No. 8

Dam Safety Outlet

DAM SAFETY PROGRAM

February 2005

Montana Department of Natural Resources and Conservation

Trees on Dams - Myth and Reality

Make no mistake about it! Trees growing on dams are a major safety concern. Yet control of these trees is a maintenance item often neglected. When the trees are small, the problem can be taken care of with less than a day's worth of labor. But too often, trees are allowed to grow to such a large size that an expensive rehabilitation project is required.

Why do dam owners neglect trees? The answer given to us by many is the belief that tree roots actually stabilize soils. Dr. B. Dan Marks, P.E., a leading expert in plant and animal penetration of dams, addresses this myth when he states, "Many otherwise knowledgeable and educated individuals believe the myth that tree roots actually stabilize soil masses by 'holding' the soil together. In actuality, tree roots loosen soil as roots grow to further stabilize the growing tree. During recent years, State Departments of Transportation and the Federal Highway Administration have come to the realization that tree-covered cut slopes and embankment slopes become more susceptible to slope failure when covered with dense woody vegetation growth. These agencies are currently spending millions of dollars to clear woody vegetation infested slopes to improve long-term performance."

The long-term goal for all high hazard dams in Montana is complete

tree removal. The fact that trees loosen soil on the dam is enough reason for this policy. However, as you will read below, there are other important reasons for tree removal.

Should you immediately cut down all trees on your dam? No. Only if all the trees were less than 6 inches in diameter would this be acceptable practice. Otherwise, you should obtain assistance from your engineer. The approach to tree removal depends on the size and location of the trees on the dam.

The major concern with trees near the crest or top of the dam is blow over. The crest of the dam is its thinnest portion. The dam crest area is used for flood storage. Typically, heavy rainfalls, high winds, and full reservoirs all occur at the same time. When a large tree is blown over, enough of the top embankment could be removed with the roots, thus creating a channel for water to begin overtopping the embankment. Once this channel is established, a complete dam breach can easily occur.

Trees along the bottom third of the dam or on the dam toe are sometimes fed water from seepage through the dam or foundation. If the dam is homogeneous (made of one soil type), it is likely that trees are being fed water from dam seepage. If the dam is constructed with a core and drains (not homogeneous), the source of water for tree growth is more difficult to determine. In eastern Montana, trees growing on a

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Fine Grained Soils Frequently Asked Questions

What are fine-grained soils?

Fine-grained soils are composed of particles so small that the soils act as one block of mass rather than as individual particles. The individual particles are impossible to see with the naked eye. Fine-grained particles are classified as silts or clays.

What is the difference between silts and clays?

Silts are derived from the weathering of rock. Clays are developed when rock minerals are chemically altered. All clays are cohesive, while most silts are not cohesive. Many clays are good soils for earthen dams, while most silts are not good dam materials.

Why are silts bad dam materials?

Most silts are non-cohesive. Therefore, they can easily erode if a concentrated seep occurs on a dam. This erosion can pipe through the dam and lead to dam failure.

How can I tell the difference between silts and clays?

If dry soil clumps and crushes easily, you have silt. If the sample stays hard and cohesive, it likely contains clays. Often silts can be confused with fine grain sands. If the soil feels gritty, you may have fine sand and not silt.

Are all clays good dam material?

Highly plastic clays and dispersive clays are generally not suited for dams. Plasticity is a measure of how moldable the soil is. Highly moldable soils, like bentonite, are highly plastic. Plastic soils are difficult to compact. Plastic soils also shrink and swell, thus are susceptible to cracking and settlement.

What are dispersive clays?

Dispersive clays are soils that detach from each other in water. Water with very little salt expedites the erosion process. The soils in the Badlands of North Dakota are dispersive clays. These soils are so erosive that earthen dams built with dispersive clays often fail during the first filling of water behind them.

Where are clays placed in a dam?

Usually clays are placed in what is called the core of the dam. The core can be thought of as basically the center. Since clays move water at an extremely slow rate, they act as a water barrier and help reduce the seepage rate through the dam.

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dam are likely a sign of seepage. In wetter climates, the type of trees and their location on the dam offer clues as to whether they are fed by seepage or normal precipitation.

Trees that are fed from seepage through the dam are of special concern. Removal of the trees and root systems, whether intentionally or by blow over, opens up a new seepage path. If this seepage is left uncontrolled, internal erosion of the dam could lead to complete dam failure. Removing the trees but leaving the root systems can have the same effect, because the root systems will eventually decompose.

Brush growing on dams is also a concern. Although brush does not have the extensive root system that trees do, heavy brush cover prevents adequate dam inspection and also provides cover for rodents. Rodent tunnels and burrows in dams can have many of the same impacts as tree roots.

Therefore, for high hazard dams in Montana, our long-term goal is to remove all trees and brush. To prevent surface erosion, all earthen dams should have a cover of native grasses.

