Appendix A: Bank Stabilization

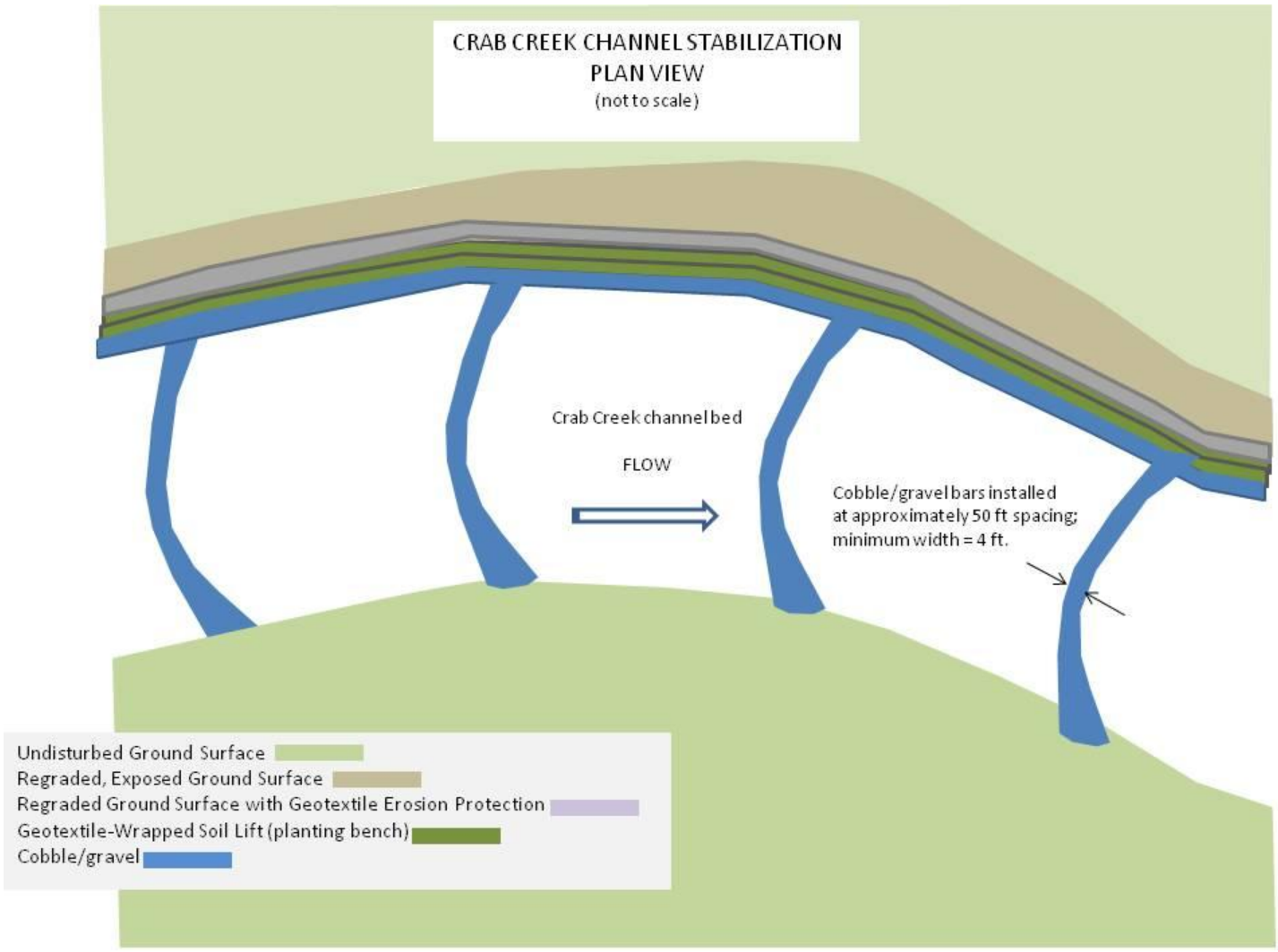


Figure 1. Middle Crab Creek Channel Stabilization, Plan View.

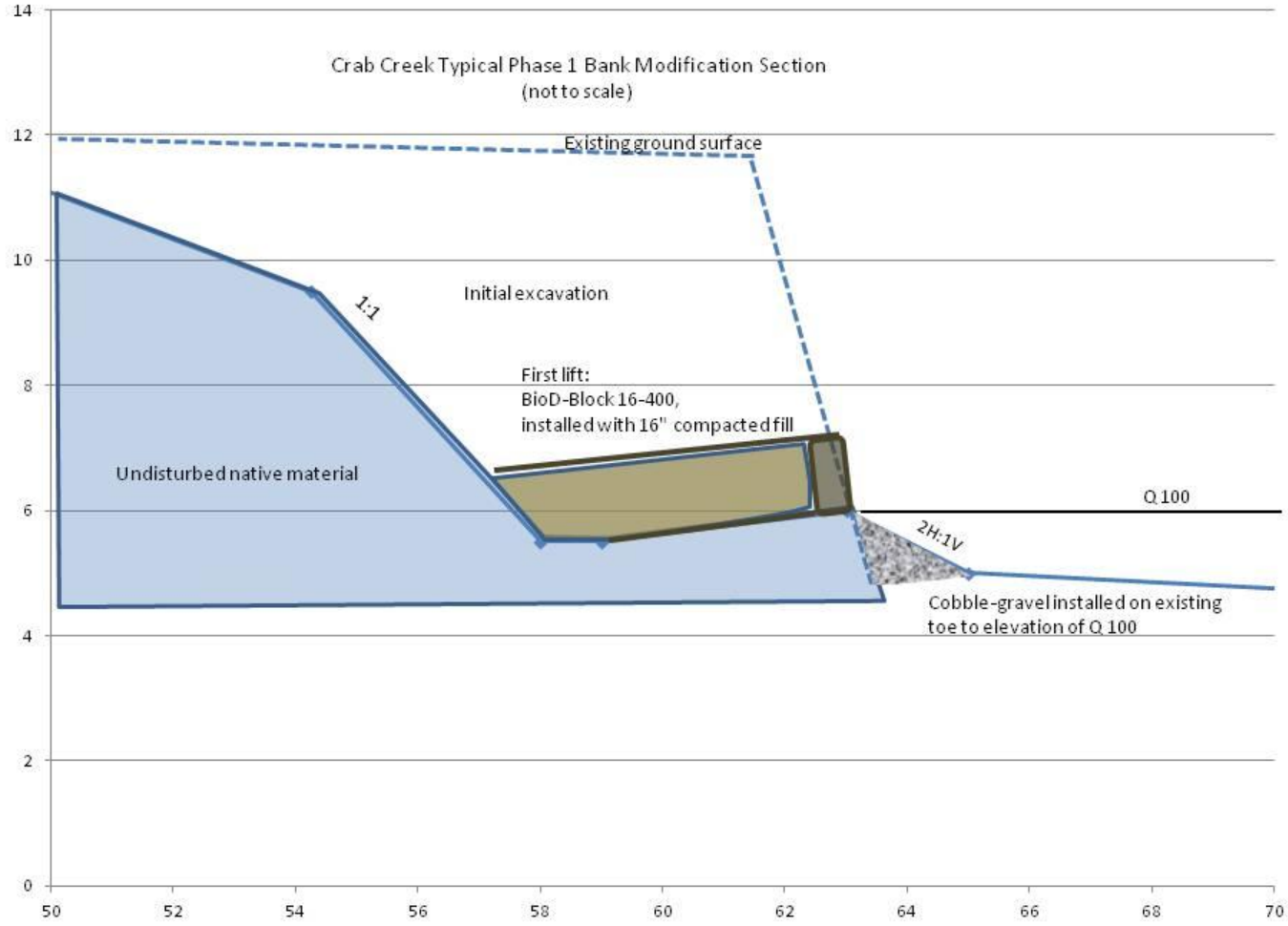


Figure 2. Middle Crab Creek Bank Modification, Phase 1.

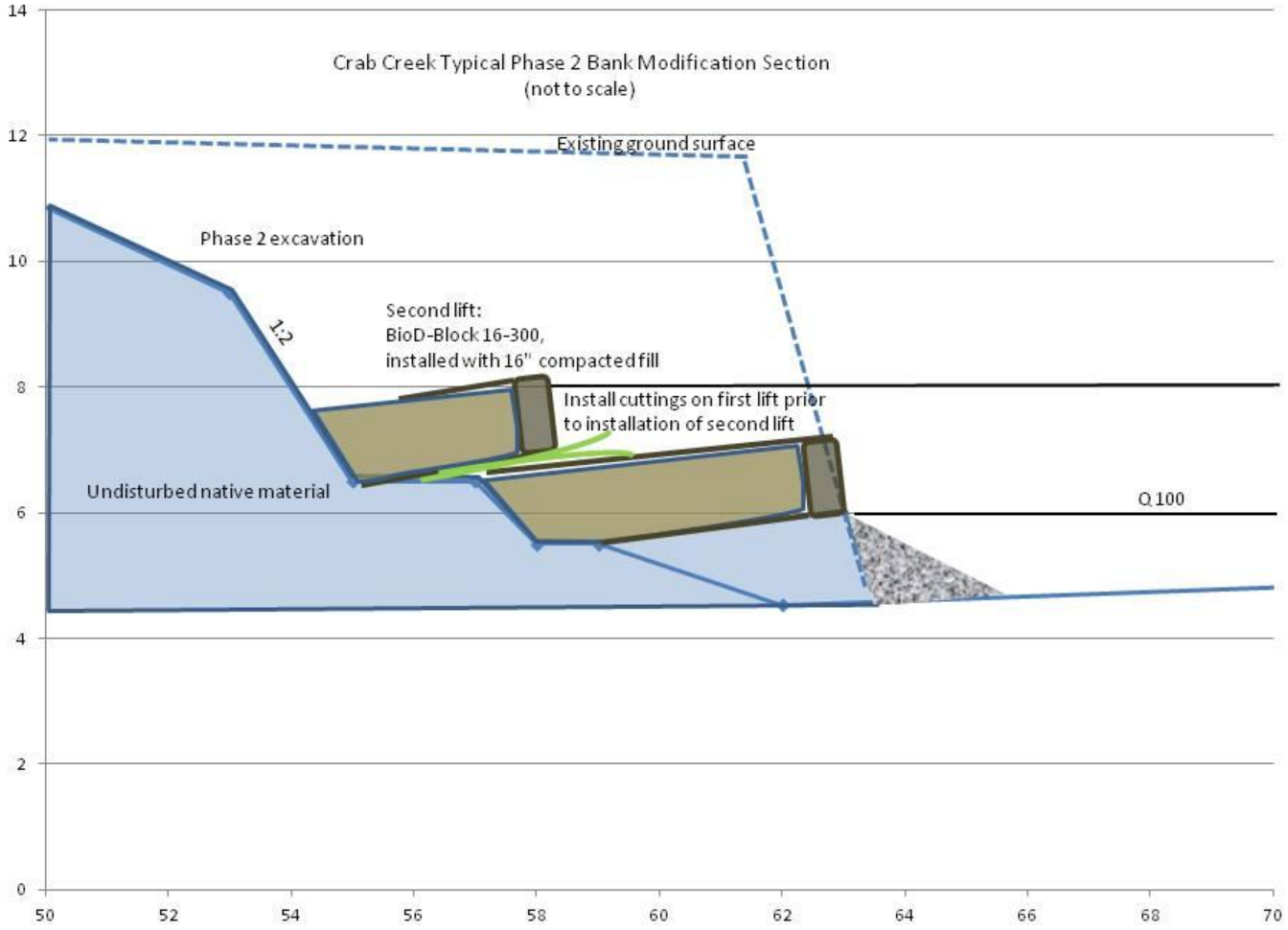


Figure 3, Middle Crab Creek Bank Modification, Phase 2.

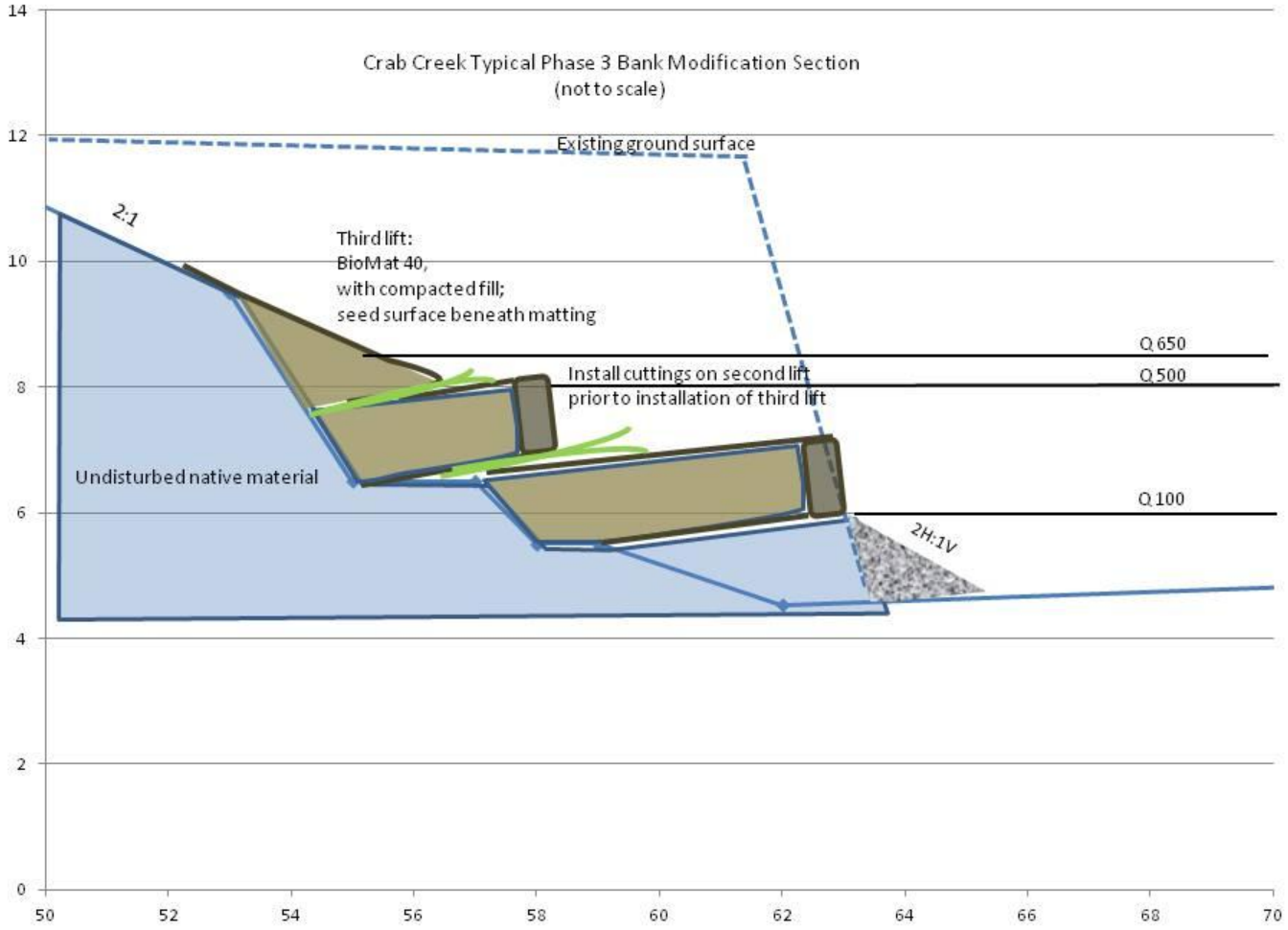


Figure 4. Middle Crab Creek Bank Modification, Phase 3.

