
McClain Creek Landslide

Installation of Drainage Systems, August to October 2001

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Background and Project History

The McClain Creek Landslide is located on National Forest Service lands in the Bitterroot Mountains in the upper drainage area of McClain Creek. The landslide is more than one-half mile long and 200 feet wide (figure 1).

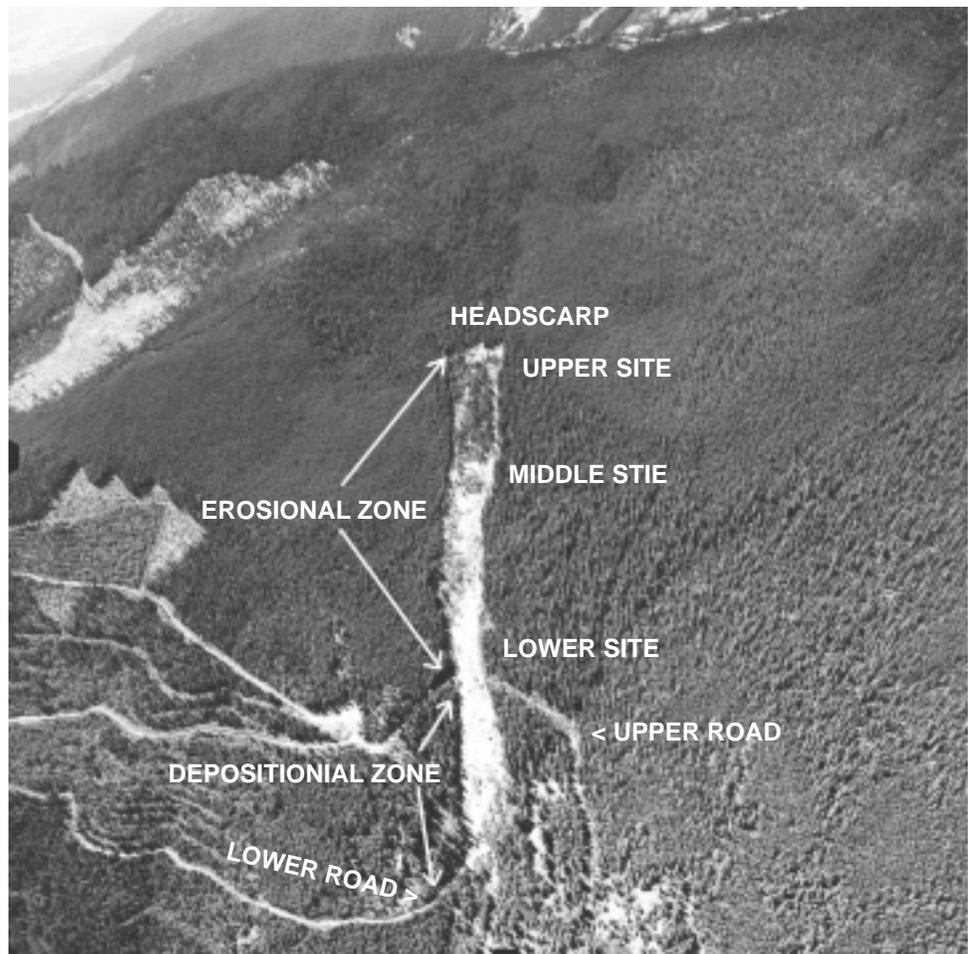


Figure 1. Aerial view of McClain Creek landslide.

Geotechnical Investigations and Alternatives Considered

A significant amount of the slide material consists of decomposed mica schist and gneiss within a silty sand matrix. The mica schist has a plate-like structure and a relatively low shear strength when saturated. Although the landslide may have been reactivated by road construction in 1963, evidence of ancient landslide activity exists within the current boundaries of the present slide. Previously existing pressure ridges occur along both sides of the landslide. These pressure ridges consist of material pushed up laterally as the main slide mass moves downslope.

