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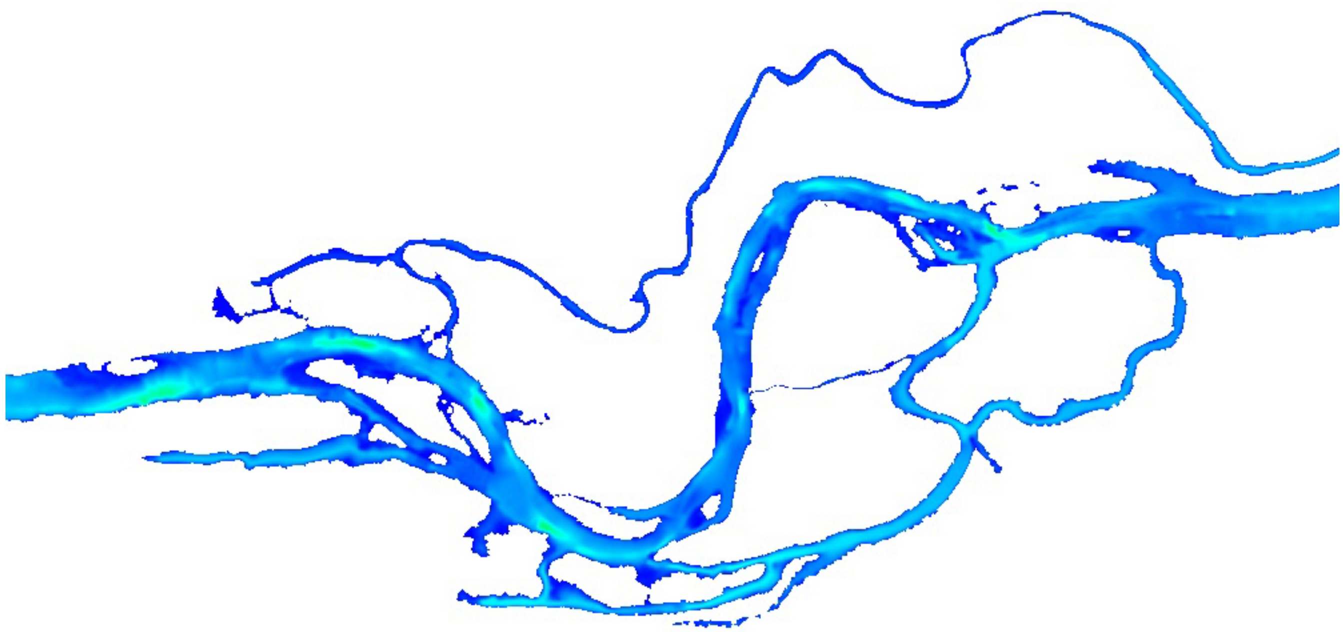
# Proposed Rehabilitation for the Schaake Reach of the Yakima River, Washington

**Yakima River Basin Water Enhancement Project**

**Pacific Northwest Region**



**U.S. Department of the Interior**
**Bureau of Reclamation**

**March 2007**

# Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

# Proposed Rehabilitation for the Schaake Reach of the Yakima River, Washington

## Yakima River Basin Water Enhancement Project

## Pacific Northwest Region


*By*

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**Peer reviewed by**

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Bureau of Reclamation
Technical Service Center
Water Resources Division
Sedimentation and River Hydraulics Group
Denver, Colorado

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# Executive Summary

Levee setback and side channel construction has been proposed for the former Schaake property, currently owned by the Bureau of Reclamation. This is the third report addressing rehabilitation on this property. The first report (Hilldale and Klinger, 2003) was an interim report addressing the feasibility and rehabilitation potential of the Schaake reach. The second report (Hilldale, 2004) detailed the results of a two-dimensional (2-D) modeling effort exploring three levee removal/setback scenarios and a series of proposed side channels on the floodplain of the Schaake property. The current report addresses setting back the levee on the Schaake property while maintaining the existing conditions of all right bank levees. Moreover, some locations of proposed side channels have changed since the last report due to results of a soil phosphorous study.

Analysis of modeled hydraulic properties following the levee setback on the Schaake property indicate a decrease in flow depth and an increase in flow velocity when compared to existing conditions at the area of greatest concern, which is the location where the Yakima River is nearest Interstate 90. Some procedures are suggested in this report that address potential channel migration in this area. Shear stress values in this portion of the reach do not change significantly after the modification.

The proposed side channels comprise greater than 4,000 linear feet of new habitat and reinvigorate approximately 3,800 feet of existing side channels, creating a total of 1.5 miles of new or improved habitat. Currently the reinvigorated side channels are primarily supplied by ground water and experience little or no surface water connection throughout most of the year. None of the proposed side channels have a surface connection with the main channel at discharges less than 1,000 $ft^3/s$, although it is expected that these channels will have some interaction with the water table. A brief sediment transport analysis was performed for the proposed side channels using modeled shear stress values and the Shields criterion. This analysis shows that a large majority of the side channels will not accumulate sediment finer than one millimeter.

The setback of the left levee and addition of side channels along this reach of the Yakima River will increase channel/floodplain interaction, improving the overall habitat of the river. Additional side channels will provide an increase in available habitat, the type of which is thought to be beneficial to salmonid productivity. The prevailing conclusions in the literature support the increase of side channel habitat where warranted, although there are opinions that counter this thought.

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# Acknowledgments

The Bureau of Reclamation Yakima River Basin Water Enhancement Project (YRBWEP) provided funding and support for this project. Jeff Graham of YRBWEP is serving as Study Manager in Yakima. Robert Hilldale from the Bureau of Reclamation Technical Services Center (TSC), Sedimentation and River Hydraulics Group in Denver is serving as the TSC Study Team Leader and developed the results and conclusions presented in this report. Ronald Ferrari of the Sedimentation and River Hydraulics Group contributed tremendous support for the bathymetry survey of the Yakima River using GPS and depth sounding equipment. Thanks to Steve Croci and Jeff Graham for assistance during the river survey. Kurt Willie of the TSC Remote Sensing and Geographic Information Group provided computer routines that aided in the final production of the bathymetry and topography. Steven Fanciullo of YRBWEP provided the flow records from the Ellensburg gage and 1912 maps of the study site. Aerial LiDAR and infra-red photography was provided by Ed Young of the Upper Columbia Area Office.

# Introduction

This is the third report submitted to the Yakima River Basin Water Enhancement Project (YRBWEP) addressing the setback of levees and creation of side channels on the Schaake property near Ellensburg, WA. The first report (Hilldale and Klinger, 2003) was an interim report addressing the feasibility and rehabilitation potential of the Schaake reach. The second report (Hilldale, 2004) detailed the results of a two-dimensional (2-D) modeling effort exploring three levee removal/setback scenarios and a series of proposed side channels on the floodplain of the Schaake property. During the summer of 2006, YRBWEP requested that further modeling be done; 1) to include what has been referred to in the previous modeling report (Hilldale, 2004) as right levee number 1 (Figure 1), and 2) to investigate alternatives for selected side channel locations due to elevated levels of phosphorous contamination reported in Small (2006). Previous modeling efforts removed right levee number 1 under all but the existing scenario. Since the 2004 report was written it has been learned that right levee number 1 can not be removed due to the lack of cooperation from a private landowner,

The Schaake reach of the Yakima River (Figure 1) has a series of levees on both sides of the river, five within the study reach. The presence of these levees has confined the river and prevented regular interaction between the river and the floodplain. This has caused some incision of the river channel and a coarsening of the bed material in this reach (Hilldale and Klinger, 2003). The disconnection of the floodplain from the river has significantly decreased the ability of the river to build and maintain side channel habitat critical to the existence of salmonid fish species in the Yakima River Basin (Ring and Watson, 1999, Stanford et al., 2002). Side channel habitat is beneficial to fish attempting to escape high velocities during flood events and provides rearing habitat throughout the year for juvenile fish. These side channels may also provide spawning habitat. Food is typically more abundant in side channels due to increased vegetative cover and reduced flow velocities.

The current report details the modeling results for moving left levee #1 from its existing location (Figure 1 A) to the setback location (Figure 1 B) while maintaining the existing alignment of right levee #1 and all other levees. The primary difference regarding levee scenarios from the 2004 report is that right levee #1 and all other right bank levees remain intact. This report also details modeling results of newly proposed side channel locations (Figure 2) that differ from the previous report (Hilldale, 2004).

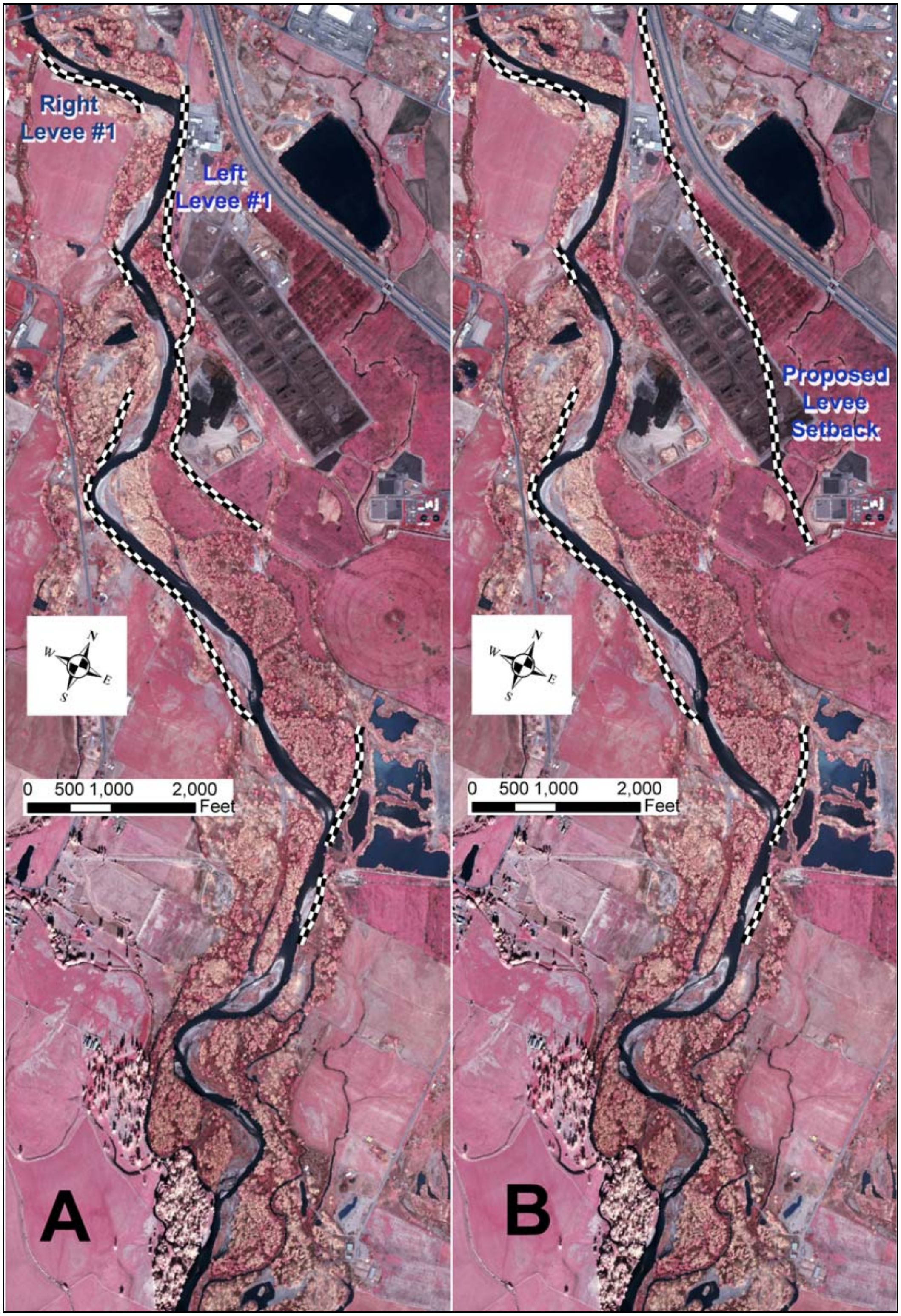


*Figure 1: False color IR aerial photograph of the study site showing the existing levee configuration (A) and the proposed levee alignment (B). Flow direction is top to bottom of the figure.*

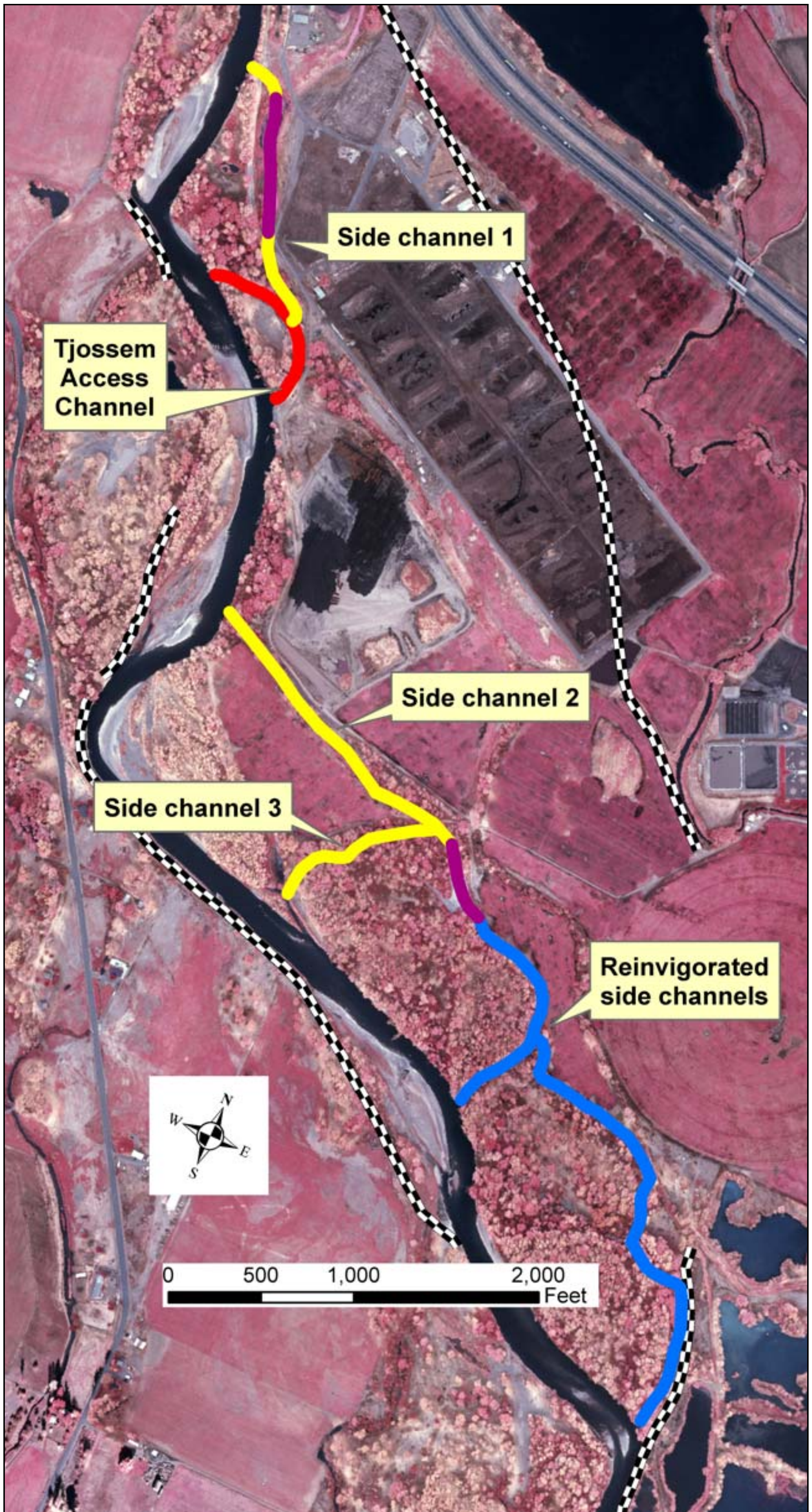


*Figure 2: False color IR aerial photograph showing the proposed side channels. Yellow indicates newly wetted side channels, purple indicates existing ponds connected to side channels and blue indicates reinvigorated side channels. Flow direction is from top to bottom of the figure.*

# Modeling Specifics

## Model Mesh

The present 2-D hydraulic modeling was performed with GSTAR-W (Generalized Sediment Transport for Alluvial Rivers and Watersheds, available at www.usbr.gov/pmts/sediment) (Lai, 2006). This model allows the formation of a combined structured and unstructured mesh, as opposed to a Cartesian mesh required by MIKE-21 (www.dhiwae.com), used previously. An unstructured mesh has the ability to match the river planform and adapt varying mesh resolutions as needed (Figure 3). All mesh construction was performed with Surface-Water Modeling System (SMS, www.scisoftware.com) and imported to GSTAR-W.

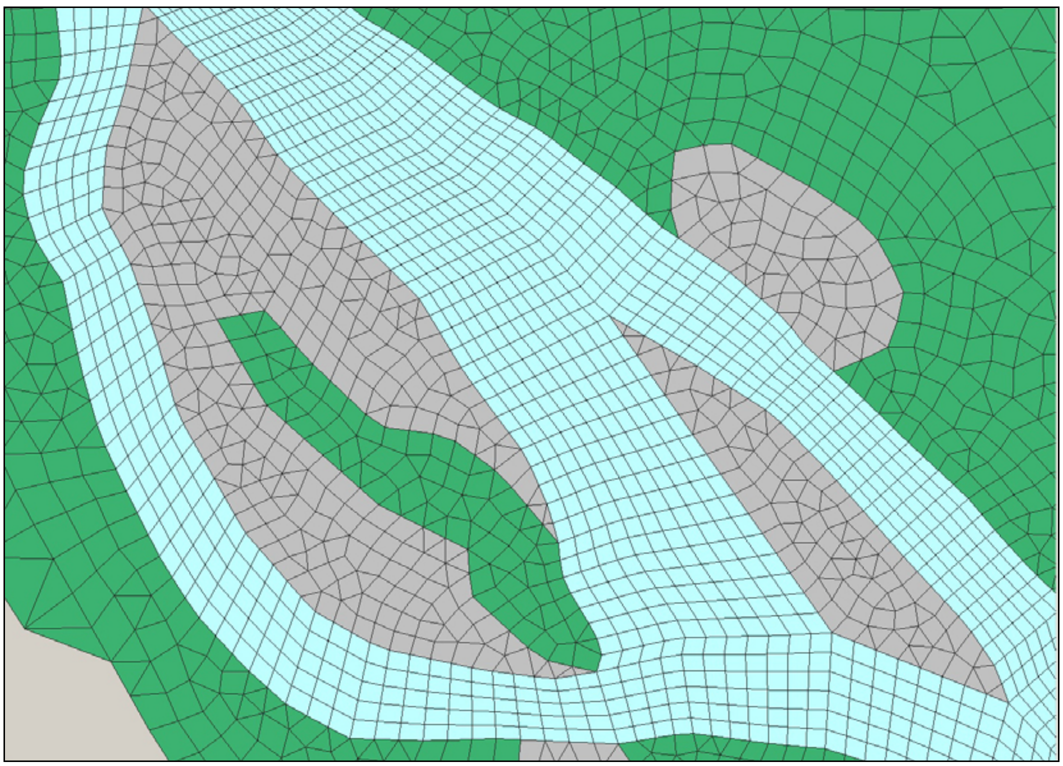

*Figure 3: Example of structured and unstructured mesh. Colors represent different roughness values. Note the structured quadrilateral elements representing the channel and a combination of quadrilateral and trilateral unstructured elements representing the floodplain. Also note the finer resolution within and near the channel and coarser resolution toward the edges of the mesh.*

Typical dimensions for mesh cells representing the main channel are 6 ft. X 10 ft. with the long dimension coincident with the longitudinal direction. Mesh cells representing the floodplain begin at this cell size and increase with increasing distance from the channel. Mesh cells in the side channels are often smaller than the main channel in order to force multiple cells across a narrow channel width.

