RECLAMATION

Managing Water in the West

Stormy Reach Assessment Update
Entiat River Subbasin

Chelan County, Washington

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Pacific Northwest Regional Office, Boise, Idaho

May 2013

U.S. DEPARTMENT OF THE INTERIOR

Protecting America's Great Outdoors and Powering Our Future

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

MISSION OF THE BUREAU OF RECLAMATION

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.

Cover Photo: Aerial view of Stormy Reach, Entiat River, Chelan County, Washington.

RECLAMATION

Managing Water in the West

Stormy Reach Assessment Update
Entiat River Subbasin

Chelan County, Washington

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Pacific Northwest Regional Office, Boise, Idaho

May 2013

This page intentionally left blank

Table of Contents

This page intentionally left blank

INTRODUCTION

The Stormy Reach of the Entiat River in central Washington consists of roughly 2.83 miles of channel between River Mile (RM) 18.02 and 20.85 (Figure 1, Figure 2, and Figure 3). This reach is within the "Stillwater area" of the Entiat River and is characterized by a sinuous, relatively low gradient, unconfined channel with a gravel-dominated bed and active floodplain. The *Stormy Reach Assessment* was completed by the Bureau of Reclamation in November 2009 (Reclamation 2009a) which documented existing conditions, human features and their impacts, and many appropriate actions for habitat improvement centered on those documented human impacts.

As a result of the Stormy Reach's natural channel character, it possesses a high intrinsic habitat potential which is not currently fully utilized due in large part to human impacts on the landscape. New analyses and conclusions are presented in this update which emphasize maximizing habitat potential throughout the entire reach as opposed to focusing primarily on areas impacted by human features. This update recognizes that human features (e.g., bridges, levees, riprap) have impacted the landscape, but broadens the scope of habitat improvement to include other human impacts that do not or have not left behind visible features on the landscape (e.g., historic timber harvests, floodplain clearing, removal of logjams and other obstructions from the channel).

To provide context, this update includes a summary of the original 2009 Reach Assessment followed by a brief discussion of historic and existing conditions. This information is used to support a list of target conditions and geomorphically appropriate actions suitable for addressing those impacts and maximizing habitat potential. The goal of this document is to expand upon those actions outlined in the 2009 *Reach Assessment* to include a broader set of geomorphically appropriate solutions aimed at improving habitat form and function for threatened and endangered salmonids in the Stormy Reach of the Entiat River.

SUMMARY OF EXISTING REACH ASSESSMENT

The 2009 Stormy Reach Assessment is summarized in the following points:

- The Assessment focused primarily on human features and their impact on habitat and channel characteristics.
- Outer and inner floodplain zones were defined (both considered part of the active floodplain).
    - Outer = floodplain processes and riparian vegetation dominate.
    - Inner = active channel processes and ground disturbance dominate.

- Reach Based Ecosystem Indicators based on limiting factors were evaluated as Adequate, At Risk, or Unacceptable.
    - Water Quality: At Risk due to pH, temperature, and suspended solids.
    - Habitat Access: Adequate.
    - Habitat Quality: At Risk due to elevated fine sediment and limited off-channel habitat.
    - Dynamics: At Risk due to levees and riprap disconnecting the floodplain, limiting channel migration and potentially causing channel incision.
    - Riparian Vegetation: At Risk due to lack of large/mature riparian vegetation.
- A levee and associated riprap near RM 19.7 were identified as the greatest human impacts responsible for the majority of the At Risk conditions associated with channel dynamics (i.e., reduced channel migration, potential for increased vertical incision).
- Large woody material (LWM) was considered to be Adequate based on existing pieces observed and recruitment potential although the general lack of large wood for recruitment was identified as a limitation.
- A summary of proposed actions included:
    - RM 20.36 – 20.85: Reconnect processes (riparian vegetation within 30-meter buffer zone).
    - RM 19.79 – 20.1: Reconnect processes (LWM and/or boulder placement to dissipate stream energy associated with road riprap; riparian vegetation within 30-meter buffer zone on right bank).
    - RM 19.5 – 19.8: Reconnect processes (left bank; remove levee and small access road; reconnect disconnected inner zone and outer zone; reintroduce natural channel migration; reduce instream velocity associated with confined/straightened subreach; LWM placement for increased complexity).
    - RM 18.28 – 19.86: Reconnect processes (riparian vegetation within 30-meter buffer zone).
    - RM 18.42 – 19.07: Reconnect processes (replace rock structures and abandoned bridge abutments with log structures to increase habitat).
    - RM 18.02 – 18.42: Reconnect isolated habitat (modify rock spur with wood placements to increase habitat while maintaining bank protection).

- RM 18.1 – 18.35: Reconnect processes (riparian vegetation within 30-meter buffer zone on right bank).

UPDATE

Historic Conditions

The historic conditions of the Stormy Reach are summarized as:

- Meandering channel potentially with multiple side channels.
    - Ancient channel scars visible in LiDAR topography suggest the channel has migrated consistently following a highly sinuous path across the entire valley bottom over at least the past several hundred years. The upper half of the channel (upstream of RM 19.3) shows evidence of consistent lateral migration (meander scrolls, see Figure 4) and meander cut-off avulsions (Figure 5). The downstream half of the reach (downstream of RM 19.3) is affected by backwater conditions associated with the natural channel constriction formed by the Stormy Creek alluvial fan (Figure 6). Ancient channel scars in this portion of the Reach are distinct, but with fewer well-defined meander scrolls than upstream suggesting avulsion had a greater influence than lateral channel migration in the lower reach.
    - Hard points throughout the valley bottom (old-growth forest and large logjams) very likely initiated split flow and side channel activation and provided long-term maintenance of these features particularly in the lower half of the reach where avulsion played a more dominant role.
    - Side channels and alcoves may have preferentially formed along the valley wall where flood flows concentrated and more rapidly initiated scour (Figure 7.
- Bank conditions were likely hydraulically rough and with ample cover provided by dense/mature riparian vegetation and LWM. Vegetation provided structure and cover and was capable of capturing and retaining LWM as trees fell from the bank and/or as LWM was transported from upstream.

Existing Conditions

The existing conditions of the Stormy Reach are summarized as:

- Single- threaded, meandering channel with relatively few (short) side channels.

- Meander wavelength ranges from over 1,500 feet to under 400 feet. Longer wavelengths tend to be associated with erosion-resistant banks while, based on historic aerial photo evidence, shorter wavelengths (less than 600 feet) are at the greatest risk of meander cutoff (Figure 8).

- The channel transitions from transport-dominated with a moderately active floodplain in the upper half of the reach to transport-limited with a highly active floodplain in the lower half of the reach. Backwater conditions resulting from a constriction formed by the Stormy Creek alluvial fan likely account for the conditions in the lower half of the reach.

- Dense but relatively immature vegetation in the upper half of the reach and dense with appropriate age-class distribution including relatively mature vegetation in the lower half of the reach (Figure 9 and Figure 10). Differences in vegetation are primarily the result of disturbance (e.g., fire, logging, floods). Greater wetland conditions in the lower reach may have reduced the disturbance potential associated with fire and logging in this area.

- Human impacts include:

    - The levee at RM 19.75 is the most significant human impact (Figure 9).

        - Restricts natural channel migration and flooding; downstream impacts include increased instream velocity and sediment transport capacity altering rates and extent of channel migration and floodplain interaction (Reclamation 2009b).

    - Highway constrictions have minimal impact because the highway is on the edge of the valley wall, and channel migration would not be significantly altered if the highway and associated bank protection were removed.

    - Historic bridge abutments near RM 18.74, while unnatural, represent singular hard points in the floodplain that increase hydraulic diversity in this subreach and may rack wood to form logjams in the future. Removal of the bridge abutments should be offset by installing similar size or larger logjams.

    - Bank protection (riprap) tends to produce hydraulic surfaces that are relatively smooth which have the potential to increase instream velocity and scour affecting natural channel migration and sediment transport.

    - Lack of large mature trees (old-growth forest) as a result of timber harvest and fire has reduced the number of hard points on the floodplain and large logjams forming in the reach.

Target Conditions

The target conditions of the Stormy Reach are summarized as:

- Greater number and length of side channels and split flow resulting from large logjams.
- Many hard points primarily provided by LWM throughout the channel and floodplain.
- Increased bank structure emulating mature riparian vegetation providing greater hydraulic diversity and cover.
- Unlimited channel migration, avulsion and side-channel potential across the entire valley bottom (to the extent possible). Meander wavelengths average around 1,000 feet. Smaller wavelengths will promote overbank flow, side channel development, and avulsions while longer wavelengths are more appropriate along erosion-resistant banks.
- Improved riparian vegetation (density and age-class distribution).

POTENTIAL ACTIONS

Following is a list of potential habitat improvement actions based on the geomorphic conditions in the Stormy Reach. This reach of the Entiat River is dynamic, and many habitat improvements may be appropriate. As a result, the list outlined below is not considered inclusive, rather representative of geomorphically appropriate habitat improvement actions with the potential to collectively address human impacts within the Stormy Reach.

