Transforming a Railroad Grade into a Multiuse Transportation Corridor

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The Chicago, Milwaukee and St. Paul Railway Company constructed its westward extension through Missoula, Montana, to Tacoma, Washington, in 1907 and 1908. Design, construction, and maintenance of the 72-km (45-mi) section of railroad grade from St. Regis, Montana, to Avery, Idaho, involved engineering feats that have valuable historical significance. Fills were placed under existing temporary trestles using hydraulic mining technology. Tunnels were dug using air-powered shovels and electric ore cars. The regenerative electrification of the line through western Montana to Avery, Idaho, in 1917, was the first major railroad electrification in the world. Preserving the history of these engineering feats is a worthwhile challenge. After the Milwaukee Railroad abandoned the line in 1980, engineers with the USDA Forest Service, the Federal Highway Administration, and Shoshone County in Idaho began evaluating the route for various transportation needs. In 1988 the Forest Service and Shoshone County cooperated in reconstructing a segment of the railroad grade into a county road. This 14.5-km (9-mi) segment with six tunnels and two large trestles cost about $727,000 to reconstruct. The $50,000/km ($81,000/mi) reconstruction cost was far less than the cost of new construction through this difficult country. In 1991 the Federal Highway Administration reconstructed a 21-km (13-mi) railroad segment from Avery, Idaho, west, as Forest Highway 50. The flat, straight alignment of the railroad grade was conducive to a very economical, high-speed reconstructed roadway. Since 1993, the USDA Forest Service has been evaluating and designing repairs and modifications to allow pedestrian and mountain biker use of the 58-km (36-mi) segment from St. Regis, Montana, westward. Repair and reconstruction of this segment would include preservation and interpretation of the historic engineering features of the route. This segment includes 11 tunnels [the longest of which is 2666 m (8,771 ft)] and 9 large trestles.

Various sections of the abandoned Milwaukee Railroad in western Montana and northeastern Idaho are being converted to multiple-use transportation facilities by the USDA Forest Service, the Federal Highway Administration, and Idaho's Shoshone County.

Construction of the Chicago, Milwaukee and St. Paul Railway from Missoula, Montana, through Avery, Idaho, began in 1907 and was opened to train traffic in 1908 (*1*). This segment of railroad line [a distance of 121 km (75 mi)] follows the Clark Fork River, from Missoula to St. Regis, Montana, where it begins its climb over the Bitterroot Mountains (Figure 1). From an elevation of 760 m (2,500 ft) at St. Regis, the railroad grade climbs to an elevation of 1268 m (4,170 ft), 35 km (22 mi) later at the Montana-Idaho border. This elevation is actually 305 m (1,002 ft) below the ground surface. The railroad enters a 2666-m-long (8,771 ft)