## Bathymetry

In addition to terrestrial LiDAR flown in November, 2000, a bathymetric survey was performed in August, 2003 using a raft mounted single beam SONAR in conjunction with Real Time Kinematic Global Positioning System (RTK GPS) survey equipment (Hilldale, 2004). Since this survey additional surveys have been completed to define some of the ditches on and near the property. These include Tjossem ditch, the Tjossem access ditch, proposed side channel #2 and portions of the side channel outlined in blue in Figure 2. All this information was used to create a modeling surface for input to the 2-D model.

## Model Verification

The model was run for a range of discharges (Table 1). This model was verified using water surface elevations obtained during the bathymetric survey, for which the discharge of the Yakima River was 3,150 $ft^3/s$, as measured at the Ellensburg Gage (ELNW) located approximately 2.7 miles upstream of the property. The comparison of the surveyed and modeled water surface elevations are shown in Figure 4. At the upstream end of the reach potential errors may exist in the survey due to extended loss of satellite and radio reception as the raft passed under the Umptanum Road Bridge. After passing under the bridge the equipment would take a few minutes to reacquire an accurate position. Because the raft was moving during this reacquisition the GPS survey was less accurate for some distance downstream of the bridge. The error in this portion of the reach prompted the replacement of the raft-surveyed bathymetric data with aerial surveyed bathymetric data using water penetrating LiDAR (Hilldale and Raff, 2007). The other locations where disagreement exists between modeled and surveyed water surface elevations in Figure 4 B are locations where there was a brief loss of GPS acquisition due to riparian vegetation interfering with satellite reception. These errors exist for short distances and do not represent significant concern regarding the model results.

*Table 1: Modeled discharges*.*

| **Discharge ($ft^3/s$)** | 600 | 1000 | 2000 | 3150 | 4000 | 5700 | 10000 | 13900 | 18400 | 25000 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Return Period** | N/A | N/A | N/A | N/A | N/A | 2-yr | 5-yr | 10-yr | 20-yr | N/A |

*For more discussion regarding the return period refer to Hilldale (2004).

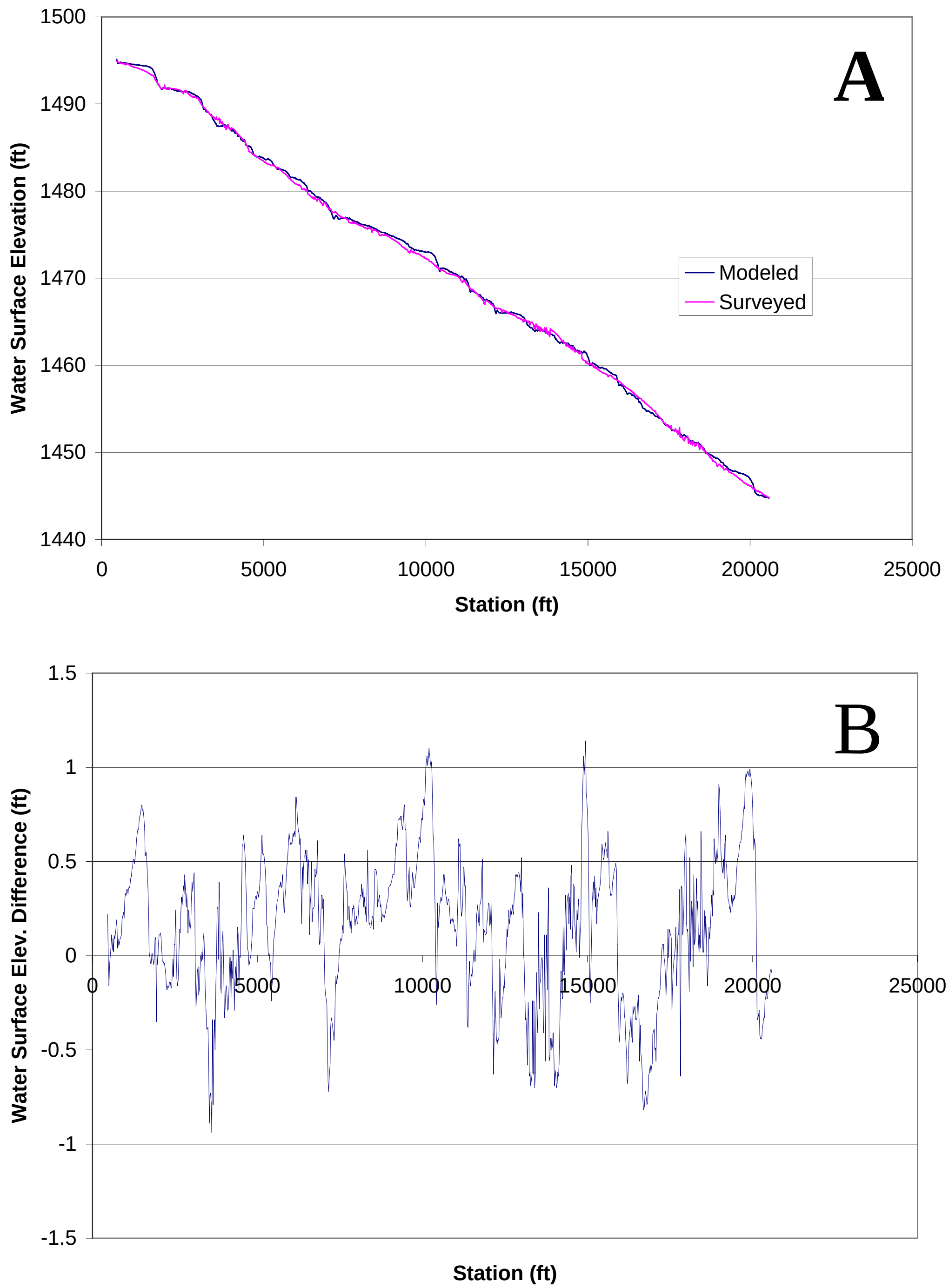


*Figure 4: Comparison of the modeled and surveyed water surface elevations (A), and difference between modeled and surveyed water surface elevations (B). The surveyed value was subtracted from the modeled value.*

# Modification of the Modeling Surface

## Removal of Left Levee #1

After all flows were modeled with the existing topography and levee configuration, proposed modifications were incorporated into the modeling surface. Left levee #1 was removed in such a way that existing ground elevations on both sides of the levee were used to determine the new ground elevation where the levee had existed in the original modeling surface. This anticipates the physical levee removal will occur in a similar fashion. The existing and proposed alignments are shown in Figure 1 and Figure 2.

## Side Channels

Proposed side channel widths were set to approximately 15 feet, with the expectation that the channels will determine their own width and side slope as they develop over time. These morphological adjustments may result in increased discharges through the side channels compared to the modeled discharge. The side channels downstream of the Schaake reach are on the order of 25 to 30 feet wide and carry greater discharges than the proposed side channels for a common main channel discharge. If warranted, engineering measures can be taken to limit erosion at the inlet of the side channel(s) which, over time, will maintain a more constant discharge into the side channel for a specific main channel discharge.

### *Side Channel #1*

Side channel #1 is approximately 1,485 feet in length (Figure 2). The inlet and outlet invert elevations of side channel #1 were set at an elevation equal to one foot beneath the water surface elevation for a main channel discharge of 1,000 $ft^3/s$. This channel flows into and out of an existing pond on the property. This pond has a long and narrow configuration and is approximately 2 to 3 feet deep (Philip Small, pers. comm.). The intent behind such a configuration is to add complexity in the channel while reducing the excavation cost and level of disturbance to the site. Side channel #1 also flows into an existing slough that is situated between the current levee and the Tjossem access ditch. Existing vegetation along side channel #1 precludes the need for planting of the riparian areas in this channel. Constructing side channels in the currently proposed locations is favorable with respect to phosphorous levels (Small, 2006).

### *Side Channel #2*

Side channel #2 is approximately 1,650 feet in length (Figure 2). The invert elevation for side channel #2 was based on the elevation of the existing dry ditch through which side channel #2 flows. This location currently supports mature cottonwood and willow of varying age. There will be no need to vegetate the banks of this side channel to provide stability and shade. The channel is currently dry throughout its length with the exception of approximately 350 feet at the downstream end, which is fed by groundwater. Phosphorous levels in this area are very low (Small, 2006).

***Side Channel #3***
Side channel #3 is approximately 945 feet long and connects side channel #2 to the main channel (Figure 2). This channel has a lower slope than the other side channels, which may present the possibility of aggradation. This poses two potential problems; 1) the channel could become ineffective at lower discharges in side channel #2 due to excessive aggradation, and 2) if fine sediment accumulates in this channel, the growth of macrophytes could be promoted, starving the water of oxygen during no/low flow periods. Although the soil in the vicinity of side channel #3 was not tested, it is not expected that this area has elevated levels of phosphorous. The area is forested and was not subjected to activities related to the stockyard or direct spraying of vegetable production waste.

***Reinvigorated Side Channels***
Downstream of side channel #2 is an existing pond of unknown depth (Figure 2). It is proposed that this pond be connected to side channel #2 in such a way that flow from side channel #2 can be connected to existing side channels that currently experience little or no surface water interaction, depending on the main channel discharge. These channels combine to form a total of approximately 3,800 linear feet. Currently, these channels are primarily fed by groundwater. These side channels are expected to increase the overall habitat potential with additional surface water flow.

# Modeling Results

## Left Levee #1 and Vicinity

The area of greatest concern with respect to the removal of left levee #1 is the 90 degree bend in the river near the north end of the Schaake property (Figure *5*). This is also the reach of greatest change in hydraulic conditions with respect to the removal of left levee #1. In addition to plan-view results, it is instructive to show changes in depth and velocity in graphical form. For this reason, Figure *5* shows stationing along the reach, which only has significance for location reference. Station zero begins at the upstream end of the model.

The centerline flow depth and velocity for the 25,000 $ft^3/s$ discharge along this reach is graphed in Figure 6 A and B. It can be seen that the flow depth decreases following the setback of left levee #1, however the main channel velocity increases. The velocity increase is contrary to previous findings when left levee #1 was set back and right levee #1 was removed (Hilldale, 2004). This increase in velocity is likely due to the lack of flow attenuation on the right floodplain with right levee #1 in place. Modeling results are shown in plan-view in Appendix A.

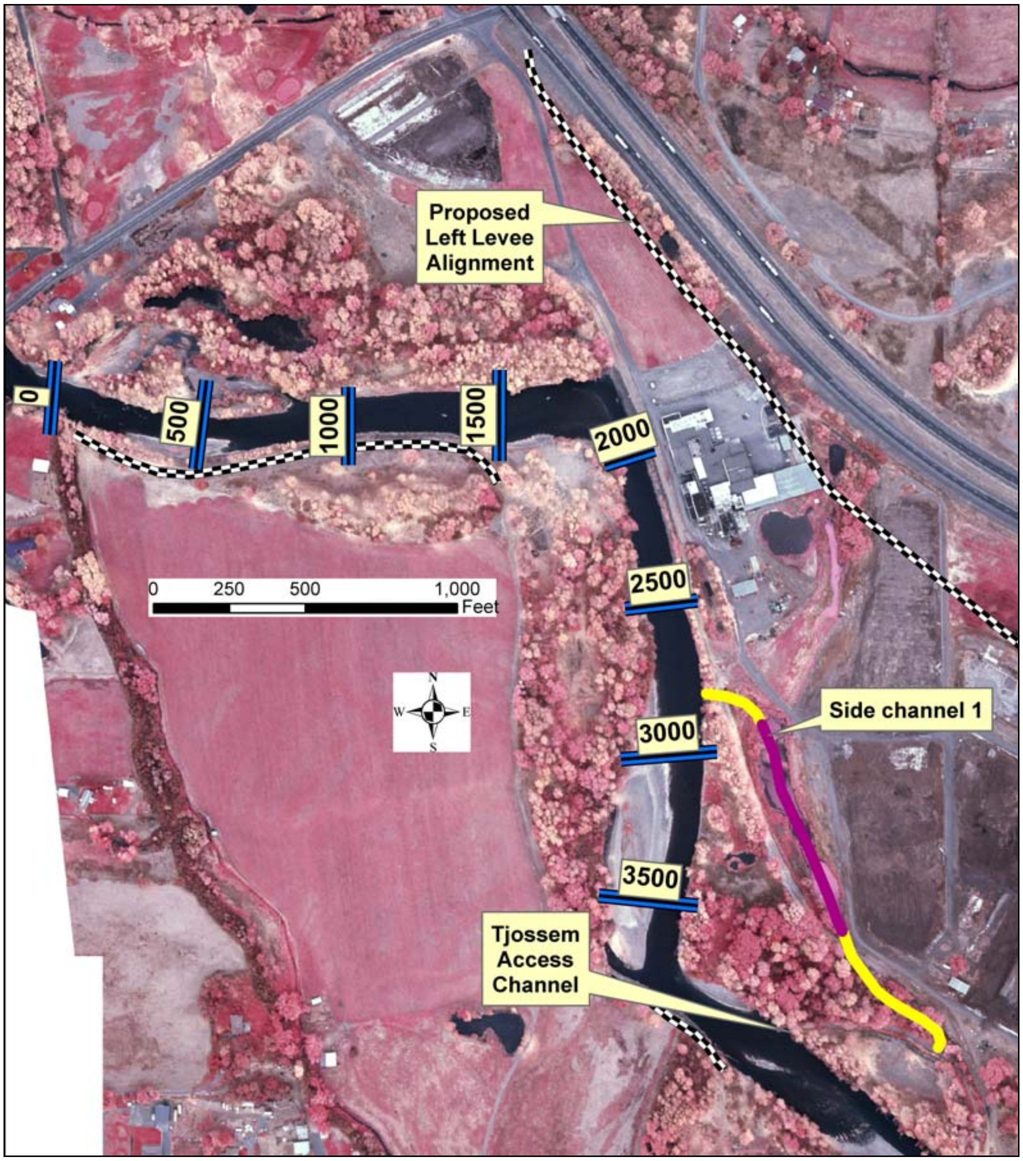


*Figure 5: False color IR aerial photograph showing the area of greatest concern with the removal of left levee #1 at the 90 degree bend. Stationing is used to reference specific locations along this reach in Figures 6.*

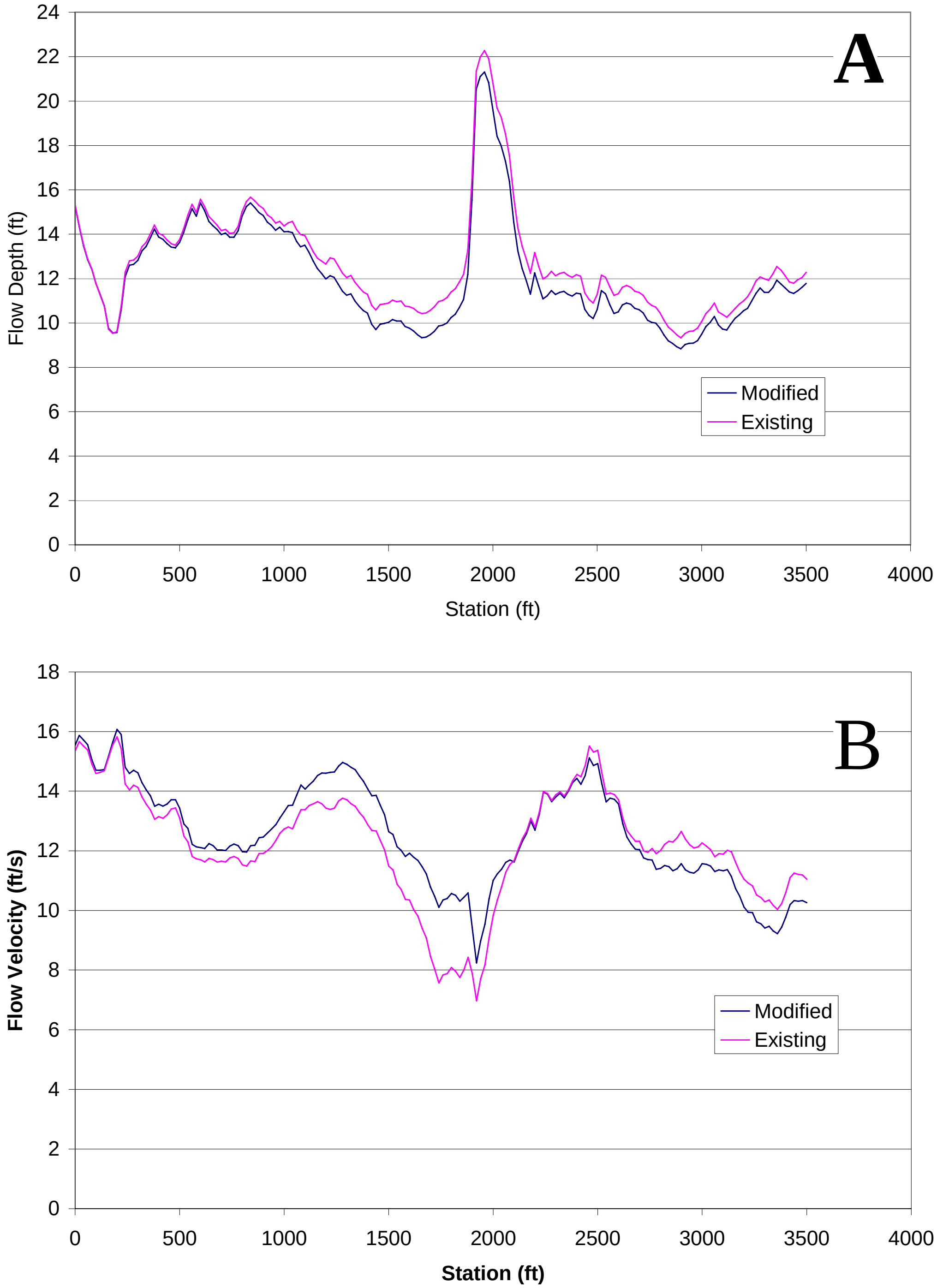


*Figure 6: Charts showing the modeled change in centerline flow depth (A) and change in centerline velocity (B) in the vicinity of the 90 degree bend at a discharge of 25,000 $ft^3/s$ following the removal of left levee #1.*