- Remove/alter levee at RM 19.75 (Figure 11 and Figure 12); remove riprap armoring from levee and allow the levee to unravel over time; and/or strategically breach the levee allowing partial recovery of channel migration.
- Replace those areas of riprap (RM 18.75) that are hydraulically smooth with roughened bank protection including LWM to increase habitat and hydraulic diversity while maintaining bank stability (e.g., log and rock barbs, log barbs, log crib walls, series of rootwads).
- Install large logjams adjacent to potential side channel inlets to increase overbank flow and side-channel activation; may require areas of side channel excavation and/or enhancement (Figure 13).

- Install strategically placed large logjams or other hard points to obstruct and/or split flow in order to activate and scour side channels and/or flood channels (Figure 14). Prolonged split flow commonly requires relatively stable banks (typically provided by mature vegetation); therefore, bank stabilization projects may be required as a supportive action.

- Strategically place large logjams within the active channel to obstruct flow and promote increased overbank flow that can concentrate against the valley wall (or other erosion resistant surface) enhancing existing alcoves, potentially forming new alcoves (Figure 15).

- Place log bank protection structures along inappropriately/anthropogenically accelerated eroding banks to stabilize banks while riparian vegetation matures (Figure 14). Although no obvious anthropogenically accelerated bank erosion was observed in the Stormy Reach during field reconnaissance in 2012, removal of the levee near RM 19.75 will potentially expose a large area that has been cleared of vegetation and may require bank stabilization until riparian vegetation can be established (Figure 15).

- Plant riparian vegetation where lacking.

FIGURES

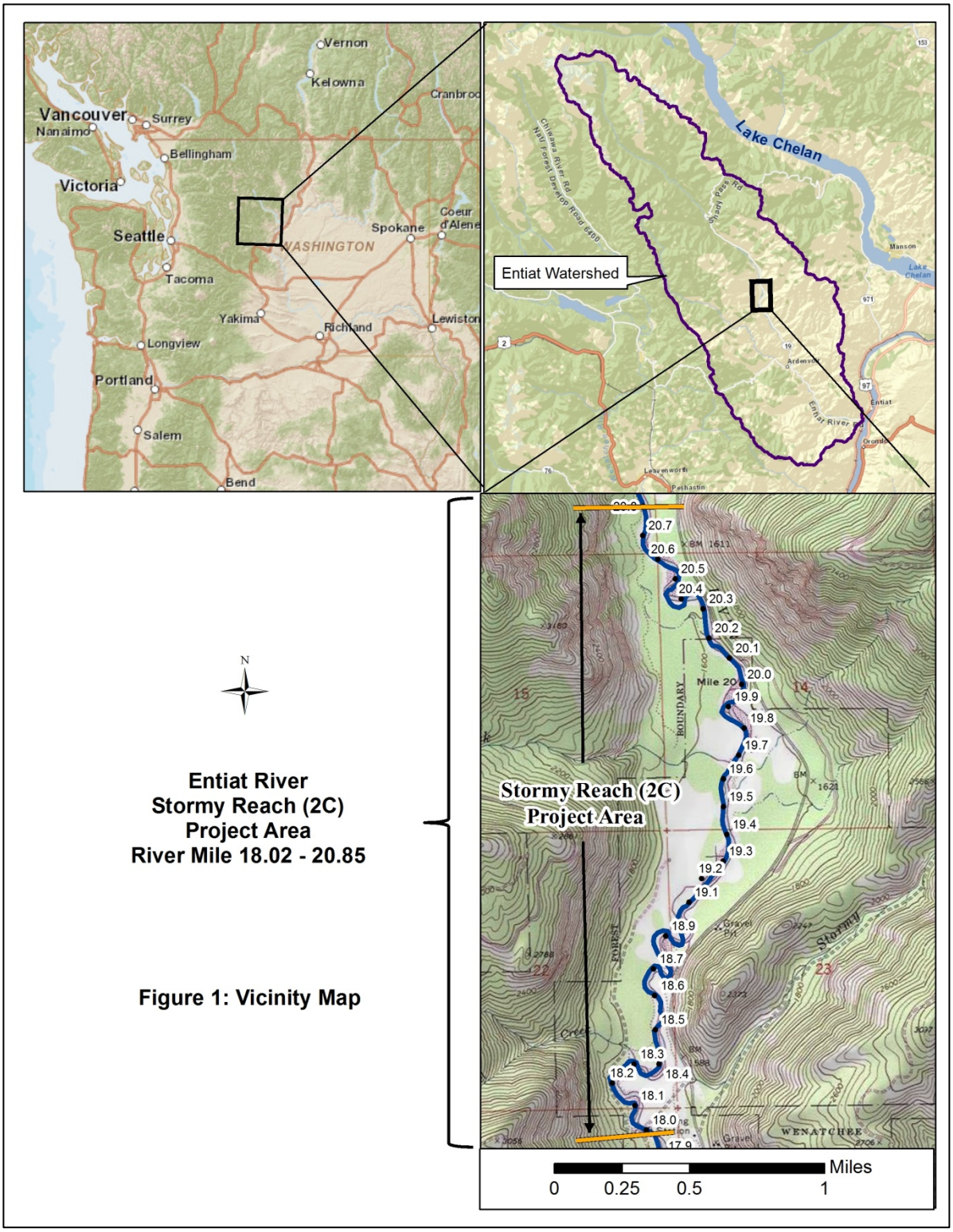

Figure 1. The Stormy Reach of the Entiat River is located between RM 18.02 and 20.85.

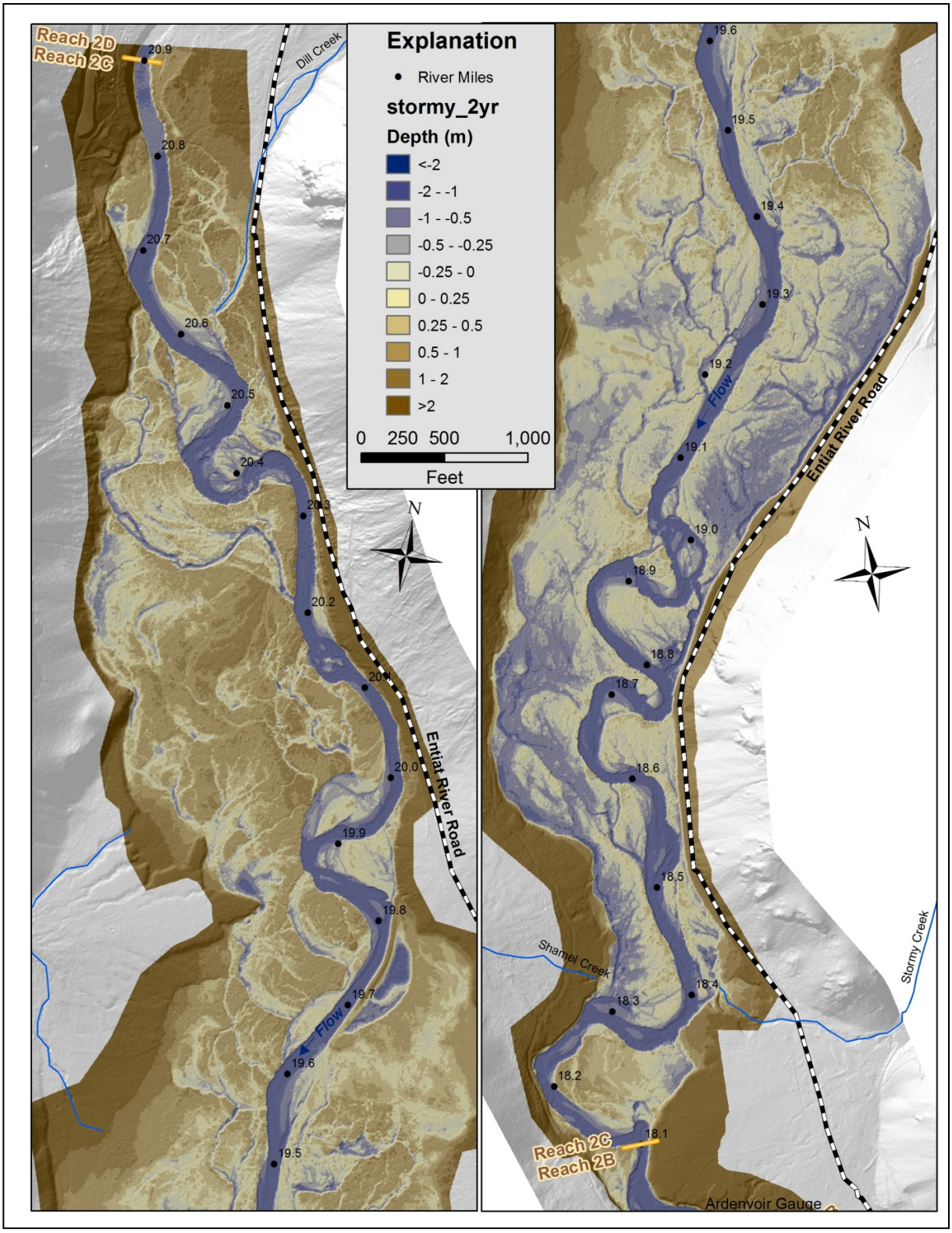

Figure 2. Stormy Reach project area shown with an approximate 2-year flood inundation area generated from LiDAR topography and HEC-RAS hydraulic modeling.