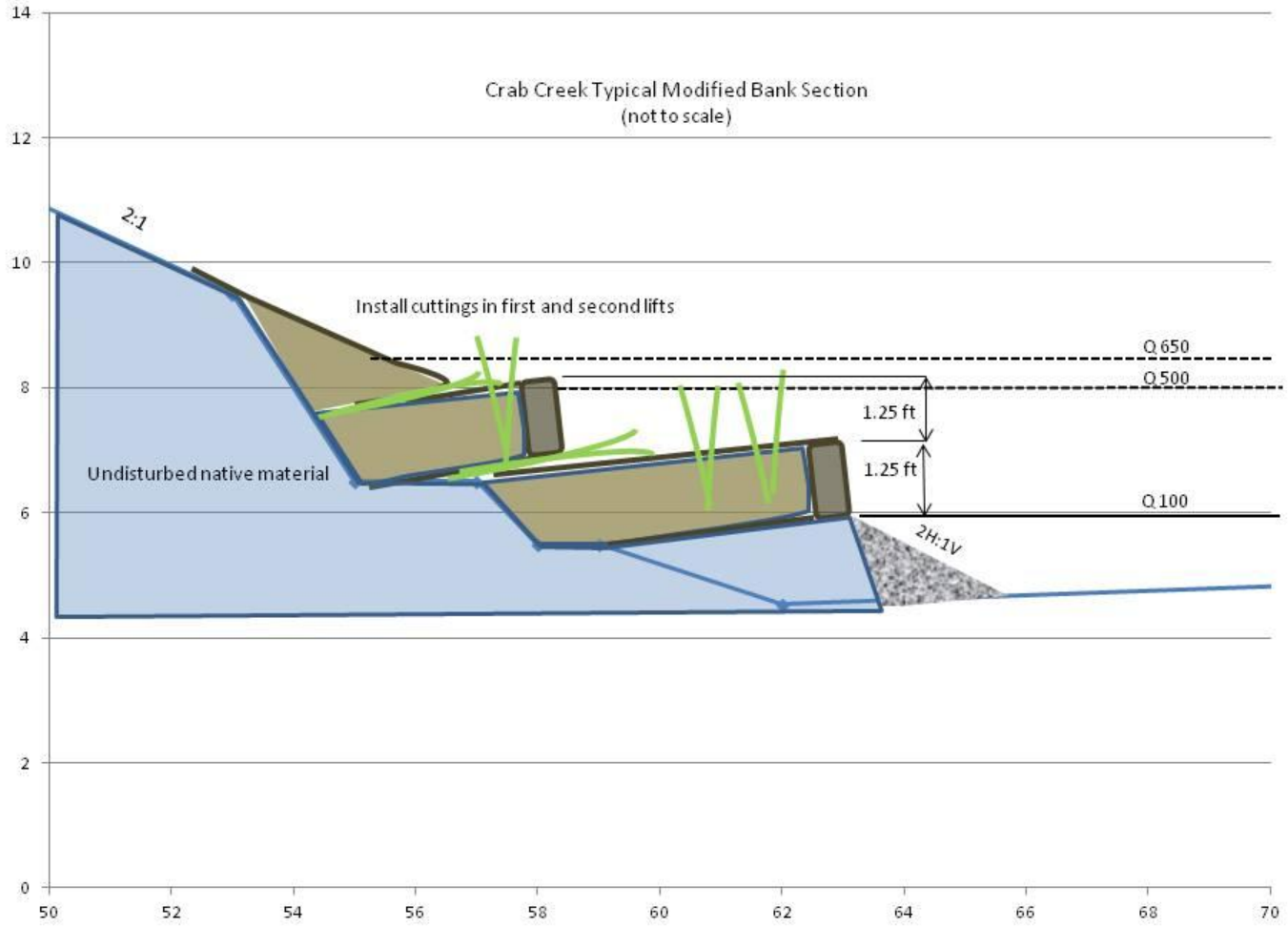


Figure 5. Middle Crab Creek Bank Modification, Phase 4.

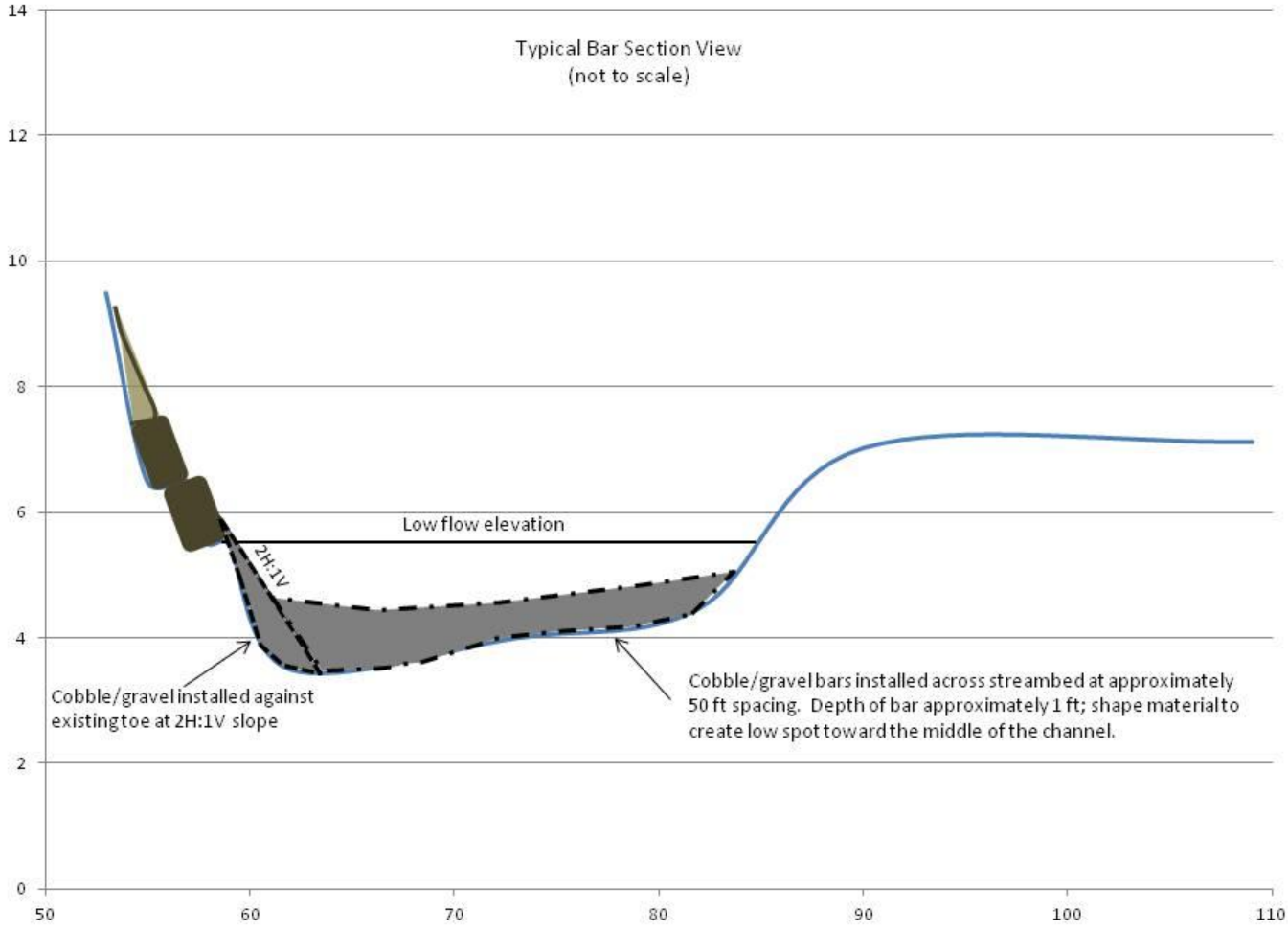


Figure 6. Typical Bar Section View, Middle Crab Creek.

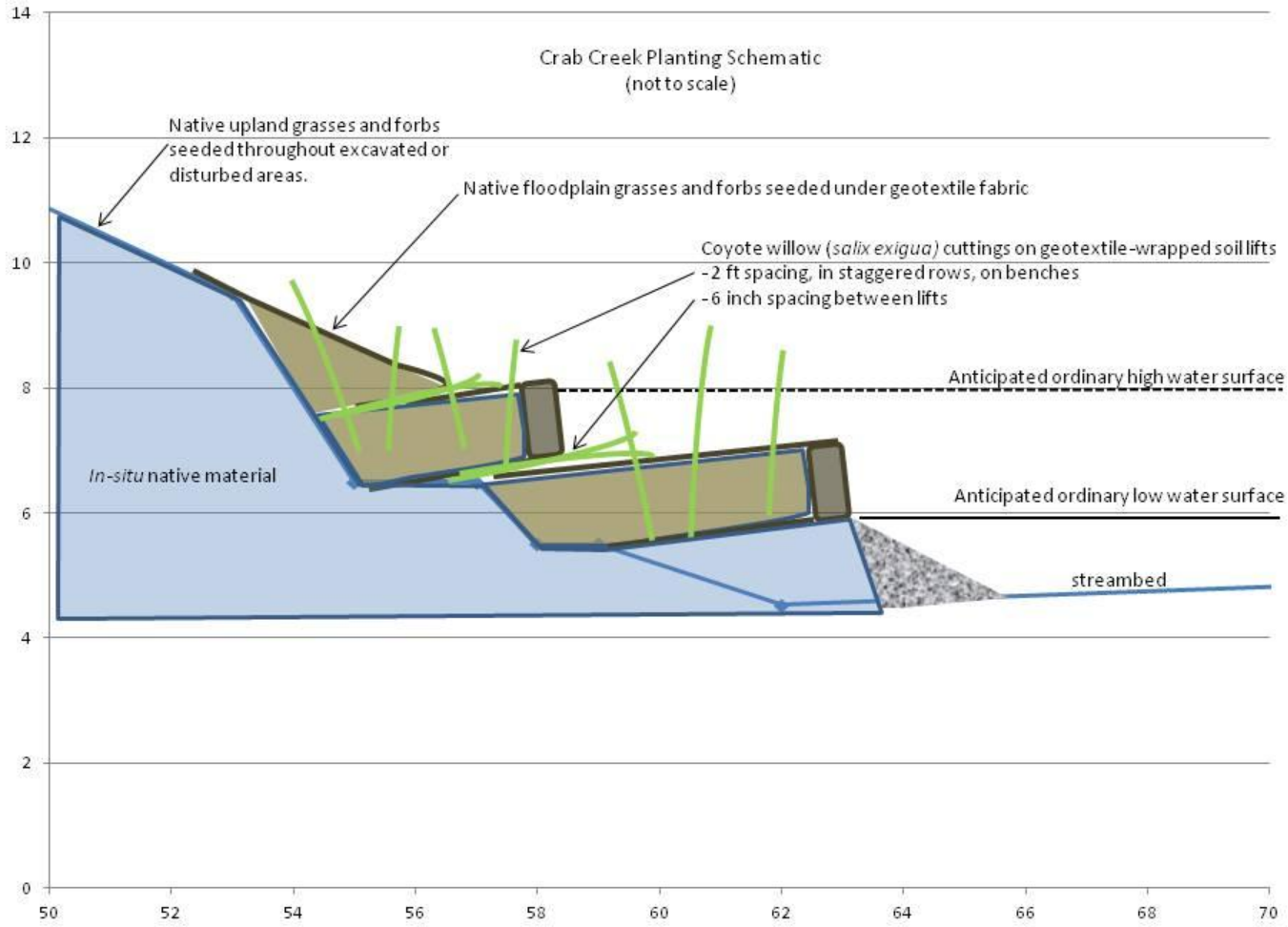


Figure 7. Middle Crab Creek Planting Schematic, Bank Stabilization.

Appendix B: Wetland Management Cells

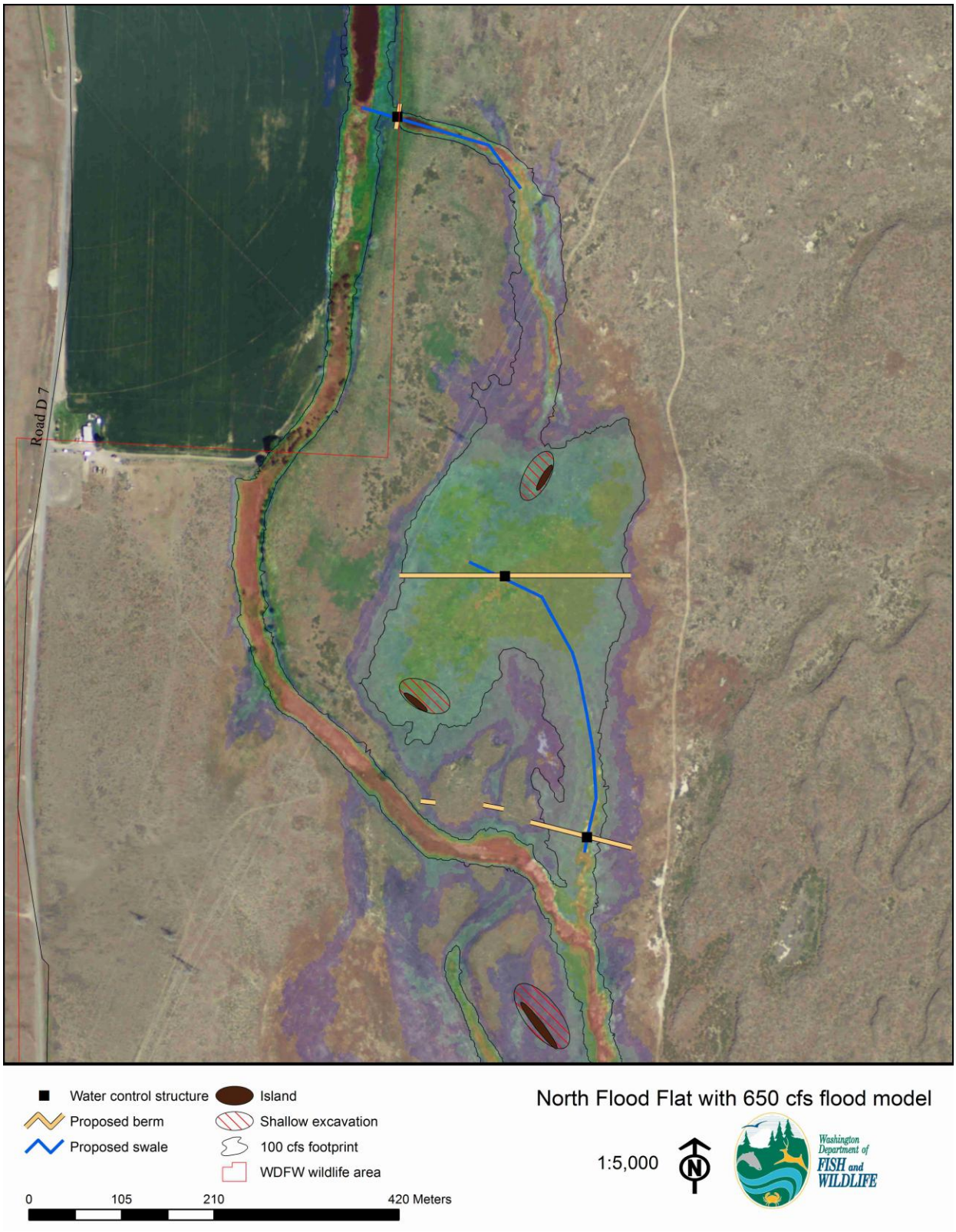


Figure 8. North Flood Flat, 650 cfs, Middle Crab Creek.

