
Final Report

**Schaake Property Habitat
Improvement Designs,
Yakima River Basin Water
Enhancement Project**

Executive Summary to Phase 1 Report

Prepared for
Bureau of Reclamation

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CH2MHILL®

Boise, Idaho

Executive Summary

This Executive Summary describes CH2M HILL's work on Phase 1 of the Schaaque Property Habitat Improvement Designs Project on the Yakima River from fall 2009 until spring 2011. The complete Phase 1 final report is posted online at the following website:

<http://www.usbr.gov/pn/programs/yrbwep/phase2/schaaque/index.html>

Background and Scope

Through the Yakima River Basin Water Enhancement Project (YRBWEP), the Bureau of Reclamation (Reclamation) is actively pursuing opportunities to protect, mitigate, and enhance fish and wildlife habitat along the Yakima River. The 285-acre Schaaque property, bordering the Yakima River south of Ellensburg, Washington (Exhibit ES1), was acquired by Reclamation in 2003 because of its high potential for habitat improvement for salmon and steelhead. The property previously supported a slaughterhouse and stockyards that have since been removed. Existing infrastructure near the Schaaque property includes Tjossem Ditch, Interstate 90 (I-90), the City of Ellensburg's Wastewater Treatment Plant (WWTP), Twin City Foods' (TCF) spray fields, and a proposed TCF lagoon.

As it flows past the property, the Yakima River is confined by artificial levees along both banks that constrain the river and prevent water and fish access to the floodplain. As a result, the river appears to be gradually incising and juvenile salmonids are unable to access refuge habitat during high flows and rearing habitat during most of the year. To help restore river processes and create self-sustaining habitat, Reclamation has proposed removal and reconfiguration of the levees on the left bank (facing downstream). These changes would increase the flow of water to the floodplain, both by dispersed overbank flooding and especially through floodplain side channels. These types of channel and floodplain connections would more closely resemble existing interactions in a nearby unleveed reach where higher quality instream and floodplain habitat is present. Reclamation has modeled a preliminary set of designs that include levee removal and reconfiguration and creation of side channels on the left bank of the river (Exhibits ES2, ES3, and ES4).

This report presents the findings and recommendations from Phase 1 of the Schaaque Habitat Improvement Designs Project. The scope for Phase 1 included the following elements: (1) assist Reclamation and stakeholders, via a series of meetings and conference calls, to refine the project goals and objectives and revise the proposed levee and side channel alignments; (2) evaluate work completed to date and identify the major remaining data and knowledge gaps; (3) characterize historic and current trends and potential risks and outcomes of the planned project from geomorphic and geotechnical perspectives; (4) complete a wetlands survey; (5) collect missing topographic data and develop a plan for hydraulic modeling in Wilson Creek, a tributary that flows parallel to and near the Yakima River in the Schaaque area (Exhibits ES1 and ES2); and (6) describe the components of a potential long-term monitoring plan based on an adaptive management strategy and the associated testing of clearly defined hypotheses.

In addition to addressing the above elements, this report includes proposed strategies for addressing the remaining data and knowledge gaps. The report also presents possible design refinements that our team believes could help Reclamation better achieve the overall project goals.

Project Goals and Objectives

Five overall goals have been established by Reclamation for the Schaaque Property Habitat Improvement Designs Project. The goals and objectives specified by Reclamation are as follows:

- **Goal 1.** Create and maintain refuge and rearing habitat for juvenile salmonids.
 - **Objective 1.1.** Provide rearing habitat during spring and fall and provide refuge habitat during high flows for Chinook salmon, summer steelhead, and coho salmon.
 - **Objective 1.2.** Increase geomorphic (hydraulic and habitat) complexity through the reach.
- **Goal 2.** Promote natural geomorphic processes as much as possible while reducing ongoing maintenance.
 - **Objective 2.1.** Maintain irrigation flows in Tjossem Ditch by incorporating features into the design to maintain the existing flows and establish an operations and maintenance plan to implement if necessary.
 - **Objective 2.2.** Design and construct project to promote channel-floodplain interaction while managing risk of channel avulsion into floodplain.
 - **Objective 2.3.** Allow side channels to evolve through natural processes.
 - **Objective 2.4.** Induce bed aggradation (sediment deposition) by diverting water into the floodplain.
- **Goal 3.** Maintain the risk of downstream flooding at current levels or lower.
 - **Objective 3.1.** Define the current level of protection and reach consensus with landowners.
 - **Objective 3.2.** Incorporate features into the design to maintain the existing level of protection.
 - **Objective 3.3.** Better define Wilson Creek (existing and proposed conditions) using two-dimensional hydraulic modeling.
- **Goal 4.** Protect existing infrastructure from inundation and erosion at the design discharge.
 - **Objective 4.1.** Complete the flow frequency analyses and determine the design discharges for the Yakima River and Wilson Creek.
 - **Objective 4.2.** Protect I-90.

- **Objective 4.3.** Protect WWTP facility, pipeline, and outfall.
- **Objective 4.4.** Protect TCF lagoon.
- **Objective 4.5.** Protect Tjossem Ditch.
- **Goal 5.** Minimize release of contaminants to the extent possible.
 - **Objective 5.1.** Better characterize the distribution of phosphorus on the floodplain.
 - **Objective 5.2.** Continue refining design locations of proposed side channels.
 - **Objective 5.3.** Enhance understanding of short- and long-term interaction between phosphorus and channels (side channels and river).
 - **Objective 5.4.** Mitigate interaction by removing/sequestering/immobilizing phosphorus or limiting channel access.

Existing Conditions

Exhibit ES2 shows the current configuration of the Yakima River through the project reach, including the existing levees and infrastructure. The Yakima River flows generally from north to south, entering the Schaaake Reach after flowing under the Umptanum Road Bridge. After crossing under the bridge, the river is diverted towards the east (left; facing downstream) by Right Bank Levee 1, which has been partially eroded by high flows in winter and spring 2011. The river continues to the east towards I-90 until it reaches Left Bank Levee 1 which then forces the river to make a sharp turn to the right (south), referred to throughout this report as the 90-Degree Bend. Downstream of the 90-Degree Bend, the river is confined to a relatively narrow band within four separate levee segments (Exhibit ES2). These levees provide some protection for existing infrastructure, including I-90, the WWTP, and spray fields used by TCF. Because the land was previously used for a slaughterhouse and stockyards, some of the property has high levels of phosphorus and possibly other contaminants (Exhibit ES5). In its current configuration between the levees, the channel is constrained from moving laterally, and water is prevented from entering the floodplain. Past analysis by Hilldale (2007) suggests that the Yakima River through this reach may have incised, or degraded, and the bed material of the river coarsened, as a result of the levee construction.

Habitat for salmonids appears to be limited in the Schaaake Reach by a lack of rearing and refuge zones for fry and juveniles; side channels can help provide this missing habitat. Compared to the main channel, high flow side channels (smaller channels that traverse the floodplain and are occupied by water during higher flows) contain lower velocities during periods of high flow and high quality habitat (abundant food and cool temperatures) during the summer, and they provide other ecological benefits, including riparian cover for terrestrial species. Side channels were naturally created and maintained by the Yakima River prior to the levees, as observed from historic maps and photographs (Exhibit ES6). In addition to high flow side channels, the river historically contained multiple threads (channels) during both high and low flows, separated by relatively stable, vegetated islands. A similar pattern of channels currently exists in the unleveed reaches of the Yakima River downstream of the Schaaake Reach (Exhibit ES7). Such a configuration with multiple

perennial channels separated by stable vegetated islands is called an anabranching channel pattern, and this pattern provides several advantages for habitat and sediment transport.

Although limited in its availability, geologic and historic evidence suggest that in the vicinity of the Schaaake Reach, bedload transport and lateral channel change controls geomorphic form and process more than suspended sediment transport and vertical floodplain accretion. The floodplain typically consists of a thin (<3 feet) layer of overbank sand and silt overlying a much thicker section of coarse gravel bedload facies (see Appendix C of main report: Initial Geotechnical Data Summary Technical Memorandum). The widespread presence of scroll bars (curved ridges left by the river as a result of channel movement) and other indicators of channel shifting in non-tilled areas on the floodplain suggest that lateral movement of the channel is relatively rapid compared with the rate at which these topographic relics of lateral channel movement would be covered up by fine sediment deposition.

Analysis of historic maps and air photographs combined with anecdotal evidence suggest the Yakima River is prone to sudden, major realignments of the channel in response to large floods or human intervention. This dominant process of channel change should be a primary consideration for the design of habitat improvement actions.

Despite the prevalence of bedload deposits in the floodplain and the dominance of lateral migration over floodplain sedimentation, the suspended load in the Yakima River probably dominates the total load (bedload plus suspended load), similar to most rivers. Based on analyses of historic sediment and flow data, we estimate that the suspended sediment load of the river in the vicinity of the Schaaake Reach averaged about 75,000 tons per year (tpy) between 1986 and 1999. We also estimate that the interannual variability encompasses at least an order of magnitude range from 25,000 tpy to 250,000 tpy (Exhibit ES8). Our average value is in general agreement with the estimate of 100,000 tpy recently developed by Reclamation (R. Hildale, 2011, personal communication) using a different approach. The similarity in results between the two methods may suggest that 50,000 to 150,000 tpy is a reasonable estimate of the long-term average sediment load for the Yakima River. The estimated average annual suspended sediment load (75,000 tpy) is equivalent to a basin-wide average erosion rate of about 18 tons per square kilometer per year, a relatively small amount for a mountainous drainage basin. This relatively low sediment yield is likely because of a combination of resistant bedrock, large areas of lowland floodplain, and upstream dams. However, even though the long-term average suspended sediment transport rate through the Schaaake Reach is calculated to be relatively low, frequent and short-duration events will continue to transport tens of thousands of tons of sediment in several days. By extrapolating the relationship between sediment concentration and discharge as measured at the Umtanum gage, we estimate that about 57,000 tons of sediment was transported in suspension past the gage in the 5 days between February 7 and February 11, 1996 (Exhibit ES8). Thus, habitat improvement features like side channels must be designed with a sufficient capacity to transport a temporarily high suspended load, or they could quickly fill with sand and fines.

During fall 2010, our project team further characterized existing conditions on the Schaaake property. The preliminary wetland delineation identified the ordinary high water mark (OHWM) of regulated streams, and potential wetlands were estimated to cover approximately 22 of the 285 acres. Thirteen wetlands were identified within the OHWM

(Exhibit ES9), and three were identified outside the OHWM boundary (additional wetlands outside the OHWM may also be present). Despite the low flow in the Yakima River and Wilson Creek at the time of the geotechnical investigation, the groundwater table on the left bank floodplain was relatively high, ranging from 0.2 to 5.8 feet below ground surface (bgs).

Alternatives Proposed by Reclamation

Under a “no action” alternative, the levees would remain in their current locations, but some would not be maintained by Reclamation or Kittitas County. Opportunities to improve habitat complexity in the river and floodplain would be lost, and long-term flood risks could increase through this reach. On the left bank, unmaintained levees would likely remain intact for the foreseeable future, but, as is now occurring at multiple levees on both sides of the river, some erosion and undermining of levees would continue. On the right bank, as of spring 2010, the county plans to maintain Riverbottom Road as the only levee on the right bank upstream of the upper part of Right Bank Levee 3 (Exhibit ES2), and portions of Right Bank Levee 1 continued to erode during winter and spring 2011.