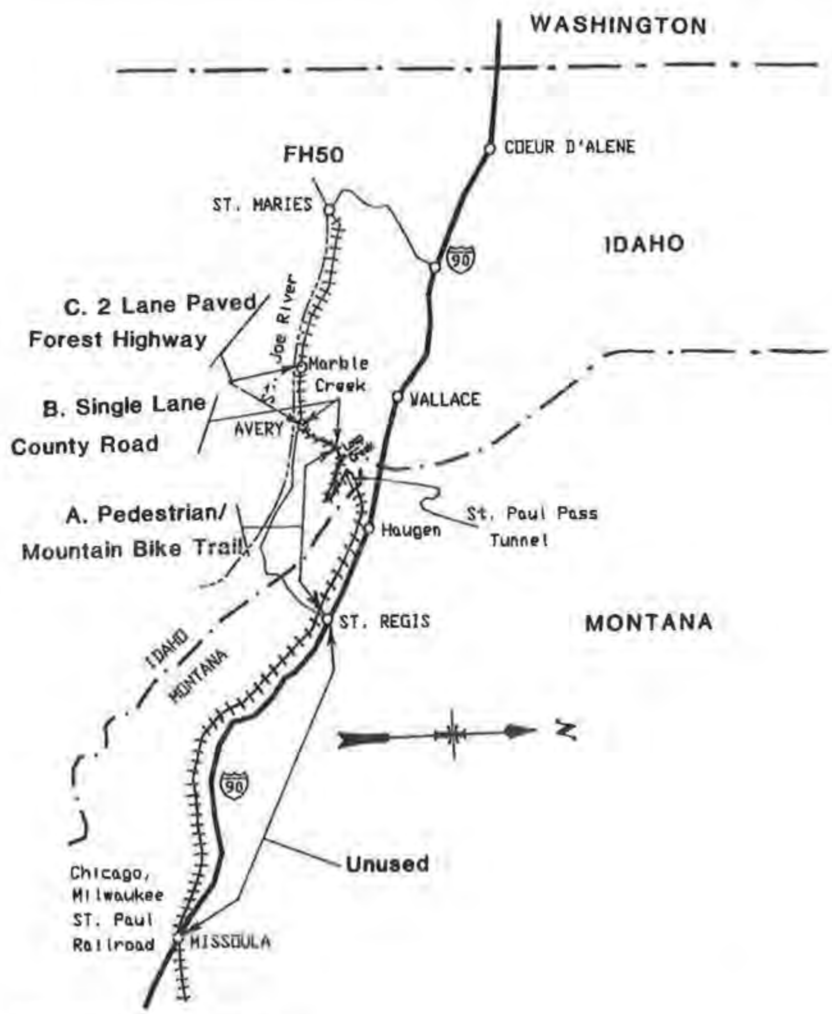

FIGURE 1 Area map.

tunnel that made maintaining a maximum 1.7 percent grade possible through this steep rugged country. The railroad grade drops back to a 730-m (2400-ft) elevation, 37 km (23 mi) later at Avery, Idaho. From there, the railroad grade follows the scenic St. Joe River to St. Maries and, eventually, Tacoma, Washington. From St. Regis, Montana, to Avery, Idaho, the railroad crossed 18 bridges, 11 of which are major trestles, and passes through 17 tunnels. The trestles rise over 76 m (250 ft) out of canyon bottoms and vary in length up to 258 m (850 ft). The 17 curved and straight tunnels vary in length from 54 m (178 ft) to 2666 m (8,771 ft).

History

The rugged Bitterroot Mountain Range with its steep canyons posed an almost insurmountable obstacle to the construction of the original Chicago, Milwaukee and St. Paul Railway from Missoula, Montana, westward in 1907 and 1908. The final 305 m (1002 ft) of climb over the Bitterroot Mountains was avoided by construction of the St. Paul Pass Tunnel (2).

Construction of the tunnel was an engineering feat of amazing proportion (Figure 2). Electric power was available at both portals in these remote mountain outposts when New York and Chicago were just beginning to experience electrification. Air shovels were used to load materials on electric cars. The bore pushed through at a rate of an average of 6 m (20 ft) per day from both ends for about 7 months. Both crews met in the center of this 2666-m (8,771-ft) tunnel only 3 to 5 cm (1 to 2 in.) off-line. The tunnel is straight with a 0.2 percent grade rising from both portals to a high point in the center. It is 5 m (16.5 ft) wide by 7 m (23 ft) high at the center of the arched roof. The tunnel has treated timber snowsheds at both portals and full concrete lining extending for most of its length. The remainder of