Drought Conditions Lead to Plugged Outlets

As drought conditions persist, we are getting more and more reports in regard to plugged outlets on dams. If your reservoir level drops so low that the inlet structure is barely below the water or exposed, the outlet can easily become plugged.

The outlet plugs while the reservoir is low because wave and wind action deposit material in front of the inlet structure and also in the conduit. The inlet structure to your outlet should be checked frequently to make sure that it is free of debris and obstructions. Sometimes, moss will accumulate on the trashrack and partially plug the inlet. Once this occurs, it is easier for debris to accumulate on the trashrack. It is a good idea to remove moss and debris from the inlet before the reservoir fills in the spring.

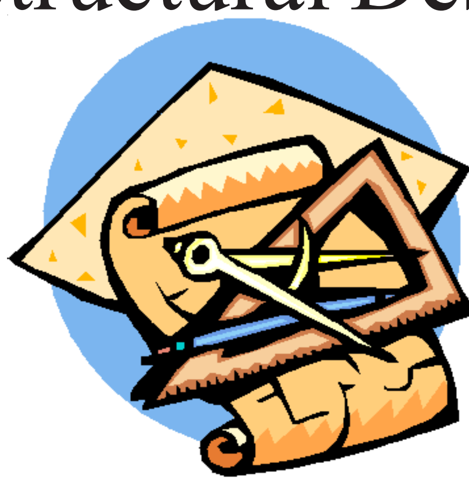
Once the reservoir gains substantial water, it becomes very difficult to clean debris in front of the inlet. At this point, a method used by many dam owners is to occasionally flush their outlets. The flushing is accomplished by opening the outlet gate to about half open and running water out of the outlet until the water flows clear. This flushing is not limited to just spring time, but should <u>not</u> be done when there is ice on the reservoir. Ice prevents movement of materials to your inlet structure. Therefore, little is gained by the flushing.

Often, the outlet needs to be flushed for a long period to be effective. This would seem to be a waste of stored water, but is far less costly than hiring someone to water jet the conduit or hiring divers to clean the inlet.

If you find that your outlet is plugged, you may want to contact Art Taylor with DNRC. Art can be reached at 444-6665. He has helped with unplugging a number of inlets and conduits and is willing to offer suggestions on how to best open your outlet structure.

Concrete Structural Design Course

Engineers should mark their calendars for August 23-24, 2005. The Dam Safety Program is sponsoring a concrete structural design course during these two days. The course, which will be taught by professors from Montana State University, is intended for civil engineers whose specialties are outside structural design. The course will be held at Fairmont Hot Springs. Tuition will be about $50. If you are not mailed a registration form by the end of June, contact Windy Pennington at wpennington@state.mt.us or at 444-6632.



Trees on Dams - Engineering Approach

Not all tree growth on earthen dams imposes the same level of impact on the safety of the dam. Anyone can recommend removal of all trees, stumps, and root systems. However, dam engineers need to prioritize the significance of tree growth. Many private dam owners do not have the economic resources to take care of all their dam safety problems at once. In most cases, a long-term plan is needed to allow the dam owner time to budget for eventual removal of all trees.

The most critical trees to remove are those that consume water from seepage within the dam or foundation. These trees may be found growing directly on the dam or on the toe. Work on these trees should never occur when the reservoir is full. Trees larger than 6 inches in diameter need to have their root system completely removed. To prevent material movement, a filter and/or drain system must be installed where the roots once were. Trees less than 6 inches in diameter can be removed by cutting flush with the ground. The stumps should then be treated with polyurethane to prolong the decaying process.

If many large trees must be removed, necessary repairs could range from installing a toe berm to completely replacing the embankment. Obviously, such a repair will be very expensive. Therefore, it may be best to leave the trees in place and develop a long-range plan to remove them in stages. The dam owner should be strongly encouraged to monitor the situation and be prepared to notify their engineer if a tree should die. A blow over would need immediate attention.

The second most critical area for tree removal is near the dam crest. All trees should be removed near the dam crest. Root removal is a judgment call. The engineer needs to factor in the size of the tree and the width of the crest. All root systems that are not removed should be treated with polyurethane to prolong the decaying process. The trees should be cut 2 feet above ground for easier root removal, if needed, in the future. If the root system is removed, the backfill will need to be placed in no greater than 8-inch loose lifts. The backfill is then compacted either with manually operated compacting equipment or equipment attached to a backhoe.

The least critical need for tree removal is when trees are neither near the dam crest nor fed water from dam seepage. These trees should be cut and the stumps treated. If a tree is so large that the engineer feels that the roots may have penetrated into the dam core, the root system may need to be removed.

Brush on the dam should always be removed. The best time for this removal is before the dam inspection. Brush removal is time consuming, but not expensive.

