LEG I: ALTERNATE SOUTHERN APPROACH

From Interstate 5 to Morton via State Route 508 and to Elbe via State Route 7

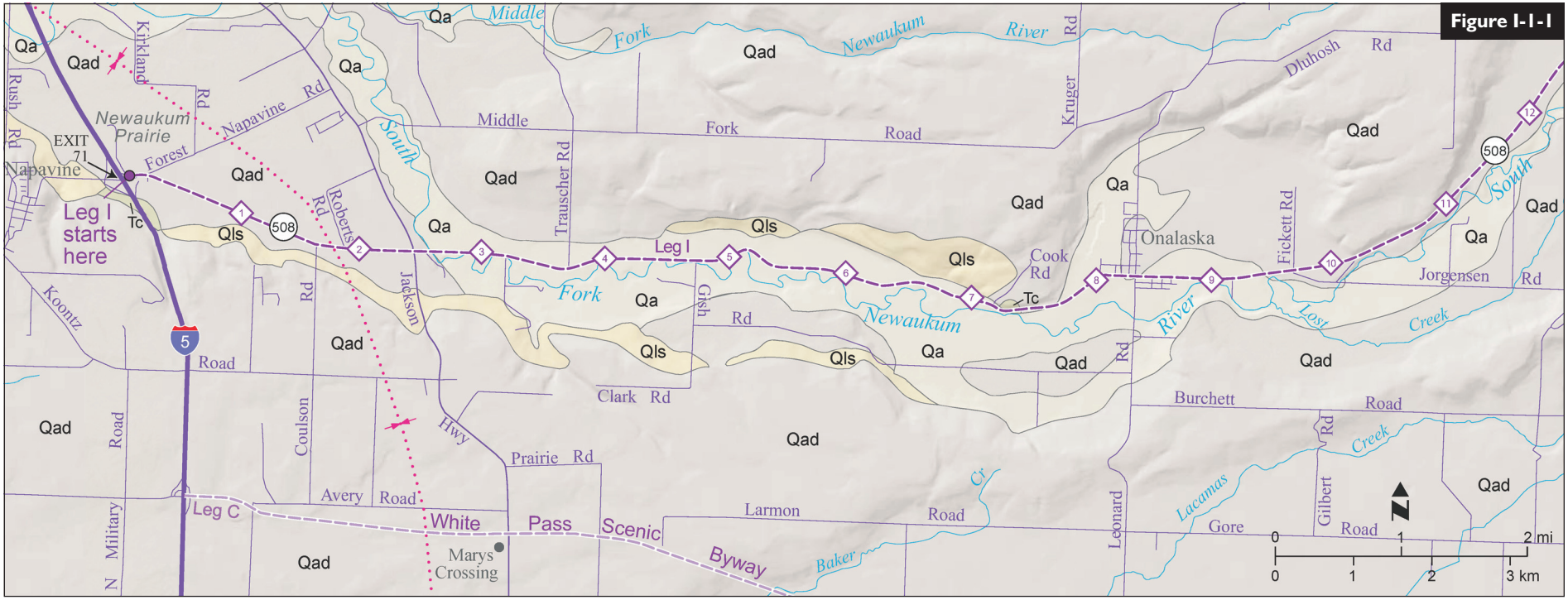
This 49-mi (78 km) leg starts at the junction of Interstate 5 (I-5) and State Route (SR) 508 (Exit 71) in the southern Puget Lowland at the town of Napavine (elev. ~210 ft or 133 m). SR 508 begins on the Newaukum Prairie, composed of gravelly glacial outwash, and winds to the east and upstream along the South Fork Newaukum River, which drains into the Chehalis River (Fig. I-1). Between the towns of Alpha and Cinebar, the road crosses a low drainage divide into the Mill Creek watershed, which drains into the Cowlitz River, a major tributary of the Columbia River. Not far beyond Cinebar, the road enters the Cascade Range physiographic province and the Tilton River watershed. To the north and east rise the faulted, folded, and eroded, mostly andesitic rocks of the hills near Bald Mountain and The Rockies. This pile of lavas is a relic of the Eocene Northcraft volcano, one of the Cascade Range's founding members! Hammond (1998) has concluded that the Northcraft eruptive center was located roughly 12 mi (20 km) northwest of Morton. The Northcraft rocks are probably about 40 million years old because they sit above the middle Eocene sedimentary rocks of the McIntosh Formation and below the sedimentary rocks of the uppermost middle Eocene Skookumchuck Formation.