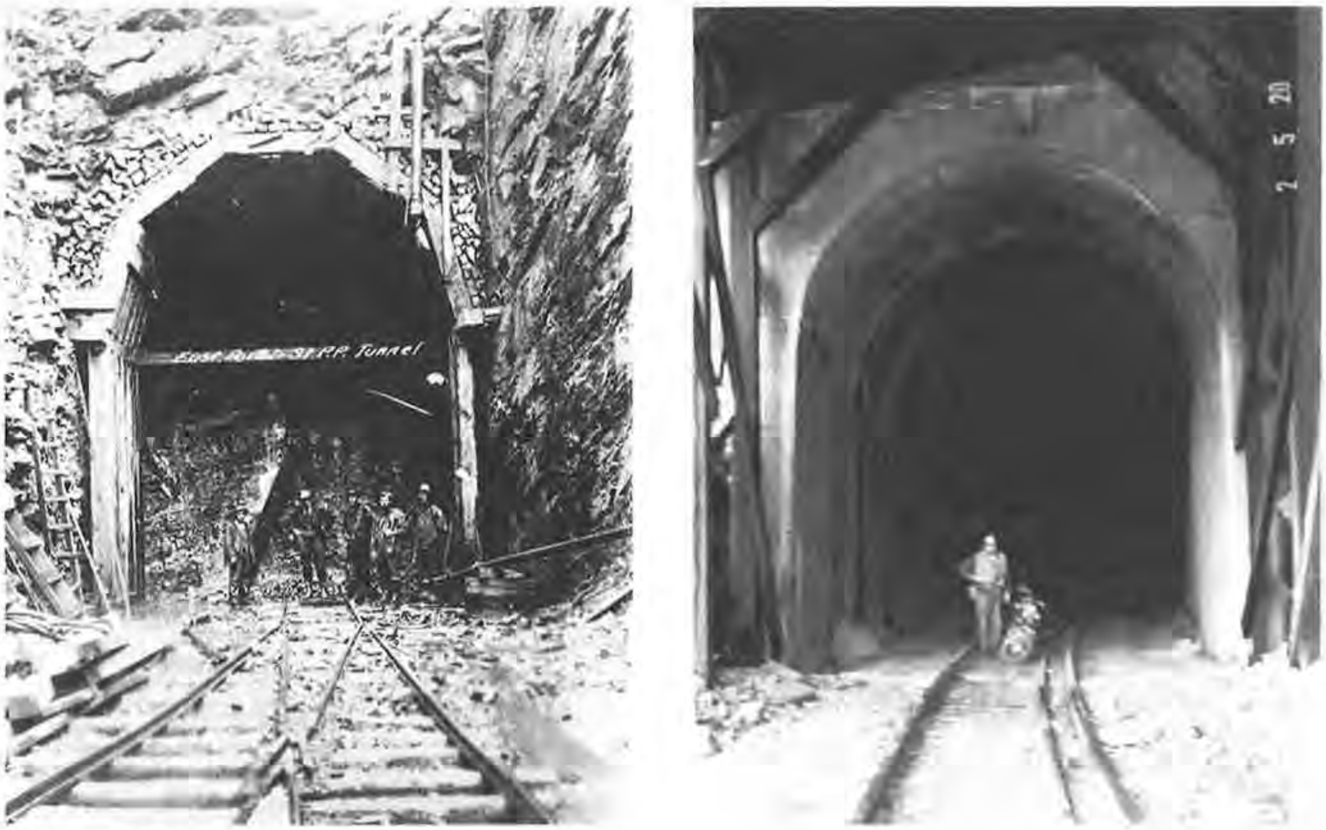

FIGURE 2 ***Left*, east portal, 1907; *right*, east portal, 1982.**

the tunnel is partially lined with concrete and timbers. The unlined portions are in quite competent rock. As expected of such a long bore over 300 m below a mountain pass, a sizable stream of water runs out both tunnel portals.

The $46,600/km ($75,000/mi) construction cost in 1907 dollars for the railroad grade from the St. Paul Pass Tunnel to Avery, Idaho, was the most expensive segment of railroad in the world in 1907 (*3*). The 10 tunnels in this section of railroad were lined with 4720 cm^3 (2 million bd ft) of timber. The seven trestles had a combined length of over 1200 m (4,000 ft).

The original 1908 railroad startup with steam and coal-fired locomotives lasted only 2 years. In 1910 devastating wildfires burned most of northern Idaho, including most of the wooden trestles on this route. Milwaukee trains saved whole communities from the fires by transporting them to the tunnels near the Idaho border (*4*). The burned trestles were reconstructed with steel trestles or earth fills (Figure 3).

In 1914 the Chicago, Milwaukee and St. Paul Railway started converting to electrified engines; by 1917 all infrastructure was in place and operating on the 610 km (380 mi) from Harlowtown, Montana, to Avery, Idaho (*5*). Electrical substations were constructed every 61 km (38 mi). The electric locomotives used "regenerative braking" when descending mountainous grades. They generated 40 to 60 percent of the power needed for the next train coming up the grade (*6*).

The railroad operated until 1980, when the Milwaukee Railroad officially closed its lines west of Miles City, Montana. In the early 1980s, as the track and rail were being salvaged, the potential value of portions of this grade as a transportation corridor was becoming evident (*7*).

Most of the abandoned railroad grade from Missoula to St. Regis, Montana, is currently unused. Much of the right-of-way is privately owned, and the track and ties have been salvaged and much of the grade obliterated.

Reconstruction of Route

The railroad grade from St. Regis through the 2666-m-long (8,771 ft) St. Paul Pass Tunnel to the confluence of Loop Creek and the North Fork of the St. Joe River is presently being evaluated for use as a mountain bike and hiking trail. Design work is under way to repair the

FIGURE 3 Temporary trestle during fill placement.

tunnels and trestles, to erect interpretive displays, and to construct parking and tourist facilities.