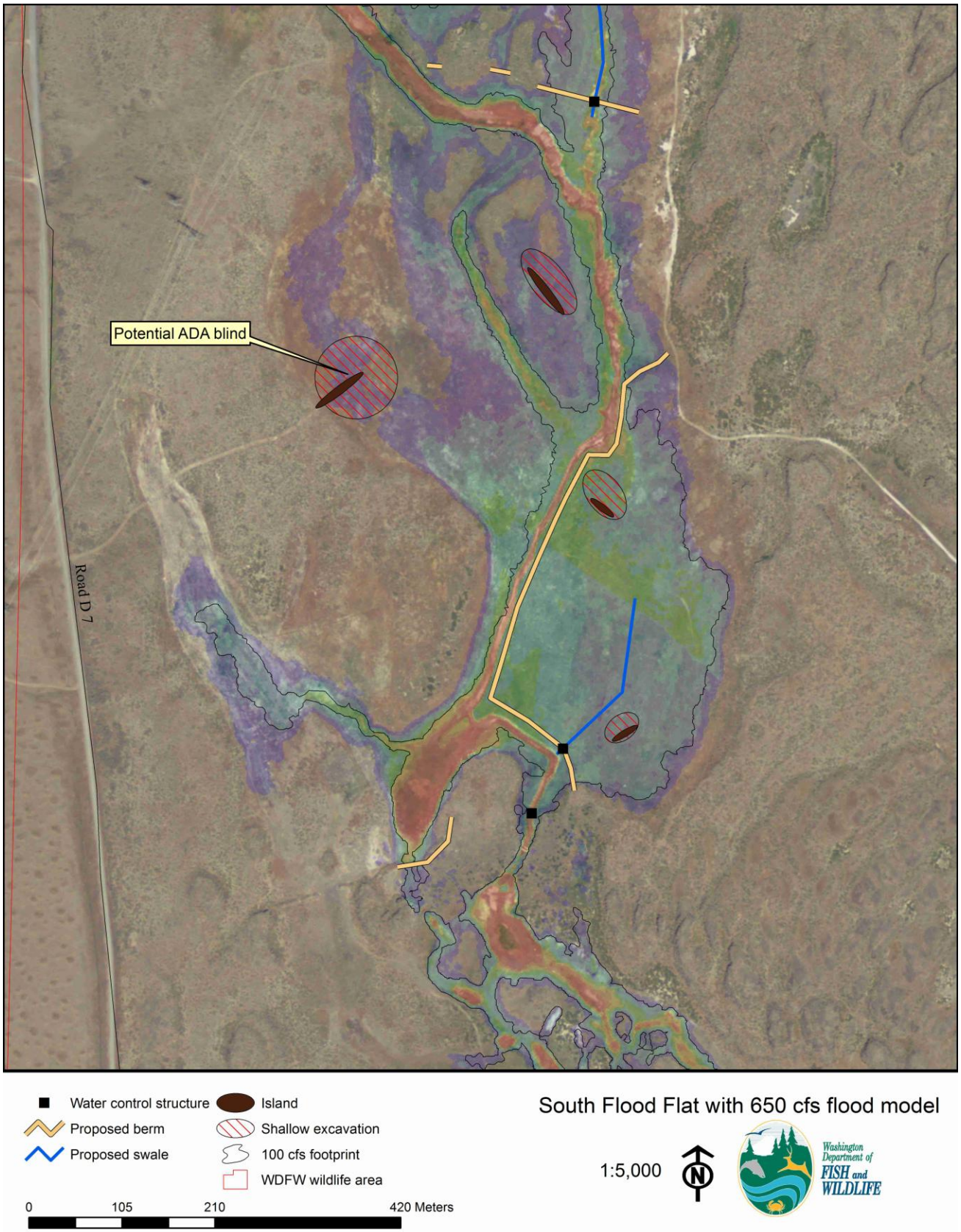


Figure 9. South Flood Flat, 650 cfs, Middle Crab Creek.

Figure 10. Spud Field, 650 cfs, Middle Crab Creek.

Appendix C: Public Access Site

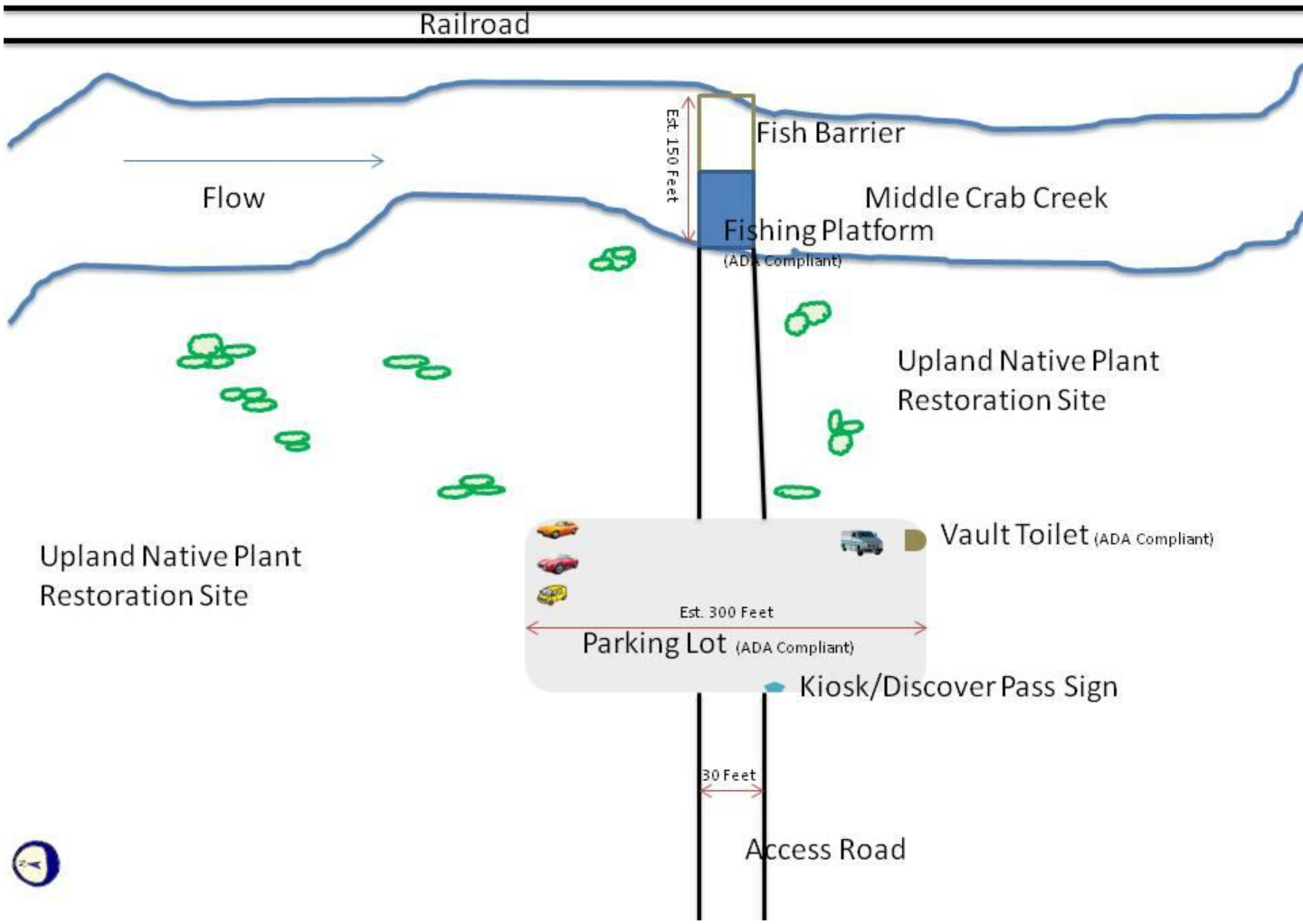


Figure 11. Preliminary Schematic, Public Access Site for Recreational Fishery, Middle Crab Creek.

Figure 12. Fish barrier and public access site location, Grant County.

Appendix D: 90% Pre-Design Report

Bureau of Reclamation – Supplemental Feed Route for Potholes Reservoir

Crab Creek Fish Barriers

PREPARED BY: Josh Butler
Steve Clayton
Joe Young

REVIEWED BY: Stan Schweissing
Ron Fehringer

DATE: July 8, 2008

PROJECT NUMBER: 375055

TASK ORDER: 08A210677B (Task 2)

Executive Summary

CH2M HILL is supporting Reclamation in its continued efforts to develop Crab Creek as a supplemental feed route to supply water to the Potholes Reservoir. As a part of this effort, Reclamation is working with Washington Department of Fish and Wildlife (WDFW) to address habitat impacts along Crab Creek from Road 20 down to a location approximately 2 miles below Road 16 (in the vicinity of the Spud Field) and with Grant County to address ingress/egress issues at Road 16. This report is intended to provide Reclamation and WDFW with sufficient information to ensure that WDFW's goals will be met to the extent reasonably possible.

WDFW would like to control fish movement along Crab Creek as much as possible, preserve existing habitat, and create new habitat for other wildlife using structures to be constructed at key locations. CH2M HILL is also working with Reclamation and Grant County to complete the design of a road crossing for Road 16 over Crab Creek, downstream of the Crab Creek confluence with Loan Springs. The Road 16 crossing will be configured to serve as both a point of public ingress/egress and as a fish passage barrier. (The Road 16 design will be described in a separate document.)

Based upon input from Reclamation, WDFW, and Grant County, a list of goals was developed that include the following highlights:

- Create a put-and-take trout fishery in Crab Creek
- Keep planted trout on public land
- Limit the movement of fish in Crab Creek
- Manage water levels to benefit waterfowl and Northern Leopard Frog
- Maintain ingress/egress at Road 16 during Reclamation-managed/operating flows
- Minimize long-term structure operation and maintenance
- Minimize structure cost

An associated set of design criteria has been developed that address the above-noted goals.

Reclamation has indicated that they intend to release approximately 100 cfs from Billy Clapp Lake from June 15 to March 15 and 500 cfs from March 15 to June 15. The focal point of CH2M HILL's preliminary design work is on in-channel hydraulic structures intended to meet fish barrier objectives.

On June 2, 2008, CH2M HILL completed its Preliminary Report that described the field visit and meeting as well as an analysis of locations and structures that best met the project goals. On June 5, representatives from Reclamation, WDFW, and CH2M HILL had a conference call to discuss the Preliminary Report. Feedback from that conference call was incorporated into the 50 Percent Pre-Design Report.

On June 20, 2008, CH2M HILL completed its 50 Percent Pre-Design Report that described the field visit and meeting as well as an analysis of locations and structures that best met the project goals. On July 1, representatives from Reclamation, WDFW, and CH2M HILL met in person and by conference call to discuss the Preliminary Report. Feedback from that conference call has been incorporated into this 90 Percent Pre-Design Report.

Exhibit 1 is a general vicinity map showing the proposed structure locations. Exhibit 2 depicts the longitudinal profile of Crab Creek through the project area and describes the fish presence in terms of existing conditions, acceptable future conditions, and ideal future conditions. The remaining exhibits included with this report depict the concept designs for each location.

Table 1 identifies the proposed locations and types for the five structures and flow control berms along with estimated costs. Costs range from $12,900 to $222,500 with a total cost of $1,116,700.

TABLE 1
Draft Summary Table Describing Crab Creek Structures

Location	Description	Type	Cost[1]	Comments
Old Railroad Station	Barrier to downstream carp movement and upstream trout movement	Velocity/vertical	$222,500	Appears to meet all criteria, except keeping trout on public land and serving as a complete barrier to downstream carp movement
Upper Flood Flat Area	Northern leopard frog habitat	Berms	$12,900	Berm work likely to be completed by WDFW using State equipment
Upper Wildlife Structure (Flood Flat)	Waterfowl and northern leopard frog habitat	Improvements to existing structure	$164,000	No fish passage modifications; includes both overflow and underflow gates
Upper Loan Springs Diversion	Barrier to downstream carp movement	Permeable berm	$51,700	Located at narrowest section
Lower Loan Springs Structure	Barrier to upstream carp movement	Velocity/ vertical	$61,100	Located at existing Road 16 ford
Lower Wildlife Area (Spud Field)	Northern leopard frog habitat	Berms	$18,900	Berm work likely to be completed by WDFW using State equipment

TABLE 1
Draft Summary Table Describing Crab Creek Structures

Location	Description	Type	Cost[1]	Comments
Lower Wildlife Structure (Spud Field)	Waterfowl and northern leopard frog habitat; barrier to upstream carp movement	Replacement of existing structure using velocity, vertical, and screen	$218,000	Includes both overflow and underflow gates
Total			$1,116,700	

[1]Total includes mark ups and escalation.

Project Overview

CH2M HILL is supporting Reclamation in its continued efforts to develop Crab Creek as a supplemental feed route to supply water to the Potholes Reservoir. As a part of this effort Reclamation is working with Washington Department of Fish and Wildlife (WDFW) and Grant County to address habitat impacts along Crab Creek from Road 20 down to a location approximately 2 miles below Road 16 (in the vicinity of the Spud Field) and ingress/egress issues at Road 16.

WDFW would like to limit carp movement along Crab Creek as much as possible to preserve existing habitat and create new habitat for other wildlife, especially Northern Leopard Frog, a State-listed species. The area addressed by this report encompasses an upper riparian corridor, Flood Flat, Willow Lake, and Loan Springs that are currently dry (excepting portions of the Loan Springs area) during most summer conditions, but may become at least partially inundated once Crab Creek is used as a supplemental feed route. Loan Springs presently supports both rainbow trout and carp; carp that have moved upstream out of Moses Lake and downstream from Round Lake (and other locations) are also distributed throughout the entire project reach.

This 90 Percent Pre-Design Report is organized into two primary sections. The first section summarizes the review process, goals, design criteria, and cost estimating approach. The second section describes each of the seven locations and the corresponding site considerations, concept design, and cost estimate.

Preliminary and 50 Percent Pre-Design Report Reviews

Participants in and decisions from the May 19 site tour and May 20 meeting at Reclamation are documented in the Preliminary Report issued by CH2M HILL on June 2, 2008. On June 5, staff from Reclamation (Jim Blanchard), WDFW (Rich Finger, Greg Fitzgerald), and CH2M HILL (Doug Busko, Josh Butler, Ron Fehringer, Katherine Rowden, Stan Schweissing) participated in the phone call that had been scheduled during the May 20 meeting to discuss the Preliminary Report. Some participants in the May 20 meeting were not able to attend the phone call. A summary of the June 5 phone call was included as

Attachment 1 to the 50 Percent Pre-Design Report. The 50 Percent Pre-Design Report was updated to reflect the review comments provided by Reclamation and WDFW on the Preliminary Report.