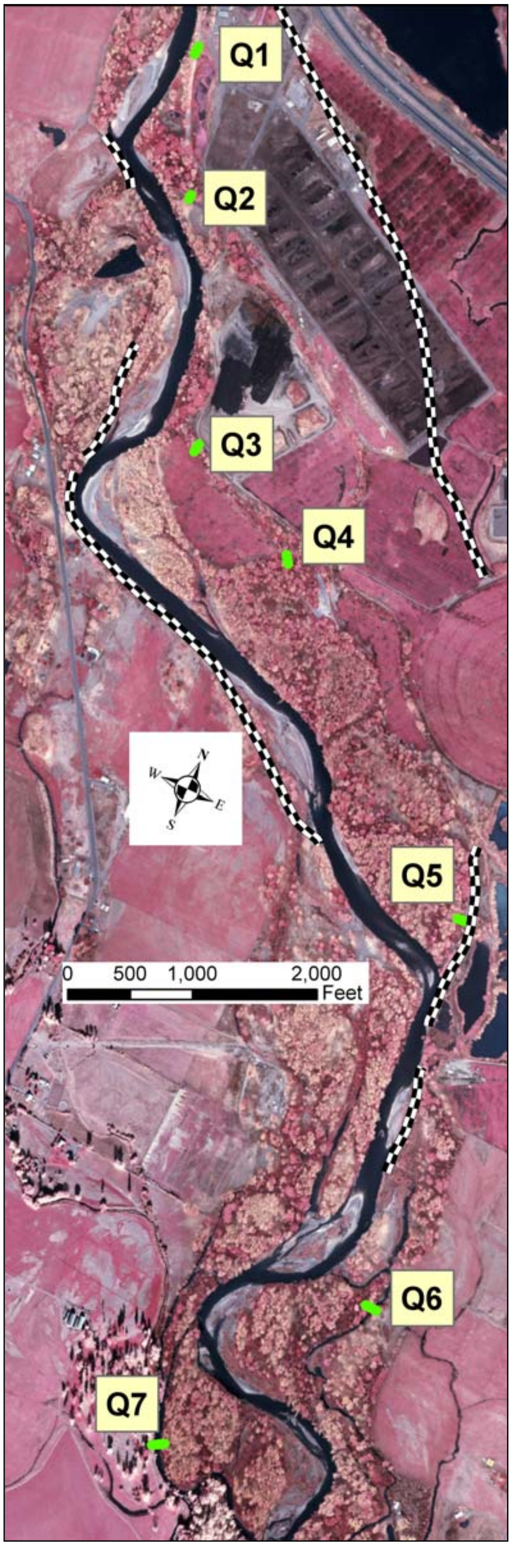

*Figure 7: False color IR aerial photograph showing the location of monitoring lines for discharge. Flow is from top to bottom of the figure.*

## Side Channels

Discharge through each of the side channels was monitored at specific locations in the model (monitoring lines shown in Figure 7). Not all of the monitoring lines indicate flow for all modeling scenarios.

Table 2 lists which side channel is monitored with each monitoring line. Monitoring lines 6 and 7 (Q6 and Q7) are used as a reference under the existing scenario but were not monitored during the modified scenario because discharge in these two side channels will not change under the modified scenario. There was no survey performed in these side channels and as such, the channel bottom was approximated. It was assumed that the channel bottom was 2 feet below the lowest contour line provided by the terrestrial LiDAR. This is a reasonable assumption based on observation made during site visits to some of these side channels. The downstream portion of the side channels indicated as reinvigorated (in the vicinity of Q5) were cut 2 feet below the lowest contour. The upstream portion of this channel was surveyed. Depth and velocity maps of the side channels are contained in Appendix B for a main channel discharge of 4,000 $ft^3/s$.

The measurement of discharge using the monitoring lines was not effective above the 5-year return period because the side channels begin to flow over their banks and onto the floodplain, making discharge measurements more difficult. However the side channel discharge beyond the 5-year return period is of little concern.

*Table 2: Monitored discharges at selected side channels.*

| Location | Monitored Channel | Main channel Flow Rate ($ft^3/s$) | Existing Flow Rate ($ft^3/s$) | Modified Flow Rate ($ft^3/s$) |
|---|---|---|---|---|
| Q1 | Side Channel #1 | 600 | Does Not Exist | 0 |
| | | 1000 | Does Not Exist | 3.1 |
| | | 2000 | Does Not Exist | 36 |
| | | 3150 | Does Not Exist | 88 |
| | | 4000 | Does Not Exist | 129 |
| | | 5678 | Does Not Exist | 208 |
| | | 10066 | Does Not Exist | 420 |
| Q2 | Tjossem Access Ditch | 600 | 0 | 0 |
| | | 1000 | 3.9 | 3.6 |
| | | 2000 | 19 | 0.2 |
| | | 3150 | 37 | -13 |
| | | 4000 | 54 | -24 |
| | | 5678 | 96 | -38 |
| | | 10066 | 206 | -83 |
| Q3 | Side Channel #2 | 600 | Does Not Exist | 0 |
| | | 1000 | Does Not Exist | 0 |
| | | 2000 | Does Not Exist | 11 |
| | | 3150 | Does Not Exist | 35 |
| | | 4000 | Does Not Exist | 57 |
| | | 5678 | Does Not Exist | 112 |
| | | 10066 | Does Not Exist | 295 |
| Q4 | Side Channel #3 | 600 | Does Not Exist | 0 |
| | | 1000 | Does Not Exist | 0 |
| | | 2000 | Does Not Exist | 2.5 |
| | | 3150 | Does Not Exist | 8 |
| | | 4000 | Does Not Exist | 9.5 |
| | | 5678 | Does Not Exist | 13 |
| | | 10066 | Does Not Exist | 124 |
| Q5 | Reinvigorated Side Channel | 600 | 0 | 0 |
| | | 1000 | 0 | 0 |
| | | 2000 | 0 | 0 |
| | | 3150 | 10 | 13 |
| | | 4000 | 25 | 48 |
| | | 5678 | 61 | 108 |
| | | 10066 | 264* | 315* |
| Q6 | Existing Side Channel Downstream of Schaake Property | 600 | 2 | Not Monitored |
| | | 1000 | 12 | Not Monitored |
| | | 2000 | 48 | Not Monitored |
| | | 3150 | 95 | Not Monitored |
| | | 4000 | 176 | Not Monitored |
| | | 5678 | 443 | Not Monitored |
| | | 10066 | 1102* | Not Monitored |
| Q7 | Existing Side Channel Downstream of Schaake Property | 600 | 19 | Not Monitored |
| | | 1000 | 328 | Not Monitored |
| | | 2000 | 726 | Not Monitored |
| | | 3150 | 1241 | Not Monitored |
| | | 4000 | 1621 | Not Monitored |
| | | 5678 | 2219 | Not Monitored |
| | | 10066 | 2981* | Not Monitored |

## Flow Reversal in Tjossem Access Channel

When the main channel discharge is greater than 2,000 ft$^3$/s, discharge of side channel #1 into the Tjossem access channel causes a change in flow direction in the upstream portion of the Tjossem access channel. Figure 8 shows this

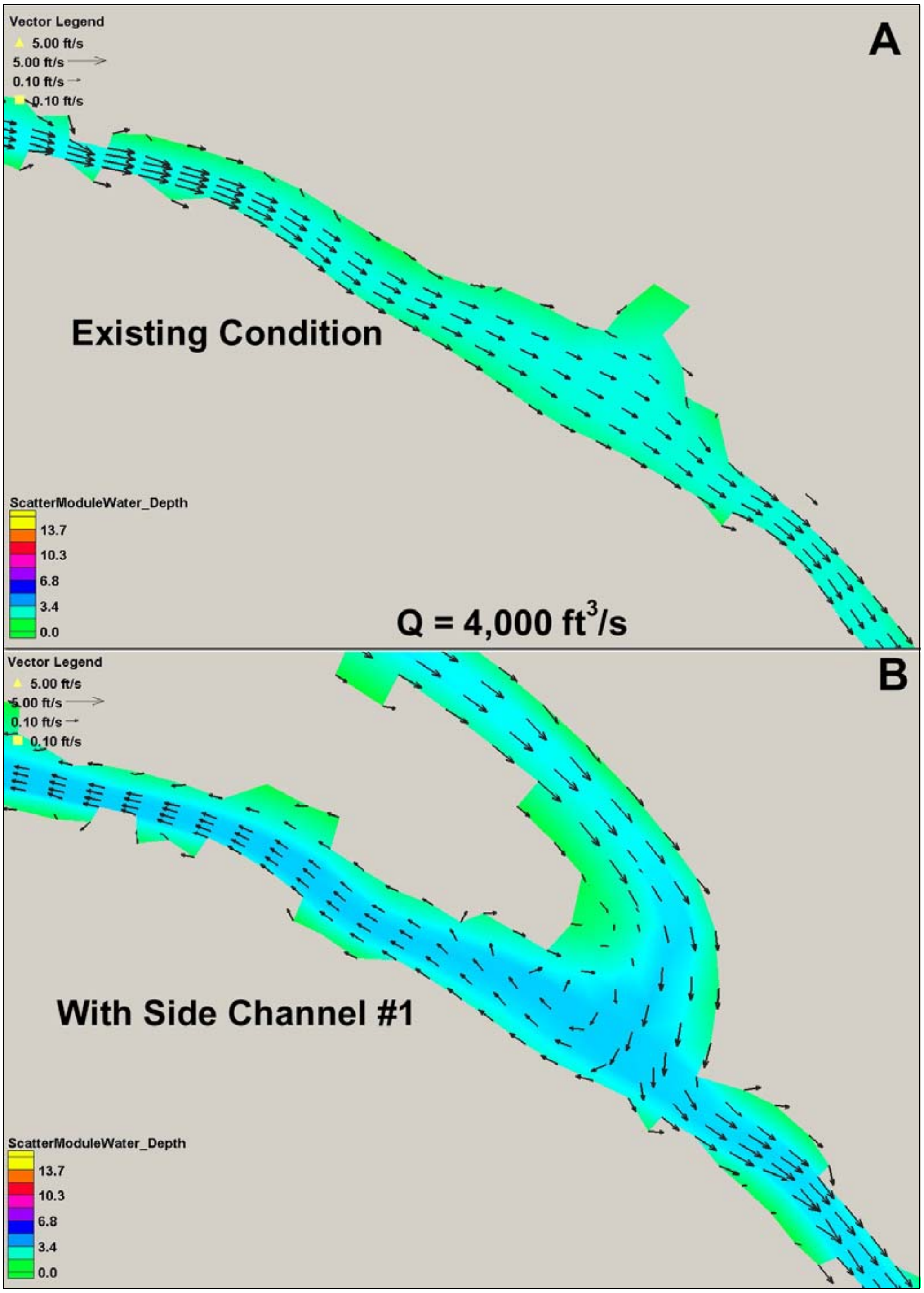


*Figure 8: Velocity vectors and depth color ramp for the Tjossem access ditch where proposed side channel #1 enters the ditch. (A) Existing condition, (B) with proposed side channel #1.*

occurrence with a main channel discharge of 4,000 $ft^3/s$. This result is consistent with the previous report (Hilldale, 2004). The change in flow direction at this location is not expected to have any impact on habitat or water delivery to Tjossem Ditch. Discharges through proposed side channel #1 are sufficient to provide the 8 $ft^3/s$ required for the water right to Tjossem Ditch during the summer irrigation season (see Table 2).

# Discussion

## Removal of Left Levee #1

The area of greatest concern regarding the levee setback is at the north end of the property, where the river makes a 90 degree turn to the south. At this location the river is as close as 500 feet to Interstate 90. The inability to remove right levee #1 prevents flow attenuation on the right floodplain, thereby increasing depth and velocity in the main channel. Furthermore, flow direction continues to be directed toward the interstate.

Currently, left levee #1 is minimally effective at 25,000 $ft^3/s$. Althought the levee is not overtopped at the 90 degree bend during this discharge, the levee is flanked to the north (Figure 9). This allows flow between the levee and the interstate. Additionally, high water on the left floodplain upstream of the modeled area may flow across Umptanum Road, increasing the amount of water flowing on the Schaake property. As the river continues south, portions of left levee #1 are overtopped at 25,000 $ft^3/s$ (Figure 9), further indicating that the existing configuration of left levee #1 is ineffective.

After left levee #1 is setback, migration of the river east toward the interstate must be anticipated. although that is not to say that the river will rapidly migrate completely to the proposed levee. Early maps (ca. 1913) indicate that the main channel at the 90-degree bend has moved approximately 350 feet eastward (Hilldale and Klinger, 2004) to its current location. Current levee removal plans are to remove the levee and riprap above the existing ground elevation on the floodplain side of the levee. Leaving the riprap below the new bank elevation should slow the migration of the river eastward. It is possible that overtopping flows may scour behind the remaining riprap that is level with the new bank elevation, possibly creating a scour hole in this location. As this process progresses over a few flood cycles, a split channel configuration may form, which is what existed in 1966 aerial photography, albeit further west (Hilldale and Klinger, 2003). Widening of the channel decreases energy and therefore the potential to migrate all the way to the proposed levee location. This is only considered to be a probable scenario and no guarantee that the river will not migrate to the proposed levee location over time. Modeled depth for the proposed scenario is shown in Figure 10.

Results showing modeled velocity (Figure 11) indicate generally low velocities (approximately 1 ft/s or less) along the proposed levee during a 25,000 $ft^3/s$ discharge. The area of highest velocity along the levee, indicated with a black circle on Figure 11, has been changed by regrading after the removal of the structures on the site. This suggests that the velocity in this area will be similar to velocities along the rest of the levee.

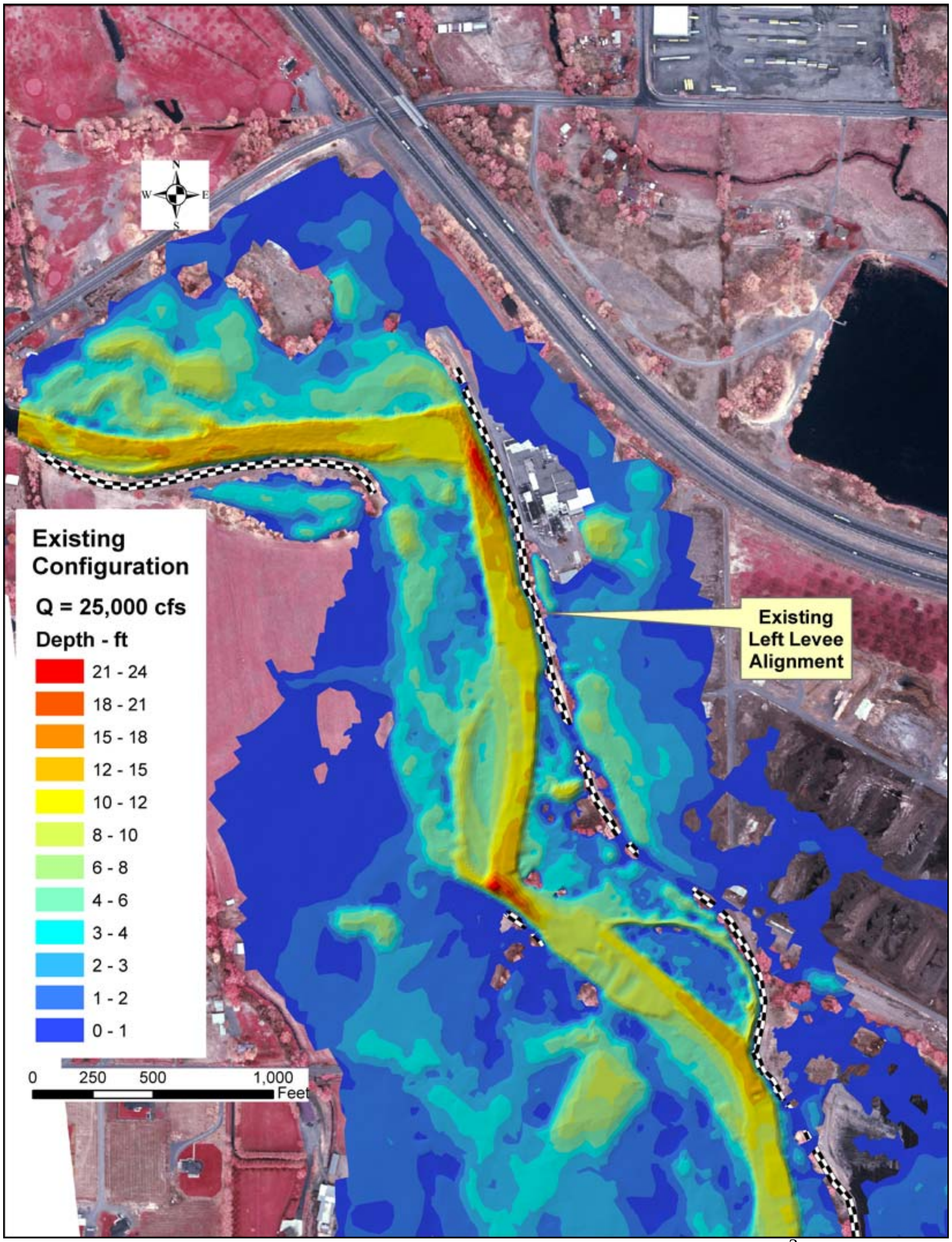


*Figure 9: Modeling results showing modeled flow depth at 25,000 $ft^3/s$ under existing conditions. Flow direction is toward the bottom of the figure.*