In 1994 a tort claim was filed against the Forest Service by adjacent landowners alleging damage to their property as a result of the McClain Creek landslide. The alleged damages included the deposition of sediment into the landowner's irrigation system. A settlement agreement was reached in November 1998 between the plaintiffs and the Forest Service. The Forest Service agreed to develop and execute a project to remove surface water from the landslide, revegetate the landslide surface area, and abate the heavy sedimentation flowing into McClain Creek and the landowner's irrigation system. The parties agreed that it would take through 2005 to evaluate the effectiveness of the project.

Prior to the settlement agreement in 1998, a seismic survey and reconnaissance survey were conducted in 1978 and 1980, respectively. In 1994 a geotechnical review by Landslide Technology (January 2, 1994) provided the initial geotechnical evaluation by an outside source. Lynne Dickman, Bitterroot NF geologist, documented a case history of the landslide.

In 1999 Aquoneering Inc., in conjunction with Womack & Associates, prepared a report for the U.S. Department of Justice (DOJ) to advise the DOJ and the Forest Service of potential alternatives to stabilize the slide. This report also included the first comprehensive field assessment of the hydrologic, hydraulic, and geotechnical aspects of the slide. Their basic plan involved the collection of surface and ground water from the top of the slide, then diverting it through lateral piping to the base of the slide. Directly below the toe of the slide, they proposed a sediment dam to collect sediment from the landslide.

In the fall of 1999, Doug McClelland, USFS Northern Region Geotechnical Engineer, implemented an independent peer review of the Aquoneering and Womack proposal. Four independent experts in geotechnical and landslide technology were hired. They included Landslide Technology (Portland, OR), Klohn-Crippen (Richmond, B.C., CN), G.N. Richardson & Associates (Raleigh, NC), and Don Hyndman (Professor of Geology, University of Montana). In these independent reviews, significant problems associated with the surface water diversion and collection system and sediment dam in the Aquoneering/Womack proposal were identified. The major problems included: 1) inaccurate hydrologic estimates for the drainage area, which led to an overdesigned, impractical water diversion and collection system; 2) the sediment dam location at the toe of an active slide mass which could saturate the toe of the slide and potentially increase the risk for unstable conditions; 3) costly and difficult maintenance of the sediment dam; and 4) difficult maintenance of the lateral piping system because of potential ground movement and the high probability of debris plugging the pipe.

However, some success was accomplished by the installation of Womack's experimental drainage systems, which were installed in fall 1999. Two prototype elements of their proposed drainage system were installed including 1) a subsurface geocomposite (Eljen) drain above the headscarp of the slide and 2) a geotextile-reinforced embankment and drainage sump. In addition, three surface-water diversion ditches, constructed of geotextile liner and vertical log posts, were installed at the request of the Forest Service to divert surface-water laterally off the slide through the pressure ridge on the west edge of the landslide. During his May 2000 field review, Doug McClelland noted that the experimental drainage systems installed in the fall of 1999 appeared to have some beneficial effect, and removing the surface water with the three diversions through the lateral pressure ridge reduced potential sediment generation by significantly drying out the surface of the landslide.

Rodney Prellwitz, P.E., former USFS geotechnical research engineer, was hired by the Forest Service to serve as a technical advisor for the installation of the monitoring wells. Also, he was to assist with the development and implementation of a monitoring program to better understand the ground water and surface water characteristics affecting the stability of the slide. The monitoring program included installation of state-of-the-art instrumentation to continuously record ground water levels. Monitoring results will be used to determine the effectiveness of mitigation measures to control ground water and surface runoff. For example, following the installation of ground water observation wells, it was noted that the Eljen drain located above the headscarp appeared to have some drawdown effect on ground water levels, observed during the installation of 11 ground water-monitoring wells in July 2000 (Installation Report, Prellwitz, November 2000).

Ground water observation wells were installed in July 2000 using a tripod and motorized cathead to advance the holes by standard penetration test (ASTM D1586) techniques. The drilling equipment was sling-loaded to the top of the slide by helicopter. Holes were cased with 1.5-inch-sch 40-PVC pipe, which was slotted in the anticipated aquifer zone. Continuous monitoring of ground water levels in 10 of the observation wells was initiated in October 2000 and will continue for the duration of the project. Standard penetration tests were conducted from the ground surface to the bottom of each well. Soil samples throughout the entire well depth were collected and analyzed. Depths to ground water also were recorded for each well. This subsurface information helped to more accurately define characteristics of the slidemass failure in the stability analysis. Using this analysis, the critical depth of ground water (at which failure of the slidemass is expected to begin) was determined.