Older rocks of middle Eocene age, such as the McIntosh Formation, are exposed locally where anticlines have warped the rocks upwards or where faults have shoved older rocks up. Conversely, synclines, or downward folds in the rocks, have exposed younger, later late Eocene sedimentary rocks (Skookumchuck Formation) and still younger volcaniclastic rocks of probable Miocene age. Mining areas of historic interest sprang up where past igneous activity concentrated metalliferous minerals or other deposits of economic value.

The Tilton River area was covered by alpine glaciers about 140,000 years ago during the extensive Hayden Creek glaciation in the southern Washington Cascades. The huge glaciers of that and earlier glaciations carved out the broad valleys we see today.

At Morton, the leg joins SR 7 and heads north through a dissected anticlinorium that exposes sedi-

Figure I-1. Geologic map for Leg I (four consecutive panels). The geology was adapted from 1:100,000- and 1:500,000-scale digital versions of Schasse (1987a) and Schuster (2005) and has been draped over a shaded relief image generated from 10-m elevation data. The leg maps were constructed using source-map data whose scale is smaller than the leg map scale, thus minor exposures may not appear on leg maps. The numbers in diamonds indicate mileposts. The map explanation is on the inside back cover.



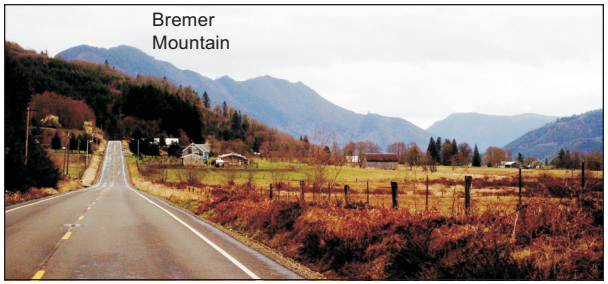


Figure I-2. Glacially carved rocks of the Cascade Range as seen from the Tilton River valley near MP 20 along SR 508. The flat-lying valley bottom is composed of glacial outwash, probably of Hayden Creek age (~140 ka). View is to the east.

mentary rocks of the Eocene Puget Group. En route you will pass small bodies of intrusive dacite. The rocks have been tightly folded and faulted throughout this area, and many large landslides are testimony to the fact that tilted, altered, and fractured fragmental and (or) weak rocks are highly susceptible to gravitational failure. A short distance south of Elbe, you will leave the Tilton River drainage at a low divide (elev. ~1760 ft or 537 m) and enter the watershed of the Nisqually River, which flows into Puget Sound.

Distances along the route are given in miles, followed by kilometers in italics. If you take any side trips, you'll have to keep track of and add those miles to all the remaining mileages in the leg. Having a pencil and paper handy, and even a calculator will be helpful.

Note: There are a limited number of outcrops on this leg.

Mileage

0.0 *0.0* Intersection of I-5 and SR 508 (Exit 71). Start mileage on the west side of the freeway. You will be crossing an alpine glacial outwash plain for the next 2.5 mi (4.0 km).

1.7 *2.7* Coulson Road.

1.9 *3.1* Roberts Road (stop sign).

2.4 *3.9* Intersection of SR 508 with Jackson Highway.