On July 1, staff from Reclamation (Jim Blanchard), WDFW (Dennis Beich, Steve Dauma, Rich Finger, Gina McCoy), and CH2M HILL (Steve Clayton, Ron Fehringer, Stan Schweissing) participated in a conference call from WDFW's office in Ephrata to discuss the 50 Percent Pre-Design Report. A summary of this phone call is included as Attachment 1. This 90 Percent Pre-Design Report incorporates group feedback and decisions from that phone call.

Goals and Design Criteria

Goals

Based upon input from Reclamation, WDFW, and Grant County, CH2M HILL prepared the following list of overall project goals.

- Supply Potholes Reservoir with additional irrigation water via Crab Creek
- Create a put-and-take trout fishery in Crab Creek (similar to that on Rocky Ford Creek) through planting of catchable-size trout
- Keep planted trout on public land
- Limit movement of carp into Loan Springs
- Eliminate upstream movement of carp from Moses Lake beyond Road 16
- Minimize downstream movement of carp from upstream of Road 20
- Provide means to stop all water flow to control carp periodically (2-3 years out of 10)
- Improve riparian habitat, especially between Road 20 and Upper Flood Flat
- Manage water levels to benefit waterfowl and Northern Leopard Frog
- Maintain ingress/egress at Road 16 during Reclamation-managed/operating flows
- Minimize long-term structure operation and maintenance
- Minimize structure cost
- Optimize tradeoffs

To the extent possible, the pre-design incorporates these goals at each location. Specific design considerations and tradeoffs are presented and discussed by location later in this report.

Design Criteria

CH2M HILL will work alongside Reclamation and WDFW to meet as many of the goals as possible by using the following objectives and design criteria as general guidelines, with site-specific modifications as necessary.

- Convey flows in Crab Creek resulting from approximately 100 cfs releases from Billy Clapp Lake from June 15 to March 15 and 500 cfs releases from March 15 to June 15. These flows are the design criteria; the 10-year flow of 2,400 cfs is not part of the design criteria.
- Prevent flows of up to 650 cfs from entering the Loan Springs drainage from Willow Lake.
- Prevent carp and trout passage using one or a combination of the four following structure types:
  - Velocity
  - Vertical
  - Electrical
  - Picket
- From a structural stability and maintenance standpoint, limit the maximum velocity across pickets or trash racks to 2 to 3 ft/sec.
- Attempt to provide stable water levels from mid-March through May to support Northern Leopard Frog breeding and rearing habitat, with a primary focus on North Flood Flat and a secondary focus on the Spud Field.
  - Specific locations, depths, durations/timing to be provided by WDFW
  - Water control structures will likely be pre-cast and designed.
  - Water control structures would also be designed to minimize potential of stranding trout.
- Repair and/or construct berms at wildlife sites to produce forage crops and provide nesting and rearing habitat for waterfowl, with a primary focus on the Spud Field and a secondary focus on North Flood Flat.
- To control cost and because Reclamation and WDFW do not wish to have any of these facilities (including the fish barriers and control gate structures) classified as jurisdictional dams or levees, berms (including those at the wildlife sites and at the Willow Lake overflow to Loan Springs) will be designed and constructed in recognition of the following performance limitations:
  - Not intended to withstand overtopping without damage or possibly complete loss of the structure when flows in Crab Creek exceed 650 cfs.
  - Not intended to be impermeable.
  - Not intended to survive a seismic event.

    (Note that it will be important to verify as soon as possible that the structures being contemplated are not jurisdictional due to height or volume characteristics.)

The focal point of CH2M HILL's design is on in-channel hydraulic structures intended to meet fish exclusion objectives. Fish exclusion structures will be designed to minimize carp movement upstream of Road 16 and minimize carp movement downstream of Road 20. The structures will attempt to retain planted hatchery trout on public land. Where possible,

some of the structures may also be designed to enhance other wildlife populations, including waterfowl and Northern Leopard Frog, through water level regulation.

Cost Estimate

A conceptual-level cost estimate was prepared for the construction of each of the structures. Current unit cost information was collected for materials, as opposed to relying strictly on historical information.

The cost estimate excludes permitting, final design, and potential impacts from tasks that have not been performed such as detailed soils investigations and hydraulic modeling. Also, the cost estimate excludes operation and maintenance costs.

The estimate was prepared in accordance with the guidelines of the Association for the Advancement of Cost Engineering (AACE) International. According to the definitions of AACE International, the Class 5 Estimate is defined as the following:

> *Class 5 Estimate*: This estimate is prepared based on limited information, where little more than proposed plant type, its location, and the capacity are known. Strategic planning purposes include but are not limited to, market studies, assessment of viability, evaluation of alternate schemes, project screening, location and evaluation of resource needs and budgeting, and long-range capital planning. Examples of estimating methods used include cost/capacity curves and factors, scale-up factors, and parametric and modeling techniques. Typically, little time is expended in the development of this estimate. The expected accuracy ranges for this class estimate are –20 to –50 percent on the low side and +30 to +100 percent on the high side.

The cost estimates shown, which include any resulting conclusions on project financial or economic feasibility or funding requirements, have been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project and resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. Therefore, the final project costs will vary from the estimate presented here. Because of these factors, project feasibility, benefit/cost ratios, risks, and funding needs must be carefully reviewed before making specific financial decisions or establishing project budgets to help ensure proper project evaluation and adequate funding.

The cost estimate is included as Attachment 2 with the summary cover followed by eight itemized cost estimates, labeled as Attachment 2 – Exhibit 1 to Exhibit 8.

Recommended Locations and Structures

This section, originally presented in the Preliminary Report, has been revised to focus on just those locations and structures selected by Reclamation and WDFW following their reviews of the Preliminary Report.

Exhibit 1 shows the general vicinity of the proposed structure locations from upstream to downstream: Old Railroad Station, Upper Wildlife Structure (Flood Flat), Loan Spring, Road 16 Crossing, and the Lower Wildlife Structure (Spud Field).

Exhibit 2 depicts the longitudinal profile of Crab Creek through the project area and describes the fish presence within each reach. Existing conditions in Crab Creek and Loan Springs include both trout and carp. Acceptable future conditions, as stated by WDFW, would entail maintaining Loan Springs and the Crab Creek reach between the Road 20 vicinity and Road 16 as trout only. Ideal future conditions would extend the downstream boundary of the trout-only reach to the Lower Wildlife Structure and eliminate downstream movement of carp at all life stages below the Road 20 vicinity.

Each of the proposed locations and corresponding structures is described in more detail in the following sections. (Exhibits describing the existing conditions at each of the locations (plan, profile, and cross section along with ground-level and some aerial photos) were included in the Preliminary Report and are not repeated here. Photos depicting locations of test pits and borings completed during the geotechnical exploration are included as Attachment 2 of the 50 Percent Pre-Design Report and are not repeated here.)

Old Railroad Station

Following review of the Preliminary Report, Reclamation and WDFW directed CH2M HILL to focus the continued design at the Old Railroad Station location. This location is expected to meet almost all the goals for the uppermost fish exclusion structure, with the exception of failing to contain the trout only to the public land reaches and providing a complete barrier to downstream movement of carp. Final site selection would be subject to field verification and approval by any affected landowners, Reclamation, and WDFW.

Design Considerations and Criteria

This location meets many of the requirements for a vertical and velocity barrier including the following:

- Based on the available contours provided by Reclamation, an elevation drop of approximately 7 feet is present through this reach.
- Channel is confined and relatively well defined.
- Backwater effects are not expected to adversely affect the private land adjacent to this site, but this needs to be verified as part of a future design step.
- Old railroad grade could provide protection for the existing railroad grade (potential effects on the railroad would need to be addressed but given the steepness of this reach a solution should be possible).
- Subsurface conditions are typically a poorly graded gravel with sand and clay (GP-GC). Very little to no topsoil was encountered. Groundwater was not encountered, and sidewall stability was good in two test pits excavated in this area. Material to construct any levee associated with the barrier can be sourced locally from within the floodplain. It is anticipated that the subsurface will function well as-is with the type of proposed barrier structure, and will not require additional measures such as a cutoff wall.

- There are very large boulders present at this site. At the surface, some were observed with a maximum dimension of 10 feet, and have an estimated weight of 7 tons. There are locations within the vicinity that can be selected to avoid most of these boulders, and thereby minimize excavation and construction costs.

The structure is intended to minimize upstream movement of trout and downstream movement of carp and not be classified as a dam. This requires optimizing the following design criteria and considerations:

- Structures with impoundment heights less than 6 feet and that do not pose a significant public risk if they should fail can be exempted from compliance with State of Washington Dam Safety requirements. There is minimal public risk posed by failure of any of the proposed structures and all structures will create an impoundment depth of less than 6 feet.
- A total drop of at least 3 feet at all flows is recommended to prevent upstream trout movement (Korth, personal communication, 2008).
- The structure will develop higher velocities across the crest and apron that along with the vertical wall may serve to inhibit the upstream movement of trout, especially if the flow is shallow.
- The existing barrier on Rocky Ford at the lower hatchery has a vertical drop of 4 feet and an apron with shallow flow that appears to be stopping most upstream trout migration (Korth, personal communication, 2008).
- The proposed design of this structure would not typically be considered a barrier to downstream movement of fish, but there are hydraulic conditions at this structure that may discourage downstream movement. In general, carp would be expected to try to avoid being swept downstream over the top of a structure through high velocity, shallow depth flows that would occur over the proposed concrete structure.

Concept Drawing Description and Exhibits

CH2M HILL prepared the pre-design for a combined vertical and velocity barrier at the Old Railroad Station location (Exhibit 1). The vertical barrier would span the full channel width of 180 feet and have two concrete aprons as well as a rip rap apron. The concrete aprons total 25 feet in length while the rip rap apron is 20 feet long (Exhibit 3).

Based upon the initial design and hydraulic analysis, the proposed structure has been configured to meet the 6.0 feet maximum height criteria. Combined with the fact that it appears to not pose a significant risk to public safety, the structure will likely attain an exempt status. However, it has been designed to just meet the maximum height allowable.

From a fish barrier perspective, the design criteria appear to be met all the time when the flow is 100 cfs, and most of the time when flows are 650 cfs. Specifically, with 100 cfs flows, 3 feet of drop will occur over the structure onto the apron where the depth of flow will be about 0.2 feet (Exhibit 3). During the three months of the year when the flows increase to 650 cfs, there will be a drop of 3.0 feet into about 0.5 feet of water (Exhibit 3). However, because of the unstable hydraulics, there will be brief, but repeated, moments when the drop is reduced to about 2.5 feet if the hydraulic jump occurs on the apron.

The combined vertical and velocity barrier approach should generate velocities across the apron that are fast enough to minimize fish movement across the apron toward the vertical barrier at the 650 cfs flow scenario, thereby addressing the concern that the vertical barrier may be less than 3.0 feet for brief periods of time. For example, at flows of 650 cfs, the velocity across the 15-foot long declined apron, when the hydraulic jump forms downstream from the upstream wall, is 7.5 ft/sec. This combination of vertical drop and velocity exceed the passage criteria for trout (WAC, 2008).

Cost Estimate

The total construction cost for the Old Railroad Station Structure is $222,524, excluding mark ups and escalation. Individual line item components and the total amount are summarized in Attachment 2 – Exhibit 1.

Remaining Question

- Are there any potential effects on private land, the adjacent railroad grade, or related permitting implications if backwater is created by a velocity or vertical barrier?

Upper Flood Flat Berms

With the creation of perennial flow in Crab Creek, WDFW sees Upper Flood Flat as an excellent location to create new habitat for Northern Leopard Frog for a relatively minimal cost through the construction of strategically-placed berms and two water control structures.

Design Considerations and Criteria

The site would be filled early in the spring, during the 100 cfs flow, to provide frog breeding habitat. The site would be partially drained and then maintained at that new elevation for most of the summer. The site would be fully drained in the fall in a way that would prevent stranding of trout. WDFW is providing additional detail for the design criteria.

Because WDFW does not want to have the frog breeding and rearing habitat areas and associated berms classified as impoundments and dams, WDFW will provide additional details to Reclamation and CH2M HILL to limit risks. No geotechnical exploration was completed by CH2M HILL at this location, and therefore the expected geotechnical performance of any constructed berm would be uncertain.

Concept Description and Exhibits

The concept design for the Upper Flood Flat isolation areas is described below. It is expected that WDFW would use State equipment or hire a local contractor to move local material around as needed to repair washed-out sections of the existing berm and create new berms to restore the ability to impound water. It is also expected that this process would be repeated from time to time in future years as needed to repair minor damage or replace as needed if major damage or complete loss occurs.

It is not cost effective or reasonable to design flood-proof structures for these berms. Crab Creek is subject to large although infrequent, flash flood flows that would make it costly to design structures that will remain in place during flood events along Crab Creek. It is possible to construct the berms with a portion of the berm crest set at a lower elevation to

promote breaching of the berm during flood flows in a specific location. This may localize the failure thereby limiting the amount of time and cost required for repairs. However, the performance during high flows is uncertain and breaching could result in significant damage to the berm. A typical berm section is shown in Exhibit 4.

North Flood Flat Isolation from Crab Creek channel

WDFW provided the following specifications to isolate a section of North Flood Flat from the Crab Creek channel (Exhibit 5A).

> North Flood Flat inlet levee is 29 meters in length with an average height of 0.71 m (28 in) and includes a drop board WCS (water control structure). The North Flood Flat outlet levees (n=3) total 159 m in length with an average height of 0.64 m (25 in) and includes a drop board WCS. Two swales are necessary to ensure proper filling and drainage and provide levee material. The swales are 212 m (upper) and 342 m (lower) in length with an average depth of 0.61 m (24 in). One cross-levee will enhance management flexibility and is 305 m in length with an average height of 0.91 m (36 in). The cross-levee also includes a drop board WCS.

Together, the North Flood Flat berms and swales would require approximately 2,900 cubic yards of fill and 1,300 cubic yards of excavation for a balance of 1,600 cubic yards of fill (Exhibit 6).

South Flood Flat Isolation from Crab Creek channel

WDFW provided the following specifications to isolate a section of South Flood Flat from the Crab Creek channel (Exhibit 5B).

> South Flood Flat levee repair includes 95 m of material at an average height of 0.53 m (21 in) in height. Isolation of the South Flood Flat from Crab Creek would require a 615 m levee at an average height of 0.61 m (24 in). A swale is necessary to ensure proper drainage and provide levee material. The swale is 209 meters in length with an average depth of 0.61 m (24 in).

Together, the South Flood Flat berms and swale would require approximately 2,700 cubic yards of fill and 500 cubic yards of excavation for a balance of 2,200 cubic yards of fill (Exhibit 6).

Cost Estimate

The total construction cost is $6,864 for the North Flood Flat Berms and $6,029 for the South Flood Flat Berms, excluding mark ups and escalation. Individual line item components and the total amount are summarized in Attachment 2 – Exhibits 6 and 7. Cost includes the berms, swales, and three water control structures *(to be included in the 100 Percent Pre-Design Cost Estimate)*.

