (mg/l)	3,590
BOD, Daily Avg. Load (lb/d)	131,035
BOD, Load Max. Month (lb/d)	300,000
TSS, AVG (mg/l)	2,140
TSS, Avg. Load (lb/d)	78,170
TN, Avg. (mg/l)	114
TN, Daily Avg. Load (lb/d)	4,170
TN, Load Max. Month (lb/d)	8,140
Operating pH (s.u.)	6.5-7.5
Temperature (ºF)	85-98
Avg. HRT (days)	15.8
Max. Month HRT(days)	8.1

Parameter	Design Conditions
AVG. Organic Loading Rate (kg/COD/$m^3 \cdot d$)	0.5
Max Month Organic Loading Rate (kg/COD/$m^3 \cdot d$)	1.04
WANS (lb/d)**	21,390
WANS (MG/y)***	23.4
Biogas Flow, Annual Avg. (ft^3/d)	1,830,000
Biogas Flow, Month Peak (ft^3/d)	4,190,000

*Assumed
**Dry weight basis, consisting of anaerobic biosolids and undigested raw wastewater TSS and WAS
*** Assumed wasted at 4 percent solids concentration

4.6.1 BVF Reactor Recycle Pumps

4.6.1.1 Supernatant Recycle Pump (SREC)

A supernatant recycle (SREC) system, with one SREC pump (1,900 gpm) and the SREC piping, serves to recycle digester supernatant from near the top of the reactor (through a single draw-off point) back into the influent line and into the sludge bed. Recycle provides attenuation of any shock loadings, pH and temperature swings and provides better bios/substrate contact. The supernatant collection point will be approximately 3’ below the normal operating level (NOL), located close to the influent end and within the influent lateral zone.

An in-line flow meter will be installed on the discharge of the SREC pump to monitor the SREC flow rate. Instantaneous and totalized daily flow rates will be displayed and trended at the HMI.

4.6.1.2 Return Anaerobic Sludge (RANS) Pump

A return anaerobic sludge (RANS) system with one RANS pump (1,900 gpm) and RANS piping, consisting of laterals on the bottom of the reactor at the effluent end, is used to recycle settled anaerobic sludge from the back half of the reactor into the influent distribution system. The RANS system serves to improve biomass-substrate contact and ensure that a sludge bed is maintained over the entire influent distribution system. RANS lines can also be used to waste excess reactor sludge (WANS) via sludge loadout connection for off-site disposal.

RANS laterals in the effluent end of the reactor are to be installed on the reactor floor, each complete with vented (under cover) cleanouts on both ends. Outside the reactor, each RANS lateral will have a plug valve to isolate and alternate the RANS lateral(s) in service. The plug valves should be easily accessible using a valve operator. The RANS lines will converge downstream of the manual valves.

A gas elimination chamber (GEC) will be installed on the common RANS line on the suction side of the RANS pump. The GEC is a fiberglass (or stainless steel) vessel used for removal of entrained biogas in the RANS to minimize the chance of pump cavitation. The GEC should be located as close as possible to the RANS pump inlet to minimize the amount of entrained gas entering the pump. Removed gas will be vented back to the BVF reactor.

The recycle pump control system should allow for the following:

- Operator to select the mode of operation (SREC or RANS) for each pump
- Pump selected in SREC mode to operate in one of the following methods:
    - Continuous operation when BVF reactor heating is required (this is the normal mode of SREC pump operation)
    - Operate using a repeating cycle timer
    - Operation interlocked with the reactor feed pumps (SREC pump activates when the duty reactor feed pump(s) is called to operate)

- Interlocks to prevent the simultaneous operation of the SREC and RANS pumps. Priority is assigned to the following (in order of highest priority):
    1. WAS
    2. RANS
    3. SREC

The control system should allow for easy operator control of the recycle pumps through the HMI.

Manual sample taps are to be provided on the discharge side of the SREC and RANS pumps. Gas venting at all high points on the recycle lines should also be provided using a sewage air release valve.

The characteristics of the SREC and RANS/WANS for the BVF reactors are summarized in Table 4.2.

Table 4.2 - BVF Reactor SREC and RANS/WANS Characteristics

Parameter	SREC	RANS/WANS
Flow (gpm)	1,900	1,900
pH	6.5 -7.5	6.5 – 7.5
Solids (mg/l)	0 – 3,000	0.5 - 8%*
Temperature (°F)	85 – 98	85 - 98
Gas**	May contain significant quantities	Will contain significant quantities

*Up to 8% at commencing of pumping before falling to 1 to 4%. Use 3% for continuous flow design.
**Special care is required in the design of the recycle system, and it is essential to prevent gas locks and associated pumping problems.

4.6.2 Waste Anaerobic Sludge Removal

Waste anaerobic sludge (WANS) is removed via the RANS system (laterals and pump). It requires the operator to manually set valves to direct the flow through the loadout connection to a truck. The loadout should be located in a location with truck access. Refer to Table 4.1 for calculations of expected WANS quantities.

4.6.3 BVF Reactor Heating

At average design conditions in winter, up to 736 MMBtu/d of heat will need to be supplied to the BVF reactors to maintain the reactor at 85 °F at design conditions. Accounting for energy losses, up to 1,290 MMBtu/d of natural gas will need to be supplied to the heating system at average conditions (866 MMBtu/d at annual average conditions).

A heat exchanger will be installed on each BVF reactor supernatant recycle (SREC) line. The heat exchanger will be used to add supplemental heat to the BVF reactor during normal operation (if/when required) and during start-up conditions or extended plant shutdowns during which no wastewater is delivered to the BVF reactors.

During normal operation, each heat exchanger will transfer up to 26.8 million Btu/hr of thermal energy to the BVF recycle (SREC). A bypass line around the heat exchanger will be installed and will be used during RANS recycle, boiler or heat exchanger maintenance.

Temperature transmitters are to be installed on the BVF reactor SREC line (upstream and downstream of the heat exchanger) which will continually monitor the recycle temperature as a means of indicating reactor operating temperature and heating performance. E. low, low, high, and E. high temperature alarms should be signaled at the HMI.

Two 700 hp boilers (one dedicated to each BVF reactor) will be installed to provide supplemental heat to the anaerobic reactor. Hot water from the boiler will be circulated through the heat exchanger to transfer heat to the BVF reactor SREC, which will maintain the BVF reactor within a temperature range of 85 to 98°F.

The SREC pump will be called to run continuously by the main WWTP PLC when BVF reactor heating is required.

A three-way control valve on the boiler recirculation loop will modulate to maintain the boiler return water temperature, as measured by the boiler return water temperature transmitter, at a setpoint. The purpose of this control loop is to control the heat load on the boiler and heat exchanger to a value within acceptable design limits for the boiler and heat exchanger as the BVF reactor temperature changes.

The duty hot water recirculation pump will be started whenever the boiler is required to run and stopped after the boiler has been stopped and not called to run for a period of time. While the pump is operating, its speed will be modulated via a VFD to maintain the water recirculation loop flow rate (as measured by the associated flow transmitter) at a fixed setpoint.

The boiler will be started when the BVF reactor temperature, as measured by the SREC temperature transmitter on the inlet side of the heat exchanger, falls to a “Boiler Start Setpoint”, and stopped when the BVF reactor temperature rises to a “Boiler Stop Setpoint”.

Each boiler is controlled using a dedicated control panel, and includes a local HMI that provides access to boiler configuration and control functions and displays boiler parameters, fault annunciation, and alarm history. The control system provides firing rate control to maintain the hot water supply temperature at a setpoint. The basic principles of boiler operation are as follows:

- Prior to operation, the boiler goes through a pre-purge cycle, where the air blower motor is started and the air damper opens to its fully-opened position. Opening the damper allows a flow of purging air through the boiler prior to the ignition cycle.
- Following the air purge, the damper returns to its low fire position and the ignition cycle begins. The ignition transformer and gas pilot valve are energized, and once a pilot flame is established, the main fuel valves are energized. Once the main flame is established, the ignition transformer and gas pilot valve are deenergized.

- When the main flame is established, the control system allows for operation above the low-fire range. In automatic control, the firing rate will be controlled by the air damper and fuel valves.
- The burner will fire until water temperature in excess of demand is generated. In this scenario, the air damper will return to the low fire position, the fuel valves are deenergized and the main flame is extinguished. The air blower continues to run to force air through the boiler during a post-purge period.