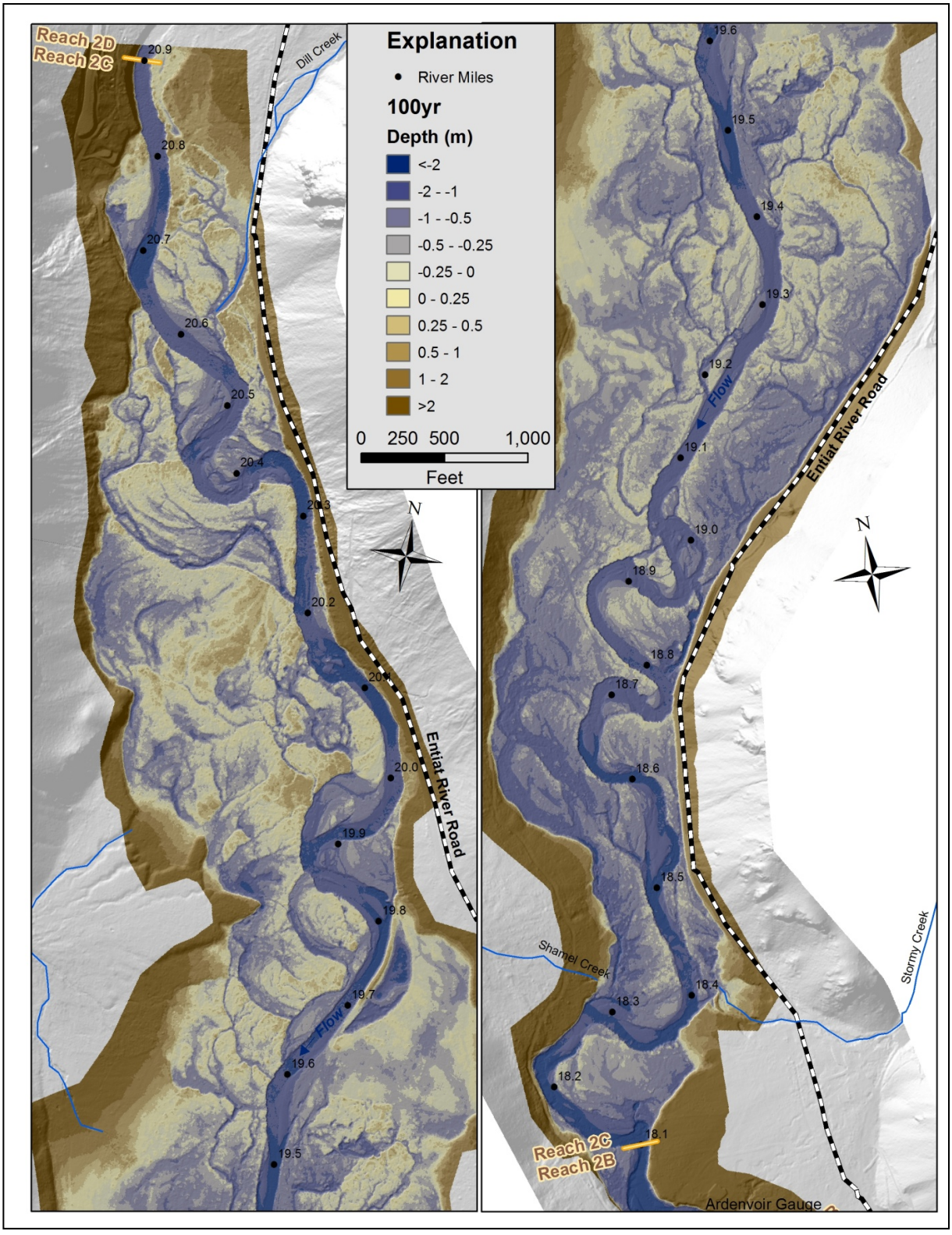

Figure 3. Stormy Reach project area shown with an approximate 100-year flood inundation area generated from LiDAR topography and HEC-RAS hydraulic modeling.

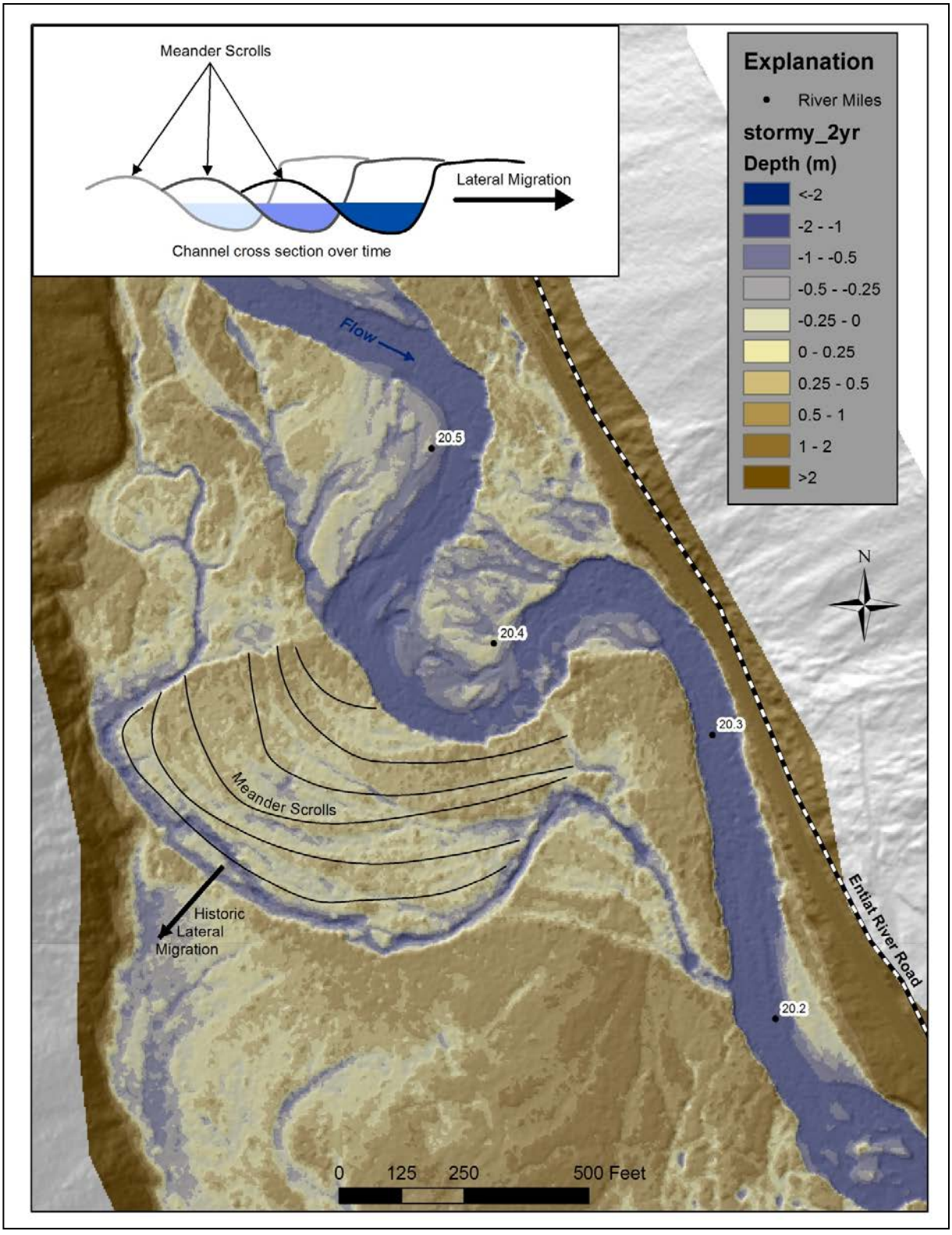

Figure 4. Meander scrolls evident in LiDAR topography suggest channel migration was a dominant process in the upper half of the Stormy Reach.