In contrast to a “no action” approach, the Schaake Habitat Improvement Designs Project is specifically intended both to increase channel-floodplain interaction and to protect existing and proposed infrastructure by using a combination of side channels, levee removals, and levee setbacks. As more flow is routed from the main channel onto the floodplain and through the side channels, the potential for gravel deposition (aggradation) increases in the mainstem. Aggradation of the river is considered to be beneficial to habitat because aggrading channels tend to be more hydraulically and geomorphically complex than incising (degrading) channels. Also, as the river bed aggrades, the depth to groundwater on the floodplain would be expected to decrease, encouraging the growth of native riparian vegetation.

Exhibits ES3 and ES4 depict the levee and side channel configurations proposed by Reclamation. Two different levee alignments (“continuous” and “abbreviated”) are presented. The side channel alignments consist of three new side channels that would be connected to the main channel by surface flow most of the year, as well as “reinvigoration” of several existing side channels (Exhibits ES3 and ES4). The side channel alignments are the same for both levee alignments. In keeping with the wording of Hilldale (2007), in this report, “reinvigorating” side channels refers to the goal of reoccupying pre-existing floodplain channel features by levee removal and minor earthwork as opposed to excavation of new side channels through higher ground. Both levee alignments are considered to be preliminary, pending final endorsement from stakeholders following additional field data collection, hydraulic modeling, and analyses planned by Reclamation. *Because of the potential to change the inundation patterns from existing conditions, further consideration of the Abbreviated Levee alternative will depend on results of hydraulic modeling of Wilson Creek, which will be completed during Phase 2 following the collection of necessary field data (bathymetric data collected by CH2M HILL in fall 2010 and discharge measurements collected by Reclamation in spring 2011).*

The “continuous levee alignment” consists of removal of Left Bank Levee 1 (estimated to be 30,000 cubic yards [cy] of fill and 2,200 cy of riprap based on fall 2010 field investigations) and replacement with a single, continuous levee from near I-90 to the existing Left Bank

Levee 2 (Exhibit ES3). The proposed continuous levee would have a total length of 9,300 feet and be designed to provide some measure of protection to I-90, the WWTP, TCF spray fields, and downstream landowners. The “abbreviated levee alignment” would consist of two separate levee segments (totaling 7,900 feet), helping to protect I-90, TCF spray fields, and downstream landowners (Exhibit ES4). Under both proposed levee alignments, the other existing levees (Right Bank Levee 1, Right Bank Levee 2, Right Bank Levee 3, and Left Bank Levee 2) would be left in place. Because of the potential for both levee alignments to affect flooding, the continuous levee alignment could contain flood gates. Continued consideration of the abbreviated levee alignment alternative will require that future hydraulic modeling of Wilson Creek demonstrate little or no adverse flooding impacts associated with this alternative.

Under both levee alignment alternatives, the side channels (new side channels 1, 2, and 3, and the reinvigorated side channels connected to the new side channels) would be designed to flow when the river discharge through the project reach is approximately 1,000 cubic feet per second (cfs), which occurs every year and persists, on average, for 249 days per year (Hilldale, 2004). The side channel inlets could be designed and constructed at several different elevations so that surface water connections can exist at different flow levels. This could help maintain the inlets through time if the main channel aggrades, as is expected, or if one of the inlets fills with sediment. Because they will be designed to also intercept the shallow groundwater table, which is found as high as 1 foot below the ground surface across much of the property but fluctuates up to 5 feet per year (Land Profile Inc., 2004), all the side channels would be expected to maintain a surface water connection to the river at their downstream ends until late summer. This connection will help to reduce the potential for stranding of juvenile salmonids and increase the potential for establishment and growth of riparian vegetation.

These habitat improvement actions are based on an approach that restores physical processes, specifically increasing the frequency, duration, and extent of interaction between the mainstem Yakima River channel and left bank floodplain. These actions will restore important floodplain habitat that juvenile salmonids can use for refuge during high flows and rearing throughout the year. Increased river-floodplain interaction will also improve floodplain function by attenuating floods; improving hyporheic (subsurface) flows, which help reduce water temperature; and increasing biological activity. Additional stakeholder feedback, hydraulic modeling results, and a more refined understanding of geomorphic and geotechnical site conditions (including the distribution and concentration of contaminants on site) are required to finalize the designs for the left bank floodplain. Revised levee realignments may also be considered and incorporated into the plans during Phase 2. Some suggestions for revised levee and side channel alignments to better meet project goals are proposed later in this Executive Summary.

Expected Outcomes

The purpose of this project is to improve habitat for juvenile salmonids by increasing channel-floodplain interaction using relocated levees and side channels. Following relocation of Left Bank Levee 1 and construction of the side channels, high quality floodplain habitat would most likely be created within a matter of years. Under both the

continuous and abbreviated levee alignments, more than 7,500 feet of new side channel habitat would be created, including 4,000 feet of new side channels and 3,800 feet of “reinvigorated” side channels. The overall project will be designed to be as self-sustaining as possible by allowing the side channels and river to evolve through time. The side channels would be intentionally “undersized” during design and construction (compared with the sizes of naturally formed side channels) to allow the dimensions and alignment to adjust (Hilldale, 2007) in response to future flows, sediment load, and boundary conditions (e.g., levees, bedrock, and riparian vegetation). However, the side channels would initially need to be constructed to convey enough flow to reduce the potential for them to fill in immediately. Over time, as more flow is allocated to the floodplain, the Yakima River through the project reach may aggrade and increase habitat complexity within the main channel. If aggradation of the main channel also causes some side channels to fill in, others may form elsewhere, thus creating a sustainable network of evolving side channels.

The post-construction changes expected in the Yakima River and side channels present some risks that will be monitored and managed by Reclamation and its project partners as part of the design, construction, and long-term operations and maintenance. For example, I-90 and the proposed TCF lagoon, located on the left bank behind Left Bank Levee 1 at the 90-Degree Bend (Exhibits ES3 and ES4), would be more prone to erosion risk following removal of Left Bank Levee 1. New structures below the ground surface on the floodplain have been proposed to help reduce the erosion risk (Hilldale, 2007). Similarly, although much of the WWTP already meets the required level of flood protection, additional protection may be incorporated around the WWTP itself to reduce the potential for flooding from Wilson Creek and the Yakima River.

In addition to managing risk to infrastructure, precautions may be required to reduce the risk of mobilizing contamination on the floodplain, a legacy of past land use on the property. Post-construction lateral migration of the river and floodplain side channels will likely mobilize phosphorous and other contaminants stored on sediments in the floodplain within the project reach. Phosphorus has been documented in the Yakima Basin at higher-than-recommended levels (Fuhrer et al., 2004), but the potential rate of phosphorous loading to the Yakima River from a site-scale project such as the Schaake project relative to other sources is unknown based on available information. The phosphorus study by Land Profile, Inc. (2007) showed very high levels of phosphorus (as high as 1,500 milligrams per kilogram [mg/kg], where 100 mg/kg in soil is considered “excessive” by Marx et. al., 1999) immediately adjacent to some of the proposed side channel alignments (Exhibit ES5). As a result of the Land Profile, Inc. (2007) study, Hilldale (2007) changed the proposed side channel alignments to avoid the areas where some of the highest levels were measured. While the sampling conducted by Land Profile Inc. identified some potential areas where phosphorus may be problematic (Exhibit ES5), their study did not characterize the distribution of phosphorus throughout the Schaake property, including locations where the side channels may be expected to migrate. Without additional site sampling and characterization, the effect of the proposed project on the mobilization of phosphorus and other potential contaminants is currently unknown. Additional suggestions for quantifying, reducing, and mitigating the risk of phosphorus movement are presented in the next section.

Proposed Design Refinements

The overall strategy of the Reclamation plan is to increase the amount and frequency of flow into the floodplain to improve the quality and quantity of fish habitat in the Schaaake Reach, while also protecting existing infrastructure and reducing potential contaminant transport. Phase 1 of this project included the review of previous work and existing information as well as additional data collection and analysis. As part of our Phase 1 work, we also developed a set of recommendations for consideration as part of the design effort in Phase 2. These design recommendations are shown in Exhibit ES10 and discussed below.

Recommendation #1: Realign the new levee. We suggest leaving the uppermost 1,000 or so feet of Left Bank Levee 1 in place to continue to force the channel to make the 90-Degree Bend to flow south (see yellow levee feature in Exhibit ES10). The most obvious hazard of removing levees is rapid or gradual channel shifting at the 90-Degree Bend towards I-90 and the WWTP. Although a new levee could be built to protect this infrastructure, project success would be jeopardized if the channel were to get pinned against the new, riprap-lined levee, which appears to be a likely outcome (Exhibit ES4). The subsequent channel would have decreased channel complexity, and the new alignment could leave the newly created side channels disconnected from the flow and unusable for fish. To mitigate this hazard, we recommend that Reclamation consider leaving the upper part of Left Bank Levee 1 in place and tie either the Abbreviated or Continuous Levee Alignment into Left Bank Levee 1 well south of the 90-Degree Bend (Exhibit ES10).

Recommendation #2: Construct additional side channel alignments in the riparian zones within the Schaaake Reach (Exhibit ES10). These new side channel alignments are preliminary and not field-checked. The alignments proposed in Exhibit ES10 are based on the past locations of either the main channel or side channels as depicted in 1912 or 1966. The network of channels proposed is meant to approximate the anabranching channel pattern seen in unleveed reaches of the Yakima River and in the historic river planform. These additional alignments are meant as a starting point; the specific lengths, widths, and density of additional channels will require more detailed evaluation and consideration of construction cost versus habitat benefit.

Recommendation #3: Design both perennial (constantly flowing, even at low flow) channels and high flow side channels. Based on existing and historic conditions, an anabranching channel pattern may be typical of this reach. This pattern would benefit fish, creating at least twice as much edge habitat as currently exists and reducing flow velocities and depths over larger areas to create more rearing and refuge habitat. An additional benefit of multiple perennial anabranches, as compared with high flow side channels, is that they are less likely to fill with sediment.

Recommendation #4: Incorporate the use of rock and wood in the habitat designs. Although large boulders are not typical in this reach of the Yakima River, during our field visit we noted that, in some cases, large immobile rocks from the riprap created geomorphic complexity and added habitat value. Rock as part of a rip-rapped levee adjacent to a long stretch of river is not our first recommendation for habitat. However, individual boulders or small boulder clusters, isolated in the main channel or in new side channels, could enhance the habitat value of the project. Large wood placement would be better than rock from a

habitat perspective. Large wood could be incorporated as Engineered Log Jams (ELJs), which are based on detailed designs and could be placed at the apex of some stable vegetated islands to split flow. In addition to or instead of ELJs, strategic placement of individual or small accumulations of logs and root wads could be easily incorporated into the design. These could improve habitat locally and also improve bank protection in particular areas, such as near known hot spots for contamination.

Recommendation #5: Better understand and mitigate the contamination issue as part of the final design process in Phase 2. Currently, the area occupied by the former stockyard and slaughterhouse is known to contain high levels of phosphorus. The full distribution and magnitude of phosphorous contamination across the entire property are not well known. Also, the presence, distribution, and magnitude of other potential contaminants are unknown. We recommend better characterizing the distribution of phosphorus in soils on and around the property (both vertically as well as in surface extent) to better define the apparent problem. As part of the phosphorus characterization, we also recommend additional analyses for other potential contaminants that may exist on the property. Based on this information, a combination of approaches could be adopted to mitigate the problem while still permitting the project to move forward. Phytoextraction (removal of nutrients by planting and harvesting irrigated crops, such as alfalfa) may help reduce phosphorus concentrations in areas with low to moderate phosphorus levels. Other areas could be isolated from flooding by grading or bank protection. In some of the more highly concentrated and contaminated zones, excavation or capping may be the most viable options for reducing phosphorus as well as the most appropriate long-term solution. If the extent of the problem can be well defined prior to design and construction, the excavation or capping could be completed at the same time as the habitat project work.