2.6 *4.2* Cross the South Fork Newaukum River, which heads in volcanic and sedimentary rocks of Eocene age. The highway will be on the flood plain for the next 2.5 mi (4 km).

Cinnabar

by Rebecca A. Christie and Katherine M. Reed

In western Washington, cinnabar (HgS), the primary ore of mercury, is found in pods or lenses and breccia zones in Eocene Puget Group sedimentary rocks. Its presence may be related to nearby volcanic activity (Huntting, 1956). At some localities, it occurs as bright red needle-like crystals.

In 1913 (the year is disputed), Edward Barnum noticed cinnabar in a seam of coal near Morton. Within the next year, retorts were operating, and soon several mines were producing in the area about 2 mi (3 km) southeast of the town. Two notable mines north of Davis Lake were the Roy and the Barnum-McDonnell. Production from 1929 to 1940 was $509,717*; the peak year was 1929 (Mackin, 1944). Clevinger (1968, p. 20), however, mentioned that between 1927 and 1931 more than 5000 flasks were produced; the total value exceeded $1 million. The Morton area was Washington's most significant producer of mercury.

The Depression years saw low mercury prices and little mining activity in the area. After about 1940, no more high-grade ore was found. A large flotation mill built in 1940 near one of the Barnum-McDonnell tunnels was dismantled in 1943; remains are still visible. When the price of mercury spiked in the late 1950s and early 60s to more than $570 per flask, there was some leasing activity in the Morton area. A minor amount of cinnabar was produced in the 1950s at the Royal Reward mine in Green River Gorge State Park, King County, about 2.5 mi (4 km) south of Black Diamond, where coal was mined until recently.

Massive cinnabar. Photo courtesy of R. Weller/Cochise College.

Land in the Morton area is for the most part now privately owned. No mining is going on in this area at present (2008). The Washington Department of Natural Resources and Department of Ecology sampled water at the inactive mines in 2001 and found that it was suitable for drinking (Wolff and others, 2001). The mined area now supports hemlock and Douglas-fir trees.

Cinnabar gives its name to the town of Cinebar, the small town on SR 508 near its intersection with Cinebar Road. ■

*Mercury prices are quoted per 76-lb (34.5 kg) flask. The average annual price fluctuated considerably during this period, from $57.93 in 1932 to $176.86 in 1940. To convert to dollars/kg, multiply by 0.029008. Values from http://minerals.usgs.gov/minerals/pubs/commodity/mercury/430798.pdf.

3.0 *4.8* The meandering river is still south of the highway. The rolling bar and swale topography common on flood plains is evidence of migrating meanders. The core of ridges or swells is generally composed of bars of sand or larger particles, and depressions (swales) are sloughs filled with silt and clay.

4.3 *6.9* Note the two terraces visible to left (north), one 20 to 23 ft (6–7 m) in height, the other 33 to 40 ft (10–12 m) in height. The lower terrace is younger. Deposits from landslides that head in the Pleistocene Logan Hill Formation are common along the margins of the north valley wall (Schasse, 1987b). Dethier (1988) speculated that the Logan Hill Formation is between 0.63 and 1.7 Ma, that it could correlate with the 840 ka Salmon Springs Drift dated by Easterbrook and others (1981), and that it is associated with marine isotope stage 22 (see Fig. 25, p. 29).

7.2 *11.6* Ascend a small alluvial terrace before the road begins to make some curves. Where trees have been cut, you can see more terraces to the north. There is a small outcrop of the Wilkes Formation (Miocene) on the north side of the road (left if eastbound) slightly before where the road curves to the left. The Wilkes Formation includes semiconsolidated nonmarine sediments, as well as lignite and some tuff (Roberts, 1958). Yancey and Mustoe (2007) recently obtained a provisional radiometric age of 11.6 Ma on tuff deposits in the Wilkes Formation at Toledo, about 10 mi (16 km) west-southwest of this location. This age is similar to that of some volcanic deposits of the Ellensburg Formation described in Part I and in Leg F.

