Quality Assurance Project Plan

Springwood Geotechnical Exploration Plan

July 2025

Agreement No. WRYBIP-2325-KittRD-00052

Publication 25-12-012

Publication Information

Each study conducted for the Washington State Department of Ecology (Ecology) must have an approved Quality Assurance Project Plan (QAPP). This QAPP describes the objectives of the Proposed Springwood Geotechnical Exploration Project.

The final completed QAPP is available at
https://apps.ecology.wa.gov/publications/SummaryPages/2512012.html.

Data for this project will be available on Ecology's Environmental Information Management (EIM) website: https://fortress.wa.gov/ecy/eimreporting/default.aspx; at www.data.wa.gov; and from Project Proponent Kittitas Reclamation District at 509-925-6158. In EIM, search Study ID: WRYBIP-2325-00052.

This QAPP is valid through July 2030.

COVER PHOTO: Springwood Reservoir Site. PHOTO BY JACOBS.

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Agreement No. WRYBIP-2325-KittRD-00052

by Maria Daugherty, Belal Hossen, Brett Campbell, Sharonne Park

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1.0 Abstract

This Quality Assurance Project Plan (QAPP) addresses the scope of the proposed geotechnical explorations at the Springwood Reservoir site to support the Upper Yakima System Multi-Benefit Water Storage (UYSS) Project using funds provided by the Washington State Department of Ecology (Ecology) Grant (Agreement No. WRYBIP-2325-KittRD-00052). The overall goal of the UYSS Feasibility Study is to provide multiple benefits for improving the water supply for agriculture and fish and address drought mitigation concerns. The systematic planning process of the QAPP includes a description of the project, goals, and objectives; the project organization, key staff, and schedule; the study design; the specification of quality assurance (QA) and quality control (QC) to assess the quality performance criteria; and a description of the analyses, data storage, and reporting of acquired data for the proposed geotechnical exploration plan.

By way of background, in November 2023, a *Geotechnical Field Exploration Plan – Springwood Reservoir* document (2023 Exploration Plan) (Jacobs 2023b) was developed to describe all the exploration activities anticipated at the Springwood Reservoir site (Appendix A). In May 2024, the *2024 Geotechnical Field Exploration Plan – Springwood Reservoir* document (2024 Exploration Plan) (Jacobs 2024b) was developed to describe the anticipated activities that will occur using the funds provided in the Washington State Department of Ecology (Ecology) Grant (Agreement No. WRYBIP-2325-KittRD-00052) (Appendix B). This QAPP is intended for the exploration activities anticipated at the Springwood Reservoir site using funds provided by the Washington State Department of Ecology (Ecology) Grant (Agreement No. WRYBIP-2325-KittRD-00052) and therefore describes the details provided in the 2024 Exploration Plan.

The 2024 Exploration Plan (Jacobs 2024b) describes the proposed geotechnical explorations and procedures that will be implemented at the Springwood Reservoir site to acquire geotechnical information in support of the feasibility study and the ultimate design and construction of the proposed Springwood dam and reservoir. The exploration program includes field reconnaissance, site survey, geotechnical borings, test pits, soil and rock sampling, piezometer installations, downhole televiewer logging, field testing (such as packer tests, permeability tests, and in situ density tests), laboratory testing of soil and rock, and reporting/documentation (geotechnical exploration report [GER]).

This QAPP also outlines the purpose, parameters of interest, and standard testing methods and procedures, including data quality objectives (DQO) and measurement quality objectives (MQO) for each planned field and laboratory test performed under the geotechnical exploration plan.

2.0 Background

2.1 Introduction and Problem Statement

The Kittitas Reclamation District (KRD), the U.S. Bureau of Reclamation (Reclamation), and Ecology identified KRD's unique location relative to many important tributaries in the Upper Yakima River Basin as an opportunity to facilitate projects that provide multiple benefits to improve the water supply for agriculture and fish.

In 2022, Reclamation, Ecology, and the Yakama Nation agreed to continue studying the KRD UYSS Springwood Reservoir site as a new proposed storage reservoir to meet the goals of the Yakima Basin Integrated Plan (YBIP) with the desired benefit to increase overall smolt outmigration survival in the Yakima Basin during early spring and early summer. This QAPP discusses initial geotechnical exploration including field and laboratory testing for the Springwood Reservoir site using funds provided under the existing Ecology grant (Agreement No. WRYBIP-2325-KittRD-00052).

The purpose of UYSS is to provide additional stored water that would allow greater operational flexibility to supplement salmon and steelhead smolt outmigration pulse flows. Storage at the Springwood Reservoir site is an opportunity to incrementally increase storage in the Yakima River Basin and to support the purposes of the YBIP. The purposes of the YBIP are to implement a comprehensive program of water resource and habitat improvements in response to existing and forecast needs of the Yakima River Basin and to develop an adaptive approach for implementing these initiatives and for long-term management of basin water supplies that contributes to the vitality of the regional economy and sustains the health of the riverine environment.

There is a need to restore ecological functions in the Upper Yakima River Basin and to provide reliable and sustainable water resources for the health of the Yakima River. Yakima River flows and natural riverine function are impaired due to the current demands of federal Yakima Project Operations and other irrigation water usage. Reduced snowpack additionally lowers instream flows during critical stages of salmon and steelhead life cycles — juvenile salmon rearing and migration and adult upstream migration and spawning timing (Reclamation and Ecology 2012).

The proposed storage reservoir and associated infrastructure improvements could facilitate restoration and spring flow supplementation to the Yakima River. The additional Springwood Reservoir site water storage volume would allow for flexible Yakima Project Operations, including storing off-season, available water to be retimed to a more biologically beneficial use.

The primary goals of the overall project are guided by the YBIP — to provide additional stored water that would be used to allow flexibility to supplement salmon and steelhead smolt outmigration pulse flows in late spring and early summer each year. The desired benefit is to increase overall smolt outmigration survival in the Yakima Basin. The primary goals of the geologic investigation described herein are to acquire geotechnical design information at the

Springwood site in support of alternatives evaluation for the feasibility study, and ultimate construction of the Springwood Dam and Reservoir using funds provided under the existing Ecology grant (Agreement No. WRYBIP-2325-KittRD-00052). The project activities include conducting a field reconnaissance, survey coordination, geotechnical borings, test pits, associated laboratory testing and reporting.

2.2 Study Area and Surroundings

The study area is the Springwood Reservoir site which is located approximately 9 miles northwest of Ellensburg in Kittitas County, Washington, and along the western edge of Kittitas Valley. The property is situated between Interstate 90 and the Yakima River in Sections 19, 20, 28, 29, 30 and 32 of Township 19 North, Range 17 East, Willamette Meridian (Figure 1).

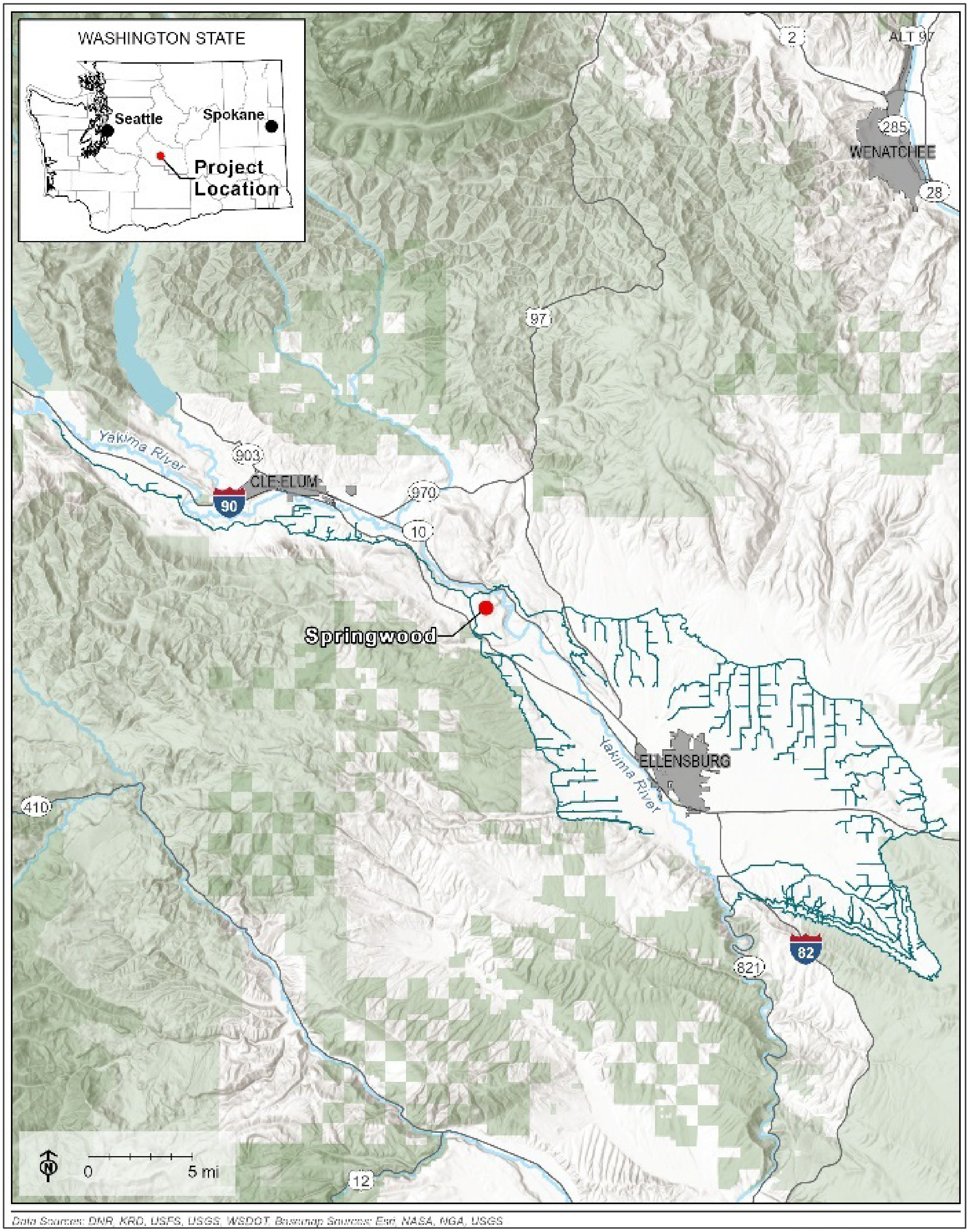


Figure 1. Vicinity map

The Springwood Reservoir site straddles the Columbia Plateau and the East Cascades ecoregions of the Pacific Northwest in central Washington (DNR 2019). The climate in this area is characterized by low rainfall; cold winters; and hot, dry summers. Habitat within the Springwood Reservoir site is generally characterized as non-native grasslands with small patches of low to moderate quality shrub-steppe. The site is situated in a hilly landscape with basalt outcroppings and ephemeral drainages leading to a natural basin area with elevations ranging from approximately 2,280 feet to 1,720 feet at the outlet of an unnamed perennial drainage. The unnamed perennial drainage at the eastern edge of the site flows a short distance to the Yakima River.

The KRD owns and operates two canals within close proximity to the site: the North Branch Canal and the South Branch Canal. The North Branch Canal flows west to east to the north of the site. The South Branch Canal flows to the west of the site. Several ephemeral and intermittent drainages occur within the site and flow to an unnamed perennial drainage which then flows to the Yakima River(see Figure 2) (Jacobs 2025).

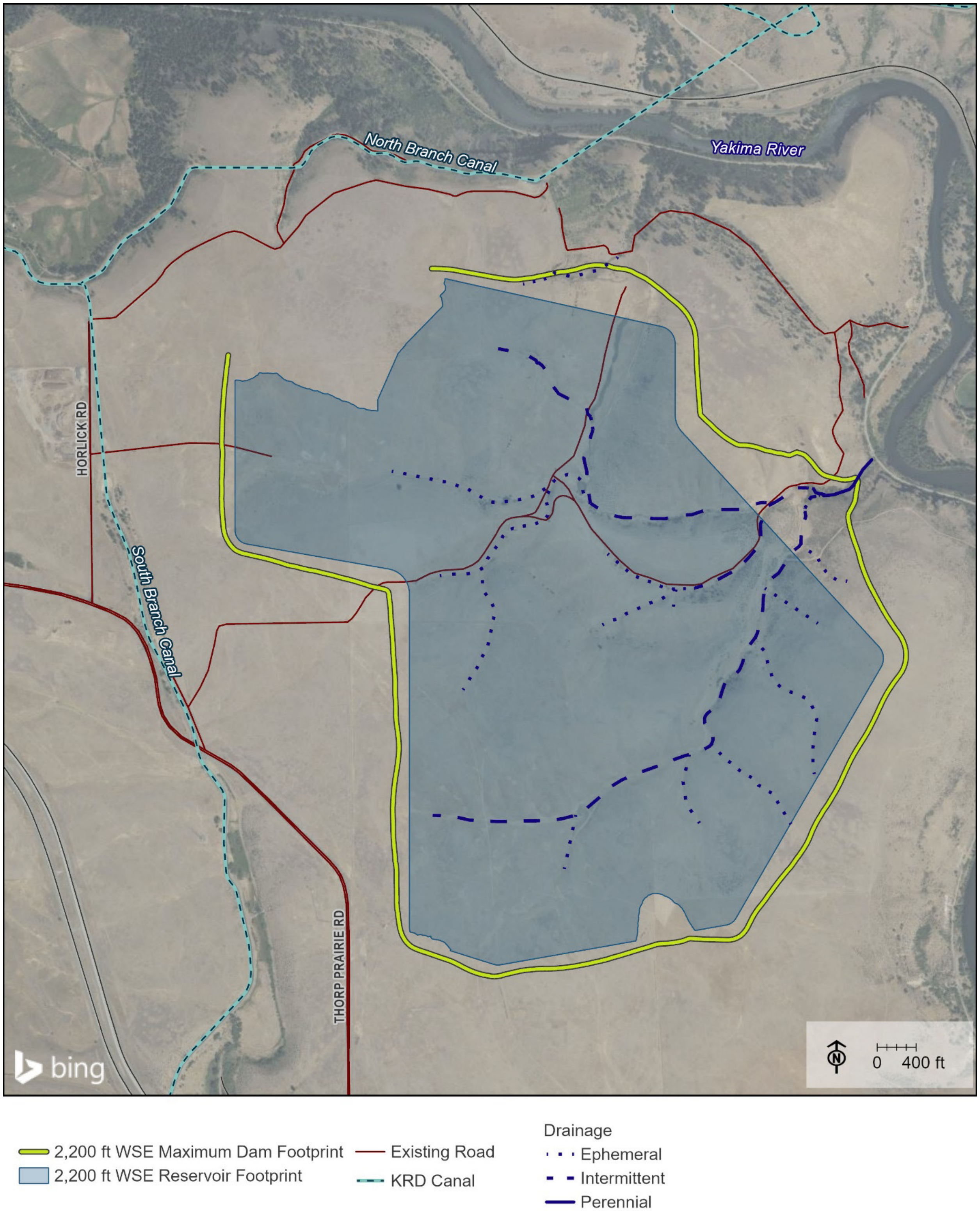
The closest downstream impaired water listed as impaired under Section 303(d) of the Clean Water Act is the Yakima River, approximately 1.5 miles downstream of the study area, near Thorp, Washington.

2.2.1 History of Study Area

The Springwood Reservoir site is located on the northwestern edge of the Kittitas Valley, in an area that is primarily rangeland. There are no residences located within the Springwood Reservoir site. The Palouse to Cascades State Park Trail occurs along the eastern and northern boundary of the site, adjacent to the Yakima River.

The Springwood Reservoir site is within Kittitas County's *Comprehensive Plan* land use designation "Rural Working" (Kittitas County 2021). The Springwood Reservoir site is currently used for cattle grazing. The Natural Resources Conservation Service's Web Soil Survey (2025) identifies several soils as farmland of statewide importance and prime farmland within the Springwood Reservoir site.

The 2022 census of agriculture data indicates there are 165,205 acres of farms in Kittitas County, of which 49,757 acres were irrigated (USDA 2022). Approximately 93% of farms in Kittitas County are either cropland or pastureland and over half of that farmland is used as pasture. Derelict canals on the site indicate portions of the Springwood Reservoir site were irrigated in the past; however, it is likely farming this land was not as productive compared to other parcels currently in agriculture in the county, which could explain why farming it was abandoned.



Data Sources: Jacobs, Kittitas County, KRD, WSDOT. Basemap Sources: © 2025 Microsoft Corporation © 2025 Maxar ©CNES (2025) Distribution Airbus DS

Jacobs

Figure 2. KRD canals and drainages

2.2.2 Summary of Previous Studies and Existing Data

To address multi-benefit surface water storage options in the Upper Yakima River Basin, KRD, Ecology, and Reclamation initiated a study in 2017 to provide an initial assessment of geographic locations for consideration of siting water storage facilities. The initial assessment considered the physical location and other readily differentiating critical factors for determining the validity and priority for further evaluation of these potential sites. The *KRD Phase 1 Initial Water Storage Assessment* (Jacobs 2017) identified 51 sites, with 10 sites identified as priority locations for potential water storage.

KRD continued the analysis of potential UYSS locations in 2020 in coordination with Ecology, initiating the UYSS Study Phase 2. Phase 2 of the evaluation was executed in two subphases, 2A and 2B. Phase 2A assessed the 10 priority locations and identified the highest-ranked sites or alternatives as the Springwood Reservoir site and the Wymer Tunnel (Jacobs 2021). Phase 2B conducted site-specific data collection and evaluation, resulting in an appraisal-level evaluation of the Springwood Reservoir site (Figure 1) (Jacobs 2022).

In July 2023, in preparation for the UYSS primary value planning study (VPS) meeting, Jacobs summarized the existing geotechnical data, evaluations completed, and recommendations for further geotechnical studies for five storage alternatives at the Springwood Reservoir site (varying by full pool water surface elevation [WSE], associated storage volume, and footprint extent), as well as three other locations (Currier Creek Reservoir, Shale Pit Reservoir, and Wymer Tunnel) previously identified in the UYSS Phase 2A reports (Jacobs 2021, 2023a). The Springwood Reservoir site alternative with full pool WSE at 2,200 feet (selected alternative) was selected by the value planning team for further evaluation.

A second VPS meeting, with a more focused group of attendees, was conducted in January 2024 to refine the alternatives that would go forward in the feasibility phase. VPS workshop outcomes included identifying three alternatives to advance to 5% conceptual design:

1. Springwood Reservoir Site (2,175 feet WSE)
2. Springwood Reservoir Site (2,200 feet WSE)
3. Springwood Reservoir Site (2,230 feet WSE)

Based on the outcomes of the January 2024 VPS workshop, Jacobs developed preliminary construction quantities for these three storage alternatives at the Springwood Reservoir site for screening-level cost estimating purposes. For each storage alternative, earthwork quantities and foundation and reservoir preparation items were developed that considered a range of parameters to reflect a Probable Low, a Most Probable, and a Probable High estimate.

Jacobs developed a preferred alternatives geologic summary (Jacobs 2024a) to summarize the geologic considerations of the Springwood Reservoir site and the screening-level design assumptions considered in developing the quantities to support the second VPS meeting.

The 2023 Exploration Plan (Jacobs 2023b) was developed to describe all the exploration activities anticipated at the Springwood Reservoir site (Appendix A). The 2024 Exploration Plan (Jacobs 2024b) was developed to describe the anticipated activities that will occur using the funds provided in the Ecology Grant (Agreement No. WRYBIP-2325-KittRD-00052) (Appendix B).

This QAPP describes anticipated activities for the first round of funding by the Ecology Grant (Agreement No. WRYBIP-2325-KittRD-00052), as summarized in the 2024 Exploration Plan (Jacobs 2024b).

2.2.3 Parameters of Interest and Potential Sources

The below-mentioned parameters will be useful to interpret the variability of foundation conditions. The permeability testing data of the overburden materials and rock will define the foundation conditions to reduce bedrock seepage, including the need for and extent of a trench or grout curtain cutoff for seepage control. The geotechnical borings and test pit excavations within the reservoir limit will support assessing potential borrow sources for different dam construction alternatives.

Geotechnical parameters of interest for feasibility of reservoir design and construction include the following:

- Subsurface stratigraphy (material type, layer thickness, physical properties and permeability of overburden materials) beneath the dam foundation
- Depth to groundwater
- Depth to bedrock, bedrock quality, types of bedrock, strength of the rock (unconfined compressive strength, elastic moduli), degree and orientation of jointing and fracture, and permeability of the rock

2.2.4 Regulatory Criteria or Standards

Drilling activities will comply with chapter 173-160 WAC, specifically under WAC 173-160-151 (notification process and associated fees) and WAC 173-160-400, which describes the standards for resource protection wells and geotechnical soil borings.

2.3 Water Quality Impairment Studies

Not Applicable.

2.4 Effectiveness Monitoring Studies

Not Applicable.

3.0 Project Description

This QAPP describes the anticipated geotechnical exploration activities using the funds provided by the Washington State Department of Ecology (Ecology) Grant (Agreement No. WRYBIP-2325-KittRD-00052). However, a full geotechnical exploration plan, as provided in Appendix A, was developed to describe all the exploration activities anticipated at the Springwood Reservoir site. As additional funding becomes available, the intent is to conduct additional geotechnical explorations to inform design. Refer to Figure 3 for a project flow chart.

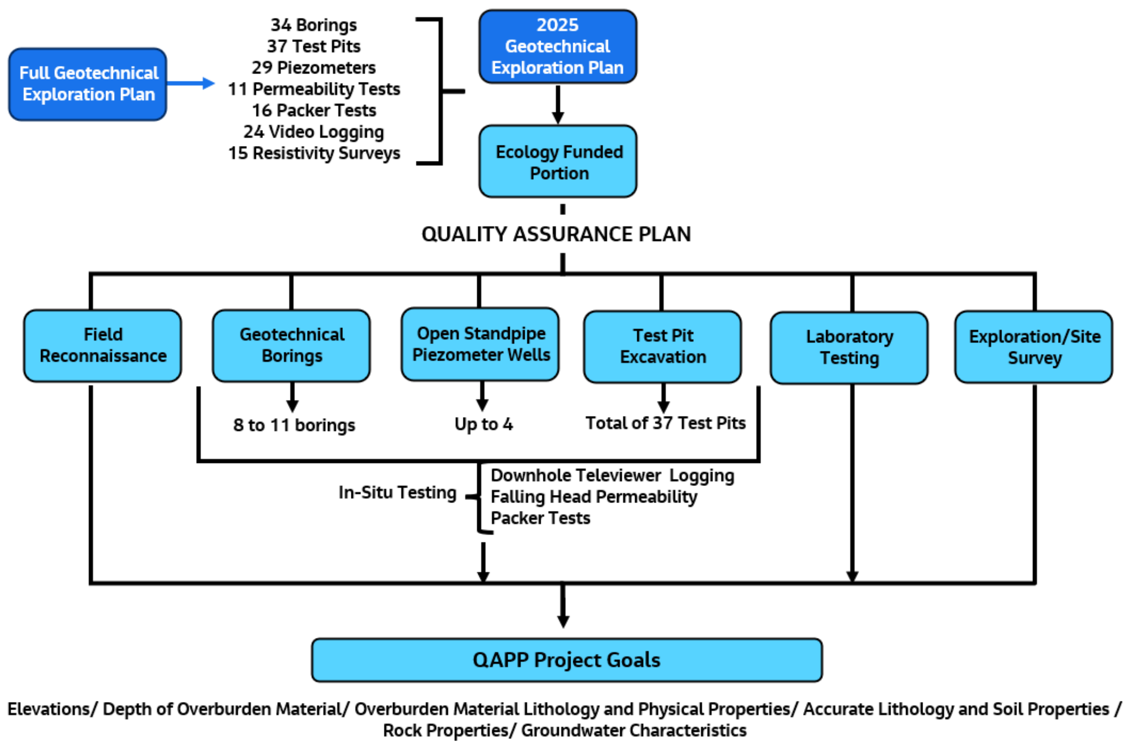


Figure 3. Project flow chart

The Springwood Reservoir site and proposed reservoir footprint along with other salient features are shown in Figure 4 (next page). Within this study area, geotechnical explorations will be conducted to acquire geotechnical design information in support of an alternatives evaluation for the feasibility study and the ultimate construction of the Springwood Reservoir. Project activities include conducting field reconnaissance, geotechnical borings, test pits, associated field and laboratory testing, site survey and reporting.

The expected outcome of this work is to summarize the geotechnical exploration activities within the geotechnical exploration report (GER) and provide preliminary recommendations and geotechnical design considerations for the ultimate construction of the Springwood Reservoir.

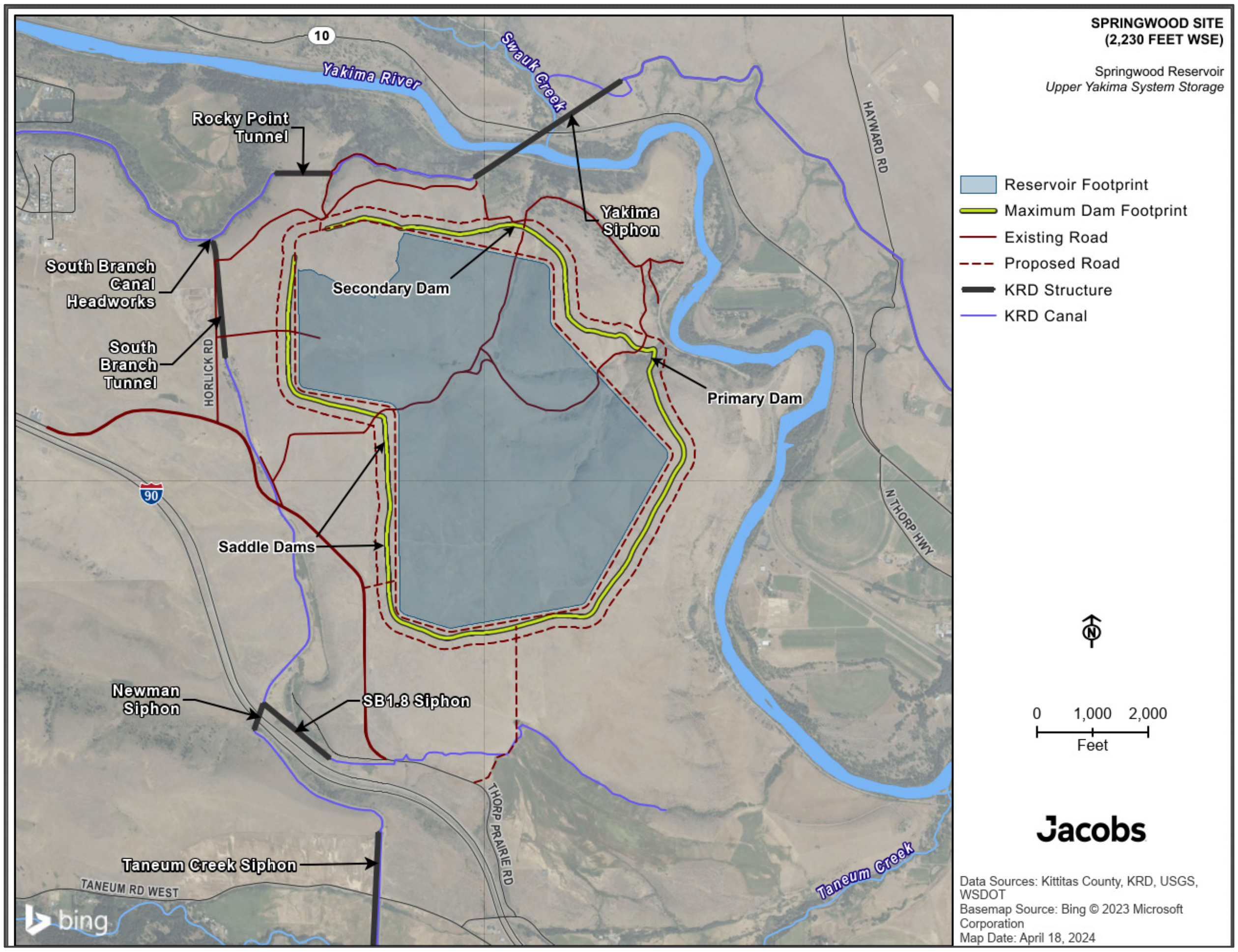


Figure 4. Proposed reservoir footprint and salient features

3.1 Project Goals

The geotechnical exploration program described herein is planned to evaluate subsurface conditions along the profile of the proposed primary, secondary, and saddle dams as well as within the reservoir limit to aid in feasibility design. It supports the goals and objectives of the overall drilling program. The goals for the geotechnical exploration program that will be done with this first round of funding include the following:

- Conduct geotechnical explorations to gather data for evaluating the feasibility of the Springwood Reservoir site.
- Gather information on the subsurface conditions, including stratigraphy, physical properties of the soil/rock, depth to bedrock, rock quality, and permeability, to help interpret the variability of foundation conditions for the proposed dams.
- Collect data that will ultimately support the design and construction plans for the primary dam, secondary dam, and saddle dams associated with the potential reservoir, ensuring they meet safety and operational requirements.
- Assess potential borrow sources for different dam construction alternatives. The explorations will be used to evaluate characteristics and thicknesses of recent alluvium, till, and bedrock.

3.2 Project Objectives

The objectives to meet the goals described above are as follows:

- Field Reconnaissance: Jacobs will conduct a field reconnaissance to review the proposed locations of geotechnical explorations and to identify access requirements. Locations of some borings and test pits may be revised so that they can be advanced from areas that have better access, improved site safety, or less impact to sensitive vegetation and potential cultural resources. The field reconnaissance will also be used to evaluate topography and determine anticipated boring and test pit depths. All federal and state requirements for cultural resources and environmental evaluation will be followed.
- Geotechnical Dam Profile Borings: Complete borings along the dam profiles to assess subsurface geological conditions.
- Open Standpipe Piezometer (OSP) Wells: Advance OSP wells for in situ testing and groundwater monitoring.
- Geotechnical Borrow Borings: Complete borings in the reservoir area to identify construction material sources.
- Test Pit Excavation: Excavate test pits to evaluate soil variability and conditions at strategic locations.
- Laboratory Testing: A Jacobs Senior Engineer is to assign laboratory testing after reviewing samples and field logs. Laboratory assignment to be reviewed by a Jacobs independent technical reviewer (ITR). Once laboratory assignment concurrence is achieved between the Senior Engineer and ITR the samples will be transported to

Kleinfelder's Redmond laboratory. Kleinfelder is a United States Army Corp of Engineers (USACE) and American Association of State Highway and Transportation (AASHTO) accredited laboratory.

- Exploration/Site Survey: Perform a site survey to obtain coordinates and elevations of test pits and boreholes.

