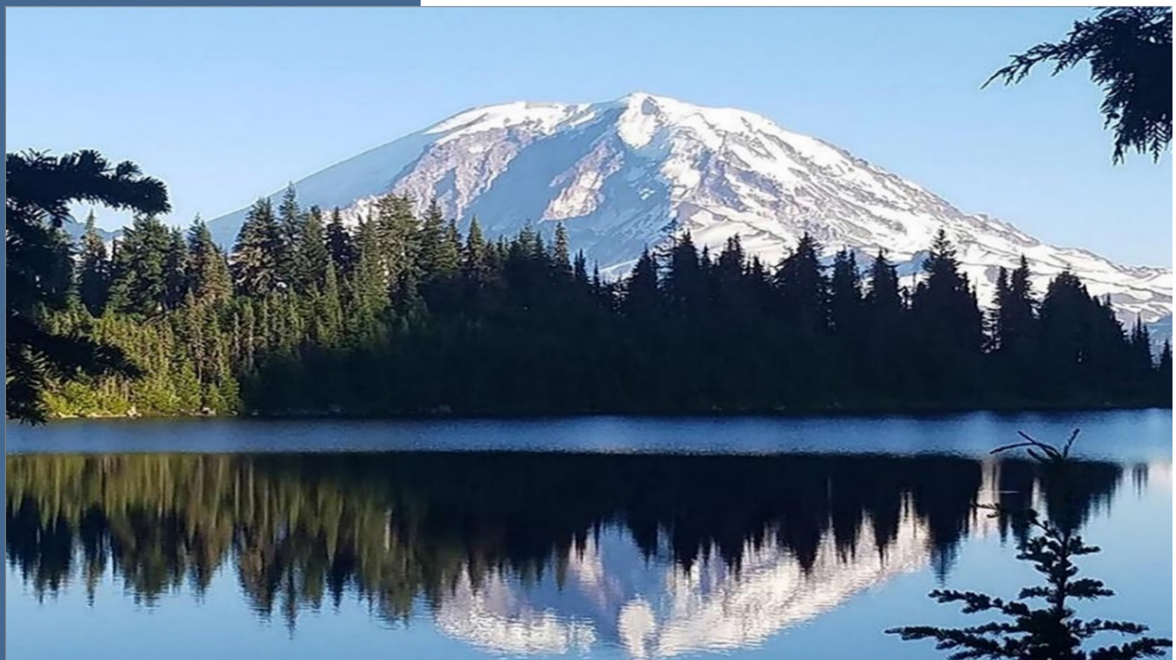

Quality Assurance Project Plan

Ellensburg ASR Feasibility Study Groundwater Level Monitoring

Grant No. WRYBIP-2123-EllePW-00028

For the

Office of Columbia River

Washington State Department of Ecology
Central Regional Office
Union Gap, Washington

August 2024, Publication 24-12-008

DEPARTMENT OF ECOLOGY State of Washington

City of Ellensburg WASHINGTON

Coho Water Resources
Integrated Water Resource Management

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For

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ADA Accessibility

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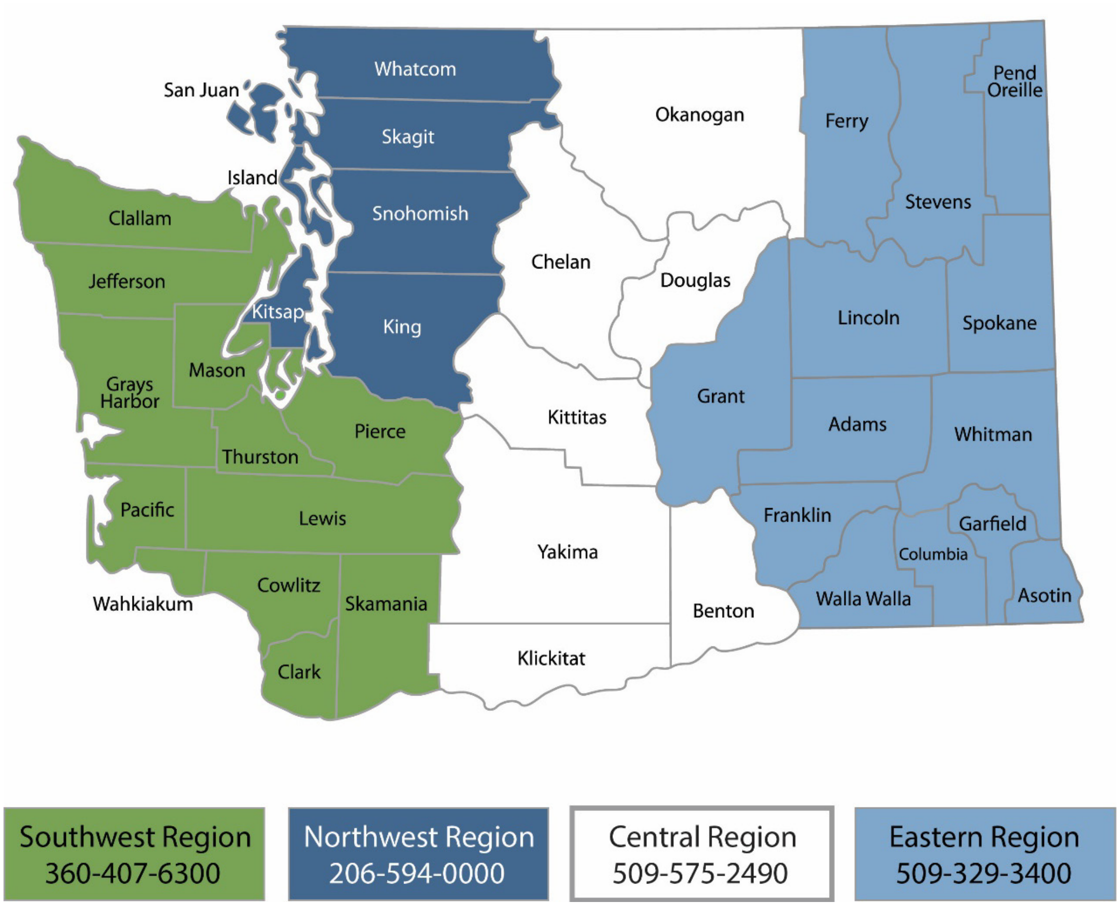
Department of Ecology's Regional Offices