The railroad grade from the mouth of Loop Creek to Avery, Idaho [14.5 km (9 mi) following the North Fork of the St. Joe River] has been converted to a single-lane county road. This stretch includes six tunnels and two major trestles.

The line from Avery, Idaho, west to Marble Creek was converted to a two-lane paved forest highway. This 21-km (13-mi) project was designed and constructed by the Federal Highway Administration (*8*).

Following is a discussion of (a) the 58-km (36-mi) proposed trail segment from St. Regis, Montana, to the mouth of Loop Creek in Idaho; (b) the 14.5-km (9-mi) segment that was converted to a single-lane county road, from the mouth of Loop Creek to Avery, Idaho; and (c) the 21-km (13-mi) segment that was converted to a double-lane forest highway.

Trail Segment

The 58-km (36-mi) trail segment of railroad grade is truly one of the engineering marvels of this century. The grade parallels the St. Regis River for 26 km (16 mi) before beginning its final assault on the Bitterroot Mountains. The railroad grade then climbs 8 km (5 mi) to the east portal of the St. Paul Pass Tunnel. After exiting the tunnel, the railroad grade makes a 23-km (14-mi) switchback down to the North Fork of the St. Joe River. The impressive trestles, massive rock bore tunnels, towering earth fills, and the electrification of the entire segment bear witness to the engineering creativity and determination of the builders. Preservation of the remaining features is historically vital and could provide an outstanding recreational opportunity.

The Milwaukee Railroad struggled financially for many years and although the quality of the initial construction was amazingly good, minimal maintenance after 1970 has caused deterioration. In 1982, a company purchased salvage rights to the rails, ties, copper wire, and timber wire support towers. Little regard was given to maintaining drainage or the historical nature of any of the system. In 1986, all private landholdings along the railroad grade and all remaining aboveground construction features, from the St. Paul Pass Tunnel to Avery, Idaho, were purchased by the federal government, using money provided by a special act of Congress (*9*).

Most of the ties and all of the rail were removed from the grade, but in the St. Paul Pass Tunnel the ties and much of the ballast were bulldozed to either side to allow trucks from the salvage company to haul through the tunnel. The drainage ditches were blocked and perforated drainpipe was torn up. In 1987, a U.S. Army Reserve engineering unit spent its 2-week summer training time regrading and cleaning out the tunnel. The Forest Service, in 1991, evaluated converting the St. Paul Pass Tunnel to a logging truck haul route. The ideal was dropped due to the high cost of repair and potential problems with one-way hauls through a tunnel this long. Meanwhile, the public was discovering this natural transportation corridor; use of the grade by mountain bikers and pedestrians was increasing steadily. In 1993, because of liability concerns, the Forest Service closed the St. Paul Pass Tunnel to all traffic. Concrete closures, with small steel doors for administrative access, were installed at each portal.

Although the tunnel is closed to the public, the railroad grade, from both ends of the tunnel, continues to be very popular. These 58 km (38 mi) of railroad grade traverse some of the most spectacularly beautiful country in North America. In 1993, the Forest Service, at the urging of a local economic development group, began studying the feasibility of converting the entire route to a trail system. The maximum vertical gradient of the route is 1.7 percent, which is ideal for mountain bike and handicapped use. The ballast varies from 0.6 m (2 ft) deep in the tunnels to over 30 m (100 ft) deep in some of the larger fills. The ballast itself varies from crushed rock to gravels hydraulically washed off adjacent hillsides to stream-washed rock (*10*). In some of the areas where course or loose rock is present, finer material or surfacing will be needed for a stable riding surface. Most of the culverts under the fills, or "water tunnels" as the railroad referred to them, are reinforced concrete boxes. They are in relatively good condition and require only minor cleaning and repair.

The 11 large trestles are in relatively good structural condition (Figure 4). All trestles have reinforced concrete spread footings supporting steel lattice piers. Two built-up steel beams 2.3 m (7.5 ft) apart support the deck system across the spans, which vary in length from 17.6 to 22.8 m (58 to 75 ft). The decks are either reinforced concrete or treated timber "boxes" filled with rock or gravel ballast. The abutments are reinforced concrete. One-meter-wide timber walkways are cantilevered from the deck systems and, in places, a two-cable handrail system is still in place.