4.6.4 BVF Reactor Level

A pressure-transducer type level transmitter is used to continuously measure the liquid level in the BVF reactor. Reactor level is to be trended at the HMI. E. low, low, high, and E. high reactor level alarms should be signaled at the HMI. Interlocks to be provided in the control logic to prevent recycle pump operation when either the low or E. low level alarm condition is active.

Table 4.3 – BVF Reactor Effluent Characteristics

Parameter	BVF Reactor Effluent
Flow, minimum (gpm)	0
Flow, avg (gpm)*	3,000 per reactor
Flow, peak (gpm)	4,340 per reactor
pH	6.5 – 7.5
TSS (mg/l)	350
Temperature (°F)	85-98
Dissolved gases (CH_4, CO_2, H_2S)	effervescent, odorous, corrosive, toxic, and flammable

*Based on a 6 hr SBR cycle with 90 min of SBR fill time per cycle

4.6.5 BVF Reactor Effluent Pumps

The three inline BVF reactor effluent pumps (3 @ 4,340 gpm, two duty, one standby) with VFDs will deliver flow to the SBRs (during the SBR Feed event), as well as send anaerobic effluent to the effluent structure to the storage lagoons, based on modulating flow control valves, flow meters, and corresponding operator-adjustable setpoints.

5 BIOGAS COLLECTION, TRANSMISSION, UTILIZATION, AND FLARING SYSTEM

5.1 Components of the Biogas System

1. Collection: The biogas generated in the BVF reactor will be collected and transported under slight vacuum through the main gas pipeline to the blower system. A biogas vent line must be provided for emergency use.

2. Transmission: Five positive displacement blowers (four duty/one standby) will be used to pressurize and transmit the biogas to a standard waste gas flare system or to a utilization system. Each biogas blower is sized for a flow of 1,070 scfm at a design discharge pressure of 5 psi (to be verified during detailed design). The blower speed will be controlled by a variable frequency drive (VFD), via a signal from the PLC, based on the readings of the BVF cover pressure transmitter. A pressure regulating valve will be used to control the discharge pressure if biogas is being utilized.

3. Venting: A vent stack will be used for release of the biogas from beneath the BVF cover when the blowers are not available. Position switches on the vent and transmission valves will prevent the blowers from running when the vent is open.

4. Flaring: Biogas that is not utilized will be combusted in two enclosed flares complete with flame trap assembly and natural gas pilot.

5.2 Quantities and Characteristics of Biogas

The projected quantity and quality of biogas generated in the BVF reactor are shown in Table 5.1.

Table 5.1 - Projected Quantity/Quality of Biogas

Parameter	Value
Annual Average Biogas Flow (ft^3/d)	1,830,000
Average Biogas Energy (MMBtu/d)	1,190
Max. Month Biogas Flow (ft^3/d)	4,190,000
Max. Month Biogas Energy (MMBtu/d)	2,720
Methane, CH_4 (%)	60 - 70 typical 50 - 80 extreme range
Carbon Dioxide, CO_2 (%)	30 - 40 typical 20 - 50 extreme range
Hydrogen Sulfide, H_2S (ppm)	3,000*
Temperature (°F)	85-98

Parameter	Value
Water Vapor	saturated
Oxygen, O_2 (%)	normally 0 - 1, but at no time greater than 5

*Assume value as no wastewater sulfur concentration was provided

5.3 Biogas Pipelines and Valves

All biogas piping is to be SS 316L. All biogas isolation valves are to be rubber-lined (Buna-N), cast iron-bodied, wafer butterfly type valve with all 316 SS trim.

All pipes and valves for the biogas system should be selected/sized considering:

- Estimated biogas flows
- Wet and corrosive nature of biogas
- Temperature and pressure of blower discharge
- Suction piping to include sediment moisture trap

5.4 Floating Geomembrane Covers

Each BVF reactor will be covered with an insulated floating geomembrane cover. The cover system is designed to insulate the reactor, collect biogas, and prevent odors. Since the cover is flexible and floating, it allows for some variation in operating level. The reactor cover is constructed using geomembrane material and includes insulation, sampling ports, a rainwater collection/drain system, and perimeter attachment system. ½" of closed cell insulation on the cover system allows for sufficient buoyancy to permit personnel with appropriate safety equipment to safely walk on the cover system for maintenance and sampling.The cover system includes appropriate membrane material (top layer of XR-5 and HDPE underskin), insulation, access hatch, sampling ports/vents, rainwater drains, cleanout hatches, and a gastight perimeter attachment system. The cover system allows for sufficient buoyancy to permit personnel with appropriate safety equipment to safely walk on the cover system for maintenance and sampling.

To allow for automatic disposal of rainwater into the reactor, the membrane cover is arranged with a series of bay floats and weight pipes that force the rainwater to central areas that permit the rain to drain by gravity into the reactor.

The capped sampling ports allow access to reactor contents for temperature profiles, sludge height measurements, and collection of supernatant and sludge samples. A minimum of 16 ports is suggested. These ports will also serve as emergency gas vents.

5.4.1 Cover Pressure Transmitter and Manometer

A differential pressure instrument continuously compares the pressure under the cover to atmospheric pressure. It sends a 4-20 mA signal to the PLC which changes the biogas withdrawal rate (i.e., the biogas blower speed) in order to control system pressure within a target range. In addition, high and low pressure setpoints will register alarms through the PLC.

Selection of the pressure transmitter should consider:

- Wet, corrosive nature of biogas.
- Measurement range (-1.5” to +1” WC).
- Transmitter will be located in an enclosure that provides weatherproof protection. In order for the system to work properly, the transmitter should be as close as possible to the reactor, and the designer must verify that the biogas pipeline headlosses from the BVF reactor to the control transmitter location on the suction side are insignificant compared to the normal operating range (i.e., -0.20” to -0.30” WC); otherwise, the control transmitter should be as close as possible to the reactor.
- "Atmosphere" line on differential pressure cell must be protected from wind; use ½” diameter.
- Field calibration of instrument.
- Line from transmitter to the biogas pipeline must slope down to the pipeline and be free-draining to eliminate condensate accumulation or any restrictions that would give false readings.

A manometer will be installed in the heated fiberglass enclosure to verify the cover pressure transmitter reading.

5.4.2 Biogas Vent (manually operated)

The purpose of the vent is to permit venting of biogas directly to atmosphere without damage to the BVF reactor cover in the event that the biogas transmission system is disabled (e.g., extended power outages or blower failure), or during the start-up period. The vent should also be used to vent biogas if the gas oxygen content is greater than 5%.

Design considerations for the vent include:

- Sized to prevent the cover from inflating under peak gas flow conditions
- Vent and biogas transmission isolation valves are to be controlled manually, have easily accessible manual handwheel operators, include suitable heat tracing to prevent freezing and limit switches to verify open/closed positions and alarm at the HMI
- Metering of biogas through vent is not required

- Opening of the vent valve (after closing the biogas transmission isolation valve) will be initiated by the operator after a high-pressure alarm is sounded
- If the blowers are off because of mechanical or electrical failure, then a high-pressure alarm must sound when the cover just begins to rise off the liquid surface. This will alert the operator of the need to open the vent. The vent must remain open until the blowers are back in service.
- The limit switches on the biogas vent and transmission valves must be interlocked with the operation of the biogas blowers. If the vent valve is not in the fully closed position and the biogas transmission valve is not in the fully opened position, the PLC shall prevent operation of the blowers until the valve positions are positioned correctly.
- Before the vent is opened, the operator must be able to positively verify that the blowers are off

5.4.3 Biogas Blowers

Five positive-displacement blowers (1,070 scfm) with gastight mechanical seals will be installed to handle the peak biogas flow generated from the BVF reactors. Each blower shall be driven by a high-efficiency motor. Motor type should be suitable for operation in a Class 1, Div. 2 environment and particular attention to power requirements throughout its operating range is required. The motor must also be suitable for operation with a VFD.

Blower operating temperature must also be acceptable, especially at low flow conditions, such that high temperatures do not cause problems with other components of the biogas delivery system. Another important point to consider is blower turndown; the blower should be capable of running for extended periods at low flow conditions, i.e., when biogas flow is low. In the event of very low biogas production, the duty blower will run at its minimum operating speed to minimize motor stops/starts. Blower lobes shall be teflon coated with extra tolerances between the lobes.

5.4.4 Variable-Frequency Drives

The variable-frequency drive (VFD) units drive the motors which power the biogas blowers. They are a part of the biogas control loop which includes the cover pressure transmitter, discharge pressure transmitter, the PLC, and the blowers.

The purpose of the VFD units is to match blower capacity with biogas production, with the intention of maintaining the reactor cover pressure within a setpoint range. The PLC processes the signal from the cover pressure transmitter and, in turn, relays a control signal to the VFD units to establish the proper blower operating speed.