Upper Wildlife Structure (Flood Flat)

The Upper Wildlife Structure at the downstream end of Flood Flat needs improvements so that it can be operated to control water levels for waterfowl habitat. A repair to an existing berm is also required to meet the management goal. The structure will not be managed as a fish exclusion structure.

Design Considerations and Criteria

No geotechnical exploration was completed by CH2M HILL at this location, and therefore the expected geotechnical performance of any constructed berm or structure is uncertain. The existing concrete is considered to be in workable condition and will be used as is. Based on CH2M HILL's discussions with gate manufacturers, the manufacturers recommend using separate gates for undershot and weir flows to meet WDFW's management goal. The metalworks on the existing structure will be removed, slide gates with operators suitable for use with a gas-powered actuator will be installed, abutments on the existing structure will be sealed on each end, and the berm will be repaired. Repair of the berm has been included in the discussion of flow control berms for the upper flood flat area.

Concept Drawing Description and Exhibits

CH2M HILL prepared the pre-design for a new structure at the Upper Wildlife Structure location (Exhibit 1). The existing structure spans the full channel width of 25 feet (Exhibit 7). The each of the two gate openings will be approximately 8 feet wide by 3 feet tall (Exhibit 7). Exhibit 7 depicts the conceptual drawing showing separate gates for undershot and weir flows.

Cost Estimate

The total construction cost for the Upper Wildlife Structure is $163,972, excluding mark ups and escalation. Individual line item components and the total amount are summarized in Attachment 2 – Exhibit 2. No cost is included for demolition or concrete since the existing concrete foundation will be used in its current condition.

Upper Loan Springs Diversion

A concept design for the Upper Loan Springs Diversion was previously prepared by CH2M HILL and documented in the April 17, 2007, report titled "Supplemental Feed Route for Potholes Reservoir – Alternative C – Crab Creek." The berm would be located near the central portion of Willow Lake.

Design Considerations and Criteria

The structure should minimize downstream movement of carp into Loan Springs based upon the following design criteria:

- Top of berm is high enough so that 650 cfs continues to be routed through the west outlet of Willow Lake
- Water seepage through the berm is allowable
- Berm is impermeable to larval-size carp (exact size to be determined)
- Flows greater than 650 cfs may overtop the berm
- The berm may require maintenance repairs or complete replacement following flows greater than 650 cfs, following overtopping, or following a seismic event
- Subsurface conditions vary from east to west across the proposed structure location (Attachment 3). Within the eastern paleo-alluvial bench (test pits WETP-5, -6, -7, and

boring WEB-1), up to 2 feet of a dry, desiccated silt overlies a poorly graded gravel with sand and silt (GP-GM). At the time of drilling, groundwater was encountered approximately 17 feet below the surface of this bench (in the boring). The groundwater table is expected to fluctuate seasonally. Sidewall stability was good in the test pits excavated in this area. Material to construct the embankment can be sourced locally from this alluvial bench, upstream of the proposed location (i.e. within the area to be inundated by Willow Lake at typical future flows). It appears that sufficient volume is available for the embankment.

- Toward the center of the drainage, the alluvial bench begins to slope downward until the lacustrine surface from Willow Lake is encountered. This surface extends to the western sidewall of the drainage valley. The lacustrine subsurface material consists of lean clay and silt with some organics (CL and ML), and an interbedded sandy layer (depth varies from 2-5 feet down, depending on ground surface elevation). Groundwater was encountered within this sandy layer (test pits WETP-1, -2, -3, -4, and boring WEB-3). Based on boring WEB-3, the fine-grained lacustrine deposits overly alluvial material (similar to the bench) which was encountered at a depth of approximately 15 feet. The depth to basalt rock within the valley bottom is unknown. It is anticipated that the existing subsurface will provide foundation support for the embankment, and will also work as an effective cutoff for seepage beneath the embankment.
- The need for a cutoff wall should be evaluated where the embankment overlies the alluvial bench material.
- Both sidewalls of the drainage valley are bounded by basalt. Near the surface, this material is present as talus. This layer has the greatest thickness on the eastern sidewall, although the actual thickness overlying intact basalt is unknown. On the western sidewall, there is little or no talus, and intact basalt is present at the surface in some locations. In boring WEB-2, approximately 35-feet of basalt was cored. This material was found to have poor rock mass quality in the upper 10 feet, but the rock mass quality was good to excellent below that depth.

The design composition of the berm will be determined, utilizing information from the geotechnical exploration. The intent is to use exclusively on-site material. The group recognizes that the berm may become less permeable over time.

Based upon the hydraulic modeling completed for the Road 16 crossing and the available contour data provided by Reclamation, it appears that at 650 cfs Crab Creek will continue to flow out to the northwest and not to the east as discussed during the field visit. The contours provided by Reclamation also indicate the water surface in Willow Lake is currently controlled by the elevation between Willow Lake and Road 16. This ground could be excavated if a lower water surface elevation were desired in Willow Lake by Reclamation and WDFW.

Concept Drawing Description and Exhibits

The group agreed that a permeable berm should be constructed at the narrowest section to minimize disturbance and cost. This location is approximately 500 to 1000 feet further downstream than the location shown in the April 17, 2007, report.

CH2M HILL prepared the pre-design for a permeable berm at the Upper Loan Springs Diversion location (Exhibit 1). The proposed structure would span the full width of the channel valley (265 feet) and have a maximum height of 6 feet, but the configuration of the berm will generally fit to the configuration shown in the April 17, 2007, report. Under normal operation hydraulic modeling results suggest that the water surface elevation will be slightly less than the crest of the berm set to an elevation of 1165.0 feet (Exhibit 8A and 8B). Actual flows with natural losses would result in approximately 2 feet of freeboard. With the toe of the structure at an elevation of 1160.0 feet the proposed structure has been configured to meet the 6.0 feet maximum height criteria. Combined with the fact that it appears to not pose a significant risk to public safety, the structure will likely attain an exempt status.

Cost Estimate

The total construction cost for the Upper Loan Springs Diversion is $51,702, excluding mark ups and escalation. Individual line item components and the total amount are summarized in Attachment 2 – Exhibit 3.

Remaining Questions

- Stability and seepage analyses of the embankment are necessary to determine if additional foundation improvements are needed for the portion of the embankment that overlies the lacustrine deposits in the drainage bottom. Bearing capacity and settlement will also be evaluated.
- Will the placement of the berm affect Crab Creek hydraulics by reducing the capacity of the floodway so as to create a temporary jurisdictional impoundment (during higher flows)?

Lower Loan Springs Structure

The Lower Loan Springs Structure would be located in the vicinity of the current Road 16 ford over Loan Springs. This structure would be designed to minimize upstream movement of carp from Crab Creek into Loan Springs.

Design Considerations and Criteria

The structure must be located far enough upstream on Loan Springs to not be inundated by the structure creating the Road 16 crossing. The structure must be located far enough upstream that it is above any surface water connection between Crab Creek and Loan Springs that exists at up to 650 cfs. At the Road 16 ford over Loan Springs, there is a drop of approximately 4 feet from the pool above the road to the pool below the road. This drop provides the opportunity to employ a vertical and velocity barrier at the site.

The structure is being designed based upon the following hydraulic parameters:

- Creates a barrier impassable to carp with 10 cfs of flow in Loan Springs
- Remain impassible to carp even when the flow in Loan Springs exceeds 10 cfs due to water seeping through the Upper Loan Springs Diversion berm
- Not be inundated by backwater from the Road 16 crossing at flows of 650 cfs

- Subsurface conditions at the current Loan Springs crossing consist of poorly graded gravel with sand and silt (GP-GC) overlying shallow basalt (see test pits LSTP-1, -2). The depth to rock was less than 5 feet. Sidewall stability was good in the test pits excavated in this area, and groundwater was not encountered. Material to construct the barrier levees should be sourced locally from the Road 16 alignment.
- Two other potential material sources were evaluated nearby. Refer to the discussion for the Road 16 and Diversion Structure in the 50 Percent Pre-Design Report.

The structure would look similar to, but be smaller than, the structure being designed for the Old Railroad Station location. Provided the hydraulic criteria can be met, the structure would be placed close to the existing path of Road 16 because the road will be abandoned and use of this site would minimize disturbance to the existing channel and riparian area.

Based upon the hydraulic modeling completed for the Road 16 crossing and the available contour data provided by Reclamation (that does not cover all of the proposed location of the Lower Loan Springs Structure or Loan Springs itself), it appears that the extent of inundation at 650 cfs through this flat area will not create a direct surface water connection between Crab Creek and Loan Springs upstream of the proposed location of the fish exclusion structure. However, this should be addressed during the final design in case the structure needs to be relocated further upstream on Loan Springs or fill material needs to be added in the low area between the two channels to prevent the surface water connection.

Concept Drawing Description and Exhibits

CH2M HILL prepared the pre-design for a combined vertical and velocity barrier at the Lower Loan Springs Structure location (Exhibit 1). Based upon the initial design and hydraulic analysis, the proposed structure has been configured to meet the 6.0 feet maximum height criteria. Combined with the fact that it appears to not pose a significant risk to public safety, the structure will likely attain an exempt status. The vertical barrier would span the full channel width of 45 feet and have a concrete apron that is 10 feet long (Exhibit 9). A rip rap apron would be placed at the downstream side at channel grade. This configuration of the structure assumes that approximately 750 feet of downstream channel re-grading would be required.

From a fish barrier perspective, the design criteria appear to be met all the time when the flow is 40 cfs. Specifically, 3 feet of drop will occur over the structure onto the apron where the depth of flow will be about 0.2 feet (Exhibit 9). The combined vertical and velocity barrier approach should generate velocities across the apron that are fast enough to minimize fish movement across the apron toward the vertical barrier. For example, at flows of 40 cfs, the velocity across the 10-foot long apron is 4.4 ft/sec (Exhibit 9).

Cost Estimate

The total construction cost for the Lower Loan Springs Structure is $61,096, excluding mark ups and escalation. Individual line item components and the total amount are summarized in Attachment 2 – Exhibit 4.

Spud Field Berms

With the creation of perennial flow in Crab Creek, WDFW sees the Spud Field area as an excellent location to create new habitat for Northern Leopard Frog for a relatively minimal cost through the construction of strategically-placed berms and water control structures.

Design Considerations and Criteria

The site would be filled early in the spring, during the 100 cfs flow, to provide frog breeding habitat. The site would be partially drained and then maintained at that new elevation for most of the summer. The site would be fully drained in the fall in a way that would prevent stranding of trout. WDFW is providing additional detail for the design criteria.

Because WDFW does not want to have the frog breeding and rearing habitat areas and associated berms classified as impoundments and dams, WDFW will provide additional details to Reclamation and CH2M HILL to limit risks. No geotechnical exploration was completed by CH2M HILL at this location, and therefore the geotechnical performance of any berm or structure constructed at this location is uncertain.

As discussed during the June 5 conference call, regarding the berms for the amphibian areas, WDFW will provide lengths and elevations. To maintain access to the structure, a low, drivable berm will need to be constructed for driving out across habitat area to reach operating gates and/or service the new structure. This access road would need to be about 12 feet wide and 1.5 to 3 feet high.

Concept Drawing Description and Exhibits

The concept design for the Spud Field isolation areas is described below. It is expected that WDFW would use State equipment or hire a local contractor to move local material around as needed to repair washed-out sections of the berm and restore the ability to impound water. It is also expected that this process would be repeated from time to time in future years.

It is not cost effective or reasonable to design flood-proof structures for these berms. Crab Creek is subject to large although infrequent, flash flood flows that would make it costly to design structures that will remain in place during flood events along Crab Creek. It is possible to construct the berms with a portion of the berm crest set at a lower elevation to promote breaching of the berm during flood flows in a specific location and thereby potentially limiting the amount of time and cost required for repairs. However, a significant flood could require in major repairs and replacement of the berm.

Spud Field isolation from Crab Creek channel

WDFW provided the following specifications to isolate a section of the Spud Field from the Crab Creek channel (Exhibit 5C).

> The Spud Field levee is 1,095 m in length with an average height of 1.27 m (50 in) and includes a drop board WCS. A swale is necessary to ensure proper drainage and provide levee material. The swale is 501 meters in length with an average depth of 0.61 m (24 in). Southeast of the Spud Field, additional levee material is needed to isolate the Homestead Creek system (currently carp-free) from Crab Creek. This would be an addition of material to an existing levee to raise it high enough to

effectively isolate the system. This levee is 84 m in length and would need to be 0.91 m (36 in) in height.

At the Spud Field, all the berms and swales would require approximately 13,100 cubic yards of fill and 1,200 cubic yards of excavation for a balance of 11,900 cubic yards of fill (Exhibit 6).

Cost Estimate

The total construction cost for the Spud Field Berms is $18,884, excluding mark ups and escalation. Individual line item components and the total amount are summarized in Attachment 2 – Exhibit 8. Cost includes the berms and one water control structure *(to be included in the 100 Percent Pre-Design Cost Estimate)*.

Lower Wildlife Structure (Spud Field)

The Lower Wildlife Structure at the downstream end of the Spud Field needs improvements so that it can be operated to control water levels for waterfowl habitat. The structure will also be managed as a fish exclusion structure to minimize upstream movement of carp into Crab Creek. In addition to the structure, repairs to an existing berm may also be required to meet management goals.

Design Considerations and Criteria

Hydraulic analysis at the new Road 16 Crossing indicates that perched culverts are not a feasible alternative for a fish exclusion structure at that location. Therefore, the Lower Wildlife Structure will be designed and constructed to both function as a fish exclusion structure and control water levels.

No geotechnical exploration was completed by CH2M HILL at this location. However, based on observations made at the site and in the excavated Crab Creek channel, basalt rock is very shallow in the vicinity of the proposed structure. Adequate support for any embankment or concrete structures is anticipated. Material sources are also anticipated to be found locally for short levees or berms. The rock stockpiled along the channel can also be utilized for armoring or riprap.

The existing structure is considered to not be in workable condition and will need to be demolished so that the new structure can be built. Based on CH2M HILL's discussions with gate manufacturers, the manufacturers recommend using separate gates for undershot and weir flows to meet WDFW's management goal. Slide gates with operators suitable for use with a gas-powered actuator will be installed, and the berm will be repaired.

The structure should control water levels and minimize upstream movement of carp into Crab Creek based upon the following design criteria:

- Minimize maintenance requirements associated with cleaning and operating the structure.
- Allow flow both over and under the gates and include a screen component to minimize upstream movement of carp when the gates are open so that the Spud Field can drain.