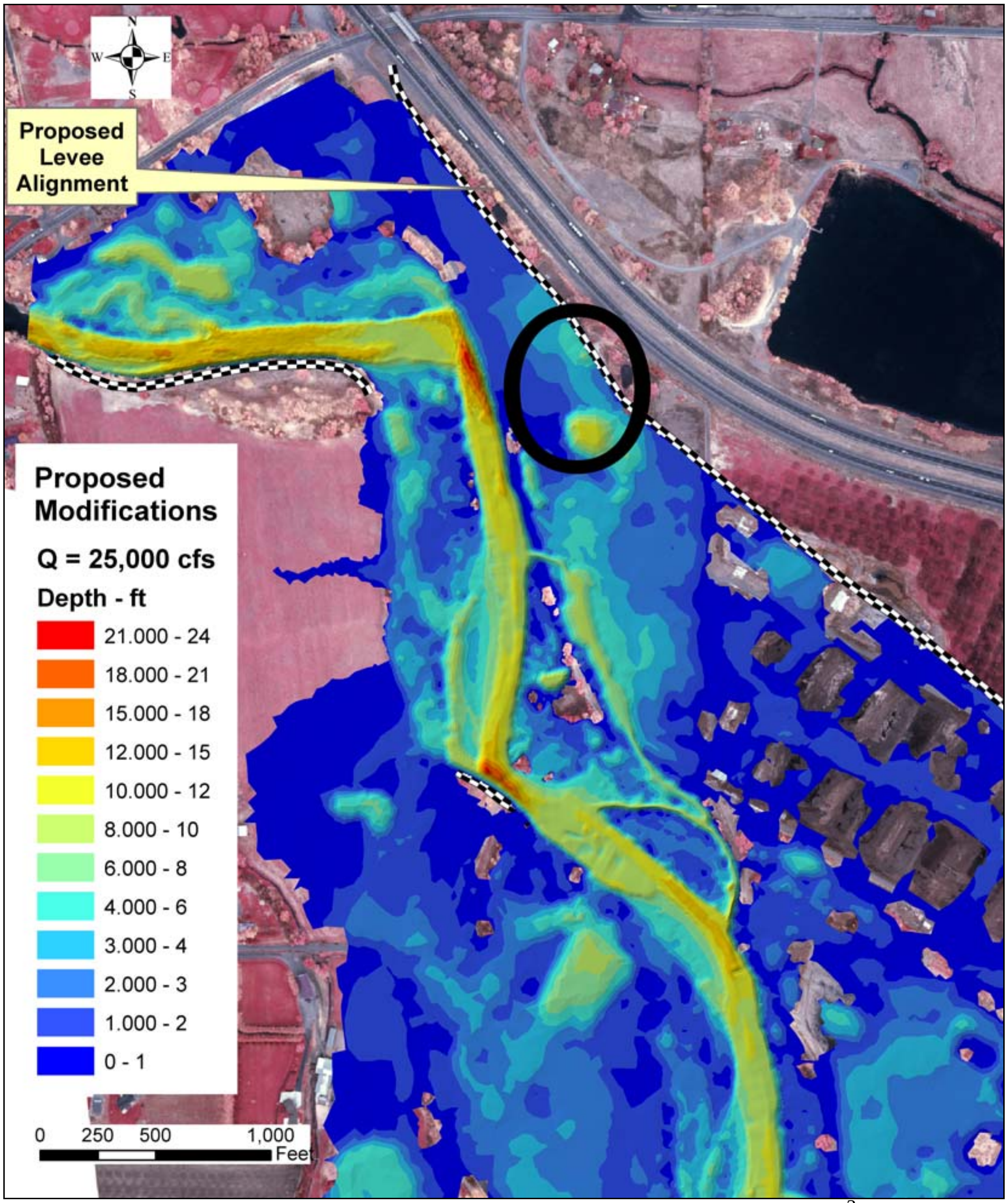


*Figure 10: Modeling results showing modeled flow depth at 25,000 $ft^3/s$ under the proposed conditions. Circle indicates area of greatest depth, which has changed following regrading of the site. Flow direction is toward the bottom of the figure.*

## Reinforcing the Proposed Levee and Floodplain

It is advisable that the proposed levee and perhaps the floodplain be protected against erosion and channel migration. There are several possibilities for this type of protection, some of which are shown in Figure 12. At a minimum the levee surface should be reinforced for approximately 3,000 feet, beginning at the north end. Other possibilities include burying riprap at the toe of the levee to an elevation similar to the current main channel thalweg elevation (Figure 12 B).

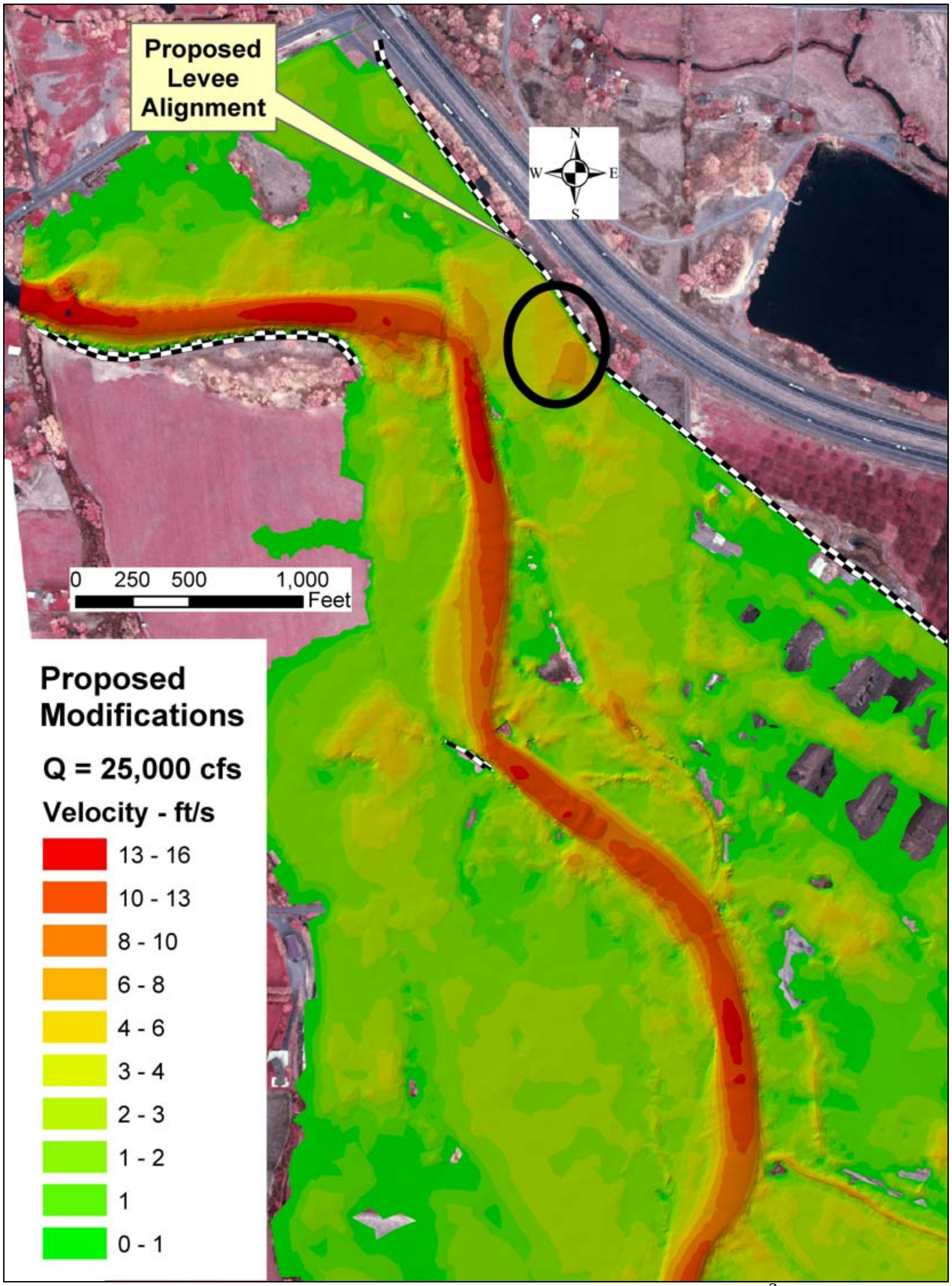


*Figure 11: Modeling results showing modeled velocity at 25,000 $ft^3$/s under proposed conditions. The circled area with high velocity has been changed since regrading of the site. Flow direction is top to bottom of the figure.*

A potential remedy for preventing channel migration all the way to the proposed levee is to bury riprap in the floodplain (trenched rock) between the current location of left levee #1 and the proposed location of the setback levee (Figure 12). The proposed trench location shown in Figure 12 A and B suggests placing the trench approximately half way between the main channel and the proposed levee. The length of the trench is 700 feet (Figure 12 A). If a trench is placed in the floodplain, the north end should begin at such a location that potential migration will not flank the trench to the north. Another possible solution for reinforcing the toe of the proposed levee is to place trenched rock at the toe of the levee (Figure 12 C). The trenched rock is expected to launch the accumulated riprap along the face of the eroding bank should the river migrate to the trench. An advantage of the trenched rock is that it is not seen until such a time that the river begins to erode the material from the buried rock. More detail regarding trenched rock can be found in river restoration manuals (e.g. Design of Riprap Revetment, FHWA, 1989 and Sacramento River Conservation Area Forum Handbook, 2003). Consideration needs to be given that the river channel may not migrate completely to the trench or the levee and that these measures can be considered an added level of protection against complete migration to the proposed levee toe. The level of protection required for this levee has yet to be determined.

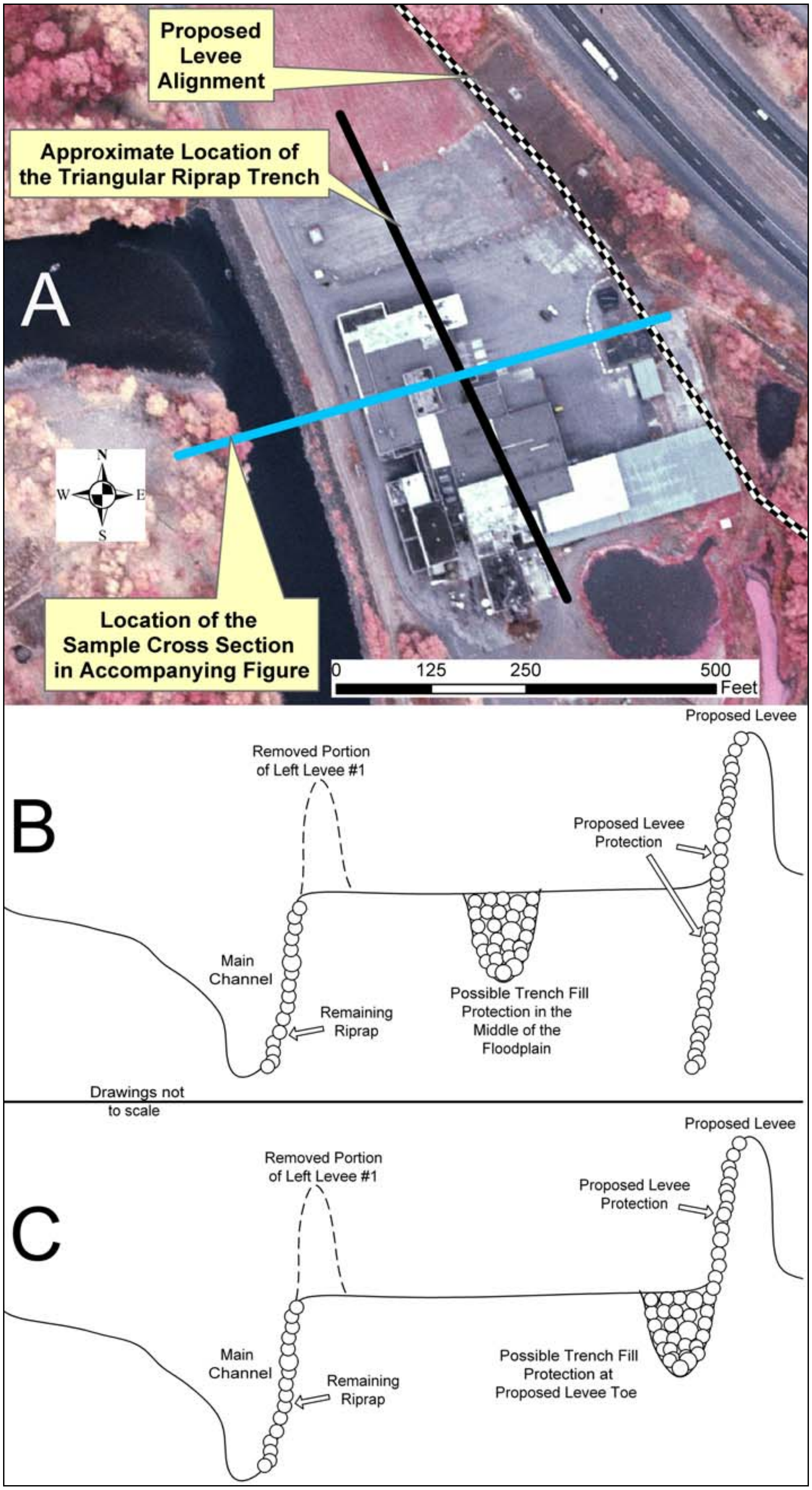


*Figure 12: Diagrams of possible bank protection schemes and location.*

## Construction of Side Channels

The dimensions of the proposed side channels are narrower than many of the natural side channels just downstream of the Schaake reach of the Yakima River. The purpose of this is to provide a surface water connection to the floodplain and allow natural forces to create the cross sectional dimensions, such as width and side slope. The most important guideline in this report related to side channels is the invert elevation of the inlet and outlet locations. This elevation was determined by subtracting one foot from the water surface elevation in the main channel at the inlet or outlet with a main channel discharge of 1,000 $ft^3/s$. The side channels proposed in this report were located based on the following criteria:

- Sustainability of the side channel with little or no maintenance. This is primarily dependent upon localized aggradation at either end of the side channel that may disconnect the established surface water connection.
- Results from Small (2006) indicating various levels of contamination in the floodplain
- Opportunity to construct the side channel with limited excavation
- Opportunity to construct the side channel in areas that require limited or no riparian planting
- A channel slope that minimizes the potential for aggradation or headcutting

### Side Channel Sedimentation

The ability of side channels to transport sediment has been briefly evaluated. Fine sediment aggradation is a concern because these sediment can promote the growth of aquatic vegetation. For example, dense beds of *Elodea Canadensis, Potamogeton crispus* and *Myriophyllum spp.* have been observed in side channels downstream of the Schaake reach of the Yakima River. Respiration by these plants resulted in low dissolved oxygen levels that killed juvenile salmon after the channels became disconnected from the main channel (Lance Clarke, pers. comm.). It is possible that some macrophyte growth in the side channels is not necessarily a detriment when these plants do not dominate the channel, as this provides habitat diversity (Lance Clarke, pers. comm.). Additionally, pollutants can adhere to clay sized particles, which may increase the concentration of these pollutants if a disproportionate amount of fine sediment accumulates (Huang et al., 2006). It is presumed that if sediment smaller than 1 millimeter is frequently transported for a sufficient duration, accumulation of fine sediment should not be a problem.

Using the Shields criterion it can be said that the critical shear stress value required to transport a 1 millimeter particle is approximately 0.5 Pascal (Pa) (0.01 $lb/ft^2$) (Julien, 1998). If a main channel discharge of 4,000 $ft^3/s$ is considered, which occurs on an annual basis, conclusions can be made regarding the minimum particle size in the side channels. The modeled values of shear stress in the side channels obtained from GSTAR-W are shown in Figures 13 – 15. Details regarding the computation can be found in Lai (2006). All figures are shown with a main channel discharge of 4,000 $ft^3/s$. Along much of the length of the side channels, shear stresses are greater than 0.5 Pa. The primary exceptions to this are the ponds in side channel #1 (Figure 13) and in the reinvigorated side channel (Figure 15).

Modeling results indicate very low levels of shear stress in side channel #3 along its length (Figure 16), indicating the potential for aggradation of fine sediment. This may not meet the goals of creating side channels that require little or no maintenance and provide appropriate habitat for salmonid species. This side channel is proposed to be constructed through portions of what is thought to be a remnant channel. The model results indicate that there is likely not enough slope to maintain the desired channel type. It should be noted that one of the existing side channels has a similar condition (Figure 16), yet maintains a bed primarily consisting of coarse sand and fine to medium gravel. This is likely a result of the Yakima River carrying low suspended sediment concentrations, meaning that a source for fine sediment must be available for it to deposit.

The change in flow direction in the upstream portion of the Tjossem access channel changes the shear stress values from existing conditions (Figure 8). At 4,000 $ft^3/s$ shear stresses range from 0.18 to 15 Pa under existing conditions and 0.10 to 2 Pa with side channel #1 present. The difference in shear stresses at 1,000 $ft^3/s$ is less, with 0.03 to 1.8 Pa under existing conditions and 0.06 to 0.70 Pa with side channel #1 present. The entrance to the channel experiences the lowest shear stress in the portion of the channel where the flow direction changes. The portion of the access channel where flow direction is changed will likely experience a decrease in particle size and may aggrade. Over time this aggradation may create a condition whereby the surface connection is lost at common summer discharges. However, the Yakima River in this reach has relatively low suspended sediment concentrations, which indicates that any aggradation in the access channel will be slow and more likely dependant on conditions related to the falling limb of a flood hydrograph. Should this portion of the access channel aggrade such that a surface connection is lost, discharge through the proposed side channel #1 will be able to accommodate the required water right to Tjossem Ditch. Although the existing system has been operable for many years with respect to providing sufficient discharge to Tjossem Ditch, there is no guarantee that morphological changes will not occur as to render the access channel useless, with or without the proposed changes being implemented. Maintenance at the entrance of the Tjossem access channel has been necessary in the past (Jeff Graham, per. Comm.).