Recommendation #6: Although the current scope of the Schaaake Habitat Improvement Designs Project is focused on the left bank, actions on the right bank, especially on the inside of the 90-Degree Bend, would help achieve the overall project goals. If Left Bank Levee 1 were to be removed or set back at the 90-Degree Bend, without at least partial removal of Right Bank Levee 1, the river will most likely migrate or avulse toward the outside of the bend and toward I-90 (Exhibit 2).

If some of the high flows could be routed across the inside of this bend, the erosion potential through the outside of the bend would decrease. This routing of water onto the right floodplain could be accomplished in different ways. Removal of some of Right Bank Levee 1 (the upstream portion of the levee would remain in place to protect the Fogarty Ditch headworks) would allow inundation on the right bank, reducing flow depth, velocity, and shear stress in the main channel and along the left bank. A partial levee removal and creation of a side channel across the right bank floodplain would create additional habitat and reduce shear stress in the main channel and on the outside of the 90-Degree Bend. Routing some of the high flow onto the right bank would also further enhance aggradation of the mainstem, a stated goal of the project (Hilldale and Klinger, 2003). With Right Bank Levee 1 partially removed so that the left bank erosion risk is reduced, Reclamation could be in a position to take a more aggressive restoration approach to the Schaaake project by designing a system of side channels that would take more water to the left bank (than would occur if Right Bank Levee 1 is left alone to gradually erode over time).

Right bank landowners may benefit also from changes to Right Bank Levee 1. For example, active removal of some of Right Bank Levee 1 could increase the ability to manage inundation on the right bank (compared to the no action alternative where the right bank levee will gradually erode over time and potentially trap high flows behind it). Water accessing the right bank floodplain may also provide a source of nutrients and fine sediment, improving agricultural productivity.

Data/Knowledge Gaps and Reducing Uncertainties

A considerable amount of study and preparatory work (Hilldale and Klinger, 2003; Hilldale, 2004 and 2007; Land Profile, Inc., 2007) has helped to define an initial set of data and knowledge gaps and set the stage for a successful project. Building upon a review of these documents, our Phase 1 site visit, stakeholder meetings, and our fall 2010 field work, we compiled Exhibit ES11, which summarizes the most important remaining data and knowledge gaps along with recommendations for possible approaches to address them. Some of the data and knowledge gaps in Exhibit ES11 reflect uncertain knowledge of current conditions (numbers 1 through 8), and others (9 through 15) relate to unknown future conditions that can be managed as part of an ongoing monitoring program.

Given the multiple information needs and limited resources, Reclamation, with input from project stakeholders and support from CH2M HILL, will need to prioritize which information gaps must be addressed and when. To support this effort, Exhibit ES11 includes an explanation of potential consequences of not addressing each gap, a subjective ranking of the level of importance of each piece of missing information, and a relative estimate of the level of effort required to fill each gap. Following the work completed and presented in this report, we consider the following two categories of information gaps to be the highest priorities regarding present conditions:

1. Insufficient characterization of phosphorus and other contaminants.
2. Insufficient understanding of acceptable long-term geomorphic processes for side channels and the mainstem.

The contamination problem was discussed in more detail in the preceding section, and it is linked to the question regarding geomorphic processes for the side channels and mainstem. As the project moves to Phase 2, decisions must be made specifying which reaches of side channels and the mainstem will be allowed to exhibit dynamic, geomorphic behavior and which need to remain more stable and static to protect infrastructure and reduce potential phosphorus mobilization. Additional field reconnaissance and hydraulic modeling can help to bracket potential outcomes and inform decision making.

Proposed Monitoring and Adaptive Management Plan

Our recommendations for a draft monitoring plan for the Schaake Habitat Improvement Designs Project are based on an adaptive management approach. Formal adaptive management is a structured, iterative process to guide decision making in the face of uncertainty, by testing specific hypotheses using the results of a structured monitoring program. In the context of river restoration projects, adaptive management approaches

follow plans designed from the outset to “learn by doing,” and to *actively test hypotheses* and adjust treatments as new information becomes available through monitoring.

Adaptive management and monitoring are closely linked. An adaptive management approach requires an ongoing commitment to a project, prior to and following construction, to develop hypotheses, monitor responses, and implement actions. At a minimum, an effective adaptive management program must be based on explicit hypotheses that are directly related to the overall project goals and objectives and tested with the monitoring program. Specific metrics or performance criteria associated with each hypothesis provide the means to document whether project goals are being met at an acceptable rate and whether some type of intervention (i.e., corrective action) is warranted. For the Schaae project, these two example hypotheses could provide a starting point:

1. Side channels, once created, will become high quality (or at least usable) habitat for target species.
2. Levee setback and diversion of flows into the side channels will initiate aggradation and enhance habitat in the mainstem Yakima River.

Additional hypotheses can be incorporated as part of Phase 2 along with associated quantitative performance criteria.

The details of the monitoring plan will depend on the final hypotheses and available resources. Exhibit ES12 describes a potential set of measurements to test hypotheses such as those above, recognizing that the actual monitoring plan may consist of a subset of these measurements given available resources for monitoring.

The proposed monitoring plan includes two phases: baseline characterization and ongoing monitoring (Exhibit ES12). The baseline characterization phase would be implemented prior to and during project construction. One purpose of the baseline characterization phase is to fill data and knowledge gaps identified in previous work and summarized in Exhibit ES11. Some baseline information is still needed for making decisions about final project design. In addition, the baseline phase of the monitoring program establishes the initial conditions against which future project performance can be measured.

The ongoing monitoring phase provides the project team with the data needed to document the future evolution of the project. The ongoing monitoring phase builds on the baseline phase by continuing previously established methods at repeat locations to efficiently conduct the monitoring, either following large flood events or at set intervals. Results from the monitoring program also provide the basis to decide which actions, such as bank stabilization, re-opening of closed inlets, and additional plantings, may be appropriate as part of the adaptive management approach. In addition, this ongoing monitoring creates opportunities to engage local volunteers, park users, school children, and university classes and to educate them and other residents about the Yakima River.

The monitoring plan outlined in Exhibit ES12 is intended to address the data and knowledge gaps that have been identified to date (Exhibit ES11). Exhibit ES12 describes the groups of monitoring parameters and associated elements as well as the specific monitoring tasks that could be implemented during both phases. Once the final set of hypotheses is developed during Phase 2, specific, quantitative performance standards (see Exhibit 5 of

main report: Summary of Proposed Goals, Objectives, Performance Standards, and Monitoring Methods) can be refined for each of the monitoring elements in Exhibit ES12. As part of that process, the list of possible monitoring elements in Exhibit ES12 will need to be prioritized to best allocate the available funding resources.

Next Steps

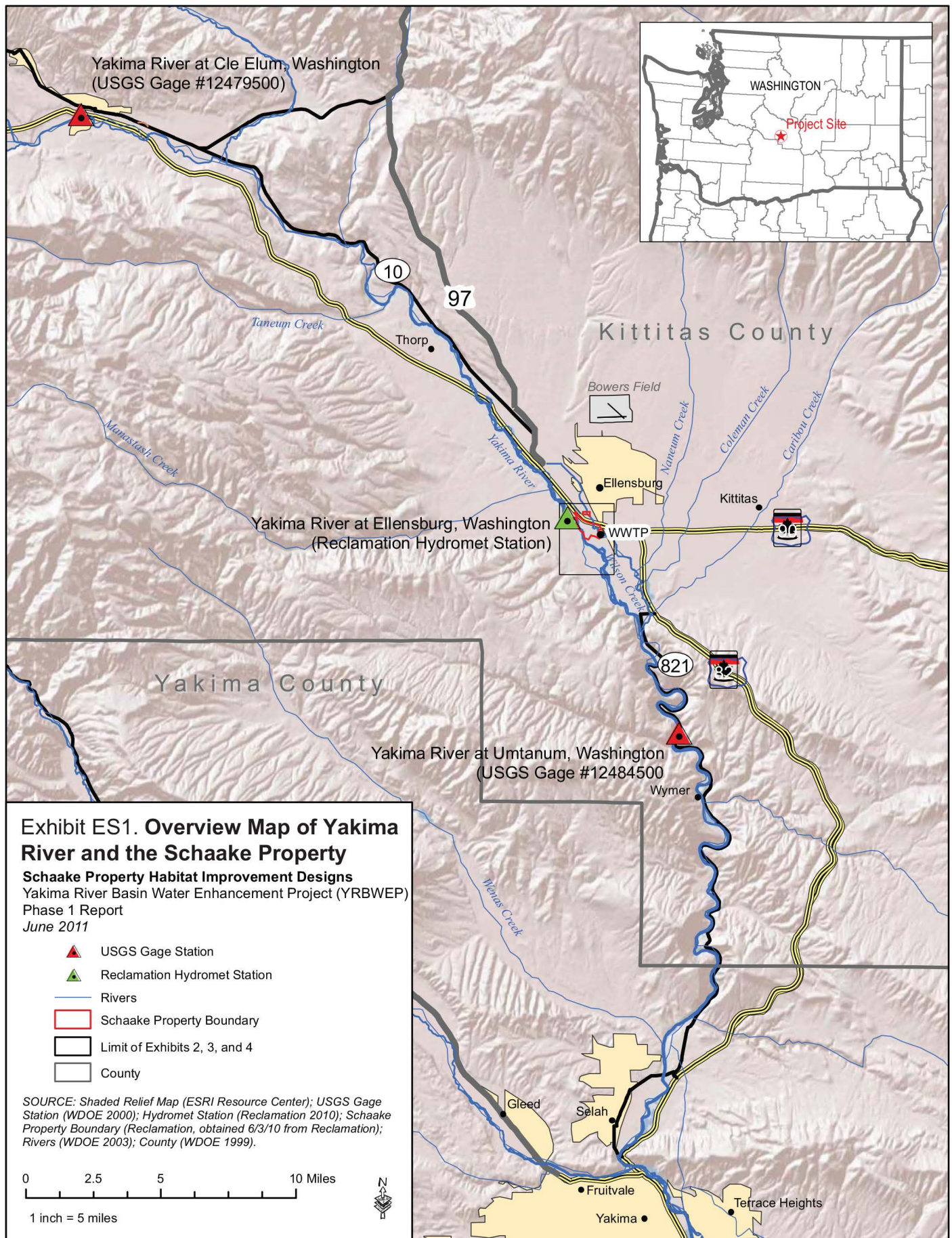
Work accomplished by Reclamation over the past decade has substantially improved the overall understanding of opportunities and constraints associated with the Schaake Habitat Improvement Designs Project. A potential strategy for transitioning from Phase 1 to Phase 2 and beyond is summarized in Exhibit ES13 for Reclamation's consideration. Implementation of this plan could position Reclamation for construction in summer or fall 2012. We recognize that the plan presented in Exhibit ES13 is aggressive from a schedule perspective and contingent on budget and many factors beyond the control of the project team, but the list provides an overall path forward for this project.