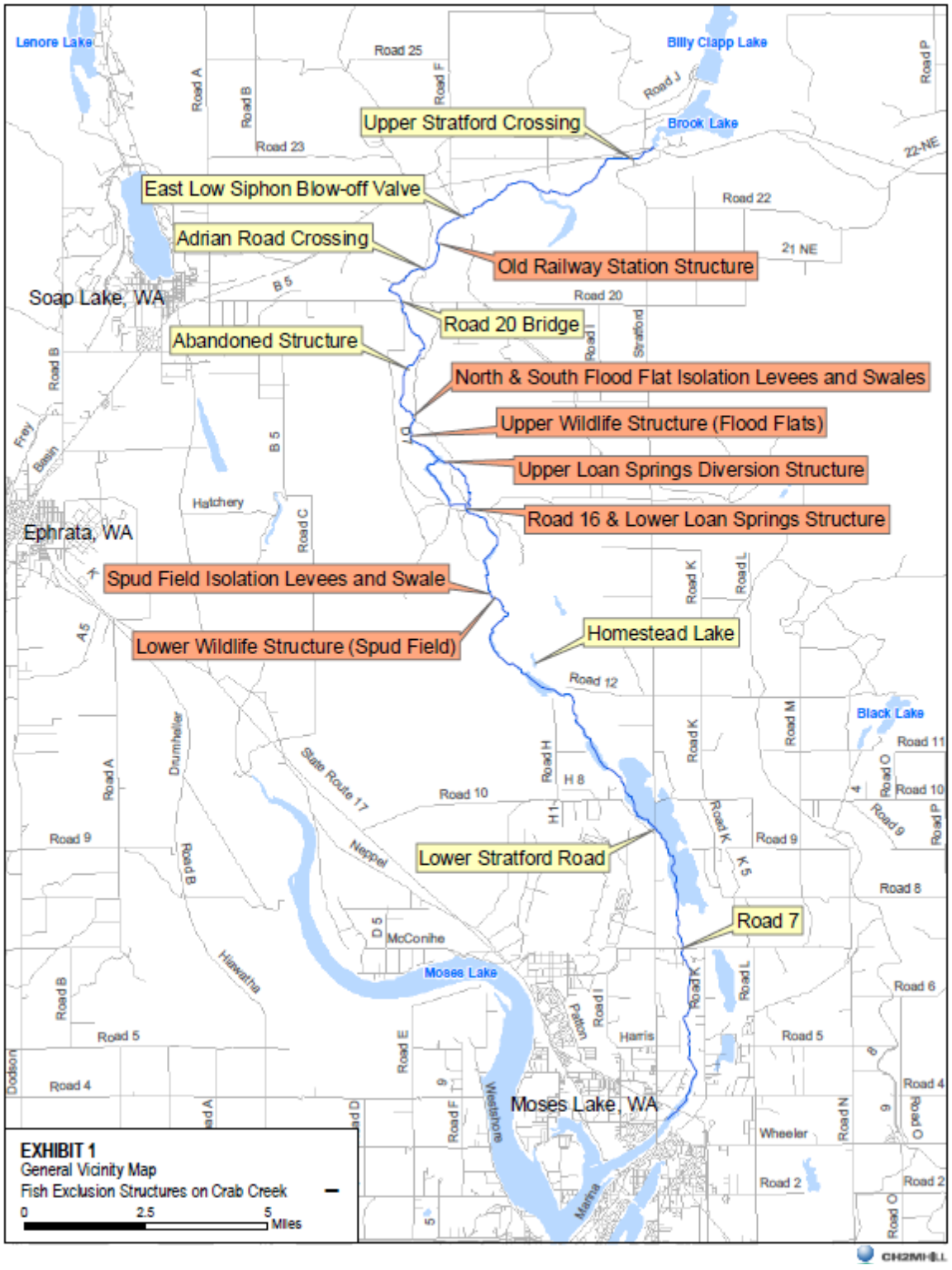
Concept Drawing Description and Exhibits

CH2M HILL prepared the pre-design for a new structure at the Lower Wildlife Structure location (Exhibit 1). The existing structure spans the full channel width of 25 feet (Exhibit 10A). The each of the two new gate openings will be approximately 10 feet wide by 3 feet tall (Exhibit 10B). Exhibit 10B depicts the conceptual drawing showing separate gates for undershot and weir flows.

Cost Estimate

The total construction cost for the Lower Wildlife Structure is $218,007. Individual line item components and the total amount are summarized in Attachment 2 – Exhibit 5. Costs include demolition and concrete as well as construction of the access road and berms.

Exhibits


Lenore Lake
Billy Clapp Lake
Brook Lake
Upper Stratford Crossing
East Low Siphon Blow-off Valve
Adrian Road Crossing
Old Railway Station Structure
Soap Lake, WA
Road 20 Bridge
Abandoned Structure
North & South Flood Flat Isolation Levees and Swales
Upper Wildlife Structure (Flood Flats)
Upper Loan Springs Diversion Structure
Road 16 & Lower Loan Springs Structure
Ephrata, WA
Spud Field Isolation Levees and Swale
Lower Wildlife Structure (Spud Field)
Homestead Lake
Lower Stratford Road
Road 7
Moses Lake, WA
Black Lake
Road 25
Road 23
Road 22
Road 20
Road 12
Road 10
Road 9
Road 8
Road 6
Road 5
Road 4
Road 2
Road 11
Road A
Road B
Road C
Road F
Road I
Road J
Road K
Road L
Road M
Road N
Road O
Road P
Stratford
Hatchery
Drumheller
State Route 17
Neppel
McConihe
Hiawatha
Dodson
Peyton
Harris
Westshore
Wheeler
Marina
B 5
A 5
D 5
H 8
H1
K 5
21 NE
22-NE
EXHIBIT 1
General Vicinity Map
Fish Exclusion Structures on Crab Creek
0
2.5
5
Miles
CH2MHILL

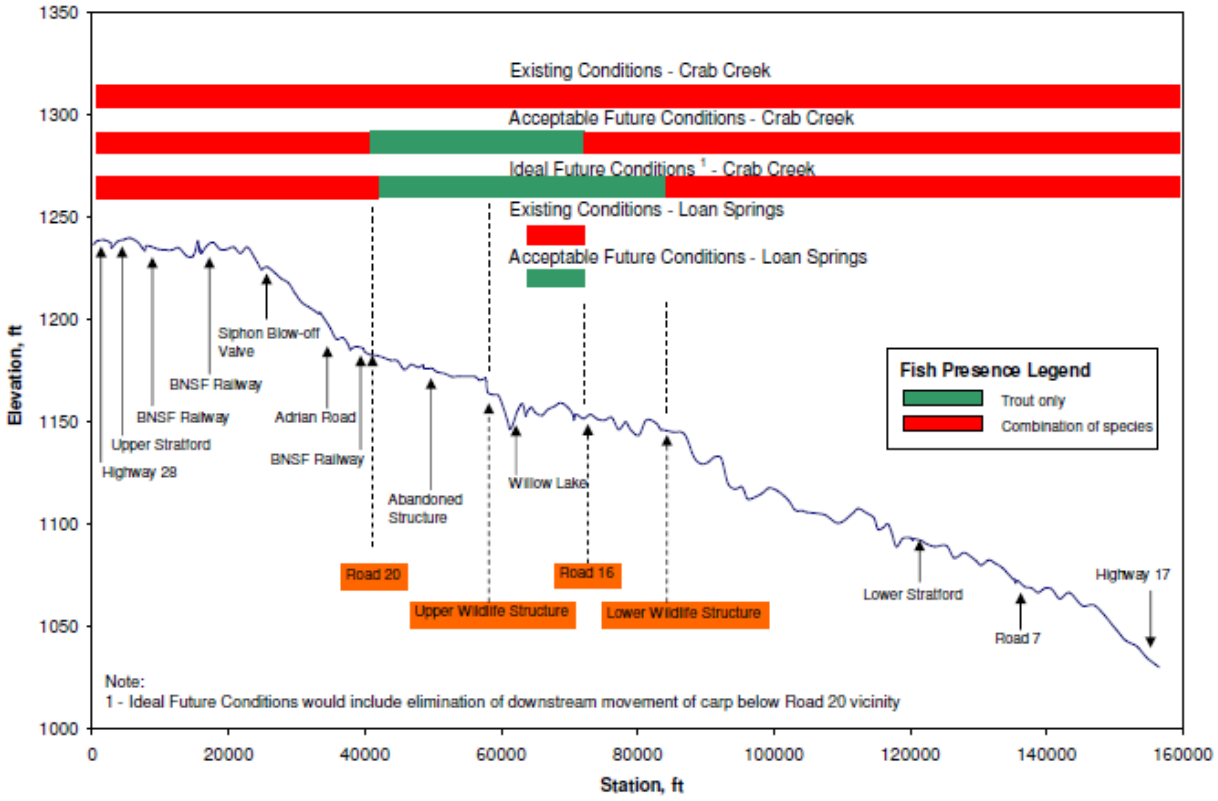
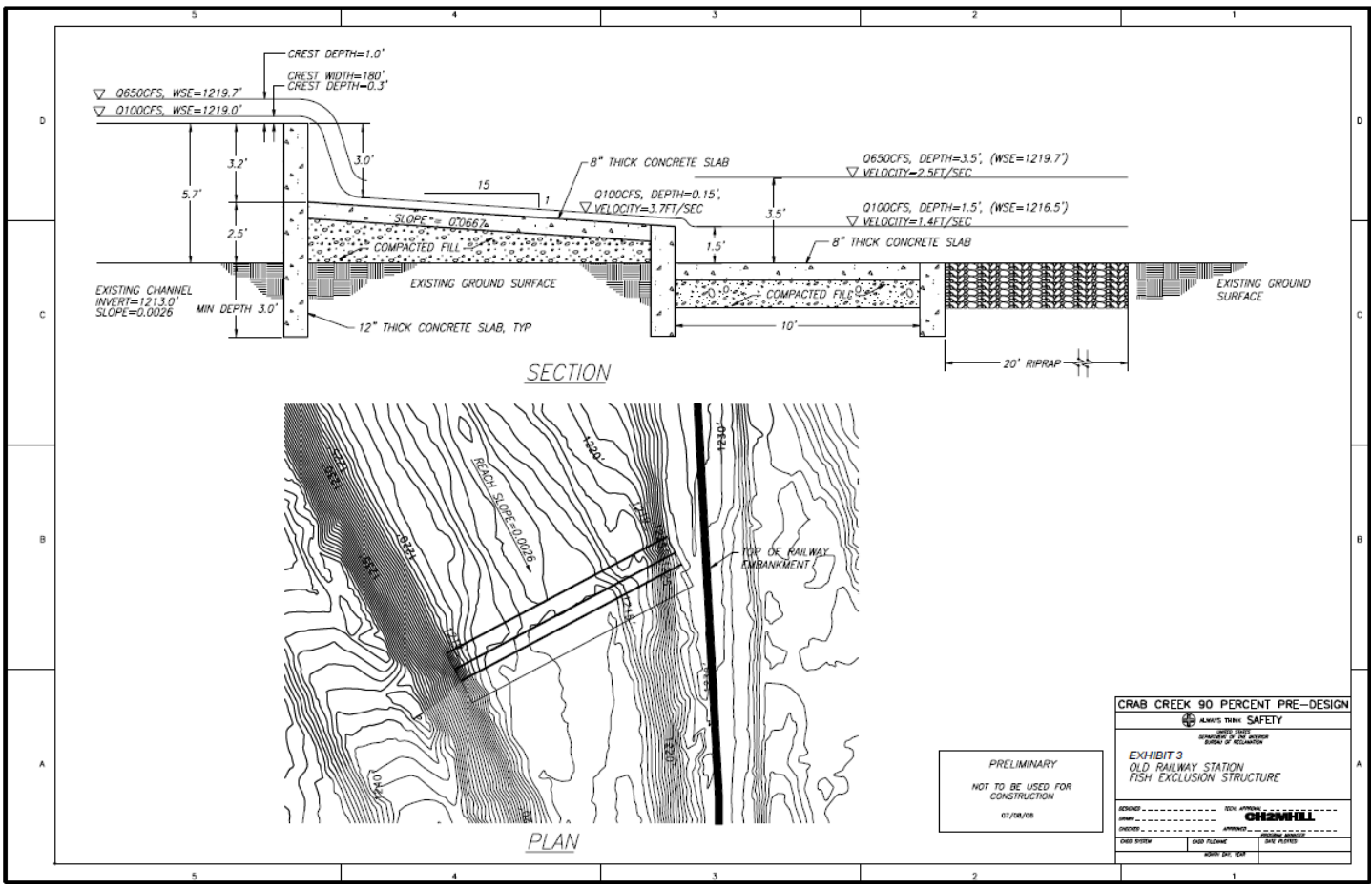
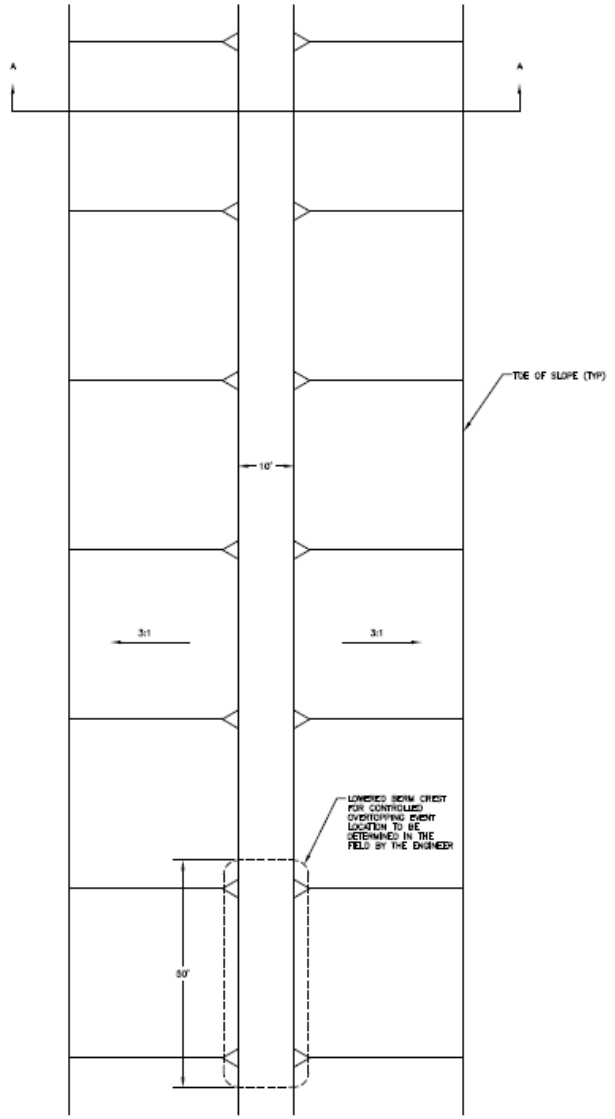
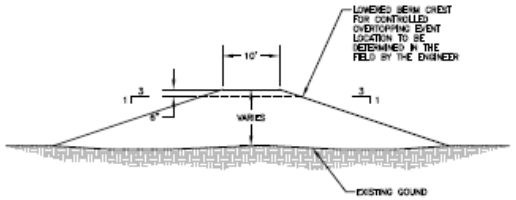