Recall that the connection of the side channels to the main channel is well above the thalweg of the main channel. Because finer sediment is carried in suspension, and the sediment concentration in the water column decreases toward the surface,

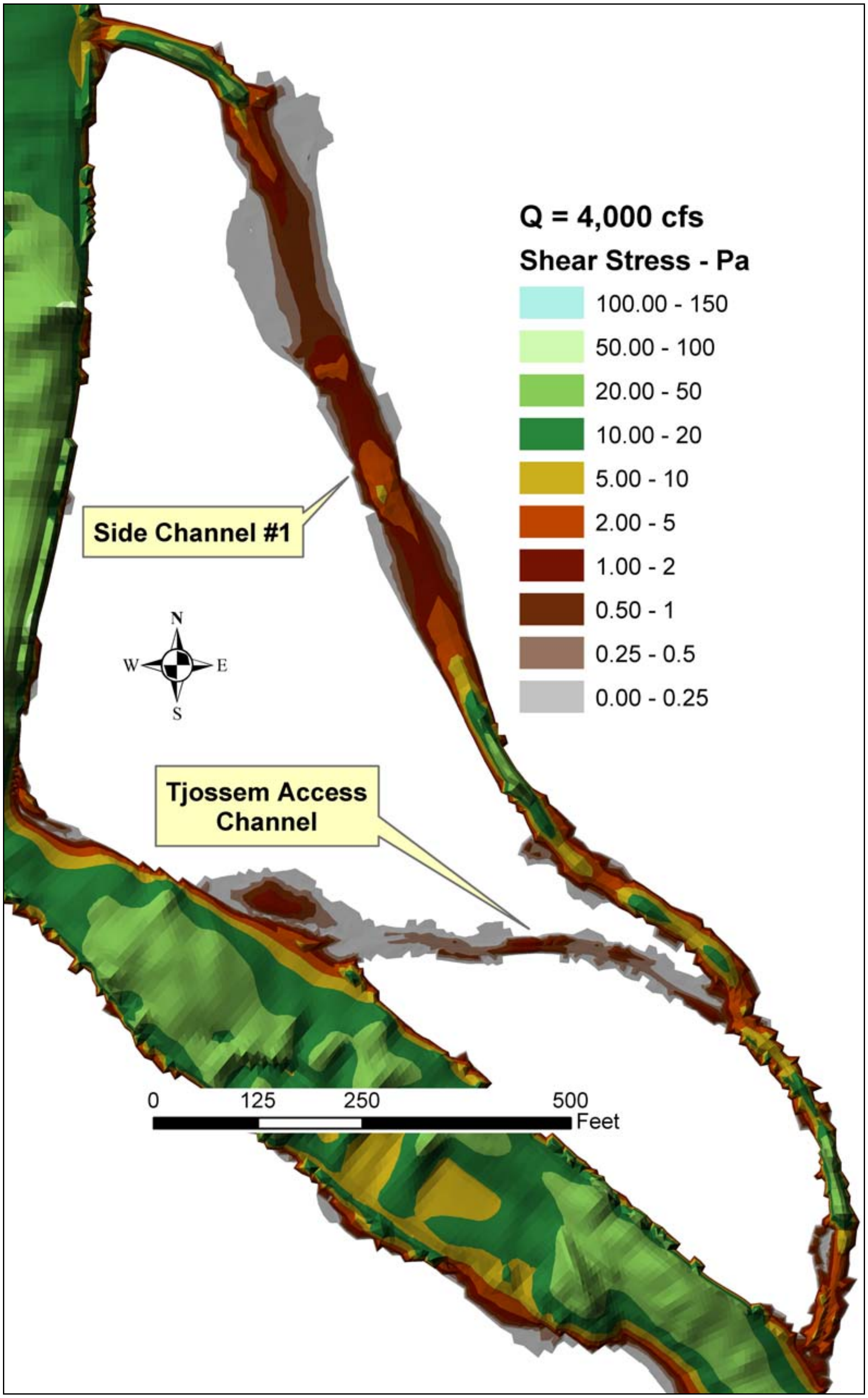


*Figure 13: Model results showing predicted shear stress in side channel #1 and the Tjossem access channel. Flow is from top to bottom of the figure.*

the primary source of fine sediment in the side channels will be from the side channels themselves. After the side channels begin to develop and are flushed of fine sediment, the source of the fine sediment should decrease significantly. Flood events may carry additional fine sediment into the channels however the regular occurrence of a 4,000 $ft^3/s$ discharge is expected to flush the remaining fine sediment from the side channels.

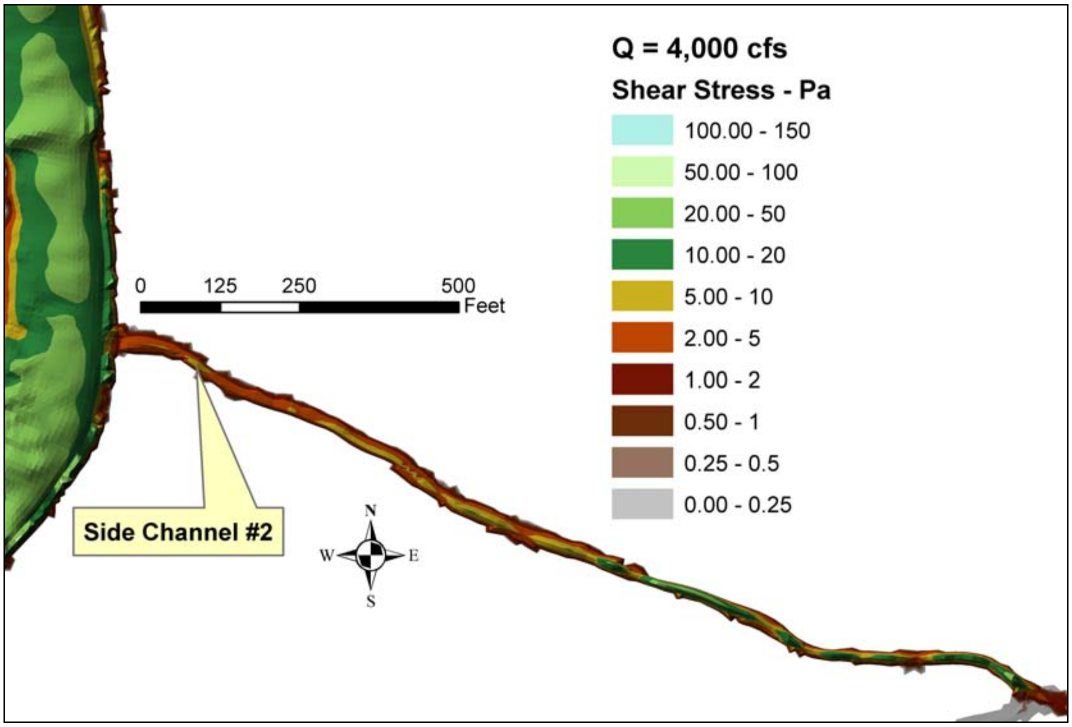


*Figure 14: Model results showing predicted shear stress values for side channel #2. Flow in the side channel is from right to left of the figure.*

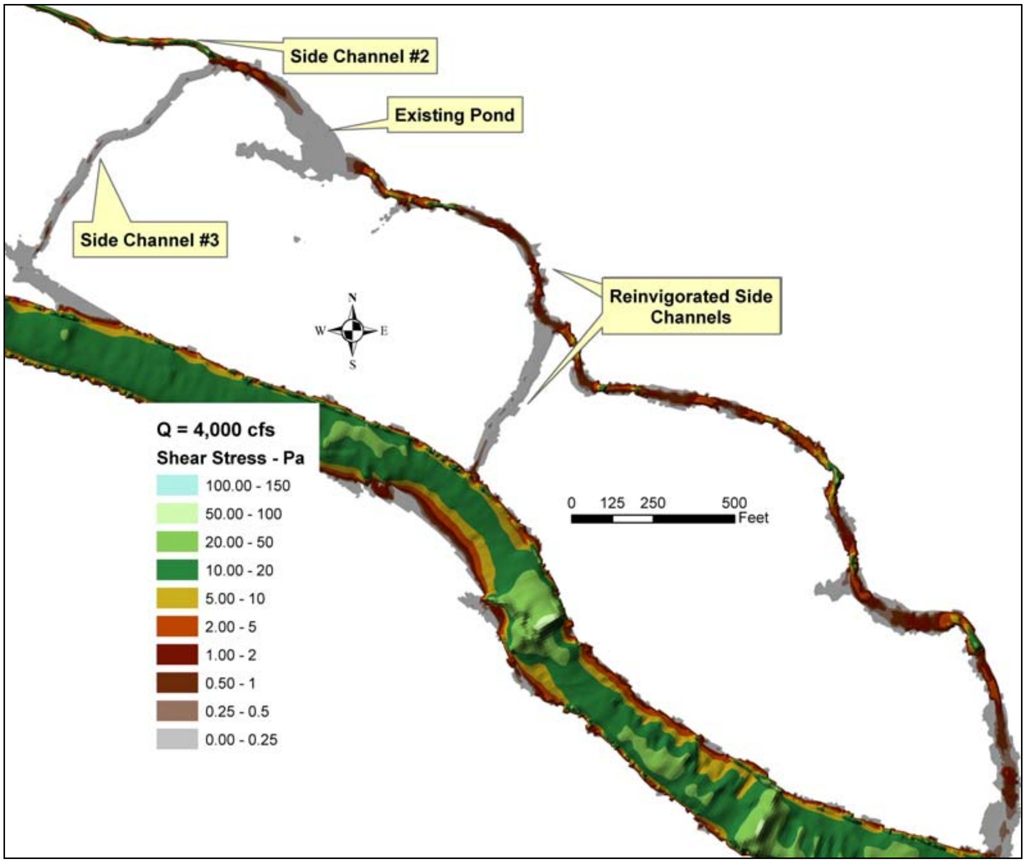


*Figure 15: Model results showing predicted values of shear stress for the reinvigorated side channels. Flow is from upper left to lower right of the figure.*

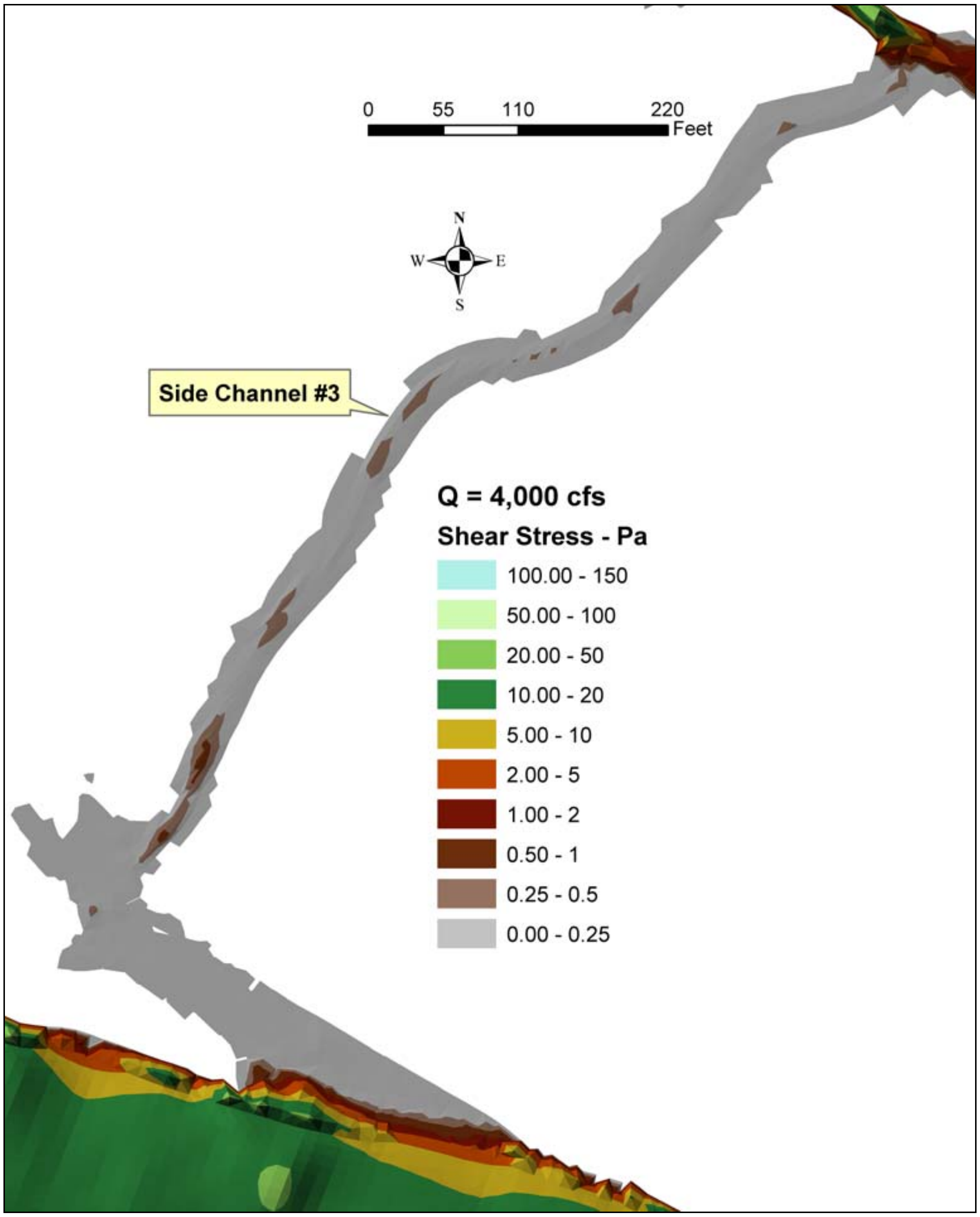


*Figure 16: Model results showing predicted shear stress values for side channel #3. Flow is from upper right to lower left of the figure.*

## Partial Removal of Levees

It is possible to remove less than the entire length of the existing left levee #1 and still fulfill the goal of habitat improvement. Figure 17 shows the existing levee configuration broken into three segments. It is recommended that all of segment 1 be removed. All of segment 2 should remain to stabilize the bank at the head of Tjossem Ditch. It is recommended that a minimum of 50% of segment 3 be removed, with no continuous length of remaining levee being longer than the length of removed levee.

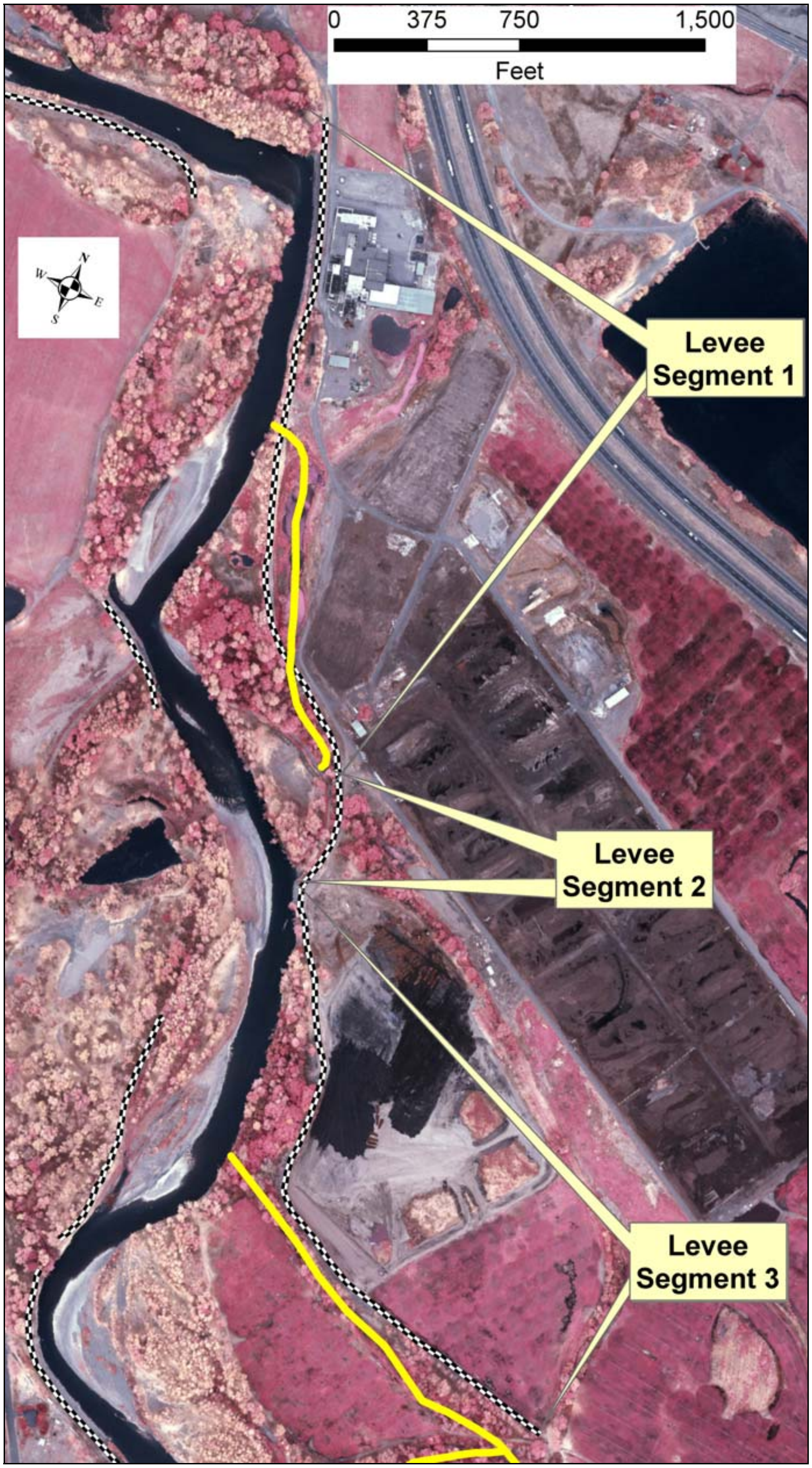


*Figure 17: False color IR aerial photograph of the study reach showing three segments of the existing left levee#1.*

# Conclusions

The modeling performed for this study forms the initial design stage for rehabilitation of the Yakima River at the former Schaake property. The proposed alternatives will be considered by the Yakima River Basin Water Enhancement Project and other interested agencies within the basin. Final design criteria for the proposed levee construction has yet to be determined. Dimensions for the proposed side channels should be based on those used for the modeling.