8.1 *13.0* The road ascends a 10-ft (3 m)-high terrace of Hayden Creek Drift (~170–130 ka) as you enter Onalaska.

8.4 *13.5* Leonard Road, Onalaska. Descend the Hayden Creek terrace to the flood plain of the South Fork Newaukum River.

8.6 *13.8* More bar and swale topography for the next 0.3 mi (0.5 km) indicates that you are once again in a flood-plain environment.

Figure I-3. North-dipping, carbonaceous sedimentary rocks of the Puget Group along SR 508 east of Bear Canyon. Some small fault offsets are exposed in the outcrop. The rock hammer (lower right center) is 13 in. (33 cm) long. View is to the north.

9.6 *15.4* Ascend yet another terrace (composed largely of sand), about 7 ft (2 m) in height.

10.1 *16.3* The highway runs right next to a 20- to 23-ft (6–7 m)-high grass-covered terrace of the Logan Hill Formation to the north of the highway.

12.6 *20.3* The Cascade Range lies dead ahead and to the northeast.

13.3 *21.4* Centralia–Alpha Road.

13.6 *21.9* Cross a bridge over the South Fork Newaukum River.

14.0 *22.5* Jagged peaks of folded, faulted, and eroded Cascade Range rocks loom ahead.

14.3 *23.0* The highway enters a broad, glaciated(?) valley with mountains on the north and south. The gently rolling topography of the valley floor is underlain by glacial outwash deposits of Hayden Creek age (~170 to 130 ka).

16.4 *26.4* Intersection of Johnson Road (south) and Van Hoesen Road (north). Continue straight ahead on SR 508.

18.1 *29.1* Milepost (MP) 18. Cinebar Road and town of Cinebar. The reddish mineral cinnabar (HgS), the most important ore of mercury, is associated with veins in volcanic rocks and is found along fault zones in the sedimentary rocks of this area. It has also has been found in the East Fork Tilton River basin, north and east of Morton. Most production was southeast of Morton. (See Fig. C-6, p. 78, and the "Cinnabar" sidebar on p. 136.)

18.3 *29.4* Cross over Mill Creek, then ascend a low terrace.

18.4 *29.6* Cinebar post office.

19.5 *31.4* Cinnabar Creek. North of here, a southeast-trending normal fault uplifts Eocene sediments on the southwest and down-drops lavas of the Eocene Northcraft Formation on the northeast (Walsh and others, 1987). The Northcraft Formation is poorly exposed along the north side of the highway near MP 20, about 0.4 mi (0.6 km) east of here.

19.7 *31.7* The mountains ahead (east) have steep scarp slopes on their south sides that are the result of chiseling by Pleistocene glaciers (Fig. I-2).

20.0 *32.2* The highway ascends a terrace next to a valley on the right. The terrace surface may be Logan Hill Formation.

21.3 *34.3* The road curves to the north (left) into Bear Canyon.

21.5 *34.6* The road curves within and crosses a high bridge over Bear Canyon. The storm of November 2006 triggered a 160,000-ft^2 (~14,800 m^2) landslide that affected or threatened a 500-ft (152 m) section of road here. The bulk of the landslide material is composed of glacial deposits that evidently became saturated and moved downslope into Bear Canyon Creek.

Slightly east of the canyon on the north side of the highway is an outcrop of north-dipping middle Eocene sedimentary rocks (shales and sandstone) of the Puget Group (Fig. I-3). Glacial sediments of Hayden Creek age are exposed on the south side of the road, and farther to the east are more lavas of the Northcraft Formation—also dipping to the north in an area of tight folds. Rugged peaks called "The Rockies", about 4.5 mi (7 km) northeast of this location, are situated roughly at the center of the Northcraft volcanic pile; they are apparently locally covered by younger (Miocene?) rocks (Walsh and others, 1987).