Exhibit 2
Overview of Proposed Fish Exclusion Structures on Crab Creek


CREST DEPTH=1.0'
CREST WIDTH=180'
CREST DEPTH=0.3'
Q650CFS, WSE=1219.7'
Q100CFS, WSE=1219.0'
3.2'
3.0'
5.7'
2.5'
15
1
8" THICK CONCRETE SLAB
Q100CFS, DEPTH=0.15',
VELOCITY=3.7FT/SEC
SLOPE = 0.0667
COMPACTED FILL
EXISTING CHANNEL
INVERT=1213.0'
SLOPE=0.0026
MIN DEPTH 3.0'
EXISTING GROUND SURFACE
12" THICK CONCRETE SLAB, TYP
Q650CFS, DEPTH=3.5', (WSE=1219.7')
VELOCITY=2.5FT/SEC
3.5'
Q100CFS, DEPTH=1.5', (WSE=1216.5')
VELOCITY=1.4FT/SEC
1.5'
8" THICK CONCRETE SLAB
COMPACTED FILL
10'
20' RIPRAP
EXISTING GROUND SURFACE
SECTION
1220'
1230'
REACH SLOPE=0.0026
TOP OF RAILWAY EMBANKMENT
PLAN
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION
07/08/08
CRAB CREEK 90 PERCENT PRE-DESIGN
ALWAYS THINK SAFETY
EXHIBIT 3
OLD RAILWAY STATION
FISH EXCLUSION STRUCTURE
CH2MHILL





PRELIMINARY

NOT TO BE USED FOR CONSTRUCTION

07/08/08

CRAB CREEK 90 PERCENT PRE-DESIGN

ALWAYS THINK SAFETY

UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION
POTHOLES SUPPLEMENTAL FEED ROUTE STUDY

CRAB CREEK IMPROVEMENTS

SUBFEATURE

EXHIBIT 4

TYPICAL ISOLATION BERM DETAILS

DESIGNED

DRAWN

CHECKED

DSN APPROVAL

APPROVED

CH2MHILL

PROGRAM MANAGER

CAD SYSTEM

CAD FILENAME

DATE PLOTTED

ROYAL CITY, WASHINGTON

WORK ORD. YEAR

SHEET OF

XXXX-155-XXX

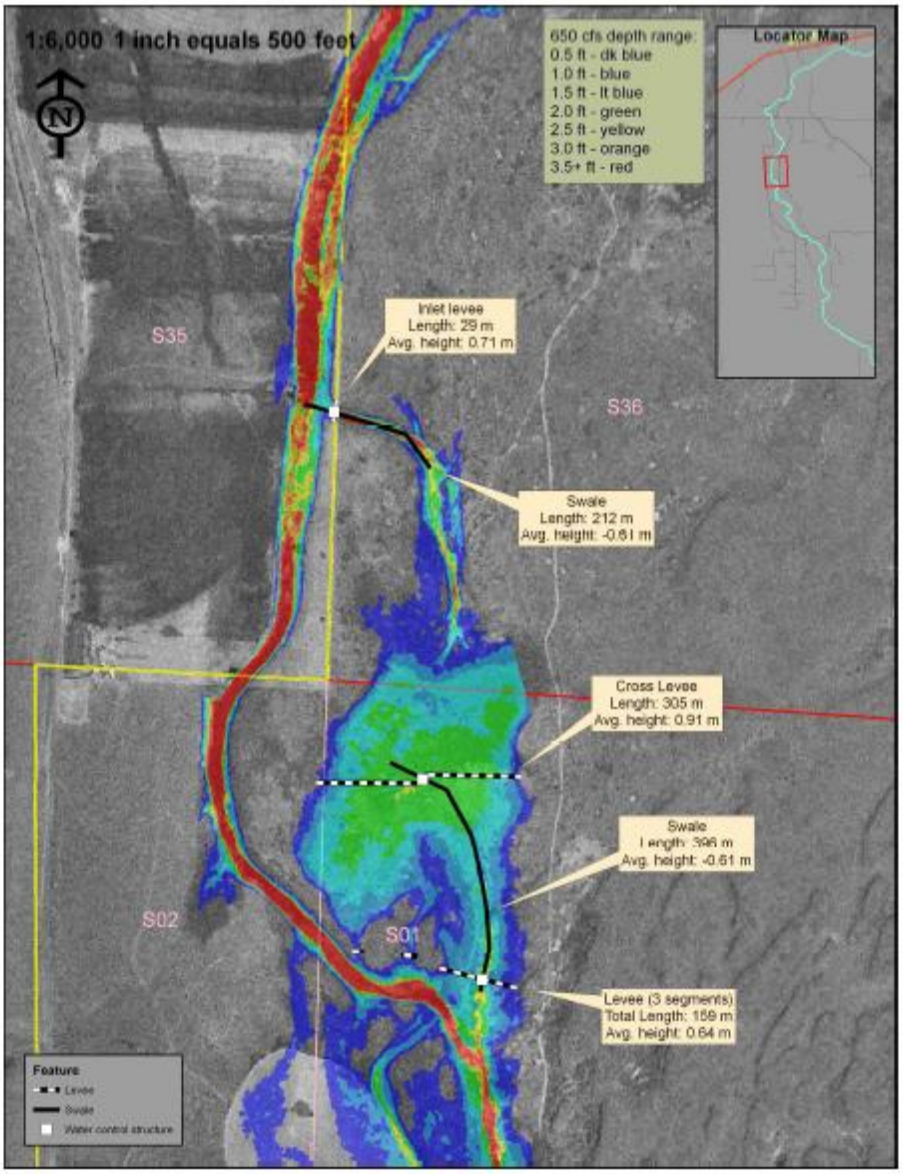


EXHIBIT 5A
North Flood Flat Isolation from Crab Creek channel

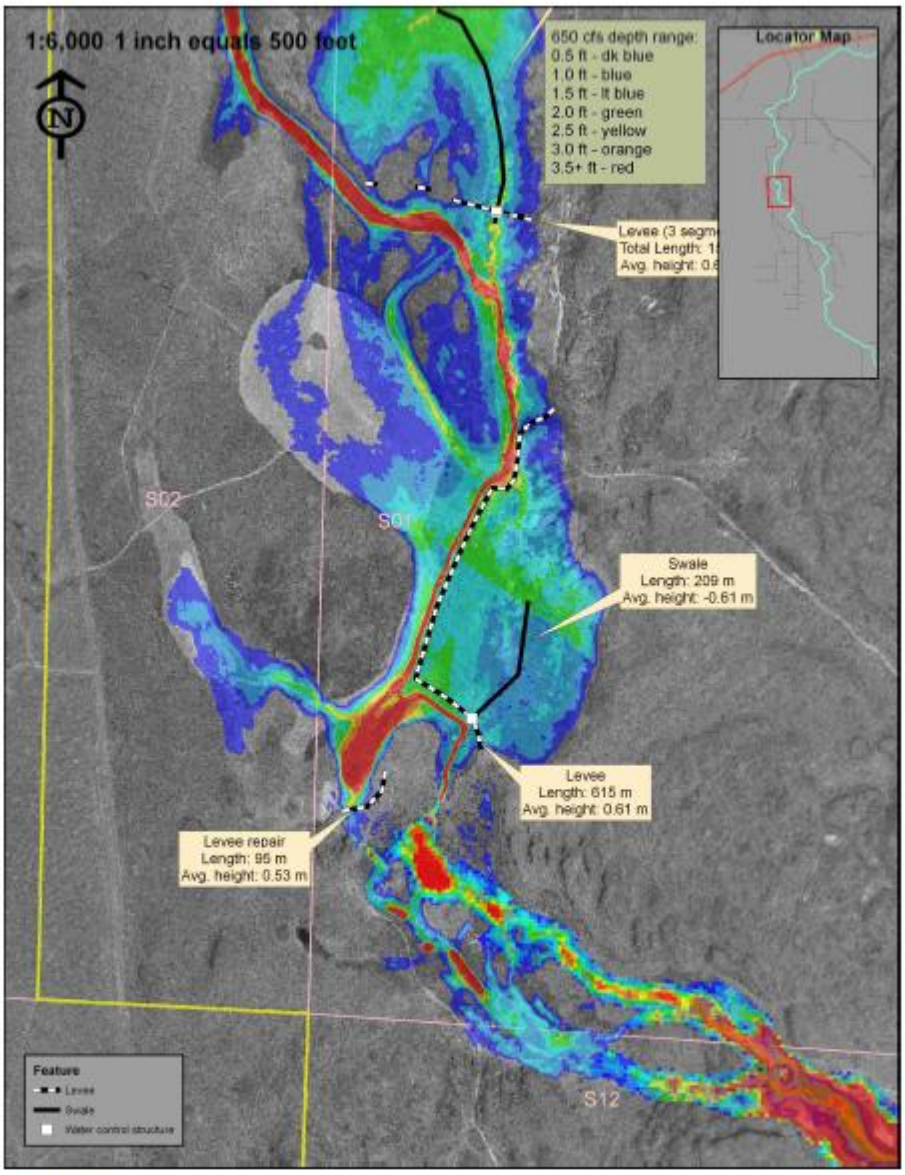


EXHIBIT 5B
South Flood Flat Isolation from Crab Creek channel

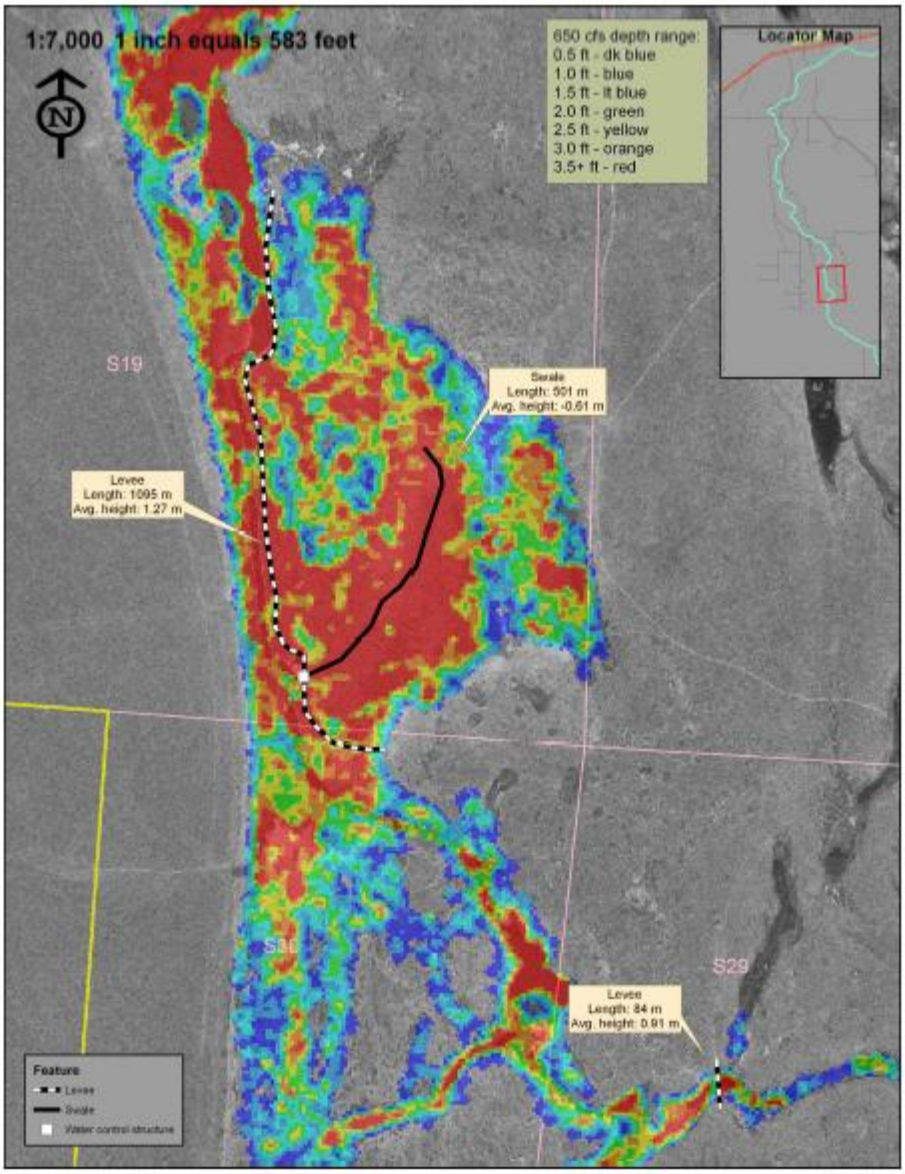
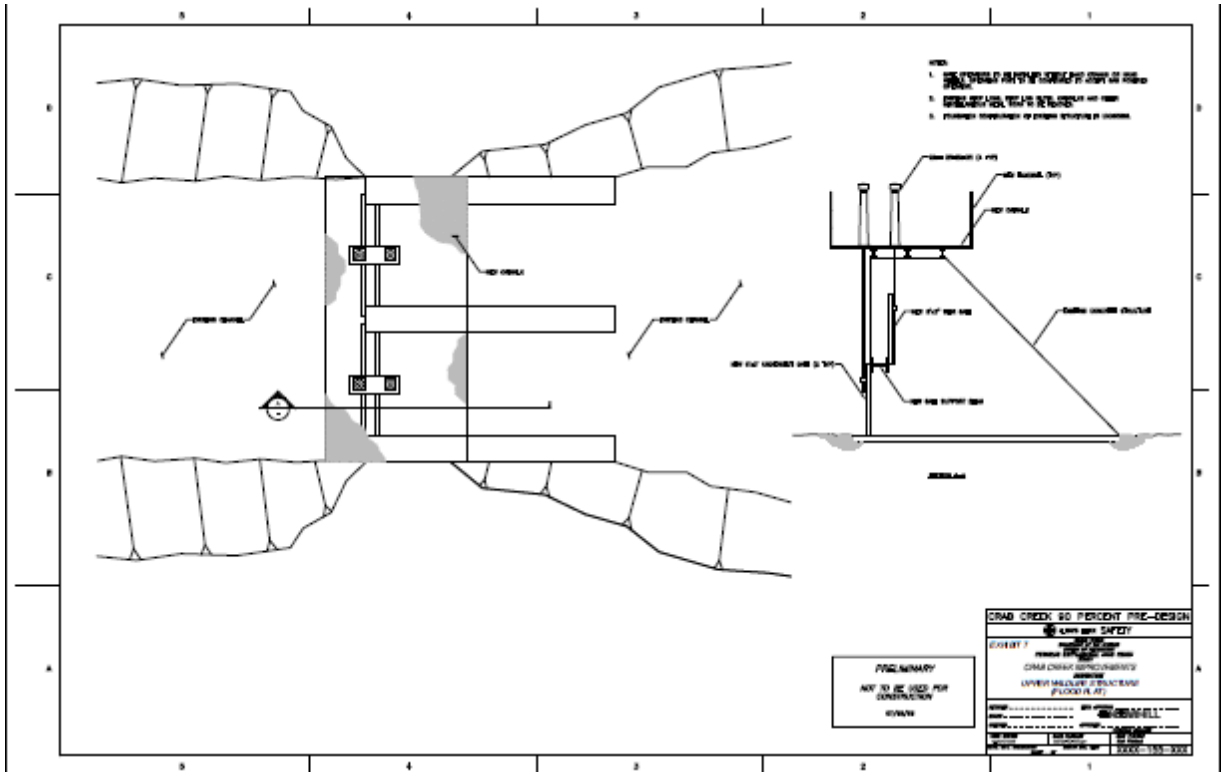
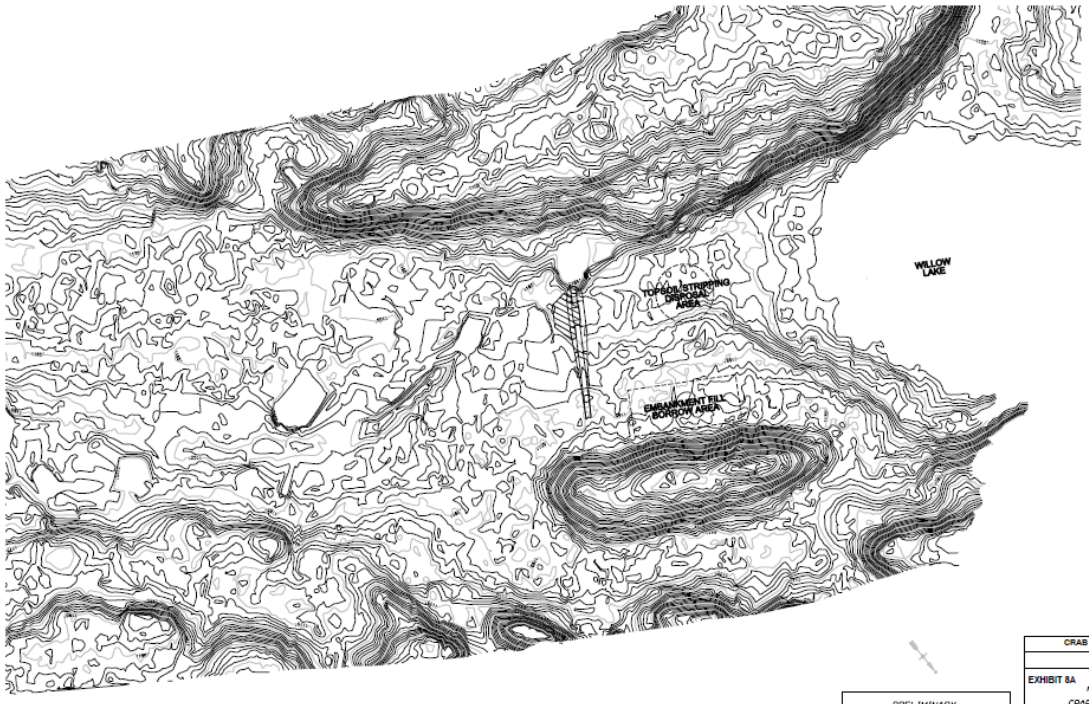