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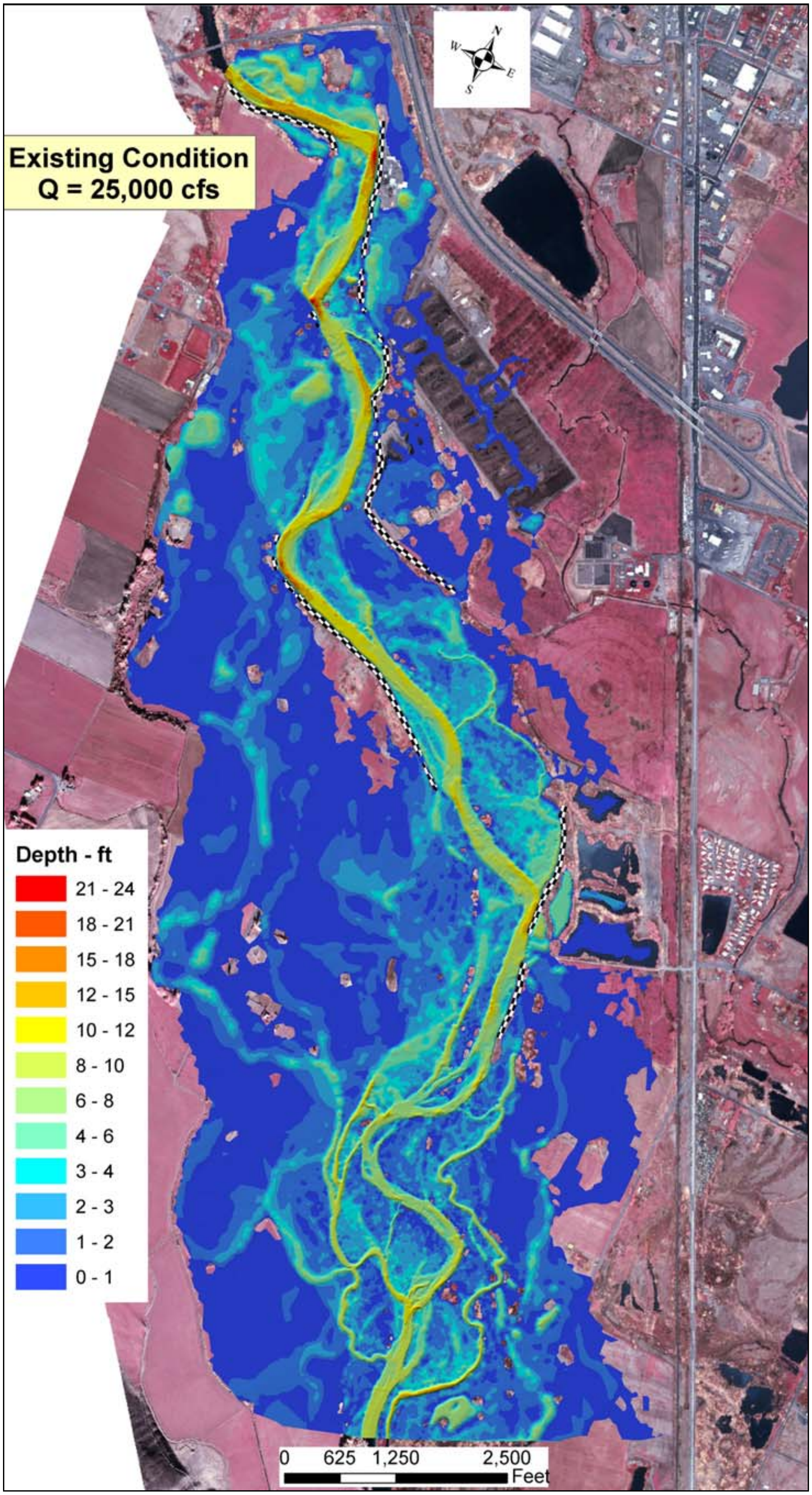
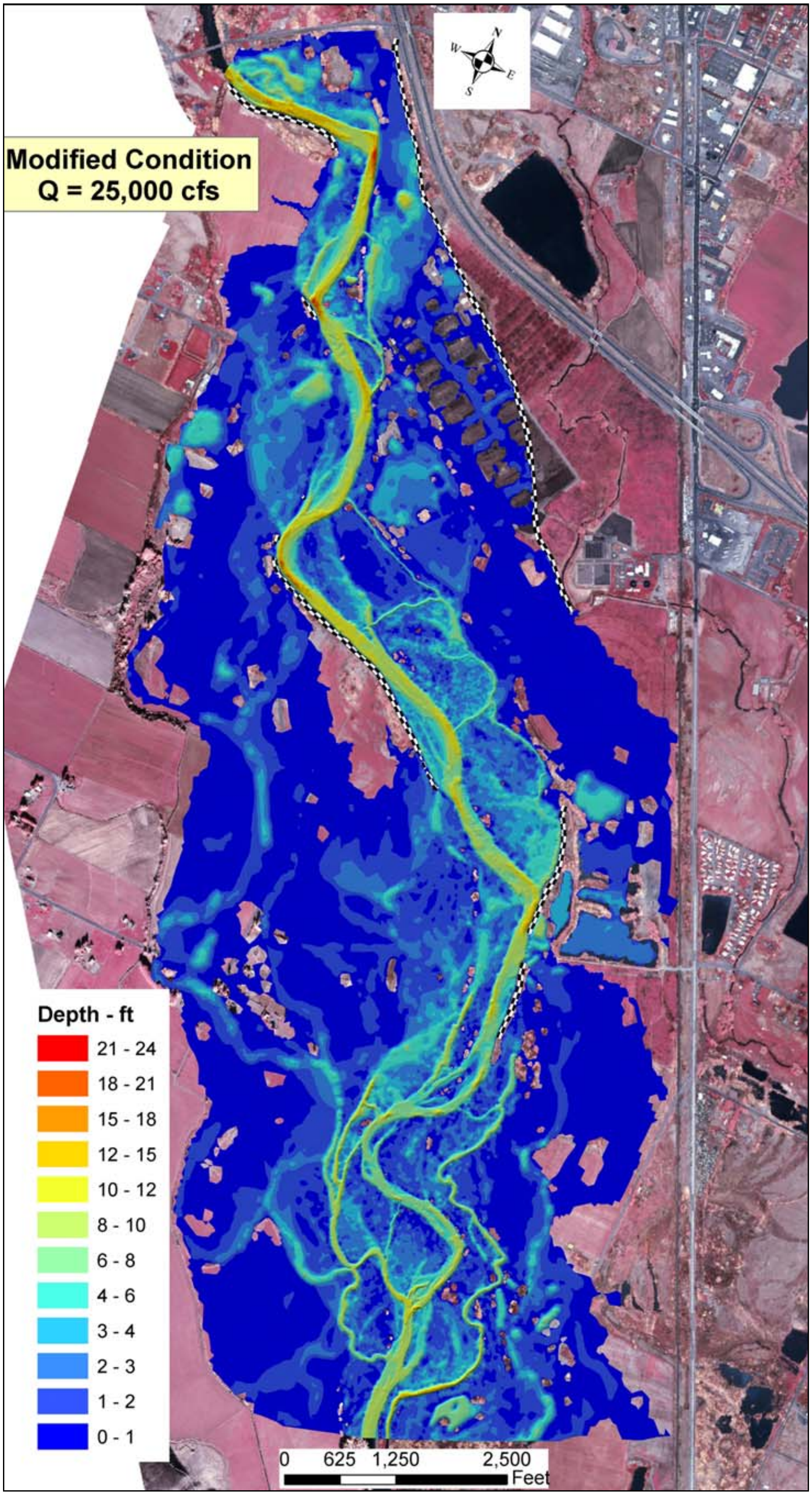
# APPENDIX A

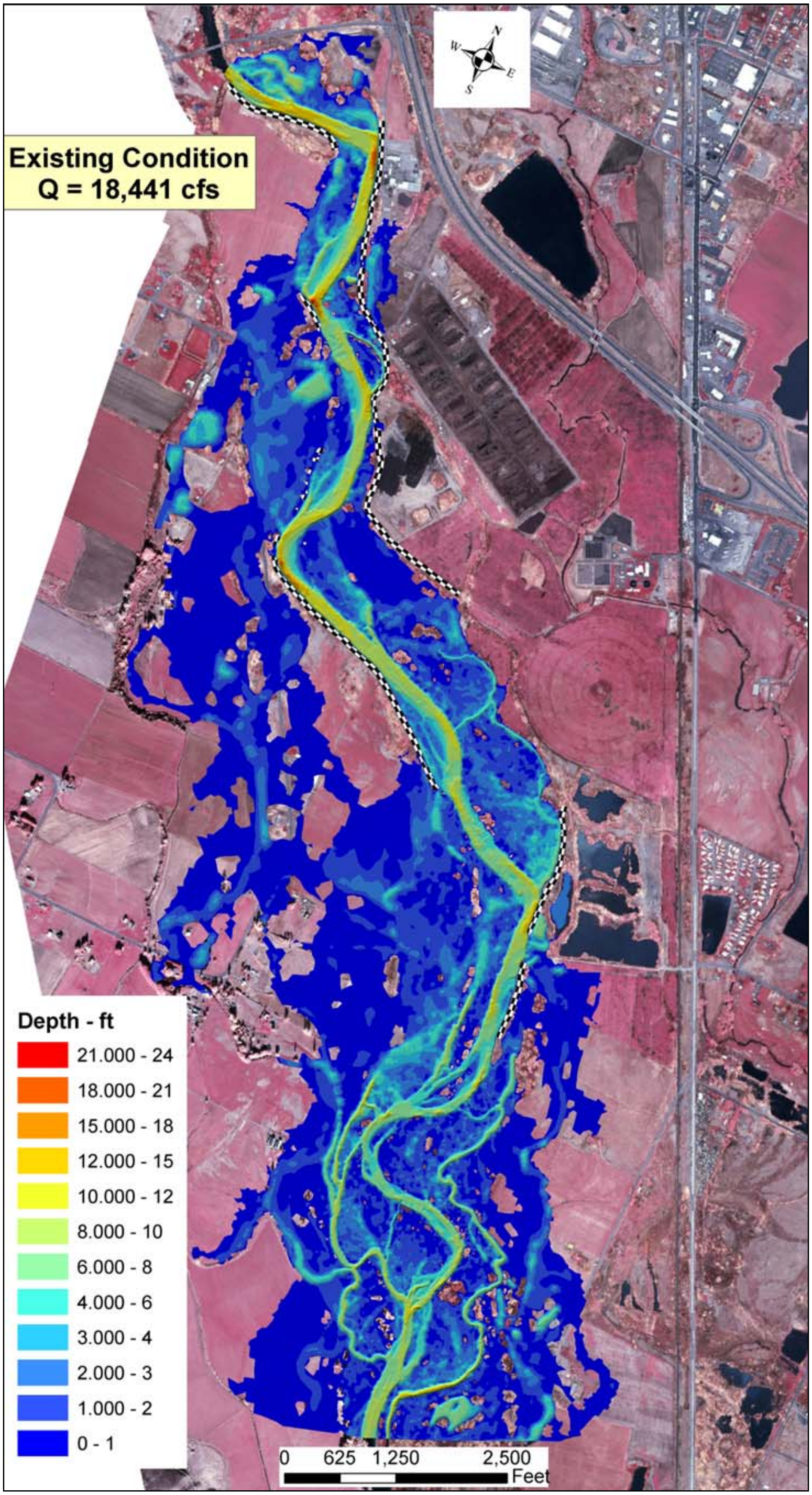
## Modeled Flow Depth for Selected Discharges of the Schaake Reach



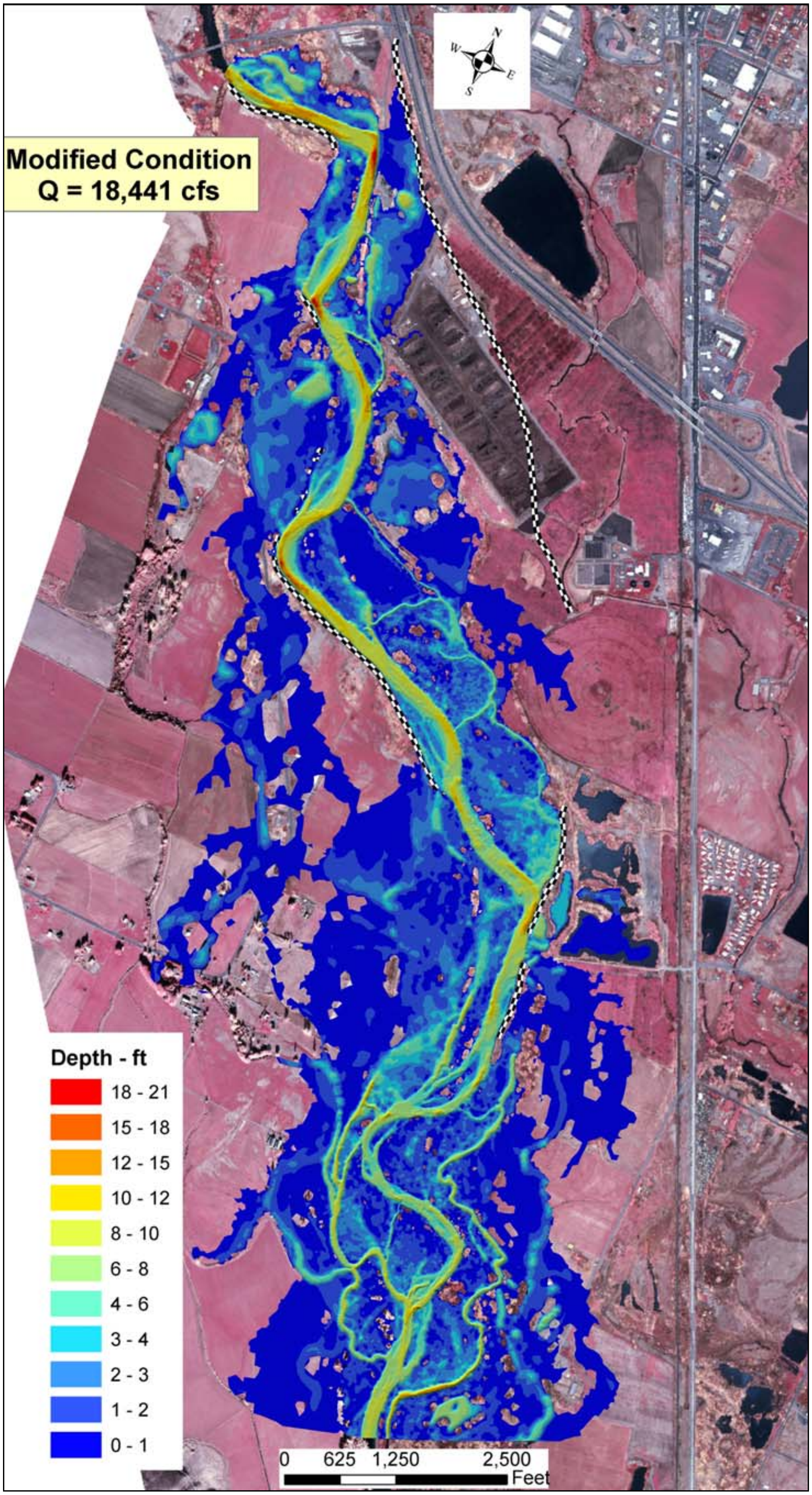
Existing Condition
Q = 25,000 cfs
N
E
S
W
Depth - ft
21 - 24
18 - 21
15 - 18
12 - 15
10 - 12
8 - 10
6 - 8
4 - 6
3 - 4
2 - 3
1 - 2
0 - 1
0
625
1,250
2,500
Feet