Map of Counties Served



Region	Counties served	Mailing Address	Phone
Southwest	Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Mason, Lewis, Pacific, Pierce, Skamania, Thurston, Wahkiakum	PO Box 47775 Olympia, WA 98504	360-407-6300
Northwest	Island, King, Kitsap, San Juan, Skagit, Snohomish, Whatcom	PO Box 330316 Shoreline, WA 98133	206-594-0000
Central	Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, Yakima	1250 W Alder St Union Gap, WA 98903	509-575-2490
Eastern	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman	4601 N Monroe Spokane, WA 99205	509-329-3400
Headquarters	Across Washington	PO Box 47600 Olympia, WA 98504	360-407-6000

Quality Assurance Project Plan

Ellensburg ASR Feasibility Study
Groundwater Level Monitoring

August 2024

Approved by:

Signature: ______________________ Date 09/03/2024

Derek Mayo, City Engineer
City of Ellensburg

Signature: ______________________ Date 2024-08-17

Chris Pitre, Principal
Coho Water Resources

Signature: ______________________ Date 9/4/2024

Jeff Dermond
Office of Columbia River Project Manager

Signature: ______________________ Date 09/06/2024

Scott Tarbutton,
Office of Columbia River Quality Assurance Coordinator

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Acronyms and abbreviations.

amsl	above mean sea level
ASR	Aquifer Storage and Recovery
bgs	below ground surface
BOR	Bureau of Reclamation
cfs	cubic feet per second
City	City of Ellensburg
Coho	Coho Water Resources, LLC
Ecology	Washington Department of Ecology
EIM	Environmental Information Management
ft	feet
gpm	gallons per minute
GWSC	Groundwater Subcommittee
mA	Milliampere
mi	Mile
msl	mean sea level
psi	pounds per square inch
QAPP	Quality Assurance Project Plan
RM	River mile
RTU	Remote Terminal Unit
SCADA	Supervisory Control And Data Acquisition
SOP	Standard Operating Procedures
TRS	Township Range Section
TWSA	Total Water Supply Available
USGS	United States Geological Survey
YBIP	Yakima Basin Integrated Plan

1. Background and Project Description

Background information is compiled in the Aquifer Storage and Recovery (ASR) pre-feasibility study (Pitre and Wilhelm, 2021).

1.1. Problem statement and introduction

Problem Statement: Original pervasive flowing artesian conditions in the Kittitas Valley have largely dissipated due to pumping of groundwater (Appendix D), which has:

- Reduced cold water seeps to the Yakima River that were critical habitat to salmonids.
- Lowered groundwater levels limiting production from City of Ellensburg drinking production wells.
- Reduced groundwater seepage to the Yakima River thereby reducing Total Water Supply Available (TWSA[2]).

Introduction: Approximately 60,000 acre-feet per year (afy) is pumped from the Kittitas Valley floor, which includes all the Upper Ellensburg Formation in the Kittitas Valley and may include deeper basalt wells (Pitre and Wilhelm, 2021). The City of Ellensburg (City) pumps approximately 5,000 afy. The groundwater storage capacity is estimated to be 61,300-137,000 afy (Pitre and Wilhelm, 2021). Maintaining groundwater storage by ASR or reduction of deep groundwater pumping will: improve aquatic habitat downstream of river mile 148 (e.g., cold water seeps); improve the reliability of municipal water supply; and increase TWSA.

The City obtains municipal water supply from two distinct sources (Figures 1, 2 and 3):

1) "City Wells", a shallow (~20-foot deep) infiltration gallery that is in close hydraulic continuity with the Yakima River. This is the anticipated source of recharge water for an ASR program.
2) Approximately nine deep municipal drinking water wells are completed in the sedimentary Upper Ellensburg Formation. These are candidate wells through which water may be recharged.

This study will inform the feasibility study for the City of Ellensburg ASR program, which will analyze relevant components of ASR, including: hydrogeology; water quality and potential treatment needs; distribution system hydraulics; engineering and well performance; and legal, permitting and water rights issues.

[2] Defined in the 1945 Consent Decree, U.S. District Court, 1945. When TWSA is insufficient to meet water demand served by the Bureau of Reclamation (i.e., "Junior" rights), Junior water rights are curtailed.