Table 1 summarizes the proposed geotechnical explorations that will be conducted with the first round of funding for the Springwood Reservoir site. The number of explorations were determined based on estimated production rates and available funding. Selected exploration locations were coordinated between Jacobs Senior Engineers and the Bureau of Reclamation reviewers. The selected borings are located primarily at main dam features such as the primary and secondary dams. Additionally, borrow borings were included to evaluate potential borrow sources, one of the biggest potential construction costs.

Table 1. Summary of Proposed Borings for 2024 Geotechnical Field Exploration Plan

Exploration ID	Dam Structure	Estimated Till Depth (ft)	Estimated Rock Depth (ft)	In-Situ Testing	Installs	Est. Days to Complete
B-01	Secondary	80	280	Televiewer	2 VWPs	13
B-01P**	Secondary	Up to 80	-	Falling Head	1 OSP 1 VWP	2
B-03	Secondary	240	95	5 Packer Tests	2 VWPs	11
B-05	Primary	160	270	Televiewer	2 VWPs	16
B-06	Primary	50	60	3 Packer Tests Televiewer	2 VWPs	7
B-06P**	Primary	Up to 50	-	Falling Head	1 OSP 1VWP	2
B-07	Primary	60	180	9 Packer Tests Televiewer	2 VWPs	14
B-07P**	Primary	Up to 60	-	Falling Head	1 OSP 1VWP	2
B-10	South-East Ridge	320	155	Televiewer	2 VWPs	14
B-10P**	South-East Ridge	Up to 100	-	Falling Head	1 OSP 1 VWP	2
B-12	South-East Ridge	310	155	8 Packer Tests	2 VWPs	14
B-25	Borrow	Up to 100	-	-	-	2
B-27	Borrow	Up to 100	-	-	-	2
B-29	Borrow	Up to 100	-	-	-	2
B-31	Borrow	Up to 100	-	-	-	2

*Note that if sufficient time and budget is available after conducting these borings, an additional boring, B-17, along the saddle will be developed. The estimated till depth of B-17 is 200 feet with an estimated rock depth of 20 feet. Two VWPs would be installed.

** The OSP wells are designated with adding letter "P" at the end of original boring label. The OSP wells will be advanced close to the original boring to facilitate in situ testing and installation of open standpipe piezometers.

3.3 Information Needed and Sources

The following information will be collected to meet the project goals:

- Elevations: Elevations of the completed borehole locations will be used to develop accurate soil profiles along the dam alignment. The site survey will provide the elevations and coordinates of borehole locations.
- Depth of Overburden Material: The depth of the overburden materials (non-rock material) will be obtained through Standard Penetration Tests (SPT), soil sampling, and visual observation/classification of the materials.
- Overburden Material Lithology and Physical Properties: The lithology (soil layering) and physical properties (density, strength, and permeability) of the overburden material will be obtained from in situ field tests (SPTs and percolation tests) and laboratory tests (Atterberg limits, sieve analysis, moisture content, etc.). A list of anticipated laboratory tests is presented in Section 9.0.
- Obtaining accurate lithology and soil property information will aid in evaluating dam stability, potential seepage issues, and potential borrow source material.
- Rock Properties: Key rock properties to be obtained consist of strength, durability, structural integrity, jointing and discontinuities, and permeability. Physical properties will be obtained from in situ field tests (rock quality designation, packer testing, and downhole geophysics), and laboratory tests (unconfined compression, point load, and CERCHAR abrasivity index, etc.). A list of anticipated laboratory tests is presented in Section 9.0.
- Obtaining accurate rock property information will aid in evaluating dam stability and potential seepage issues.
- Groundwater: Long-term static groundwater levels and seasonal fluctuations will be monitored through the use of vibrating wire piezometers (VWP) and data loggers installed at the surface. Data will be downloaded approximately every quarter. The long-term static groundwater levels and seasonal fluctuations will be used to evaluate dam stability and potential seepage issues.

3.4 Tasks Required

The specific activities planned for the Springwood Reservoir site geotechnical investigation using the current grant funding are as follows:

- Geotechnical Borings: For this initial field program approximately 8 to 11 geotechnical borings will be completed along the profile of the primary dam, secondary dam, saddle dams, outlet works tunnel, and potential borrow source locations. The number of borings will be dependent on drill rig advancement rates and available budget.
- Test Pits: For this initial field program a total of 37 test pits will be completed along the profile of the primary dam, secondary dam, saddle dams, inlet pipeline and intake structure, outlet and dissipation structure, and potential borrow source locations.

- Packer Testing: Up to 25 stepped hydraulic pressure tests (packer tests) will be completed in select boreholes along the primary dam, secondary dam, and saddle dams. The packer tests will be completed within rock and in accordance with Chapter 16 of the *Engineering Geology Field Manual* (Reclamation 2001) to estimate the hydraulic conductivity and seepage behavior of the rock.
- Falling Head Permeability: Up to 4 in situ water percolation tests will be completed in select borings with the till material to estimate the permeability of the foundation material. The tests will be completed in general accordance with the U.S. Army Corps of Engineers' approach (USACE 1986).
- Downhole Televiewer Logging: Downhole teleview logging will be completed at select boreholes along the primary dam, secondary dam, and saddle dams. Televiewer logging, either optical or acoustic, will provide information to interpret the geology in the dam foundations and outlet works alignment.
- Laboratory Testing: A Jacobs Senior Engineer is to assign laboratory testing after reviewing samples and field logs. Laboratory assignment to be reviewed by a Jacobs independent technical reviewer (ITR). Once laboratory assignment concurrence is achieved between the Senior Engineer and ITR the samples will be transported to Kleinfelder's Redmond laboratory. Kleinfelder is a United States Army Corp of Engineers (USACE) and American Association of State Highway and Transportation (AASHTO) accredited laboratory.
- Geotechnical Exploration Report: At the completion of all geotechnical activities, a GDR will be developed that summarizes the subsurface conditions at the site, including soil and rock properties, groundwater levels to inform design and construction decisions.
- Site Survey: Coordinates and elevations of test pits and boreholes will be obtained.

3.5 Systematic Planning Process

This QAPP represents the systematic planning process and includes the following:

- The project description, goals, and objectives
- The project organization, key staff, and schedule
- The study design
- The specification of QA/QC to assess the quality performance criteria
- The description of analyses and data storage and reporting on acquired data

4.0 Organization and Schedule

4.1 Key Individuals and Responsibilities

Table 2 (next page) shows the responsibilities of those who will be involved in this project.

Table 2. Project staff organization and responsibilities

Staff	Title	Responsibilities
Urban Eberhart Kittitas Reclamation District Phone: 509-925-6158	Client	Clarifies the project scope. Provides internal review of the QAPP and approves the final QAPP.
Rebeka Triolo Bureau of Reclamation Phone: 208-378-5336	Project Manager	Provides external review of the QAPP. Manages the overall project for Reclamation.
Sharonne Park Jacobs Phone: 206-300-5084	Project Manager	Manages the project and works with the Principal Investigator to oversee field sampling and transportation of samples to the laboratory.
Maraia Daugherty Jacobs Phone: 541-214-5599	Hydrogeologist	Supports the project.
Brett Campbell Jacobs Phone: 425-879-7555	Principal Investigator	Oversees field sampling and transporting samples to the laboratory. Conducts QA data review, analyzes and interprets data, and enters data into Water Quality Exchange. Writes the draft report and final report.
Jacob Reactor Jacobs Phone: 360-594-2734	Field Assistant	Helps collect samples and records field information.
Craig Broadhead Jacobs Phone: 425-456-9763	Supervisor for the Project Manager	Provides internal review of the QAPP, approves the budget, and approves the final QAPP.
Kasey Goble Cascade Drilling Phone: 425-466-8588	Senior Operations Manager	Drilling Contractor.
Laboratory Contact Dan Hootman Kleinfelder Phone: 425-539-9065	Laboratory Director	Reviews draft QAPP, coordinates with Jacobs' QA coordinator.
Kevin Haydon Ecology Phone: 509-823-6947	Program Planner/Project Manager Office of Columbia River	Reviews and approves the draft QAPP and the final QAPP.
McKenna Murray Ecology Phone: 509-823-0996	Quality Assurance Coordinator/Hydrogeologist Office of Columbia River	Reviews and approves the draft QAPP and the final QAPP.
Leif Krapas Ecology Phone: (509) 514-5440	Environmental Engineer Office of Columbia River/Dam Safety Program	Reviews and approves the draft QAPP and the final QAPP.

4.2 Special Training and Certifications

Drilling and test pit excavation, including various field/in situ testing, will be completed in the presence of the qualified geotechnical engineer or geologist who will direct the drilling operations, test pit excavations, and sample collection and will provide continuous observation and logging of each of the boreholes/test pits. The geotechnical engineer or geologist will have at least 2 to 3 years of relevant experience with subsurface investigation and material characterization training and field safety training.

4.3 Organization Chart

Not applicable; see Table 2.

4.4 Proposed Project Schedule

Tables 3 through 5 list key activities, due dates, and lead staff for this project.

Table 3. Schedule for completing field and laboratory work

Task	Due date	Lead staff
Fieldwork	Summer/fall 2025	Brett Campbell
Laboratory analyses	Summer/fall 2025	Brett Campbell

Due dates listed in Table 3 refer to activities anticipated with the current available funding, under the existing Ecology grant (Agreement No. WRYBIP-2325-KittRD-00052), corresponding to activities discussed within the 2024 Exploration Plan (Jacobs 2024b).

Table 4. Schedule for data entry

Task	Due date	Lead staff
Upload data to Ecology's Environmental Information Management EIM as appropriate	At the conclusion of fieldwork and laboratory analysis (estimated fall/winter 2025)	Elyse Woda

Table 5. Schedule for final report

Task	Due date	Lead staff
Draft to supervisor	Spring 2026	Brett Campbell
Draft to client/ peer reviewer	Spring 2026	Brett Campbell
Draft to external reviewers	Spring 2026	Brett Campbell
Final report due on web	Spring 2026	Brett Campbell

Due dates listed in Table 5 refer to activities anticipated with the current available funding, under the existing Ecology grant (Agreement No. WRYBIP-2325-KittRD-00052), corresponding to activities discussed within the 2024 Exploration Plan (Jacobs 2024b).

Note that at the end of this initial geotechnical fieldwork (winter/fall 2025), a geotechnical exploration report (GER) will be developed. This report will include boring and test pit logs, in situ testing raw data, laboratory testing data, and televiewer logging data. This data will be uploaded to the EIM database. This report will summarize the geotechnical exploration activities and provide preliminary recommendations and geotechnical design considerations at the site for dam construction.

4.5 Budget and Funding

Tables 6 through 9 show the project budget and laboratory costs for the initial phase of the geotechnical activities anticipated for summer/fall 2025, using funds provided under the existing Ecology grant (Agreement No. WRYBIP-2325-KittRD-00052).

Table 6. Project budget and funding

Cost Category	Cost
Laboratory	$197,731
Dam Perimeter and Internal Borings	$1,019,157
Downhole Geophysics	$60,113
Labor Cost	$513,239
Travel	$108,359

Table 7. Laboratory budget details – Soil Testing Borings

Test	ASTM	Quantity	Unit Cost (each)	Total	Notes
Moisture Content	D2216-19	225	$38.60	$8,685.00	
Dry Density	D2216-19	30	$69.50	$2,085.00	
Specific Gravity	D854-23	30	$340.00	$10,200.00	
Sieve Analysis (C+F)	D422-63(2007)e2, D6913	145	$250.00	$36,250.00	Includes SA's for hydrometer samples
Hydrometer	D422-63(2007)e2	30	$230.00	$6,900.00	Requires a sieve analysis, not included
Atterberg (Multi-Point)	D4318-17e1	45	$230.00	$10,350.00	
Organic Content	D2974-25	30	$160.00	$4,800.0	
			Total	$79,207.00	

Table 8. Laboratory budget details – Rock Testing

Test	ASTM	Quantity	Unit Cost (each)	Total	Notes
Unconfined Compression with Youngs Modulus	D7012-23	65	$320.00	$20,800.00	Includes specimen preparation to ASTM D4543-19, specimen unit weight, unconfined compression strength, and specimen
Point Load	D5731-16	65	$120.00	$7,800.00	Specify diametral, axial, block, or lump
CERCHAR Abrasivity Index	D7625-22	72	$235.00	$16,920.00	Specify stylus and surface type
Direct Shear Test	D5607-16		$440.00		Specify normal stress(es); each additional normal load add $240; includes rock core preparation
Brazilian Tensile Strength Test	D3967-23		$120.00		
Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock	D7012-23		$600.00		Includes specimen preparation to ASTM D4543-19, specimen unit weight, unconfined compression strength, specimen photographs, stress-strain curve, Young's Modulus, and Poisson' Ratio
LA Abrasion	C131		$250.00		
Sodium Sulfate Soundness	C88		$720.00		Specify magnesium sulfate or sodium sulfate; includes five cycles; if gradation is needed add $105

Test	ASTM	Quantity	Unit Cost (each)	Total	Notes
Rock Specific Gravity and Absorption	D6473		$120.00		
			Total	$45,520.00	

Table 9. Laboratory budget details – Soil Testing – Test Pits

Test	ASTM	Quantity	Unit Cost (each)	Total	Notes
Moisture Content	D2216-19	185	$38.60	$7,141.00	
Sieve Analysis (C+F)	D6913	185	$250.00	$46,250.00	
Atterberg (Multi-Point)	D4318-17e1	10	$230.00	$2,300.00	
Crumb Test	D6572-21	10	$170.00	$1,700.00	
Pinhole Test	D4647	10	$420.00	$4,200.00	Add $50.00 for each remolded specimen and specify density and moisture condition
Soundness and Durability Test	C88 (Corrected from C289-07)	10	$720.00	$7,200.00	Aggregate only; tests are billed by each size fraction tested. The quantity of fractions tested is dependent on the sample gradation and test method. Specify magnesium sulfate or sodium sulfate. Includes five cycles; if gradation is needed add $105
Modified Proctor Test	D1557-12(2021)	10	$320.00	$3,200.00	6-point
Proctor Oversize Correction	D4718	10	$95.00	$950.00	
			Total	$72,941.00	
			Grand Total	$197,731.00	

5.0 Quality Objectives

5.1 Data Quality Objectives [1]

The main data quality objective (DQO) for this project is to complete between 4 and 7 borings along the profile of the primary, secondary, and saddle dams, up to 4 open standpipe (OSPs) wells along the profile of dams (designated as B-01P, B-06P, P-07P, and B-10P in Table 1), and between 2 and 4 borings within the reservoir area to identify potential borrow source areas. The OSP wells will be advanced close to the original borings to facilitate in situ testing and installation of open standpipe piezometers. Additionally, The proposed geotechnical exploration program includes excavation of 37 test pits (designated T-01 through T-37). The 37 test pits will be excavated at the following locations:

- 7 test pits (TP-01 to TP-07) within the footprint of the proposed primary dam
- 3 test pits (TP-08 through TP-10) within the footprint of the secondary dam
- 7 test pits (TP-11 through TP-17) within the footprint of the saddle dams
- 4 test pits (TP-18 through TP-21) along the inlet pipeline and intake structure
- 2 test pits (TP-22 and TP-23) at the outlet intake and dissipation structures
- 14 test pits (TP-24 through TP-37) to locate potential borrow source areas

Samples collected from borings and test pits will undergo laboratory tests. The data will be collected from certified laboratories using standard USBR (Reclamation) and ASTM International methods to obtain subsurface information for the feasibility study of the Springwood Reservoir site. Refer to Section 8 for the laboratory testing standards.

The exploration quantities noted above are limited to the available funding at this time. Subsequent explorations are planned in the future when additional funding is available.

The number of explorations were determined based on estimated production rates and available funding. Selected exploration locations were coordinated between Jacobs Senior Engineers and the Bureau of Reclamation reviewers. The selected borings are located primarily at main dam features such as the primary and secondary dams. Additionally, borrow borings were included to evaluate potential borrow sources, one of the biggest potential construction costs.

[1] DQO can also refer to ***decision*** quality objectives. The need to identify decision quality objectives during the planning phase of a project is less common. For projects that lead to important decisions, DQOs are often expressed as tolerable limits on the probability or chance (risk) of the collected data leading to an erroneous decision. For projects that intend to estimate present or future conditions, DQOs are often expressed in terms of acceptable uncertainty (e.g., width of an uncertainty band or interval) associated with a point estimate at a desired level of statistical confidence.)

5.2 Measurement Quality Objectives

During the field exploration MQOs will be completed by Jacobs senior engineer's site visits and confirming that appropriate equipment is on-site and that the exploration and sampling methods are being performed to the appropriate standards.

For laboratory testing accredited geotechnical laboratories will have equipment calibrated and certified annually from a third-party testing firm. Accreditation of laboratory testing procedures will be the primary determination of achieving laboratory MQOs. Additional laboratory MQOs such as site visits by Jacob's personnel will be performed to confirm that testing is being completed in accordance with the appropriate standards.

Table 10. Measurement quality objectives for results - Soil Drilling and Test Pits– Laboratory Tests

Parameter	Standard	Test Information			Precision	Expected Range
		Accuracy	Resolution	Range		
Moisture Content	USBR 5300-89	+/-1%	0.01 – 0.1%	0% – 500+%	+/- 1.0 – 1.5%	—
Dry Density	USBR 5375-89	+/-0.5% – 1%	0.01 grams	Adaptable to sample size and moisture content	+/-0.5% – 2%	—
Specific Gravity	USBR 5320-89 ASTM D854-23	+/- 0.01	0.001	1.5 – 3.0	Clay +/- 0.02; Sand and Gravel +/- 0.01	1.5 – 3
Sieve Analysis	USBR 5325-89	+/-0.01 mm for a 4.75 mm sieve	Sieve dependent (typically logarithmic, following a √2 or 4√2 progression)	0.075 mm (No. 200 sieve) – 75 mm (3-inch sieve)	±1 – 3%	—
Hydrometer	USBR 5330-89	1% – ±3%	Smallest Detectable Change	0.001 mm (clay) and 0.075 mm (silt)	±1% – ±2% for mass retained on each sieve	—
Atterberg (Liquid Limit)	USBR 5355-89 (1990g)	No absolute true value	Water content reported to 0.1% – 1%	20% to >100% depending on soil plasticity. High plastic clays may exceed 100%.	+/- 5% – 7% water content +/- 3% – 5% cone penetrometer method	—
Atterberg (Plastic Limit)	USBR 5355-89 (1990g)	Relies on adherence to the thread-rolling method (3 mm diameter criterion)	Water content reported to 0.1% – 1%	10 to 40% for plastic soils. Non-plastic soils lack a measurable plastic limit.	+/- 1% – 2% (water content)	—
Atterberg (Shrinkage Limit)	USBR 5355-89 (1990g)	Sensitive to method details	Water content reported to 0.1 – 1%	5% – 30% representing the water content where soil volume stabilizes during drying	+/-2% – 3%	—
Organic Content	USBR 5430-89	Near-true value for organic carbon (+/-1% – 2%)	0.01%	0.01% – 100%	+/- 0.1% – 0.5%	—
Crumb Test	USBR- 5400-89	Moderate (screening)	Low	Clayey soils	Low	—
Pinhole Test	USBR 5410-89	High	Moderate	Fine-grained	High	—

Parameter	Standard	Test Information			Precision	Expected Range
		Accuracy	Resolution	Range		
Soundness and Durability Testing	ASTM C289-07	Moderate	+/-0.01 – 0.1 mmol/L (silica); +0.05 mmol/L (alkalinity)	10 – 100+ mmol/L (fine aggregates)	+/- 5% – 10% repeatability; +/-15% – 20% reproducibility	—
Modified Proctor Test	USBR 5500-89	+/-0.1% (mass); +/- 1% (volume)	0.1 gram (mass), 0.05% (moisture)	5% – 30% (moisture); 90% – 150 lb/ft^3 (density)	+/- 0.5% (moisture); +/- 1.5 lb/ft^3	—

Table 11. Measurement quality objectives for results - Rock Drilling – Laboratory Tests

Parameter	Standard	Test Information			Precision	Expected Range
		Accuracy	Resolution	Range		
Unconfined Compression w/ Youngs Modulus	USBR 6210/6220	+/- 5-%	1 µε (strain), 0.001 mm (Linear Variable Differential Transformer)	1 – 100 GPa, 0.01% – 1% strain	~5%	—
Point Load	USBR 6535	+/-15-25%	Load: 0.1% – 1% of full scale; Displacement: 0.01 –0.1 mm	2 – 300 MPa	5-15%	—
CERCHAR Abrasivity Index	ASTM D7625-22 (2022)	+5% – 10%	0.01 grams (high precision scale)	0 - 100	+/- 2% – 5%	—
Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock	ASTM D7012-23 (2023)	±1% – 3%	0.1 – 1 MPa	5 – 300+ MPa	±1% – 2%	—
Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock (Youngs Modulus)	ASTM D7012-23 (2023)	±3% – 7%	0.1 – 1 GPa	1 – 100 GPa	± 2% – 5%	—
Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock (Poisson's Ratio)	ASTM D7012-23 (2023)	±10% – 15%	0.01 – 0.05	0.1 – 0.35	±5% – 10%	—

Table 12. Measurement quality objectives for results – misc.

Parameter	Standard	Test Information			Precision	Expected Range
		Accuracy	Resolution	Range		
Downhole Geophysics Program						
Borehole Televiewer Acoustic and Optical	ASTM D5753-18 (2018c)	±2° azimuth, ±0.1 m depth	1 – 5 mm (optical), 5 – 10 mm (acoustic)	75 – 300 mm, 0 – 5,000 m, 0 – 175°C	±1° azimuth, ±0.1 m depth	—
Drilling						
Sonic Drilling	ASTM D6914 (2024)	98% – 100% core recovery	Captures layers as thin as 1 – 10 cm	Depending on equipment and ground conditions.	Consistency in achieving target depths and maintaining borehole alignment	—
In Situ Field Testing						
Falling Head Permeability Test	USACE (1986)	+/- 20% – 50%	0.5 – 1 mm (markings); 0.1 – 1 second (time)	0.01 – 1 m (head)	+/- 10 – 20%	—
Stepped Hydraulic Pressure Testing	Reclamation (2001)	+/- 15% – 30%	0.1 – 1kPa (pressure); 0.01 – 0.1 L/min (flow)	K: 10^-6 – 10^-12 cm/s	+/- 10 – 20%	—
Field In Situ Density Test (Sand Cone)	USBR 7205-89 (1990n)	+/- 3% – 5%	0.5 – 1 lb/ft^3	90 – 140 lb/ft^3	+2 – 5 lb/ft^3	—
Hourly Groundwater Level Measurements						
Piezometer Data Collection	EAP074, v. 1.2	+/-0.05% from 0°F – 122°F	+/-0.01% FS or better	16 – 162 ft	—	0 to 15 ft

°C = degree Celsius
°F = degree Fahrenheit
cm/s = centimeters per second
FS = % of full scale
ft = feet
GPa = gigapascal
lb/ft = pound per foot
lb/ft^3 = pound per cubic foot
L/min = liters per minute
m = meter
mm = millimeter
mmol millimole or one-thousandth of a mole
MPa = megapascal

5.2.1 Precision

High-precision calibrated instruments in a certified laboratory setting will be used to conduct testing.

5.2.2 Bias

Systematic errors through laboratory protocols, equipment checks, and QA improves accuracy and will ensure results reflect true material properties. Field bias will be reduced through instrument calibration according to field measurement protocols. Other field biases include measurement procedures and will be minimized through protocol training and field visit expectations.

5.2.3 Sensitivity

Sensitivity, described by equipment range, accuracy, and resolution, is reported in Table 8. The recorded value shown in this table is a measure of the capacity of the equipment used to detect change.

5.3 Comparability, Representativeness, and Completeness Targets

5.3.1 Comparability

The field exploration includes geotechnical borings and test pit excavations for sampling of subsurface materials (soils and/or rock), and associated field and laboratory testing will be conducted following standard ASTM and USBR methods provided in Section 8.2, Section 9.1 and Section 9.2. As the field geotechnical exploration and data collection are progressed in the field, the data will be reviewed by the senior geotechnical engineer for comparability.

5.3.2 Representativeness

Field and laboratory samples will be considered representative of existing conditions based on professional judgment of geotechnical engineers and standards listed in Table 8. Laboratory tests will overrule field descriptions.

5.3.3 Completeness

This study from the initial field program will be considered successful if measured data is gathered from 95% of the test pits and 4 borings. The information gathered from these test pits and borings will provide useful preliminary information on the primary dam, secondary dam, saddle dams, inlet pipeline and intake structure, outlet and dissipation structure, and potential borrow sources. This data will provide useful geotechnical information in support of the feasibility study and the ultimate design and construction or the proposed Springwood dam and reservoir.

5.4 Acceptance Criteria for Quality of Existing Data

Field and laboratory samples will be considered representative of existing conditions based on professional judgment of geotechnical engineers during sample collection and prior to reviewing laboratory results.

5.5 Model Quality Objectives

Not applicable.

6.0 Study Design

6.1 Study Boundaries

This geotechnical field exploration plan has been developed to describe the proposed geotechnical explorations and procedures that will be implemented at the Springwood Reservoir site to acquire geotechnical design information in support of an alternatives evaluation for the feasibility study and the ultimate construction of the Springwood Ranch Dam and Reservoir using funds provided by the Washington State Department of Ecology (Ecology) Grant (Agreement No. WRYBIP-2325-KittRD-00052). The exploration program includes field reconnaissance, site survey, geotechnical borings, test pits, soil and rock sampling, piezometer installations, downhole televiewer logging, field testing (such as packer tests, permeability tests, and in situ density tests), laboratory testing of soil and rock, and reporting/documentation (geotechnical exploration report [GER]).

The GER will include boring and test pit logs, in situ testing raw data, laboratory testing data, and televiewer logging data. This data will be uploaded to the EIM database. This report will summarize the geotechnical exploration activities and provide preliminary recommendations and geotechnical design considerations at the site for dam construction.

Refer to Appendix C for the figure showing the study area and proposed boring locations. Refer to Appendix D for the figure showing the study area and proposed test pit locations.

6.2 Field Data Collection

6.2.1 Sampling Locations and Frequency

The geotechnical exploration program consists of 8 to 11 geotechnical borings (see Table 1) and 37 test pits. Depending on drilling advancement rates, between 4 and 8 borings will be along the primary, secondary, and saddle dams. Additionally, 4 borings will be advanced within the reservoir area to identify potential borrow source areas. Proposed boring locations are shown in Appendix C, but it is expected that these locations may be modified based on findings of the geologic mapping and/or test pits.

Between 30% and 50% of the borings along the dams will be inclined (Borings B-01, B-04, B-08, B-09, B-11, B-13, B-15, B-16, B-18, and B-22). At least one inclined boring will be advanced at each abutment of the primary and secondary dams. The inclined boreholes will be advanced at angles up to 65 degrees from horizontal. The borings' orientation will be determined based on results of geologic surface mapping and downhole televiewer logging of vertical borings.

Of the 37 test pits, 17 test pits (TP-01 through TP-17) will be excavated within the footprint of the proposed primary dam, secondary dam and saddle dams, 4 test pits (TP-18 through TP-21) will be excavated along the inlet pipeline and intake structure, 2 test pits (TP-22 and TP-23) will be excavated at the outlet intake and dissipation structures, and the remaining 14 test pits (TP-

24 through TP-37) will be excavated within the reservoir footprint to locate potential borrow sources (Figure 3). Proposed test pit locations are shown in Appendix D.

6.2.2 Field Parameters and Laboratory Analytes to be Measured

The piezometers will be installed to facilitate periodic observation of the depth to groundwater. In each dam boring, two vibrating wire piezometers (VWP) will be installed (one in overburden soils and one in the bedrock).

The VWPs will be unvented and manufactured by Geokon (Model Number 4500S) or similar. Data from VWPs will be collected and stored on waterproof dataloggers (Geokon 8002-WP-2, LC-2 series or similar) daily and downloaded periodically. This plan assumes up to four download site visits for 1 year. Prior to installation, the initial zero reading for each VWP sensor will be recorded according to manufacturer recommendations.

VWPs equipped with battery-operated dataloggers will be installed at each standpipe piezometer to monitor daily groundwater fluctuations. The VWP sensor will be attached to the outside of the standpipe casing, near the bottom of the screened interval.

VWPs installed in boreholes will be installed using installation method “C” per Geokon’s manual (i.e., grouted directly into the borehole). The VWPs and wires at about 5 feet on-center will be taped to a 1-inch tremie pipe and grouted from the bottom up using the 50 pounds per square inch (psi) grout mixture recommended in their manual and provided in Table 9.

Table 13. Recommended mixture

Material	50 PSI Grout for Medium to Hard Soils[1]		4 PSI Grout for Soft Soils[2]	
	Amount	Ratio by Weight	Amount	Ratio by Weight
Water	30 gallons	2.5	75 gallons	6.6
Portland Cement	94 lbs (one sack)	1	94 lbs (one sack)	1
Bentonite	25 lbs (as required)	0.3	39 lbs (as required)	0.4

[1] The 28-day compressive strength of this mix is about 50 psi, similar to very stiff/hard clay. The modulus is about 10,000 psi.
[2] The 28-day strength of this mix is about 4 psi, similar to very soft clay.
lb = pound

The open standpipe piezometers (OSP) will consist of 2 inch-diameter polyvinyl chloride casing and up to 20 feet of machine-slotted screen. Sand will be placed in the annular space from 0 to 2 feet below the bottom of the screen (0 to 6 inches if the piezometer will be installed at the bottom of borehole) to 2 to 3 feet above the top of the screen. A bentonite seal will be placed above the sand and up to ground surface. Bentonite will also be used below the sand in locations where the screened interval is installed above the bottom of the boring.

Piezometers will be protected at the surface with an aboveground casing and 2-foot by 2-foot concrete pad. Piezometer construction details and measured water levels will be included on the boring logs.

The actual number and locations of piezometers may change depending on the ability to access the proposed boring locations and the findings of the field reconnaissance. Installation of fully grouted nested VWPs may be considered at Borings B-06 or B-07 to better evaluate the possibility of artesian groundwater conditions. Changes and installation depths will be field determined and discussed with Jacobs senior engineer prior to installation. Installation determination will be dependent on the depth to rock, groundwater levels, groundwater conditions (artesian), and presence of aquifers and aquitards.

6.3 Modeling and Analysis Design

Not applicable.

6.3.1 Analytical Framework

Not applicable.

6.3.2 Model Setup and Data Needs

Not applicable.

6.4 Study Design Assumptions

Not applicable.

6.5 Possible Challenges and Contingencies

6.5.1 Logistical Problems

Jacobs is currently working with KRD and Reclamation to obtain the necessary Categorical Exclusion permits to conduct the initial fieldwork anticipated for summer/fall 2025.