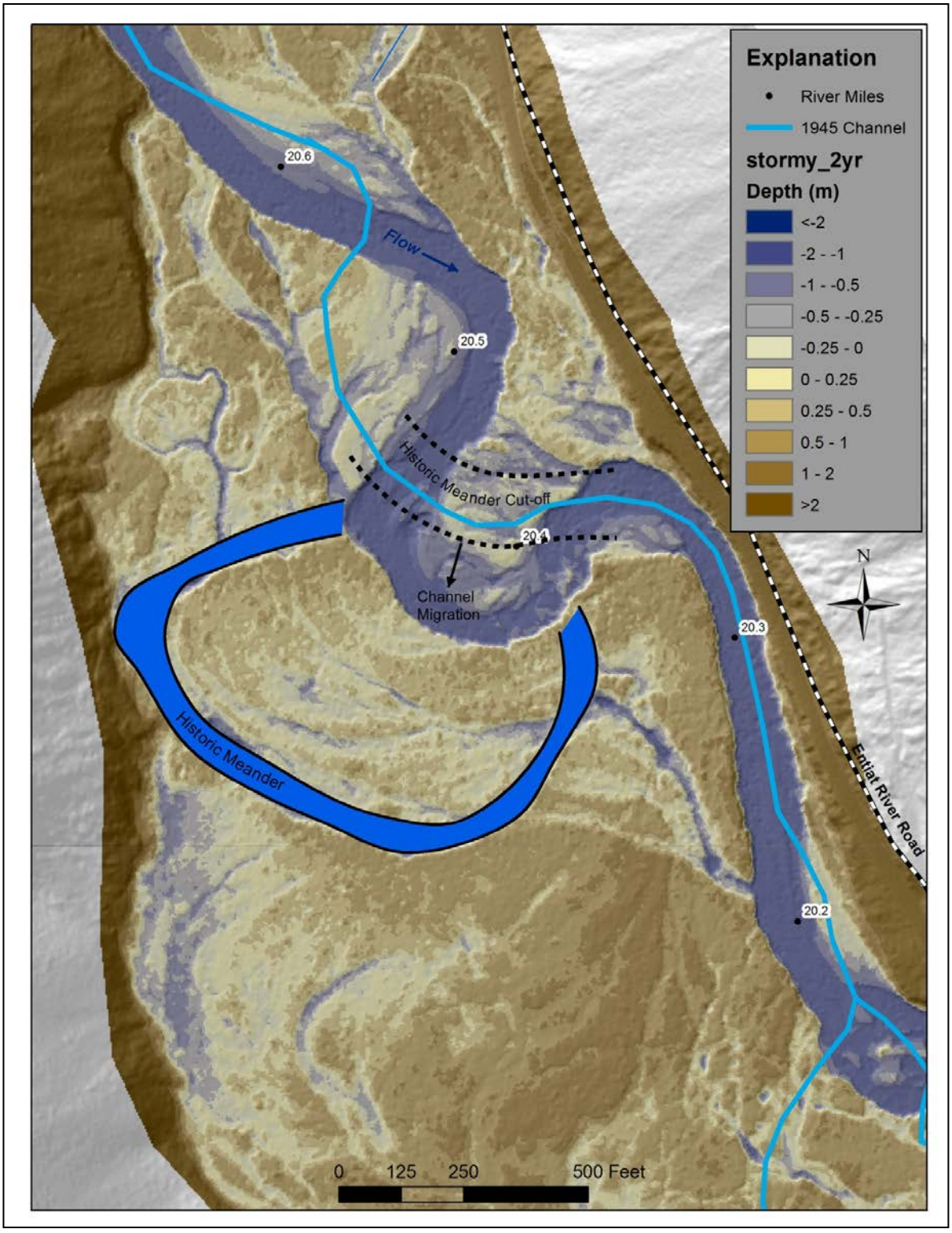

Figure 5. Abrupt termination of meander scrolls in the floodplain topography suggest meander cut-off avulsion was a dominant process in the upper half of the Stormy Reach, as illustrated by this historic meander and 1945 channel which appears to have cut off the meander. Subsequent channel migration (after 1945) may result in a similar meander cut off at this location again in the future.

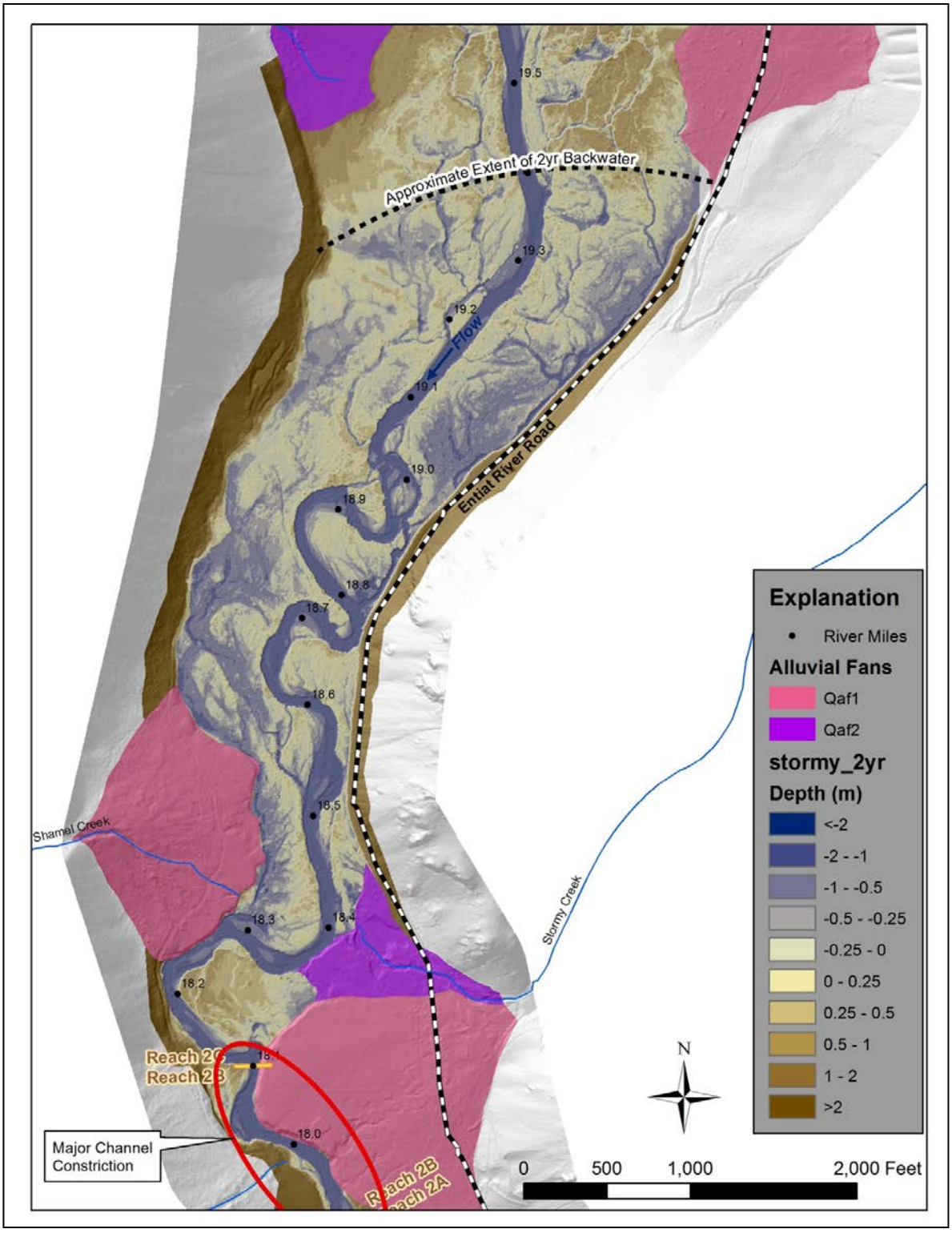

Figure 6. The Stormy Creek alluvial fan has constricted flow at the downstream end of the reach to such a degree that floodwater passage is restricted, creating a backwater that persists upstream for over 1 mile during a 2-year flood and even farther during larger floods.

