Appendix D

Geology

Middle Twisp River (RM 7.8 – 18.12)

Contents

1 Geologic Setting

The Twisp River basin is located within the eastern portion of the Northern Cascades geologic province. Within this province, the Twisp River lies within the Methow Terrane. This terrane is a combination of sandstone and shale sediments left behind by the Methow Ocean, which covered today's Methow valley region 200 to 100 million years ago. A simplified geologic map is presented in Figure 1.

The Twisp River's U-shaped valley is derived primarily from consecutive glaciation cycles (see Section 4). Within this valley, development of the Twisp River, like almost any river system, has been governed by the underlying geology that it flows over and through. Over time, the Twisp River corridor has formed in a path more easily erodible than surrounding areas. Throughout the channel corridor, fault zones have fractured underlying bedrock and brought together geology types of differing composition, creating opportunities for incision and lateral migration (PWI 2003).

2 Bedrock Types

Within the contributing watershed of the study area, there are four primary types of bedrock: (1) Cretaceous igneous rocks, (2) Late Cretaceous continental sedimentary deposits, (3) Cretaceous-Jurassic volcanic sedimentary and volcanic conglomerate, and (4) Quaternary sedimentary rocks which line the channel corridor. Below RM 9, the bedrock is relatively erodible. Above RM 10, the crystalline structure of the bedrock is relatively erosion resistant. Further upstream, above RM 15, underlying lithology through the channel corridor includes mylonitized materials, rocks which are formed under shear pressures in fault zones, as well as glacially-transported clasts (fragments of larger rocks) and hillslope-sourced metamorphic and igneous rocks (PWI 2003, Bunning 1990). In this portion of the study reach, these lithology types are exposed through much of the study area where alluvium has been eroded away (PWI 2003).

3 Faulting and Geologic Structure

Regionally, there are several major fault systems that affect the study area. These fault systems create topographical and hydrographic divides, and affect the position of the major structural blocks and bedrock elements in the area.

The upper Twisp river corridor (above RM 15 and Scaffold Creek) primarily occupies the Twisp River-Foggy Dew fault zone, a fault-bound structural basin approximately 0.9 miles wide that trends from northwest to southeast (PWI 2003, Bunning 1990). Relative motion along these faults includes both strike-slip (primarily horizontal) and dip-slip (primarily vertical) movement (Haugerud and Tabot 2009). A graben-bounding fault crosses that channel at RM 9, which creates an erosion-resistant "step," or noticeable increase in grade, between RM 9 and RM 10. Downstream of Scaffold Creek, the Twisp flows across a northwest-trending syncline, a fold where the rock dips downward due to pressure from both sides (created between anticlines Thompson Ridge and the adjacent ridgeline) (PWI 2003).

Many faults run adjacent to the mainstem within the contributing drainages, intersecting the mainstem in a perpendicular fashion. This has led to right-angle confluences between many of the Twisp river tributaries and the mainstem (PWI 2003).