22.3 *35.9* The Tilton River valley opens up from here to the east. South of the highway at this location is a remarkably flat landform some 200 ft (61 m) above the river level. This surface probably is a glacial outwash or kame terrace (see Fig. 24, p. 29). The highway drops closer to river level over the next several miles as it heads east.

Figure I-4. Glacial outwash of Hayden Creek age exposed along the Tilton River near mile 28.5. Raveling from the exposed face contributes to formation of riffles in the stream. This exposure is about 40 ft (12 m) high.

22.7 *36.5* Cross over the west branch of Alder Creek, which drains a debris fan extending from an unnamed peak to the northeast.

23.0 *37.0* Cross the east branch of Alder Creek, which also heads on the unnamed peak composed of sedimentary rocks of the Puget Group.

25.0 *40.2* The road crosses the Tilton River slightly past MP 25. Outwash deposits of Hayden Creek age are exposed in the bank, slightly upstream of the bridge (Fig. I-4). The name Hayden Creek was assigned to the deposits of an extensive episode of alpine glaciation in the Cascade Range. This glaciation is

now thought to be associated with the global period of intense glaciation between about 170 and 130 ka and recorded in "stage 6" of the global climate record interpreted from oxygen isotope ratios (see Fig. 25, p. 29). During the Hayden Creek glaciation, enormous valley glaciers from nearby mountains covered all but the highest peaks in this area. (See more on the Hayden Creek glaciation on p. 27.)

Andesitic rocks of the Northcraft Formation, representing one of the earliest episodes of Cascade volcanism, are exposed about 0.5 mi (0.8 km) west of a long eastward bend in road.

25.5 *41.0* The road follows the river. Mountains to the north of the valley are andesitic lavas of the middle and upper Eocene Northcraft Formation, which is locally exposed along the highway for about 5 mi (8 km) east of here. To the south are younger basaltic andesites (about 36 Ma) (Walsh and others, 1987).

27.2 *43.8* The fan-shaped landform at the base of the south valley wall at the second junction of Dodge Road on the right (south) originates on a landslide.

27.6 *44.4* Pass coalescing fans of rock debris from Bellicum Peak on the right (south) for the next 0.2 mi (0.3 km). The ridge is composed of andesitic lavas.

27.9 *44.9* Gray amygdaloidal volcaniclastic rocks of andesitic composition crop out in a borrow pit on the south side of road. There are additional exposures for about 0.3 mi (0.5 km).

28.5 *45.9* Cross the Tilton River about 0.4 mi (0.6 km) upstream of its confluence with the North Fork Tilton River.