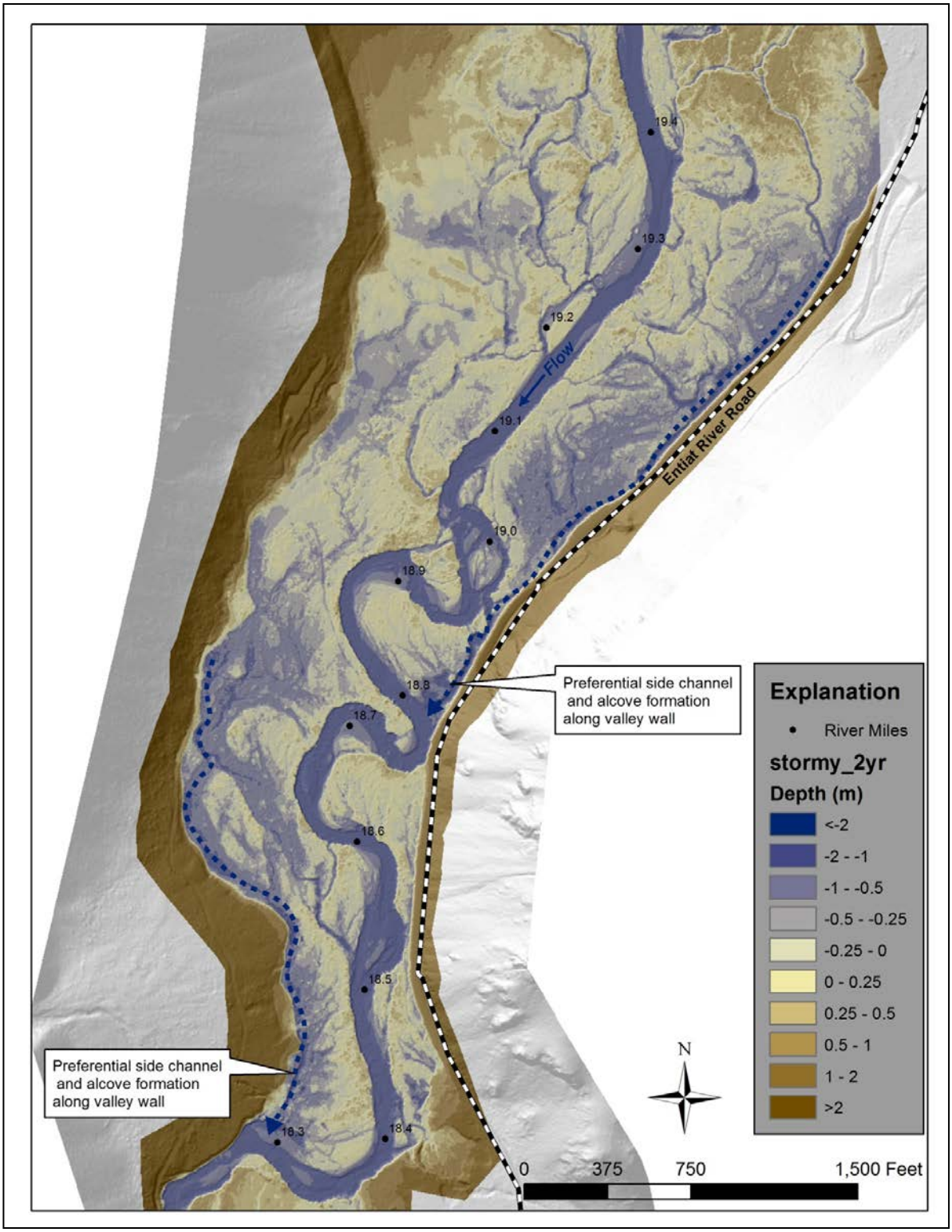

Figure 7. Floodwater tends to pass across the floodplain as sheet flow with little erosive power until it becomes concentrated against a topographic obstruction (such as the valley wall) where flow becomes concentrated with increased shear stress and scour, potentially forming side channels and/or alcoves.

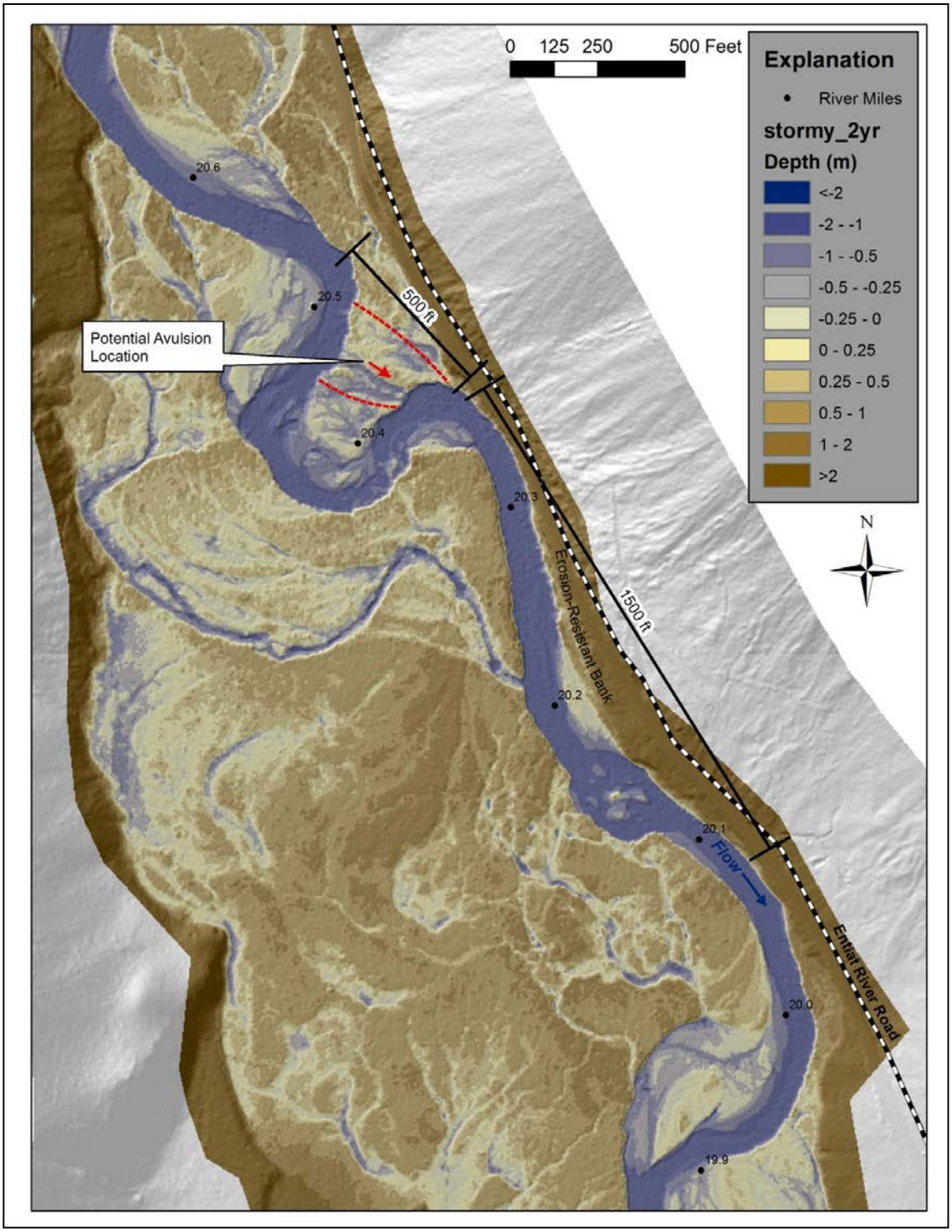

Figure 8. Meander wavelength defines the distance between the apexes of two consecutive bends. Meander wavelengths in the Stormy Reach vary, but average roughly 1,000 feet. Wavelengths tend to become extended along erosion resistant boundaries while short wavelengths risk meander cut-off avulsion.