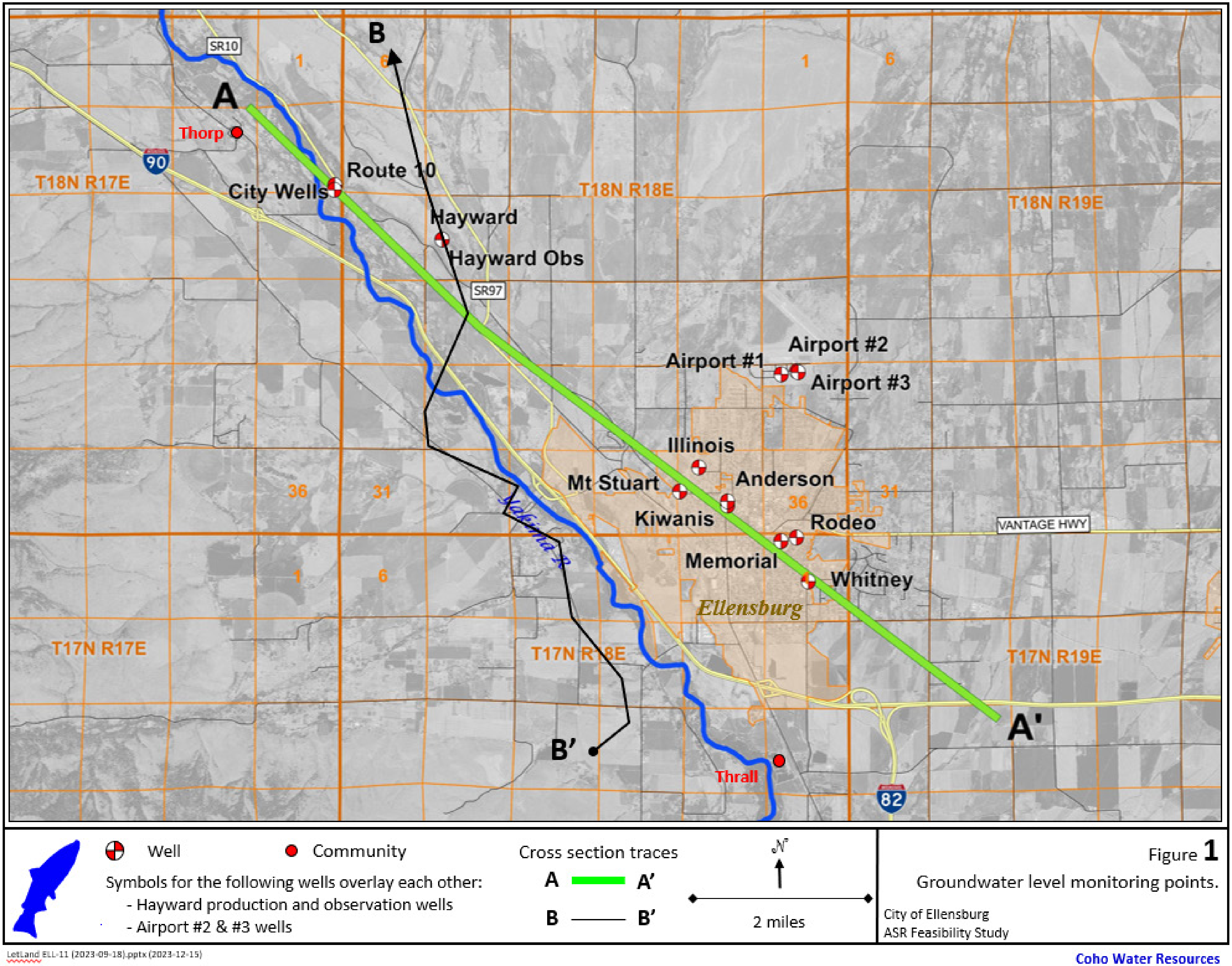

Figure 1: Groundwater level monitoring points.

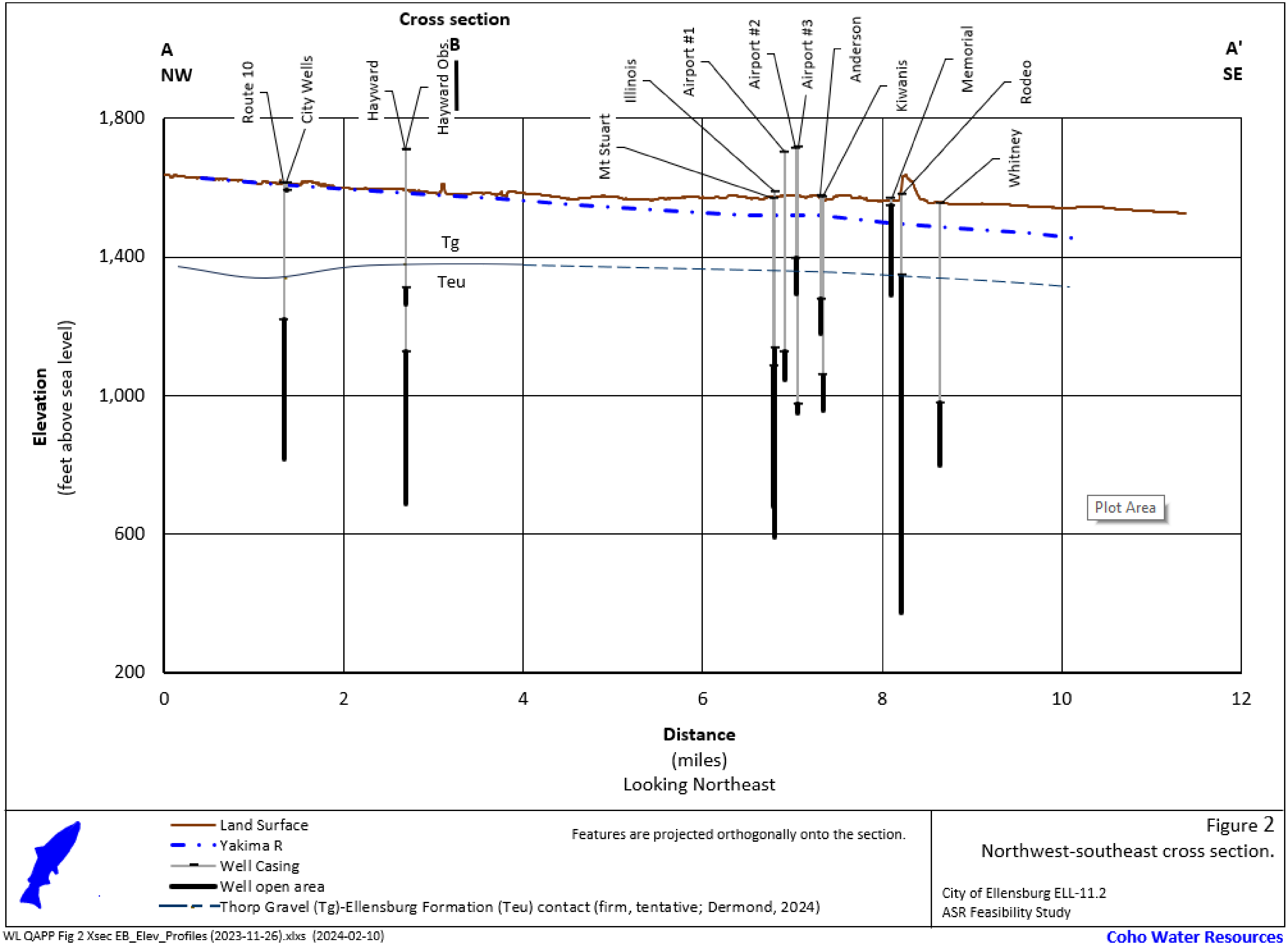

Figure 2: Northwest-southeast cross section.