Section 106 compliance and a "call before you dig" notification with the Utility Notification Center of Washington, as required by law, will be conducted as applicable, to inform utility owners of the pending site improvements and field explorations to allow them to locate and mark their utilities. Jacobs will coordinate with KRD regarding the timing of private utility locate markings if it is needed.

New access road construction and site clearing may be required for access to the boring/test pit locations. For the borings on the steep slope along the outlet works and left abutment of the primary dam, more earthwork is anticipated to build the access road and work pad for drilling.

For the initial geotechnical fieldwork anticipated in summer/fall 2025, no new access road construction or site clearing is required. Jacobs will coordinate with the drilling company to verify adequate site access prior to drilling and test pit excavation.

6.5.2 Practical Constraints

Practical constraints include scheduling problems, budgetary constraints, unreliable transportation, road conditions, and unexpected changes in site project design.

For the initial geotechnical fieldwork anticipated in summer/fall 2025, Jacobs is actively coordinating with the drillers, Cascade Drilling Services, and Reclamation, and Ecology on the schedule. Likewise, for the initial geotechnical fieldwork anticipated in summer/fall 2025, the budget has been secured from the Ecology grant.

6.5.3 Schedule Limitations

Unexpected, restricted staff availability may limit project progress.

7.0 Field Procedures

7.1 Invasive Species Evaluation

Not applicable.

7.2 Measurement and Sampling Procedures

While drilling in cohesive materials, sampling shall be performed in accordance with ASTM D1587 (*Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes*) (2015). If cohesionless soils are encountered, Standard Penetration Tests (SPT) shall be performed in accordance with ASTM D1586 (*Standard Test Method for Penetration Test (SPT) and Split-Barrel Sampling of Soils*) (2018a). If rock is encountered, sampling shall be performed in accordance with ASTM D2113-14 (*Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation*) (2014).

Where cohesionless soils are encountered, SPTs will be performed. Samples shall be obtained at 5-foot intervals, or when a significant change in materials is observed during drilling, with a standard 2-inch outer diameter split-barrel drive sampler driven 18 inches per test. The sampler will be driven by a 140-pound automatic hammer with a 30-inch drop. The sampler will be driven 18 inches (or until refusal) with blow counts for each 6-inch increment noted on the boring logs. Refusal will be defined as 10 blows with no advancement, 50 blows for less than 6 inches of advancement, and 100 blows for 6 to 18 inches of advancement. SPT samples will be placed in Ziploc baggies or sealable jars and contain the project information, boring name, sample number, and depth.

Undisturbed (intact) sampling of cohesive soil will be obtained by using a 30-inch long by 3-inch outer diameter thin-walled Shelby tube sampler. Shelby tubes will be lowered to the bottom of the borehole by the drill rod and hydraulically pushed (continuously) 24 inches, or a portion thereof if refusal, into undisturbed soil. The subcontractor will be equipped to measure downward pressure applied to the drill string as the Jacobs representative will note push pressure on the soil boring log.

Potential very stiff to hard clays may be present in the soil profile; therefore, for sample intervals where less than 6 inches of recovery is encountered, the sample interval should be drilled and cleaned to the bottom of the push interval, and then an SPT will be taken. The rock core samples shall be logged, marked, preserved, and placed into rock core boxes in accordance with ASTM D2113-14.

Bulk samples from test pits shall be collected in double layers of sealable plastic bags (bag samples) and 5-gallon buckets with lids (bulk sample). Samples in the Ziploc baggies will be used to obtain in situ moisture. The remaining sample will be used for determining the physical properties of soil.

The OSP wells will be installed according to Ecology's regulations as outlined in the chapter 173-160 WAC (Minimum Standards for Construction and Maintenance of Wells), WAC 173-160-151 (Does the Department Require Prior Notice and Fees for Well Constructing, Reconstructing, or Decommissioning a Water Well?), and WAC 173-160-400 (What are the Minimum Standards for Resource Protection Wells and Geotechnical Soil Borings?).

See Table 10 for a summary of the anticipated field methods and standards.

Table 14. Anticipated field methods/tests and standards.

Field Method	Standard
SPTs for sampling in coarse-grained soils	ASTM D1586: Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils (ASTM International 2018a)
Soil sampling in fine-grained soils	ASTM D1587: Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes (ASTM International 2015)
Rock core drilling and sampling	ASTM D2113-14: Standard Practice for Rock Core Drilling and Sampling of Rock for Site Exploration (ASTM International 2014)
Examination and visual classification of soil samples recovered from the borings	USBR 5005-86: Procedure for Determining Unified Soil Classification of Soils (Visual Method) (Reclamation 1990a, 1990b)
Examination and visual classification of rock cores	Chapters 4 and 5 of the *Engineering Geology Field Manual* (Reclamation 2001)
Falling head permeability tests in the OSPs installed within the overburden material	Seepage Analysis and Control for Dams (USACE 1986)
Stepped hydraulic pressure tests (also known as packer tests) within rock	Chapter 16 of the *Engineering Geology Field Manual* (Reclamation 2001)
Piezometer installation for groundwater monitoring	Ecology regulations as outlined in chapter 173-160 WAC
Field/in situ density tests by sand cone method	USBR 7205-89, Procedure for Determining Unit Weight of Soils In-Place by the Sand Cone Method (Reclamation 1990n)

7.3 Containers, Preservation Methods, Holding Times

Soil sample, and rock cores obtained from geotechnical borings will be placed in Ziploc baggies or sealable jars and a rock coring box, respectively, after the field examination and verification. Each container (baggie/jar, rock core box) will be labeled containing the project information, boring number, sample number, sampling depth, and date of sampling.

7.4 Equipment Decontamination

Not applicable.

7.5 Sample ID

A geotechnical sampling ID protocol during the exploration program will be followed in accordance with the below guidelines:

- Potential strength test samples extracted with thin wall Shelby tubes will be labeled containing the project information, boring number, sample number, sampling depth, and date of sampling.
- The representative soil samples collected at various depths during test pit excavations will be placed in 5-gallon buckets (bulk samples) or double layers of sealable plastic bags (bag samples) and labeled accordingly with project information, test pit number, sample number, sampling depth, and date of sampling.

7.6 Chain of Custody

Soil samples, and rock cores obtained during the exploration program, except for those that will be sent for laboratory testing, will be stored at the KRD storage facility at the Whipple Pump Station. Laboratory test samples, including diamond rock core samples, will be transported to the Kleinfelder Redmond laboratory accredited by AASHTO and/or USACE for required testing. Sample boxes will have a letter of transmittal and preliminary drill hole logs attached.

7.7 Field Log Requirements

Standard borehole logs and test pit logs will be prepared as outlined in Chapter 10 and Chapter 11 of *Engineering Geology Field Manual* (Reclamation 2001) upon completion of each of the geotechnical borings/test pits.

7.8 Other Activities

Not applicable.

8.0 Laboratory Procedures

8.1 Laboratory Procedures Table

Table 11 shows the anticipated laboratory tests and standards.

Table 15. Anticipated laboratory tests and standards

Parameter	Standard
Moisture %	USBR 5300-89 (Reclamation 1990c) or equivalent
Dry Density	USBR 5375-89 (Reclamation 1990i) or equivalent
Specific Gravity	USBR 5320-89 (Reclamation 1990d) or equivalent
Sieve Analysis	USBR 5325-89 (Reclamation 1990e) or equivalent
Hydrometer	USBR 5330-89 (Reclamation 1990f) or equivalent
Atterberg (Multi-Point)	USBR 5360-89 (Reclamation 1990h) or equivalent
Organic Content	USBR 5430-89 (Reclamation 1990l) or equivalent
Rock Coring - Lab Tests	
Unconfined Compression with Youngs Modulus	USBR 6210 (Reclamation 2015a, 2015b)/6220 (Reclamation 2015c) or equivalent
Point Load	USBR 6535 (Reclamation 2015d) or equivalent
CERCHAR Abrasively Index	ASTM D7625-22 (ASTM International 2022) or equivalent
Test Pits - Lab Tests	
Moisture %	USBR 5300-89 (Reclamation 1990c) or equivalent
Sieve Analysis	USBR 5325-89 (Reclamation 1990e) or equivalent
Atterberg (Multi-Point)	USBR 5360-89 (Reclamation 1990h) or equivalent
Crumb Test	USBR 5400-89 (Reclamation 1990j) or equivalent
Pinhole Test	USBR 5410-89 (Reclamation 1990k) or equivalent
Soundness and durability testing	ASTM C289-07 (ASTM International 2003)
Laboratory compaction of soils	USBR 5500-89 (Reclamation 1990m) or equivalent

8.2 Sample Preparation Methods

Refer to Section 8.2, Measurement and sampling procedures, for a discussion on the sample preparation methods.

8.3 Special Method Requirements

Not Applicable.

8.4 Laboratories Accredited for Methods

The laboratory testing of the soil and rock samples shall be performed by Kleinfelder, Inc., a certified laboratory accredited by AASHTO and USACE, following the testing standards listed in Table 8 and Table 11.

9.0 Quality Control Procedures

9.1 Table of Field and Laboratory Quality Control

During field exploration, the sampling of subsurface materials (soils and/or rock) and associated field and laboratory testing will be conducted in accordance with ASTM and USBR standards listed and summarized in Section 8.2, Section 9.1, and Section 9.2 to meet the quality of the field and laboratory data.

The field exploration works will be completed in the presence of the qualified geotechnical engineer or geologist who will direct the drilling operations, test pit excavations, and sample collection and provide continuous observation and logging of each of the boreholes/test pits. Upon completion of the field exploration and laboratory testing, the data will be reviewed by the senior geotechnical engineer to meet the data quality objectives and measurement quality objectives (MQO).

9.2 Corrective Action Processes

During the field exploration, if explorations and /or field tests are determined to be not conducted per the appropriate standards Jacobs geotechnical engineers will send an initial notification to the subcontractor and provide recommended corrective actions. If the exploration and /or field test has been grossly mis performed the boring and/or field test will be recompleted at the cost of the subcontractor.

During laboratory testing, if testing procedures are not being conducted per the appropriate standards Jacobs geotechnical engineers will send an initial notification to the laboratory manager and provide recommended corrective actions. If the lab test has been grossly mis performed additional samples maybe tested (above and /or below the selected sample) at the cost of the subcontractor.

10.0 Data Management Procedures

10.1 Data Recording and Reporting Requirements

The standard soil and rock boring log and test pit log will be used for geotechnical borings and test pit excavation, respectively, for field logging soil and rock. The standard logs provide a template to document information recommended by *Engineering Geology Field Manual* (Reclamation 2001), ASTM D5434-25 (*Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock*) (2025), ASTM D2488-17e1 (*Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*) (2018b), and ASTM D2113-14 (*Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation*) (2014). Borehole abandonment details and piezometer installation will be recorded in the field logs.

Field and laboratory testing data will be recorded in the test data sheets as per applicable ASTM/USBR testing standards listed in Table 10 and Table 11. The recorded field data will be reviewed by the senior geotechnical engineer to prepare the final logs.

10.2 Laboratory Data Package Requirements

Laboratory test results will be provided as a factual report consisting of the data required by the applicable USBR/ASTM test procedures.

10.3 Electronic Transfer Requirements

The laboratory data will be submitted as a PDF report and uploaded to EIM in a CSV file, and in accordance with the Ecology EIM coordinator's request for upload.

10.4 Data Upload Procedures

All electronic transfer requirements will be executed in readily usable formats to minimize data entry problems and to facilitate data analysis. All data will be formatted and entered into Ecology's EIM system.

10.5 Model Information Management

Not applicable.

11.0 Audits and Reports

11.1 Audits

Audit and report procedures will be followed as outlined in this QAPP. In situ field collection audits will occur during sample collection.

11.2 Responsible Personnel

Responsible personnel include the following:

- Field audit: project managers and geotechnical staff
- Field consistency review: geotechnical staff
- Data analysis: project manager and others familiar with analyses

11.3 Report Frequency and Distribution

A report will be drafted and submitted to Ecology's Administration of Grants and Loads system describing testing results for each round of funding and respective testing.

11.4 Responsibility for reports

The project manager for Jacobs will analyze data with assistance from field staff and others. The project manager from Jacobs, KRD, Ecology, and other personnel will be responsible for verifying completeness prior to producing the technical report or entering data into Ecology's EIM system.

12.0 Data Verification

12.1 Field Data Verification, Requirements, and Responsibilities

The following will be conducted to ensure verification is completed in the field prior to leaving the site:

- For each of the geotechnical borings or test pits, the field engineer/geologist will complete any documentation related to subsurface materials (soil and/or rock) on the standard borehole logs or test pit logs as outlined in Chapter 10 and Chapter 11 of the *Engineering Geology Field Manual* (Reclamation 2001).
- The field engineer/geologist will complete the standard in situ test data sheet, including preliminary test results (if any), after completing each field tests (e.g., water percolation test, packer test, in situ density test). The field tests will be performed in accordance with the standard testing procedures outlined in Table 10.

After the site visit:

- The field engineer/geologist will upload draft/preliminary field borehole logs, test pit logs, in situ test data sheet, and photographs taken during the field event.
- The draft field logs and in situ test data will be reviewed by the senior geotechnical engineer for accuracy/acceptance. After internal review, the updated draft field exploration logs, field data, and laboratory results can be provided to Ecology by uploading applicable data to the EIM database. Once all fieldwork is complete, a GDR will be developed.

12.2 Laboratory Data Verification

Data verification involves examining the data for errors, omissions, and compliance with QC acceptance criteria. The geotechnical laboratory testing manager will perform laboratory verification following standard ASTM/USBR laboratory practices as outlined in Table 11. The laboratory manager will also provide a written report of their data review, which will include a discussion of whether:

1. MQOs were met.
2. Calibrations and controls were within limits.
3. Data was consistent, correct, and complete, without errors or omissions.

The senior geotechnical engineer will review the laboratory testing data for final acceptance prior to uploading applicable data to the EIM database. At the end of this initial geotechnical fieldwork (winter/fall 2025), a geotechnical exploration report (GER) will be developed. This report will include boring and test pit logs, in situ testing raw data, laboratory testing data, and televiewer logging data. This data will be uploaded to the EIM database. This report will summarize the geotechnical exploration activities and provide preliminary recommendations and geotechnical design considerations at the site for dam construction.

As more funding is available, continued geotechnical activities will be conducted, as described herein. A final GDR will be developed once all geotechnical activities are complete.

12.3 Validation Requirements

Not applicable.

12.4 Model Quality Assessment

Not applicable.

12.4.1 Calibration and Validation

Not applicable.

Precision

Not applicable.

Bias

Not applicable.

Representativeness

Not applicable.

Qualitative Assessment

Not applicable.

12.4.2 Sensitivity and Uncertainty Analysis

Not applicable.

13.0 Data Quality (Usability) Assessment

13.1 Process for Determining Project Objectives Were Met

All geotechnical field and laboratory data will be assessed to determine if data collection meets project objectives, and results will be verified against compliance with MQOs during GDR preparation.

13.2 Treatment of Non-Detects

Not applicable

13.3 Data Analysis and Presentation Methods

At the end of this initial geotechnical fieldwork (winter/fall 2025), a GER will be developed. This report will include boring and test pit logs, in situ testing raw data, laboratory testing data, and televiewer logging data. This data will be uploaded to the EIM database. This report will summarize the geotechnical exploration activities and provide preliminary recommendations and geotechnical design considerations at the site for potential dam construction.

As more funding is available, potential continued geotechnical activities will be conducted, as described herein. A final GDR will be developed once all geotechnical activities are complete.

The GDR will include documentation of all fieldwork completed, including geologic mapping findings; photographs and discussions; a narrative of geologic units encountered; borings and test pits logs; installation data logs; laboratory test results; photographs of site geology, rock cores, and test pits; geologic maps; and cross sections developed from existing and new data.

13.4 Sampling Design Evaluation

The senior geotechnical engineer, along with other key personnel, will determine which data meets the MQOs. The study will be considered successful if the data collected is analyzed as within the ranges listed in Table 8 and at the discretion of the geotechnical engineers.

13.5 Assessment Documentation

The senior geotechnical engineer will review the laboratory testing data for final acceptance prior to uploading applicable data to the EIM database. At the end of this initial geotechnical fieldwork (winter/fall 2025), a GER will be developed. This report will include boring and test pit logs, in situ testing raw data, laboratory testing data, and televiewer logging data. This data will be uploaded to the EIM database. This report will summarize the geotechnical exploration activities and provide preliminary recommendations and geotechnical design considerations at the site for potential dam construction.

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15.0 Appendices

Appendix A. Geotechnical Field Exploration Plan – Springwood Reservoir (Jacobs 2023b)

Geotechnical Field Exploration Plan – Springwood Reservoir

Date: November 1, 2023
Project name: UYSS Facilities Scoping
Project no: W3Y10903
Attention: Urban Eberhart, KRD Manager
Client: Kittitas Reclamation District
Revision no. 0

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1. Introduction

In July 2023, in preparation for the Upper Yakima System Multi-Benefit Water Storage (UYSS) Study value planning meeting, Jacobs summarized the existing geotechnical data, evaluations completed, and recommendations for further geotechnical studies for five storage alternatives at the Springwood Reservoir site (varying by full pool water surface elevation [WSE], associated storage volume, and footprint extent), as well as three other locations previously identified in the UYSS Phase 2A reports (Jacobs 2021, 2023). The Springwood Reservoir site alternative with full pool WSE at 2,200 feet was selected by the value planning team for further evaluation.

This geotechnical field exploration plan has been developed to describe the proposed geotechnical explorations and procedures that will be implemented by a geotechnical consultant(s) in conducting the exploration program for the selected Springwood Reservoir project. The explorations will be performed as part of the feasibility study and will include completion of 34 geotechnical borings, 37 test pits, and geophysical surveys at 15 locations. The explorations will supplement previously completed geotechnical explorations completed for an appraisal-level study of the Springwood Reservoir site with the WSE at 2,080 feet.

2. Project Location

The Springwood Reservoir site is located within the 3,615-acre Springwood Ranch property, approximately 9 miles northwest of Ellensburg in Kittitas County, Washington, and along the western edge of Kittitas Valley (Attachment 1, Figure 1). The property is situated between Interstate 90 and the Yakima River in Sections 20, 28, and 29 of Township 19 North, Range 17 East, Willamette Meridian.

3. Project Description

The Springwood Reservoir with a WSE of 2,200 feet will require construction of a primary dam, a secondary dam, and two saddle dams. The primary dam would have a length of approximately 7,560 feet and a maximum height of about 440 feet. The secondary dam would have a length of approximately 6,970 feet and a maximum height of about 220 feet. The two saddle dams would have lengths of approximately 2,930 feet and 2,500 feet and a maximum height of about 75 feet. The reservoir would require direct pumping from the Yakima River where the North Branch Canal passes under the river via the Yakima River Pressure Tunnel. Figure 2 (Attachment 1) provides a general configuration of the proposed Springwood Reservoir project.

4. Existing Geotechnical Information

An appraisal-level geological and geotechnical investigation consisting of a desktop study, a geologic site reconnaissance, subsurface explorations, and laboratory testing was completed by Aspect Consulting, LLC (Aspect 2022) for the Springwood Reservoir site.

4.1 Site Reconnaissance

The geologic site reconnaissance consisted of walking the project site by traversing the terrain over a 2-day period, primarily in the vicinity of the primary and secondary dams. Visible features, such as slope inclination, rock outcrops and conditions, scarps, and the general geomorphology were noted. A summary, key observations, and select photographs from the reconnaissance were included in the geotechnical data report prepared by Aspect (2022).

4.2 Subsurface Investigation

The subsurface exploration consisted of 9 borings advanced using a combination of sonic and rock coring drilling techniques to total exploration depths between 100 and 231 feet below ground surface (bgs). Of the 9 borings, 5 were completed downstream of the current alignment of the proposed primary dam, 3 were completed downstream of the current alignment of the proposed secondary dam, and 1 was completed within a potential borrow area. Figure 2 (Attachment 1) shows the locations of the borings advanced by Aspect.

The borings were completed on behalf of the Phase 2B report, the appraisal-level evaluation for the Springwood Reservoir site (Jacobs 2022), which focused on storage alternatives with a full pool WSE of 2,080 feet and approximate storage capacity of 21,000 acre-feet. Since the primary and secondary dams for all the alternatives are in the same location, the geotechnical data obtained from the geotechnical investigation by Aspect (2022) are applicable to the proposed project having a WSE of 2,200 feet.

The geotechnical explorations indicate that the general stratigraphy at the primary and secondary dam locations include thin veneers in the near surface of recent alluvium and/or loess, over glacial Indian John Outwash and/or Swauk Prairie Till capping Ellensburg Formation and Grande Ronde Basalt bedrock.

Where encountered in exploratory borings, the Swauk Prairie Till generally consisted of alternating deposits of silty gravel with sand, with or without cobbles and boulders up to 1- to 2-foot-diameter (GM), and gravel with silt and sand, with or without cobbles and boulders up to 1- to 2-foot-diameter (GW-GM). The relative densities ranged between dense to very dense.

The Indian John Outwash, which was only encountered in the boring advanced in the upper right abutment of the primary dam, generally consisted of sand with silt (SP-SM) or silty sand deposits with or without gravels (SM). The relative densities ranged between medium dense to very dense.

The Ellensburg Formation was generally interpreted by Aspect (2022) as fresh to moderately weathered, extremely weak to moderately weak sandstone, siltstone, and conglomerate with fine to coarse, subrounded gravel and subrounded cobbles in a matrix of fine to coarse sand and silt. The core recovery was low (less than 50 percent), and, when recovered, the rock quality designation (RQD) ranged between 5 and 25.

The Grande Ronde Basalt at the primary and secondary dams was typically gray, fresh to slightly weathered, and strong to extremely strong (R5 to R6), with aphanitic groundmass. Depending on the basalt position within the individual flows, the basalt could be non-vesicular to highly vesicular, with the higher vascularity generally near the interflow boundaries. The core recovery was generally from 90 to 100 percent. The RQD varies between and within borings between 0 and 100. The rock discontinuities primarily consisted of fracture zones and joints that were highly variable in orientation. In general, the discontinuities were in fair to excellent condition with very closely to closely spaced, horizontal to vertical fracture orientations, and very tight to tight apertures that had iron oxide surface staining and occasional spotty clay infilling with slight rough to rough surfaces. Neither Packer permeability testing nor downhole televiewer logging within the basalt rock was part of the previous explorations.

5. Proposed Explorations

Table 1 summarizes the proposed geotechnical explorations for the Springwood Reservoir site. Figure 3 (Attachment 1) shows the proposed boring and test pit locations.

Table 1. Summary of the Proposed Geotechnical Explorations for the Springwood Reservoir Site

Alt. ID	Facility	Length (feet)	No. of Borings[1]	No. of Test Pits[2]	No. of Piezometers VWP/OSP	No. of Borings with Permeability Tests	No. of Borings with Packer Tests	No. of Downhole Televiewer Logging	No. of MASW/ Resistivity Surveys
5	Primary Dam	7,560	8	7	8/3	5	5	8	5
	Secondary Dam	2,930	4	3	4/3	2	3	4	2
	Saddle Dams	9,475	8	7	6/3	4	4	8	8
	Outlet Works Tunnel	1,775	4	2	1/1	—	4	4	—
	Inlet Channel/ Pipeline	2,300	—	4	—	—	—	—	—
	Borrow Area	—	10	14	—	—	—	—	—
	Total	—	**34**	**37**	**19/10**	**11**	**16**	**24**	**15**

[1] Boreholes are proposed for advancement using sonic drilling and rock coring techniques. Boreholes advanced for assessing borrow areas will be vertical. Between 30 and 50 percent of the boreholes advanced for the primary, secondary, and saddle dams will be inclined up to 65 degrees from horizontal. At least one inclined boring would be advanced at each abutment of the primary and secondary dams.

[2] Test pits excavated along dam, inlet, and outlet alignments will provide data that will be used to evaluate variability of near-surface conditions and assess potential borrow sources.

MASW = multichannel analysis of surface waves; OSP = open standpipe piezometer; VWP = vibrating wire piezometer

5.1 Site Access and Utility Locates

The Springwood Ranch property ownership is currently held by the Trust for Public Land with planned distribution to various UYSS stakeholders. It is anticipated that Kittitas Reclamation District (KRD) will coordinate with the Trust for Public Land or other stakeholder(s) to arrange for right of entry to conduct the exploration and provide awareness and/or location of any private subsurface utilities existing in the area. All private utilities should be marked by others prior to commencement of drilling.

The geotechnical consultant(s) will work with KRD to facilitate cultural resources assessment Section 106 compliance and complete a "call before you dig" notification with the Utility Notification Center of Washington, as required by law, to inform utility owners of the pending site improvements and field explorations to allow them to locate and mark their utilities. The geotechnical consultant(s) will coordinate with KRD regarding the timing of private utility locate markings, if it is needed.

5.2 Field Reconnaissance

5.2.1 Purpose

The geotechnical consultant(s) will conduct a preliminary field reconnaissance to review the proposed locations of geotechnical explorations and to identify access requirements. Locations of some borings and test pits may be revised so that they can be advanced from areas that have better access, improved site safety, or less impact to sensitive vegetation and potential cultural resources. The field reconnaissance will also be used to evaluate topography and determine anticipated boring and test pit depths.

5.2.2 Requirements

The geotechnical consultant(s) will locate and stake the boring and test pit locations prior to mobilization of drilling equipment. The exact locations and depths of the borings and test pits are subject to change based on conditions encountered and determined by the geotechnical consultant(s) onsite. Final boring and test pit properties will be documented by the geotechnical consultant(s) and submitted for the records recorded for inclusion in the geotechnical data report.

5.3 Geologic Mapping

5.3.1 Purpose

Surface geologic mapping will be conducted to better understand the composition and structure of the exposed materials and evaluate how the structural geology may impact the siting, risks, design, and construction requirements of the dams, spillway, inlet, and outlet works. The effort will include developing a map of the surficial deposits and characteristics of exposed site geology, identifying structural geology such as bedding, folds, joints, and faults.

The mapping will also support identification of possible borrow sources for various types of dams that could be constructed. Outcrops of basalt observed in the preliminary geologic mapping work previously completed by Aspect (2022) were primarily noted along the eastern boundary of the reservoir, downstream of the primary dam. A goal of the geologic mapping should be determining if there may be a source of basalt bedrock within the footprint of the reservoir, where overburden materials are less than 20 to 30 feet bgs, which could be further evaluated with test pits and/or geotechnical borings.

The ridgeline southeast of the proposed reservoir separates the Springwood Reservoir site from the Yakima River Canyon. Since the hydraulic gradient between the proposed reservoir and the bottom of the adjacent Yakima River Canyon will be relatively large, there is potential that seepage water could daylight on the canyon walls, possibly resulting in erosion and sloughing off the walls. Geologic mapping, including discontinuities, will be performed on the Yakima River Valley slope downgradient of the proposed primary and secondary dams to determine the need for and the extent of the cutoff trench or grout curtain.

Locations of slope failures or potential instability will be mapped along with areas of seepage. Other signs that might be indicative of artesian groundwater conditions will be carefully evaluated during geological reconnaissance.

5.3.2 Requirements

Surficial units at the dam site and within the reservoir will be mapped to differentiate between surficial colluvium and regolith from potential terrace deposits for borrow. Bedrock outcrops will be located, and fracture mapping will be completed to develop local fracture network attributes. The fracture mapping will include dip and dip direction, length, spacing, aperture, and infillings.

Geologic mapping will be completed on the Yakima River Valley slope face downgradient of the proposed primary and secondary dams. Geologic mapping will be completed before commencing the geotechnical explorations and may result in modifying proposed explorations to explore borrow sources or other features of interest.

5.4 Site Survey

5.4.1 Purpose

The site survey will provide coordinates and elevations of test pits and boreholes. Locations of geologic features identified as part of the geologic reconnaissance mapping may also be surveyed.

5.4.2 Requirements

Test pits, boring locations, and top of casing where piezometers are installed (after completion) will be surveyed to 0.5-foot accuracy.

5.5 Geotechnical Borings

The geotechnical exploration program consists of 34 geotechnical borings (designated B-01 through B-34). Of the 34 borings, 20 borings will be advanced along the profiles of the primary, secondary, and saddle dams (B-01 through B-20), 4 borings will be advanced along the outlet works tunnel alignment (B-21 through B-24), and 10 borings will be advanced within the reservoir area to identify potential borrow source areas (B-25 through B-34). Proposed boring locations are shown on Figures 4A through 4D (Attachment 1). The locations of the 10 borings to be advanced within the footprint of the reservoir (B-25 through B-34) are shown on Figures 4A through 4D, but it is expected that these locations may be modified based on findings of the geologic mapping and/or test pits.

5.5.1 Purpose

The explorations along the profile of the primary, secondary, and saddle dams will be used to gather information on the stratigraphy beneath the dam foundations, physical properties of stratum, depth to bedrock, rock quality, and permeability data and provide information to help interpret the variability of foundation conditions. The visual observations and results of in situ and laboratory testing will be used to evaluate foundation properties.

Based on the geotechnical investigation completed by Aspect (2022), basalt bedrock beneath the Springwood Reservoir site appeared moderately to highly jointed or fractured. The RQD recorded in the collected rock core ranged from 0 (very poor) to 100 (excellent), with lower RQDs generally observed near the top of the basalt contact (Aspect 2022). Based on limited drilling of the site to date, some of the bedrock is poor quality, consisting of highly fractured areas that may accept considerable grout. Geotechnical borings that include permeability testing will be completed to better define the foundation conditions and to develop a foundation to reduce bedrock seepage. The explorations will be used to determine the need for and extent of a trench or grout curtain cutoff for seepage control.

The ridgeline southeast of the proposed reservoir separates the Springwood Reservoir site from the Yakima River Canyon. Since the hydraulic gradient between the proposed reservoir and the bottom of the adjacent Yakima River Canyon will be relatively large, there is potential that seepage water could daylight on the canyon walls, possibly resulting in erosion or sloughing on the slopes above the river. If permeable rock mass conditions are discovered along this ridge, which could result in greater seepage leading to erosion or slope instability at the canyon wall, the seepage could be mitigated by installing a grout curtain or other seepage barrier along the southern ridge. The potential for seepage at the ridgeline will be studied in more detail using deep borings and permeability testing to determine requirement for seepage control.

The explorations along the outlet tunnel alignment will be used to determine the depth to bedrock and the bedrock quality along the tunnel. The quality and variability of bedrock will impact suitable tunneling methods and tunnel liner requirements for constructing the outlet works tunnel.