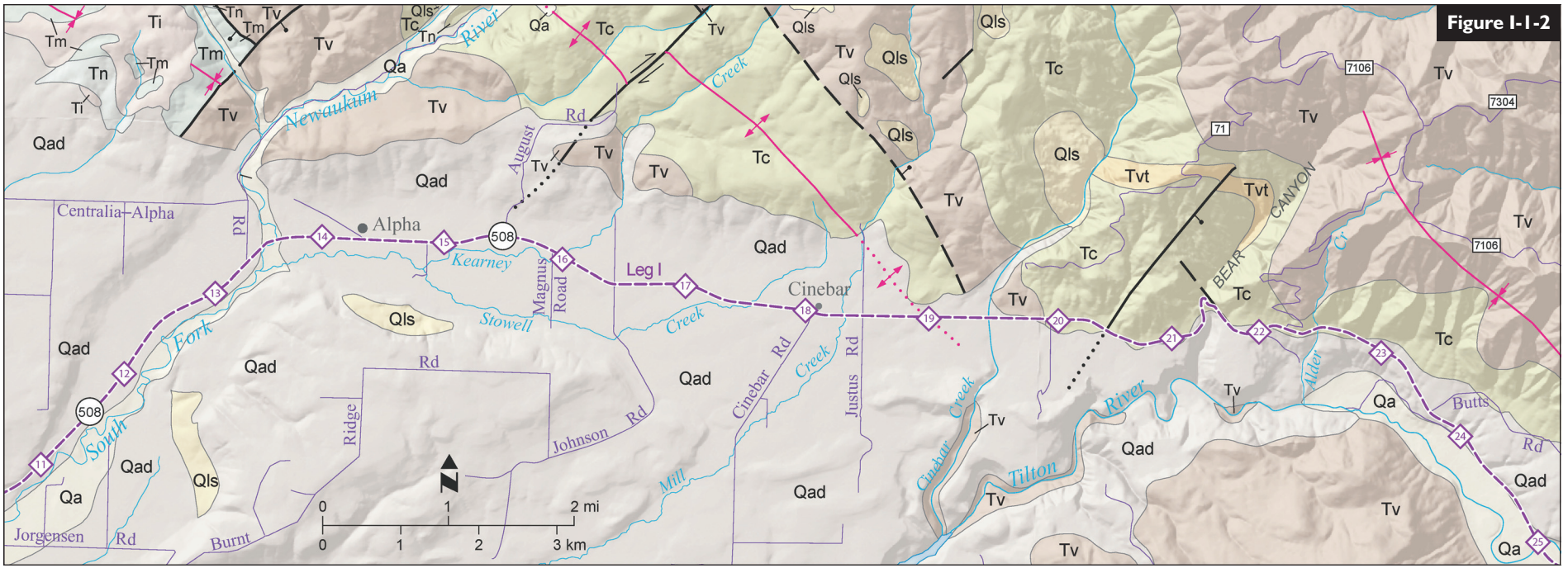
28.9 *46.5* The many boulders of sedimentary and igneous rocks in the streambed attest to the long history of erosion that has cut through the great thickness of rocks here. More than 10,000 ft (3048 m) of strata are exposed in the Morton area. Rock collectors have found specimens of chalcedony, petrified wood, geodes, zeolites, agates, calcite crystals, fossils, and more. Clevinger (1968, 1969) described the geology of the Morton area and collecting locales.

29.0 *46.7* Ascend a terrace composed of drift of Hayden Creek age. Hayden Creek Drift mantles the lowermost 400 ft (122 m) of the north valley wall here.

photo by Dave Norman

Figure I-5. At Gust Backstrom City Park, a waterfall created by a ledge of resistant sandstone of the Puget Group offers an interesting place to play. Note the potholes and smoothed surface of the rock caused by the scouring action of entrained sediment during higher flows of the Tilton River.

29.8 *48.0* In this stretch of road, look for Northcraft Formation exposures here and there on the left side of the road from about MP 29.5 to 30.7 and for oxi-



dized, or rusty, cobble gravels from the Hayden Creek Drift in the left bank of the river. The Northcraft rocks here have a K-Ar age of 38.3 ±1.9 Ma (Schasse, 1987b).

30.4 *48.9* A dike intrudes the Northcraft Formation volcanic rocks on north side of the highway.

32.3 *52.0* Cross the Tilton River again. Gust Backstrom City Park, which can be reached by a turnoff about 500 ft (150 m) southeast of this bridge, has access to the river (Fig. I-5). Clevinger (1969) described the geology at this site, including a waterfall created by a ledge of resistant sandstone of the Puget Group. Petrified wood and fossils have been found among the well-polished cobbles and boulders composing bars near this site.

32.5 *52.3* As you enter the central area of Morton, you climb a 20- to 23-ft (6–7 m)-high terrace that is locally capped by till of Hayden Creek age. Morton is a good place to take a break for lunch.

32.8 *52.8* Intersection of SR 508 with SR 7; mile markers for SR7 begin here. Continue northward on SR 7 to its junction with SR 706 at Elbe. Note that Leg C, on US 12, passes on the south side of Morton and continues east. The junction with US 12 is about 0.5 mi (0.8 km) to the south.