A resistivity survey had been conducted by EchoTech Geophysical (August 2001) prior to the installation of the wells. Resistivity surveys, or profiles, are geophysical surveys used to delineate subsurface saturated zones and other geological characteristics. These profiles were useful in optimizing the location of the ground water monitoring wells and provided additional information for the stability analysis.

Prellwitz was recruited to advise in the development of alternatives and, eventually, the final drainage system design. He completed a new, more thorough slope stability analysis. The new analysis, based on additional

investigation and data from drilling the ground water monitoring wells, reflected a more accurate evaluation of the slide mass geotechnical properties, such as soil shear-strength parameters, density, depth to failure surface, and so on (*Stability Analysis Report*, Prellwitz, January 2001). He describes the failure mode as primarily translational. The mode is characterized by the downslope displacement of slide mass material moving on a surface that is generally parallel to the general ground surface with little rotational movement. Ground water characteristics of the landslide include both confined and unconfined aquifers.

The resistivity subsurface profiles and hydrographs from the first year of ground water monitoring indicate that more than multiple aquifers are feeding ground water into the slidemass at different locations. The Aquoneering and Womack plan addressed only one unconfined aquifer at the main headscarp. This aquifer would have been drained and collected in a closed piping system running from the top of the slide to the sediment dam near the toe of the slide. Prellwitz recommended installing additional subsurface drains throughout the upper two-thirds of the slide to pull the ground water levels down below the critical level. This would control ground water levels not only at the top of the slide, but also in other locations not necessarily recharged completely by the aquifer located at the top of the slide.

The settlement agreement requires the removal of surface water from the landslide and abatement of heavy sedimentation from McClain Creek. The drainage plan (*Drainage Analysis Report*, Prellwitz, January 2001) included lined ditches at several locations across the width of the landslide to direct the surface water and sediment outside of the west pressure ridge to the forest floor. A lined ditch was designed over the top of a subsurface drain to minimize the amount of excavation and ground disturbance.

During the environmental assessment process, concerns arose about the potential risk of erosion caused by diverting flows to the forest floor west of the slide. McClelland addressed these concerns in several internal memorandums, including a December 12, 2000, memorandum to Betsy Ballard, Project NEPA (National Environmental Policy Act) Coordinator. He pointed out that the forest floor was already saturated, and mass stability was unlikely to be decreased with additional water because the phreatic surface would not be significantly increased. McClelland also pointed out that the forest floor was very porous and adsorbed water readily, and he hypothesized that the forest floor remained essentially the same from the end of the wet Pleistocene, when the original landslide occurred, creating the large lateral pressure ridges. Thus, the existing forest floor adjacent to the landslide had probably been exposed to numerous 100-year flood events, and many 1,000-year flood events, that generated flows far in excess of the 50-year design criteria for the McClain landslide stabilization project.

Based on initial observations of the experimental drainage systems and recommendations from Doug McClelland and Rodney Prellwitz, the interdisciplinary team selected the proposed alternative that included the installation of subsurface drains to lower ground water levels in conjunction with surface water drainage systems to control runoff and erosion.

The landslide is located in steep, unstable terrain. Because approximately two thirds of the landslide is located above the upper road, the majority of the slide is inaccessible by road. The portion of the slide located between the upper and lower roads (see figure 1) is extremely steep and inaccessible by conventional excavating equipment. After considering the terrain and potential for encountering high ground water, the team decided to eliminate conventional excavating equipment, and instead, use a spider hoe excavator with an experienced operator. All Terrain Excavating from Polson, MT, was selected because of the company's qualifications and past experience working in steep, rough terrain and difficult conditions, including wet and boggy terrain.