The depth to groundwater in one of the boring advanced near the bottom of the valley, about 250 feet downstream of the primary dam alignment, was noted at 3 feet bgs at the time of drilling. During subsequent monitoring using a vibrating wire piezometer (VWP) installed at the location, artesian water pressure conditions were recorded, with the high groundwater reading at approximately 25 feet above ground surface. The presence of artesian groundwater conditions will be carefully evaluated during geological reconnaissance, geotechnical explorations, and subsequent groundwater monitoring.

The explorations within the reservoir limit will be used to assess potential borrow sources for different dam construction alternatives. The explorations will be used to evaluate characteristics and thicknesses of recent alluvium, till, and bedrock.

Parameters of interest will include the density, variability, and particle size distribution of overburden; top of bedrock; strength of the rock; degree and orientation of jointing and fracturing; presence of other rock types besides the Grande Ronde Basalt; and permeability of the rock mass.

5.5.2 Requirements

All borings are in open field areas, and it is anticipated that borings will be advanced using track-mounted drill rigs. New access road construction and site clearing may be required for access to the boring locations. For the borings on the steep slope along the outlet works and left abutment of the primary dam, more earthwork is anticipated to build the access road and work pad for drilling.

The borings are recommended to be advanced using sonic drilling methods in overburden soils and continuous HQ-sized, triple-barrel wireline rock coring in rock. Completing borings using sonic drilling methods is advantageous since continuous core samples can be obtained. Depending on availability and cost of sonic drill equipment, alternative drilling methods, such as mud-rotary drilling, can be used to complete some of the borings.

Borings along the primary and secondary dams and those along the southeast ridge (B-01 through B-13) will be advanced to the Yakima River level at an elevation of 1,720 feet NAVD88 (North American Vertical Datum of 1988) to evaluate fracturing and permeability. All other borings advanced along dam alignments will be drilled at least 20 feet below the top of the bedrock. The actual depth of the borings will be defined by qualified staff of the geotechnical consultant(s). Borings advanced within the reservoir footprint for the purpose of evaluating borrow sources (B-25 through B-34) will be advanced to maximum depth of 100 feet bgs.

Between 30 and 50 percent of the borings along the dams will be inclined (Borings B-01, B-04, B-08, B-09, B-11, B-13, B-15, B-16, B-18, and B-22). At least one inclined boring will be advanced at each abutment of the primary and secondary dams. The inclined boreholes will be advanced at angles up to 65 degrees from horizontal. The borings' orientation will be determined based on results of geologic surface mapping and downhole televiewer logging of vertical borings.

Casing, either driven or drilled, will be used (1) where necessary to prevent caving, (2) where rock drilling is to be performed beneath the overburden, or (3) where soil hydraulic conductivity testing is to be performed. Casing will be removed after completion of drilling, sampling, and testing.

Upon completion of drilling, in situ testing, and downhole televiewer logging, drilled holes not converted to open standpipe piezometers (OSPs) will be plugged and abandoned in accordance with Washington State Department of Ecology (Ecology) standards. Plugging and abandonment will consist of backfilling the hole from bottom to top through a tremie pipe with cement-bentonite grout mixed as approved by qualified staff of the geotechnical consultant(s).

Drill fluids (if any) will be contained at the drill site and recirculated during drilling operations. Upon completion of drilling each boring, the fluids and drill cuttings will be placed in a containment area and allowed to filter through silt fencing or evaporate. Drill cuttings from each borehole will then be distributed around the borehole location and not left in a pile but spread out to reduce impacts to the borehole location. Drillers will use a recirculation sump and tanks as well as setting silt fencing downslope of work area to minimize water runoff impacts.

Drilling will be completed in the presence of qualified staff of the geotechnical consultant(s) who will direct the drilling operations, collect samples, and provide continuous observation and logging of each borehole

Soil samples and soil and rock cores obtained during the exploration program, with the exception of those that will be sent for laboratory testing, will be stored at a KRD-identified storage facility.

In Situ Testing

A continuous sonic core will be obtained in the overburden soils. Standard Penetration Testing will be performed at 5-foot intervals through the overburden soil, and blow counts will be recorded on boring logs. Soil samples recovered from the borings will be examined and visually classified in accordance with the Bureau of Reclamation's (Reclamation) USBR 5005-89, *Procedure for Determining Unified Soil Classification of Soils (Visual Method)* (Reclamation 1990).

Upon reaching refusal at bedrock, the drilling method will switch to HQ-sized, triple-barrel wireline rock coring. All rock cores will be collected and preserved in core boxes provided by the driller. Rock cores will be examined and visually classified in accordance with Chapters 4 and 5 of the *Engineering Geology Field Manual* (Reclamation 2001). Potential strength test samples will be wrapped for shipping by the field engineer.

Groundwater levels will be measured during the active drilling as requested by the field engineer. Additional testing will be conducted to assess overburden and bedrock permeability.

Percolation Testing

In situ water percolation tests will be completed in select borings within the till material at approximately 10-foot intervals to estimate the permeability of the foundation material. The tests will be completed in accordance with Gravity Permeability Test – Method 2, as outlined in Chapter 17 of the *Engineering Geology Field Manual* (Reclamation 2001). It is anticipated that the tests will be completed in the following borings:

- Primary Dam: Borings B-05, B-07, B-09, B-11, and B-13
- Secondary Dam: Borings B-02 and B-03
- Saddle Dams: Borings B-15, B-17, B-19, and B-20

Packer Testing

Stepped hydraulic pressure tests (also known as packer tests) will be completed in select boreholes within rock in accordance with Chapter 16 of the *Engineering Geology Field Manual* (Reclamation 2001) to estimate the hydraulic conductivity and seepage behavior of the rock. The tests involve forcing water under pressure into an uncased section of the borehole that is sealed off by inflatable wireline packers. Typically, packer tests will be completed at 10-foot intervals, but may be switched to 20-foot intervals at depths of 100 feet or more below the top of rock. It is anticipated that the tests will be completed in the following borings:

- Primary Dam: Borings B-05, B-07, B-08, B-10, and B-12
- Secondary Dam: Borings B-01, B-02 and B-03
- Saddle Dams: Borings B-15, B-17, B-19, and B-20

The borehole will be flushed with clear water prior to actual pressure tests. Testing will be performed as the hole is advanced at locations and intervals determined by the engineer. The procedure of permeability testing as the borehole advances typically will be completed using a single-pack assembly. However, the driller will have the equipment to perform a double-pack assembly, if it is needed. Tests may be performed for the entire portion of the hole, or for isolated segments of the hole. The qualified staff of the geotechnical consultant(s) will provide recommended packer inflation and injection pressure values. The qualified staff of the geotechnical consultant(s) will determine the type of packer assembly and the sequence, location, and testing interval for all water pressure tests.

When the rock mass is too highly fractured, and fractures are open and highly permeable, constant head testing may be required to obtain the hydraulic conductivity data necessary for a test interval. This will require setting and inflating the packer in the borehole and performing a constant head test through the HQ drill casing.

Use of drilling mud, bentonite, or other substances that may affect the hydraulic conductivity of the rock will not be permitted in these holes without the specific approval of the qualified staff of the geotechnical consultant(s). Clean water will be used in all water pressure tests.

Downhole Televiewer Logging

Downhole televiewer logging will be completed at all borings along the primary, secondary and saddle dams (B-01 through B-20) and borings along the outlet works alignment (B-21 through B-24). Televiewer logging, either optical or acoustic, will provide information to interpret the geology in the dam foundations and outlet works alignment. The logging will also obtain detailed and oriented structural information of rock discontinuities, including the orientation of bedding planes, joints, and fractures. The discontinuity data obtained from the televiewer logging will be plotted on stereonets and used in the evaluations for preliminary dam design.

Piezometer Installation

The geotechnical exploration program will include installation of 10 OSPs and 19 VWPs within the geotechnical borings. The piezometers will be installed to facilitate periodic observation of the depth to groundwater. Of 19 VWPs, 10 of them will be installed in the open standpipes. It is anticipated that the piezometers will be installed in the following borings:

- Primary Dam: Borings B-05 (VWP), B-06 (OSP, VWP), B-07 (OSP, VWP), B-08 (VWP), B-09 (VWP), B-10 (OSP, VWP), B-11 (VWP), and B-12 (VWP)
- Secondary Dam: Borings B-01 (OSP, VWP), B-02 (OSP, VWP), B-03 (OSP, VWP), and B-04 (VWP)
- Saddle Dams: Borings B-15 (VWP), B-16 (VWP), B-17 (OSP, VWP), B-18 (VWP), B-19 (OSP, VWP), and B-20 (OSP, VWP)
- Outlet works: Boring B-24 (OSP, VWP)

The actual number and locations of piezometers may change depending on the ability to access the proposed boring locations and the findings of the field reconnaissance and geologic mapping of the site. Installation of fully grouted nested VWPs may be considered at Borings B-06 or B-07 to better evaluate possibility of artesian groundwater conditions.

The piezometers will be installed according to Ecology's regulations as outlined in the Washington Administrative Code (WAC) 173-160.

The standpipe piezometers will consist of 2-inch-diameter polyvinyl chloride (PVC) casing and 5 to 10 feet of machine-slotted screen. Sand will be placed in the annular space from 0 to 2 feet below the bottom of the screen (0 to 6 inches if the piezometer will be installed at the bottom of borehole) to 2.0 to 3.0 feet above the top of the screen. A bentonite seal will be placed above the sand and up to ground surface. Bentonite will also be used below the sand in locations where the screened interval is installed above the bottom of the boring.

VWPs equipped with dataloggers will be installed at each standpipe piezometer to monitor daily groundwater fluctuations. The VWP sensor will be attached to the outside of the standpipe casing, near the bottom of the screened interval.

The VWPs will be unvented and manufactured by Geokon (Model Number 4500S) or similar. Data from VWPs will be collected and stored on waterproof dataloggers (Geokon 8002-WP-2, LC-2 series or similar) daily and downloaded periodically (every few months). Prior to installation, the initial zero reading for each VWP sensor will be recorded according to manufacturer recommendations.

A handheld electronic water-level indicator will be used to measure the static water level in each of the OSPs within 3 days of installation. At least two additional water level readings will be collected in each standpipe piezometer, once in the summer or fall and once in the winter or spring.

Piezometers will be protected at the surface with an aboveground casing and, if needed, with three steel bollards set in concrete to protect the piezometers. Piezometer construction details and measured water levels will be included on the boring logs.

Laboratory Analyses

The laboratory testing program will be developed by the geotechnical consultant(s) and will consist of performing classification and engineering laboratory testing of the type and number required to obtain information to support the feasibility study.

It is expected that the laboratory testing program will consist of the following tests, with actual types and numbers of tests determined during and after the exploration program based on the actual subsurface conditions encountered:

- Moisture content – USBR 5300-89, *Determining Moisture Content of Soil and Rock by the Oven Method* (Reclamation 1990)
- Specific Gravity – USBR 5320-89, *Determining Specific Gravity of Soils* (Reclamation 1990)

- Sieve and hydrometer analysis – USBR 5325-89, *Performing Gradation Analysis of Gravel-Size Fraction of Soils* (Reclamation 1989); USBR 5330-89, *Performing Gradation Analysis of Fines and Sand-Size Fraction of Soils, Including Hydrometer Analysis* (Reclamation 1990); USBR 5335-89, *Performing Gradation Analysis of Soils Without Hydrometer and Wet Sieve* (Reclamation 1990)
- Atterberg limits – USBR 5350-89, *Determining the Liquid Limit of Soils by the One-Point Method* (Reclamation 1990); USBR 5355-89, *Determining the Liquid Limit of Soils by the Three-Point Method* (Reclamation 1990); USBR 5360-89, *Determining Plastic Limit and Plasticity Index of Soil* (Reclamation 1990)
- Dry Density – USBR 5375-89, *Determining Dry Unit Weight of Irregularity Shape Soil Specimens* (Reclamation 1990)
- Organic Content – USBR 5430-89, *Determining Moisture, Ash, and Organic Content of Soils* (Reclamation 1990)
- Moisture Density – USBR 5500-89, *Performing Laboratory Compaction of Soils – 5.5-lbm Rammer and 18-in Drop* (Reclamation 1990)
- Unconfined Strength with Young Modulus – USBR 6210, *Performing Uniaxial Compression Testing of Rock Core* (Reclamation 1990); USBR 6220, *Determining Modulus of Elasticity and Poisson's Ratio of Rock in Uniaxial Compression* (Reclamation 2017)
- Point Load Test – USBR 6535, *Estimating Compressive Strength by Pint Load Test Method* (Reclamation 2017)
- Cerchar Abrasivity Index testing for borings along the outlet works alignment - ASTM D7625-22, *Standard Test Method for Laboratory Determination of Abrasiveness of Rock Using the CERCHAR Abrasiveness Index Method* (ASTM International 2022)

5.6 Test Pits

The proposed geotechnical exploration program includes excavation of 37 test pits (designated T-01 through T-37). The 37 test pits will be excavated at the following locations:

- 7 test pits (TP-01 to TP-07) within the footprint of the proposed primary dam
- 3 test pits (TP-08 through TP-10) within the footprint of the secondary dam
- 7 test pits (TP-11 through TP-17) within the footprint of the saddle dams
- 4 test pits (TP-18 through TP-21) along the inlet pipeline and intake structure
- 2 test pits (TP-22 and TP-23) at the outlet intake and dissipation structures
- 14 test pits (TP-24 through TP-37) to locate potential borrow source areas

The preliminary test pit locations are shown on Figures 5A through 5D. The test pit locations in the footprint of the reservoir area may be revised based on the findings of the geologic mapping and previously completed borings and test pits.

5.6.1 Purpose

The explorations within the footprint of the primary, secondary, and saddle dams will be used to gather foundation physical properties and provide information to help interpret the variability of soil conditions. The test pits will also be used to evaluate the presence, or lack thereof, of near surface variability in overburden and help assess the potential for these materials to be susceptible to liquefaction, which would result in the requirement to remove the materials as part of the dam construction.

The explorations along the inlet and outlet lines will be used to characterize subsurface conditions along the pipelines and at the intake structures and allow for a visual observation of near-surface soil layers. The explorations within the reservoir will be used to identify potential borrow sources. The visual observations and results of in situ and laboratory testing will be used to evaluate material properties.

The natural soil material overlying Columbia River Basalt In Springwood Reservoir site vicinity is primarily associated with glacially deposited till. Till materials can be problematic because of the potential for wide variation in homogeneity of a particular deposit. In addition, till materials are often broadly graded, with varying amounts of cobble, gravel, sand, and fines (silt and clay).

Geotechnical investigations and characterizations of till material sites are sometimes challenging and require special attention. Obtaining or reproducing representative laboratory samples for testing gradation, permeability, strength, and compressibility is often difficult. Test pits and deep exploratory trenches result in larger representative samples and thus are better than boreholes for examining homogeneity.

5.6.2 Requirements

Test pits will be advanced to top of rock or a maximum depth of 15 feet, whichever is shallower. The test pits will be excavated using a tracked excavator with the capability of digging to a depth of at least 15 feet. Excavation of test pits will be terminated at shallower depths if groundwater seepage into the excavation occurs such that the pit is filling with water or if the seepage is causing caving of side walls that cannot be controlled using benching.

All test pits are located on restricted access property that is fenced and gated. No risk to public safety is anticipated. If test pits remain open overnight, the pits will be staked and flagged with warning tape. New access road construction and site clearing may be required for access to the test pit locations.

Test pits will be backfilled using the excavated material removed from each of the pits. Excavated material will be placed back in the pit in loose lifts not more than 18 inches thick. Each loose lift at test pits excavated within the footprint of proposed dams will be compacted

using a pinwheel roller or vibratory plate compactor prior to placing an additional loose lift of material. Lifts within test pits excavated outside of proposed footprints of dams will be compacted using the back of the excavator bucket.

Excavation will be completed in the presence of the qualified staff of the geotechnical consultant(s) who will direct the excavation operations, collect samples, and provide continuous observation and logging of each of the test pits.

Field Observations

The length, width, and depth of each test pit will be measured and recorded. Subsurface conditions exposed in the test pit walls will be photographed and visually logged from the ground surface to the bottom of the test pit. Field descriptions will be in accordance with USBR 5005-89, *Procedure for Determining Unified Soil Classification of Soils (Visual Method)* (Reclamation 1990). Groundwater or surficial water infiltration, if encountered, will be observed and noted, estimating excavation infiltration in gallons per minute.

In Situ Testing

For the test pits within the dam footprint, in situ density tests will be completed by the sand cone method (USBR 7205-89, *Determining Unit-Weight of Soils In-Place by the Sand Cone Method;* Reclamation 1990) in at least 3 test pits for each soil type and gradation testing will be performed on the materials removed for the sand cone test. If material is too coarse grained for the sand cone test, a large-diameter density test, such as 6-foot-diameter water replacement ring density tests (USBR 7221-89, *Determining Unit Weight of In-Place by the Water Replacement Method in a Test Pit*; Reclamation 1990), may be completed.

Laboratory Analyses

Representative soil samples will be collected from the test pits and placed in 5-gallon buckets (bulk samples) or double layers of sealable plastic bags (bag samples). Samples will be collected every 5 feet or change in material.

Up to five samples from each test pit will be tested for moisture content and gradations. If fine-grained material is encountered, Atterberg Limits, crumb, and pinhole tests will be conducted. Up to ten total Atterberg Limits tests will be completed where appropriate.

Testing will be completed as outlined in the following guidance documents:

- USBR 5000-89, *Determining Unified Soil Classification (Laboratory Method*) (Reclamation 1990)

- USBR 5300-89, *Determining Moisture Content of Soil and Rock by Oven Method* (Reclamation 1990)
- USBR 5360-89, *Determining Plastic Limit and Plasticity Index of Soil* (Reclamation 1990)
- USBR 5400-89, *Determining Dispersibility of Clayey Soils by the Crumb Test Method* (Reclamation 1990)
- USBR 5410-89, *Determining Dispersibility of Clayey Soils by the Pinhole Test Method* (Reclamation 1990)
- Test pit samples from the potential borrow area may be tested for soundness and durability in accordance with ASTM C289-94 method (ASTM International 1994).

Compaction testing of up to six bulk samples will be completed in accordance with USBR 5500-89, *Performing Laboratory Compaction of Soils- 5.5-lbm Rammer and 18-in Drop* (Reclamation 1990) to determine maximum dry density and optimum moisture content. Actual numbers of laboratory tests to be completed to determine engineering properties will be determined after all test pits are excavated and photographed and draft logs can be reviewed.

Other types of testing, including testing for permeability, compressibility, drained and undrained strength, and cyclic behavior, will not be completed unless cohesive, fine-grained soil layers are encountered in the explorations.

5.7 Geophysical Survey

5.7.1 Purpose

A surface geophysical survey (multichannel analysis of surface waves and/or electrical resistivity survey) would be useful in identifying transitions between soil and rock and the presence of weaker rock zones, characterized by lower density, or increased electrical resistance. These methods may be useful along the dam alignments to further evaluate potential anomalies.

5.7.2 Requirements

Geophysical surveys will be completed at 15 locations along the primary, secondary, and saddle dams. The number of geophysical surveys assumes that the length of each survey line is between 400 and 500 feet. A smaller number of surveys may be completed if the length of the survey lines is greater than 500 feet. The longer survey lines would typically have the added benefit of providing data for deeper profiles compared to the shorter surveys. Locations of survey lines will be determined after completion of field reconnaissance and geologic mapping.

5.8 Geotechnical Data Report

The geotechnical consultant(s) will prepare a geotechnical data report (GDR). The GDR will include documentation of all fieldwork completed for this field exploration request, including geologic mapping findings, photographs and discussions; a narrative of geologic units encountered; borings and test pits logs; installation data logs; laboratory test results; photographs of rock cores, and test pits; geologic maps; and cross sections developed from existing and new data. Attachment 2 contains the draft field exploration request.

Field logs can be shared with Reclamation's Technical Service Center and Ecology's Dam Safety Office staff as the fieldwork progresses. This information will be used to select samples and intervals for laboratory testing. This information is also important to define any modifications to the location and extent of the borings and test pits to be completed for the purpose of identifying potential borrow sources.

Updated drafts of logs can be provided within 4 weeks of the completing the explorations. The updated material will include draft boring and test pit logs and photographs along with results on any laboratory testing that has been completed.

A draft GDR will be distributed to Reclamation's Technical Service Center, Ecology's Dam Safety Office, and other stakeholder team members within 2 weeks of completion of the laboratory testing program. This draft can be sent electronically. The geotechnical consultant(s) will address stakeholder comments in the development of the final GDR.

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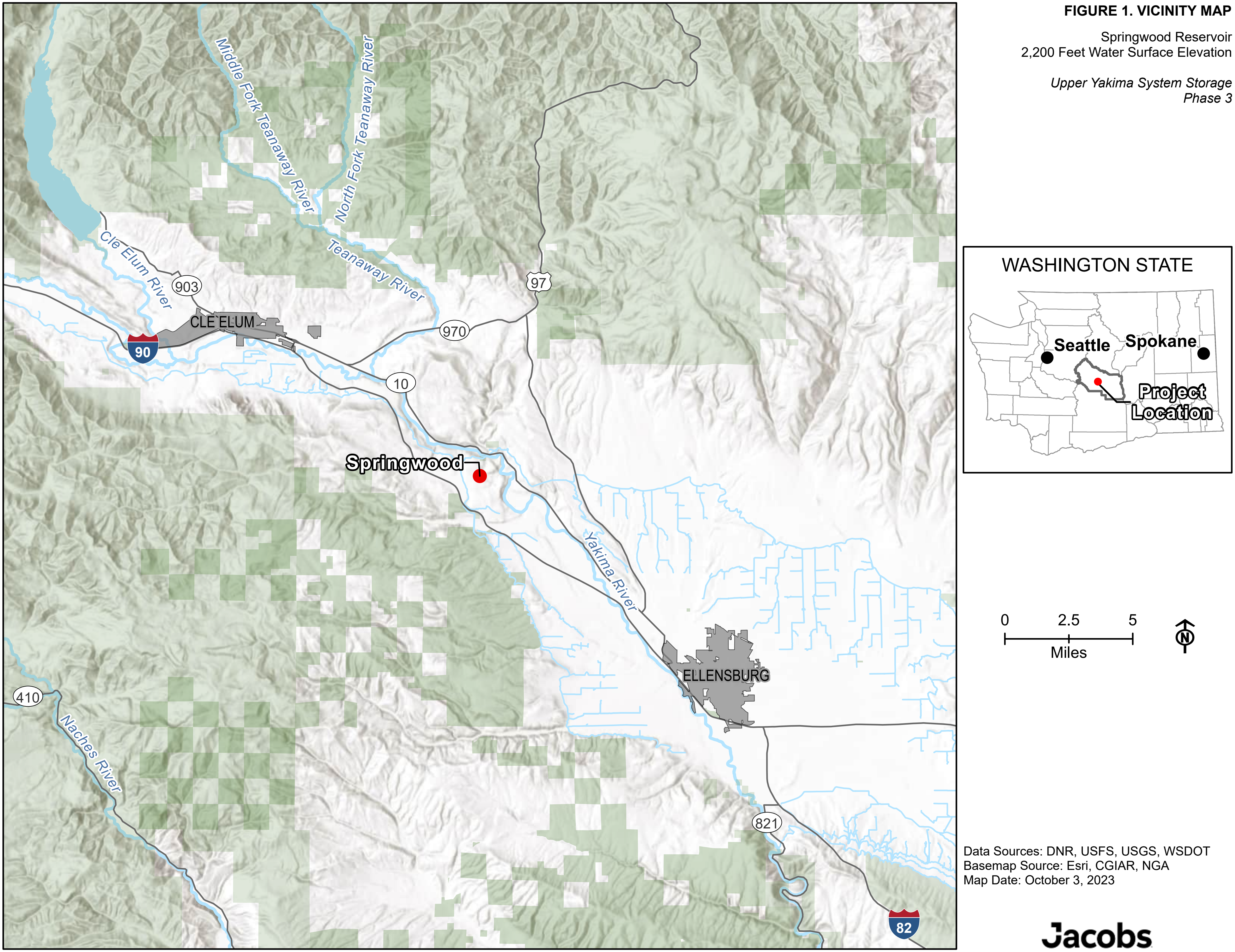
Attachment 1. Figures

- Figure 1. Site Vicinity
- Figure 2. Springwood Reservoir, 2,200 Feet Water Surface Elevation
- Figure 3. Preliminary Boring and Test Pit Locations
- Figures 4A – 4D. Boring Locations
- Figure 5A – 5D. Test Pit Locations

FIGURE 1. VICINITY MAP

Springwood Reservoir
2,200 Feet Water Surface Elevation

Upper Yakima System Storage
Phase 3



Data Sources: DNR, USFS, USGS, WSDOT
Basemap Source: Esri, CGIAR, NGA
Map Date: October 3, 2023

Jacobs

FIGURE 2. SITE

Springwood Reservoir
2,200 Feet Water Surface Elevation

Upper Yakima System Storage Phase 3

Reservoir Footprint
Dam Footprint
Aspect Geotechnical Boring (2022)

0 1,000 2,000
Feet

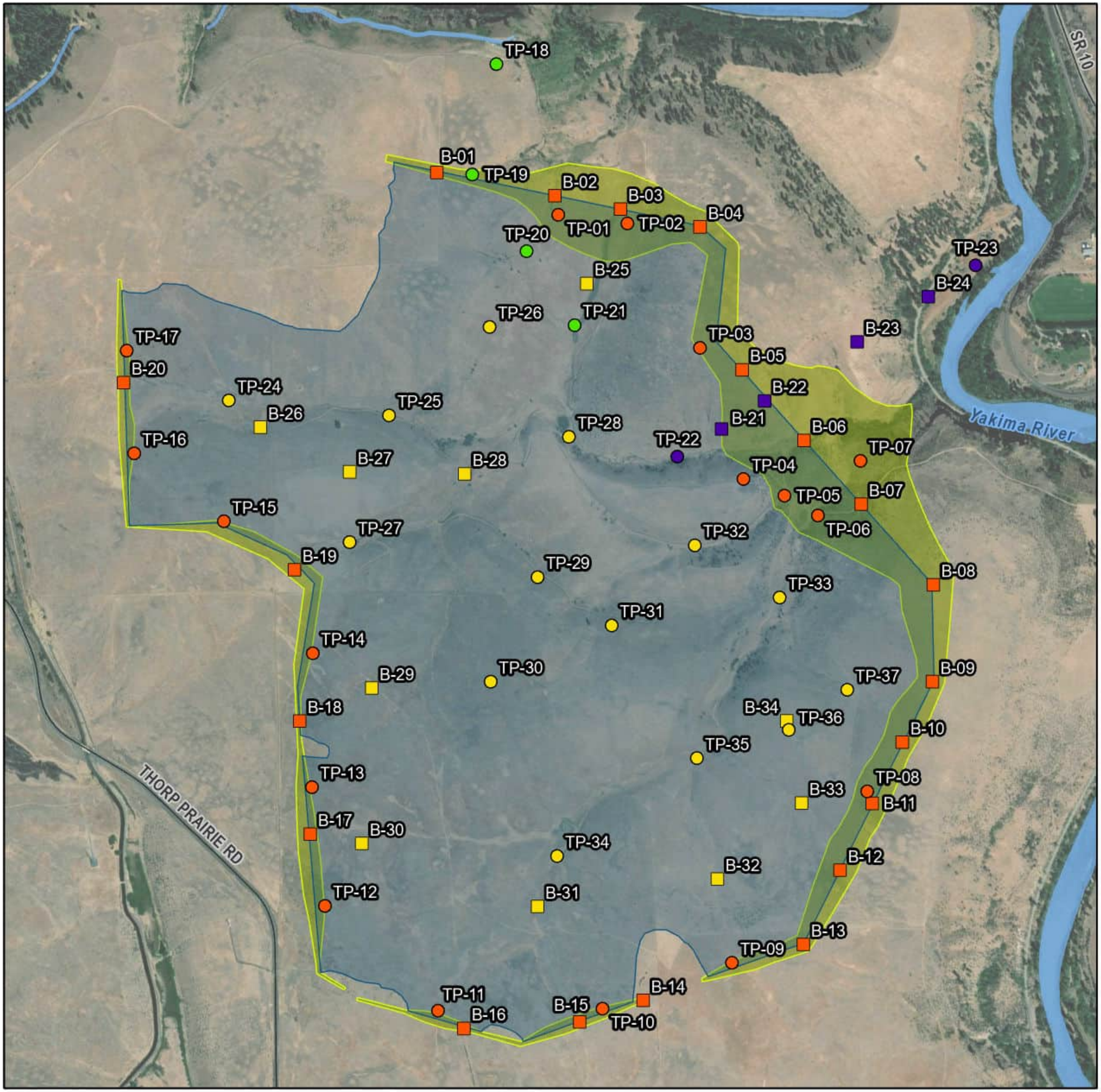
Data Sources: Kittitas County, USGS, WSDOT
Basemap Source: Maxar
Map Date: October 3, 2023

Jacobs

3. PRELIMINARY BORING AND TEST PIT LOCATIONS

Springwood Reservoir
2,200 Feet Water Surface Elevation

Upper Yakima System Storage
Phase 3



- Boring - Along Dam
- Boring - Borrow Area
- Boring - Outlet Works
- Test Pit - Along Dam
- Test Pit - Borrow Area
- Test Pit - Outlet Works
- Test Pit - Inlet
- Reservoir Footprint
- Dam Footprint