32.9 *52.9* Intrusive rock (not shown on map) on the southeast side of road has been mapped by Schasse (1987b) as a diorite of Miocene or Oligocene age.

34.4 *55.3* An outcrop of Puget Group sandstone is on the right (east) on a curve to the east, slightly north of MP 2.

34.8 *55.7* On the right (east) as the road curves is an outcrop of Puget Group sandstone. A railroad bridge is visible west of the road.

35.6 *57.3* Cross the East Fork Tilton River.

35.8 *57.6* Coarse, cobbly material, possibly an alluvial fan from the east, is exposed along the right side of the road.

37.3 *60.0* The road crosses an alluvial plain for the next 0.4 mi (1.1 km).

37.7 *60.3* The road starts to ascend a grade on Hayden Creek Drift.

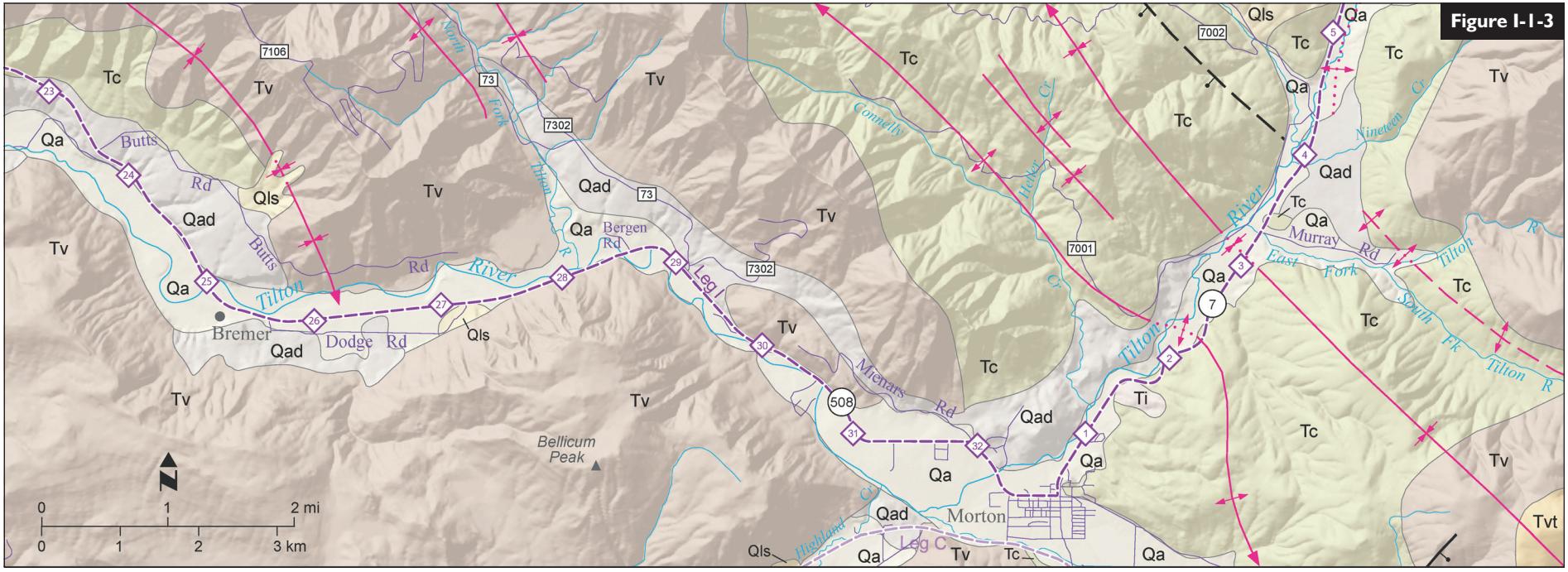
38.4 *61.8* Slump scarps and outcrops along the west side of the highway near MP 6 locally expose volcanic ash and pumice layers. The yellow pumice seen most commonly is the Yn tephra from Mount St. Helens. This tephra was ejected in an eruption about 3600 years ago that produced an estimated 1 mi³ (~4 km³) of pumice and ash. Winds carried the plume of ash and pumice north and then east into Canada. The eruption had a profound effect on the local indigenous peoples, many of whom undoubtedly perished in the eruption (McClure, 1992). The great volcanic disturbance also had long-lasting effects on the settlement patterns in this area.