5.5 Blower Discharge Temperature Transmitters

Temperature transmitters are provided at the discharge piping of each blower. If the blower discharge temperature exceeds the preset limit (indicating a possible blockage in downstream the biogas piping), the blower will be shut down (by the PLC) and an alarm will be sounded. When alarmed, the PLC should switch duty to the other blower, provided that it is available to operate and no alarm conditions exist for that blower.

5.6 Pressure Gauges

The designer should include pressure gauges for monitoring of the biogas transmission system.

5.7 Purge Points

These permit purging of the biogas handling system (or specific sections of the system) into or out of service with an approved inert gas (e.g., carbon dioxide, nitrogen, argon) for the purpose of preventing the occurrence of explosive methane-oxygen mixtures. Purge points can also be used as extraction ports to obtain biogas samples. Purge points are to be properly sealed and accompanied by a ball valve and threaded plug to prevent gas leakage. They are to be located at various key points along the biogas transmission system.

5.8 Gas Liquid Sediment Trap and Drip Traps

The purpose of the gas liquid sediment trap (GLST) is to remove particulate matter and condensation from the biogas stream immediately prior to the blower system. The GLST should be piped to a suitable drain. In addition, drip traps will be located at all low spots in the gas piping system. Each drip trap should be piped to a suitable drain.

5.9 Enclosed Biogas Flares

Biogas will be burned in two enclosed waste gas burners with dedicated control panels. The biogas flare will be sized to handle the peak biogas flow. Natural gas is provided as pilot fuel to light the flare before sending any biogas to the flare. A flame trap assembly with flame arrestor, thermal shutoff valve, and drip trap will be located upstream of the flare. The purpose of the flame trap assembly is to prevent flares flash backs through the biogas piping system. The flares must be located a minimum of 50 ft from the digester.

5.9.1 Biogas Analyzers

A Dräger kit and portable O_2 analyzer will be provided to manually analyze the biogas for CO_2, H_2S, and O_2 content; this testing is necessary to determine the integrity of the cover system (increasing O_2 might mean leaks in the cover) and biogas composition (sudden changes in composition might indicate reactor upset).

5.10 Biogas System Control/Operation

The duty blowers draw the biogas from beneath the cover(s) and deliver it to the biogas flare. The rate of biogas production within the reactors are not constant and varies according to changes in flow, wastewater characteristics, system temperature, and other operating parameters.

The biogas collection and transmission components are controlled in the following manner. The speed of the duty biogas blowers is controlled using a PID loop in order to maintain the setpoint cover pressure. Each BVF reactor is equipped with a pressure transmitter located as close to the reactor as possible. The transmitter measures the biogas pressure under the cover and transmits a 4-20 mA signal to the PLC. The PLC compares that pressure to the desired pre-set range (which may be reset). The PLC then sends a 4-20 mA signal to the blower VFD to adjust blowers speed so that the pressure will increase, decrease, or remain the same, as required. For example, if the setpoint range is -0.20” to -0.30” WC and the average cover pressure measured over the time interval inputted in the control logic is -0.15” WC. The blower VFD will increase the speed of the duty biogas blower in order to maintain the target cover pressure. The biogas controls will be tuned such that any imposed changes in blower speed should be adequate to handle changes in gas production rates without allowing the cover to inflate.

The system described in the previous paragraph accomplishes two things: it matches the rate of biogas utilization with biogas production, and it maintains a slight negative pressure underneath the BVF reactor so that any small leaks result in air infiltration rather than biogas leaking out.

The blowers will automatically shut down in an alarm situation and produce an alarm at the computer screen. The duty blower will automatically try to restart after a set time delay, and setpoint conditions for automatic shutdown no longer exist.

Should the supply of biogas start falling for any reason, the blower output will be automatically reduced (in proportion to the decrease in flow) to the minimum output or speed setting. If gas production continues to fall, the blower will shut down and restart automatically once cover pressure has returned to the setpoint range.

5.10.1 Biogas Alarm System

There are a number of possible scenarios which initiate an alarm condition and/or automatic blower shutdown. If the biogas blower discharge temperature increases to a high setpoint (temperature TBD), or the suction pressure (as measured at the reactor) decreases below -TDB WC for longer than a few seconds (or the blower speed falls below a pre-set minimum), the blowers will automatically shut down. The blowers will automatically restart when the cover pressure reaches the desired set range.

Table 5.2 summarizes the conditions that result in a biogas alarm and blower shutdown. In addition to these, the operator shall use the biogas oxygen analyzer daily to test the biogas for the presence of oxygen. If O_2 concentration reaches 1 percent, the biogas system, including the cover, should be carefully checked for leaks. If O_2 concentration reaches 2 percent, the blower should be shutdown until leaks are repaired.

Table 5.2 – Biogas Alarm Conditions

Alarm Condition	Setpoint	Possible Cause	Result
High blower(s) discharge temperature	TBD	Blockage in blower(s) discharge piping	Blower(s) shut down; automatic restart after alarm reset.
Low blower speed	TBD	Insufficient gas production at BVF reactor	Blower(s) shut down; automatic restart after fixed time delay and cover pressure returning to setpoint
High cover pressure alarm	0” WC	Blower down due to mechanical/ electrical failure, excess biogas production	Investigate and monitor prior to blower shut down.
E. high cover pressure alarm	TBD	Blower down due to mechanical/ electrical failure, blockage in suction line	Manually open valve leading to vent. Close valve leading to blower.
High cover vacuum alarm	TBD	Malfunction of blower speed control	Investigate and monitor prior to blower shut down.
E. high cover vacuum alarm	TBD	Malfunction of blower speed control	Blower shut down, computer alarm.
First (low) O_2 (based on manual measurements)	1% O_2 in biogas	Leak in reactor cover or blower suction piping	Operator to shut down biogas blower and vent to atmosphere and find leaks.
Second (high) O_2 (based on manual measurements)	2% O_2 in biogas	Leak in reactor cover or blower suction piping	Operator to shut down biogas blower, vent to atmosphere, close valve leading to blower, and find leaks.

Alarm Condition	Setpoint	Possible Cause	Result
Biogas or vent valve position	Open/close positions of valves improper	One or more valves are improperly positioned	Blower will not operate, alarm reset after valves are properly positioned

6 PHYSICAL ASPECTS AND CONTROL OF THE SEQUENCING BATCH REACTOR (SBR) SYSTEM

6.1 General Description

The sequencing batch reactor (SBR) as its name implies, is a batch treatment technology. The aerobic SBR is a variation of advanced activated sludge, where the SBR basin serves the intended purposes of the selector, anaerobic, anoxic, aeration, and clarifier basins (all unit processes of advanced activated sludge) in a single vessel

To take advantage of SBR versatility, the treatment of anaerobic effluent is done in cycles. The cycle is defined as the elapsed time between feeds of consecutive batches of wastewater. During a cycle, anaerobic effluent is fed, treated, settled, and then discharged. The cycle duration is variable; however, to reach certain treatment objectives, the cycle and event durations are limited by the hydraulics of the system and by the kinetics and settling characteristics of the biomass.

6.2 Design Criteria

The design criteria and projected performance for the SBR system are listed in Table 6.1 and have been developed based on Evoqua's research and full-scale field experiences. Further SBR process design and sizing calculations are provided in Section 8.

Table 6.1 - SBR Design Summary

Parameter	Design Conditions
Number of SBR reactor	2
Total Reactive Volume per SBR (MG)	2.0
Number of Daily Cycles per SBR	4
Cycle Length (hr)	6
Fill Event Length (min)	90
Avg. Day Flow (mgd)	4
Max. Month Daily Flow (mgd)	4
Flow per Cycle per SBR (gal)	500,000
SBR Influent BOD, Avg. (mg/l)(1)	406
SBR Influent BOD, Daily Avg. Load (lb/d)	13,540
SBR Influent TSS, Avg. (mg/l)	460
Assumed SBR Influent Sulfide (mg/l)	20

Parameter	Design Conditions
MLSS (mg/l)	3,200
MLVSS (mg/l)	2,800
Avg. HRT (d)	1
F:M (lb BOD/lb MLVSS d)	0.15
SBR Fill Rate, Avg. Design (gpm)	5,560
SBR Fill Rate, Peak Design (gpm)	5,560
SBR Decant Event Time (min)	60
SBR Decant Rate Avg. (gpm)	8,330
SBR Decant Rate Peak (gpm)	10,000
Peak AOR per SBR (lb/hr)	1,670
WAS Avg. (lb/d)(2)	14,630
WAS Avg. (gpd)(3)	219,300
WAS Pump Flow Rate (gpm)	800
WAS Avg. Time per Cycle (min)	34
WAS Duration per Cycle (min)	0-60

(1) With RWW bypass

(2) Based on 40% bios yield and 60% of incoming solids undigested in the SBR

(3) Wasted at 0.8% solids concentration

6.3 SBR System Materials of Construction

Each SBR will be 166’ x 83’ x 24’ (4 ft of freeboard), resulting in a reactive volume of 2 MG. Above ground liquid and air piping will be 304 SS, insulated and heat traced, as required. Internal air piping will be 304 SS.