0 500 1,000
Feet

N

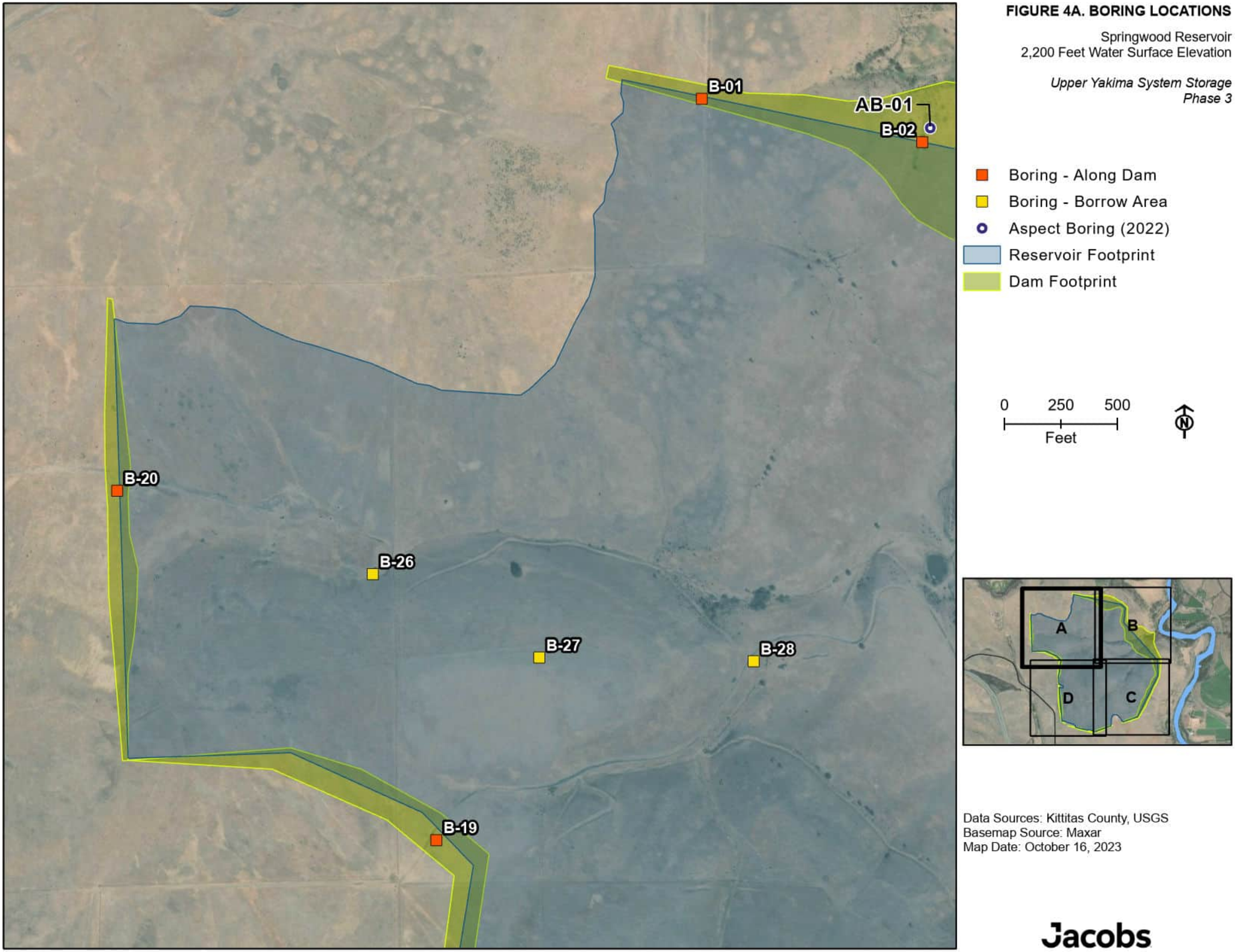
Data Sources: Kittitas County, USGS
Basemap Source: Maxar
Map Date: October 16, 2023

Jacobs

FIGURE 4A. BORING LOCATIONS

Springwood Reservoir
2,200 Feet Water Surface Elevation

Upper Yakima System Storage Phase 3



Data Sources: Kittitas County, USGS
Basemap Source: Maxar
Map Date: October 16, 2023

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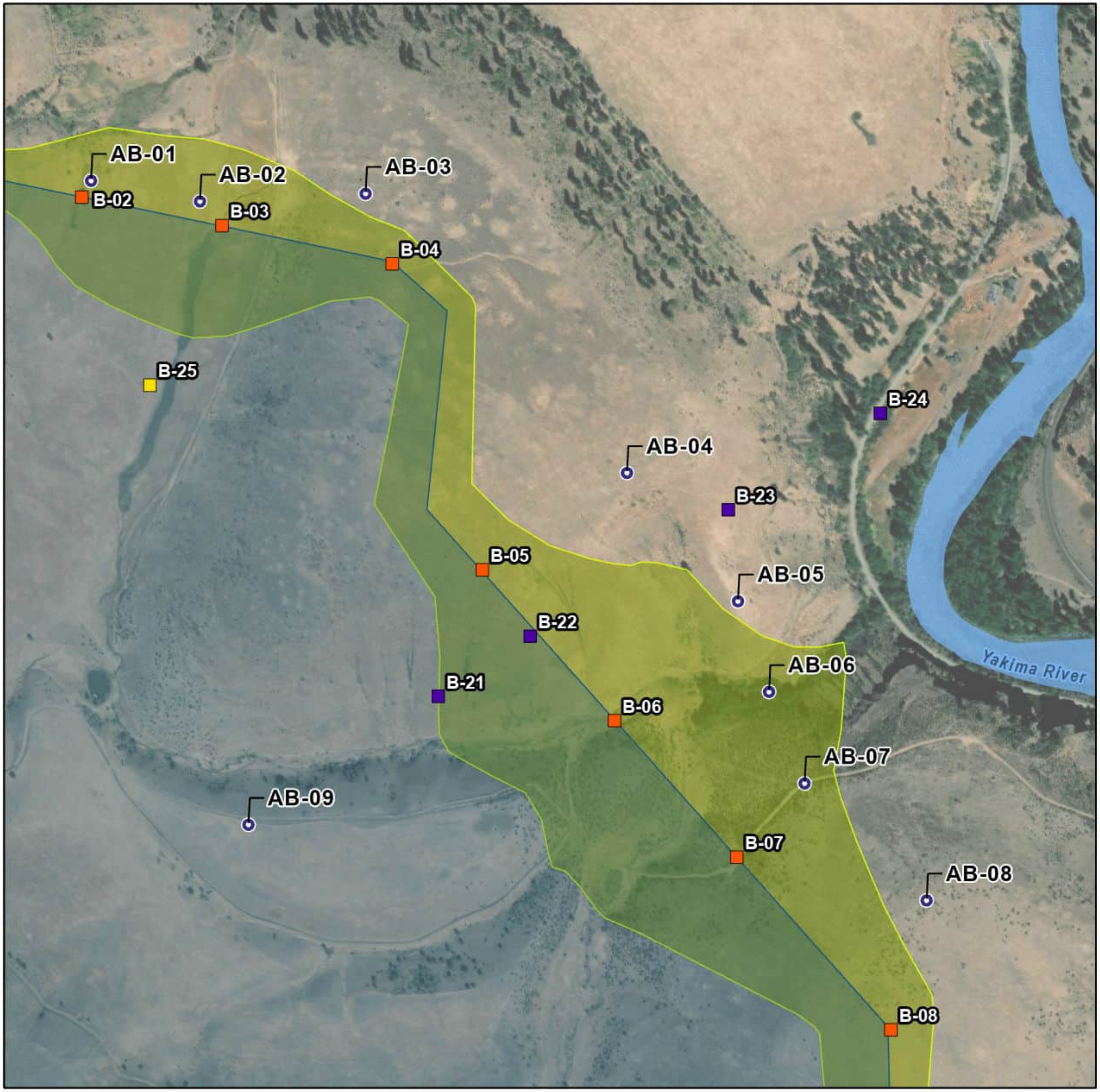
FIGURE 4B. BORING LOCATIONS

Springwood Reservoir
2,200 Feet Water Surface Elevation

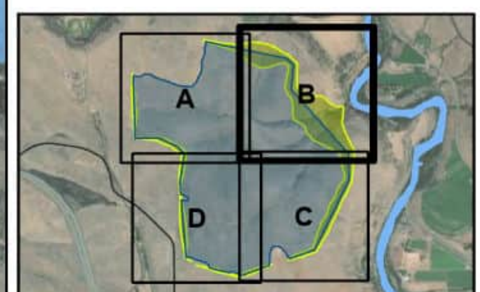
Upper Yakima System Storage
Phase 3



Boring - Along Dam
Boring - Borrow Area
Boring - Outlet Works
Aspect Boring (2022)
Reservoir Footprint
Dam Footprint

0 250 500
Feet

N



Data Sources: Kittitas County, USGS
Basemap Source: Maxar
Map Date: October 16, 2023

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FIGURE 4C. BORING LOCATIONS

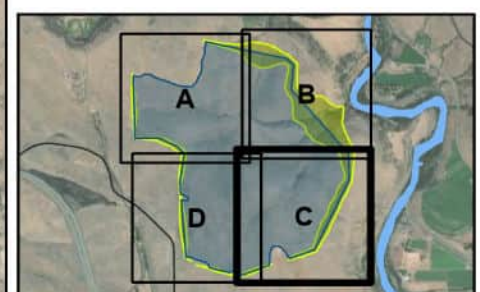
Springwood Reservoir
2,200 Feet Water Surface Elevation

Upper Yakima System Storage
Phase 3

Boring - Along Dam
Boring - Borrow Area
Reservoir Footprint
Dam Footprint

0 250 500
Feet

N



Data Sources: Kittitas County, USGS
Basemap Source: Maxar
Map Date: October 16, 2023

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FIGURE 4D. BORING LOCATIONS

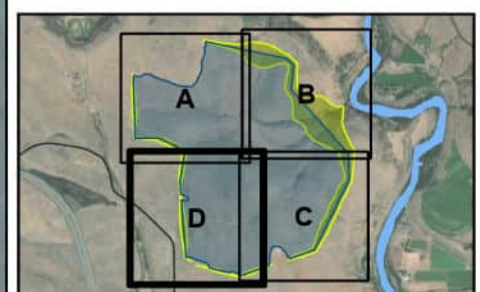
Springwood Reservoir
2,200 Feet Water Surface Elevation

Upper Yakima System Storage
Phase 3

Boring - Along Dam
Boring - Borrow Area
Reservoir Footprint
Dam Footprint

0 250 500
Feet

N



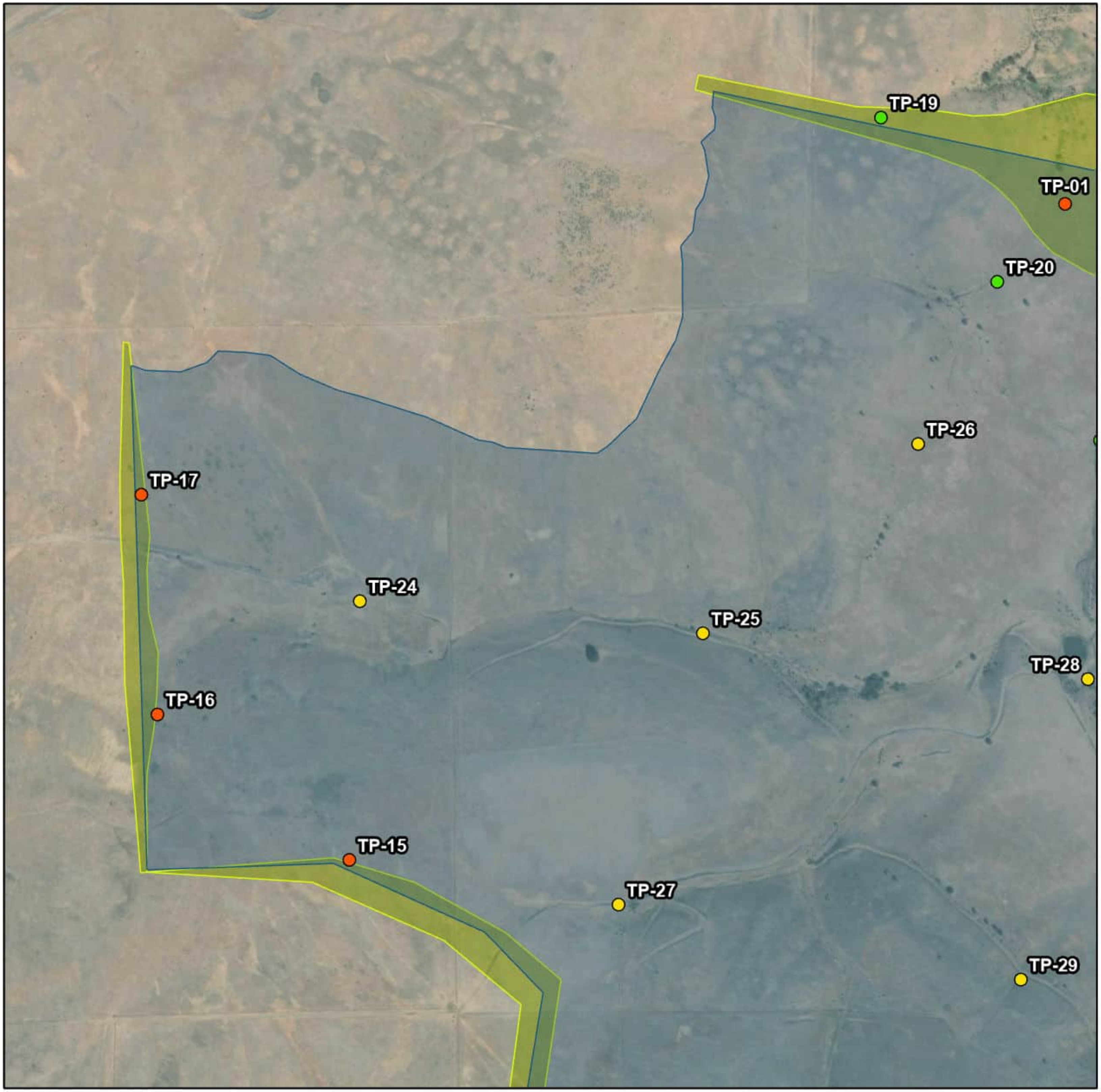
Data Sources: Kittitas County, USGS
Basemap Source: Maxar
Map Date: October 16, 2023

Jacobs

FIGURE 5A. TEST PIT LOCATIONS

Springwood Reservoir
2,200 Feet Water Surface Elevation

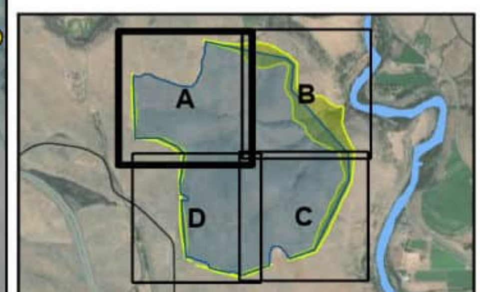
Upper Yakima System Storage
Phase 3



- Test Pit - Inlet
- Test Pit - Along Dam
- Test Pits - Borrow Area
- Reservoir Footprint
- Dam Footprint

0 250 500
Feet

N



Data Sources: Kittitas County, USGS
Basemap Source: Maxar
Map Date: October 16, 2023

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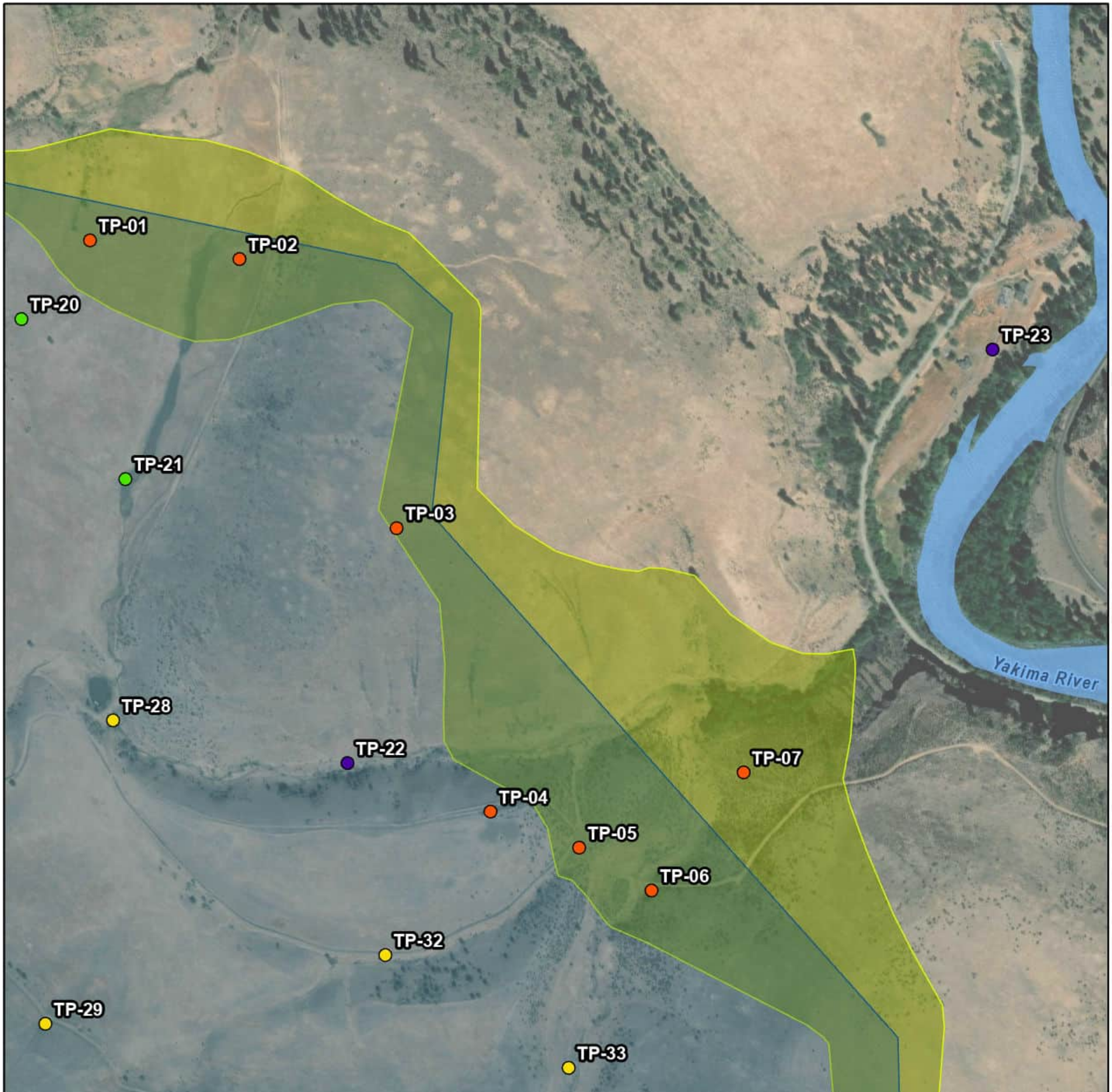
FIGURE 5B. TEST PIT LOCATIONS

Springwood Reservoir
2,200 Feet Water Surface Elevation

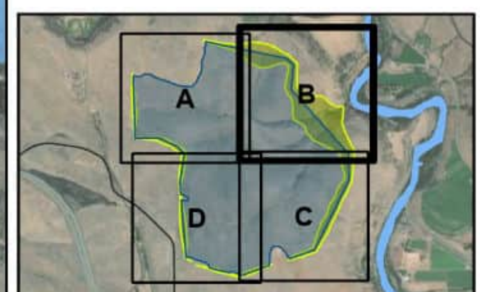
Upper Yakima System Storage
Phase 3



Test Pit - Inlet
Test Pit - Along Dam
Test Pits - Borrow Area
Test Pit - Outlet Works
Reservoir Footprint
Dam Footprint

0 250 500
Feet

N



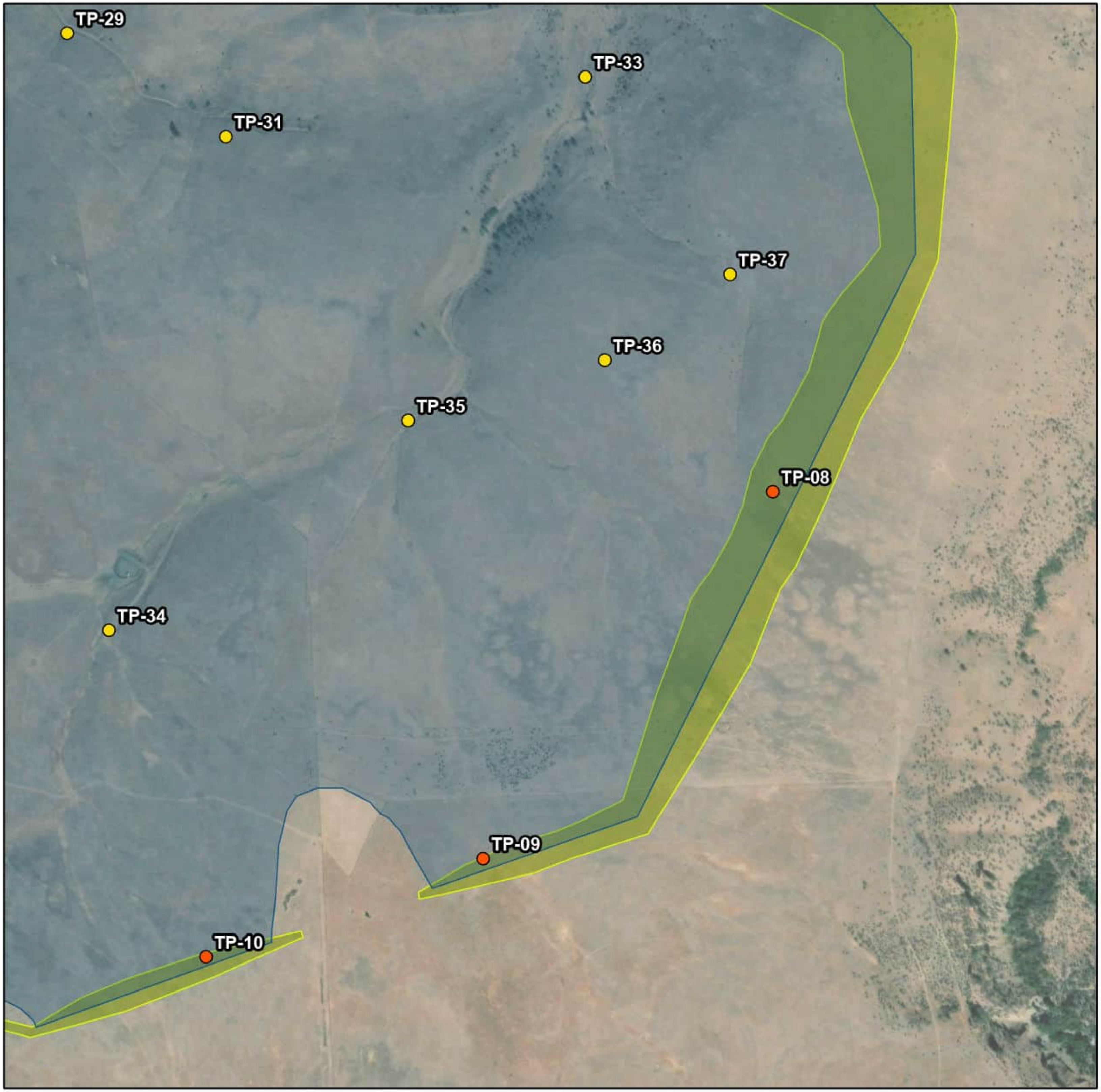
Data Sources: Kittitas County, USGS
Basemap Source: Maxar
Map Date: October 16, 2023

Jacobs

FIGURE 5C. TEST PIT LOCATIONS

Springwood Reservoir
2,200 Feet Water Surface Elevation

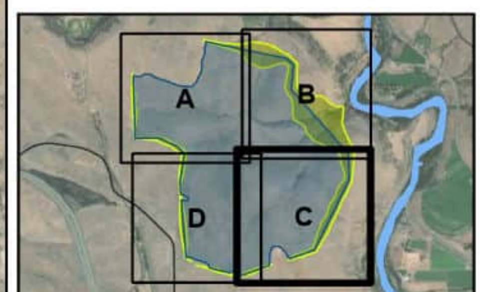
Upper Yakima System Storage
Phase 3



Test Pit - Along Dam
Test Pits - Borrow Area
Reservoir Footprint
Dam Footprint

0 250 500
Feet

N



Data Sources: Kittitas County, USGS
Basemap Source: Maxar
Map Date: October 16, 2023

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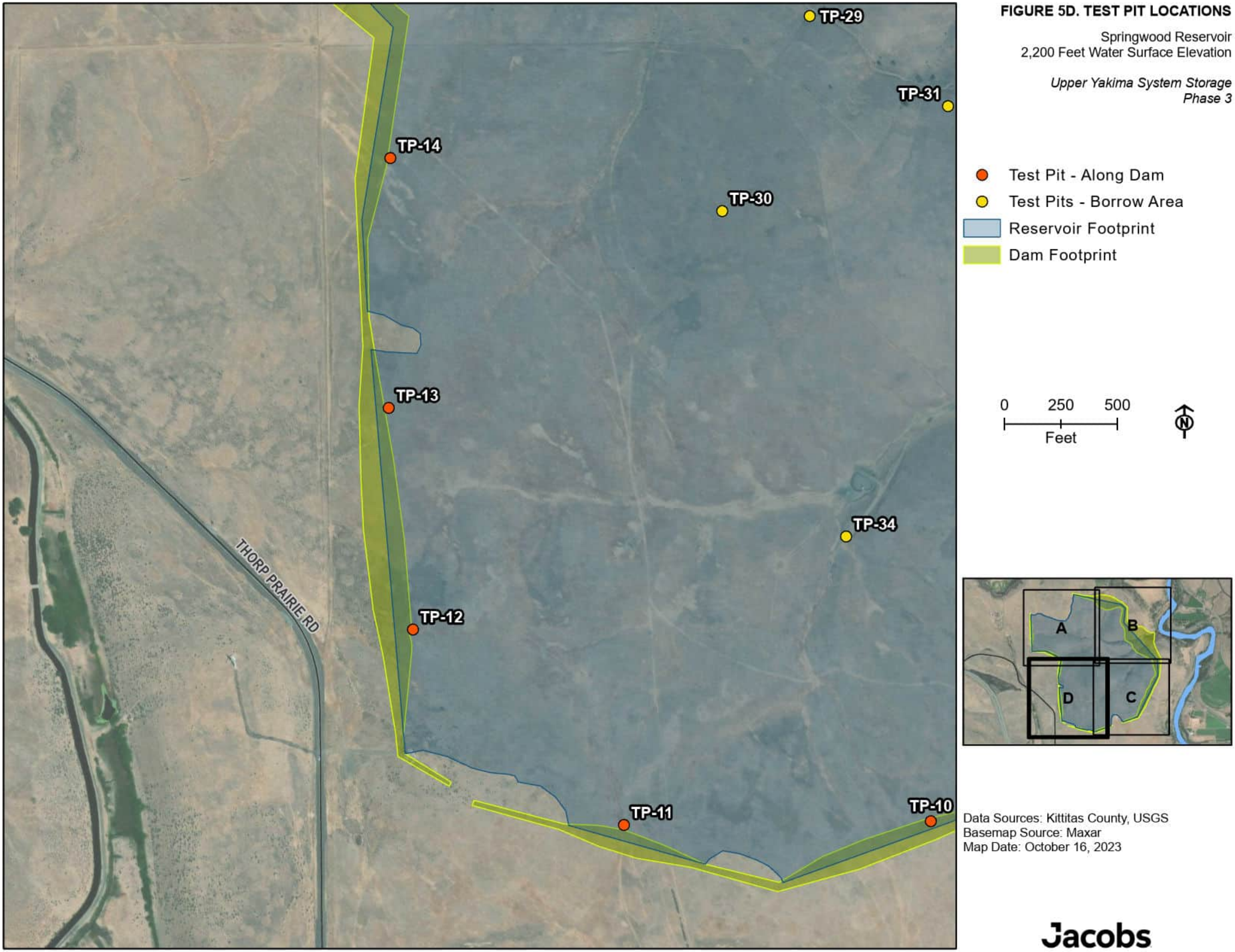
FIGURE 5D. TEST PIT LOCATIONS

Springwood Reservoir
2,200 Feet Water Surface Elevation

Upper Yakima System Storage Phase 3



Data Sources: Kittitas County, USGS
Basemap Source: Maxar
Map Date: October 16, 2023

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Attachment 2. Field Exploration Request

TSC FIELD EXPLORATION REQUEST

REGION: Pacific Northwest
PROJECT: Yakima Integrated Plan
FEATURE: NB 14.7 (Currier Creek)
DATE: October 16, 2023

PURPOSE: Develop Feasibility Geologic Design Data
TEAM LEADER: Dennis Hanneman, 303-445-2958
CONTACT: Rob Lung, 303-445-3190
DATA SUBMITTAL DATE: See Item G below

Team Leader: D. Hanneman
Principal Geologist: R. Lung
Laboratory Analysis: E. Lindenbach
PN Drill Foreman: K. Colby
PN Regional Geologist: J. Vauk
* Concurrence by e-mail

Project Geologist: D. Bennett
Lead Geotech: Jacobs Eng.
Geophysics: R. Markiemicz
Peer Reviewer: B. Simpson
Geotec Peer Review: C. Slaven

This Field Exploration Request (FER) is to develop geologic design data for feasibility design of an off-stream impoundment of approximately 68,000-acre feet of water. This FER outlines investigations to characterize the site at a feasibility level for a storage dam. The Springwood Reservoir site is located within the 3,615-acre Springwood Ranch property, approximately 9 miles northwest of Ellensburg in Kittitas County, Washington, and along the western edge of the Kittitas Valley (Figure 1). The Springwood Reservoir with Water Surface Elevation (WSE) of 2,200 feet will require a primary dam, a secondary dam, and two saddle dams be constructed (see Figure 2).

The exploration described in this FER consists of 34 geotechnical borings (designated B-01 through B-34) and 37 test pits (designated T-01 through T-37) (see Figure 3). Drilling details are described below in Item D and proposed boring locations are shown in Figures 4A through 4D. To evaluate the surficial materials at the site a test pit program is outlined in Item F. The preliminary locations of test pits are shown on Figure 5A through 5D. Generally, the boreholes are to characterize bedrock conditions in the abutments and foundation of the primary and secondary dam sites and the saddle dams. The purpose of the test pits is twofold, one, to determine the surficial material's physical properties, and two, identify any potentially useful material for borrow. This FER also outlines a geophysical investigation to identify transitions between soil and rock and the presence of weaker rock zones. PN Region will perform NEPA compliance activities, conduct required (county, State, and Federal) environmental and cultural clearances, obtain site access, and have all buried utilities located and marked. PN Region Geology will perform the field exploration, coordinating with geophysical survey and any outside contractor work required (geophysical survey, down hole testing, etc).