38.6 *62.1* Landslide deposits are on the west side of road for the next 0.3 mi (0.5 km).

38.9 *62.6* Talus or landslide deposits composed of the Puget Group are on the west side of the road.

39.0 *62.7* Outcrops of Miocene–Oligocene diorite for 0.1 mi (0.1 km).

39.2 *63.0* MP 7.



41.7 *67.1* Cross Summit Creek. You are now in the Nisqually River watershed. Summit Creek drains into the Nisqually via Roundup and Mineral Creeks.

42.3 *68.0* MP 10. Rubbly deposit on the left (northbound) is an alluvial fan.

45 0 *72.4* FR 74 is on the west side of the highway. When the weather is clear, from this prairie area there is a grand view of the rugged southwest face of Mount Rainier 23 mi (36.8 km) to the northeast.

45.5 *73.2* Mineral Road South. Mineral Lake, about 1.5 mi (2.4 km) to the northwest along this road, sits on deposits of Hayden Creek drift. The town was named for the abundant mineral deposits in this area. The remodeled Mineral Inn was once a sanitarium (Kirk and Alexander, 1990). (See "Gold and Arsenic in the Park Junction and Mineral Areas" sidebar.)

45.7 *73.5* Drive through a bedrock notch (fault controlled?) between the Northcraft Formation on the southwest and undifferentiated andesitic rocks of Tertiary age to the northeast.

45.9 *73.9* Outcrops of basaltic andesite flow breccias are on both sides of the road on a curve.

46.3 *74.5* The road descends into the large, broad, U-shaped, glacially carved Nisqually River valley.

48.3 *77.7* Mineral Hill Road (west). Lahar deposits and big boulders indicate that you are once again on the flood plain of a river that drains Mount Rainier.

48.8 *78.5* Nisqually River, then the intersection of SRs 7 and 706. If you continue on SR 7, you will reach Olympia/Tacoma. SR 706 will take you to the Longmire entrance to Mount Rainier National Park.

Remember to reset your odometer when you start another leg. ■

Gold and Arsenic in the Park Junction and Mineral Areas

by Rebecca A. Christie and Katherine M. Reed

Mineral Creek flows into the Nisqually River less than a mile (~1 km) southwest of Park Junction, about 2.5 mi (4.0 km) west on SR706 (Leg A). Mining for gold and arsenic took place along the creek for several years between 1892 and 1922.

In 1892, the Eureka Mining Company of Tacoma issued a prospectus that described Mineral Creek as the new "Eldorado of Washington". The company's claims covered about 40 acres (16 hectares), and each claim contained "a very large vein of gold bearing quarts [*sic*], about 100 feet [30.5 m] wide, running the entire length of the same" (Eureka Mining Company, 1892). Despite the company's efforts, this area had no significant yield of gold.

The Mineral Creek Mining and Smelting Company, whose operations site was 5 mi (8 km) southeast of the town of Mineral, mined realgar (AsS), from which arsenic is extracted. A surface vein of rich sulfide ore (sphalerite, galena, and realgar) was discovered in 1900 and worked until 1922. Huntting (1956, p. 23) noted that 1000 tons (900 metric tons) of arsenic ore were reported to have been produced here in 1903, less in the following years. The mine closed when a smelting process was developed that recovered arsenic as an inexpensive by-product during the recovery of other metals, making operation of the mine unprofitable (Huntting, 1956; Filley, 1996). ■

Figure I-1-4