Description of Drainage Systems

The project included the installation of ground water drainage systems, surface water drainage systems, and monitoring stations. Geocomposite drains were selected as the subsurface drains because they are more lightweight and more easily transported by helicopter than conventional trench drains (constructed of graded aggregate and perforated pipe wrapped in geotextile). The relative characteristics of geocomposite drains were discussed by McKean and Inouye (*Field Evaluation of the Long-Term Performance of Geocomposite Drains*, December 2000). In 1999, Womack installed 100 feet of experimental Eljen drain on this landslide. Based on the continuous satisfactory performance, Eljen drains were selected for the geocomposite subsurface drains. On the McClain Creek landslide project, a total of 2,190 feet of Eljen drains were installed at 14 locations. Drain lengths varied from 50 to 260 feet with a typical trench depth of 6 feet (figure 2). In addition, about 2,000 feet of lined ditches were constructed at 9 locations to divert surface water off the landslide. The Eljen drain panels used were 4 feet high by 10 feet wide. They were folded and transported, two panels per package (about 2.5 feet by 1 foot by 4 feet), and weigh about 30 pounds. The heat-sensitive panels had to be stored in a shady location until installation.



Figure 2. Installation of Eljen drains in depositional zone.

To assemble the Eljen drains, 4-inch perforated ADS (Advanced Drainage Systems) pipe was run through the bottom of the 4- by 10-foot panels, and the panels were pinned together. Typically, the entire assembly was dropped in the trench, and staked at the proper grade for backfilling operations (figure 3). A section of HDPE (high-density polyethylene) liner overlapped the Eljen drain panels to intercept and direct the flows above the panels into the Eljen drains. The downstream ends of the Eljen drains were connected to 4-inch solid ADS piping, or “collector pipes” (figure 4). The collector pipes were then routed to a location where the outflow could be monitored and directed off the landslide. For design purposes, the total drain length for any single collector pipe was limited to 300 feet. The surface water drainage systems were constructed by berming up the sides of the ditch after backfilling operations, then placing a 20-mil HDPE liner over the shaped ditch (figure 5). Initially, the HDPE liner was cut to 6-foot widths, but using 9-foot widths made the installation more efficient.



Figure 3. *Eljen drain panels staked at grade, middle site.*



Figure 4. *Collector pipes that drain upper site, located along west pressure ridge.*



Figure 5. *Installing HDPE liner over bermed ditch to divert surface water runoff from the landslide.*

The settlement agreement required a monitoring program to evaluate the effectiveness of the overall project. Monitoring stations were installed throughout the landslide, mainly along the west perimeter of the slide (figure 6). These stations allow measurements of the subsurface ground water collected by the Eljen drains, the surface water being diverted off the landslide by the lined ditches, and the total flow in the various channels, which eventually feed into McClain Creek.



Figure 6. *Monitoring station to measure ground water and surface water flows drained from the middle site.*

Brief Construction Summary

Prior to startup, all construction materials had been procured by the Forest Service and delivered by helicopter to various sites throughout the slide. Materials delivered onsite included Eljen drains, ADS piping and fittings, and several rolls of HDPE liner. The contractor's fuel for the spider hoe was also delivered by helicopter in three 55-gallon drums.

Work was started on the lowest Eljen drain (between the upper and lower roads). This location was the steepest section of the slide in terrain and would have been difficult to excavate under adverse weather conditions. Trenching operations were relatively straightforward for this drain because the ground conditions were dry throughout the length of the trench. The Eljen drain panels were installed on the uphill side of the trench, then backfilled on the downhill side, in accordance with the manufacturer's specifications (figure 2). After backfilling, the spider hoe excavator was used to shape the surface drainage ditch, and a 6-foot wide HDPE liner was installed over the shaped lined ditch. Finally, the excavator was used to place rock and excavated material to key in the sides of the ditch liner.

Upper Site

The upper site is located at the top of the slide within the vicinity of the headscarp (figure 1). Excavating a trench, through the pressure ridge, between the two monitoring stations for the 8-inch outlet pipe was the first stage. More than 200 feet of 8-inch-diameter solid ADS pipe was installed, then trenching proceeded up the hill for the four 4-inch diameter collector pipes. This piping drains the existing Womack structures and all Eljen drains at the upper site (figure 4).