Item	Description	Location	Depth	Sampling	Instrumentation or In Situ Testing	Remarks
A	Field Reconnaissance	Springwood Reservoir Site	N/A	N/A	N/A	Purpose: To conduct a preliminary field reconnaissance to review proposed locations of geotechnical explorations and identify access requirements. Locations of some borings, and test pits may be revised so that they can be advanced from areas that have better access, improved site safety, or less impact to sensitive vegetation. The field reconnaissance will also be used to evaluate topography and determine anticipated boring and test pit depths. Requirements: -Locate and stake the boring and test pit locations prior to mobilization of drilling equipment.
B	Site Surveys	Springwood Reservoir Site	N/A	N/A	N/A	-Provide survey coordinates and elevations of borehole and test pit locations, and top-of-casing where piezometers are installed (after completion) to an accuracy of 0.5 ft. -Provide survey control for borrow area test pits and borrow area extents. -Locations of geologic features identified as part of the geologic reconnaissance mapping may also need to be surveyed.
C	Geologic Mapping	Springwood Reservoir Site	N/A	N/A	N/A	Purpose: Conduct surface geologic mapping to better understand the composition and structure of the exposed materials and evaluate how the structural geology may impact the siting, risks, design and construction requirements of the dams, spillway, inlet, and outlet works. -The mapping will also be completed to support identification of possible borrow sources for various types of dams that could be constructed. -Geologic mapping, including discontinuities, will be performed on the Yakima River Valley slope downstream of both the proposed primary and secondary dams to determine the need for and extent of the cutoff trench or grout curtain. -Locations of slope failures or potential instability will be mapped along with areas of seepage. Other signs that might be indicative of artesian groundwater conditions will be carefully evaluated during geological reconnaissance. Requirements: -Map surficial units at the site and within the reservoir to differentiate between surficial colluvium and regolith from potential terrace deposits for borrow -Locate bedrock outcrops and conduct fracture mapping to develop local fracture network attributes. These should include, dip and dip direction, length, spacing, aperture, and infillings. -Complete geologic mapping on the Yakima River Valley slope face downstream of both the proposed primary and secondary dams. -Geologic mapping should be completed before commencing the geotechnical explorations and may result in modifying proposed explorations to explore borrow sources or other features of interest. -The effort will include developing a map of the surficial deposits and characteristics of exposed site geology, identify structural geology such as bedding, folds, joints, and faults.

Item	Description	Location	Depth	Sampling	Instrumentation or In Situ Testing	Remarks
D	34 geotechnical borings: - 20 borings along the profiles of primary, secondary, and saddle dams (B-01 through B-20) - 4 borings along the outlet works tunnel alignment (B-21 through B-24) - 10 borings within the reservoir area (B-25 through B-34).	See Figure 4A Through 4D	-Borings along the primary and secondary dams and those along the southeast ridge (B-01 through B-13) will be advanced to the Yakima River level at El. 1720 feet. -Other borings advanced along dam alignments (B-14 through B-20) will be drilled at least 20 feet below top of the bedrock. -Borings advanced within the reservoir footprint (B-25 through B-34) will be advanced to maximum depth of 100 feet bgs. -The actual depth of the borings will be defined by the field Engineer.	-Continuous sonic core through the overburden soils -SPT at 5 feet intervals through the overburden soils -HQ-sized, triple-barrel wire-line rock core -Soil samples recovered from the borings will be examined and visually classified in accordance with *USBR 5325, Determining Unified Soil Classification of Soils (Visual Method)*. Rock cores will be examined and visually classified in accordance with Chapters 4 and 5 of the USBR Engineering Geology Field Manual, 2nd Edition, Volume 1, 2001. Potential strength test samples will be wrapped for shipping by the field Engineer.	-Installation of 9 open standpipe piezometers (OSPs) and 18 vibrating wire piezometers (VWPs) -Secondary Dam: borings B-01(OSP, VWP), B-02 (OSP, VWP), B-03 (OSP, VWP), and B-04 (VWP) -Primary Dam: borings B-05 (VWP), B-06 (OSP, VWP), B-07 (OSP, VWP), B-08 (VWP), B-09 (VWP), B-10 (OSP, VWP), B-11 (VWP), and B-12 (VWP) -Saddle Dams: borings B-15 (VWP), B-16 (VWP), B-17 (OSP, VWP), B-18 (VWP), B-19 (OSP, VWP), and B-20 (OSP, VWP). - The actual number and locations of piezometers may change. -Boreholes which encounter water should be completed as OSP. -Optical/Acoustic Tele-viewer - SPT at 5 feet intervals through the overburden soils -Percolation tests and Packer tests will be conducted to assess permeability of overburden and bedrock.	Purpose: -To gather information on the stratigraphy beneath dam foundations, physical properties of stratum, depth to the bedrock, rock quality, permeability data, and provide information to help interpret the variability of foundation conditions. The visual observations and results of in-situ and laboratory testing will be used to evaluate foundation properties. -Geotechnical borings that include permeability testing will be completed to better define the foundation conditions and to develop a foundation to reduce bedrock seepage. The explorations will be used to determine the need for and extent of a trench or grout curtain cutoff for seepage control. -The potential for seepage at the ridge line southeast of the proposed reservoir will be studied in more details using deep borings and permeability testing to determine requirement for seepage control. -The explorations along the outlet tunnel alignment will be used to determine depth to the bedrock and quality of the bedrock along the tunnel. -The presence of artesian groundwater conditions will be carefully evaluated during geological reconnaissance, geotechnical explorations, and subsequent groundwater monitoring. -The explorations within the reservoir limit will be used assess potential borrow sources for different dam construction alternatives. The explorations will be used to evaluate characteristics and thicknesses of recent alluvium, till, and bedrock. -Parameters of interest will include the density, variability, and particle size distribution of overburden; top of bedrock; strength of the rock; degree and orientation of jointing and fracturing; presence of other rock types besides the Grande Ronde Basalt; and permeability of the rock mass. Requirements: -All borings are in open field areas, and it is anticipated that borings will be advanced using track-mounted drill rigs. See Note 1/. -New access road construction and site clearing may be required for access to the boring locations. For the borings on the steep slope along the outlet works and left abutment of the primary dam, more earthwork anticipated to build the access road and work pad for drilling. -The borings are recommended to be advanced using sonic drilling method in overburden soils and continuous HQ-sized, triple-barrel wire-line rock coring in rock. -Between 30 and 50 percent of the borings along the dams will be inclined (Borings B-01, B-04, B-08, B-09, B-11, B-13, B-15, B-16, B-18, and B-22). At least one inclined boring will be advanced at each abutment of the primary and secondary dams. The inclined boreholes will be advanced at angles of up to 65 degrees from horizontal. The orientation of borings will be determined based on results of geologic surface mapping and downhole televiewer logging of vertical borings. -Casing, either driven or drilled, will be used: 1) where necessary to prevent caving; 2) where rock drilling is to be performed beneath the overburden, or 3) where soil hydraulic conductivity testing is to be performed. Casing will be removed after completion of drilling, sampling, and testing. -Upon completion of drilling, in-situ testing, and downhole televiewer logging, drilled holes not converted to open standpipe piezometers will be plugged and abandoned in accordance with Washington Department of Ecology standards. Boreholes in the embankment footprint will be abandoned according to Reclamation guidelines. -Drilling will be completed in the presence of a Jacobs engineer or geologist who will direct the drilling operations, collect samples, and provide continuous observation and logging of each of the boreholes. -Soil samples and soil and rock cores obtained during the exploration program, except for those that will be sent for laboratory testing, will be stored at KDR storage facility. - All SPTs will be conducted using an automatic hammer set at a constant RPM rate resulting in 20 to 40 blows per minute (current calibration required for hammer). SPTs will be conducted according to ASTM standards D 1586 and D 6066. - SPT data will be collected by recording blows per inch within the seating and test intervals when testing alluvium deposits. Refusal criteria of the SPT within the seating or test intervals is reached at 50 blows. - Each SPT sample will be field classified and packaged for laboratory testing. Moisture content samples should be double bagged. -Collect “undisturbed” samples (e.g., Shelby tube, piston) if fine grained soils are encountered within the dam footprint. - Upon bedrock refusal switch to HQ3-diamond core drilling and core to total depth. - HQ3-Core of bedrock to be logged, boxed, photographed (wet and dry) and stored at KRD facilities.

Item	Description	Location	Depth	Sampling	Instrumentation or In Situ Testing	Remarks
						-Special care may be required in the field for collection and boxing of sandstone core (if encountered), consisting of plastic wrapping of core to prevent slaking, and stabilizing of core into secured half rounds to maintain core integrity. - Intact samples greater than 0.5 feet in length should be preserved with either wax or vacuum sealing. Samples will be to be transported to the TSC's Concrete, Geotechnical, & Structural Laboratory in Denver, Colorado, for rock strength testing. Samples should be shipped to the TSC in hard-sided containers and protected from damage with packing material. See Note 2/. -In-situ water percolation tests will be completed in select borings within the till material at approximately 10-foot intervals. The tests will be completed in accordance with Gravity Permeability Test – Method 2 as outlined in Chapter 17 of the Engineering Geology Field Manual (Reclamation 2001). It is anticipated that the tests will be completed in the following borings: • Primary Dam: borings B-05, B-07, B-09, B-11, and B-13 • Secondary Dam: borings B-02 and B-03 • Saddle Dams: borings B-15, B-17, B-19, and B-20 -Stepped hydraulic pressure tests (also known as packer tests) will be completed in select boreholes within rock in accordance with Chapter 16 of the Engineering Geology Field Manual (Reclamation 2001). Packer tests will typically be completed at 10- foot intervals but may be switched to 20-foot intervals at depths of 100 feet or more below the top of rock. It is anticipated that the tests will be completed in the following borings: • Primary Dam: borings B-05, B-07, B-08, B-10, and B-12 • Secondary Dam: borings B-01, B-02 and B-03 • Saddle Dams: borings B-15, B-17, B-19, and B-20 -The borehole will be flushed with clear water prior to actual pressure tests. Testing will be performed as the hole is advanced at locations and intervals determined by the Engineer. The driller will have the equipment to perform a double pack assembly if it is needed. Tests may be performed for the entire portion of the hole, or for isolated segments of the hole. -The Engineer will provide recommended packer inflation and injection pressure values. The Engineer will determine the type of packer assembly, and the sequence, location and testing interval for all water pressure tests. - The Engineer will consult with Exploration Team regarding step testing pressures (a large pumping capacity and tank volume may be required) and bracketing of packer testing across lithologic contacts. -When the rock mass is too highly fractured, and fractures are open and highly permeable, constant head testing may be required to obtain the hydraulic conductivity data necessary for a test interval. -Use of drilling mud, bentonite, or other substances that may affect hydraulic conductivity of the rock will not be permitted in these holes, without the specific approval of the Engineer. Clean water will be used in all water pressure tests. -Downhole televiewer logging will be completed at all borings along the primary, secondary and saddle dams (B-01 through B-20), and borings along the outlet works alignment (B-21 through B-24). -The use of centralizers is recommended in vertical and inclined boreholes. -Optical televiewer testing requires purging water until clear prior to logging. If unable to purge turbid water acoustic televiewing will be required to complete survey. -The piezometers will be installed per Washington Department of Ecology regulations as outlined in WAC 173-160. -The standpipe piezometers will consist of 2-inch-diameter polyvinyl chloride (PVC) casing and 5 to 10 feet of machine-slotted screen. Sand will be placed in the annular space from 0 to 2 feet below the bottom of the screen (0 to 6 inches if the piezometer will be installed at the bottom of drill hole) to 2.0 to 3.0 feet above the top of the screen. A bentonite seal will be placed above the sand and up to ground surface. Bentonite will also be used below the sand in locations where the screened interval is installed above the bottom of the boring. -Vibrating wire piezometers (VWP) equipped with dataloggers will be installed at each standpipe piezometer to monitor daily groundwater fluctuations. The VWP sensor will be attached to the outside of the standpipe casing, near the bottom of the screened interval. -The VWPs will be unvented and manufactured by Geokon (model number 4500S) or similar. Data from VWPs will be collected and stored on waterproof dataloggers (Geokon 8002-WP-2, LC-2 series or similar) daily and downloaded periodically (every few months). Prior to installation, the initial zero reading for each VWP sensor will be recorded per manufacturer recommendations. -A hand-held electronic water-level indicator will be used to measure the static water level in each of the open standpipe piezometers within 3 days of installation. At least two additional water level readings will be collected in each standpipe piezometer, once in the summer or fall, and once in the winter or spring.

Item	Description	Location	Depth	Sampling	Instrumentation or In Situ Testing	Remarks
						-Piezometers will be protected at the surface with an above-ground casing and if it is needed with three steel bollards set in concrete to protect the piezometers. -Piezometer construction details and measured water levels will be included on the boring logs. -Installation of fully grouted nested VWPs may be considered at borings B-06 or B-07 to better evaluate possibility of artesian groundwater conditions. - Standard borehole logs will be produced as outlined in the Engineering Geology Field Manual, Second Edition, Volume I. -The laboratory testing program will be developed by Jacobs and will consist of performing classification and engineering laboratory testing of the type and number required to obtain information to support the feasibility study. -It is expected that the laboratory testing program will consist of the following tests, with actual types and numbers of tests determined during and after the exploration program based on the actual subsurface conditions encountered: • Moisture content (*USBR 5300: Determining Moisture Content of Soil and Rock by the Oven Method*) • Specific Gravity (*USBR, 5320: Determining Specific Gravity of Soils*) • Sieve and hydrometer analysis (*USBR 5325, Performing Gradation Analysis of Gravel Size Fraction of Soils, USBR 5330, Performing Gradation Analysis of Fines and Sand Size Fraction of Soils, Including Hydrometer Analysis, USBR 5335, Performing Gradation Analysis of Soils Without Hydrometer& Wet Sieve*) • Atterberg limits (*USBR 5350, Determining the Liquid Limit of Soils by the One-Point Method, USBR 5355, Determining the Liquid Limit of Soils by the Three-Point Method, USBR 5360, Determining Plastic Limit and Plasticity Index of Soil*) • Dry Density (*USBR 5375, Determining Dry Unit Weight of Irregularity Shape Soil Specimens*) • Organic Content (*USBR 5430, Determining Moisture, Ash, and Organic Content of Soils*) • Moisture Density (*USBR 5500, Performing Laboratory Compaction of Soils- 5.5-lbm Rammer and 18-in Drop*) • Unconfined Strength with Young Modulus (*USBR 6210, Performing Uniaxial Compression Testing of Rock Core, USBR 6220, Determining Modulus of Elasticity and Poisson's Ratio of Rock in Uniaxial Compression*) • Point Load Test (*USBR 6535, Estimating Compressive Strength by Pint Load Test Method*) • Cerchar Abrasivity Index testing (*ASTM D7625, Standard Test Method for Laboratory Determination of Abrasiveness of Rock Using the CERCHAR Abrasiveness Index Method*) for boring along the outlet work alignment.
F	37 test pits (designated T-01 through T-37): -7 test pits within the footprint of the proposed primary dam (TP-01 to TP-07) -3 test pits within the footprint of the secondary dam (TP-08 through TP-10) -7 test pits within the footprint of the saddle dams (TP-11 through TP-17) -4 test pits along the inlet pipeline and intake structure (TP-18 through TP-21) -2 test pits at the outlet intake and dissipation structures (TP-22 and TP-23) -14 test pits within reservoir to locate potential borrow source areas (TP-24 through TP-37).	See Figure 5A Through 5D The locations of test pits in the footprint of the reservoir area may be revised based on the findings of the geologic mapping and previously completed borings and test pits.	To top of rock or a maximum depth of 15 feet, whichever is shallower. Excavation of test pits will be terminated at shallower depths if groundwater seepage into the excavation occurs such that the pit is filling with water, or if the seepage is causing caving of side walls that can't be controlled using benching.	Bulk samples every five feet or change in materials.	For the test pits within the dam footprint, in-situ density tests by sand cone method in at least 3 test pits for each soil type, and gradation testing on the materials removed for the sand cone test.	Purpose: -The explorations within the footprint of the primary, secondary, and saddle dams will be used to gather foundation physical properties and provide information to help interpret the variability of soil conditions. -The test pits will also be used to evaluate the presence, or lack thereof, of near surface variability in overburden and help assess the potential for these materials to be susceptible to liquefaction, which would result in the requirement to remove the materials as part of the dam construction. -The explorations along the inlet and outlet alignments will be used to characterize the subsurface condition along the pipelines and at the intake structures and allow for a visual observation of near-surface soil layers. -The explorations within the reservoir will be used to identify potential borrow sources. -The visual observations and results of in-situ and laboratory testing will be used to evaluate material properties. Requirements: -The test pits will be excavated using a tracked excavator with the capability of digging to a depth of at least 15 feet. See Note 1/. -All test pits are located on State of Washington property that is fenced and gated. No risk to public safety is anticipated. If test pits remain open overnight, the pits will be staked and flagged with warning tape. -New access road construction and site clearing may be required for access to the test pit locations. -Test pits will be backfilled using the excavated material removed from each of the pits. Excavated material will be placed back in the pit in loose lifts not more than 18 inches thick. Each loose lift at test pits excavated within the footprint of proposed dams will be compacted using a pinwheel roller or vibratory plate compactor prior to placing an additional loose lift of material. Lifts within test pits excavated outside of proposed footprints of dams will be compacted using the back of the excavator bucket. -Excavation will be completed in the presence of Jacobs engineer or geologist who will direct the excavation operations, collect samples, and provide continuous observation and logging of each of the test pits.

Item	Description	Location	Depth	Sampling	Instrumentation or In Situ Testing	Remarks
						-The length, width and depth of each test pit will be measured and recorded. Subsurface conditions exposed in the test pit walls will be photographed and visually logged from the ground surface to the bottom of the test pit. Field descriptions will be in accordance with *USBR 5325-89, Determining Unified Soil Classification of Soils (Visual Method).* Groundwater or surficial water infiltration if encountered, will be observed, and noted, estimating excavation infiltration in gallons per minute. -For the test pits within the dam footprint, in-situ density tests will be completed by sand cone method (*USBR 7205, Determining Unit-Weight of Soils In-Place by the Sand Cone Method*) in at least 3 test pits for each soil type, and perform gradation testing on the materials removed for the sand cone test. -If material is too coarse grained for sand cone test, large diameter density test such as six-foot diameter water replacement ring density tests (*USBR 7221 Determining Unit Weight of In-Place by the Water Replacement Method in a Test Pit*) may be completed. -Representative soil samples will be collected from the test pits and placed in five-gallon buckets (bulk samples) or double layers of sealable plastic bags (bag samples). -Up to five samples from each test pit will be tested for moisture content and gradations. If fine grained material is encountered Atterberg Limits, crumb and pinhole tests will be conducted. Up to ten total Atterberg Limits tests will be completed where appropriate. Testing will be completed as outlined in *USBR 5000, Determining Unified Soil Classification (Laboratory Method); USBR 5300, Determining Moisture Content of Soil and Rock by Oven Method; USBR 5360, Determining Plastic Limit and Plasticity Index of Soil; USBR 5400-89 Determining Dispersibility of Clayey Soils by the Crumb Test Method, and USBR 5410-89 Determining Dispersibility of Clayey Soils by the Pinhole Test Method*. Samples from test pits within reservoir to locate potential borrow may be tested for Aggregate Soundness and Durability in accordance with ASTM C289 method. -Compaction testing of up to six bulk samples will be completed in accordance with *USBR 5500, Performing Laboratory Compaction of Soils- 5.5-lbm Rammer and 18-in Drop* to determine maximum dry density and optimum moisture contents. Actual numbers of laboratory testing to be completed to determine engineering properties will be determined after all test pits are excavated and photographed and draft logs can be reviewed. -Other types of testing, including testing for permeability, compressibility, drained and undrained strength, and cyclic behavior, will not be completed unless cohesive, fine-grained soil layers are encountered in the explorations.
E	Geophysical Survey	- At 15 locations along the primary, secondary and saddle dams. -Locations of lines will be determined after completion of filed reconnaissance and geologic mapping.	N/A	N/A	N/A	Purpose: -To identify transitions between soil and rock and the presence of weaker rock zones, characterized by lower density or increased electrical resistance. -To further evaluate potential anomalies along the dam alignments. Requirements: -Geophysical survey will be completed at 15 locations along the primary, secondary and saddle dams. The number of geophysical surveys assumes that the length of each survey line is between 400 and 500 feet. A smaller number of surveys may be completed if the length of the survey lines is greater than 500 feet. The longer survey lines would typically have the added benefit of providing data for deeper profiles compared to the shorter surveys. -Locations of survey lines will be determined after completion of filed reconnaissance and geologic mapping.
G	Prepare Geotechnical Data Report	N/A	N/A	N/A	N/A	-A Geotechnical Data Report (GDR) will be prepared by Jacobs. -The GDR will include documentation of all field work completed for this FER, including geologic mapping findings, photographs and discussions, a narrative of geologic units encountered, borings and test pits logs, installation data logs, laboratory test results, photographs of site geology, rock cores, and test pits, geologic maps and cross sections developed from existing and new data. -Field logs can be shared with Reclamation’s Technical Service Center (TSC) staff as the field work progresses. This information will be used to select samples and intervals for laboratory testing. This information is also important to defining any modifications to the location and extent of the borings and test pits to be completed for the purpose of identifying potential borrow sources. -Updated drafts of logs can be provided within four weeks of the completion of the explorations. The updated material will include draft boring and test pit logs and photographs along with results on any laboratory testing that has been completed. -A draft GDR will be distributed to TSC and Regional team members within two weeks of completion of the laboratory testing program. This draft can be sent electronically. -Jacobs will address Reclamation comments in the development of the final GDR.

NOTES:
1. Applicable National Environmental Protection Act (NEPA) activities and permits (including notification of underground utility locator services) are to be obtained prior to initiation of any ground-disturbing field activities. Boreholes in the embankment footprint will be abandoned according to Reclamation guidelines all other boreholes will be abandoned in compliance with local, state and federal requirements.

2. Diamond core samples for testing will be transported to the Technical Service Center Laboratories: Bureau of Reclamation, Technical Service Center, Denver Federal Center, Building 56, Entrance S-6 (phone mounted by door), Denver, Colorado, 80225-0007. Note: Sample boxes shall have a letter of transmittal and preliminary drill hole logs attached. Call Evan Lindenbach at (303) 445-2336 for detailed shipping instructions.

Figure 1. Regional location map of the Springwood Reservoir Site.

Figure 2. Springwood Reservoir Site.

Figure 3. Proposed Boring and Test Pit Locations.

Figure 4. Proposed Boring Locations.

Figure 5. Proposed Test Pit Locations.

Appendix B. 2024 Geotechnical Field Exploration Plan – Springwood Reservoir (Jacobs 2024b)

2024 Geotechnical Field Exploration Plan – Springwood Reservoir

Date:	May 29, 2024
Project name:	2024 Geotechnical Field Exploration – Springwood Reservoir
Project no:	W3Y10908
Attention:	Urban Eberhart, KRD Manager
Client:	Kittitas Reclamation District
Revision no.	0

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1. Introduction

This *2024 Geotechnical Field Exploration Plan* has been developed to describe the proposed geotechnical explorations and procedures that will be implemented at the Springwood site to acquire geotechnical design information in support of alternatives evaluation for the feasibility study, and ultimate construction of the Springwood Ranch Dam and Reservoir. Project activities include conducting a field reconnaissance, survey coordination, geotechnical borings, test pits, associated laboratory testing and reporting.

The expected outcome of this work is to summarize the 2024 geotechnical exploration activities and provide preliminary recommendations and geotechnical design considerations at the site for dam construction.

Field work is anticipated to occur between summer/fall 2024 and spring 2025.

This work is to satisfy the scope outlined in Task 2, Geotechnical Evaluation, of the grant Agreement No. WRYBIP-2325-KittRD-0052 between the State of Washington Department of Ecology and Kittitas Reclamation District. The grant funding expires on 9/30/2026.

2. Project Location

The Springwood Reservoir site is located within the 3,615-acre Springwood Ranch property, approximately 9 miles northwest of Ellensburg in Kittitas County, Washington, and along the western edge of Kittitas Valley (Attachment 1, Figure 1). The property is situated between Interstate 90 and the Yakima River in Sections 20, 28, and 29 of Township 19 North, Range 17 East, Willamette Meridian.

3. Project Description

The Springwood Reservoir with a WSE of 2,200 feet will require construction of a primary dam, a secondary dam, and two saddle dams. The primary dam would have a length of approximately 7,560 feet and a maximum height of about 440 feet. The secondary dam would have a length of approximately 6,970 feet and a maximum height of about 220 feet. The two saddle dams would have lengths of approximately 2,930 feet and 2,500 feet and a maximum height of about 75 feet. The reservoir would require direct pumping from the North Branch Canal.

4. Background and Purpose

In July 2023, in preparation for the Upper Yakima System Multi-Benefit Water Storage (UYSS) Study value planning studies workshop, Jacobs summarized the existing geotechnical data, evaluations completed, and recommendations for further geotechnical studies for five storage alternatives at the Springwood Reservoir site (varying by full pool water surface elevation [WSE], associated storage volume, and footprint extent), as well as three other locations previously identified in the UYSS Phase 2A reports (Jacobs 2021, 2023). The Springwood site alternative with full pool WSE at 2,200 feet (selected alternative) was selected by the value planning team for further evaluation.

In November 2023, Jacobs developed a *Geotechnical Field Exploration Plan* (Jacobs 2023) for the selected Springwood Reservoir alternative (WSE at 2,200 feet) which provided a recommended field exploration program for feasibility evaluation of the dam and was approved by USBR and KRD. In an overview, the plan included completion of 34 geotechnical borings (vertical and inclined), in-situ permeability testing of overburden soils and bedrock rock, 37 test pits, a robust laboratory testing program, and geophysical surveys at 15 locations.

A second VPS meeting, with a more focused group of attendees, was conducted in January 2024 to refine the alternatives that would go forward in the feasibility phase. VPS workshop outcomes included identifying three alternatives to advance to 5 percent conceptual design:

1. Springwood Site (2,175 feet WSE)
2. Springwood Site (2,200 feet WSE)
3. Springwood Site (2,230 feet WSE)

Figures 2 through 4 (Attachment 1) provides general configurations of each proposed Springwood Reservoir project.

In March 2024, the Kittitas Reclamation District received a grant to partially fund the *Geotechnical Field Exploration Plan* (Jacobs 2023). The purpose of this *2024 Geotechnical Field Exploration Plan* is to obtain the maximum amount of geotechnical data within the allotted budget available, per Ecology grant Agreement No. WRYBIP-2325-KittRD-0052, to aid in the feasibility evaluation of the Springwood Dam. In general, the recommendations outlined in the *Geotechnical Field Exploration Plan* (Jacobs 2023) were used to develop this *2024 Geotechnical Field Exploration Plan,* however, due to limited funds, adjustments to select activities and quantities were made.

5. Proposed Explorations

5.1 Site Access and Utility Locates

The Springwood Ranch property ownership is currently held by the Trust for Public Land with planned distribution to various UYSS stakeholders. It is anticipated that Kittitas Reclamation District (KRD) will coordinate with the Trust for Public Land or other stakeholder(s) to arrange for right of entry to conduct the exploration and provide awareness and/or location of any private subsurface utilities existing in the area. All private utilities should be marked by others prior to commencement of drilling.

Jacobs will work with KRD to facilitate cultural resources assessment Section 106 compliance and complete a "call before you dig" notification with the Utility Notification Center of Washington, as required by law, to inform utility owners of the pending site improvements and field explorations to allow them to locate and mark their utilities. Jacobs will coordinate with KRD regarding the timing of private utility locate markings, if it is needed.

5.2 Field Reconnaissance

5.2.1 Purpose

Jacobs will conduct a field reconnaissance to review the proposed locations of geotechnical explorations and to identify access requirements. Locations of some borings and test pits may be revised so that they can be advanced from areas that have better access, improved site safety, or less impact to sensitive vegetation and potential cultural resources. The field reconnaissance will also be used to evaluate topography and determine anticipated boring and test pit depths.

5.2.2 Requirements

Jacobs will locate and stake the boring and test pit locations prior to mobilization of drilling equipment. The exact locations and depths of the borings and test pits are subject to change based on conditions encountered and determined by Jacobs onsite. Staking will initially be completed using a handheld GPS. Once the field explorations have been completed, actual as-drilled locations will be surveyed as discussed in Section 5.4

Final boring and test pit properties will be documented by Jacobs and submitted for the records for inclusion in the geotechnical data report.

5.3 Geologic Mapping

*Note that the *Geotechnical Field Exploration Plan* (Jacobs 2023) stated that surface geologic mapping would be conducted to better understand the composition and structure of the exposed materials and evaluate how the structural geology may impact the siting, risks, design, and construction requirements of the dams, spillway, inlet, and outlet works. Due to current funding limitations, this task is not anticipated to be conducted during the 2024 Geotechnical Field Exploration program.

5.4 *Site Survey*

5.4.1 Purpose

The site survey will provide coordinates and elevations of test pits and boreholes. KRD will contract directly with a surveyor to provide surveying of the as-drilled locations, test pits, and geophysics transect lines up to 148 survey points. Jacobs will provide coordination support of this effort. Each transect line is to have a total of eight (8) survey points to aid in laying out arrays. The locations will be staked using WA state plane coordinates with NAVD88 elevation datum.

5.4.2 Requirements

Test pits, boring locations, and top of casing where piezometers are installed (after completion) will be surveyed to 0.5-foot accuracy. The locations will be staked using WA state plane coordinates with NAVD88 elevation datum.

5.5 *Geotechnical Borings*

The *Geotechnical Field Exploration Plan* (Jacobs 2023) recommended a total of 34 geotechnical borings (designated B-01 through B-34) along the profile of the primary, secondary and saddle dams. Due to current funding limitations, not all of the boring can be conducted during the 2024 Geotechnical Field Exploration program.

This *2024 Geotechnical Field Exploration Plan* intends to complete between 4 and 7 borings along the profile of the primary, secondary, and saddle dams, up to 4 open standpipe (OSPs) wells along the profile of dams (designated as B-02P, B-06P, P-07P, and B-10P in Table 1), and between 2 and 4 borings within the reservoir area to identify potential borrow source areas. The OSP wells will be advanced close to the original borings to facilitate in situ testing and installation of open standpipe piezometers.

This *2024 Geotechnical Field Exploration Plan* follows the general recommendations noted in the *Geotechnical Field Exploration Plan* (Jacobs 2023), however, adjustments were made to obtain the needed data for preliminary design while staying within the budget provided.

5.5.1 Purpose

The explorations along the profile of the primary, secondary, and saddle dams will be used to gather information on the stratigraphy beneath the dam foundations, physical properties of stratum, depth to bedrock, rock quality, and permeability data and provide information to help interpret the variability of foundation conditions. The visual observations and results of in situ and laboratory testing will be used to evaluate foundation properties.

Based on the geotechnical investigation completed by Aspect (2022), basalt bedrock beneath the Springwood Reservoir site appeared moderately to highly jointed or fractured. The RQD recorded in the collected rock core ranged from 0 (very poor) to 100 (excellent), with lower RQDs generally observed near the top of the basalt contact (Aspect 2022). Based on limited drilling of the site to date, some of the bedrock is poor quality, consisting of highly fractured areas that may accept considerable grout. Geotechnical borings that include permeability testing will be completed to better define the foundation conditions and to develop a foundation to reduce bedrock seepage. The explorations will be used to determine the need for and extent of a trench or grout curtain cutoff for seepage control.