The concrete is spalling on many of the abutments, but all high-stress-bearing areas are in good condition. Some light surface rusting is occurring on the steel lattice, or "trestle" pier towers, and on the steel beams. The steel in these towers and beams would have to lose a large percentage of their cross section before being in danger of failing from dead loads, which are their only major loading after the trains quit running. Some of the concrete and treated timber ballast boxes have deteriorated and may have to be repaired or replaced; however, most are adequate to carry their ballast load for many years. The cantilevered timber walkways and rail systems are the major items needing repair before the trestles will be safe for pedestrian use (Figure 5). All deteriorated timber and the entire railing system will be replaced. The new railing will be pedestrian height [1.07 m (42 in.)] since bicycles will not be allowed on the walkways. The ballast will be lowered and regraded so the edge of the ballast boxes will act as a 4-in.-high curb.

The 16 shorter tunnels [the longest of which is 456 m (1,500 ft)] are in relatively good condition. In several areas, the concrete lining is spalling and may require repair. If the St. Paul Pass Tunnel is reopened, its repair will be the largest challenge. All tunnels are 7 m (23 ft) high and 5 m (16.5 ft) wide. The top third of the tunnel is a circular arch. The tunnels vary from being completely concrete lined to unlined. The St. Paul Pass Tunnel is fully or partially concrete lined throughout its length. About 2280 m (7,500 ft) of the tunnel has a full perimeter lining. About 395 m (1,300 ft) of the tunnel has a partial lining consisting of an arched roof, longitudinal beams at the spring lines, and columns on grade beams supporting the roof and longitudinal beams. The lining thickness is estimated to be 0.6 to 1.2 m (2 to 4 ft) in most of the tunnel. In general, the concrete lining is in very good condition. However, about 10 percent of the total length of the St. Paul Pass Tunnel is spalling, due primarily to groundwater leaching of cement from the concrete. Spalling areas have again plugged the drainage system, and water has ponded to a depth of 10 to 20 cm (4 to 8 in.) in several areas of the tunnel.

FIGURE 4 Dominion Creek trestle in Montana.

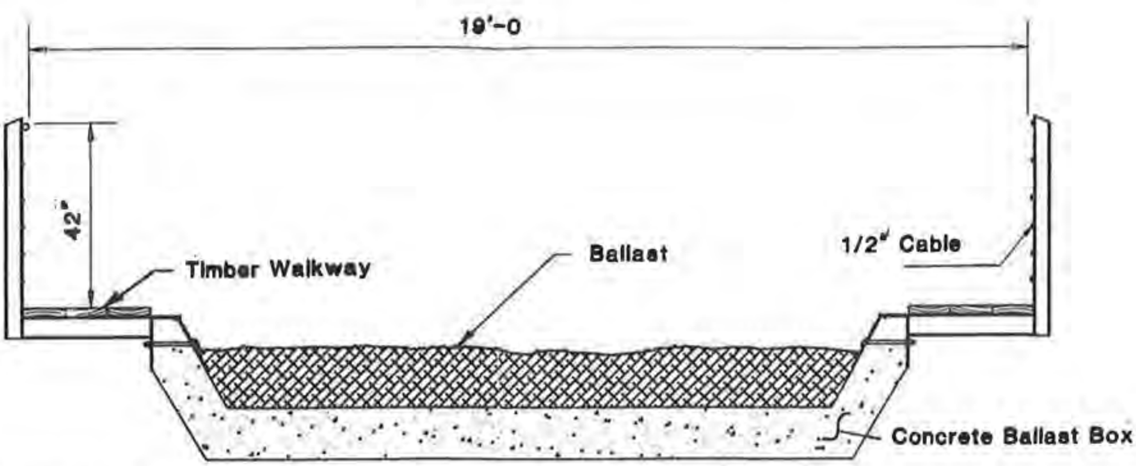

FIGURE 5 Proposed typical section for trestles.

The minimum repair necessary to make the tunnel usable by mountain bike and pedestrian traffic will be repair of the concrete liner, repair of the groundwater drainage system through the concrete lining, cleaning and regrading of the surface drainage system, and surfacing of the travelway surface. Estimates of the repair cost for just this tunnel vary upward from $1 million.