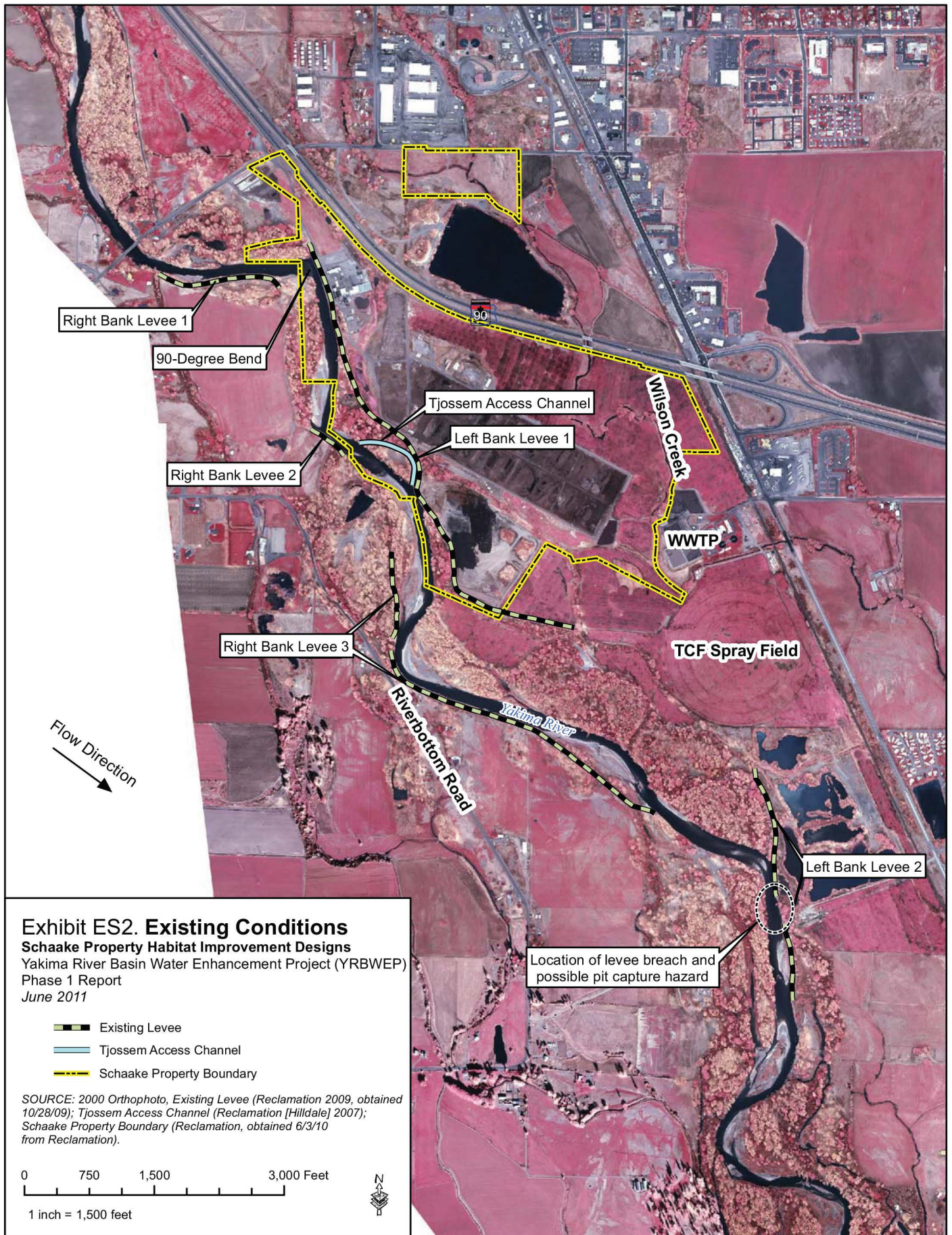
References

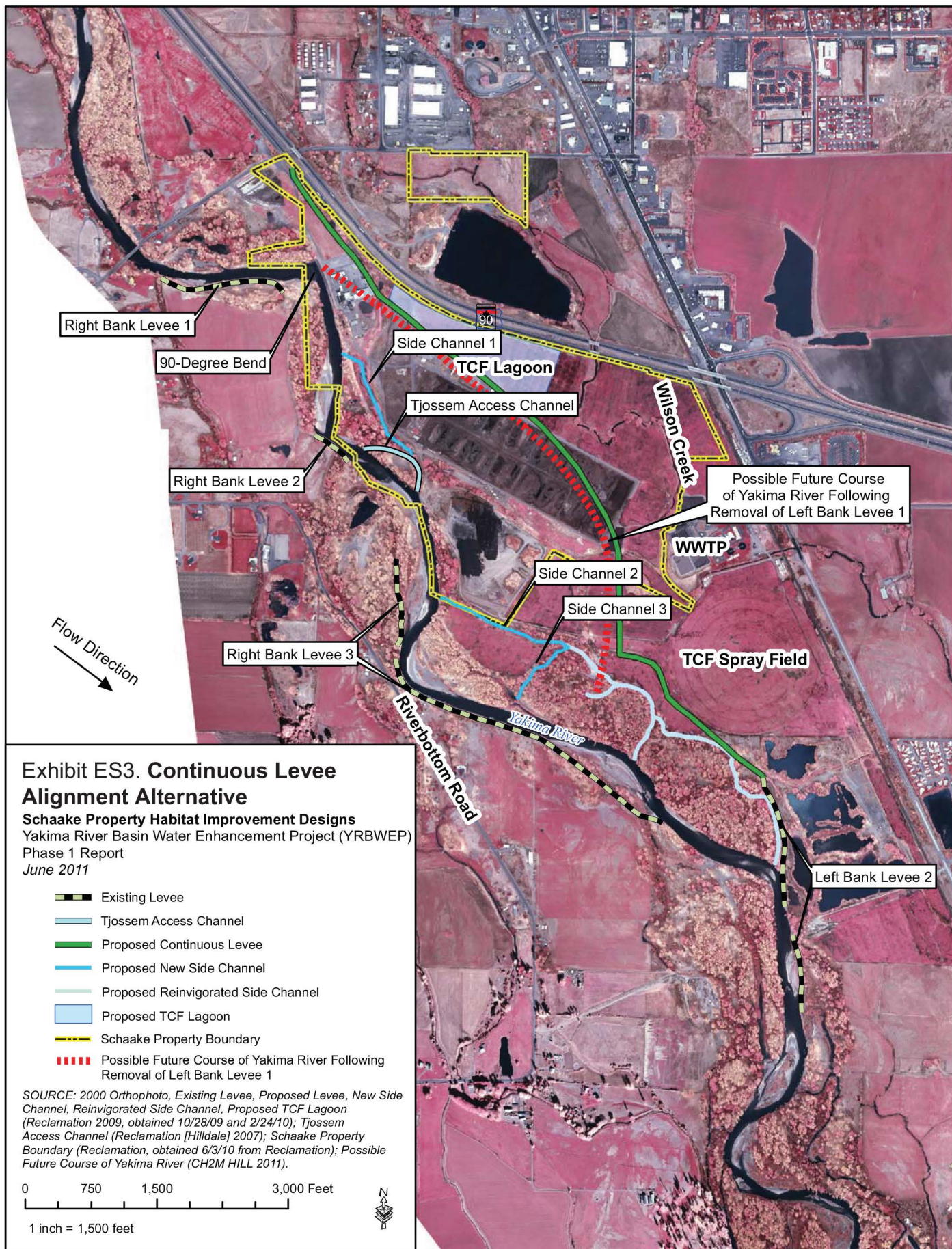
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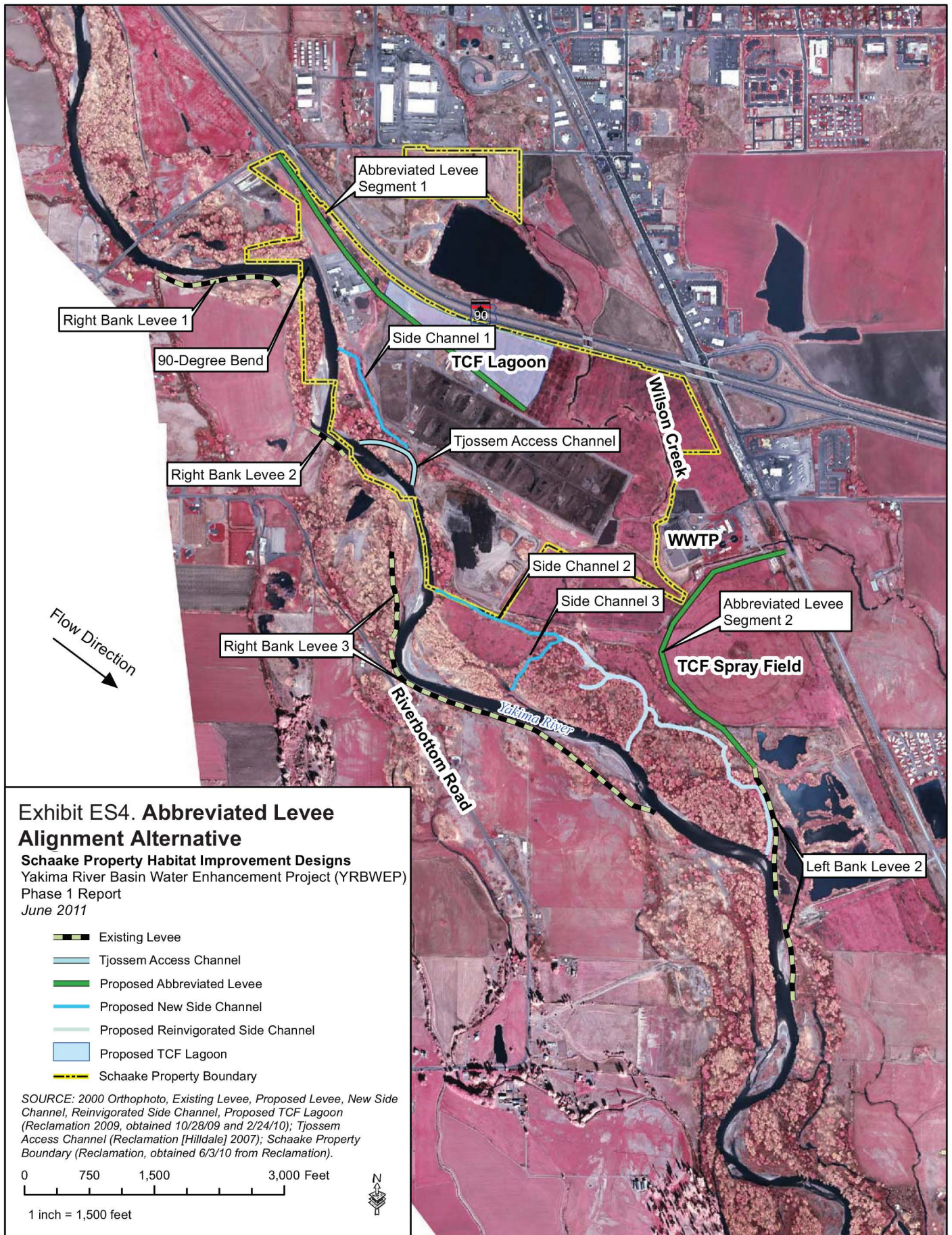
Executive Summary Exhibits