Trenching operations were difficult for three of the Eljen drains at the upper site because of cave-ins caused by saturated ground conditions and groundwater pooling in the bottom of the trench. Therefore, shorter sections of trench were opened, and the Eljen drains were installed immediately and then backfilled. Extremely wet ground conditions and cave-ins from the old slide debris were also encountered during the excavation for an Eljen drain located directly below the headscarp of the slide. McKean and Inouye (December 2000) discussed similar cave-in problems at wet locations at their evaluation sites and recommended Eljen-type drains so they could be preassembled and installed quickly after excavation. This proved to be correct advice for this project, with one additional observation. Cave-in of the trench wall at saturated locations was almost always on the uphill side of the trench (the direction of ground water flow). To maintain drain alignment, it was necessary to abandon the manufacturer's recommendation and place the drain panels on the downhill side of the trench and backfill on the uphill side over the cave-in debris (figure 7). In deeper trench sections, laborers tied off Eljen panels with bailing twine and lowered them into the trench to maintain their position and grade during backfilling.



Figure 7. Excavation for Eljen drain located directly below headscarp. Note trench cave-in onto Eljen drain, mid-photo.

Middle Site

The middle site is located approximately 600 to 1,000 feet downhill of the headscarp below the section of toppled trees and undergrowth (figure 1). This site was selected for additional drains because it still has local unstable slidemass, apparently affected by a different aquifer than the one at the upper site.

Lower Site

The lower site included drainage systems between the middle site and the upper road (figure 1). In addition to Eljen drains extending the entire width of the landslide, lined ditches were installed at closer intervals across the width of the slide to ensure that sufficient surface water is diverted off of the landslide before it reaches the steeper slope below the upper road. After a Parshall flume was located along the upper road, the original work was completed on October 10, 2001.

Additional Work in Depositional Zone

The depositional zone is located between the upper and lower roads. This section contains the steepest slopes on the slide—more than 45 percent. These steep slopes were caused by the eroded material from above, which was deposited in a “bulging” shape near the toe of the slide, hence the name “depositional zone” (figure 8). To control erosion in this steeper section, 15 check dams, constructed from native materials (rocks and dead trees), were added to the original work. This phase of work was completed October 17, 2001.



Figure 8. Spider hoe excavator in depositional zone, located between the upper and lower roads.

Project Data

Total Length of Eljen Drains Installed:	2,190 feet
Total Length of Lined Ditches:	2,100 feet
Engineer's Estimate:	\$93,000.00
Contractor's Bid:	\$74,188.09
Final Construction Cost:	\$89,651.28
Materials Cost:	\$24,950.72 (purchased by Forest Service)
Contractor:	All Terrain Excavating, Inc., Polson, MT
Contract Time Began:	August 21, 2001
Contract Completed:	October 17, 2001
Contract Days Allowed:	60 Calendar Days (actually used 58 calendar days)

Changes were made during construction to the lengths and locations of some of the Eljen drains and lined ditches in the original plans and specifications. The final constructed lengths and locations of drainage systems are reflected in an as-built drawing in the final construction report. To obtain a copy of this report or more information related to this project, contact Terri Anderson at the Bitterroot National Forest, 406-363-7112.

Plans for Revegetation and Continued Monitoring

To develop a plan to meet the revegetation requirements in the settlement agreement, Thomas Parker of Bitterroot Restoration Inc. prepared a draft proposal, dated July 2001, to revegetate the McClain landslide within 5 years. His proposal included establishing native vegetation and fixing soil nutrients, providing for soil surface protection using erosion control blankets, and controlling runoff by using contour wattles, rock fill, or log cribs. In late summer and fall of 2001, the Forest Service botany crew started implementing this plan by planting 700 shrubs in bare areas throughout the slide, installing straw wattles, and strategically scattering logs to control surface erosion. The crew also installed two experimental erosion-control-blanket test plots in a raw area of the slide directly above the upper road. The revegetation plan implementation is likely to continue through 2005, with evaluation and modification of revegetation and erosion control measures each field season to improve their effectiveness and ultimately meet the settlement agreement objectives.

A plan to monitor the effectiveness of the Forest Service in meeting the requirements in the settlement agreement was developed and a general outline of the plan was included in the Environmental Assessment, March 2001. The results of this monitoring program will provide the basis for determining project effectiveness, and help determine whether or not additional mitigation measures are necessary.

List of References

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