EXHIBIT 5C
Spud Field Isolation from Crab Creek channel

	North Flood Flat					South Flood Flat			Spud Field		
	Inlet	Outlets	Cross	Upper	Lower	Repair	Isolation	Swale	Spud Field	Homestead	Upper
Structure Type	berm	berm	berm	swale	swale	berm	berm	swale	berm	berm	swale
Length (ft)	95	522	1,000	696	1,122	312	2,018	686	3,593	276	1,644
Height (ft)	2.3	2.1	3.0	2.0	2.0	1.7	2.0	2.0	4.2	3.0	2.0
Shape	Trapz	Trapz	Trapz	V	V	Trapz	Trapz	V	Trapz	Trapz	V
Top Width (ft)	10	10	10	na	na	10	10	na	10	10	na
Side Slope	3 : 1	3 : 1	3 : 1	3 : 1	3 : 1	3 : 1	3 : 1	3 : 1	3 : 1	3 : 1	3 : 1
Fill (berms) (cu yd)	140	662	2,098	na	na	306	2,395	na	12,478	578	na
Exc. (swales) (cu yd)	na	na	na	507	819	na	na	500	na	na	1,199
Balance by Location											
Fill (cu yd)			2,900				2,700			13,100	
Cut (cu yd)			1,300				500			1,200	
Fill Balance (cu yd)			1,600				2,200			11,900	

EXHIBIT 6
Cut and Fill Calculations Based Upon Details Provided by WDFW


PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION
CRAB CREEK 90 PERCENT PRE-DESIGN
SAFETY
EXHIBIT 7
CRAB CREEK IMPROVEMENTS
UPPER MEADOW STRUCTURE
(FLOOD PLAT)



PRELIMINARY

NOT TO BE USED FOR CONSTRUCTION

MO/DY/YR

CRAB CREEK 90 PERCENT PRE-DESIGN

ALWAYS THINK SAFETY

EXHIBIT 8A

UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION YAKIMA SUPPLEMENTAL FEED ROUTE STUDY

CRAB CREEK IMPROVEMENTS

SUBFEATURE

UPPER LOAN SPRINGS DIVERSION STRUCTURE

DESIGNED

DRAWN

CHECKED

TECH. APPROVAL

APPROVED

CH2MHILL

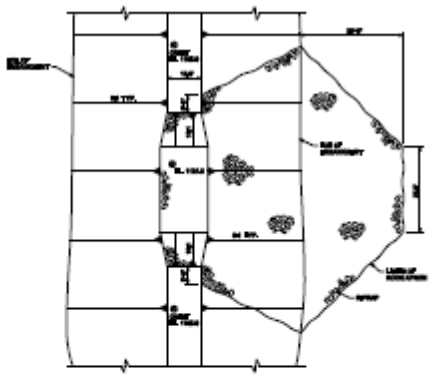
PROJECT NUMBER

CADD SYSTEM

CADD FILENAME

DWG PLOTTED

XXXX-155-XXX



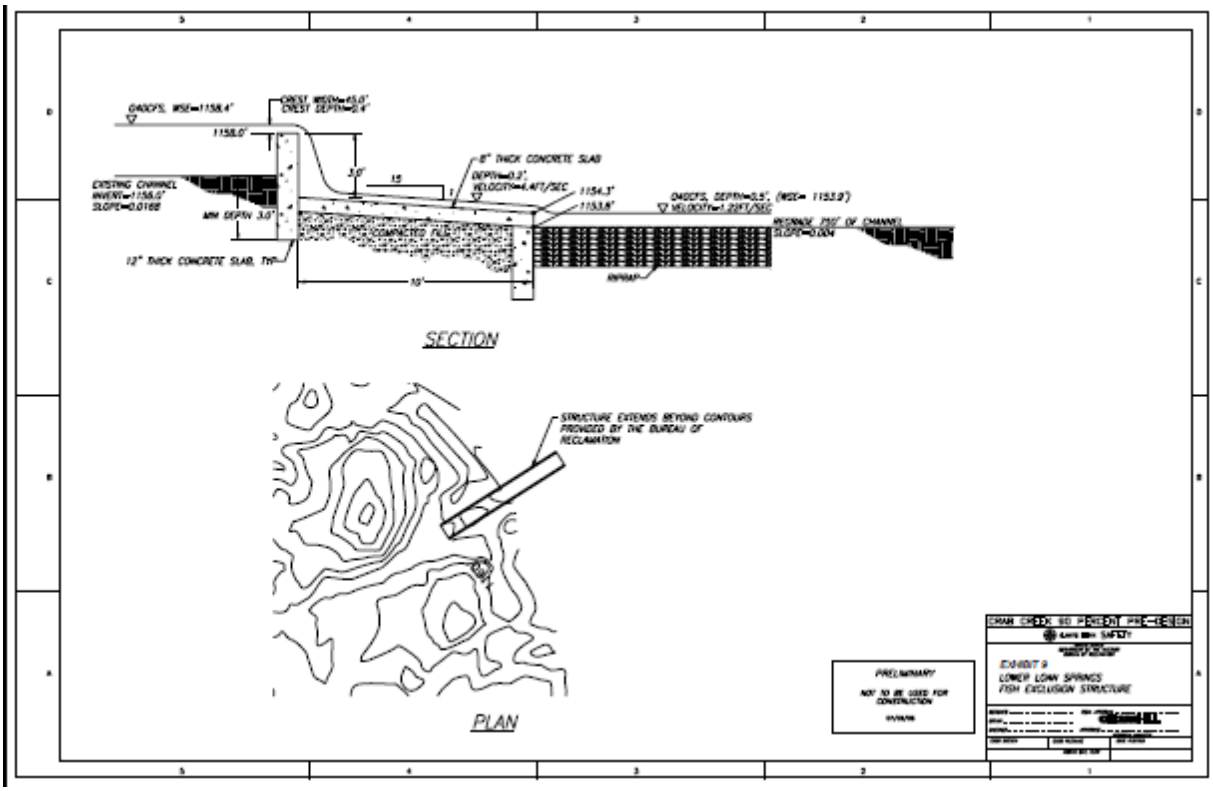
ROCK APRON OVERFLOW DETAIL

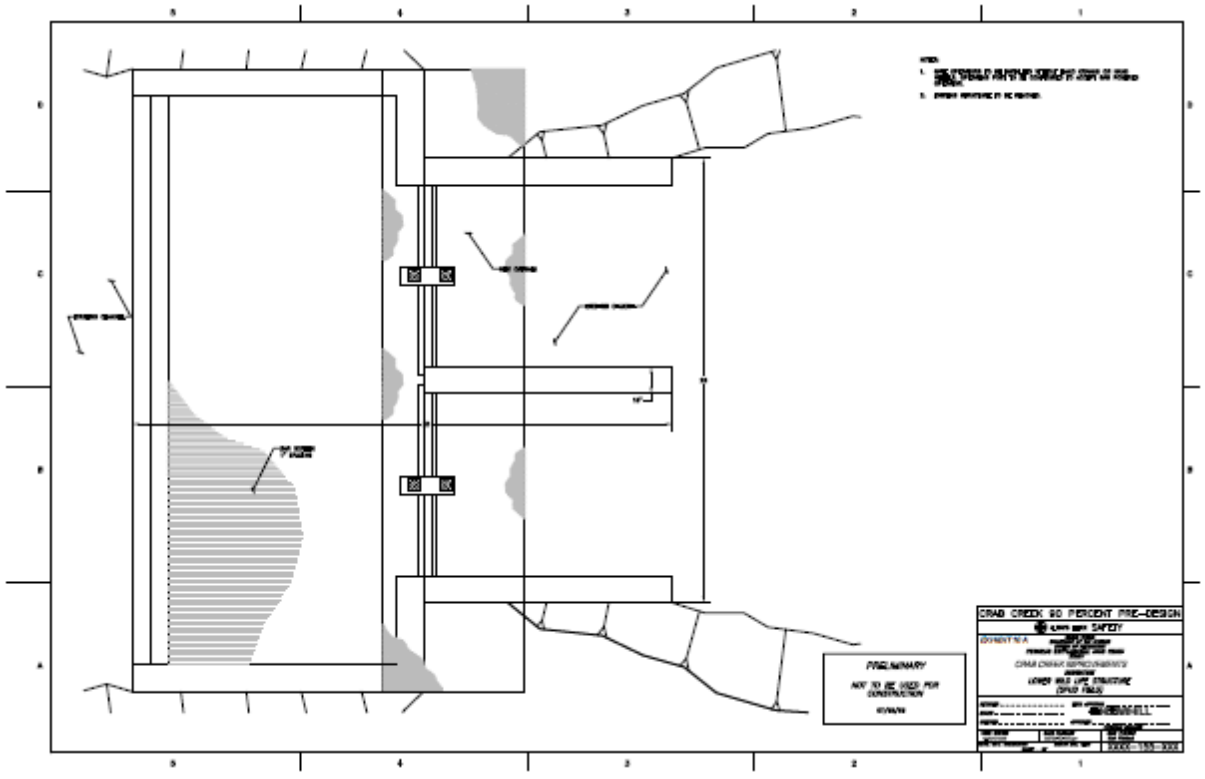
TYPICAL SECTION

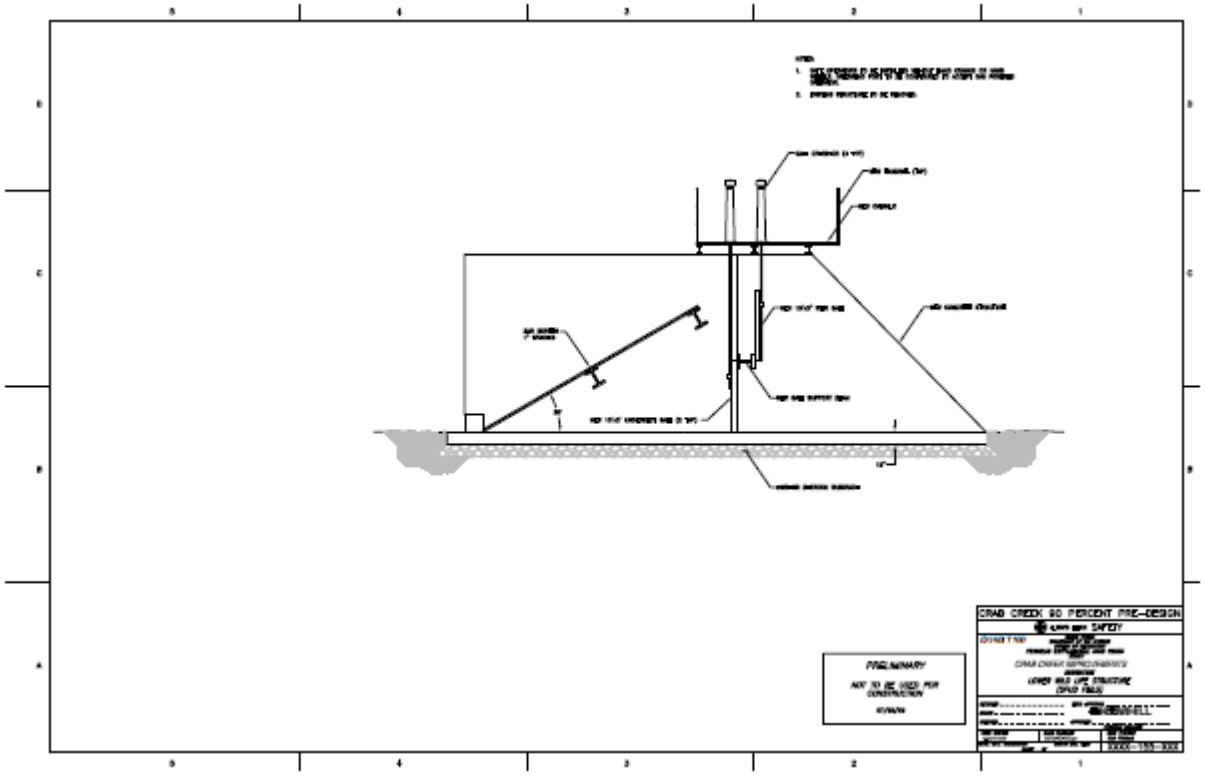
UPPER LOAN SPRINGS FISH PASSAGE BARRIER
TYPICAL SECTION & DETAILS

EXHIBIT 8B

348226.04.01


CHECK BEFORE PRE-DRILLING
SAFETY
EXHIBIT 9
LOWER LOAN SPRINGS
FISH EXCLUSION STRUCTURE
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION
SECTION
PLAN
STRUCTURE EXTENDS BEYOND CONTOURS PROVIDED BY THE BUREAU OF RECLAMATION
8" THICK CONCRETE SLAB
12" THICK CONCRETE SLAB, TYP.
COMPACTED FILL
EXISTING CHANNEL
RIPRAP


PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION
CRAB CREEK 90 PERCENT PRE-DESIGN
SAFETY



PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION
01/04/05

CRAB CREEK 90 PERCENT PRE-DESIGN
SAFETY
CRAB CREEK IMPROVEMENTS
LOWER MID LIFE STRUCTURE
(SPUD PILE)