6.4 SBR Cycle

The list and sequence of possible SBR cycle events and the default SBR cycle event times are outlined in Table 6.2. SBR cycle event durations are operator-adjustable and can be altered based on process requirements. For example, if a longer Settle time is necessary, then part of the time dedicated to Aerate may be shifted to the Settle event. If a longer Static Fill is required, that time can be subtracted from Fill/Aerate.

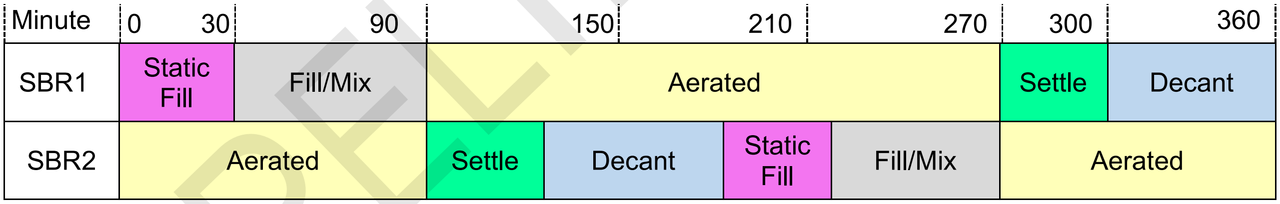
Table 6.2 - SBR System Cycle Event Sequence and Durations

Event	Typical Event Duration (Min)
STATIC FILL	30
FILL/MIX	60
AERATE	180
SETTLE	30
DECANT	60*
Total	**360**

The SBR control system must be designed for intra-cycle flexibility to allow for process optimization as operating conditions dictate. The cycle time should be adjustable between 4 and 8 hours and should be inputted at the control system HMI.

*WAS concurrent with the start of decanting. WAS event may occur each cycle or every X cycles. Based on WAS pump flow rate of 800 gpm, preliminary design suggests WAS duration of 34 min each cycle for average conditions.

Schematic 1 - Proposed SBR Cycle Condition



6.5.1 SBR Feed

During normal operation, BVF reactor effluent will be pumped to an SBR during any of the Fill events (Static Fill, Fil/Mix, and Fill/Aerate) and/or to the effluent structure via BVF effluent pumps. One automatic modulating valve will be installed on the influent piping of each SBR. The control valve will be modulated during a Fill event to evenly. Transfer the operator-adjustable cycle flow to the SBR over the Decant event time.

At the HMI, the operator will enter the following setpoints:

- SBR low level
- SBR high level
- SBR max level

6.6 SBR Mixing and Aeration System

Mixing and aeration for the SBR are provided by the fine-bubble diffused aeration system and floating mixers, which supply sufficient agitation and oxygen transfer to meet the respiration requirements for the biological process. For each SBR, the aeration manifold piping will consist of headers to distribute air throughout the base of the SBR. The aeration system is sized to handle the design air demand requirements (see Section 7 for AOR calculations).

Mixing is accomplished with two floating mixers (one per SBR) operated by the soft starters. Each mixer will be equipped with a 75 hp motor. One floating mixer will be dedicated to each SBR. When the SBR is in a Fill/Mix, Fill/Aerate or Aerate cycle event, the floating mixers will operate continuously. During all other cycle events, the aerators will be off.

Four aeration blowers will be used to supply air to the SBRs. Automatic open/close valves on the air lines for each SBR will be used to control the direction of air flow. The control valve for each SBR will open when the SBR is in a Fill/Aerate or Aerate event.

Each aeration blower will have a 250 hp motor and VFD for blower speed control. Each aeration blower will be equipped with a temperature switch that prevents the blower from running if a high temperature is measured. If a high temperature is measured by the switch, the associated blower will shut down, and an alarm will register at the HMI.

Each aeration blower enclosure is equipped with a cooling fan operated by FVNR starter. The cooling fans are interlocked with the operation of the aeration blowers such that the cooling fans will run continuously when the associated aeration blower is running and stop when the associated aeration blower is stopped.

A DO/temperature probe and transmitter will be used to continuously monitor the DO concentration and temperature of the mixed liquor in the each SBR. The DO and temperature will be trended and displayed at the control system HMI. The DO probe should be installed sufficiently deep in the SBR (approximately 10' below TOW) to ensure the probe is submerged in liquid at all times in order to protect the probe.

During Fill/Aerate and Aerate cycle events, a control loop will be used to modulate the speed of the duty aeration blowers in order to maintain a target DO concentration range in the SBR.

The DO transmitter sends a 4-20 mA signal to the PLC, which periodically changes the target duty aeration blower's speed depending on whether the SBR DO concentration is rising or falling. If the VFD for the duty aeration blowers ramps the blowers down to their minimum operating speed and the DO concentration is within or above the target range, the duty aeration blowers will continue to operate at the minimum operating speed. The normal DO target range will be 1.5-3 mg/l; however, if needed, the DO target range can be reduced (i.e., 0.3-0.7 mg/l) to achieve simultaneous nitrification/denitrification in the SBR tanks.

At the HMI, the operator will enter values for the following setpoints:
- Maximum DO (mg/l)
- High DO (mg/l)
- Low DO (mg/l)
- Minimum DO (mg/l)
- Maximum aeration (%)
- Minimum aeration (%)
- Update interval (seconds)
- Large negative adjustment (%)
- Small negative adjustment (%)
- Small positive adjustment (%)
- Large positive adjustment (%)

6.7 SBR Level

A differential pressure level transmitter (probe-type) will be installed in each SBR tank. The transmitter is used to continuously measure the liquid level in each tank. The tank levels are to be trended at the HMI. E. low, low, high, and E. high tank level alarms should be signaled at the HMI.

The maximum operating level in the SBR, after all Fill events are complete, is approximately 20 ft; there will be small variations in full operating depth between cycles.

6.8 SBR Effluent System

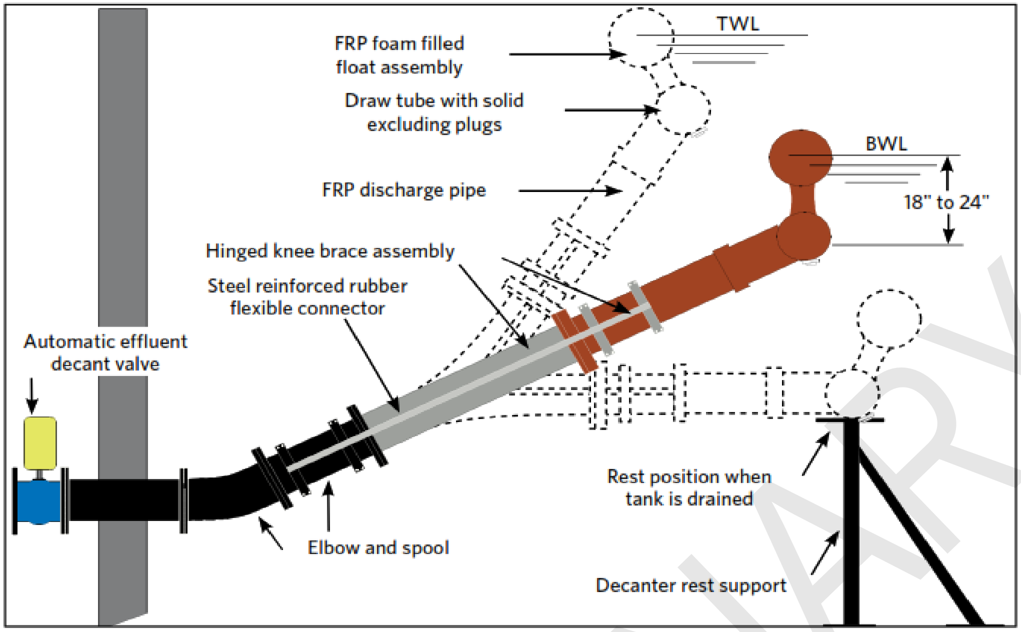
At the end of each SBR cycle, treated effluent will be decanted and discharged by gravity to the discharge point.