The ridgeline southeast of the proposed reservoir separates the Springwood Reservoir site from the Yakima River Canyon. Since the hydraulic gradient between the proposed reservoir and the bottom of the adjacent Yakima River Canyon will be relatively large, there is potential that seepage water could daylight on the canyon walls, possibly resulting in erosion or sloughing on the slopes above the river. If permeable rock mass conditions are discovered along this ridge, which could result in greater seepage leading to erosion or slope instability at the canyon wall, the seepage could be mitigated by installing a grout curtain or other seepage barrier along the southern ridge. The potential for seepage at the ridgeline will be studied in more detail using deep borings and permeability testing to determine requirement for seepage control.

The depth to groundwater in one of the boring advanced by Aspect (2022) near the bottom of the valley, about 250 feet downstream of the primary dam alignment, was noted at 3 feet bgs at the time of drilling. During subsequent monitoring using a vibrating wire piezometer (VWP) installed at the location, artesian water pressure conditions were recorded, with the high groundwater reading at approximately 25 feet above ground surface (Aspect 2022). The presence of artesian groundwater conditions will be carefully evaluated during geological reconnaissance, geotechnical explorations, and subsequent groundwater monitoring.

The explorations within the reservoir limit will be used to assess potential borrow sources for different dam construction alternatives. The explorations will be used to evaluate characteristics and thicknesses of recent alluvium, till, and bedrock.

Parameters of interest will include the density, variability, and particle size distribution of overburden; top of bedrock; strength of the rock; degree and orientation of jointing and fracturing; presence of other rock types besides the Grande Ronde Basalt; and permeability of the rock mass.

5.5.2 Requirements

All borings are in open field areas, and it is anticipated that borings will be advanced using track-mounted drill rigs.

The borings are recommended to be advanced using sonic drilling methods in overburden soils and continuous HQ-sized, triple-barrel wireline rock coring in rock. Completing borings using sonic drilling methods is advantageous since continuous core samples can be obtained. Depending on availability and cost of sonic drill equipment, alternative drilling methods, such as mud-rotary drilling, can be used to complete some of the borings.

The drilling production depends on soil drilling and rock coring advancement rates. A minimum advancement rate of 50 feet per day in till soils and 30 feet per day in rock is assumed. A maximum of 105 working days for the borings along the dam (approximately 90 working days drilling + 15 working days of in situ testing) and up to 8 working days for the borrow borings is assumed. In total, two separate drilling crews are planned for this investigation. Drilling and in-situ testing operations will require the use of the South Branch Canal for adequate and nearby water source. This will be coordinated with KRD.

For perimeter borings, priority will be issued to the primary and secondary dams (including South-East ridge). All borings are proposed to be vertical as rock orientation / slip planes angles are unknown currently and advanced using sonic drilling methods in overburden soils (till) and continuous HQ-sized, triple-barrel wireline rock coring in rock. Table 1 provides a summary of the proposed borings, in-situ testing, and installs for this exploration.

Borings for the primary and secondary dam (including the South-East ridge) will be advanced to Elevation 1,720 feet or approximately the Yakima River elevation to evaluate fracturing and permeability. The saddle dam borings will be advanced to at least 20 feet into rock. Borrow borings will be advanced up to 100 feet into the till soils and will not extend into the rock formations.

Table 1 – Summary of Proposed Borings for 2024 Geotechnical Field Exploration Plan

Exploration Id	Dam Structure	Estimated Till Depth (ft)	Estimated Rock Depth (ft)	In-Situ Testing	Installs	Est. Days to Complete
B-02	Secondary	80	280	Televiewer	2 VWPs	13
B-02P**	Secondary	Up to 80	-	Falling Head	1 OSP 1 VWP	2

Exploration Id	Dam Structure	Estimated Till Depth (ft)	Estimated Rock Depth (ft)	In-Situ Testing	Installs	Est. Days to Complete
B-03	Secondary	240	95	5 Packer Tests	2 VWPs	11
B-05	Primary	160	270	Televiewer	2 VWPs	16
B-06	Primary	50	60	3 Packer Tests Televiewer	2 VWPs	7
B-06P**	Primary	Up to 50	-	Falling Head	1 OSP 1VWP	2
B-07	Primary	60	180	9 Packer Tests Televiewer	2 VWPs	14
B-07P**	Primary	Up to 60	-	Falling Head	1 OSP 1VWP	2
B-10	South-East Ridge	320	155	Televiewer	2 VWPs	14
B-10P	South-East Ridge	Up to 100	-	Falling Head	1 OSP 1 VWP	2
B-12	South-East Ridge	310	155	8 Packer Tests	2 VWPs	14
B-25	Borrow	Up to 100	-	-	-	2
B-27	Borrow	Up to 100	-	-	-	2
B-29	Borrow	Up to 100	-	-	-	2
B-31	Borrow	Up to 100	-	-	-	2

*Note that if sufficient time and budget is available after conducting these borings, an additional boring, B-17, along the saddle will be developed. The estimated till depth of B-17 is 200 feet with an estimated rock depth of 20 feet. Two VWPs would be installed.

** The OSP wells are designated with adding letter "P" at the end of original boring label. The OSP wells will be advanced close to the original boring to facilitate in situ testing and installation of open standpipe piezometers.

Upon completion of drilling, all drilled holes without installs will be plugged and abandoned in accordance with Washington State Department of Ecology (Ecology) standards. Plugging and abandonment will consist of backfilling the hole from bottom to top through a tremie pipe with cement-bentonite grout mixed as approved by qualified staff of the geotechnical consultant(s).

Drill fluids (if any) will be contained at the drill site and recirculated during drilling operations. Upon completion of drilling each boring, the fluids and drill cuttings will be spread on-site. Drill cuttings from each borehole will then be distributed around the borehole location and not left in a pile but spread out to reduce impacts to the borehole location.

For each drilling crew, a Jacobs geotechnical engineer or geologists will be present and will direct the drilling operations, collect samples, and prepare them for shipping, and provide continuous observation and logging of each borehole.

<u>Soil and Rock Sampling</u>

A continuous sonic core will be obtained in the overburden soils. Standard Penetration Testing will be performed at 5-foot intervals through the overburden soil, and blow counts will be recorded on boring logs. Soil samples recovered from the borings will be examined and visually classified in accordance with the Bureau of Reclamation's (Reclamation) USBR 5005-89, *Procedure for Determining Unified Soil Classification of Soils (Visual Method)* (Reclamation 1990).

Upon reaching refusal at bedrock, the drilling method will switch to HQ-sized, triple-barrel wireline rock coring. All rock cores will be collected and preserved in core boxes provided by the driller. Rock cores will be examined and visually classified in accordance with Chapters 4 and 5 of the *Engineering Geology Field Manual* (Reclamation 2001). Potential strength test samples will be wrapped for shipping by the field engineer.

All soil samples and soil and rock cores obtained during the exploration program will be picked up twice a week by the laboratory and stored at their warehouse.

<u>Vibrating Wire Piezometers (VWPs) and Open Standpipe Piezometers (OSPs) Installation</u>

This *2024 Geotechnical Field Exploration* program includes installation of up to 4 OSPs and up to 18 VWPs (2 within each boring and 1 in each OSP). Refer to Table 1 for proposed locations. The piezometers will be installed to facilitate periodic observation of the depth to groundwater. In each dam boring, two VWPs will be installed (one in overburden soils and one in the bedrock).

The VWPs will be unvented and manufactured by Geokon (Model Number 4500S) or similar. Data from VWPs will be collected and stored on waterproof dataloggers (Geokon 8002-WP-2, LC-2 series or similar) daily and downloaded periodically. This plan assumes up to 4 download site visits for 1 year. Prior to installation, the initial zero reading for each VWP sensor will be recorded according to manufacturer recommendations.

VWPs equipped with battery operated dataloggers will be installed at each standpipe piezometer to monitor daily groundwater fluctuations. The VWP sensor will be attached to the outside of the standpipe casing, near the bottom of the screened interval.

VWPs installed in boreholes will be installed using installation method "C" per Geokon's manual (i.e., grouted directly into the borehole). The VWPs and wires at about 5 feet on-center will be taped to a sacrificial 1-inch tremie pipe and grouted from the bottom up using the 50-psi grout mixture recommended in their manual and provided below.

	50 PSI Grout for Medium to Hard Soils		**4 PSI for Soft Soils**	
	Amount	**Ratio by Weight**	**Amount**	**Ratio by Weight**
Water	30 gallons	2.5	75 gallons	6.6
Portland Cement	94 lb. (one sack)	1	94 lb. (one sack)	1
Bentonite	25 lb. (as required)	0.3	39 lb. (as required)	0.4
Note:	The 28-day compressive strength of this mix is about 50 psi, similar to very stiff/ hard clay. The modulus is about 10,000 psi.		The 28-day strength of this mix is about 4 psi, similar to very soft clay.	

The open standpipe piezometers will consist of 2 inch-diameter polyvinyl chloride (PVC) casing and up to 20 feet of machine-slotted screen. Sand will be placed in the annular space from 0 to 2 feet below the bottom of the screen (0 to 6 inches if the piezometer will be installed at the bottom of borehole) to 2 to 3 feet above the top of the screen. A bentonite seal will be placed above the sand and up to ground surface. Bentonite will also be used below the sand in locations where the screened interval is installed above the bottom of the boring.

Piezometers will be protected at the surface with an aboveground casing and 2-foot by 2-foot concrete pad. Piezometer construction details and measured water levels will be included on the boring logs.

The actual number and locations of piezometers may change depending on the ability to access the proposed boring locations and the findings of the field reconnaissance. Installation of fully grouted nested VWPs may be considered at Borings B-06 or B-07 to better evaluate possibility of artesian groundwater conditions.

The piezometers will be installed according to Ecology's regulations as outlined in the Washington Administrative Code (WAC) 173-160.

Packer Testing

Stepped hydraulic pressure tests (also known as packer tests) will be completed in select boreholes within rock in accordance with Chapter 16 of the *Engineering Geology Field Manual* (Reclamation 2001) to estimate the hydraulic conductivity and seepage behavior of the rock. The tests involve forcing water under pressure into an uncased section of the borehole that is sealed off by inflatable wireline packers. Typically, packer tests will be completed at 10-foot intervals, depending on depths and test results.

This *2024 Geotechnical Field Exploration Plan* intends to complete packer testing in four (4) borings: B-03, B-06, B-07 and B-12.

The borehole will be flushed with clear water prior to actual pressure tests. Testing will be performed as the hole is advanced at locations and intervals determined by the engineer. The procedure of permeability testing as the borehole advances will be completed using double-pack assembly. Tests may be performed for the entire portion of the hole, or for isolated segments of the hole. A qualified Jacobs geologist will provide recommended packer inflation and injection pressure values and will determine the type of packer assembly and the sequence, location, and testing interval for all water pressure tests. This *2024 Geotechnical Field Exploration Plan* includes up to six (6) steps per packer test with each step anticipated to last approximately 15 minutes or less.

Use of drilling mud, bentonite, or other substances that may affect the hydraulic conductivity of the rock will not be permitted in these holes without the specific approval of the qualified Jacobs geotechnical engineers. Clean water will be used in all water pressure tests.

Falling Head Permeability Tests in OSPs

Falling head permeability tests will be completed in the OSPs installed within the overburden material (i.e., foundation zone). The tests will be completed in general accordance with U.S. Army Corps of Engineers approach (USACE, 1983). The tests will be completed in the following borings:

- Primary Dam: OSP Borings B-06P, B-07P
- Secondary Dam: OSP Boring B-02P
- South-East Ridge: OSP Boring B-10P

*Note that the *Geotechnical Field Exploration Plan* (Jacobs 2023) indicated that the permeability testing would be completed through the perforated casing following Gravity Permeability Test – Method 2 (As outlined in Chapter 17 of Engineering Geology Field Manual, Reclamation 2001). After discussion with drilling companies, it was determined that this would require additional drill rig time and costs. The proposed OSP falling head permeability test method is anticipated to provide similar permeability data within the overburden soils.

Downhole Televiewer Logging

Downhole televiewer logging will be completed by GeoVision at up to four of the proposed borings in the Primary and Secondary dams. Televiewer logging (acoustic) will provide information to interpret the geology in the dam foundations. The logging will also obtain detailed and oriented structural information of rock discontinuities, including the orientation of bedding planes, joints, and fractures. The discontinuity data obtained from the televiewer logging will be plotted on stereonets and used in the evaluations for preliminary dam design.

*Note that the *Geotechnical Field Exploration Plan* (Jacobs 2023) included downhole televiewer logging in all the borings advanced along the primary, secondary, and saddle dams. Due to current funding limitations, up to four downhole televiewer logging are included in this *2024 Geotechnical Field Exploration Plan*.

Laboratory Analyses for Geotechnical Borings

The laboratory testing program consists of performing classification and engineering laboratory testing of the type and number required to obtain information to support the feasibility study. Actual types and number of tests will be determined after the exploration program based on the actual subsurface conditions encountered.

The proposed laboratory testing rates and quantities for soil and rock are summarized in Tables 2 and 3, respectively.

Table 2 – Summary of Laboratory Testing Rates and Quantities for the Soil Testing - Drilling

Test	Interval (ft)	Total Test Quantities	Testing Guidance Document
Moisture Content (%) (USBR 5300-89 or Equivalent)	10	211	Determining Moisture Content of Soil and Rock by the Oven Method (Reclamation 1990)
Specific Gravity (USBR 5320-89 or Equivalent)	80	26	Determining Specific Gravity of Soils (Reclamation 1990)
Sieve Analysis (USBR 5325-89 / 5335-89 or Equivalent)	20	105	Performing Gradation Analysis of Gravel-Size Fraction of Soils (Reclamation 1989); USBR 5335-89, Performing Gradation Analysis of Soils Without Hydrometer and Wet Sieve (Reclamation 1990)

Test	Interval (ft)	Total Test Quantities	Testing Guidance Document
Hydrometer (USBR 5330-89 or Equivalent)	80	26	USBR 5330-89, Performing Gradation Analysis of Fines and Sand-Size Fraction of Soils, Including Hydrometer Analysis (Reclamation 1990)
Atterberg (Multi Pt). (USBR 5355-89 or Equivalent)	50	42	Determining the Liquid Limit of Soils by the One-Point Method (Reclamation 1990); USBR 5355-89, Determining the Liquid Limit of Soils by the Three-Point Method (Reclamation 1990); USBR 5360-89, Determining Plastic Limit and Plasticity Index of Soil (Reclamation 1990)
Dry Density (USBR 5375-89 or Equivalent)	80	26	Determining Dry Unit Weight of Irregularity Shape Soil Specimens (Reclamation 1990)
Organic Content (USBR 5430-89 or Equivalent)	80	26	Determining Moisture, Ash, and Organic Content of Soils (Reclamation 1990)

*Note that the *Geotechnical Field Exploration Plan* (Jacobs 2023) included laboratory testing of Moisture Density (USBR 5500-89). Due to current funding limitations, this task is not anticipated to be conducted for this *2024 Geotechnical Field Exploration Plan*.

Table 3 – Summary of Laboratory Testing Rates and Quantities for the Rock Testing - Coring

Test	Test Per Foot	Total Test Quantities	Testing Guidance Document
Unconfined Compression w/ Youngs Modulus (USBR 6210 / 6220 or Equivalent)	20	60	USBR 6210, Performing Uniaxial Compression Testing of Rock Core (Reclamation 1990); USBR 6220, Determining Modulus of Elasticity and Poisson's Ratio of Rock in Uniaxial Compression (Reclamation 2017)
Point Load (USBR 6535 or Equivalent)	20	60	Estimating Compressive Strength by Pint Load Test Method (Reclamation 2017)
Cerchar Abrasivity Index (ASTM D7625-22)	65	19	ASTM D7625-22, Standard Test Method for Laboratory Determination of Abrasiveness of Rock

Test	Test Per Foot	Total Test Quantities	Testing Guidance Document
			Using the CERCHAR Abrasiveness Index Method (ASTM International 2022)

5.6 *Test Pits*

The proposed geotechnical exploration program includes excavation of 37 test pits (designated T-01 through T-37). The 37 test pits will be excavated at the following locations:

- 7 test pits (TP-01 to TP-07) within the footprint of the proposed primary dam
- 3 test pits (TP-08 through TP-10) within the footprint of the secondary dam
- 7 test pits (TP-11 through TP-17) within the footprint of the saddle dams
- 4 test pits (TP-18 through TP-21) along the inlet pipeline and intake structure
- 2 test pits (TP-22 and TP-23) at the outlet intake and dissipation structures
- 14 test pits (TP-24 through TP-37) to locate potential borrow source areas

The preliminary test pit locations are shown on Figure 5. The test pit locations in the footprint of the reservoir area may be revised based on the findings of the previously completed borings and test pits.

5.6.1 Purpose

The explorations within the footprint of the primary, secondary, and saddle dams will be used to gather foundation physical properties and provide information to help interpret the variability of soil conditions. The test pits will also be used to evaluate the presence, or lack thereof, of near surface variability in overburden and help assess the potential for these materials to be susceptible to liquefaction, which would result in the requirement to remove the materials as part of the dam construction.

The explorations along the inlet and outlet lines will be used to characterize subsurface conditions along the pipelines and at the intake structures and allow for a visual observation of near-surface soil layers. The explorations within the reservoir will be used to identify potential borrow sources. The visual observations and results of in situ and laboratory testing will be used to evaluate material properties.

The natural soil material overlying Columbia River Basalt in Springwood Reservoir site vicinity is primarily associated with glacially deposited till. Till materials can be problematic because of the potential for wide variation in homogeneity of a particular deposit. In addition, till materials are often broadly graded, with varying amounts of cobble, gravel, sand, and fines (silt and clay).

Geotechnical investigations and characterizations of till material sites are sometimes challenging and require special attention. Obtaining or reproducing representative laboratory samples for testing gradation, permeability, strength, and compressibility is often difficult. Test pits and deep exploratory trenches result in larger representative samples and thus are better than boreholes for examining homogeneity.

5.6.2 Requirements

Test pits will be advanced to top of rock or a maximum depth of 15 feet, whichever is shallower. The test pits will be excavated using a tracked excavator with the capability of digging to a depth of at least 15 feet. Excavation of test pits will be terminated at shallower depths if groundwater seepage into the excavation occurs such that the pit is filling with water or if the seepage is causing caving of side walls that cannot be controlled using benching.

All test pits are located on restricted access property that is fenced and gated. No risk to public safety is anticipated. If test pits remain open overnight, the pits will be staked and flagged with warning tape. New access road construction and site clearing may be required for access to the test pit locations.

Test pits will be backfilled using the excavated material removed from each of the pits. Excavated material will be placed back in the pit in loose lifts not more than 18 inches thick using the back of the excavator bucket.

Excavation will be completed in the presence of the qualified Jacobs staff who will direct the excavation operations, collect samples, and provide continuous observation and logging of each of the test pits.

Field Observations

The length, width, and depth of each test pit will be measured and recorded. Subsurface conditions exposed in the test pit walls will be photographed and visually logged from the ground surface to the bottom of the test pit. Field descriptions will be in accordance with USBR 5005-89, *Procedure for Determining Unified Soil Classification of Soils (Visual Method)* (Reclamation 1990). Groundwater or surficial water infiltration, if encountered, will be observed and noted, estimating excavation infiltration in gallons per minute.

In Situ Testing

Up to 5 small-scale pilot infiltration tests will be performed in general accordance with the Stormwater Management Manual for Eastern Washington.

*Note that the *Geotechnical Field Exploration Plan* (Jacobs 2023) stated that for the test pits within the dam footprint, in situ density tests will be completed by the sand cone method (USBR 7205-89, *Determining Unit-Weight of Soils In-Place by the Sand Cone Method;* Reclamation 1990) in at least 3 test pits for each soil type and gradation testing will be performed on the materials removed for the sand cone test. If material is too coarse grained for the sand cone test, a large-diameter density test, such as 6-foot-diameter water replacement ring density tests (USBR 7221-89, *Determining Unit Weight of In-Place by the Water Replacement Method in a Test Pit*; Reclamation 1990), may be completed. Due to current funding limitations, this task is not anticipated to be conducted as part of the *2024 Geotechnical Field Exploration Plan*.

<u>Laboratory Analyses for Test Pits</u>

Representative soil samples will be collected from the test pits and placed in 5-gallon buckets (bulk samples) or double layers of sealable plastic bags (bag samples). Samples will be collected every 5 feet or change in material.

Up to five samples from each test pit will be tested for moisture content and gradations. If fine-grained material is encountered, Atterberg Limits, crumb, and pinhole tests will be conducted. Up to ten total Atterberg Limits tests will be completed where appropriate.

The proposed laboratory testing rates and quantities for the proposed test pits are summarized in Table 4.

Table 4 – Summary of Laboratory Testing Rates and Quantities for the Soil Testing – Test Pits

Test	Test Per Foot	Total Test Quantities	Testing Guidance Document
Sieve Analysis (USBR 5325-89 or Equivalent)	-	185	Determining Unified Soil Classification (Laboratory Method) (Reclamation 1990)
Moisture % (USBR 5300-89 or Equivalent)	-	185	Determining Moisture Content of Soil and Rock by Oven Method (Reclamation 1990)
Atterberg (Multi Pt). (USBR 5360-89 or Equivalent)	-	10	Determining Plastic Limit and Plasticity Index of Soil (Reclamation 1990)
Crumb Test (USBR 5400-89 or Equivalent)	-	10	Determining Dispersibility of Clayey Soils by the Crumb Test Method (Reclamation 1990)
Pinhole Test (USBR 5410-89 or Equivalent)	-	10	Determining Dispersibility of Clayey Soils by the Pinhole Test Method (Reclamation 1990)
Soundness & Durability Testing (ASTM C289-94)	-	10	(ASTM International 1994)

*Note that the *Geotechnical Field Exploration Plan* (Jacobs 2023) stated that compaction testing of up to six bulk samples will be completed in accordance with USBR 5500-89, *Performing Laboratory Compaction of Soils- 5.5-lbm Rammer and 18-in Drop* (Reclamation 1990) to determine maximum dry density and optimum moisture content. And that actual numbers of laboratory tests to be completed to determine engineering properties would be determined after all test pits are excavated and photographed and draft logs would be reviewed. Due to current funding limitations, this task is not anticipated to be conducted as part of this *2024 Geotechnical Field Exploration Plan*.

5.7 Geophysical Survey

*Note that the *Geotechnical Field Exploration Plan* (Jacobs 2023) stated that a surface geophysical survey (multichannel analysis of surface waves and/or electrical resistivity survey) would be conducted. Due to current funding limitations, this task is not anticipated to be conducted as part of this *2024 Geotechnical Field Exploration Plan*.

5.8 2024 Geotechnical Exploration Report

The *Geotechnical Field Exploration Plan* (Jacobs 2023) stated that the geotechnical consultant(s) would prepare a geotechnical data report (GDR). A GDR will be developed later, once funding is available to complete all of the geotechnical field work, per the *Geotechnical Field Exploration Plan* (Jacobs 2023). Information collected from the *2024 Geotechnical Exploration* activities, including subsurface explorations, literature research, and geologic and geophysical testing will be analyzed and presented in a Geotechnical Exploration Report that provides preliminary recommendations and geotechnical design considerations at the site for dam construction. This Geotechnical Exploration Report will summarize the results of the 2024 geotechnical explorations and will be used in conjunction with future geotechnical data acquisition to inform the final design of the project.

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Attachment 1. Figures

FIGURE 1. VICINITY MAP

Springwood Reservoir
Upper Yakima System Storage

0 2.5 5
Miles

Jacobs

Data Sources: DNR, USFS, USGS, WSDOT
Basemap Source: Esri, CGIAR, NGA
Map Date: April 10, 2024

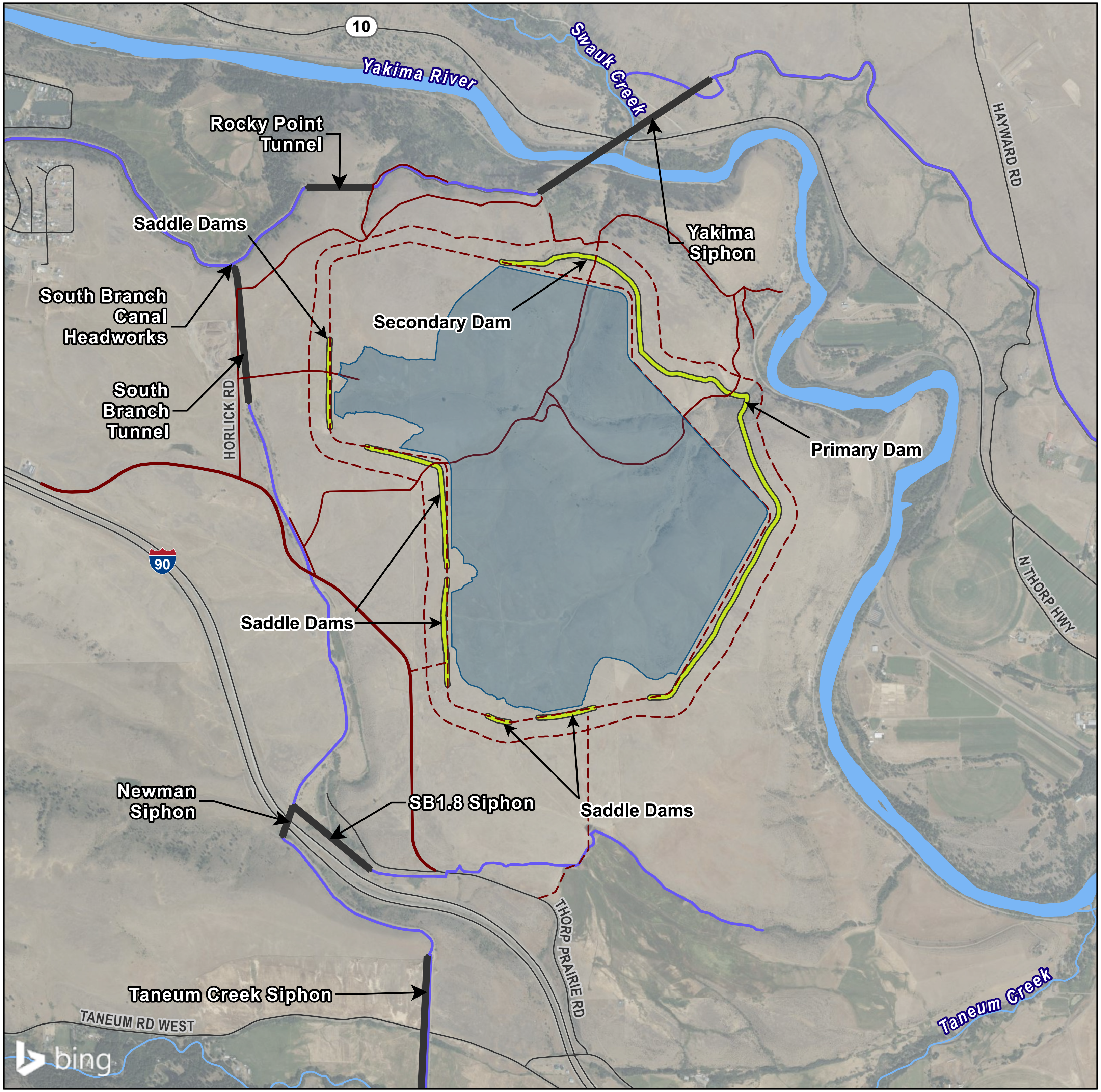


FIGURE 2. SPRINGWOOD SITE (2,175 FEET WSE)

Springwood Reservoir
Upper Yakima System Storage

Reservoir Footprint
Maximum Dam Footprint
Existing Road
Proposed Road
KRD Structure
KRD Canal

N

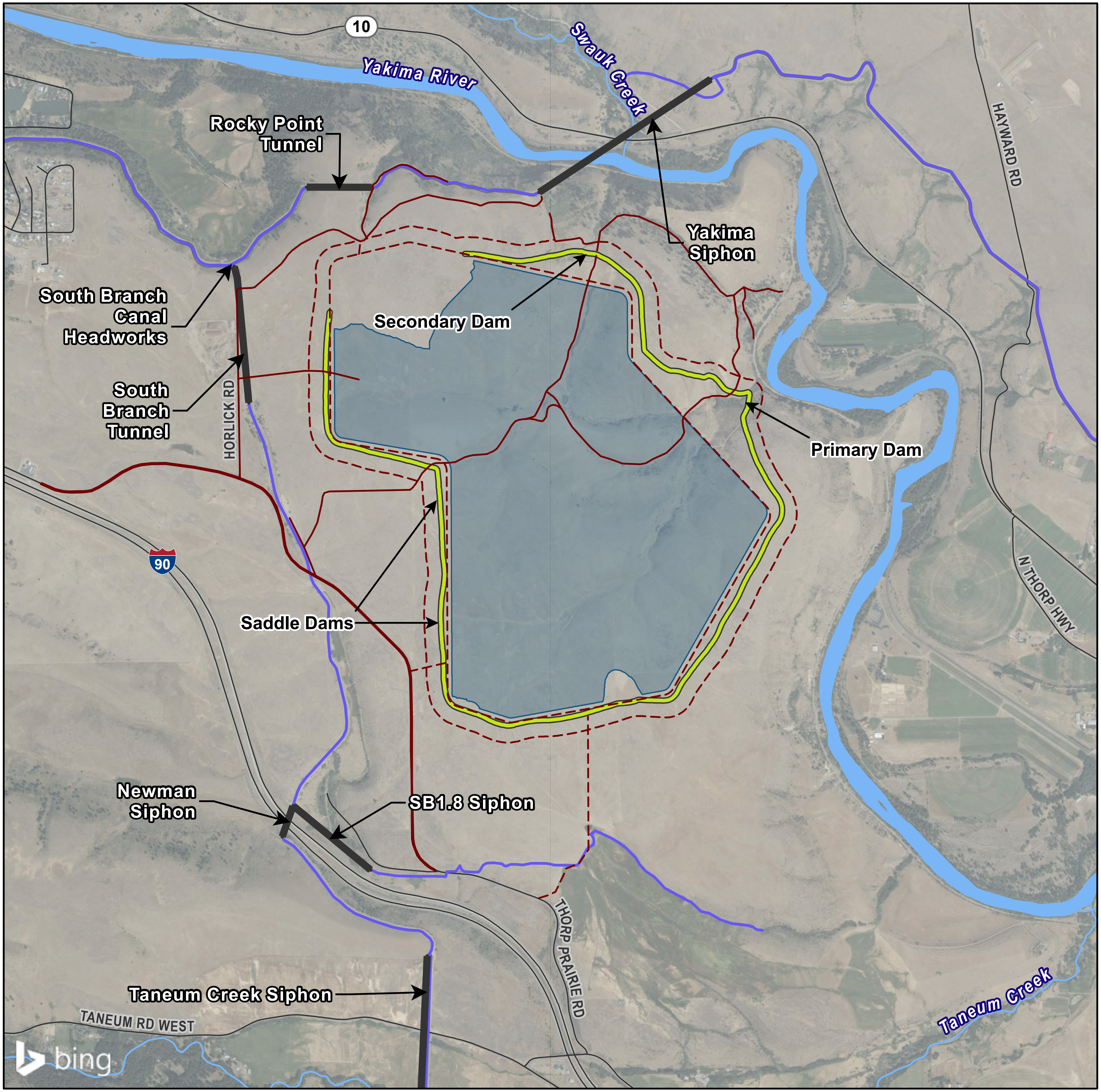
0 1,000 2,000
Feet

Jacobs

Data Sources: Kittitas County, KRD, USGS, WSDOT
Basemap Source: Bing © 2023 Microsoft Corporation
Map Date: April 18, 2024