Arranging funding for repairs, interpretive displays, and other facilities is being pursued by the local economic development group. Private grants or contributions, Rails-to-Trails participation, and local government partnerships with the Forest Service are all possibilities.

County Road Segment

The county road from the mouth of Loop Creek along the North Fork of the St. Joe River to Avery, Idaho, was a narrow, substandard dirt road that could not accommodate logging trucks safely. Both the USDA Forest Service and Shoshone County officials recognized that the railroad grade, located on the other side of the river, had a far better alignment. In 1987, the Forest Service and Shoshone County entered into a cooperative agreement to convert the railroad grade to a county road, spelling out responsibilities for each party (*11*). This 14.5-km (9-mi) segment of the railroad grade has six tunnels [varying in length from 101 m (332 ft) to 194 m (638 ft)] and two trestles [72 m (238 ft) long and 157 m (515 ft) long]. The Forest Service agreed to reconstruct the trestles to 4.3-m-wide (14 ft) travelway, single-lane bridges with guardrail and approach rail meeting the static structural requirements of the American Association of State Highway and Transportation Officials. Shoshone County would resurface the new roadway and construct connections to existing roads.

In 1988, while the Forest Service reconstructed the two trestles, Shoshone County improved the surfacing by adding fines to the coarse aggregate railroad ballast. The county also signed the tunnels for safety, constructed the road connections, and removed sections of electric wire, old railroad ties, poles, and trash left behind from the many train derailments. A large electromagnet was rented and towed behind a pickup truck over the entire grade to remove railroad spikes and shards of steel. The county's portion of the reconstruction work cost approximately $250,000.

The curved trestle crossing Dick Creek is 72 m (238 ft) long. The straight trestle crossing the North Fork of the St. Joe River near Squaw Creek is 157 m (515 ft) long. Both trestles were originally constructed with reinforced concrete ballast boxes. These boxes were 4.3 (14 ft) wide (trestle width) and about 1.2 m (4 ft) long and held about a 30-cm (12-in.) depth of gravel ballast.

The Forest Service, through a contractor, removed the ballast and ballast boxes on the trestles and replaced them with match-cast concrete panels about 5.5 m (18 ft) wide and 3.2 m (10.5 ft) long. The concrete panels were prestressed in the 5.5-m (18-ft) direction (transverse to the trestle centerline) and posttensioned with high strength Dywidag bars in the longitudinal or 3.2-m (10.5-ft) direction. The concrete replacement panels are 30.5 cm (12 in.) thick at the bridge centerline and 25.4 cm (10 in.) thick at the edges of the deck. Prior to the placement of the new deck panels, the top surfaces of the built-up steel beams were cleaned and repainted. The new concrete panels are attached to the steel beams by bolted connections into threaded inserts, embedded in the concrete panels.

The contractor first removed the ballast from the boxes by bulldozing from the center of the trestle to the ends. The ballast boxes were then removed, beginning at the center of the bridge and working toward each end (the empty ballast boxes were later used to construct a retaining wall for one of the connector roads) (Figure 6). The new concrete deck was then installed beginning at one end of the trestle. Each panel had been cast against its adjoining members so the fit was nearly perfect. A bonding agent was applied to the surfaces between the panels before applying the jacking force that posttensioned the panels together. Each panel was posttensioned to its adjoining panel before the next panel was installed. The compressive force holding each panel together is greater than 845 kN (190,000 lb). Expansion devices were installed in the Squaw Creek Bridge deck to take the calculated 7.6 cm (3 in.) of temperature change movement.

After the new concrete deck was installed, a new structural tube vehicle guardrail system was installed. A pedestrian-height [1.1 m (42 in.) above the deck] pipe

FIGURE 6 Removal of first ballast box from Dick Creek trestle.

rail was mounted above the vehicle rail in anticipation of pedestrian use of the bridge.

All deteriorated concrete in the abutments was removed and replaced, and the expansion devices were replaced.

These trestles were converted to vehicle bridges at a cost of $634 per linear foot, for a total cost of about $477,000. The cost of this 14.5-km (9-mi) segment was about $727,000. This converted section of railroad bed is adequate for a single-lane roadway. Grades vary from 0.2 percent to 1.7 percent and the horizontal curves are very flat. The entire railroad grade has from 0.6 to 1.8 m (2 to 6 ft) of ballast rock, which required only a thin surfacing course to provide an excellent aggregate roadway surface. About one-half of the old county road on the opposite side of the canyon was converted to a trail. The remainder of the old county road was left open and accesses a campground, a trailhead, and a logging road.