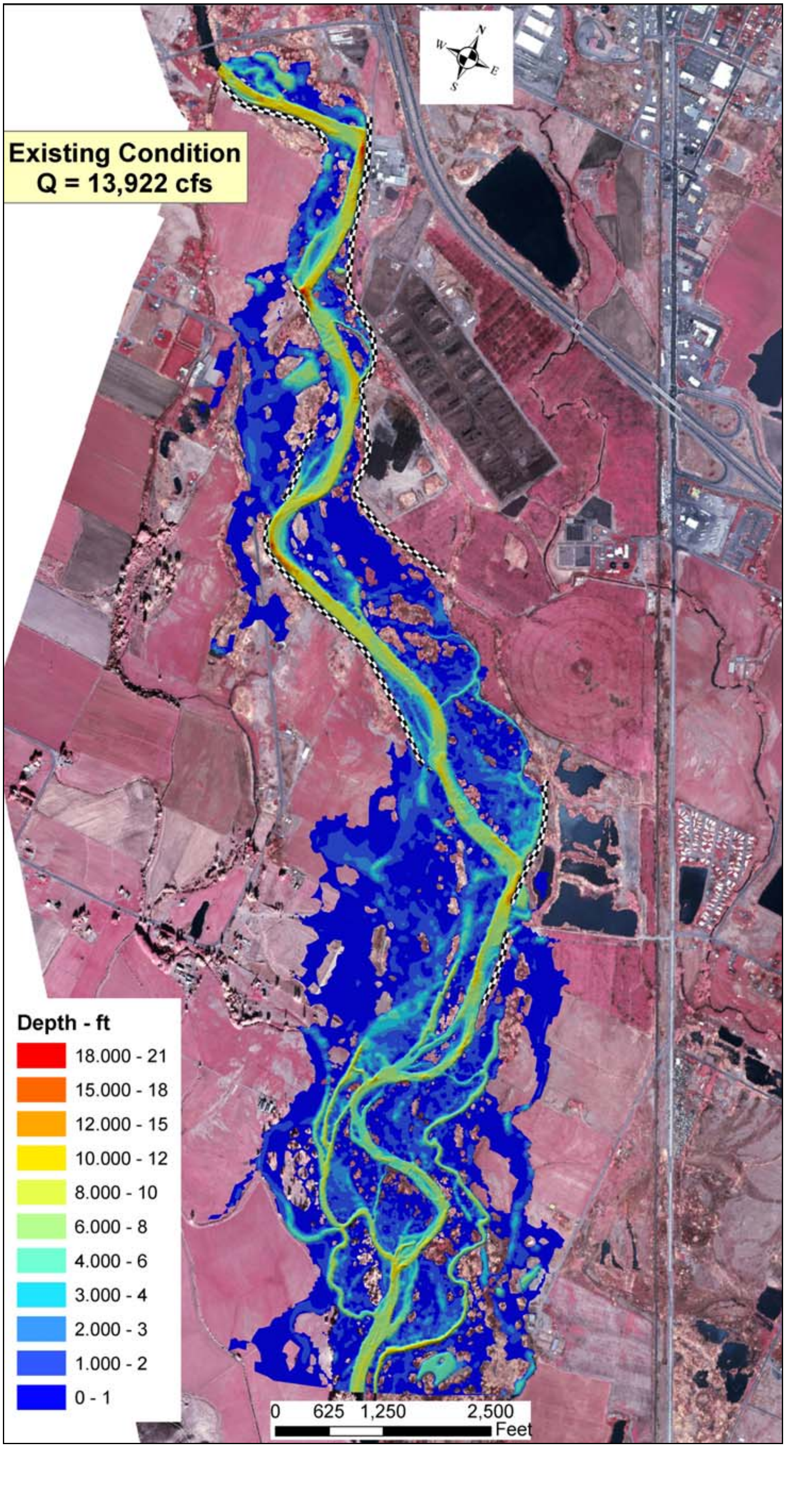


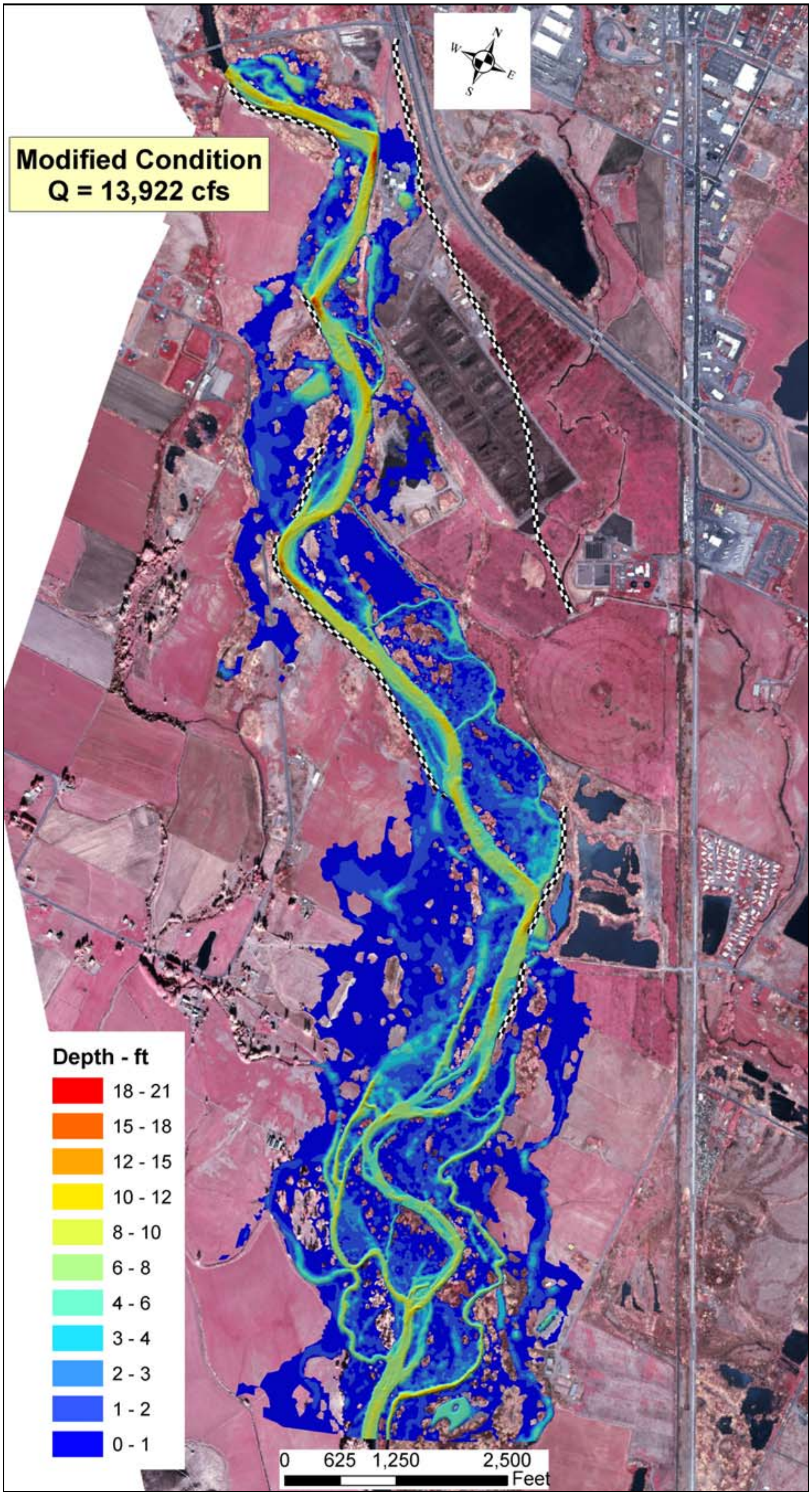
Modified Condition
Q = 25,000 cfs
N
E
S
W
Depth - ft
21 - 24
18 - 21
15 - 18
12 - 15
10 - 12
8 - 10
6 - 8
4 - 6
3 - 4
2 - 3
1 - 2
0 - 1
0
625
1,250
2,500
Feet

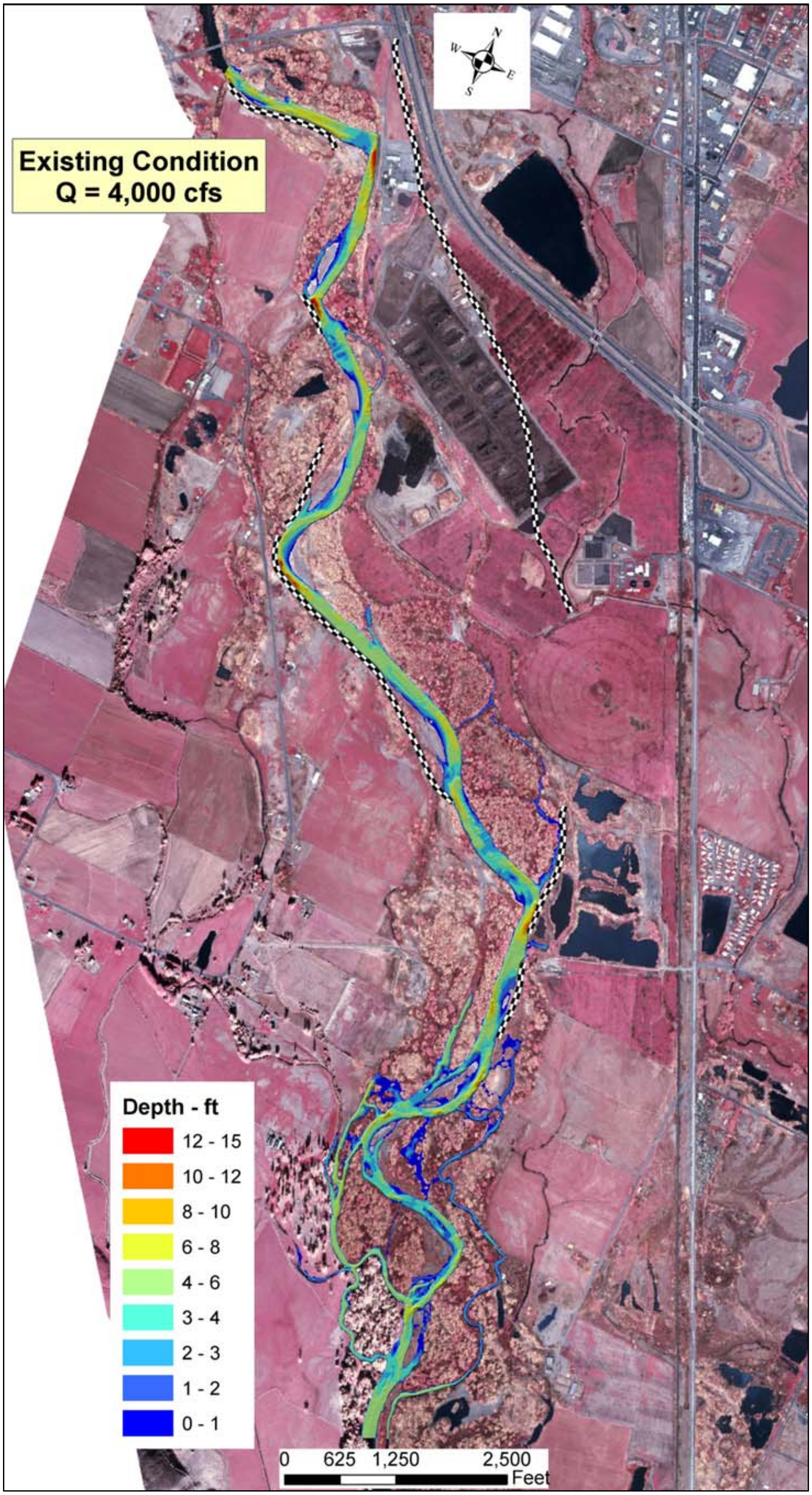


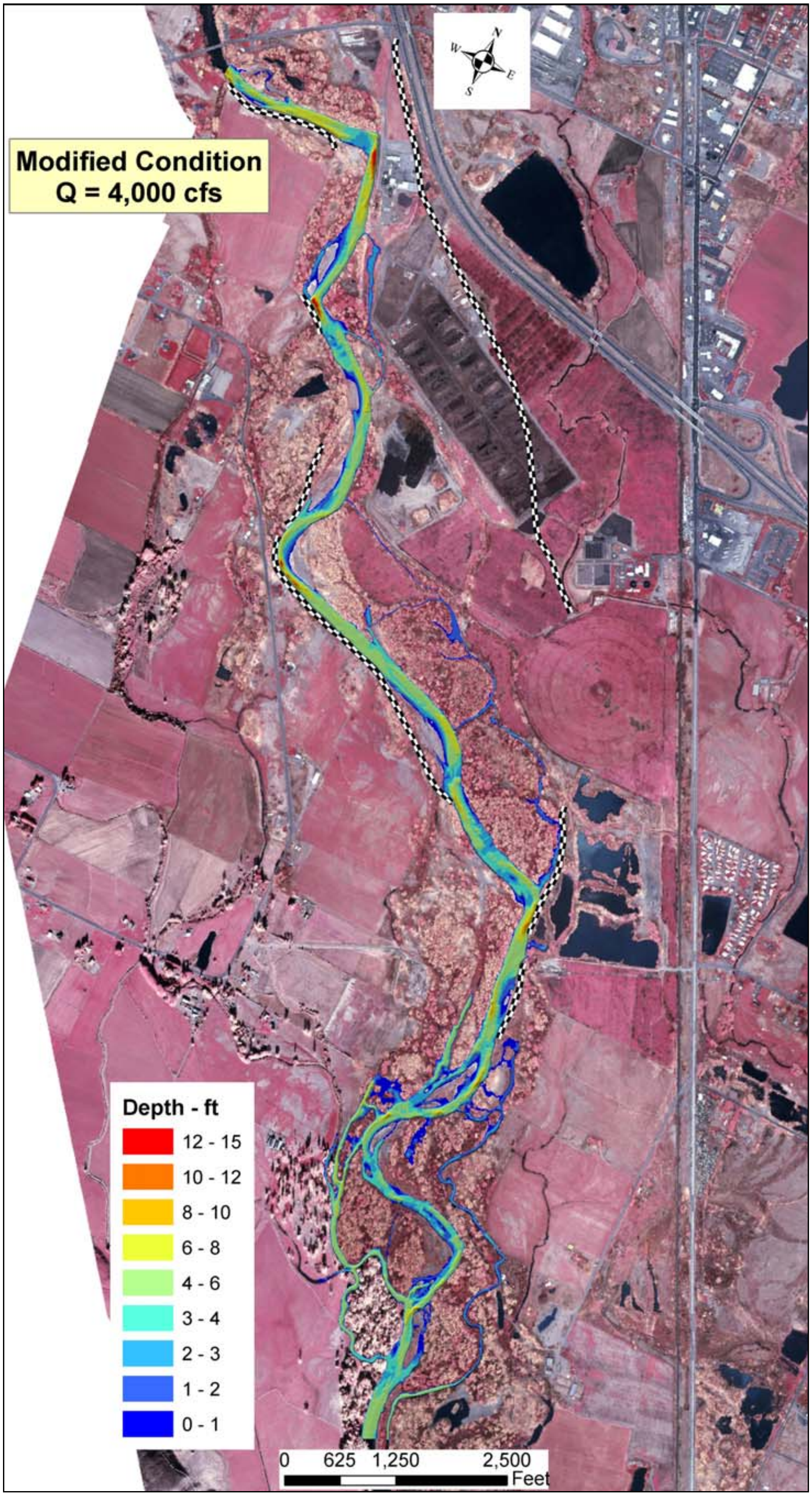
Existing Condition
Q = 18,441 cfs
N
E
S
W
Depth - ft
21.000 - 24
18.000 - 21
15.000 - 18
12.000 - 15
10.000 - 12
8.000 - 10
6.000 - 8
4.000 - 6
3.000 - 4
2.000 - 3
1.000 - 2
0 - 1
0
625
1,250
2,500
Feet


Modified Condition
Q = 18,441 cfs
W
N
E
S
Depth - ft
18 - 21
15 - 18
12 - 15
10 - 12
8 - 10
6 - 8
4 - 6
3 - 4
2 - 3
1 - 2
0 - 1
0
625
1,250
2,500
Feet


N
E
S
W
Existing Condition
Q = 13,922 cfs
Depth - ft
18.000 - 21
15.000 - 18
12.000 - 15
10.000 - 12
8.000 - 10
6.000 - 8
4.000 - 6
3.000 - 4
2.000 - 3
1.000 - 2
0 - 1
0 625 1,250 2,500
Feet

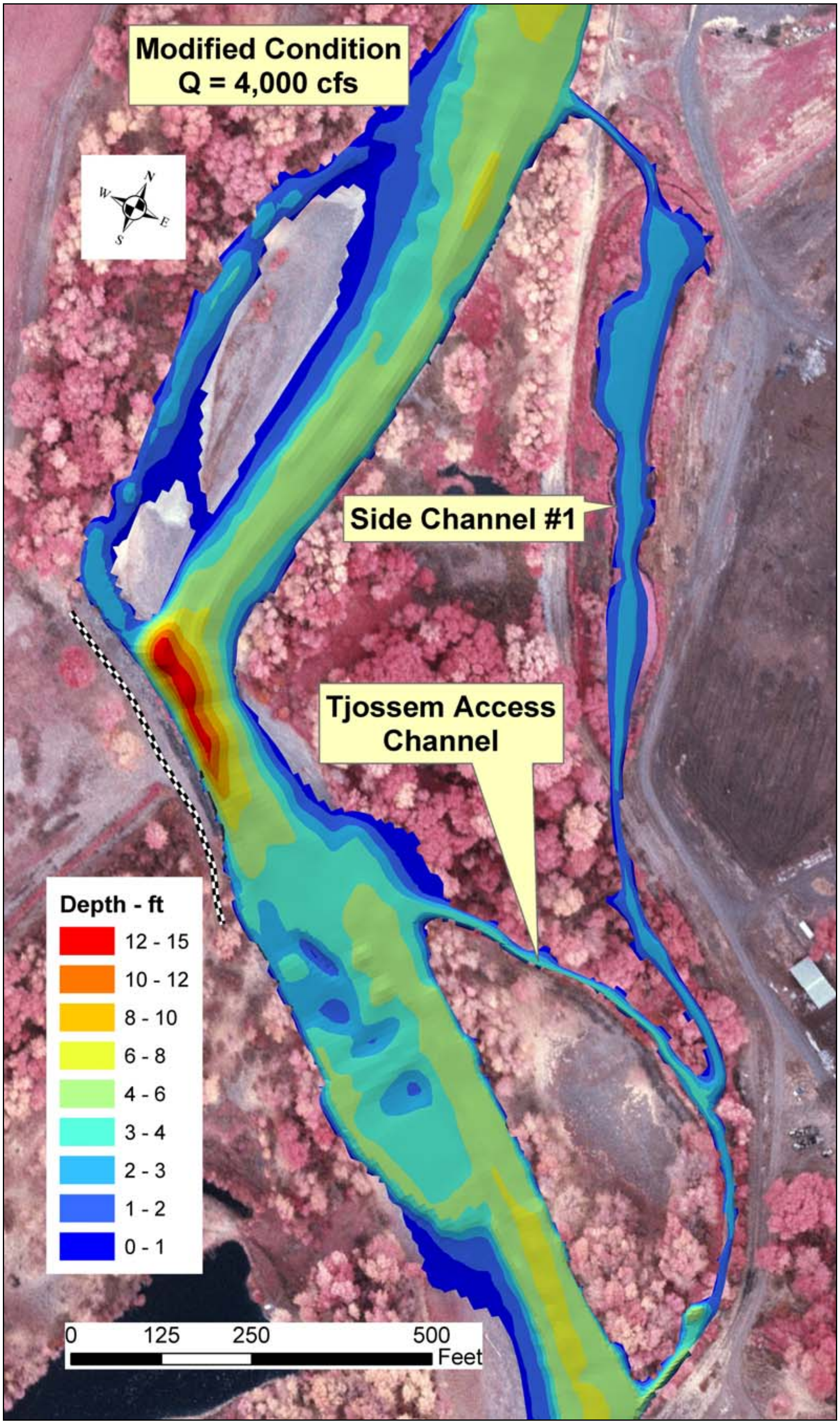

Modified Condition
Q = 13,922 cfs
Depth - ft
18 - 21
15 - 18
12 - 15
10 - 12
8 - 10
6 - 8
4 - 6
3 - 4
2 - 3
1 - 2
0 - 1
0 625 1,250 2,500
Feet
N
S
E
W

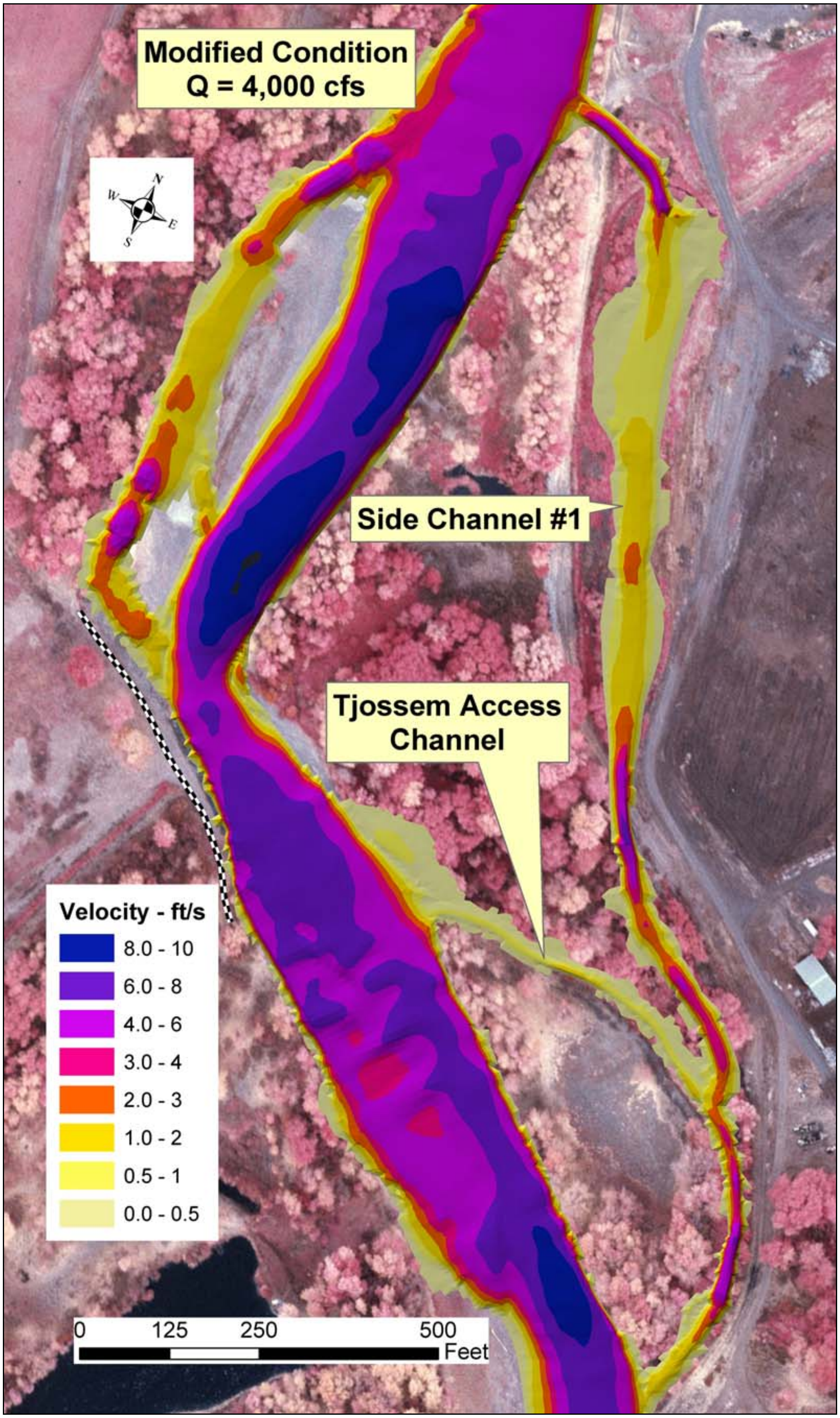

Existing Condition
Q = 4,000 cfs
N
E
S
W
Depth - ft
12 - 15
10 - 12
8 - 10
6 - 8
4 - 6
3 - 4
2 - 3
1 - 2
0 - 1
0
625
1,250
2,500
Feet