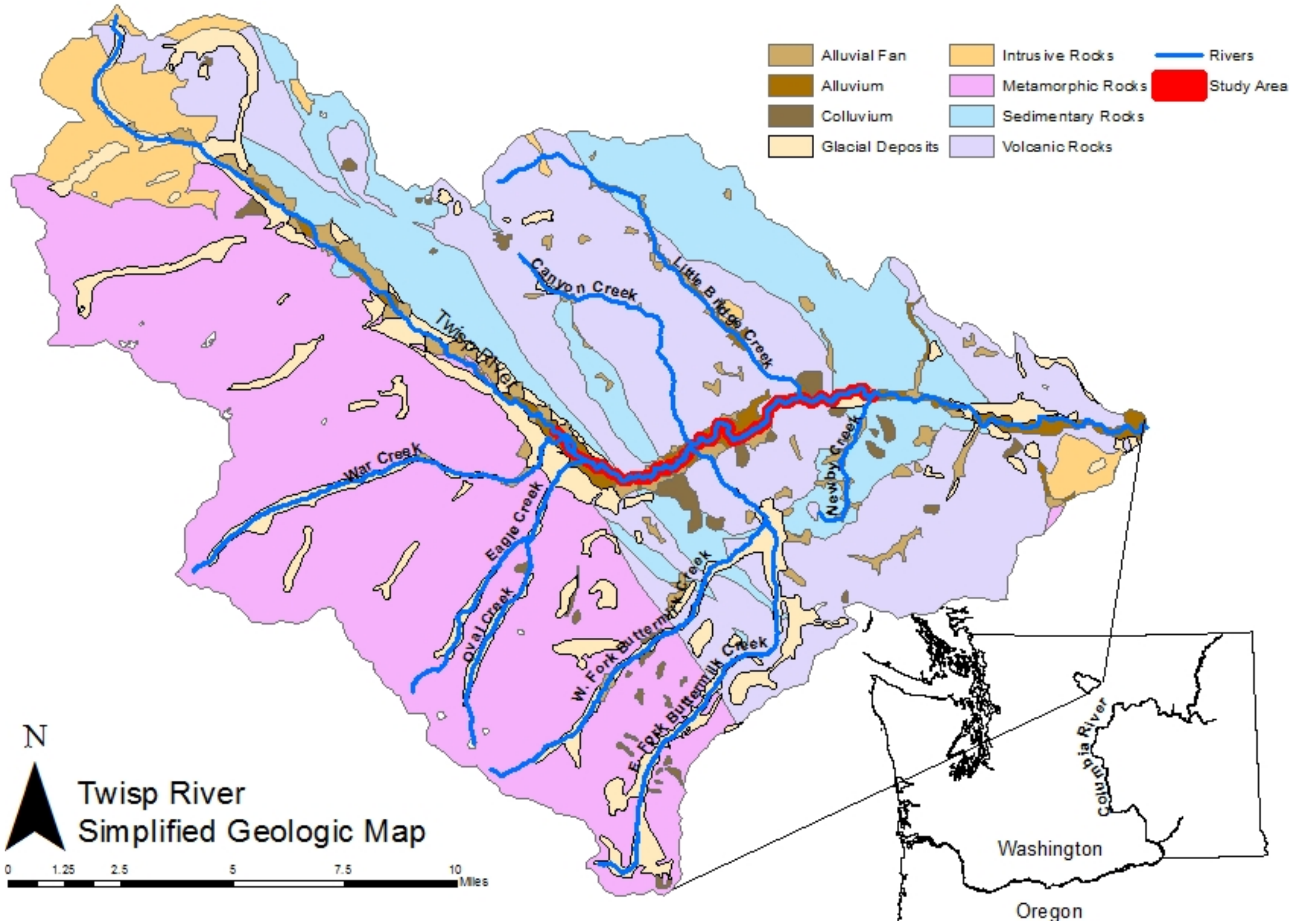

Figure 1. Generalized geologic map of the study area and its contributing watershed showing its location within Washington State and the Northern Cascades Geologic Province (Data acquired from US Bureau of Reclamation Tributary Assessment geodatabase).

4 Glacial History

Current channel and valley form is most directly influenced by glaciation that occurred as recently as 9,500 years ago (USBR 2008). From between 9,500 years ago to 30,000 years ago there were at least one, and potentially several, alpine glacial advances that carved out U-shaped valleys throughout the Methow River basin including the Twisp River basin. An advance of the continental ice sheet also covered the entire Methow basin, but had a greater effect on major topographic features than on morphology at the valley and channel scale. During periods of alpine glaciation, ice streams moved from higher elevations in the basin downslope, carving out rock masses and leaving behind glacial features including U-shaped valleys, till deposits (moraines), outwash deposits (terraces), and glacial erratics. Glaciation extended downstream from headwater valleys to approximately RM 9.3 on the mainstem Twisp River (Waitt 1972). This location approximately coincides with a major slope break in the long profile of the Twisp with slope being flatter upstream and steeper downstream.

Table 1. Methow valley ice sheet advances during the Fraser Glaciation cycle (adapted from Waitt 1972).

Fraser Glaciation Advances	Approximate Age of Deposit
Evans Creek stade	22,000 to 18,000
Cordilleran Ice Sheet	17,000 to 13,500

Although glacial advance carved out the valley of the Twisp River in the study area, fluvial and colluvial processes that occurred during and after glacial retreat have been the primary drivers of current river morphology in the study area. Upstream of RM 9.3, terraces were left behind by glacial outwash deposits and alluvial fans (Waitt 1972). These terraces and deposits have contributed to a flatter slope and exert significant influence on vertical stability, lateral migration, and bed material (Waitt 1972, USBR 2008).

5 References

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