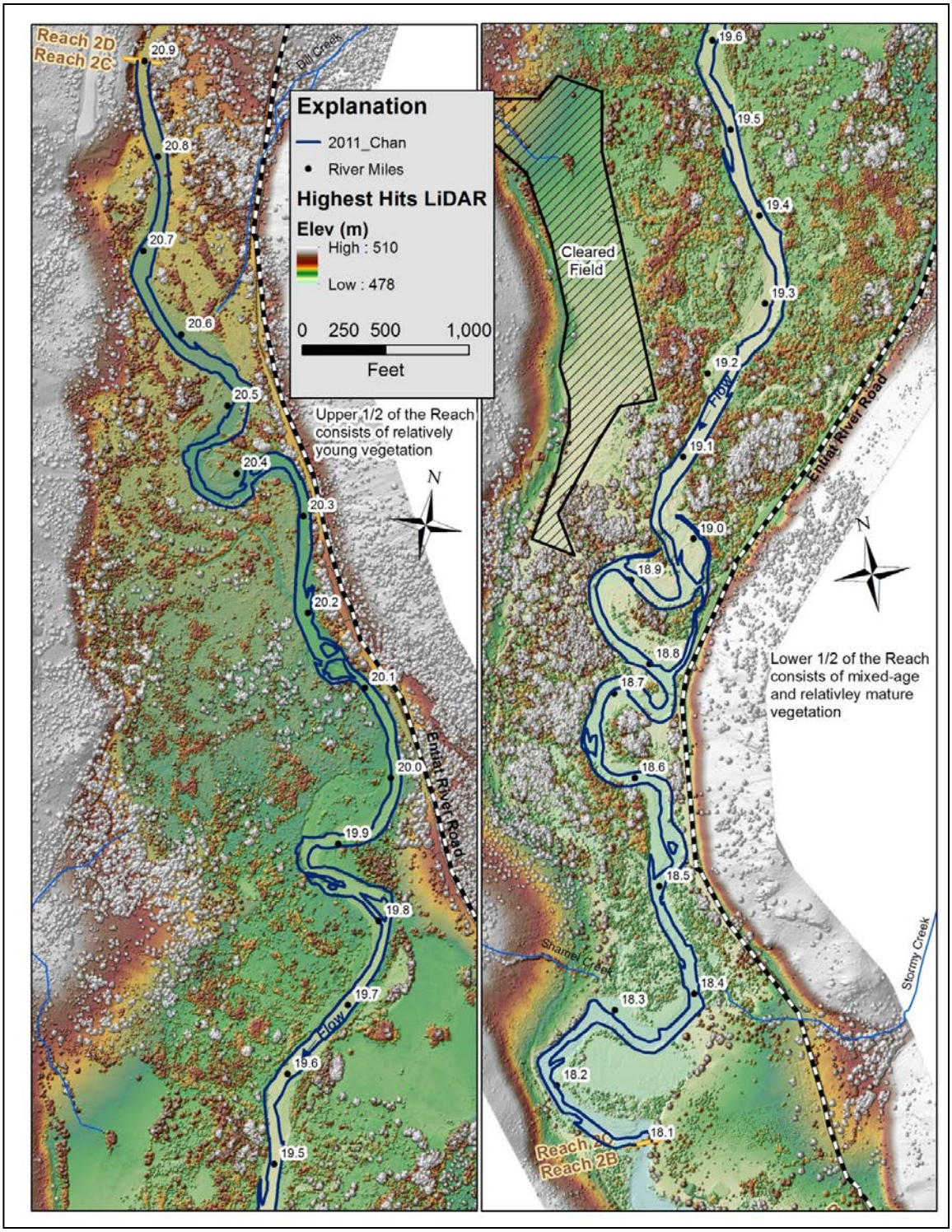

Figure 9. LiDAR highest hits returns capture vegetation heights across the floodplain. This image illustrates tall (mature) vegetation as red and white, while short (young) vegetation is green and blue. The upper half of the reach is dominated by younger age classes, while the lower half appears to be more appropriately mixed-age.

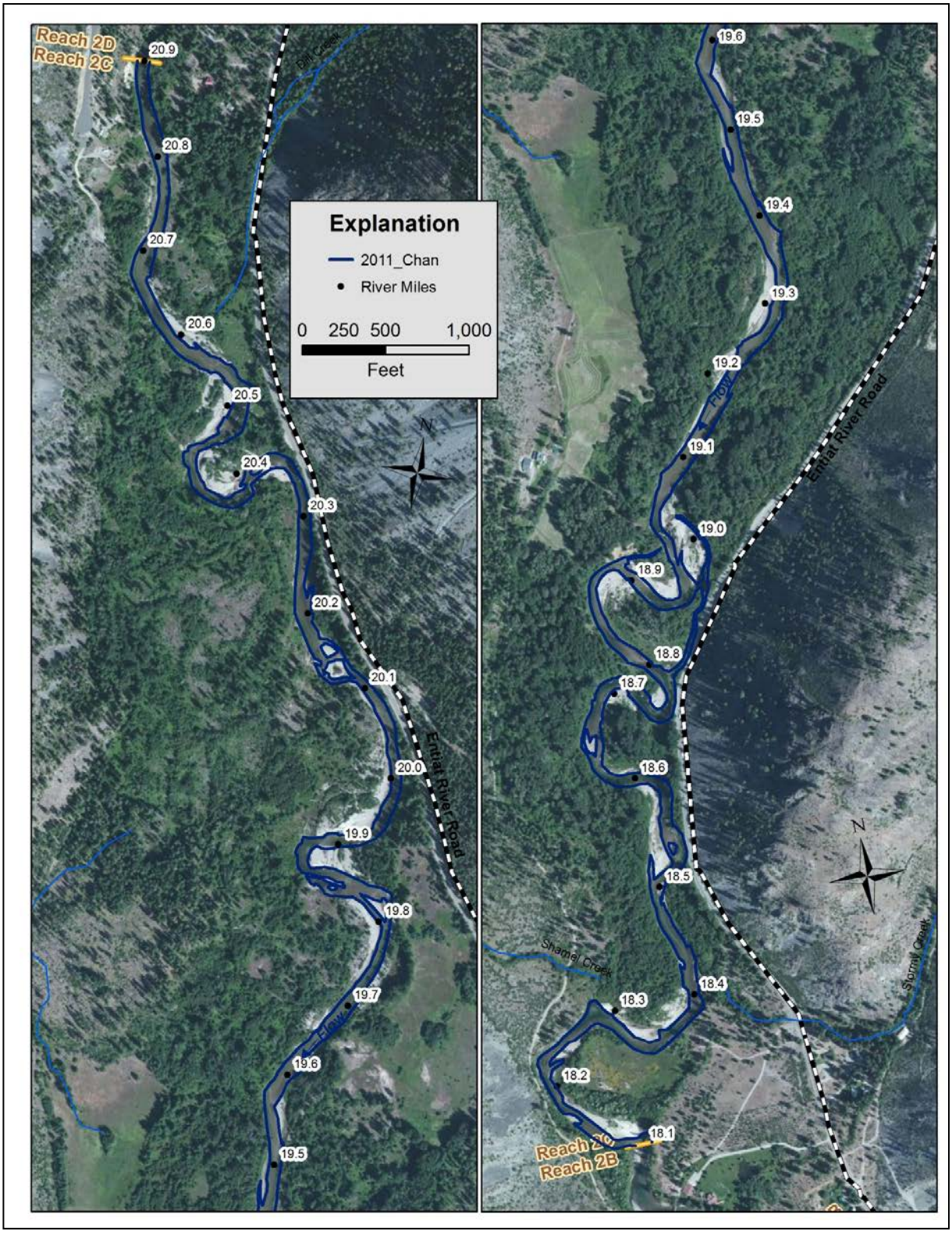

Figure 10. 2012 Microsoft Bing aerial image of the reach showing vegetation on floodplain.

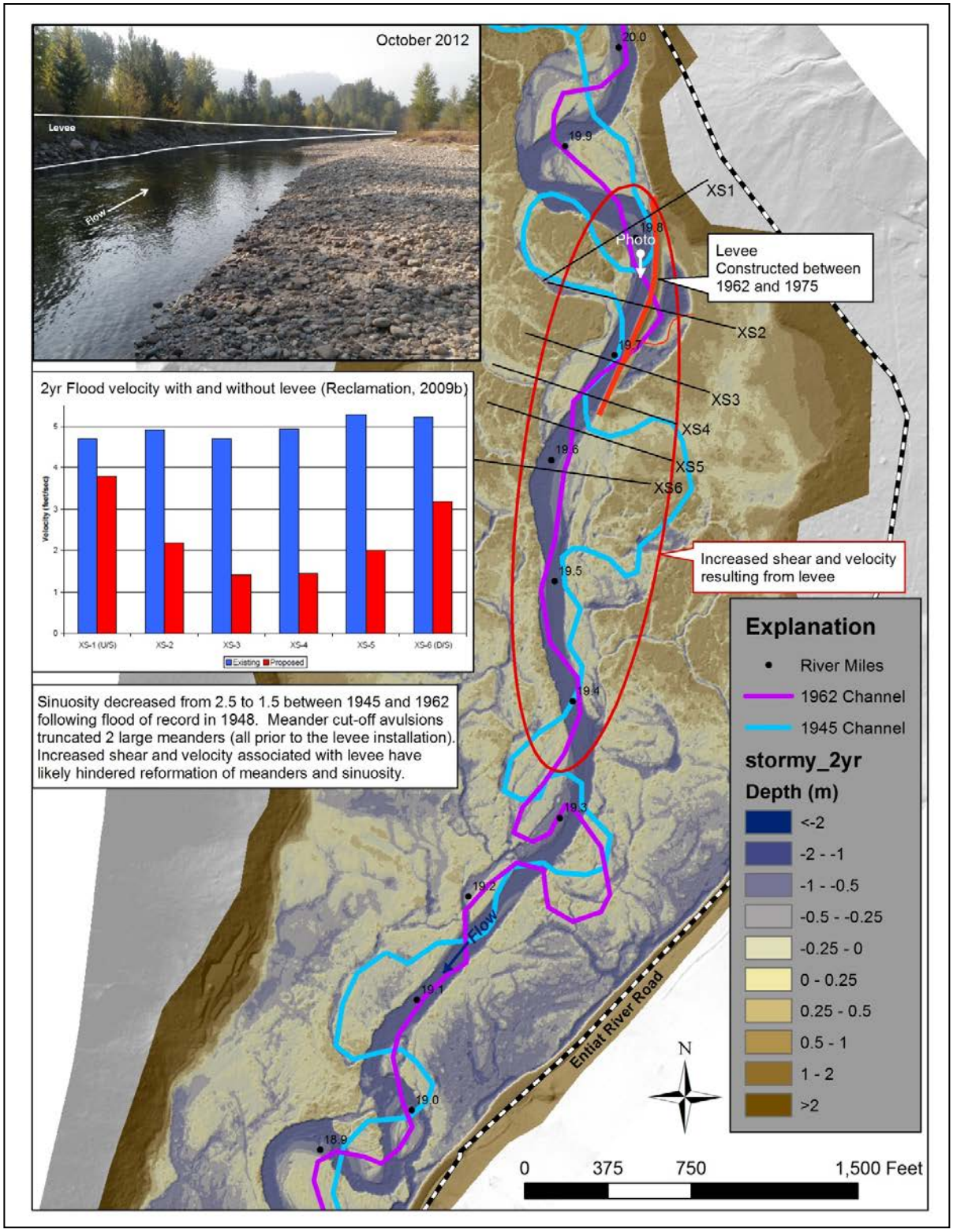

Figure 11. A levee near RM 19.75 has restricted channel migration, reduced floodplain connection, and increased instream velocity affecting downstream channel function (reduced overall sinuosity and floodplain connection).