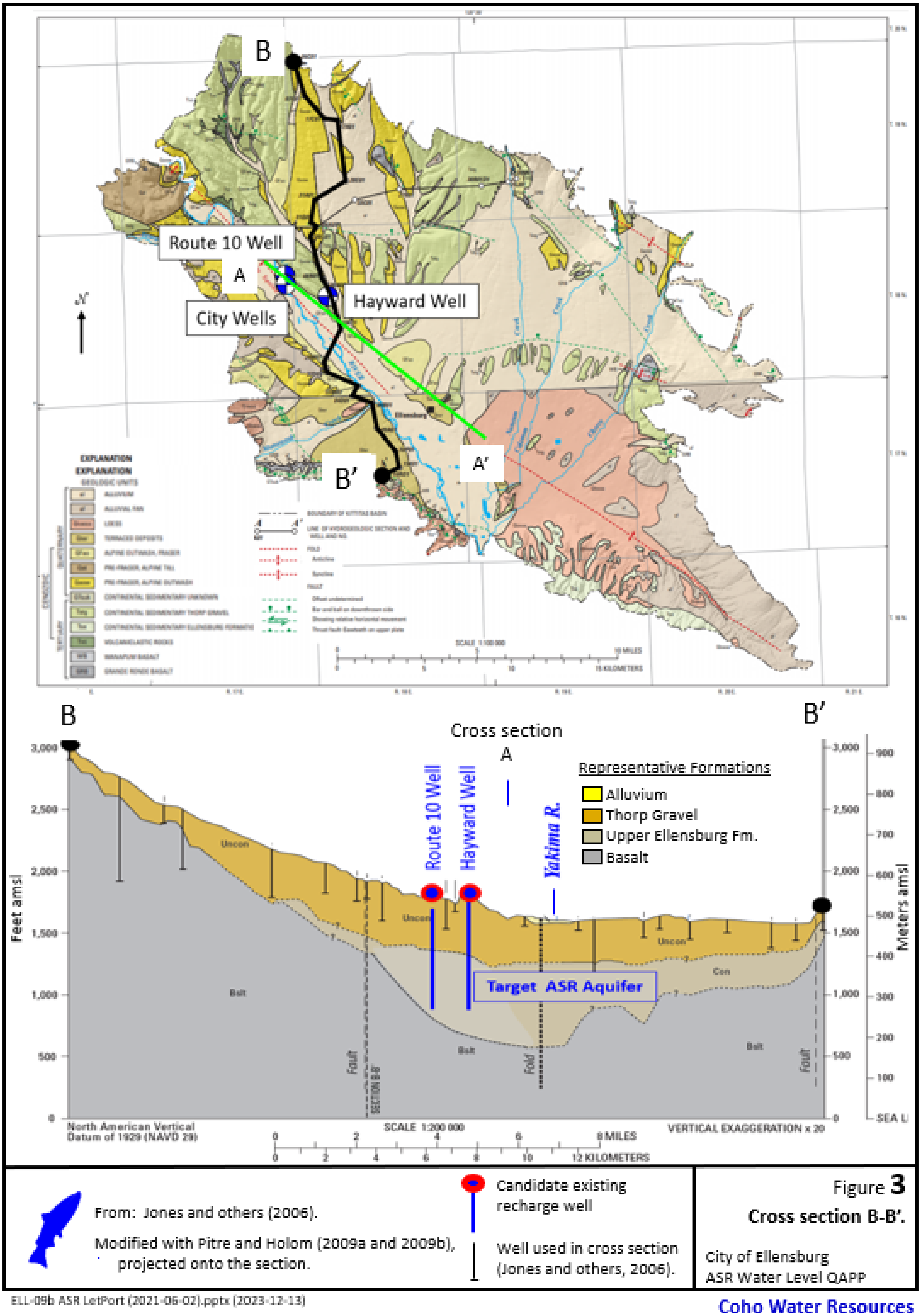

Figure 3: North-south cross section.

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The objective of the work described in this QAPP is to collect groundwater level data to extend the baseline and refine estimates of:

- Groundwater flows paths.
- Aquifer groundwater level response to seasonal climate patterns, groundwater pumping, and potential recharge activities.
- Groundwater storage potential.
- Residence time of recharged water.

1.2. Study area and surroundings

As shown in Figures 2 and 3, the major geological formations in the Kittitas Valley are:

- Alluvial/fluvial sediments: Locally distributed thin surficial veneer, principally along streams.
- Thorp Gravel: Surficial. Low permeability. Up to 400 feet thick. Laterally extensive.
- Upper Ellensburg Formation: **The target ASR aquifer**. Semi-consolidated volcaniclastic sediments valley fill of Cascade Range provenance. Over 1,000 feet thick in the middle of the valley.
- Basalt: Forms the surrounding ridges and underlies the Upper Ellensburg Formation. Forms the effective base of the groundwater system in the context of this project.

The Kittitas Valley hosts a well-developed agricultural economy, the City of Ellensburg, and Central Washington University. The 2020 census population of the City is 20,797 (Washington State Office of Financial Management, 2023). The 2020 water service population reported in the water system plan being reviewed by the Washington Department of Health is 21,723 and is projected to grow 60% to 34,588 by 2040. Operationally, the current water supply system is taxed to meet current demand.

The Yakima River flows northwest to southeast through the valley and is the conduit for delivering agricultural irrigation water by the United States Bureau of Reclamation from reservoirs in the Upper Yakima Basin to irrigators in the Lower Yakima Basin. Numerous smaller streams flow from the edges of the Kittitas Valley, across the valley floor to the Yakima River.

1.3. Summary of previous studies and existing data

The City considered ASR in the early 2000s. Knowledge of the valley's hydrogeology at that time did not support proceeding with further evaluation, primarily because municipal drinking water well installations consistently produced wells with yields on the order of 700 gpm. Wells of such yield limited the practical implementation of ASR.

Wells installed since 2000 have yields from 1,000 to 2,500 gpm. The difference in well yields installed since 2000 is primarily a function of drilling methods. Recent hydrogeological studies, including analyses for processing water right applications (e.g., GWC-926 and G4-33267) have also produced a better understanding of the hydrogeology and indicate potentially favorable conditions for ASR. This improved understanding is compiled and clearly presented in the ASR prefeasibility study (Pitre and Wilhelm, 2021).