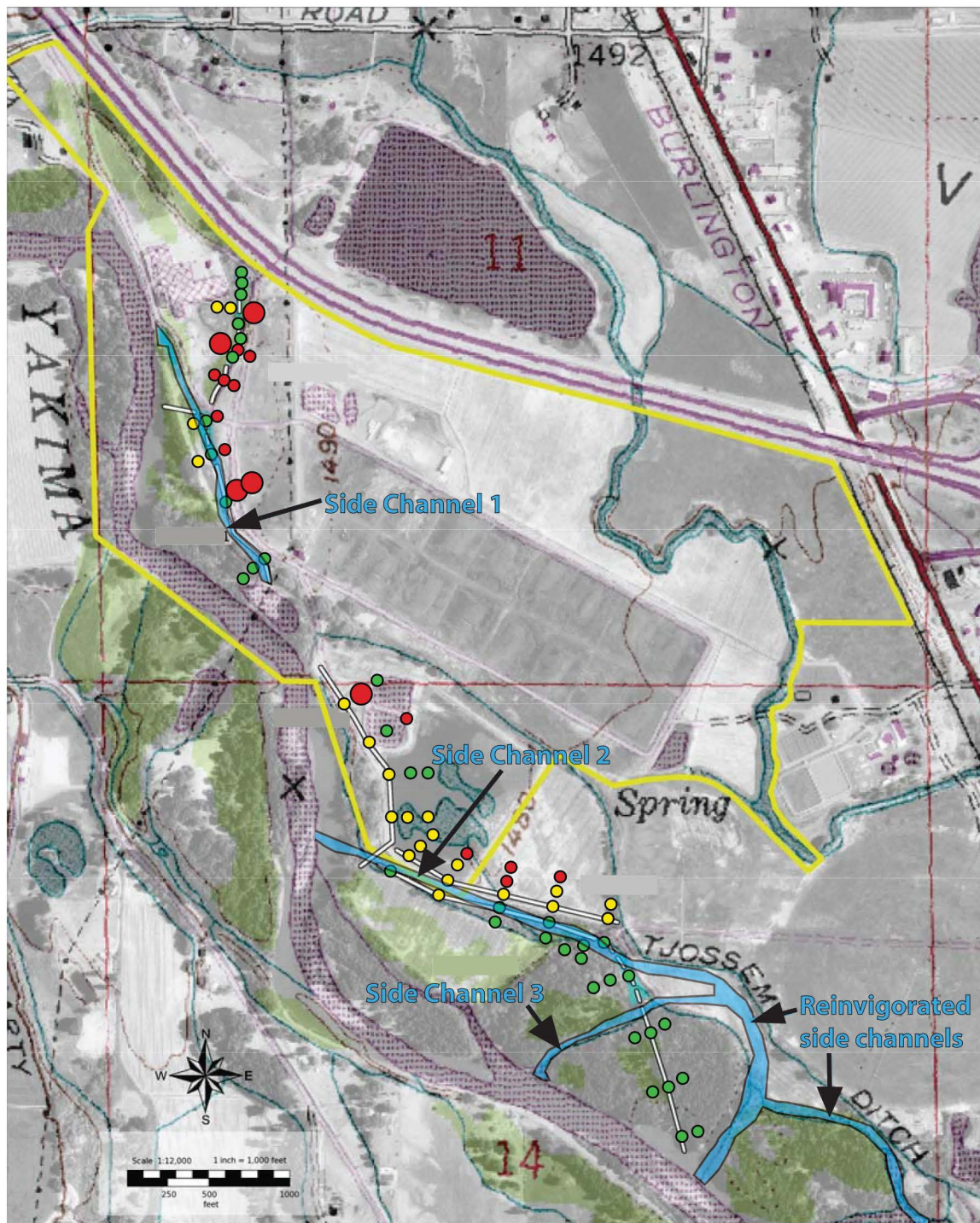
- ES1 Overview Map of Yakima River and the Schaaake Property
- ES2 Existing Conditions
- ES3 Continuous Levee Alignment Alternative
- ES4 Abbreviated Levee Alignment Alternative
- ES5 Results of Soil Phosphorus Sampling Data (from Land Profile Inc., 2007)
- ES6 Schaaake Reach Channel Planform Evolution (1912 to 2009)
- ES7 Schaaake Reach Historic Channel Bank Lines (Map 2)
- ES8 Water Discharge and Computed Suspended Sediment Transport Rates on the Yakima River (1986 to 1999)
- ES9 Wetlands and Other Waters within the Ordinary High Water Mark
- ES10 Proposed Design Refinements in Phase 2
- ES11 Data/Knowledge Gaps, Associated Consequences, and Potential Strategies for Addressing Data Gaps
- ES12 Proposed Monitoring Plan
- ES13 Proposed Timeline for Phasing and Workflow Related to the Schaaake Habitat Improvement Designs Project











Reported Phosphorus Concentration (mg/kg)

- 0 - 100
- 100 - 399
- 399 - 999
- >1000



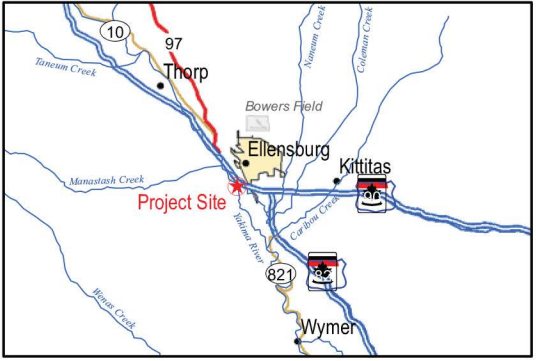
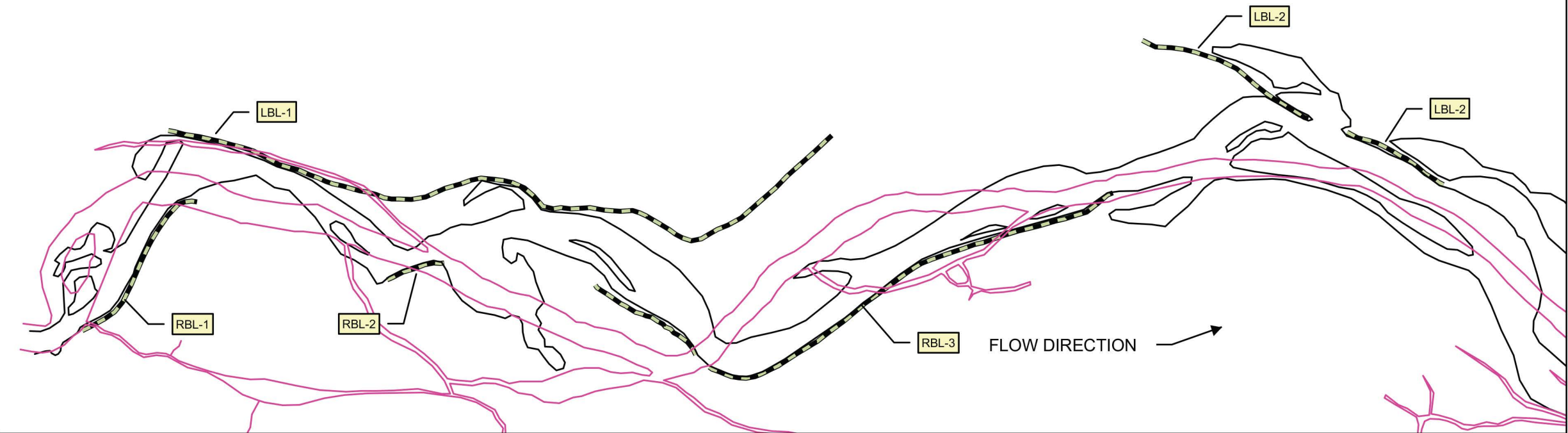
Side channel alignments proposed by Hilldale (2007); locations approximate.

Side channel feature continues to south

EXHIBIT ES5

Results of Soil Phosphorus Sampling Data (from Land Profile Inc., 2007). Phosphorus levels of more than 100 mg/kg are considered "excessive," according to the Soil Test Interpretation Guide (Marx et al., 1999, as cited in Land Profile Inc., 2007). Note that side channel alignments depicted here are only approximate, as they were hand-digitized for illustration purposes only.

ABBREVIATIONS:
LBL = Left Bank Levee
RBL = Right Bank Levee



CHANNEL BANK LINES

- 1912
- 1966
- 2009

EXISTING ELEMENTS

- Levee

SOURCE: Channel Banklines (CH2M HILL 2010); Existing Levee (Reclamation 2009, obtained from Reclamation 10/28/09).

NOTES:
1) 2009 channel bank lines digitized based on interpretation of respective orthophoto. Bank lines digitized at 1:3,000 scale.
2) 1912 and 1966 channel bank lines digitized from maps from Hilldale and Klinger (2003) (Figures A-1 and A-2), rectified by CH2M HILL, obtained from Reclamation 10/28/09.

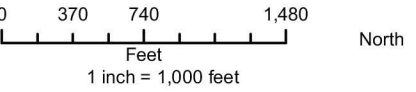
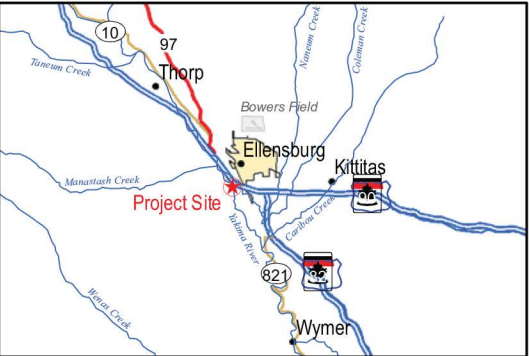


Exhibit ES6. Schaake Reach Channel Planform Evolution (1912 to 2009)

Schaake Property Habitat Improvement Designs
Yakima River Basin Water Enhancement Project (YRBWEP)
Phase 1 Report
June 2011



CHANNEL BANK LINES



EXISTING ELEMENTS



PROPOSED ELEMENTS (Locations Approximate)



SOURCE: 2006 and 2009 Orthophoto, (NAIP); Channel Centerlines (CH2M HILL 2010); Existing and Proposed Levee, New Side Channels, Reinvigorated Side Channels, Proposed TCF Lagoon (Reclamation 2009, obtained from Reclamation 10/28/09 and 2/24/10).

NOTE:
1) 2006 and 2009 channel bank lines digitized based on interpretation of respective orthophoto. Bank lines digitized at 1:3,000 scale.