Forest Highway Segment

In 1991, the segment of railroad grade from Avery, Idaho, to Marble Creek was opened for automobile and truck travel. This segment of railroad grade follows the St. Joe River, a river designated as wild and scenic. This 21-km (13-mi) segment is a double-lane, asphalt-paved, 80-kph (50-mph) forest highway (FH-50). The Forest Highway Program is a federal program that returns a portion of the federal gas tax revenue to the states for use on selected public roads that serve a substantial amount of national forest–related traffic and resources. In Idaho, the program is jointly administered by the Federal Highway Administration, the USDA Forest Service, and the Idaho Transportation Department. This forest highway project was engineered and administered by the Western Federal Lands Highway Division of the Federal Highway Administration. When construction of the project was completed, the highway was turned over to the county for maintenance.

The St. Joe River Road between Avery and St. Maries, Idaho, was placed in the Idaho Forest System in 1957. FH-50 serves a variety of important needs and uses within the St. Joe valley, including access to local residences, transportation of timber products, and recreational travel, as well as linking the small communities of St. Maries, Calder, Marble Creek, Hoyt Flat, Avery, and St. Regis. It is also a strategic arterial road for transporting logs from the forests of the large St. Joe drainage. Before 1991, the route from Avery to Marble Creek was a hazardous, single-lane, unsurfaced road with turnouts. It had poor alignment with inadequate sight distances, and its deteriorated condition required a high level of maintenance by the county. When the Milwaukee Railroad closed in 1980, the bankruptcy trustee sold the segment of railroad grade from Avery to St. Maries to Potlatch Corporation (a logging company). Potlatch used it for several years as a private short line for the transport of timber.

When the Federal Highway Administration began design work for the reconstruction of FH-50, the railroad grade was studied and selected instead of trying to improve the existing south side road through some very unstable slide areas. The railroad grade provided a better alignment in more stable terrain and resulted in reduced environmental impacts at a substantial savings in construction costs. The railroad grade, with its straight alignment and thick ballast, was the ideal location for FH-50. In about 1987, the Federal Highway Administration purchased this segment of the railroad grade from Potlatch Corporation for conversion to a vehicle travelway.

Construction costs for this 21-km (13-mi) segment were approximately $12.3 million, plus $1 million for rights-of-way purchase. A large portion of this cost was for the construction of two major bridges: one across the St. Joe River, near Marble Creek, and the other across the North Fork of the St. Joe River, at Avery. The original railroad bed was a minimum of 4.3 m (14 ft) wide. The minimum curve radius was 243 m (800 ft) and the maximum gradient was 1.7 percent. The new forest highway has 2- to 3-m-wide (10 ft) lanes and 0.6-m (2-ft) shoulders. The reconstruction of the forest highway basically consisted of widening, paving, and installing guardrail.

Reconstruction of the previously existing county road on the other side of the St. Joe River, to the same design standards, would have cost approximately $25 million.

Summary

The civil engineering feats on this portion of the Milwaukee Railroad are comparable with any in North America over the past 90 years. Eleven major trestles with a total length over 1.9 km (1.2 mi) rise high over steep canyon bottoms. Seventeen tunnels bore through 5.8 km (3.6 mi) of granite. Huge earthen fills, water tunnels carved through solid rock, and electrification of the railroad engines provide an exciting history of applied engineering skills. The 90-year history is as colorful as the surrounding mountains.

The past 14 years have been an exciting time for the local engineers who converted railroad grades, tunnels, and bridges for automobile and pedestrian use. The first 6 years were spent in controversy over ownership of the route as salvage companies ravaged the old railroad, tearing out rails, ties, and historical remnants of the railroad era. Since 1986, about one-third of the 93 km

(58 mi) from St. Regis, Montana, to Marble Creek, west of Avery, Idaho, has been converted to vehicle roadways. The remainder is in the planning stage for what could become a very popular trail system if construction money is available.

Tomorrow's challenges will be to preserve what remains for future generations to enjoy while sharing the legacy of the railroad era. The feats of the engineers and thousands of workers from all over the world who contributed to the construction of this engineering marvel should be preserved. The future holds endless possibilities for sharing this rich engineering heritage with the public.

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