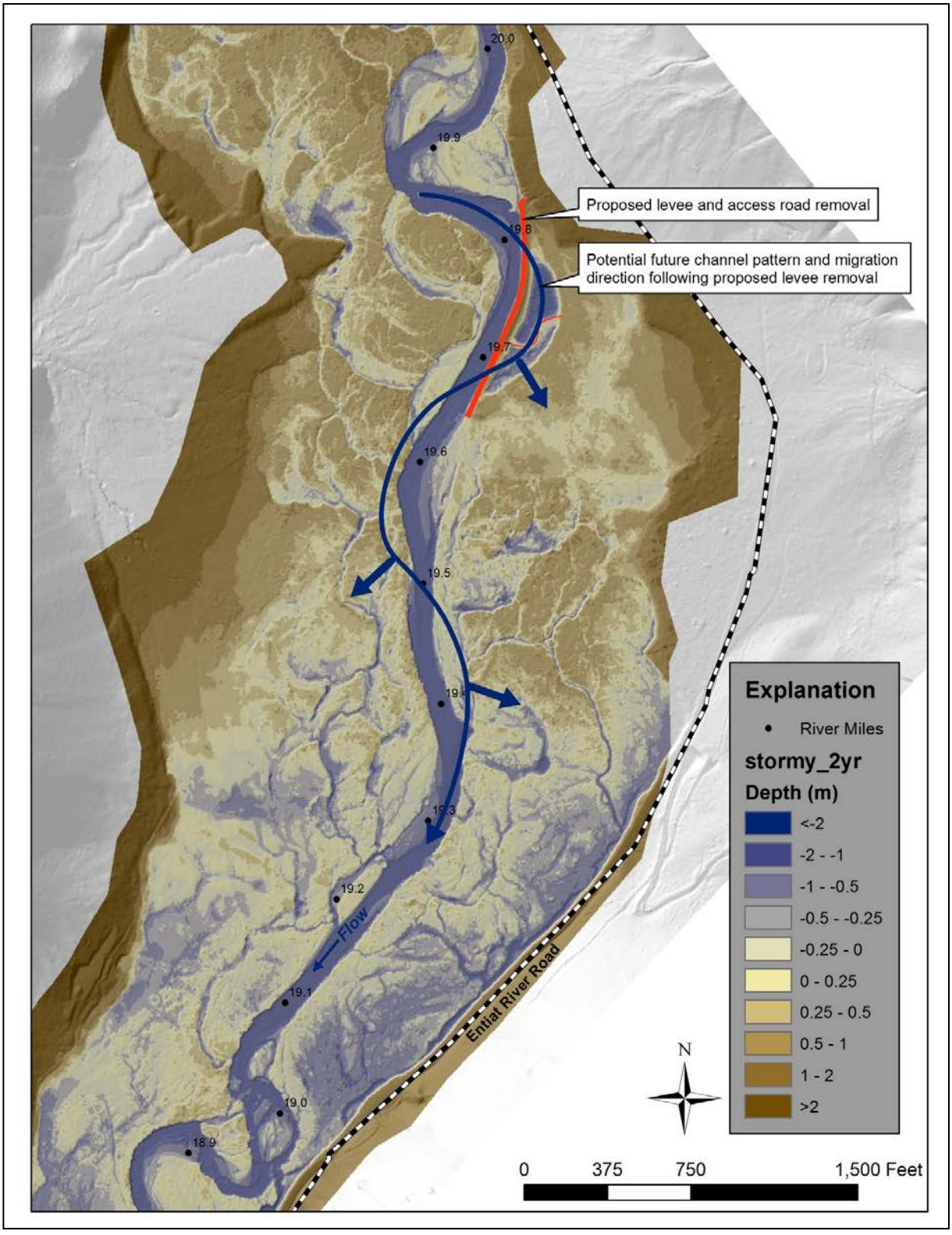

Figure 12. Given potential levee removal, the channel is likely to increase sinuosity and channel migration.

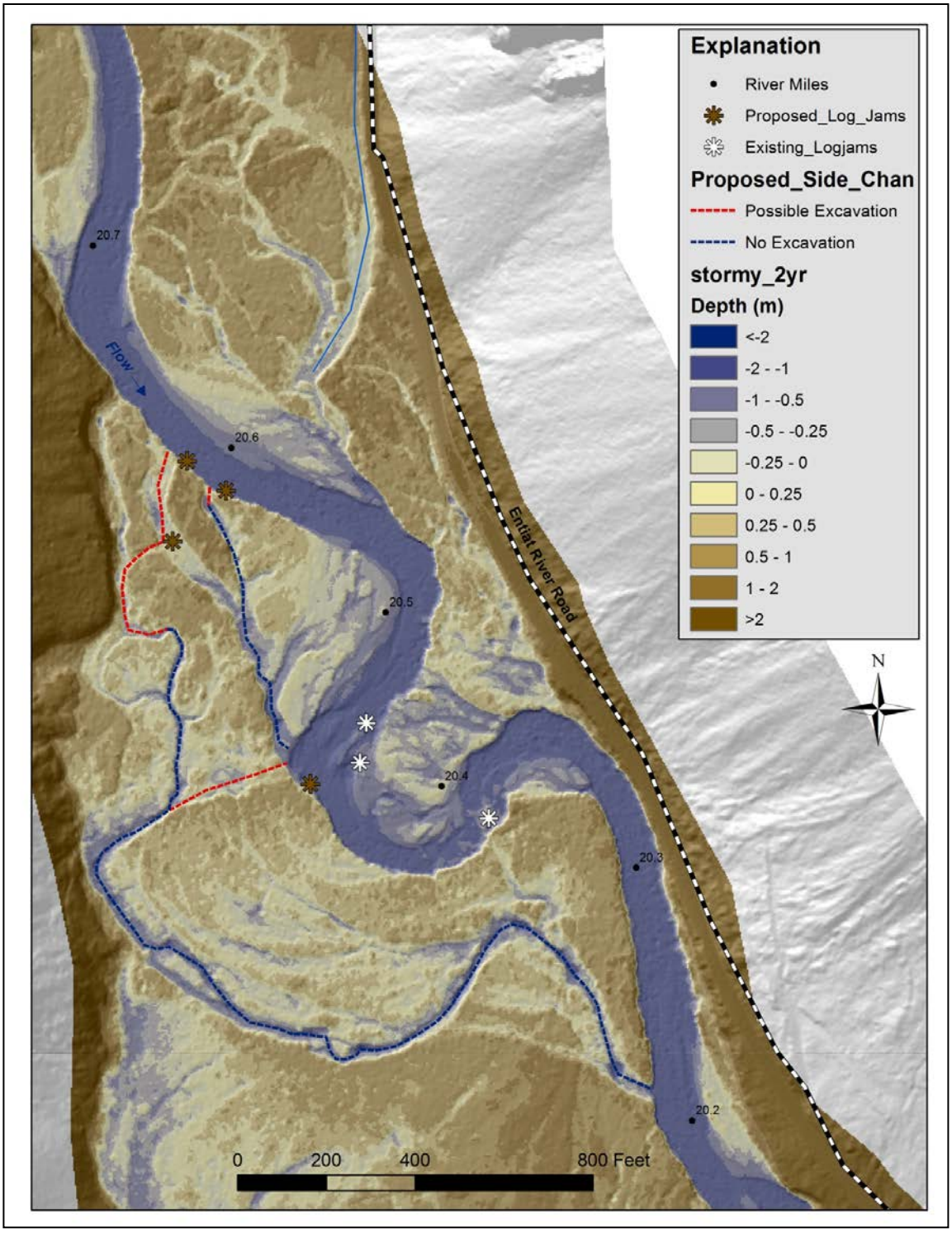

Figure 13. Adding logjams at the apex of potential side channel connections will increase overbank flow in those locations improving side-channel formation and long-term function. Small amounts of excavation at the head of the potential side channel will enhance this process. Shown in the figure is an example of one location among many potential locations where logjam supported side channels are possible/appropriate within the Stormy Reach.

Figure 14. 2012 Microsoft Bing aerial image showing an existing example of the Stormy Reach where logjams and other woody material have obstructed and/or split flow creating side channels, enhancing side channel and floodplain activation, and increased overall channel complexity.