Simply stated, the Kittitas Valley consists of a synclinal basalt bowl filled by sediments into which the Yakima River flows into near Thorp and flows out of near Thrall (Figure 1). The sediment fill of the valley has been studied over the years for general understanding (e.g., academic) and for specific purposes (e.g., oil prospecting and seismic risk) (see Pitre and Wilhelm [2021] for references). The main features of the better understanding of the sedimentary hydrogeology relevant to ASR are better definitions of:

- The stratigraphy.
- Variation of aquifer properties.
- The pumping regimen within the valley.

1.4. Parameters of interest

This QAPP addresses the collection of groundwater level elevation data.

1.5. Project description

A record of groundwater levels across the study area over time is important for the assessment of ASR feasibility for the City of Ellensburg. The target aquifer for ASR is the Upper Ellensburg Formation, which is over a thousand feet below ground surface over much of the basin. Installation of purpose-built monitoring wells would be expensive. Therefore, existing wells are used for this phase of the project.

1.6. Project goals and objectives

The goal of this study's groundwater level monitoring is to help evaluate the feasibility of ASR in the Kittitas Valley. An extended groundwater level record will refine the understanding of influences on groundwater storage (e.g., seasonal influences, recharge from precipitation and discharge to the Yakima River, groundwater pumping in the valley, inter-well pumping interference). This study may also help address:

- The sensitivity of groundwater levels to climate conditions.
- The variability of hydraulic continuity within and between aquifers, and between aquifers and surface water bodies.
- Locations in the aquifer that have higher transmissivity or storage that may affect the feasibility of an ASR project.
- The possible presence of geologic structures that influence groundwater flow (e.g., faults).

The collected data may be used for calibration and/or validation of future groundwater flow modeling. The information will also be used to inform ASR well selection and design of recharge facilities.

1.7. Information needed and sources

Data that will be generated through the study are:

- Depth to, and absolute elevation of, groundwater at monitoring points in the project area.

Data that will be gathered through other sources are:

- Web-based stage and flow data from the United States Geological Survey (USGS) and United States Bureau of Reclamation (BOR).
- Well logs, well installation and pumping test reports.
- Barometric pressure and precipitation from the Kittitas County Bowers Field airport.

1.8. Tasks required

Specific activities planned for the study are:

- Retrofit wellheads to accommodate and secure transducer installations.
- Install and maintain pressure transducer dataloggers.
- Continuously collect groundwater data using pressure transducer dataloggers for the duration of the project at the specified monitoring points.
- Download data on approximately a quarterly schedule, together with collecting manual depth to water measurements as back up to and calibration of transducer data, and conducting maintenance on monitoring equipment (e.g., ensuring adequate battery power, securing against vandalism).
- Incorporate historical water level data from various sources (e.g., city, USGS, Ecology, well logs).
- Acquire stage and streamflow data for nearby reaches of the Yakima River from USGS and BOR web sites to support source water quality analysis.
- Acquire barometric pressure and precipitation data from the Bowers Field.
- Process, interpret and present the data.
- Prepare a data analysis report.

1.9. Systematic planning process used

The QAPP is the systematic planning process for the study.

2. Organization and Schedule

Derek Mayo of the City of Ellensburg (City) has overall fiscal oversight and contract management responsibility under the grant contract with Ecology. Chris Pitre of Coho serves as the technical project manager on the Project.

Table 1 presents key personnel, role, and responsibilities.

Table 1: Key individuals and Responsibilities.

Individual	Role	Responsibility
City of Ellensburg		
Derek Mayo (509) 962-7101 mayod@ci.ellensburg.wa.us	City Engineer	Contracting and budget coordination with Ecology and Coho.
Mike Helgeson (509) 962-7133 helgy@ci.ellensburg.wa.us	Assistant Public Works Director	Coordination of City staff and Coho field work.
Russ Palmer (509) 306-9001 palmerr@ci.ellensburg.wa.us	Plant maintenance.	Facilitate Coho access to wells.
Coho Water Resources		
Chris Pitre (206) 406-9596 chris@cohowr.com	Lead Hydrogeologist	Licensed Hydrogeologist. Technical team lead, equipment manager, data interpretation, report writer.
Sherry Wilhelm (206) 276-2293 sherry@cohowr.com	Managing Principal	QA/QC and coordinator, technical editor.
Independent Contractor		
Marina Pitre (206) 554-1788 Marina172@gmail.com	Scientist	Field technician, data processing, data presentation, data upload to EIM.
Central Washington University		
Carey Gazis (509) 963-2820 carey.gazis@cwu.edu	Professor	3rd party review.
Ecology		
Jeff Dermond (509) 268-1784 jder461@ecy.wa.gov	Project Manager	Project management, technical review, and team coordination and facilitation.
Scott Tarbutton (509) 867-6534 scta461@ecy.wa.gov	Quality Assurance Coordinator	QAPP review and approval.

2.1. Special training and certifications

Individuals performing project tasks will be trained in and experienced with the standard operating procedures and will be experienced with transducer maintenance, installation, downloading and data interpretation. As required by WAC 173-157-110, the description of the hydrogeologic system will be prepared by Chris Pitre, a Washington State Licensed Hydrogeologist (license number 1439).

2.2. Funding & Budget

This project is funded by the Yakima Basin Integrated Plan, via a Washington State Department of Ecology (Ecology) Office of Columbia River agreement with the City of Ellensburg (Agreement No. WRYBIP-2123-EllePW-00028).

2.3. Proposed project schedule

Table 2: Project schedule.