The decanters are floating, solids excluding type, to minimize loss of suspended solids in the final effluent. Each SBR is equipped with one decanter to remove clarified effluent. The decanter is comprised of a fiberglass reinforced plastic float and draw tube with stainless steel spring loaded solids excluding plugs, as well as a heavy duty wire reinforced flexible hose, steel knee brace, and elbow, which connects the decanter to the wall sleeve in the basin. The decanter's horizontal movement is restricted by the hinged knee brace assembly, which is attached above and below the flexible hose. The decanter comes to rest on a support assembly when the liquid goes below the normal low level of the tank.

A decanter control valve is located on the discharge line of each SBR. During a Decant event, the decanter effluent control valve will be opened to create a hydraulic differential, causing the spring-loaded plugs to open and allow treated effluent to enter the decanter. During all non-Decant events, the spring-loaded plugs close, preventing mixed liquor suspended solids from entering the SBR effluent piping.

The flow out of the SBR will be controlled using the automatic, modulating decanter effluent control valve. During the SBR Decant event, the position of the decanter effluent control valve will modulate based on SBR level and time remaining in the Decant event. The decanter and SBR effluent piping must be sized to handle the peak design effluent flow listed in Table 6.2 (10,000 gpm).

An SBR effluent flow meter is located on the header of the SBRs. The instantaneous flow meter reading should be trended at the HMI. Totalized daily flow for the previous 7 days should be displayed at the HMI. The signal from the flow meter is used to measure and control the amount of SBR effluent sent to the effluent structure.



Schematic 2 – SBR Decanter

6.9 SBR Waste Activated Sludge (WAS) System

During the Decant event, WAS is withdrawn from the SBR through a single lateral with orifices along the floor of each SBR. WAS will be sent either to the BVF reactors for solids digestion.

A flow meter is located on the discharge of the WAS pumps. The instantaneous flow meter reading should be trended at the HMI. Totalized daily flow for the previous 7 days should be displayed at the HMI. The signal from the flow meter is used to measure and control the amount of WAS sent to the BVF reactors.

At the control system HMI, the operator will enter the following parameters:

- WAS pump operating time per WAS event for each SBR
- Number of cycles per WAS event for each SBR
- WAS event start time (relative to the beginning of the Decant event)
- WAS flow rate for each SBR

6.9.1 WAS Control Valves and WAS Pumps

An auto valve (open/close) is installed on the WAS line of each SBR. For each WAS event, the auto valve will be fully open. Once the valve open status is confirmed, the WAS pump will be called to operate at the time selected by the operator and will operate continuously for the length of time entered by the operator

WAS will be removed from the SBR using the WAS pumps equipped with VFDs (each at 800 gpm, one duty, one standby). The WAS pumps operate in a duty/standby configuration; Duty/standby designations alternate with each pumping cycle and/or if the duty pump fails. The operation of the WAS pumps will be interlocked with the WAS control valve, WAS event status, and SBR level transmitter reading on each SBR. The duty pump will stop if no SBR WAS events are active.

The sludge wasting parameters will be set by the operator in order to maintain the desired operating conditions such as mixed liquor suspended solids (MLSS) concentration, sludge retention time (SRT), and sludge volume index (SVI). Wasting may not need to occur during each SBR cycle.

The estimated WAS production rate at average design conditions is 14,630 lb/d (dry weight basis). This dry mass corresponds to a volume of 219,300 gpd based on a solids concentration of 0.8 percent. At design conditions, the WAS pump will need to operate for 274 minutes per day (34 minutes per cycle).

7 CONTROL BUILDING AND UTILITY REQUIREMENTS

7.1 Control Building

The control building will be a pre-engineered metal building. The building has preliminary dimensions of 150’ x 125’

The control building will house the following:

- Rotary drum screen
- Grit vortex system
- Bypass pumps
- SREC pumps
- Rans pumps
- WAS pumps
- Chemical storage area for $Mg(OH)_2$ tank and metering system
- Boilers and heat exchanger area
- Electrical room housing MCC, control system, VFD’s, transformer and other panels.
- Washroom
- Office
- HVAC systems as required

7.2 Utility Requirements

The utility requirements for the building and WWTP system are listed below (power requirements for the WWTP are outlined in Section 9.2):

- **Phone line & internet** – access to phone and internet are required for communication and data transfer to Evoqua.
- **Natural gas** – Natural gas will be supplied to the boiler to provide heat to the heat exchanger. Natural gas will be used as pilot gas for the enclosed biogas flares

8 PROCESS DESIGN CALCULATIONS

The wastewater characteristics upon which the design calculations are based are listed in Table 3.1.

8.1 BVF Reactor Sizing

8.1.1 BVF Reactor Volume

BVF reactor sizing is based on a volumetric organic loading rate of 1.045 kg COD/m^3 d for the Max Month Daily loading conditions, which is 600,000 lb COD /d

$$\textbf{Volume} = \frac{600{,}000 \text{ lb/d}/2.2 \text{ kg/lb}}{(1.045 \text{ kg COD}/m^3\text{d}) \text{ x } (0.003758 \text{ m}^3/\text{gal})} = \textbf{69 MG}$$

Using 2 reactors, each reactor volume = 69 MG/2 = **34.5 MG**

8.1.2 BVF Reactor Hydraulic Retention Time (HRT)

Basis:

- BVF Volume: 34.5MG per reactor
- Avg. Flow: 4.38 MGD (2.19 MGD per reactor)
- Max. Month Day Flow: 8.56 MGD (4.38 MGD per reactor)

$$\textbf{Average HRT per reactor} = \frac{34.5 \text{ MG}}{2.19 \text{ MGD}} = \textbf{15.8 d}$$

$$\textbf{Max. Month HRT per reactor} = \frac{34.5 \text{ MG}}{4.28 \text{ MGD}} = \textbf{8.1 d}$$

8.2 SBR System Sizing

8.2.1 SBR System Volume and Food: Microorganism (F: M) Ratio

The design volume for the SBR system at average day conditions is based on a design F:M ratio of 0.145 lb BOD/lb MLVSS·d.

Design basis for SBR Volume Sizing:

- Average influent flow = 4 mgd
- Average BOD influent: 406 mg/l
- MLVSS: 2,800 mg/l
- F:M 0.145 lb BOD/lb MLVSS·d.

$$\text{Volume} = \frac{\text{lb BOD}}{\text{F:M x MLVSS}}$$

$$\textbf{Volume} = \frac{\text{406 (mg/l) x 4 MGD}}{\text{0.145 (lb/BOD /lb MLVSS x 2800 (mg/l)}} = \textbf{4.0 MG}$$

For 2 SBRs, each SBR is: 4.0 MG/2 = **2.0 MG**

8.2.2 SBR System Hydraulic Retention Time (HRT)

Basis:

- SBR volume: 2 MG per tank
- Design Flow: 4 MGD (2 MGD per SBR)

$$\textbf{Design HRT per SBR} = \frac{\text{2 MG}}{\text{2 MGD}} = \textbf{1.0 d}$$

8.3 BVF Reactor Biogas Production

Basis:

- Average COD load: 262,070 lb/d
- Month COD load: 600,000 lb/d
- Theoretical methane produced per lb COD removed: 5.6 ft^3/lb COD removed
- Biogas methane concentration: 65 percent
- COD removal: 90 percent
- Raw wastewater bypass to SBRs: 10 percent
- Fraction of the removed COD converted to methane: 90%

Methane calculation (average conditions):

$$CH_4 = 262{,}070\ \frac{\text{lb}}{\text{d}}\ \text{x}\ \ 0.90\ \text{x}\ 5.6\frac{\text{ft}^3}{\text{lb}}\ \text{x}\ 0.90 = 1{,}189{,}000\ \frac{\text{ft}^3}{\text{d}}$$

Biogas calculation (average conditions):

$$\textbf{Biogas} = 1{,}189{,}000\ \frac{\text{ft}^3}{\text{d}} \div 0.65 = \ \mathbf{1{,}830{,}000}\ \frac{\mathbf{ft^3}}{\mathbf{d}}$$

Methane calculation (max. month conditions):

$$CH_4 = 600,000\ \frac{lb}{d} \times\ 0.90 \times 5.6 \frac{ft^3}{lb} \times 0.90 = 2,721,600 \frac{ft^3}{d}$$