FIGURE 3. SPRINGWOOD SITE (2,200 FEET WSE)

Springwood Reservoir
Upper Yakima System Storage



Reservoir Footprint
Maximum Dam Footprint
Existing Road
Proposed Road
KRD Structure
KRD Canal

N

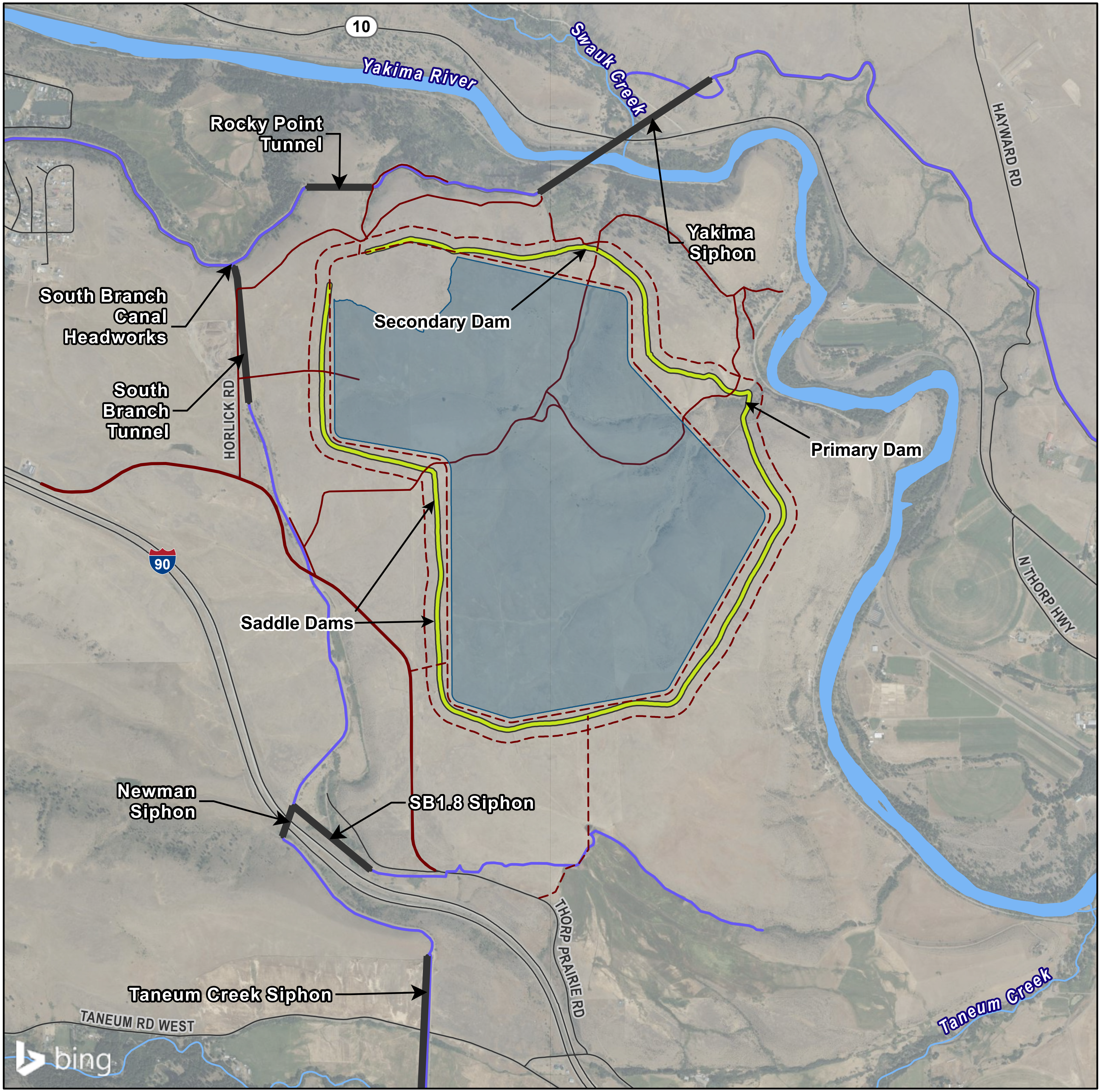
0 1,000 2,000
Feet

Jacobs

Data Sources: Kittitas County, KRD, USGS, WSDOT
Basemap Source: Bing © 2023 Microsoft Corporation
Map Date: April 18, 2024

FIGURE 4. SPRINGWOOD SITE (2,230 FEET WSE)

Springwood Reservoir
Upper Yakima System Storage



Reservoir Footprint
Maximum Dam Footprint
Existing Road
Proposed Road
KRD Structure
KRD Canal

N

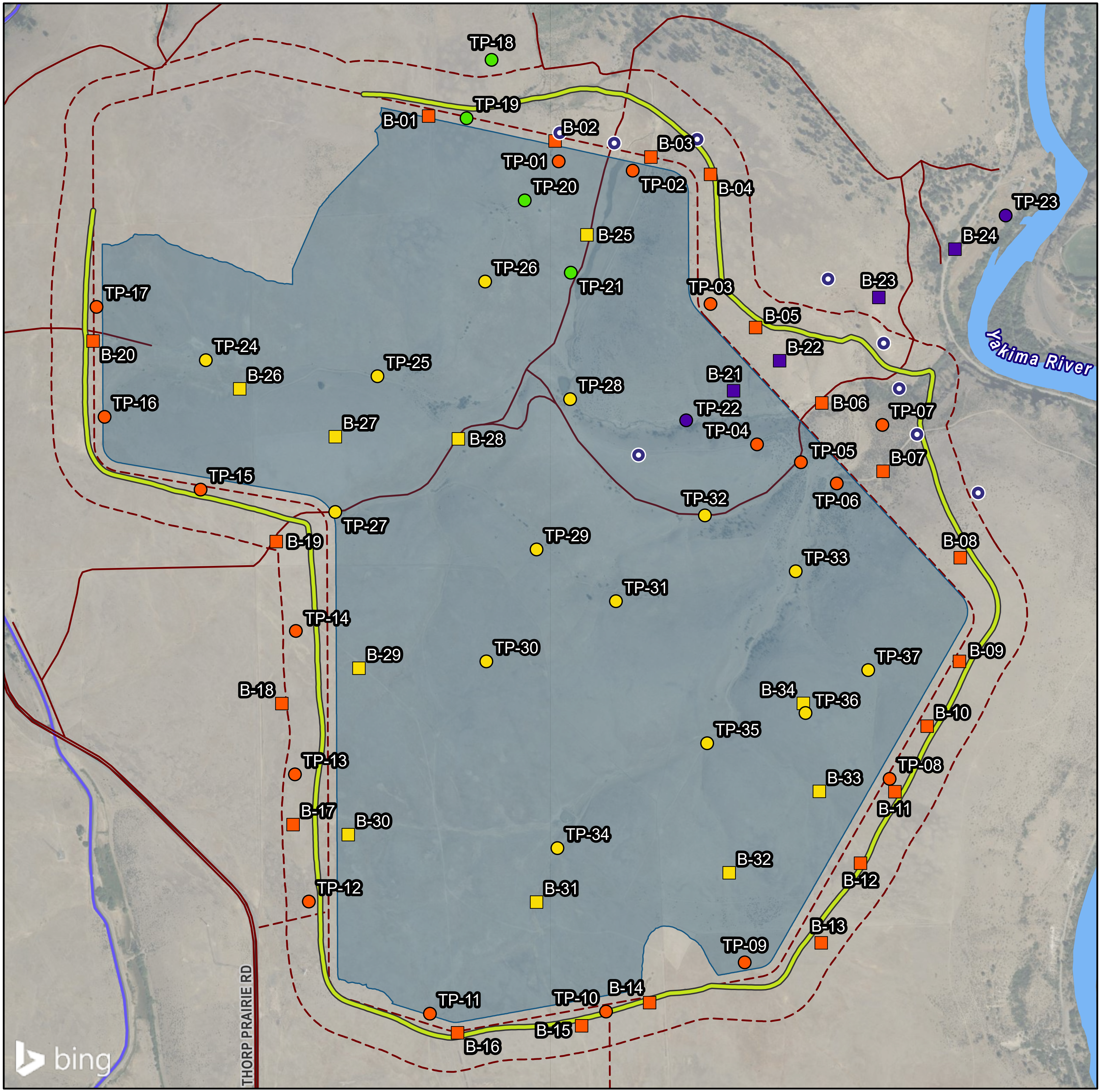
0 1,000 2,000
Feet

Jacobs

Data Sources: Kittitas County, KRD, USGS, WSDOT
Basemap Source: Bing © 2023 Microsoft Corporation
Map Date: April 18, 2024

FIGURE 5. PRELIMINARY BORING AND TEST PIT LOCATIONS

Springwood Reservoir
Upper Yakima System Storage



- 2,200 ft WSE Maximum Dam Footprint
- 2,200 ft WSE Reservoir Footprint
- Boring - Along Dam
- Boring - Borrow Area
- Boring - Outlet Works
- Test Pit - Along Dam
- Test Pit - Borrow Area
- Test Pit - Outlet Works
- Test Pit - Inlet
- Aspect Geotechnical Borings (2022)
- Existing Road
- Proposed Road
- KRD Canal

N

0 1,000 2,000
Feet

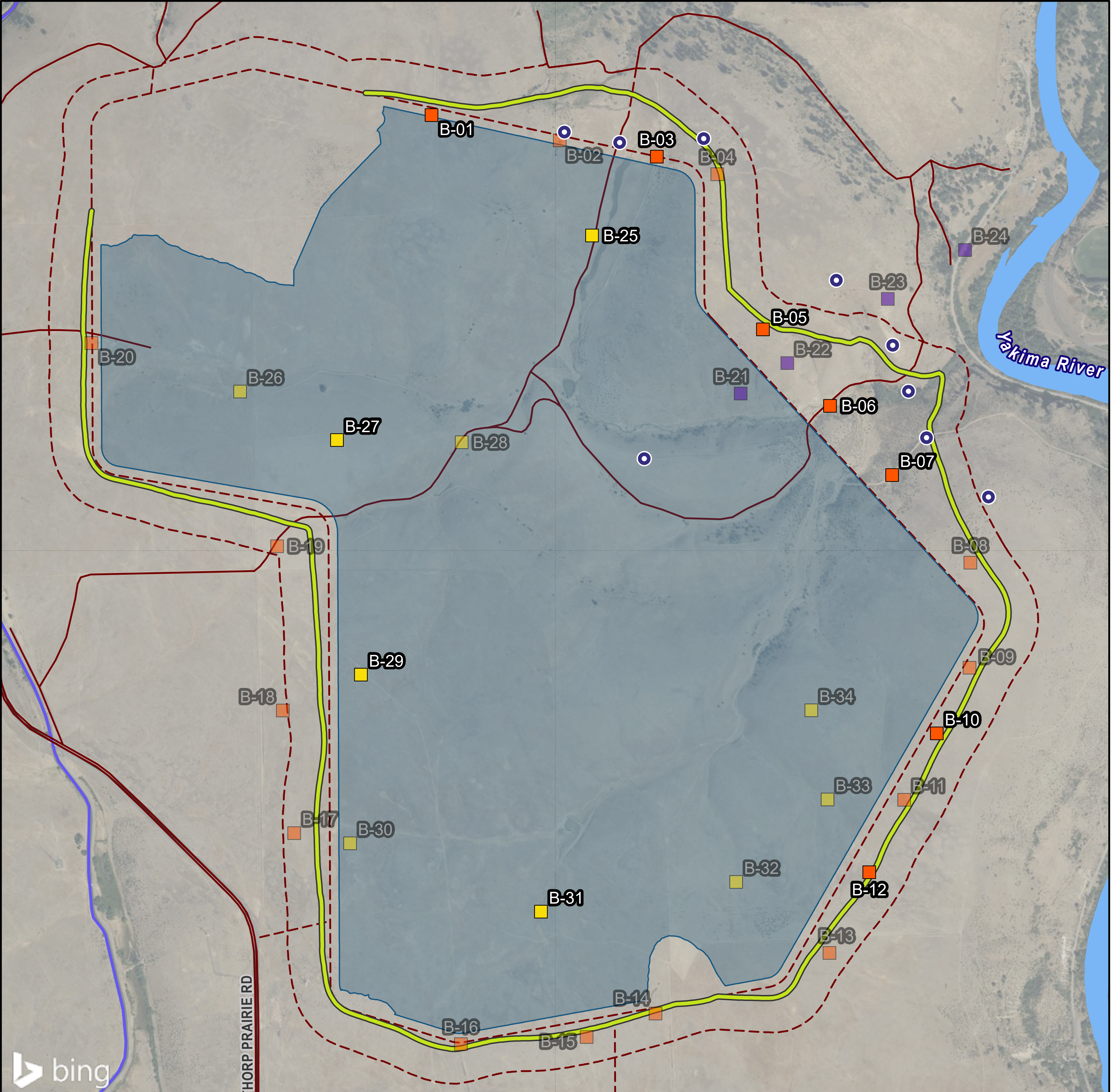
Jacobs

Data Sources: Kittitas County, KRD, USGS, WSDOT
Basemap Source: Bing © 2023 Microsoft Corporation
Map Date: April 10, 2024

Appendix C. Proposed Boring Locations

FIGURE 2. 2025 BORING EXPLORATIONS

Springwood Reservoir
Upper Yakima System Storage



2,200 ft WSE Maximum Dam Footprint

2,200 ft WSE Reservoir Footprint

2025 Geotechnical Exploration

- Boring - Along Dam
- Boring - Borrow Area

Borings Not to be Completed During 2025 Exploration

- Boring - Along Dam
- Boring - Borrow Area
- Boring - Outlet Works
- Aspect Geotechnical Borings (2022)
- Existing Road
- Proposed Road
- KRD Canal

N

0 1,000 2,000
Feet

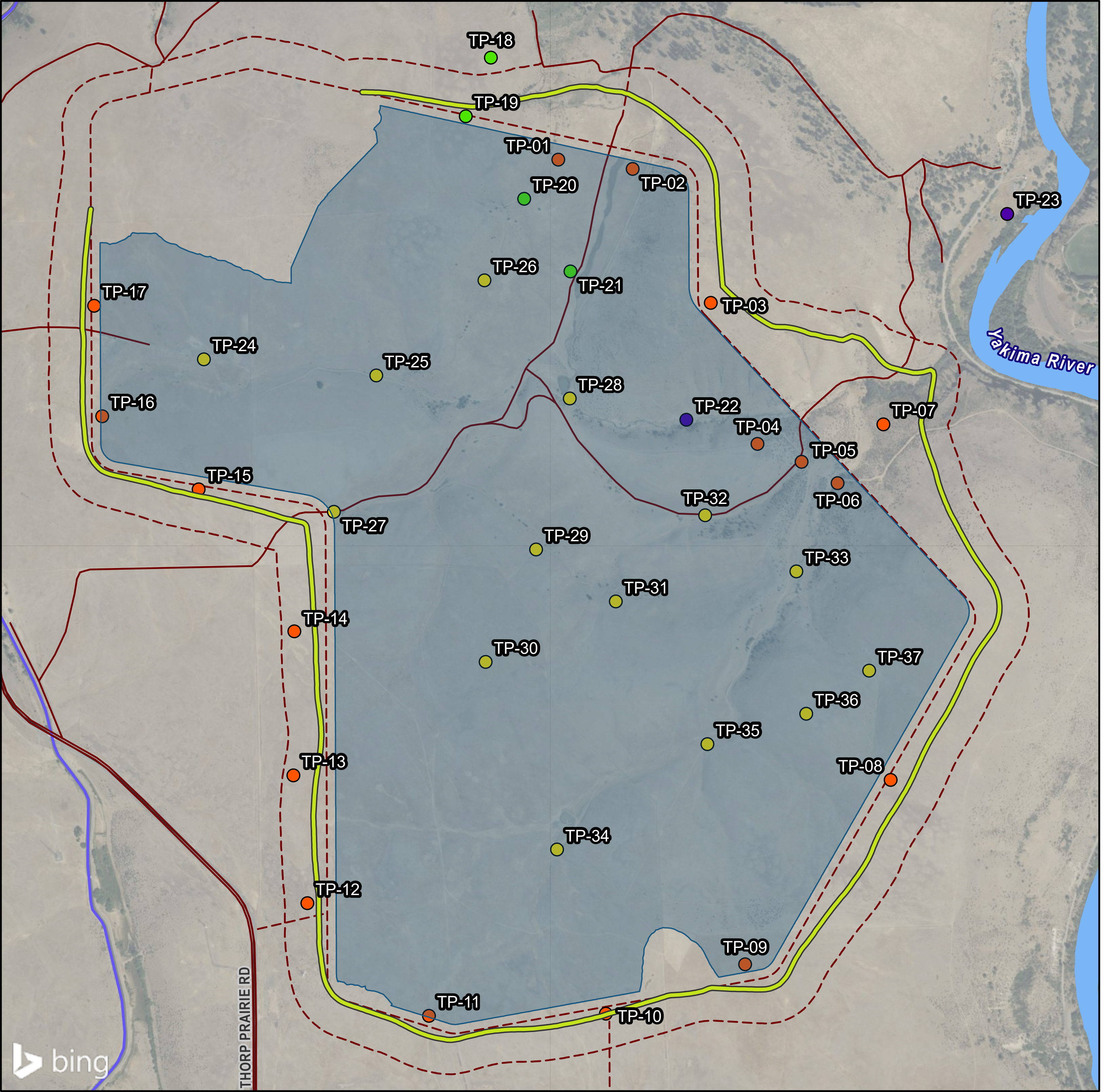
Jacobs

Data Sources: Kittitas County, KRD, USGS, WSDOT
Basemap Source: Bing © © 2025 Microsoft Corporation © 2025 Maxar ©CNES (2025) Distribution Airbus DS
Map Date: June 10, 2025

Appendix D. Proposed Test Pit Locations

FIGURE 1. 2025 TEST PIT EXPLORATIONS

Springwood Reservoir
Upper Yakima System Storage



2,200 ft WSE Reservoir Footprint
2,200 ft WSE Maximum Dam Footprint
2025 Geotechnical Exploration
Test Pit - Along Dam
Test Pit - Borrow Area
Test Pit - Outlet Works
Test Pit - Inlet
Existing Road
Proposed Road
KRD Canal

N

0 1,000 2,000
Feet

Jacobs

Data Sources: Kittitas County, KRD, USGS, WSDOT
Basemap Source: Bing © © 2025 Microsoft Corporation © 2025 Maxar ©CNES (2025) Distribution Airbus DS
Map Date: June 10, 2025

Appendix E. Glossaries, Acronyms, and Abbreviations

Glossary of General Terms

Not applicable.

Acronyms and Abbreviations

DQO	data quality objective
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management
GDR	geotechnical data report
GER	geotechnical exploration report
ITR	independent technical reviewer
KRD	Kittitas Reclamation District
MASW	multichannel analysis of surface waves
MQO	measurement quality objective
OSP	open standpipe piezometer
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
Reclamation	U.S. Bureau of Reclamation (USBR)
SPT	Standard Penetration Test
USGS	U.S. Geological Survey
UYSS	Upper Yakima System Multi-Benefit Water Storage
VPS	value planning study
VWP	vibrating wire piezometer
WAC	Washington Administrative Code
WSE	water surface elevation
YBIP	Yakima Basin Integrated Plan

Units of Measurement

^{o}C	degree Celsius
^{o}F	degree Fahrenheit
cm/s	centimeters per second
FS	% of full scale
ft	feet
GPa	gigapascal
lb/ft	pound per foot
lb/ft^3	pound per cubic foot
L/min	liters per minute
m	meter
mm	millimeter
mmol	millimole or one-thousandth of a mole
MPa	megapascal
psi	pounds per square inch

Quality Assurance Glossary

Accreditation: A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data (Kammin, 2010). For Ecology, it is defined according to WAC 173-50-040: "Formal recognition by [Ecology] that an environmental laboratory is capable of producing accurate and defensible analytical data."

Accuracy: The degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms *precision* and *bias* be used to convey the information associated with the term *accuracy* (USEPA, 2014).

Analyte: An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e.g., fecal coliform, Klebsiella (Kammin, 2010).

Bias: Discrepancy between the expected value of an estimator and the population parameter being estimated (Gilbert, 1987; USEPA, 2014).

Blank: A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process (USGS, 1998).

Calibration: The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured (Ecology, 2004).

Check standard: A substance or reference material obtained from a source independent from the source of the calibration standard; used to assess bias for an analytical method. This is an obsolete term, and its use is highly discouraged. See Calibration Verification Standards, Lab Control Samples (LCS), Certified Reference Materials (CRM), and/or spiked blanks. These are all check standards but should be referred to by their actual designator, e.g., CRM, LCS (Kammin, 2010; Ecology, 2004).

Comparability: The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator (USEPA, 2014; USEPA, 2020).

Completeness: The amount of valid data obtained from a project compared to the planned amount. Usually expressed as a percentage. A data quality indicator (USEPA, 2014; USEPA 2020).

Continuing Calibration Verification Standard (CCV): A quality control (QC) sample analyzed with samples to check for acceptable bias in the measurement system. The CCV is usually a midpoint calibration standard that is re-run at an established frequency during the course of an analytical run (Kammin, 2010).

Control chart: A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system (Kammin, 2010; Ecology 2004).

Control limits: Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +/- 2 standard deviations from the mean, action limits at +/- 3 standard deviations from the mean (Kammin, 2010).

Data integrity: A qualitative DQI that evaluates the extent to which a data set contains data that is misrepresented, falsified, or deliberately misleading (Kammin, 2010).

Data quality indicators (DQI): Commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity (USEPA, 2006).

Data quality objectives (DQO): Qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions (USEPA, 2006).

Data set: A grouping of samples organized by date, time, analyte, etc. (Kammin, 2010).

Data validation: The process of determining that the data satisfy the requirements as defined by the data user (USEPA, 2020). There are various levels of data validation (USEPA, 2009).

Data verification: Examination of a data set for errors or omissions, and assessment of the Data Quality Indicators related to that data set for compliance with acceptance criteria (MQOs). Verification is a detailed quality review of a data set (Ecology, 2004).

Detection limit (limit of detection)**:** The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero (Ecology, 2004).

Duplicate samples: Two samples taken from and representative of the same population and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis (USEPA, 2014).

Field blank: A blank used to obtain information on contamination introduced during sample collection, storage, and transport (Ecology, 2004).

Initial Calibration Verification Standard (ICV): A QC sample prepared independently of calibration standards and analyzed along with the samples to check for acceptable bias in the measurement system. The ICV is analyzed prior to the analysis of any samples (Kammin, 2010).

Laboratory Control Sample (LCS)/LCS duplicate: A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples. Monitors a lab’s performance for bias and precision (USEPA, 2014).

Matrix spike/Matrix spike duplicate: A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias and precision errors due to interference or matrix effects (Ecology, 2004).

Measurement Quality Objectives (MQOs)**:** Performance or acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness (USEPA, 2006).

Measurement result: A value obtained by performing the procedure described in a method (Ecology, 2004).

Method: A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed (USEPA, 2001).

Method blank: A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples (Ecology, 2004; Kammin, 2010).

Method Detection Limit (MDL): The minimum measured concentration of a substance that can be reported with 99% confidence that the measured concentration is distinguishable from method blank results (USEPA, 2016). MDL is a measure of the capability of an analytical method of distinguished samples that do not contain a specific analyte from a sample that contains a low concentration of the analyte (USEPA, 2020).

Minimum level: Either the sample concentration equivalent to the lowest calibration point in a method or a multiple of the method detection limit (MDL), whichever is higher. For the purposes of NPDES compliance monitoring, EPA considers the following terms to be synonymous: “quantitation limit,” “reporting limit,” and “minimum level” (40 CFR 136).

Parameter: A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene and nitrate + nitrite are all parameters (Kammin, 2010; Ecology, 2004).

Population: The hypothetical set of all possible observations of the type being investigated (Ecology, 2004).

Precision: The extent of random variability among replicate measurements of the same property; a data quality indicator (USGS, 1998).

Quality assurance (QA): A set of activities designed to establish and document the reliability and usability of measurement data (Kammin, 2010).

Quality Assurance Project Plan (QAPP): A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives (Kammin, 2010; Ecology, 2004).

Quality control (QC): The routine application of measurement and statistical procedures to assess the accuracy of measurement data (Ecology, 2004).

Relative Percent Difference (RPD): RPD is commonly used to evaluate precision. The following formula is used:

$$RPD = [Abs(a-b)/((a + b)/2)] * 100\%$$

where “Abs()” is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples (Ecology, 2004).

Relative Standard Deviation (RSD): A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

$$RSD = (100\% * s)/x$$

where s is the sample standard deviation and x is the mean of results from more than two replicate samples (Kammin, 2010).

Replicate samples: Two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled (USGS, 1998).

Reporting level: Unless specified otherwise by a regulatory authority or in a discharge permit, results for analytes that meet the identification criteria (i.e., rules for determining qualitative presence/absence of an analyte) are reported down to the concentration of the minimum level established by the laboratory through calibration of the instrument. EPA considers the terms “reporting limit,” “quantitation limit,” and “minimum level” to be synonymous (40 CFR 136).

Representativeness: The degree to which a sample reflects the population from which it is taken; a data quality indicator (USGS, 1998).

Sample (field): A portion of a population (environmental entity) that is measured and assumed to represent the entire population (USGS, 1998).

Sample (statistical): A finite part or subset of a statistical population (USEPA, 1992).

Sensitivity: In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit (Ecology, 2004).

Spiked blank: A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method (USEPA, 2014).

Spiked sample: A sample prepared by adding a known mass of target analyte(s) to a specified amount of matrix sample for which an independent estimate of target analyte(s) concentration is available. Spiked samples can be used to determine the effect of the matrix on a method’s recovery efficiency (USEPA, 2014).

Split sample: A discrete sample subdivided into portions, usually duplicates (Kammin, 2010).

Standard Operating Procedure (SOP): A document which describes in detail a reproducible and repeatable organized activity (Kammin, 2010).

Surrogate: For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis (Kammin, 2010).

Systematic planning: A step-wise process which develops a clear description of the goals and objectives of a project, and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The DQO process is a specialized type of systematic planning (USEPA, 2006).

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WAC 173-50-040. Title 173 Washington Administrative Code. Accreditation of Environmental Laboratories: Definitions. Available at: https://apps.leg.wa.gov/WAC/default.aspx?cite=173-50-040 (accessed 26 Feb. 2020).

Appendix F. Lab Accreditation Waiver

Department of Ecology

Request to Waive Required Use of Accredited Lab

Use form ECY 070-152a for a waiver for Microbial Source Tracking (MST)

Reference: Executive Policy 22-02

Date: 06/16/2025 **06/Program:** OCR

Name of Requester: McKenna Murray **Work Phone:** (509)823-0996

Project Name: Springwood Geotechnical Exploration Plan_____

Laboratory name: Kleinfelder, Inc. ___________________

Activity Tracker number: ______________________

Test(s) for which a waiver is requested:

(Identify analyte/matrix/method; for example, Dieldrin by HR-GC/MS)

- Soil Drilling and Test Pits
  - Moisture Content
  - Dry Density
  - Specific Gravity
  - Sieve Analysis
  - Hydrometer
  - Atterberg (Liquid Limit)
  - Atterberg (Plastic Limit)
  - Atterberg (Shrinkage Limit)
  - Organic Content
  - Crumb Test
  - Pinhole Test
  - Soundness and Durability Testing
  - Modified Proctor Test
- Rock Drilling
  - Unconfined Compression w/ Youngs Modulus
  - Point Load
  - CERCHAR Abrasivity Index
  - Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock
  - Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock (Youngs Modulus)
  - Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock (Poisson's Ratio)

Justification for Request:

(Describe some of the possible reasons for requesting to waive the requirement to use an accredited lab are listed. Click to check as many boxes as apply and explain in the narrative.)

☐ Data quality goal does not warrant accreditation [1]

☒ There is no lab accredited to do the test(s) [2]

☒ EAP Lab Accreditation Section cannot accredit for test(s) [3]

☐ There is no accredited lab in a reasonable distance [4]

☐ No lab can be accredited in time to meet the need [4]

☐ Other (explain in narrative)

Narrative (Explain the above checked boxes)**:**

This study/QAPP is for a Geotechnical Field Exploration. None of the labs that perform Geotechnical Laboratory testing are currently accredited by LAU because these analyses are not environmental tests, and LAU does not accredit laboratories for construction materials testing. Kleinfelder is a US Army Corp of Engineers (USACE) and American Association of State Highway and Transportation (AASHTO) accredited laboratory.

Associated Quality Control Tests:

Exemption from the requirement to use an accredited lab does not relieve the data user from the requirement to assure lab data meets quality objectives. Reviewing quality control (QC) test results, routinely performed as part of the lab accreditation process, becomes an especially important issue for the user of data coming from a non-accredited lab. Click all boxes to indicate the QC tests the lab will be required to report along with the environmental data. Refer to this description of QC tests, if needed, to determine the significance of each test.

☒ Check standards

☐ Method Blanks

☐ Matrix Spikes

☐ Matrix Spike Duplicates

☐ Duplicates (field and laboratory)

☐ Surrogates

☐ Laboratory Splits

☒ Standard/Certified Reference Materials

When completed, save the request and submit it to the Agency's QA Officer by e-mail.

[1] Screening data, for example may not necessitate use of an accredited lab.
[2] Check the Lab Accreditation website or Contact the EAP Lab Accreditation Unit, or both.
[3] Contact the EAP Lab Accreditation Unit
[4] Check the Lab Accreditation website or Contact the EAP Lab Accreditation Unit, or both.

To request materials in a format for the visually impaired, visit https://ecology.wa.gov/accessibility, call at Ecology at 360-407-6764, Relay Service 711, or TTY 877-833-6341.

Approval Signatures:

____

Ecology Quality Assurance Officer Date

____

Environmental Assessment Program Manager or Ecology Deputy Director Date

To request materials in a format for the visually impaired, visit https://ecology.wa.gov/accessibility, call at Ecology at 360-407-6764, Relay Service 711, or TTY 877-833-6341.