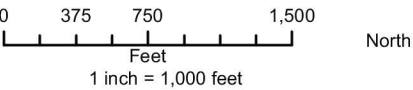


Exhibit ES7. Schaake Reach Historic Channel Bank Lines

Map 2
Schaake Property Habitat Improvement Designs
Yakima River Basin Water Enhancement Project (YRBWEP)
Phase 1 Report
June 2011

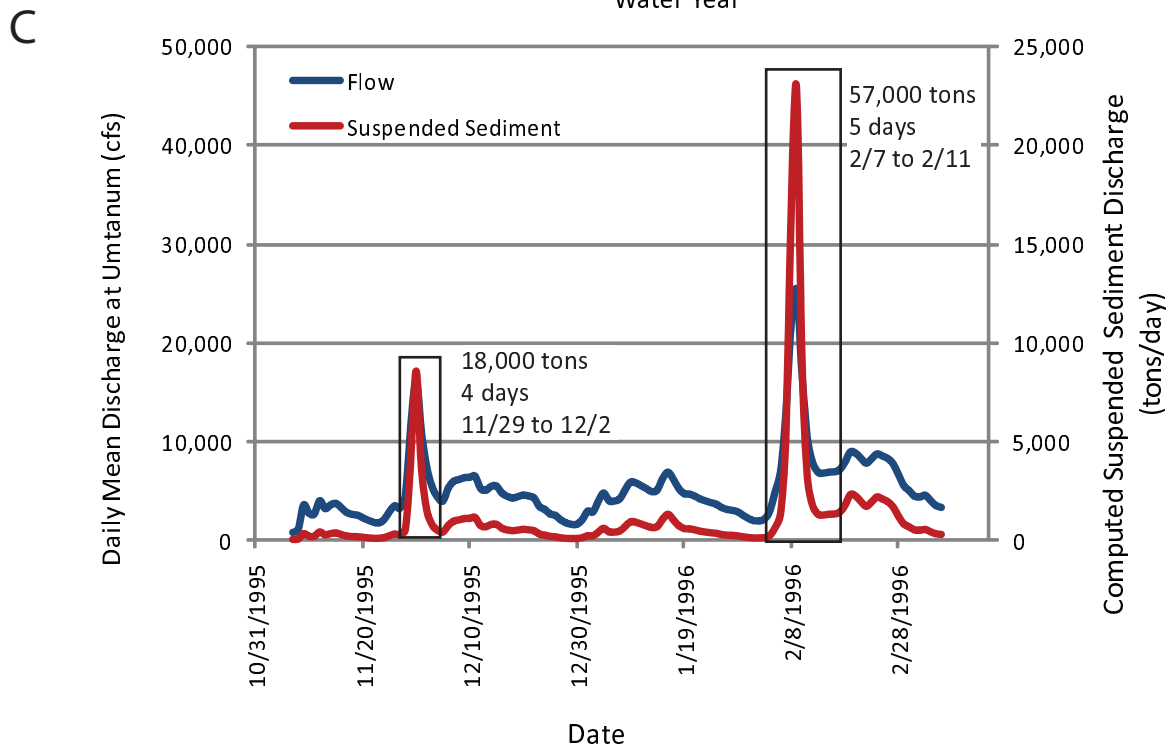
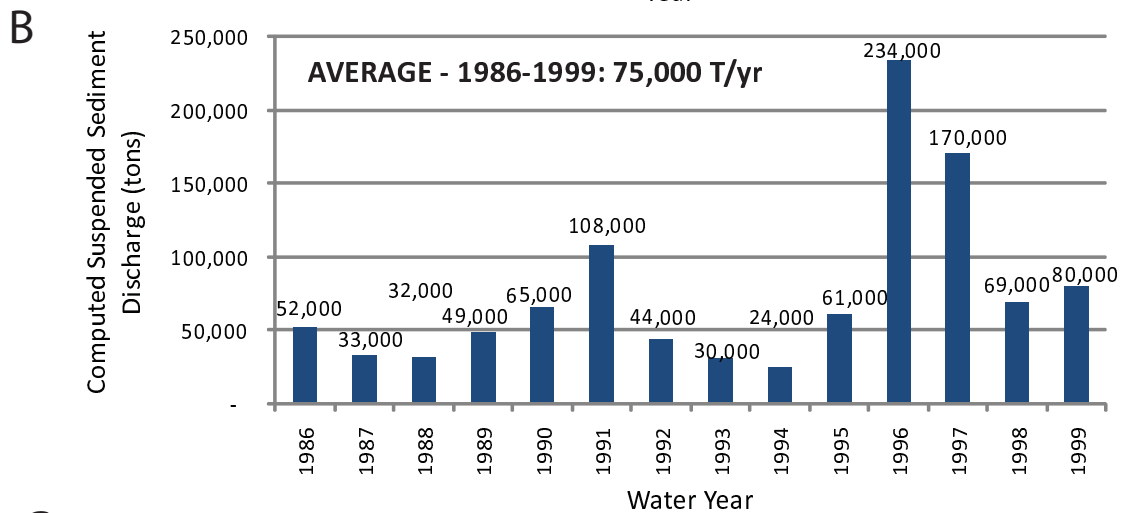
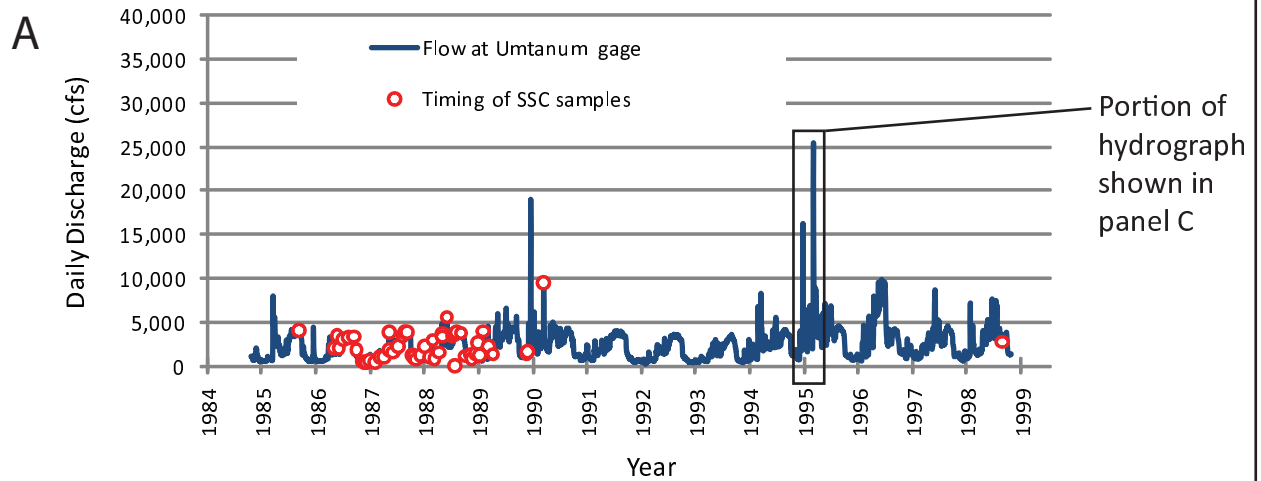


EXHIBIT ES8.

Water Discharge and Computed Suspended Sediment Transport Rates on the Yakima River (1986 to 1999). (A) Hydrograph for period that includes suspended sediment samples. (B) Computed annual suspended sediment discharge using rating curve in Exhibit 12. (C) Detail of flows and computed suspended sediment flux during two flood events in WY 1996 that contributed to the high computed suspended sediment discharge in that year.



Source: (USDA 2009)

Notes:
1) The ordinary high water mark (OHWM) is based on observed evidence of bank erosion, changes in vegetation, and water staining. The Washington Administration Code (WAC) definition of OHWM was used as the standard for determination (WAC 173.22.30[11]).
2) Data plots are points where data (such as soil samples) were collected to help characterize potential wetland status. Data plot number for each wetland are independent (i.e., there may be duplicate numbers found in different wetlands).
3) The wetland survey study boundary matches the Schaake property boundary. Delineated wetlands indicate features associated with hydric soils (based on mapping provided by Reclamation) that were confirmed as wetlands in the field. Reconnaissance wetlands are likely wetlands (based on observation of vegetation or other characteristics) that were observed in the field, but no formal delineation was performed.

Culvert

Data Plot²

Delineated Wetland

Reconnaissance Wetland

Ordinary High Water Mark (OHWM)¹

Study Area Boundary³

0

100

200

Meters

N

Exhibit ES9. Wetlands and Other Waters within the Ordinary High Water Mark
Schaake Property Habitat Improvement Designs
Yakima River Basin Water Enhancement Project (YRBWEP)
Phase 1 Report (from ICF International, Wetlands Survey Technical Memorandum, Appendix D of this report)
June 2011

00833.09/GIS - Revised: 11/17/2010

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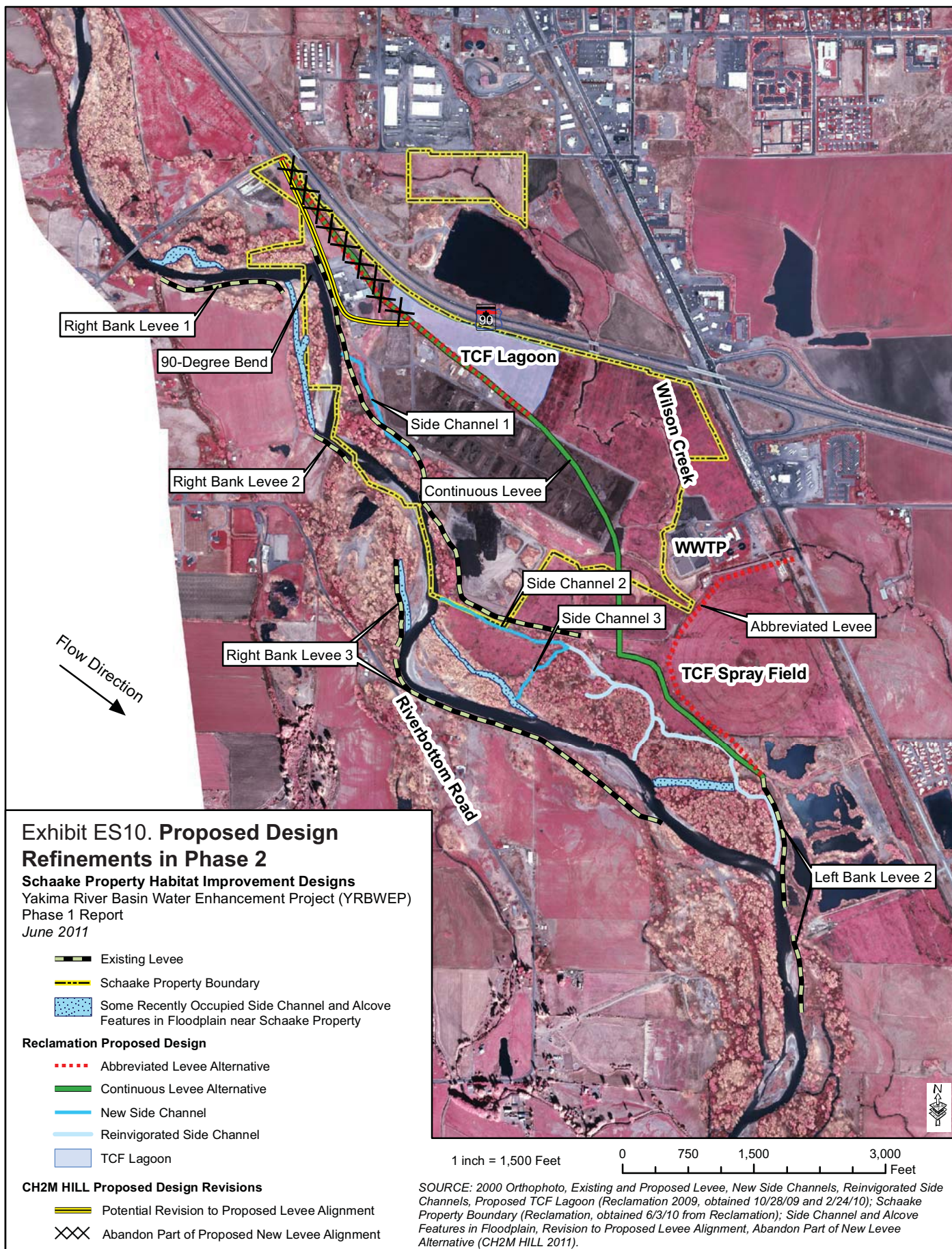


EXHIBIT ES11
Data/Knowledge Gaps, Associated Consequences, and Potential Strategies for Addressing Data Gaps