Biogas calculation (max. month conditions):

$$\textbf{Biogas} = 2,721,600 \frac{ft^3}{d} \div 0.65 = \mathbf{4,190,000\ \frac{ft^3}{d}}$$

8.4 Sludge Production

8.4.1 BVF Reactors WANS

Design basis for sludge estimate:

- Average BVF influent COD load = 262,070 lb/d
- COD removal efficiency = 90% COD removal
- Assumed yield = 0.04 lb SS/lb COD $_{\text{removed}}$
- Assumed digestion of WAS in BVF system = 50%
- Average BVF influent TSS load =78,170 lb/d
- Average BVF efluent TSS load = 16,070 lb/d
- Net undigested influent solids = 10%
- Raw wastewater bypass to SBRs: 10 %
- WAS production = 14,630 lb/d

Sludge from bios yield + undigested solids = [(0.04 lb/lb x 262,070 lb/d x 0.90) + (78,170 – 16,070) x 0.1] x 0.90

Sludge from bios yield + undigested solids = 14,080 lb TSS/d

Undigested WAS = 14,630 x 0.5 = 7,320 lb TSS/d

Total daily sludge production from BVF reactor = 14,080 + 7,320 = **21,400 lb SS/d**

Assuming the WANS is wasted from the BVF reactor at 4% solids concentration, the liquid volume of WANS generated per year is estimated as:

$$\textbf{WANS =} \frac{21,400 \text{ lb TSS/d}}{0.04 \times 8.34} = \textbf{64,150 gpd @ 4\% solids}$$

WANS = 23.4 MG/yr @ 4 % solids

8.4.2 SBR Waste Activated Sludge (WAS) Production

Design basis for WAS estimate:

- Average influent flow = 4 MGD
- Assumed yield = 0.4 lb SS/lb BOD $_{\text{removed}}$
- Average BOD influent: 406 mg/l
- TSS influent: 460 mg/l
- Digestion of solids:40%
- 0.8% WAS solids concentration

WAS (dwb) = [(406 mg BOD/l x 0.4 lb SS/lb BOD) + (460 mg SS/l x 0.6 lb SS/lb SS)] x 4 MGD x 8.34

WAS (dwb) = 14,630 lb SS/d

$$\textbf{WAS} = \frac{14{,}630 \text{ lb/d}}{0.008 \times 8.34} = \textbf{219,300 gpd}$$

8.5 Actual Oxygen Required (AOR) for the SBR System

The AOR for the SBR system at peak day design conditions is calculated based on the following assumptions:

- 1.3 lb O_2/lb BOD removed (BOD oxidation and endogenous respiration)
- 4.6 lb O_2/lb TKN nitrified
- 2 lb O_2/lb sulfide oxidized
- 2.9b O_2/lb denitrified
- Assumed 20 mg/l sulfide in SBR influent
- SBR influent TKN: 100 mg/l
- SBR effluent TN: 28 mg/l
- Bios is composed of 8% nitrogen
- Influent Peak BOD = 560 mg/l
- Influent Avg BOD = 406
- Peak Flow: 4 MGD
- Air is only required to nitrify any nitrogen that does not contribute to bios yield

AOR required at average day design conditions:

AOR, AVG = [(1.3 x 406 mg/l) + (4.6 x 100 mg/l) + (2.0 x 20 mg/l)-(2.9 x (100-28))] x 4 MGD x 8.34

AOR, Avg = 27,320 lb O_2/d

AOR, Avg = 27,320 lb O_2/d/ 2 SBR = 13,660 lb O_2/d/SBR

Assuming 12 hours of aeration per day, the peak design AOR for each SBR is calculated as:
AOR, Avg = 13,660 lb O_2/d/ 12 h/d = 1,140 lb O_2/hr/SBR

AOR required at peak day design conditions:

AOR, Peak = [(1.3 x 560 mg/l) + (4.6 x 100mg/l) + (2.0 x 20 mg/l)-(2.9 x (100-28))] x 4 MGD x 8.34

AOR, Peak = 34,000 lb O_2/d

AOR, Peak = 34,000 lb O_2/d/ 2 SBR = 17,000 lb O_2/d/SBR

Assuming 12 hours of aeration per day, the peak design AOR for each SBR is calculated as:

$$\text{AOR, Peak} = \frac{17{,}000\ \text{O}_2/\text{d/SBR}}{12\ \text{h/d}} = 1{,}420\ \text{lb O}_2/\text{hr/SBR}$$

8.6 Based on 350 operating days per annum

1. **Labor** (assume three full-time operators, 12 h/d, 7 d/week)
2. **Electricity Consumption**

Description	Installed hp	Continuous hp
Drum screen (3 @ 2 hp)	6	4
Grit auger (1 @ 2 hp)	2	1.0
Grit classifier Agitator (1 @ 1 hp)	1	0.5
Raw Wastewater pumps (3 @ 100 hp))	300	160
EQ tank mixers (3 @ 30 hp)	90	50
EQ offgas fan (50 hp)	50	15
Influent pumps (3 @ 75 hp)	225	110
BVF mixers (4 @ 6 hp)	12	---
Recycle pumps (4 @ 15 hp)	60	30
Biogas blowers (5 @ 60 hp)	300	120
Boiler air blowers (2 @ 25 hp)	50	25
Heat loop pumps (2 @ 25 hp)	50	30
Chemical metering pumps (2 @ 0.5 hp)	2	0.20
SBR aeration blowers (4 @ 250 hp)	1,000	330
SBR floating mixers (2 @ 75 hp)	150	25
WAS pumps (2 @ 20 hp)	40	7
Compressor air (1 @ 40 hp)	40	15
Air dryer	1	0.50
Total	**2379**	**923**

3. **Chemicals**
   a) Laboratory, routine purchases, allowance
   b) Macro/micronutrient chemicals (assume sufficient)
   c) Alkalinity (assume 75 mg/l alkalinity as $CaCO_3$ adding as $Mg(OH)_2$, which requires approximately 1,590 lb/d of $Mg(OH_2)$).

4. **Anaerobic Sludge Disposal** (sludge production is estimated to be 23.4 MG/yr @ 4% solids. WANS can be direct land applied as liquid fertilizer).

5. **Utilities**
   a) Heating (assume average of 736 MMBtu/d needed to heat raw wastewater to maintain BVF reactors at 85°F).
   b) Natural gas (assume 40 scfh of natural gas at 10-15 psig required for biogas flare pilot fuel)

6. **BIOGAS ENERGY CREDIT, IF UTILIZED**

1,189,000 ft^3/d of biogas generated at average design conditions with an energy value of 1,190 MMBtu/d.

APPENDIX A: LABORATORY TESTING AND MONITORING SCHEDULE

The following laboratory analyses will be routinely conducted by the operators (additional testing may be required, depending on local regulations):

Laboratory Testing and Monitoring Schedule

Parameter	RWW (24 hr Composite)	BVF Reactor Effluent	SREC	BVF Sludge Profile	Biogas	SBR Mixed Liquor	SBR Effluent
Flow (gpd)	On-line	-	-	-	-	-	On-line
COD_T (mg/l)	D	D	-	-	-	-	D
COD_F (mg/l)	D	D	-	-	-	-	-
BOD_5 (mg/l)	3	3	-	-	-	-	3
TSS (mg/l)	D	D	-	3M	-	D	D
VSS (mg/l)	W	W	-	3M	-	3	W
TS (mg/l)	-	-	-	3M	-	-	-
TVS (mg/l)	-	-	-	3M	-	-	-
Alkalinity (mg/l)	-	-	D	-	-	-	AR
VA (mg/l)	-	-	D	-	-	-	-
VA/PA	-	-	D	-	-	-	-
pH	D	D	D	-	-	D	D
Temp (ºF)	D	D	D	-	-	D	D
DO (mg/l)	-	-	-	-	-	On-line	-
Settleability (ml/l)	-	-	-	-	-	3	-
TN (mg/l)	AR	AR	-	-	-	-	3
TKN (mg/l)	AR	AR	-	-	-	-	AR
NH_3-N (mg/l)	3	3	-	-	-	-	3
PO_4-P (mg/l)	AR	AR	-	-	-	-	AR
CO_2 (%)	-	-	-	-	2	-	-
CH_4 (%)	-	-	-	-	2	-	-
H_2S (%)	-	-	-	-	2	-	-
O_2 (%)	-	-	-	-	2	-	-