During 2001, several engineers with the Montana Dam Safety Program attended a two-day course on dam penetrations by trees and animals. If you would like copies of the articles and reports we received from the course, please contact Windy Pennington at wpennington@state.mt.us or at 444-6632.

The Dam News From Around the State

Three Recorded Dam Failures in 2004

There were three documented dam failures in Montana during 2004. They occurred in Powell, Petroleum, and Fergus Counties. Corroded CMP pipes were the cause of two failures. The third failure was the result of a fish screen becoming clogged within the spillway. This failure resulted in property damage to a house, highway, and railway.

THE Dam News
FROM AROUND THE STATE

Status of Ground Shaking Map Development

Ground shaking maps are now complete and are published by the Montana Bureau of Mines and Geology. The maps will also be available on the state's Natural Resource Information Service (NRIS) website for download in a variety of formats. The Dam Safety Program will also be seeking public comment on a proposed design standard and recommended analysis techniques.

If you are on our mailing list, you will receive notification when the report and proposed design standard is available. For more information, please contact Michele Lemieux at (406) 444-6613 or Mlemiux@state.mt.us.

Lower Willow Creek Dam

Lower Willow Creek Dam was originally constructed in 1962 by the Natural Resource Conservation Service (NRCS). The dam is located 10 miles southwest of the small town of Hall. Hall is between Drummond and Philipsburg. The earth-filled dam is 96 feet high, with a storage of 4,930 acre-feet.

A seep along the downstream left groin was observed after initial construction. The seepage was considered minor. In the spring of 1996, sediment, as part of the seepage, was observed for the first time. This indicated that soil material was migrating from the dam foundation. Subsequently, engineers established a system of observing and monitoring the seepage flows. Exploration drilling, testing, and sampling of the foundation were conducted to characterize the cause and danger level of the seepage.

NRCS examined several design alternatives and chose to install a double grout curtain in the left abutment and foundation area of the dam. The Judy Company, of Kansas City, performed the grouting. Construction was completed in mid-December 2004. A total of 307 cubic yards of grout was utilized to form the grout curtains.

Total cost of the construction was $826,300. NRCS paid $650,000 of the construction cost as well as the cost of exploration, engineering design, and construction oversight. The DNRC Renewable Resources Development (RRD) Grant and Loan Program provided $69,000 in funding for construction and $31,000 for new piezometers to evaluate seepage. The water users funded the remaining $107,300 of construction cost through an RRD loan.

North Fork of the Smith River Dam

DNRC is in the process of rehabilitating the North Fork of The Smith River Dam, known locally as Lake Sutherlin, which is in Meagher County about 10 miles east of White Sulphur Springs, next to U.S. Highway 12. The dam was constructed in 1937 by the State Water Conservation Board, which is now DNRC. The dam is 84 feet high and stores 11,500 acre-feet at the spillway crest.

The spillway concrete is severely deteriorated in a number of locations. In addition, the spillway does not have enough capacity to meet the minimum requirements of the Montana Dam Safety Rules. The proposed new spillway will be a two-cycle labyrinth weir (similar to a "W" shaped weir crest structure) with a chute width of 100 feet and a crest length of about 200 feet.

Additional work to be completed will be improvements to the toe drain system to help collect and control seepage at the toe of the dam. Waste rock from the spillway excavation will be placed along the toe of the dam to add a berm for additional stability of the downstream face. The outlet structure will be replaced

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due to deteriorating concrete, if funding is available.

Total cost of design and construction is estimated to be $825,000. DNRC submitted an RRD grant and loan request to finance the construction. The loan and grant were approved by the 2003 Legislature. The grant is for $100,000, and the low-interest, 20-year loan is for $425,000. The North Fork Smith River Water Users Association is responsible for repaying the loan. DNRC is contributing an additional $300,000 from its water storage account. DNRC has hired HKM Engineers from Billings to design the project and to provide construction management services. The project is currently being designed, and the construction work will be bid in the spring of 2005, with construction following in the summer and fall of 2005.

Georgetown Reservoir

A slip lining project is taking place on an auxiliary outlet on Flint Creek Dam at Georgetown Reservoir. The reservoir is located between Anaconda and Philipsburg. The dam, which is owned and operated by Granite County, was built in the late 1800s as a masonry gravity dam. It has since undergone numerous modifications. The embankment is 44.5 feet high with a normal storage of 31,040 acre-feet at the emergency spillway crest.

The auxiliary outlet has never been used since it was installed in 1942. The original construction of the outlet was inadequate, with large gaps between the pipe joints. If the outlet were to be used, significant flow would exit through these gaps.

By slip lining this outlet and making it operable, future work could be completed on the principal outlet works, while maintaining an adequate streamflow downstream of the dam.

Construction is to be completed in spring 2005. Granite County has hired HKM, out of Butte, to design the project, and Johnson-Wilson, from Manhattan, as the construction contractor.

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