Project Schedule	Task
02/29/2024	Approval of QAPP.
Between 02/29/2024 and 06/30/2025.	Retrofits and expansion of monitoring network. Data downloads, manual measurements, maintenance.
09/30/2025	Draft report.
11/30/2025	Final report.
12/31/2025	EIM data entry, final report

3. Quality Objectives

The primary data quality objective (DQO) is to collect groundwater measurements to render a three-dimensional understanding groundwater flow in the aquifer system. Equipment specifications are provided at the following links and listed in Table 5:

Transducer and dataloggers (specification sheets are contained in Appendix C):

- GDL data logger: https://www.seametrics.com/wp-content/uploads/gdl.pdf
- GL500-2-1 Data Logger: https://www.fondriest.com/global-water-gl500-2-1-data-logger.htm.
- Seametrics PT2X transducer: https://www.seametrics.com/product/pt2x/
- Seametrics LevelSCOUT transducer: https://www.seametrics.com/product/levelscout/
- Van Essen MicroDiver transducer: https://www.vanessen.com/products/data-loggers/micro-diver/

Download cables:

- MicroDiver download cable: https://www.vanessen.com/products/accessories/diver-smart-interface-cable/
- Geotech download cable: https://www.seametrics.com/product/sensor-accessories/

Software:

- Aqua4Plus software: https://www.seametrics.com/aqua4star-2-software/?gad_source=1&gclid=EAIaIQobChMIj5_tz-6MhAMVnCCtBh014QXXEAAYASAAEgIYT_D_BwE.
- Van Essen software: https://www.vanessen.com/products/software/diver-office/.

Depth to groundwater will also be measured manually during quarterly transducer downloads using a water level meter/sounder (e.g., Solinst Model 102; Waterline Envirotech, Model 500; Powers Electric Company, 400-feet) Barometric pressure and precipitation data will be collected from the Bowers Airfield.

3.1. Measurement quality objectives (MQOs)

Groundwater level data will be collected at a minimum of 1-hour resolution. Data logger and manual water level measurements will be at a resolution of 0.1 foot or better.

The resolution of data from the City's SCADA system is limited by the measuring units of the loggers storing the data. Newer wells (e.g., the Route 10, Hayward, Illinois and Airport 3 Wells) store data through a Zetron RTU model 1708 or 1716 at a 12 bit resolution (4,095 potential values, a resolution of roughly 0.02 feet, which meets MQOs). Data from the older wells are stored into 8 bit unsigned integers (256 potential values, a resolution of roughly 0.4 feet, which does not meet MQOs and will not be used for this study).

Water level data are collected 4-20 mA water level signals from strain gage transducers as feet of water above the transducer, and converted to feet below ground level by subtracting the reading from the depth below ground level the at which the transducer is installed.

Total flow is calculated by converting a 0 to 5 volt pulse signal sent by the flow meter (e.g., every 1,000 gallons).

Transducer data will be verified with manual measurements to an accuracy of 0.01 foot. Data will be downloaded approximately quarterly (i.e., ~every three months) and will be viewed in the field and compared to the manual measurements to identify problems or drift. Inconsistencies will be attempted to be quickly resolved. This may involve replacement of equipment.

Standard operating procedures (SOPs) will comply with Marti (2023) and Sinclair and Pitz (2019).

Quarterly transducer download is considered a reasonable balance between effort and cost, and maintenance of data integrity that may be compromised by equipment malfunction, vandalism or other causes. Transducers that record measurements continually (i.e., hourly or better) will allow us to observe changes that might occur in shorter timeframes. Groundwater fluctuations are expected to occur seasonally in response to precipitation, snowmelt and irrigation pumping.

Well site survey information will be determined using lidar.

3.2. Completeness

Calibrated and maintained equipment will be used to ensure data completeness. Data logger measurements will be corrected and compared to manual measurements. Data loggers that are not collecting high quality complete data will be replaced. The study goal is to correctly collect and analyze 100% of the measurements and samples. However, problems occasionally arise during sample collection that cannot be controlled, so continuity of 95% will be considered functionally complete. Example problems are measurement drift, or equipment and operator failure.

3.3. Acceptance criteria for quality of existing data

Existing data has been plotted and reviewed and no inconsistencies have been identified.

4. Study Design

4.1. Study boundaries

The study area is within the floor of the Kittitas Valley (Figure 1).

4.2. Data collection

Wells in the monitoring network are listed in Table 3 and Table 4, and shown in Figures 1 and 2.

Data will be collected in the following ways:

1) Using existing transducers in production wells: The City's drinking production wells have transducers for operational purposes that are integral to their SCADA system. The SCADA consists of an older system with limited functionality that is being upgraded as new wells are outfitted. The older system stores data at a lower resolution (8 bit integers, ~0.4 ft; see Section 3.1) than desired, whereas the new system is of sufficiently high resolution (~0.02 ft) for this project's purposes.
    i. Data from older wells will be logged with a datalogger wired into the City's SCADA system at the wellhead, or a second transducer may be installed in the well to collect data for this project.
    ii. Data from newer wells will be downloaded from the City's SCADA system upon demand.
2) Using transducers installed for this project: Transducers will be installed in wells where there is no transducer as part of the City's SCADA system and in older production wells that are not instrumented with a datalogger at the wellhead (Table 5). Examples are irrigation wells, observation/monitoring wells and non-operational wells.
3) Barometric pressure correction for all transducers will be performed using data from Bowers Field, a regional airport that is centrally located in the study area. Past work in this region used site-specific barologgers over the course of several months, which yielded data of no significant difference from Bowers Field.

Data collection point instrumentation is presented in Table 6.

Table 3: Data collection point locations.
(from NW to SE)

Well	TRS ¼-¼ / ¼	Longitude	Latitude	Kittitas County Parcel	Address
City Wells	T18N/R17E-12 SE/SE	-120.6471265	47.05862847	18-17-12040-0003	W of Rt. 10, N of where the BNSF RR crosses the Yakima R.
Route 10	T18N/R17E-12 SE/SE	-120.6470269	47.05943504		
Hayward Prod.	T18N/R18E-17 NW/SW	-120.6201521	47.05012973	18-18-17000-0042	Passmore Rd.
Hayward Obs.	T18N/R18E-17 NW/SW	-120.6199077	47.04989386		
Mt Stuart	T18N/R18E-35 SW/NW	-120.5605877	47.00703356	18-18-35023-0003	N of W 15th Ave/W Dry Creek Rd; W of Mt Stuart Elem. School
Illinois	T18N/R18E-35 NW/NW	-120.5557995	47.01115195	18-18-35022-0005	2100 N Cora St.
Airport #1	T18N/R18E-25 NW/NW	-120.5352086	47.02709061	18-18-25068-0028	Beech Rd. between Elmview and Falcon Rds.
Airport #2	T18N/R18E-25 NE/NW	-120.5313163	47.02763997	18-18-25068-0046	3020 N Piper Rd.
Airport #3	T18N/R18E-25 NE/NW	-120.5309211	47.02746528		
Anderson	T18N/R18E-35 NW/SE	-120.5486093	47.00534389	18-18-35042-0011	N 'A' St and 14th Ave. (SE corner)
Kiwanis	T18N/R18E-35 NW/SE	-120.5486192	47.00462607	18-18-35042-0013	N 'A' St and 14th Ave. (SE corner)
Memorial	T17N/R18E-01 NW/NW	-120.5352302	46.9985435	17-18-01056-6103	Memorial Park, S of E 7th Ave. & N Poplar St
Rodeo	T17N/R18E-01 NE/NW	-120.5313604	46.99916238	No parcel number	Kittitas County Fairgrounds
Whitney	T17N/R18E-01 SW/NE	-120.5283891	46.99162485	17-18-01061-0103	120 E Capitol Ave.