Data Gap Number	Data/Knowledge Gap	Potential Consequence(s) of Data/Knowledge Gap	Level of Importance (Low, Medium, High, Unknown)	Proposed Approach(es) to Fill Data/Knowledge Gap ¹	Estimated Level of Effort (Low, Medium, High)	Best Possible Timing of Data/Knowledge Acquisition ²
Data/Knowledge Gaps Related to Existing and Past Conditions (to be addressed during baseline characterization period of monitoring plan):						
1	Limited characterization of phosphorous distribution and other contaminants of concern	Poor understanding of potential contaminant risks Potential erosion/mobilization of higher than expected amounts of phosphorous because of side channel construction and evolution Potential lost opportunities for finding “low hanging fruit” (example: discovery of well-contained, highly contaminated deposits that can be easily removed) Uncertain understanding of whether other contaminants are of concern	Unknown	Expand scope of studies done by Land Profile, Inc. (2007) to characterize entire site properties Design sampling plan in conjunction with mapping of geologic and geomorphic features to increase sampling efficiency Decide which (if any) other contaminants are of concern if mobilized by project Decide whether phytoextraction, soil amendments, excavation, or capping is warranted	Unknown	Baseline phase of monitoring program Prior to Phase 2, continuing into Phase 2 Exhibit 17 summarizes existing information; additional data may need to be collected depending on Reclamation's perspective
2	Uncertainties about specific design criteria such as design discharges and acceptable long-term geomorphic processes for side channels and mainstem	Project design, construction, and response is inconsistent with design goals, especially those that require tradeoffs	High	Continue analysis and discussions related to design discharges and initiate a plan to move ahead in the face of some uncertainties resulting from limited data Specify which reaches of side channels and the mainstem will be allowed to exhibit dynamic, geomorphic behavior and which need to remain more stable and static to protect infrastructure and reduce phosphorous mobilization (e.g., clarify which side channels need to remain functional as long as possible as designed and constructed and which side channels can fill in and be replaced by newly formed side channels) Use hydraulic models as a tool to help bracket potential outcomes and inform decision making	Low	Immediate – Prior to Phase 2
3	Uncertainties regarding geotechnical and geomorphic site conditions	Potential for unexpected “fatal flaws” in design, leading to construction change orders (examples: unknown boulder or cobble deposits or bedrock too difficult to excavate; unknown volcanic ash deposits make side channels too erodible; too much clay in side channel banks could inhibit groundwater exchange) Potential lost opportunities for using site properties to project advantage (examples: existing side channels with appropriate substrate and slope could minimize amount of earth movement required; terraces or existing bedrock provide opportunities for channel containment or grade control) Lack of baseline characterization with which to compare responses to habitat improvement actions	High	Create maps of geologic and geomorphic features at appropriate scale for project requirements (1:10,000 scale or smaller) Mapping approach: Focus on separating at least these units: coarse gravel facies; floodplain fines; volcanic ash; bedrock (if present); anthropogenic debris Use LiDAR data as base; use Kittitas County Soil Survey for guidance; acquire and georeference existing geologic maps of Yakima River valley (if available); supplement with field-based observation, description, and mapping; dig and examine additional soil pits where needed Use historic air photographs to document recent channel changes to help predict distribution of coarse-grained and fine grained deposits in valley floor	Medium	Baseline phase of monitoring program Prior to Phase 2, continuing into Phase 2 Geotechnical field work and associated report completed during fall 2010 (Appendix C)
4	Uncertainties about all target species, life stages, and habitat requirements	Potential major project design flaws (examples: frequency, depth, duration of side channel connection inadequate for fish; unsuitable water temperature and/or velocity in side channels; substrate properties not appropriate for intended vegetation) Missed opportunities for additional ecological benefit (example: can birds benefit from particular riparian vegetation distribution?)	Medium-High	More involvement from ecologists and biologists defining target species and life stages Formally define habitat goals as quantifiable targets Incorporate habitat targets into monitoring plan	Low	Initial review prior to Phase 2; then ongoing as part of monitoring and adaptive management plan Wetlands delineation completed in fall 2010 (Appendix D)

EXHIBIT ES11
Data/Knowledge Gaps, Associated Consequences, and Potential Strategies for Addressing Data Gaps

Data Gap Number	Data/Knowledge Gap	Potential Consequence(s) of Data/Knowledge Gap	Level of Importance (Low, Medium, High, Unknown)	Proposed Approach(es) to Fill Data/Knowledge Gap ¹	Estimated Level of Effort (Low, Medium, High)	Best Possible Timing of Data/Knowledge Acquisition ²
5	Uncertainty about Wilson Creek flooding issues	Unintended increase in flooding at WWTP and downstream of project reach	Unknown	Increase coordination with Kittitas County Flood Task Force Conduct Wilson Creek topographic surveys Conduct Wilson Creek hydraulic modeling Implement Wilson Creek modeling approach proposed in this report	Medium	Prior to Phase 2; Continuing into Phase 2 Wilson Creek topographic survey is summarized in Section 7 and included as Appendix E
6	Uncertainties about stakeholder needs and interests	Poor community relations Lost opportunity for design/management ideas from property users, which could improve benefit to the community Lost opportunity for local help with monitoring program	High	Continued meetings with stakeholders and local oversight of project Make contact with faculty at CWU; try to involve students in project as ongoing research/teaching opportunity; make contact with local groups interested in helping with the monitoring plan	Low	Already ongoing; continue through life of project
7	Uncertainty about upstream supply of sediment (currently and in the future)	Lack of quantitative knowledge about how long to expect to wait until intended river system change (aggradation) is likely to occur	Low-Medium	Review of existing studies of Yakima River sediment loads; identify any problems with these analyses and address those if necessary; distinguish between wash load and bed material load and compute loads separately	Low-Medium	Prior to Phase 2 or at any time afterwards Suspended sediment data analysis is summarized in Section 3.1.5
8	Uncertainty about past rate and direction of vertical channel changes	Possible lost opportunity to understand system function and history May not be necessary to know whether reach was aggrading or degrading prior to project	Low	More quantitative analyses of bank heights, channel widths, bed grain size than have been completed to date Try to identify other indicators of longer-term scour (exposed roots, piping, fences, etc) Examine past maps or surveys of the property for comparison with present	Low-Medium	Prior to Phase 2
Data/Knowledge Gaps Related to Future Conditions (to be addressed as part of ongoing monitoring portion of monitoring plan):						
9	Uncertainties in river responses to project actions	Failure of project to achieve intended habitat improvement goals (<i>examples:</i> premature infilling of side channels with sediment; main channel avulses to either occupy side channel(s) or gravel pits; channel shifting isolates side channels from main channel, making them inaccessible to fish; aggradation proceeds too quickly or not quickly enough) Unintended increased risks to infrastructure (<i>examples:</i> channel migration impacts I-90; WWTP; Tjossem Ditch; TCF lagoon)	High	Implement monitoring plan Incorporate monitoring observations into monitoring/management plan If warranted, create two-dimensional sediment routing model of project reach to evaluate possibilities of channel changes; maintain model for use in management phase of project	High	Any time from Phase 2 onward; sediment routing model could continue to be updated and used throughout life of project
10	Uncertainty about future trends in bed grain size (both in the Yakima River and in the side channels)	Unintended negative or positive impacts to habitat (<i>example:</i> bed grain size in main channel or side channels become too coarse-grained or too fine-grained for intended fish uses) Unintended consequences to project performance (<i>example:</i> changes in roughness, hiding, or armoring reduce or increase sediment movement in side channels)	High	Implement monitoring plan for detecting grain size changes Incorporate monitoring observations into monitoring/management plan	Medium	Throughout project
11	Uncertainty about beaver and human impacts on project	Unintended and unpredictable consequences if human or animal use of property will alter sediment, wood, or other parts of project	Unknown	Continue with community relations Implement monitoring plan Incorporate monitoring observations into monitoring/management plan	Medium	Throughout project

EXHIBIT ES11
Data/Knowledge Gaps, Associated Consequences, and Potential Strategies for Addressing Data Gaps

Data Gap Number	Data/Knowledge Gap	Potential Consequence(s) of Data/Knowledge Gap	Level of Importance (Low, Medium, High, Unknown)	Proposed Approach(es) to Fill Data/Knowledge Gap ¹	Estimated Level of Effort (Low, Medium, High)	Best Possible Timing of Data/Knowledge Acquisition ²
12	Uncertainties about hydraulics and flooding as system evolves	Unintended exacerbation of flood risk (<i>examples</i> : unexpected increase in stage of high discharge; new levee configuration affects flooding in Wilson Creek) Unintended consequences for particular infrastructure elements (<i>examples</i> : Tjossem Ditch, I-90; WWTP; TCF lagoon)	Medium-High	Conduct Wilson Creek modeling (see above) Update hydraulic model as river evolves Incorporate data from monitoring into updated model runs Evaluate changes to risk in ongoing monitoring/management plan	Medium	Phase 2 run model with final design configuration; then ongoing
13	Uncertainty about future behavior of the 90-Degree Bend	Bank erosion or channel avulsion leads to possible risk to infrastructure (I-90; WWTP; Tjossem Ditch; TCF lagoon)	High	Continue exploring options on right bank that provide more flexibility in river alignment Create protective barriers around infrastructure in floodplain Implement monitoring plan for channel changes Incorporate monitoring observations into monitoring/management plan	Medium-High	Phase 2 and throughout project
14	Uncertainty related to future climate change	Changes in flood regime lead to more rapid channel shifting than expected Changes in sediment supply from the watershed lead to slower or more rapid aggradation than anticipated; or more rapid infilling of side channels; or changes in grain size distribution that affect habitat suitability Changes in ratio of snowmelt to rainfall change water temperature in main channel or side channels	High	Implement monitoring plan Incorporate monitoring observations into monitoring/management plan Examine literature and/or geologic record of responses of Yakima River and nearby rivers to past climate changes	Low-Medium	Throughout project
15	Uncertainties related to future extreme events	Large flood damages or impacts to infrastructure because of flooding Large flood damages or impacts to infrastructure because of major lateral channel shifting Lateral channel changes following flooding lead to abandonment of side channels Lobes of sediment from an extreme sediment loading event (e.g., landslide) lead to rapid infilling of side channels or changes in substrate material	High	Examine responses to January 2009 flood event in Wilson Creek and in Yakima River Implement monitoring plan; conduct monitoring immediately following large floods Incorporate monitoring observations into monitoring/management plan Examine literature and/or geologic record of responses of Yakima River and nearby rivers to past extreme events	Low-Medium	Throughout project Response to January 2009 flood is summarized in Section 3.1.3.2 and Exhibit 10

NOTES:

¹ See Exhibit ES12 for monitoring plan details.

² Work completed during Phase 1 is noted in bold and references sections and exhibits in the main report.