D = DAILY; 3M = EVERY 3 MONTHS; 2 = TWO TIMES PER WEEK, W = WEEKLY; AR = AS REQUIRED; 3 = THREE TIMES PER WEEK

APPENDIX B: PROCESS FLOW DIAGRAMS

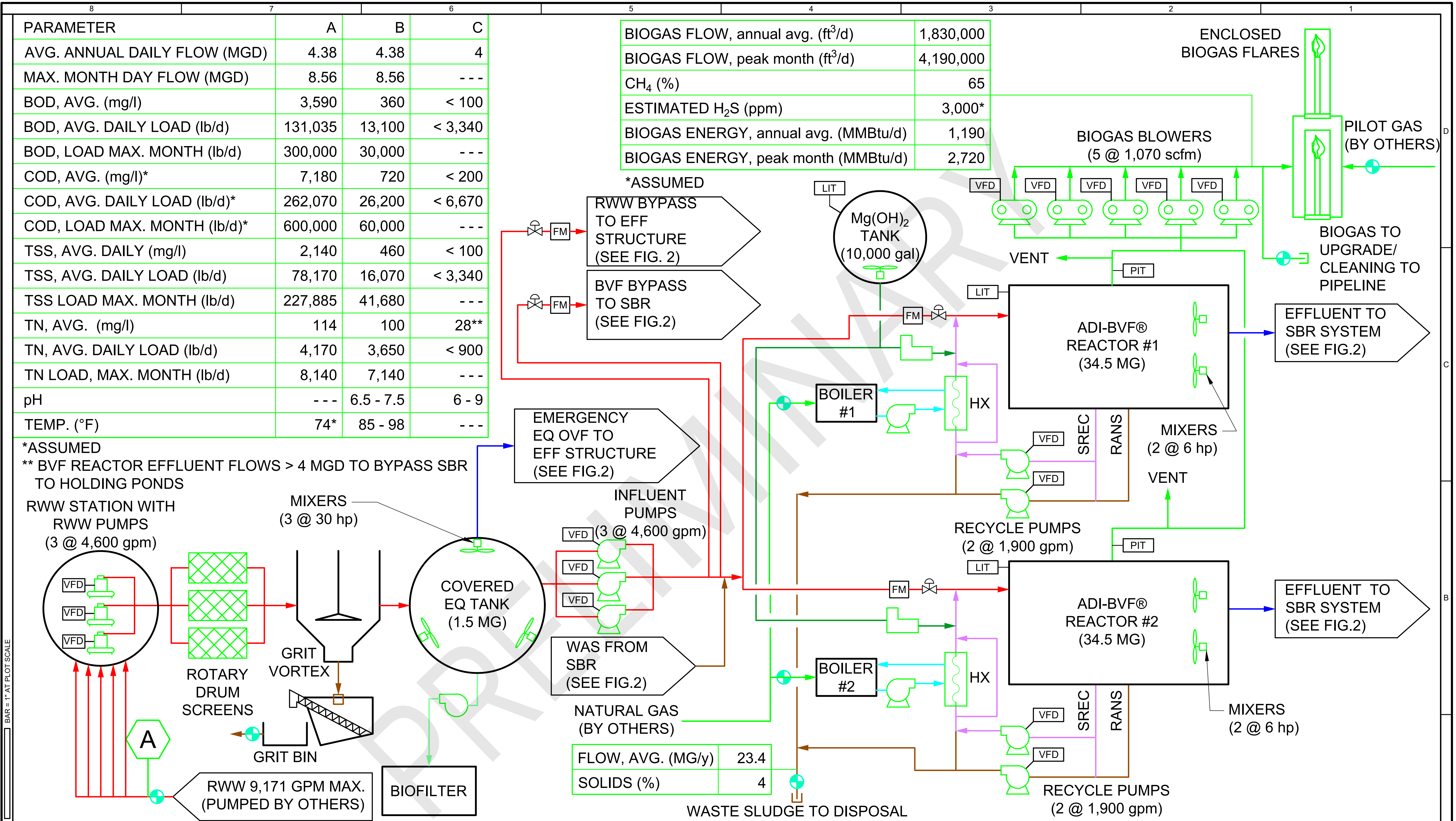
PARAMETER	A	B	C
AVG. ANNUAL DAILY FLOW (MGD)	4.38	4.38	4
MAX. MONTH DAY FLOW (MGD)	8.56	8.56	- - -
BOD, AVG. (mg/l)	3,590	360	< 100
BOD, AVG. DAILY LOAD (lb/d)	131,035	13,100	< 3,340
BOD, LOAD MAX. MONTH (lb/d)	300,000	30,000	- - -
COD, AVG. (mg/l)*	7,180	720	< 200
COD, AVG. DAILY LOAD (lb/d)*	262,070	26,200	< 6,670
COD, LOAD MAX. MONTH (lb/d)*	600,000	60,000	- - -
TSS, AVG. DAILY (mg/l)	2,140	460	< 100
TSS, AVG. DAILY LOAD (lb/d)	78,170	16,070	< 3,340
TSS LOAD MAX. MONTH (lb/d)	227,885	41,680	- - -
TN, AVG. (mg/l)	114	100	28**
TN, AVG. DAILY LOAD (lb/d)	4,170	3,650	< 900
TN LOAD, MAX. MONTH (lb/d)	8,140	7,140	- - -
pH	- - -	6.5 - 7.5	6 - 9
TEMP. (°F)	74*	85 - 98	- - -

*ASSUMED

** BVF REACTOR EFFLUENT FLOWS > 4 MGD TO BYPASS SBR TO HOLDING PONDS

BIOGAS FLOW, annual avg. (ft^3/d)	1,830,000
BIOGAS FLOW, peak month (ft^3/d)	4,190,000
CH_4 (%)	65
ESTIMATED H_2S (ppm)	3,000*
BIOGAS ENERGY, annual avg. (MMBtu/d)	1,190
BIOGAS ENERGY, peak month (MMBtu/d)	2,720

*ASSUMED



FLOW, AVG. (MG/y)	23.4
SOLIDS (%)	4

🟢 BATTERY LIMITS

REV	DESCRIPTION	DATE	DWN	CHKD	APVD	ECN

PRELIMINARY

DESIGNER S.TAYLOR DATE 2022-06-02
CHECKER DATE
ENGINEER S.ZELAYA DATE
MANAGER DATE
REF:
SCALE: NOT TO SCALE

TITLE PROCESS FLOW DIAGRAM

CLIENT WASTEWATER TREATMENT SYSTEM FOR PASCO PWRF FACILITY

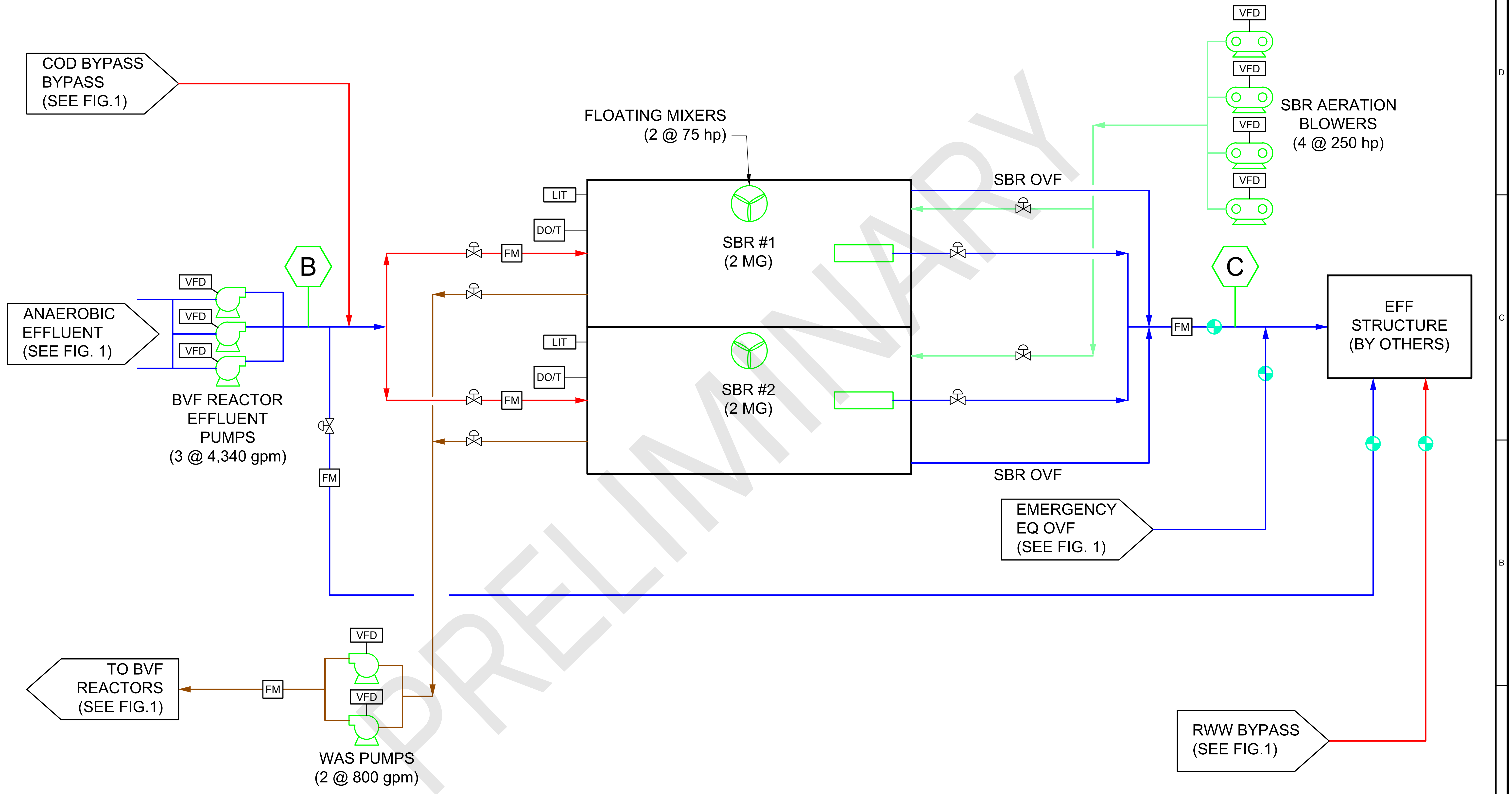
EVOQUA WATER TECHNOLOGIES
ADI SYSTEMS
370 WILSEY ROAD FREDERICTON, NB, CANADA
+1(506) 452-7307