Table 4: Well construction.
(See Figure 2. Well logs are in Appendix A. From NW to SE.
All wells are municipal drinking water wells unless otherwise noted.)

Well	Completion Date	Production Casing Diameter (inches)	Top of screen (ft bgs)	Bottom of screen (ft bgs)	Depth (ft bgs)
City Wells	1913	120	20	23	23
Route 10	9/24/2009	20	393	798	841
Hayward	6/5/2009	20	581.5	1,021.5	1,055
Hayward Observation Well	5/21/2009	8	401	446	446
Mt Stuart	3/21/1978	12.5	485	890	1,200
Illinois	9/10/2019	30	453	997	1,007
Airport #1	7/4/1943	12	580	660	730
Airport #2	9/24/1959	10	316.5	420	420
Airport #3 (modified)	11/28/2011 (10/26/2016)	12	741	766	767
Anderson (irrigation well)	7/31/1931	8	300	400	400
Kiwanis	10/29/1987	20	515	615	617
Memorial	1931	10	22.5	281.5	303
Rodeo	1/1/1946	16	232	1205	1205
Whitney	5/11/1988	20	573	757	761

Table 5: Transducers.
(unvented)

Model	Pressure Range (psi)	Accuracy	Resolution	Cable Length (feet)
LevelSCOUT	30	± 0.10% FS	0.0034% FS	Not cabled. Suspended by wire.
PT2X	30	± 0.10% FS	0.0034% FS	85
	100	± 0.10% FS	0.0034% FS	100
		± 0.10% FS	0.0034% FS	200
MicroDiver DI610	100	± 0.3 ft H_2O	0.06 ft H_2O	Not cabled. Suspended by wire.

Table 6: Data collection instrumentation.
(from NW to SE)

Well	Well Tag on Well	Comments	Instrumentation
City Wells	AFL 853	No comment.	LevelSCOUT
Route 10	BNJ 165 [b]	No comment.	SCADA
Hayward prod.	BNJ 164 [b]	No comment.	SCADA
Hayward obs.	AAS 273	Housing to be installed to secure equipment against vandalism.	PT2X
Mt. Stuart	AFK 920	Data logger to be wired in series with existing transducer.	GL500-2-1
Illinois	AAR 986 [c]	No comment.	SCADA
Airport #1	AFL 851	Well not currently in production.	MicroDiver
Airport #2	BNJ 163	Well not currently in production.	PT2X
Airport #3	BCF 685	No comment.	SCADA
Anderson	BNJ 162	Operated by the City's Parks Department for summer irrigation of Kiwanis Park.	LevelSCOUT
Kiwanis	ABR 092	Data logger wired in series with existing transducer.	GDL
Memorial	AFK 917	No comment.	MicroDiver
Rodeo	AFK 918	Data logger wired in series with existing transducer.	GDL
Whitney	AFK 916	Data logger wired in series with existing transducer.	GDL

[a] As of 2024-02-08. Equipment may be relocated and/or replaced as the project proceeds.

[b] Original well tags on Route 10 (AAS 152) and Hayward (AAS 252) production wells recorded on well logs filed with Ecology and with the Washington Department of Health were replaced during well house construction.

[c] Needs confirmation.

SCADA = Supervisory Control And Data Acquisition system

4.2.1. Sampling locations and frequency

Fourteen groundwater monitoring wells have been identified for monitoring (Figures 1 and 2). For ease of access, only wells that are the property of the City were selected. If significant data gaps become apparent, additional wells may be added to the monitoring network. Transducers will be programmed to record data hourly. Approximately quarterly manual measurements and data logger downloads will be scheduled. Streamflow monitoring by the BOR and USGS will also be sourced through the Web to support source water quality analysis and to address component 7 of the hydrogeologic system description required by WAC 173-157-120.

4.2.2. Field parameters to be measured

Manual measurements of groundwater level will be made approximately quarterly at transducer downloads.

4.2.3. Data analysis

The primary purpose of data collection is to characterize water level fluctuations across the aquifer system being monitored and to establish baseline data for future basin-scale studies. Except in the case of pumping tests at the proposed ASR injection site, analysis will be qualitative, such as:

- Seasonal variability and variability between years as compared to historic data from the City.
- Recovery of water levels from seasonal pumping.
- Interwell interference.

Graphical quantitative analysis will be applied but may be limited due to uncontrolled pumping conditions (e.g., Cooper and Jacob, 1964).

Specific capacities of wells will be calculated where sufficiently detailed pumping records allow.

Consistency of water level data with previous groundwater mapping will be discussed (e.g., Vacarro and others, 2009).

4.3. Assumptions in relation to objectives and study area

We assume that the depth-to-groundwater measurements represent the groundwater level in the screened intervals of the wells.

4.4. Possible challenges and contingencies

The City of Ellensburg will retrofit wellheads to allow installation of transducers and protect transducer installations from vandalism. Vandalism of equipment may create data gaps in the collected record. Equipment failure may also result in data gaps in the water level record. Failed equipment will be replaced.

Many of the wells are operating drinking water production wells with equipment already installed in them. Entanglement of transducers or water level sounders inserted into the wells for this project with equipment already in the wells may occur. Inserting any equipment into a well for this project will be done carefully. It is possible that irrecoverable entanglement may happen, and equipment may be lost. Contingencies will have to be evaluated on an individual basis.