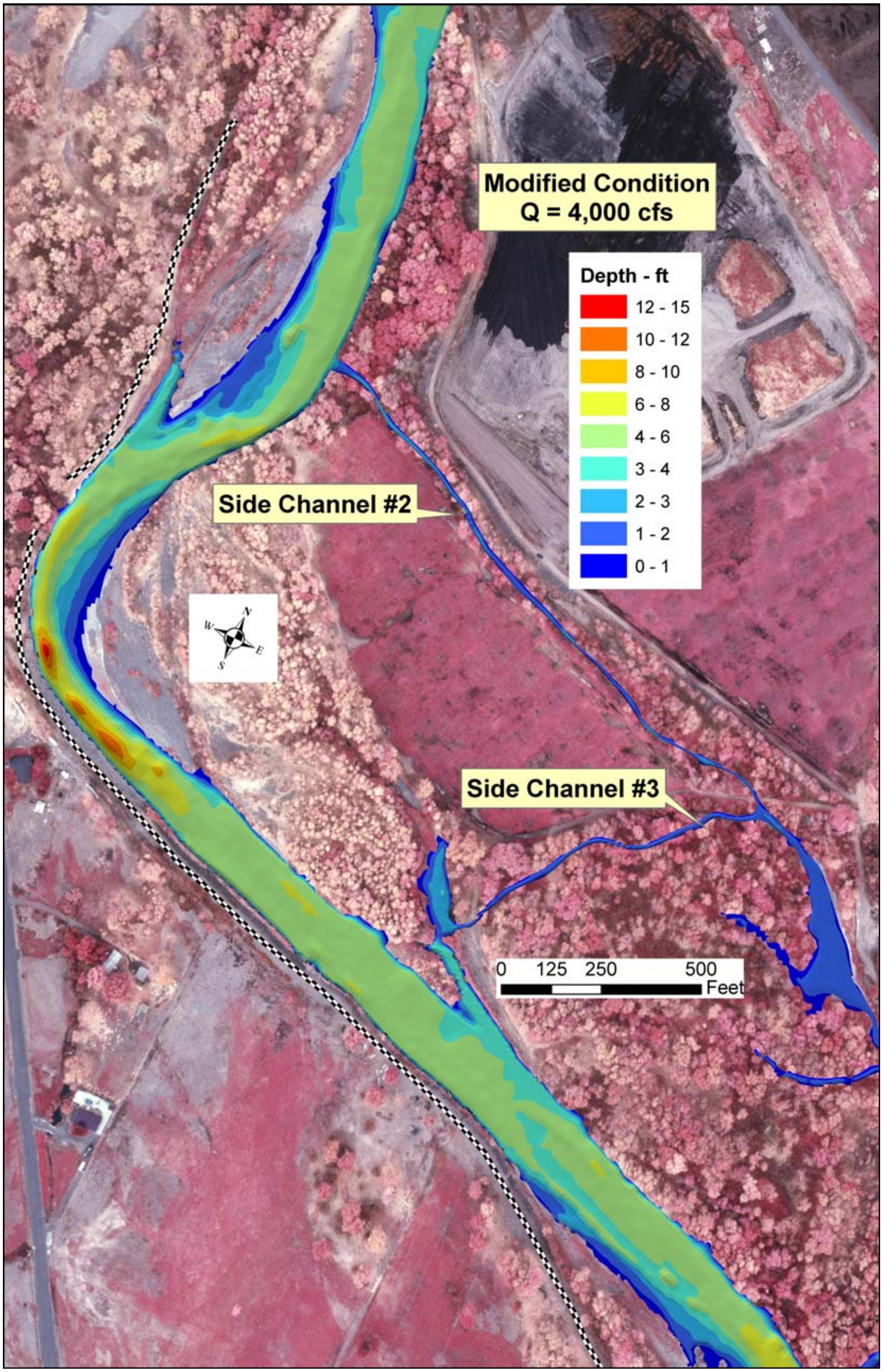

Modified Condition
Q = 4,000 cfs
N
E
S
W
Depth - ft
12 - 15
10 - 12
8 - 10
6 - 8
4 - 6
3 - 4
2 - 3
1 - 2
0 - 1
0
625
1,250
2,500
Feet

# Appendix B

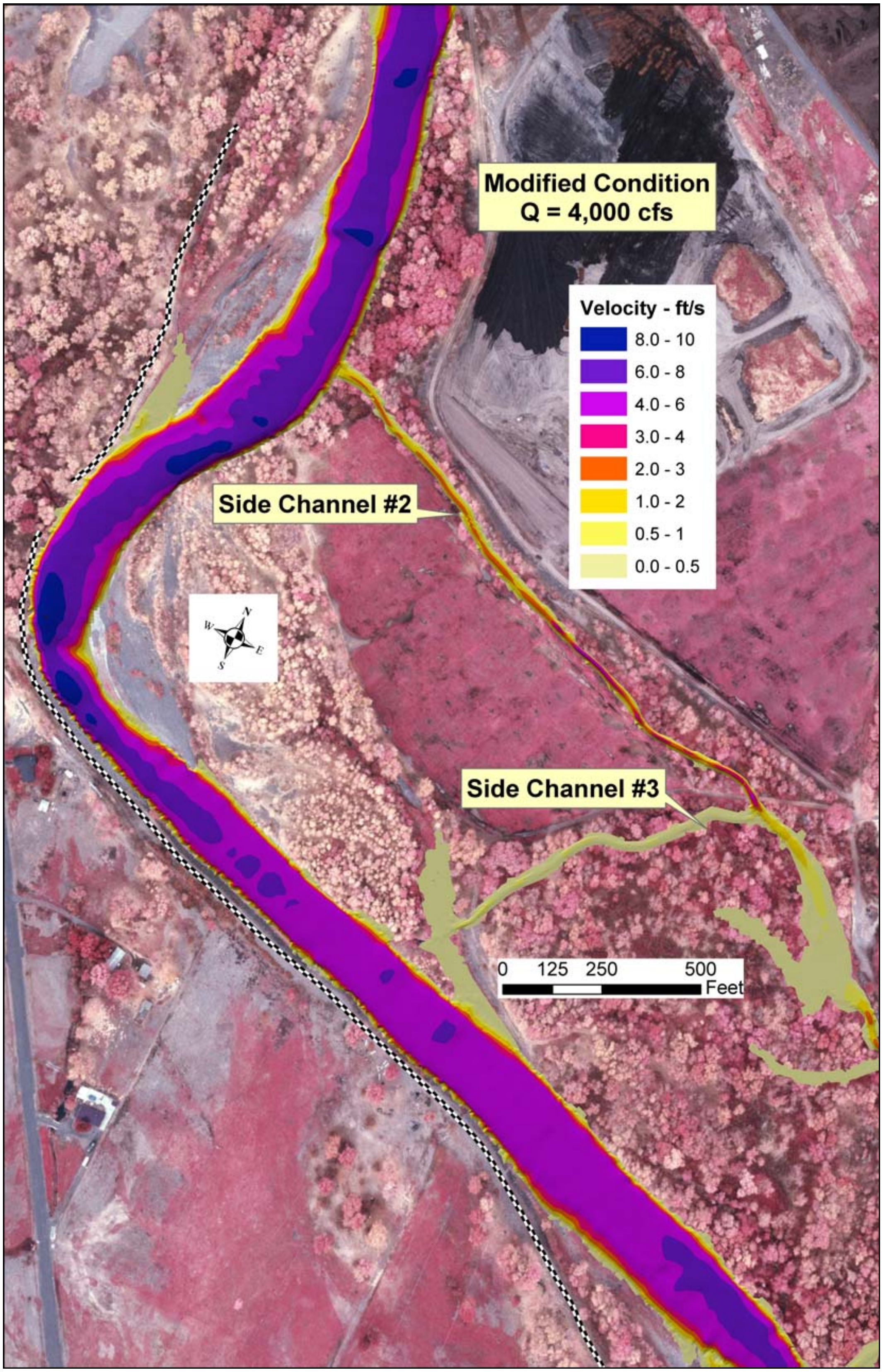
## Modeled depth and velocity maps for side channels with a main channel discharge of 4,000 $ft^3/s$

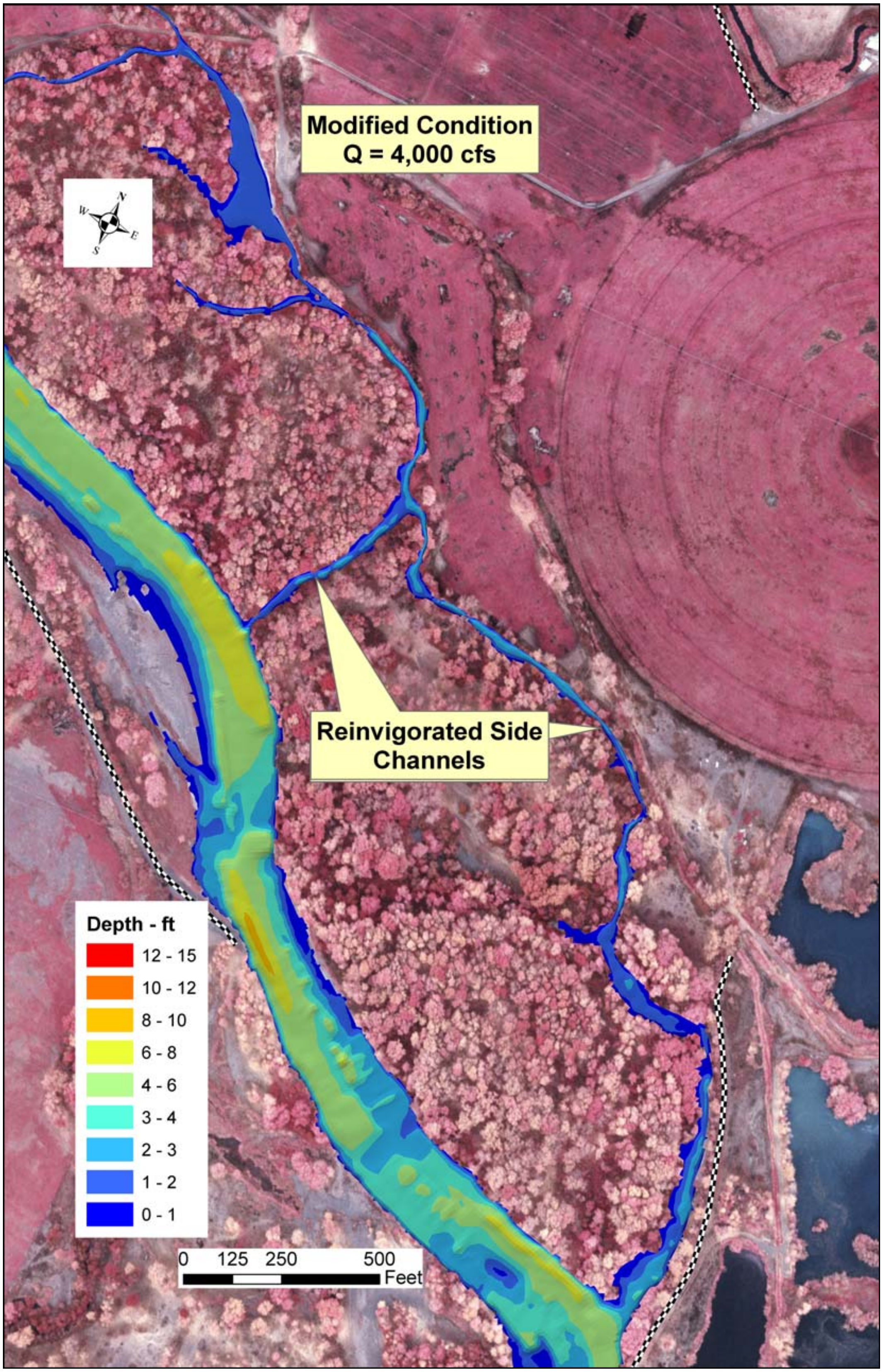

Modified Condition
Q = 4,000 cfs
N
W
E
S
Side Channel #1
Tjossem Access Channel
Depth - ft
12 - 15
10 - 12
8 - 10
6 - 8
4 - 6
3 - 4
2 - 3
1 - 2
0 - 1
0
125
250
500
Feet

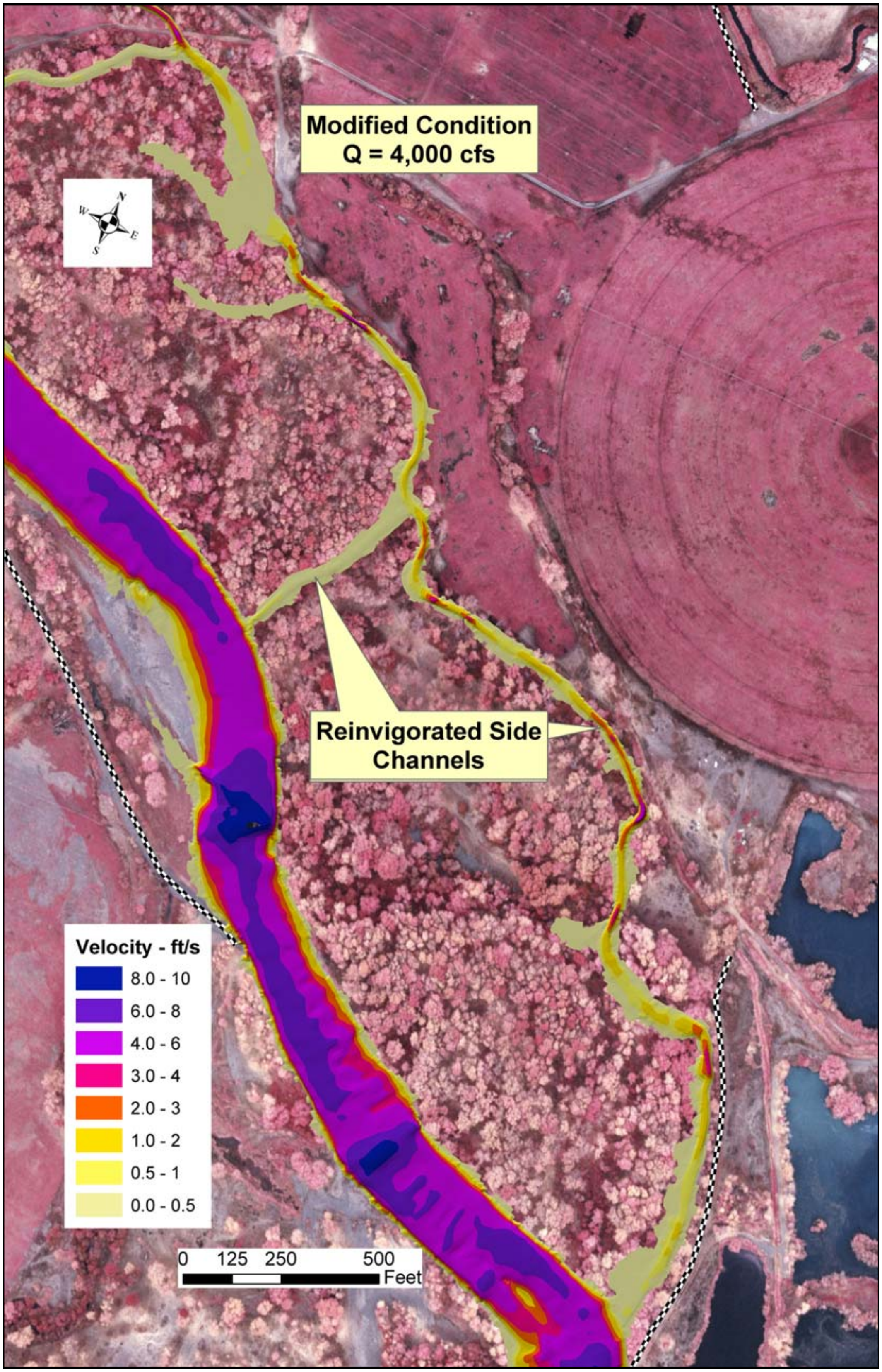

Modified Condition
Q = 4,000 cfs
N
W
E
S
Side Channel #1
Tjossem Access Channel
Velocity - ft/s
8.0 - 10
6.0 - 8
4.0 - 6
3.0 - 4
2.0 - 3
1.0 - 2
0.5 - 1
0.0 - 0.5
0
125
250
500
Feet



Modified Condition
Q = 4,000 cfs
Depth - ft
12 - 15
10 - 12
8 - 10
6 - 8
4 - 6
3 - 4
2 - 3
1 - 2
0 - 1
Side Channel #2
Side Channel #3
N
E
S
W
0 125 250 500
Feet


Modified Condition
Q = 4,000 cfs
Velocity - ft/s
8.0 - 10
6.0 - 8
4.0 - 6
3.0 - 4
2.0 - 3
1.0 - 2
0.5 - 1
0.0 - 0.5
Side Channel #2
Side Channel #3
N
W
E
S
0 125 250 500
Feet


Modified Condition
Q = 4,000 cfs
N
S
E
W
Reinvigorated Side Channels
Depth - ft
12 - 15
10 - 12
8 - 10
6 - 8
4 - 6
3 - 4
2 - 3
1 - 2
0 - 1
0 125 250 500
Feet


Modified Condition
Q = 4,000 cfs
N
W
E
S
Reinvigorated Side
Channels
Velocity - ft/s
8.0 - 10
6.0 - 8
4.0 - 6
3.0 - 4
2.0 - 3
1.0 - 2
0.5 - 1
0.0 - 0.5
0 125 250 500
Feet