PROJECT	CODE	DRAWING	SHEET	REV
6069000103		FIGURE 1	OF	0

Date Plotted: 12/07/2022 15:18 Plotted By: DE SOUZA, ANDRE A Last Saved By: ANDRE.DESOUZA F:\00486975 - PASCO CITY WA-PWRF BVF+SBR\PROP01\FIGURE 1 – PFD – PROCESS FLOW DIAGRAM.DWG
STD:11X17_B 0616 Border.dwg BAR = 1" AT PLOT SCALE

Date Plotted: 12/07/2022 15:53 Plotted By: DE SOUZA, ANDRE A Last Saved By: ANDRE.DESOUZA F:\00486975 - PASCO CITY WA-PWRF BVF+SBR\PROP01\FIGURE 2 – PFD – PROCESS FLOW DIAGRAM.DWG

STD:11X17_B 0616 Border.dwg BAR = 1" AT PLOT SCALE



⊕ BATTERY LIMITS

REV	DESCRIPTION	DATE	DWN	CHKD	APVD	ECN

PRELIMINARY

DESIGNER S.TAYLOR	DATE 2022-06-02
CHECKER	DATE
ENGINEER S.ZELAYA	DATE
MANAGER	DATE
REF:	
SCALE: NOT TO SCALE	

TITLE PROCESS FLOW DIAGRAM

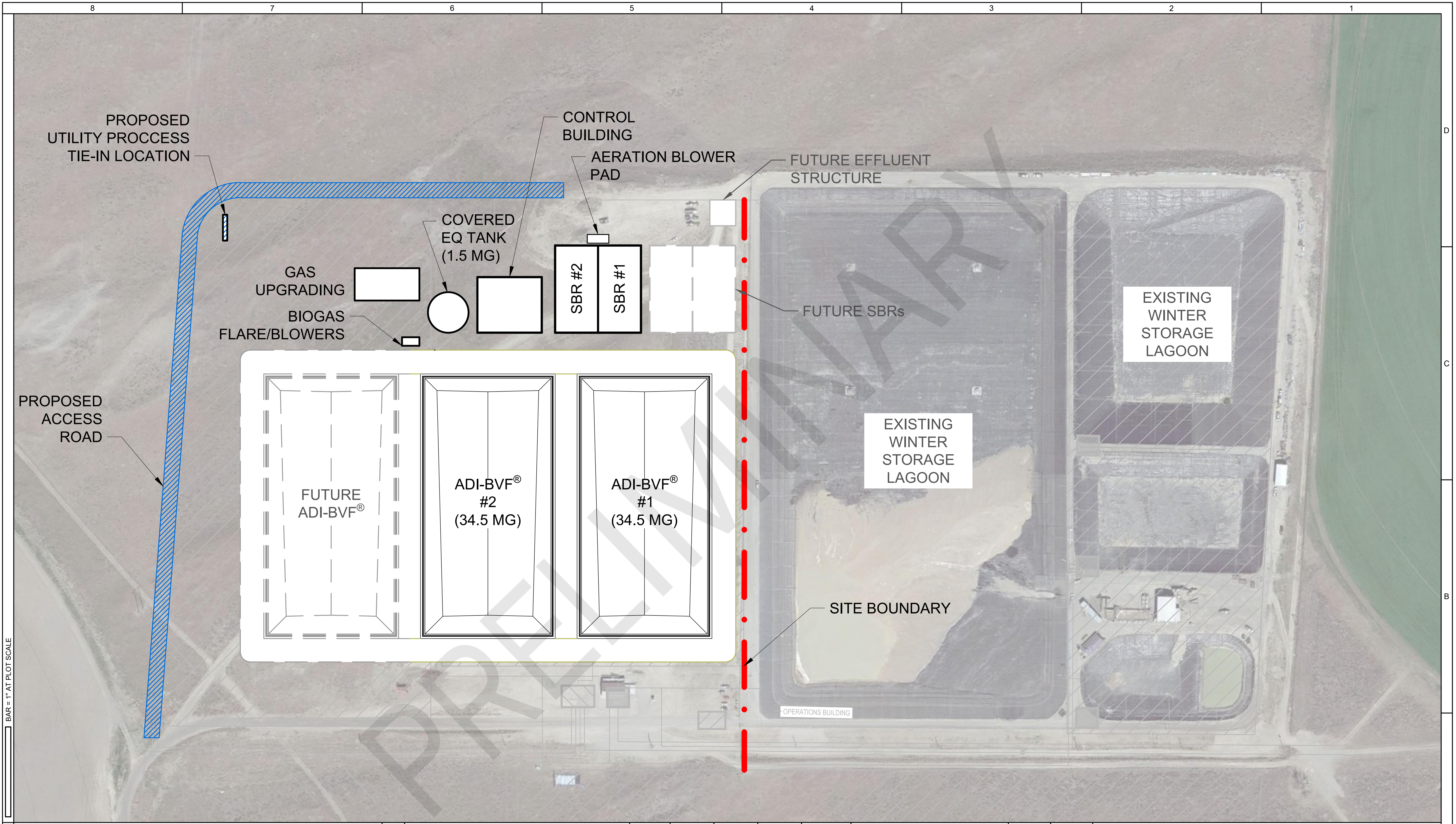
CLIENT WASTEWATER TREATMENT SYSTEM FOR PASCO PWRF FACILITY

evoqua
WATER TECHNOLOGIES

ADI SYSTEMS
370 WILSEY ROAD FREDERICTON, NB, CANADA
+1(506) 452-7307

PROJECT	CODE	DRAWING	SHEET	REV
6069000103		FIGURE 2	OF	0

APPENDIX C: PRELIMINARY SITE LAYOUT



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Date Plotted:29/06/2022 14:35 Plotted By: DE SOUZA, ANDRE A Last Saved By: ANDRE.DESOUZA

STD:11X17_B v4.11

BAR = 1" AT PLOT SCALE

REV	DESCRIPTION	DATE	DWN	CKD	APPD	ECN

DWN BY: A.DESOUZ
DATE 2022-06-28
CKD BY: ----
DATE ----
APPD BY: R.FRENET
DATE 2020-06-09
MGD BY: J.KILLAM
SCALE 1:2500
PART NUMBER

TITLE PROCESS FLOW DIAGRAM(S)
WASTEWATER TREATMENT SYSTEM
FIGURE 1: PRELIMINARY SITE LAYOUT

CLIENT PASCO
WA

evoqua WATER TECHNOLOGIES

EVOQUA WATER TECHNOLOGIES
FREDERICTON NB CANADA
+1(506) 452-7307

PROJ/PROD NUMBER	CODE	FILE/DRAWING NUMBER	SHEET	REV
1000035167	NEED CODE	V113346812	- OF -	A

A