4.5. Logistical problems

Access to the monitoring points in well houses and controlled properties requires coordination between City and consultant staff. No problems are anticipated.

4.6. Practical constraints

No practical constraints are recognized beyond those already addressed (e.g., equipment failure, monitoring site access).

4.7. Schedule limitations

Implementing the groundwater level monitoring network as soon as possible will provide the best record to inform the project. Data collection will proceed continuously throughout the duration of the project.

5. Field Procedures

Procedures for establishing field sites and groundwater level measurements are given in and are the default practices where not otherwise described in this QAPP:

- Standard Operating Procedure EAP 074, Version 1.2 for Submersible Pressure Transducers for Groundwater Studies (Sinclair and Pitz, 2019).
- Standard Operating Procedure EAP 052, Version 1.4 for Manual Well-Depth and Depth-to-Water Measurements (Marti, 2023).
- Appendix B Groundwater monitoring guidance

A field log will be maintained to record manual groundwater level measurements and surface water stage gage measurements each site visit where data is downloaded from the data loggers. The field log will include the following information:

- Name and location of project
- Field personnel
- Timing of events (logger removal and reinstall, downloading, measurements)
- Any changes or deviations from the QAPP
- Environmental conditions
- Condition of the transducer (e.g., remaining memory, battery power, mineral staining on the cable).
- Date, time, well and logger IDs (e.g., transducer serial number).
- For each well, field measurement results below established measuring point, depth to water.
- Any observations or unusual circumstances that might affect interpretation of results. This will include observations of surface water conditions (e.g., water in tributaries, irrigation on neighboring properties, surface water ponding, well pumping conditions

including that of nearby wells).

The downloaded pressure transducer data will be corrected using regional barometric pressure data from Bowers Field to obtain depth-to-water and/or absolute water level elevation measurements and the data for each well will be plotted. All data processing, treatment of anomalous data, and corrective actions will follow the procedures outlined in sections 6.9 and 6.10 of Sinclair and Pitz (2019).

6. Quality Control

Several physical quality control (QC) procedures will be observed.

Prior to field data collection, etape calibration will be performed following section 6.7 of Marti (2023).

At the first visit to each monitoring well, a handheld GPS unit will be used to either establish or verify latitude, longitude, and elevation above MSL. The measuring point for each well will be established and measured relative to land surface. These procedures will be conducted in accordance with the guidelines in sections 6.3-6.5 of Marti (2023) and section 6.4 of Sinclair and Pitz (2019).

To prevent groundwater contamination, all equipment that is deployed into a well will be disinfected as outlined in section 6.6 of Marti (2023).

The main QC procedure that will be applied to depth-to-groundwater data will be to compare pressure transducer data to manual measurements.

For each well, the logger measurement closest in time to the manual measurement value will be compared. Data will also be checked for completeness and any improbable values. If there is a discrepancy of >0.1 ft, missing data, or improbable values, corrective action will be taken unless otherwise accounted for (e.g., the well is a pumping production well).

If QC results indicate problems with data during the project, options for corrective actions include:

- Repeat manual measurement of depth-to-water.
- Comparison of data between nearby wells to qualify or reject results.
- Replace a faulty transducer if there is evidence of mid-deployment failures.

7. Data Management Procedures

7.1. Data recording and reporting requirements

All field data will be recorded in a field notebook. Field notebooks will be checked for missing or improbable measurements before leaving each site. Field-generated data will be entered into Microsoft (MS) Excel® spreadsheets after returning from the field. Data entry will be checked by the field assistant against the field notebook data for errors and omissions. Missing or unusual data will be brought to the attention of the project manager for consultation.

Raw data from transducers and data loggers will be processed according to the flow chart presented in Figure 8 of Sinclair and Pitz (2019). The original raw data files will be backed up to protect against hardware failure.

Results of quality control checks and calibrations will be recorded on electronic forms to allow for quality assurance review. Quality assurance records will be maintained until Ecology's final approval of the project report so they may be accessed for post-project analysis and audits.

7.2. Data upload procedures

Data will be transferred to Ecology's Environmental Information Management (EIM) system before the end of the project per online submittal guidelines under EIM Study ID: WRYBIP-2123-EllePW-00028. The EIM data coordinator will be consulted if data submittal problems arise. The field technician will complete EIM training offered by Ecology and follow Ecology business rules and the EIM User's Manual for loading, data quality checks, and editing.

7.3. Data verification

The data will be verified by following the procedures described in Sinclair and Pitz (2019). These procedures are summarized below:

- Compare the converted transducer values against their corresponding manual water level values to confirm that the transducer measurements are within the acceptable accuracy range.
- If the transducer results do not meet project acceptance criteria apply drift corrections as appropriate and reassess the drift corrected transducer results against the manual confirmation measurements.
- Assess the overall data quality and assign the appropriate water level method, accuracy code, and data qualifier(s) (if any), to individual transducer results.
- Based on the above analysis either:
    1) Accept each individual transducer results for use.
    2) Assign additional data qualifiers, if warranted.
    3) Reject the transducer results as unusable.

For field measurements, the field lead will verify initial field data before leaving each site. This process involves checking the data sheet for omissions or outliers. If measurement data are missing or a measurement is determined to be an outlier, the measurement will be repeated.

After field data are verified, the data will be thoroughly examined to determine if MQOs have been met. The project manager will examine the data to determine if all the criteria for MQOs, completeness, representativeness, and comparability have been met. If the criteria have not been met, the project manager will decide if affected data should be qualified or rejected. The project manager will decide how any qualified data will be used in the technical analysis.

8. Reporting and Field Activity Assessments

The summarized data collected under this QAPP, in combination with new water quality data and data compiled in Pitre and Wilhelm (2021), will be presented in a formal peer-reviewed ASR feasibility report that includes results, methods, and data quality assessment. Water level data collected under this QAPP will help describe the ASR target aquifer, assess potential injection sites, and inform components 1-4 of the broader hydrogeologic system description required under WAC 173-157-120. A draft report will be submitted to Ecology for review by September 2025. A final report will be submitted to Ecology by November 2025.

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