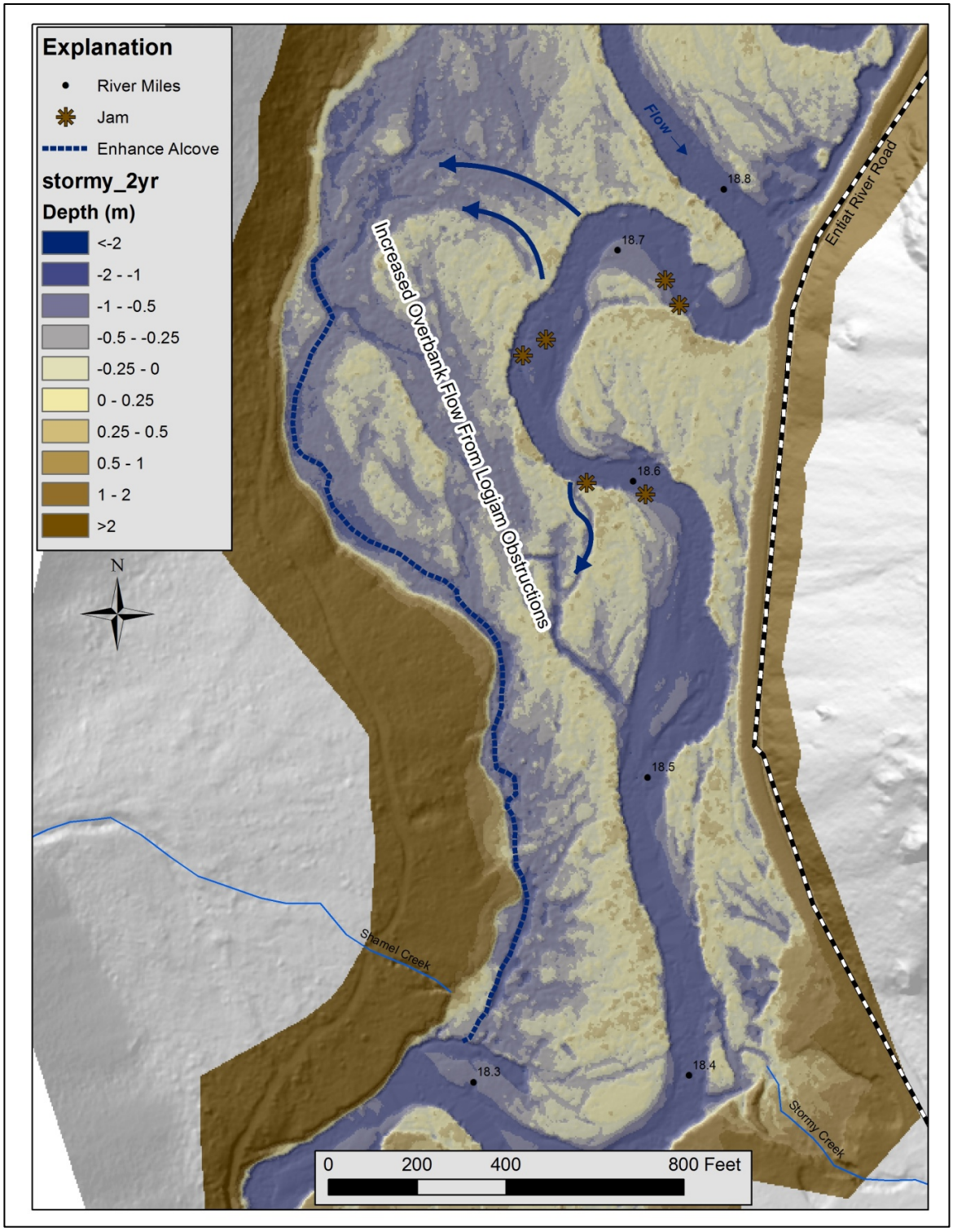

Figure 15. Instream logjams placed in the appropriate locations can obstruct flow sufficiently to promote more regular overbank flooding resulting in potential side channel and/or alcove formation. The Stormy Reach (particularly the lower half of the reach) has many locations where logjam obstructions can promote overbank flow and side channel/alcove development. This figure illustrates one such location.

Figure 16. 2012 photo of the Preston Site located approximately 1 mile upstream of the Stormy Reach. The photo was taken from the left bank looking downstream. A lack of riparian vegetation at this site had significantly exacerbated bank erosion. A series of root wad log structures were placed along the bank to emulate roots of a mature riparian forest to stabilize the bank sufficiently to allow planted riparian vegetation to mature.

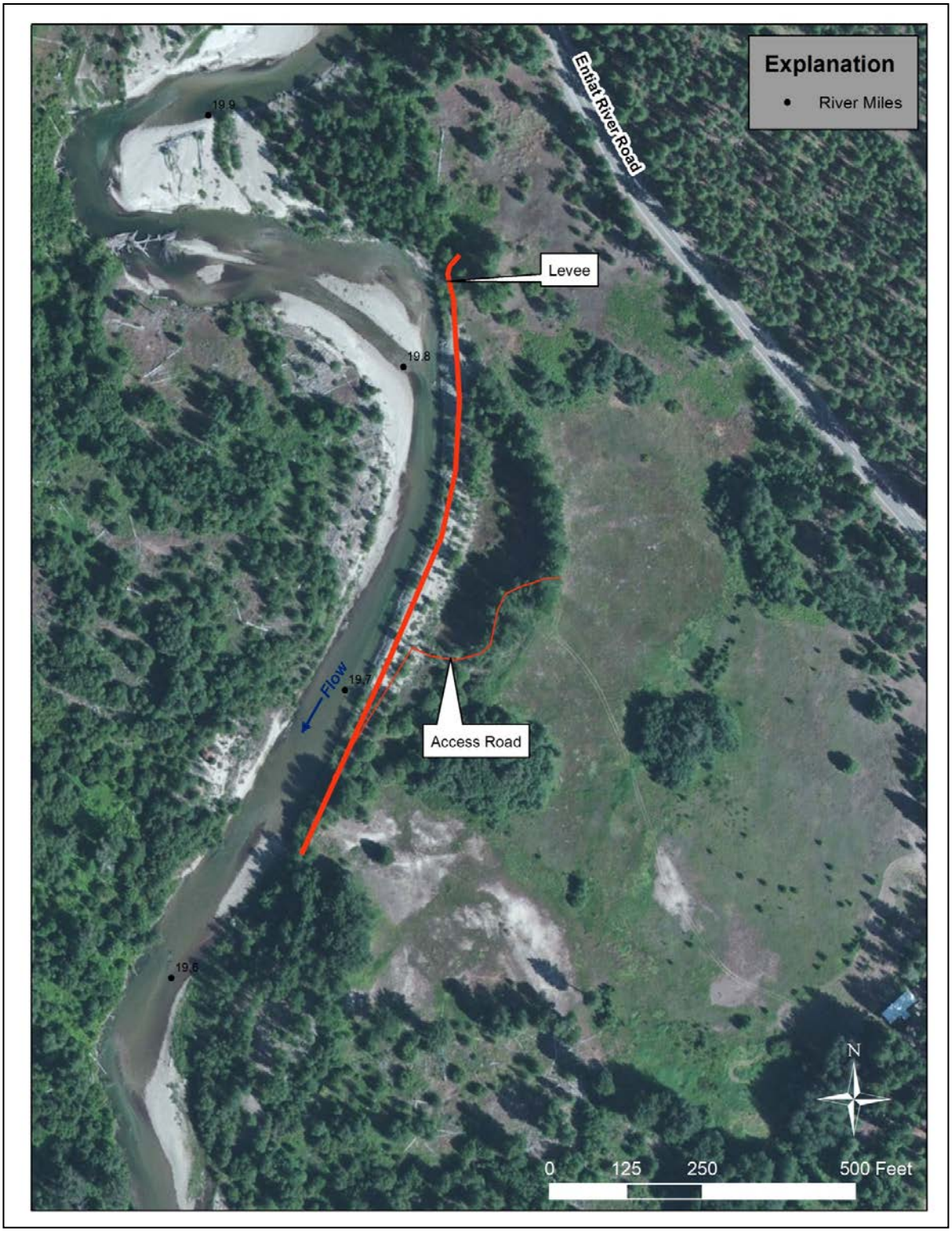

Figure 17. A large portion of the floodplain area located behind the levee near RM 19.75 has been cleared of mature riparian vegetation. Levee removal and subsequent channel relocation in this area may require short-term bank stabilization to reduce the risk of runaway channel migration.

LIST OF PREPARERS

Name	Organization	Contribution
Robert Richardson, L.G.	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Principal Author River Systems Analysis Group Geomorphologist
Terril Stevenson, L.G.	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Peer Reviewer River Systems Analysis Geomorphology Group Manager
Richard Link, L.E.G., L.G.	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Peer Reviewer Geology and River Systems Analysis Groups Program Manager
Carol Kjar	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Natural Resources Writer Liaison & Coordination Group

LITERATURE CITED

Parenthetical Reference	Bibliographic Citation
Reclamation 2009a	Bureau of Reclamation. 2009. *Stormy Reach Assessment, Entiat River, Chelan County, Washington*. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Regional Office, Boise, Idaho. November 2009.
Reclamation 2009b	Bureau of Reclamation. 2009. *Entiat Tributary Assessment, Chelan County, Washington*. U.S. Department of the Interior, Bureau of Reclamation, Technical Services Center, Denver, Colorado. January 2009.