EXHIBIT ES12
Proposed Monitoring Plan

Parameter	Monitoring Elements	Baseline Characterization: Tasks Prior to, During, and Immediately after Project Construction	Ongoing Monitoring: Tasks to Complete Periodically or After Large Floods
Hydrology	Main Channel <ul style="list-style-type: none">- Water temperature- Flow depth- Water velocity- Water quality	Install temperature loggers in main channel; monitor continuously prior to project implementation to establish baseline Install staff gage(s) at key locations in project reach; monitor at marked changes in stage prior to project implementation to develop relationship between stage at Schaake Reach and discharge at USGS gage Measure baseline reach-scale roughness: make series of measurements using tracers to determine surface water velocity through reach at a range of discharges; do this prior to project implementation to create a baseline velocity/discharge relationship Identify contaminants of concern from water quality perspective; develop baseline for contamination by sampling water at range of discharges prior to project implementation; install and maintain ISCO sampler if feasible; if not, use local volunteer labor to collect surface samples	Maintain temperature loggers to monitor changes in water temperature in reach; regularly retrieve data and provide upkeep/replacement Maintain and observe staff gages (frequently); enlist local volunteer help where appropriate Continue measurements of reach-averaged surface water velocity at range of flow using tracers; employ local contacts, volunteers and student groups; this will allow Project Team to measure changes in reach-scale roughness to monitor project performance Continue to measure contaminants of concern using same method(s) as for establishing baseline Update two-dimensional hydraulic model as necessary Compile new and previous data in periodic monitoring reports
	Side Channels and Floodplain <ul style="list-style-type: none">- Water temperature- Flow depth- Water velocity- Water quality- Groundwater depths and flow pathways	Install staff gages and crest stage gages (using shredded cork) in side channels for monitoring flow depths; likely can be installed on metal T-posts near margins of side channels Develop stage-discharge relations for side channels using cross sections (see under Geomorphology and Sediment Transport) and roughness estimates Install temperature loggers in newly established side channels Continue monitoring the three wells on the Schaake property already sampled quarterly by Reclamation Install additional piezometers or shallow floodplain monitoring wells and other groundwater monitoring equipment in floodplain as needed for characterization and subsequent monitoring – water levels, water quality, invertebrates (see below); project could use methods similar to those of Stanford et al. (2002) for area near entrance to Yakima Canyon	Maintain staff gages and crest stage gages; continue data collection Maintain groundwater instrumentation; continue data collection Survey high water marks throughout floodplain in project reach following each overbank flood event; this will help improve hydraulic model calibration for overbank areas Update two-dimensional hydraulic model as necessary Compile new and previous data in periodic monitoring reports
Geomorphology and Sediment	Main Channel <ul style="list-style-type: none">- Alignment (bank lines)- Thalweg elevation- Sediment grain size- Sediment supply- Distribution of habitat types- Distribution of habitat/geomorphic elements (pools, riffles, etc); channel complexity	Establish cross sections at key locations for monitoring; install cross section end points (e.g., using rebar) that can be reoccupied in future repeat measurements; tie benchmarks into elevation datum Conduct appropriate number of pebble counts on exposed bars at low flow; also sample bed material below low water line if possible Map distribution of sand patches within main channel, or within a representative subreach; estimate percentage of bed covered with sand vs. gravel as baseline condition Map distribution of pools, riffles, sand patches, LWD, other geomorphic features in and along main channel Establish baseline parameter(s) for quantifying channel complexity; review literature to find most appropriate type of parameter to use; measure as needed for baseline characterization Establish sites for repeat photographs of main channel Improve estimate of sediment supply at the head of Schaake Reach; use existing information and analyses to extent possible; compute washload and bed material load separately	Repeat bathymetric survey following high flow events Repeat cross section topographic surveys at beginning and end of high flow season, and immediately following floods; note high water marks on all cross section surveys; incorporate volunteers or CWU students if possible Repeat pebble counts as needed (following floods, occasionally every several years if no large floods); incorporate volunteers or CWU students if possible Repeat mapping of sand patches and distribution of pools, riffles, etc as needed (e.g., after floods, at set benchmark periods, in conjunction with biological surveys) Monitor changes in channel complexity parameter Repeat photographs at set locations along main channel Compile new and previous data in periodic monitoring reports

EXHIBIT ES12
Proposed Monitoring Plan

Parameter	Monitoring Elements	Baseline Characterization: Tasks Prior to, During, and Immediately after Project Construction	Ongoing Monitoring: Tasks to Complete Periodically or After Large Floods
Biology ¹ and Habitat	Side Channels and Floodplain <ul style="list-style-type: none">- Distribution of material properties and geomorphic features throughout Schaake property and in downstream non-disturbed reach- Distribution of contaminants- Location, size, and shape of channels- Sedimentation in side channels- Sediment grain size- Diffuse overbank sedimentation (deposition not in side channels)	Create maps of geologic and geomorphic features on property prior to finalization of project design; mapping should be done at 1:10,000 scale or smaller; use LiDAR base for mapping Sample for grain size and for contaminants (phosphorous, other); develop stratified sampling scheme on basis of geologic feature maps Survey cross sections across side channels, particularly near inlets, to establish baseline for ongoing monitoring of sedimentation near side channel inlets; install cross section end points (e.g., using rebar) that can be reoccupied in future repeat measurements; tie benchmarks into elevation datum Install floodplain sedimentation traps (pads) to monitor rates of deposition on floodplain outside side channels; use thinly mixed cement or white non-toxic substance (e.g., flour) to mark floodplain surface at time of installation Establish baseline parameter(s) for quantifying side channel complexity; review literature to find most appropriate type of parameter to use; measure as needed for baseline characterization; may simply count locations of separations and returns as done by Stanford et al. (2002) but could be worthwhile to use more quantitative measures Evaluate formation and persistence of side channels in natural system; use repeat aerial photographs of unleveed reaches to determine whether sedimentation at inlets of natural side channels occurs Conduct aerial photographic survey immediately post project construction Establish sites for repeat photographs of side channels and floodplain	Repeat aerial photograph survey as warranted (following major flood events or at set interval of several years); digitize changes in side channel alignments and/or width adjustments Repeat cross section surveys near side channel inlets, after flood events of interest Collect recent sediment or cores at floodplain sediment traps; analyze for grain size, contaminants; conduct immediately after flood event Sample fresh deposits in side channels following major flood events to check for concentrations of contaminants in sediment moving through side channels Repeat photographs at set locations in side channels and floodplain Compile new and previous data in periodic monitoring reports
	Fish <ul style="list-style-type: none">- Species presence- Species abundance	Characterize and document fish habitat present in the main channel and existing off-channel locations that may be used (e.g., adult spawning habitat, juvenile rearing habitat, etc.) Sample fish to document presence and quantify abundance by species and life stage using standard techniques such as electrofishing, mark-recapture studies, snorkel surveys, redd counts, and/or carcass surveys Possibly use Part D of Stanford et al. (2002) as a guideline for methods and metrics that have been used in the Yakima River or Johnson et al. (2007) for general methods	Repeat fish presence surveys as warranted; use comparable and consistent methods as in baseline characterization
	Invertebrates, Algae, Biomass <ul style="list-style-type: none">- Amphibitic stoneflies- Other macroinvertebrates- Algal productivity- Biomass density- Other indicators of biological health	Measure type and abundance of benthic macroinvertebrates in floodplain and main channel and in monitoring wells; amphibitic stoneflies in groundwater were found to be good indicators of river-floodplain connectivity (Part D of Stanford et al. (2002)), so should be included; other invertebrates may also provide information for characterizing reach productivity Collect baseline samples for algal productivity (chlorophyll-a) and biomass Sample for dissolved organic carbon, nitrogen, and phosphorous	Continue to monitor invertebrate populations in side channels, floodplain, and main channel; consider using Stanford et al. (2002) study from the downstream, unleveed reach as possible target Repeat other measurements from baseline survey as necessary
	Riparian Vegetation <ul style="list-style-type: none">- Riparian vegetation type- Patch size and age-class distribution	Create initial map showing existing riparian vegetation types Create map showing target distribution of riparian species by age class	Using aerial photographic surveys and ground-based surveys, including community members, CWU and school groups, update maps of riparian vegetation
Engineering Considerations and Other Infrastructure	Levees I-90 Tjossem Ditch TCF Spray Fields and Lagoon WWTP	Establish sites for repeat photographs of infrastructure Establish an Operations and Maintenance Plan for Tjossem Ditch as necessary to minimize impacts of debris and deposition on structural integrity and water delivery	Repeat photographs at set locations at regular intervals Monitor inundation during high flows around infrastructure; following high flows, survey high water marks Monitor Yakima River alignment and profile near WWTP outfall Document and assess changes and implement maintenance actions where appropriate

NOTE:
¹Monitoring plan could be expanded to incorporate terrestrial and avian species as well.

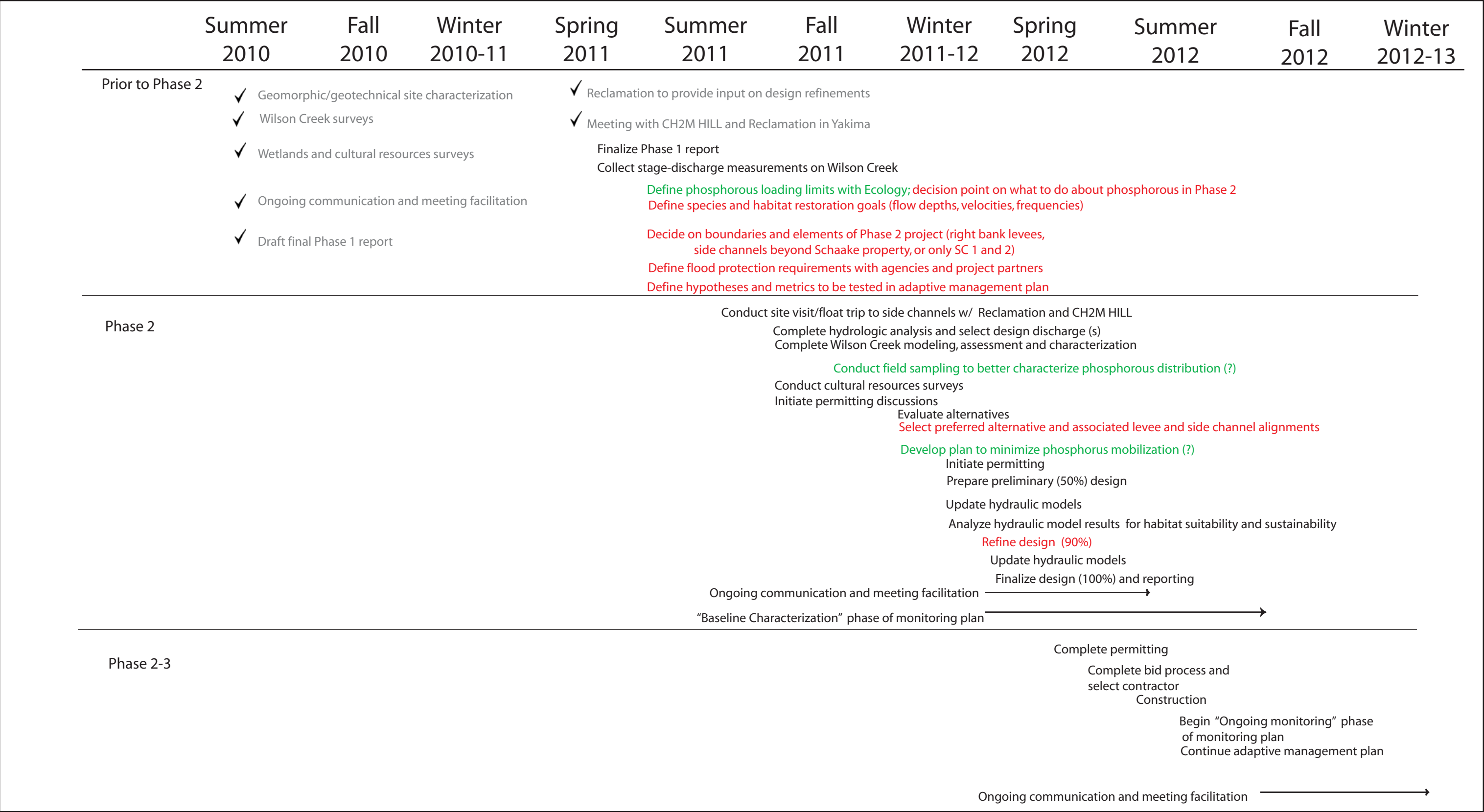


EXHIBIT ES13

Proposed Timeline for Phasing and Workflow Related to the Schaake Habitat Improvement Designs Project. Items with check mark next to them indicate tasks that were completed during Fall-Winter 2010-2011. Items in red are decision points necessary to move forward with design; items in green relate to phosphorous issue; other items are proposed tasks.