Restoration prioritization and procedures for Drakesbad Meadow, Lassen Volcanic National Park, California

BY:

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February 2012

DRAKESBAD MEADOW RESTORATION PLAN

Background

Drakesbad Meadow has a network of incised channels that were either purposefully constructed or have formed from erosion processes during the 20th century. The history, location, impacts and a pilot meadow restoration are described in Patterson and Cooper (2007). To restore the meadow these ditches and channels should be completely filled with sediment and planted with native species. We suggest filling the high priority restoration areas first, and the areas of secondary importance after all high priority areas have been treated. In addition, the "causeway" constructed of fill placed directly onto the meadow to aid hiker movement across the meadow should be removed. The road that allows vehicle access to the water tank also has caused significant impacts to Drakesbad Meadow. A pilot project on the road to install a series of culverts has been partially successful, but could be improved with the construction of a permeable road base. Each of these topics is discussed and methods presented for restoration, and monitoring.

Ditch Analysis Methods

Drakesbad Meadow was walked and the ditch network mapped in 2011. We attempted to use a total station to survey ditch cross sections, but a faulty total station coupled with the specific project goal of measuring ditch extent and volume led us to modify our methods. We measured ditch width and depth along cross sections where cross-sectional shape clearly changed. The minimum distance interval for cross section measures was ~10 m. One NPS technician and one SCA intern helped with fieldwork. The location of each point, and the ditch shape is presented in supplementary digital files for ArcGIS.

Ditches in Drakesbad Meadow have varying incision depths and vegetation. Ditch types ranged from those whose depth exceeded its width, with no vegetation and perennial running water, to fully vegetated gently sloping depressions that lack surface water. Because all ditches and channels in the meadow may not be restored, we developed a priority systems for ditches (Figure 1).

- Priority 1 ditches are the deepest and most hydrologically impactful features in Drakesbad Meadow. They are incised, usually narrow, and have perennial flowing water. The ditch bottom is typically unvegetated, and ditch width and depth are often similar. These sites are the highest restoration priority.

- Priority 2 ditches are similar to those identified in Priority 1. However, they have less severe incision and degradation. Most segments are deep and unvegetated and in need of restoration.
- Priority 3 includes gently-sloping depressions that are largely or fully vegetated. We are uncertain if these channels are actively incising. These channels typically are 1 m wide and 15 cm deep, without any distinct breaks in slope. If LAVO desires to fill these channels, we suggest that the vegetation be removed in blocks with hand shovels, sediment added, and the blocks of vegetation reinstalled.
- Priority 4 includes all channels in the northwestern corner of Drakesbad Meadow. These have formed near the break in slope from hillside to flat meadow. We are unsure if these channels should be considered for restoration. None are visibly connected to the main network of ditches (Priority 1 & 2) in the meadow.

Volume calculations

Each ditch was divided into segments based upon points that we measured in the field. We calculated the volume of each segment by multiplying its length by the mean width and depth of the segment endpoints. We then summed all segment volumes for a particular class, to yield a sediment volume needed to fill each priority class (Table 1).

Table 1. Volume (m^3) of sediment required for filling ditches/channels in each group.

	Priority 1	Priority 2	Priority 3	Priority 4
Volume (m^3)	77.0	26.4	106.5	10.1

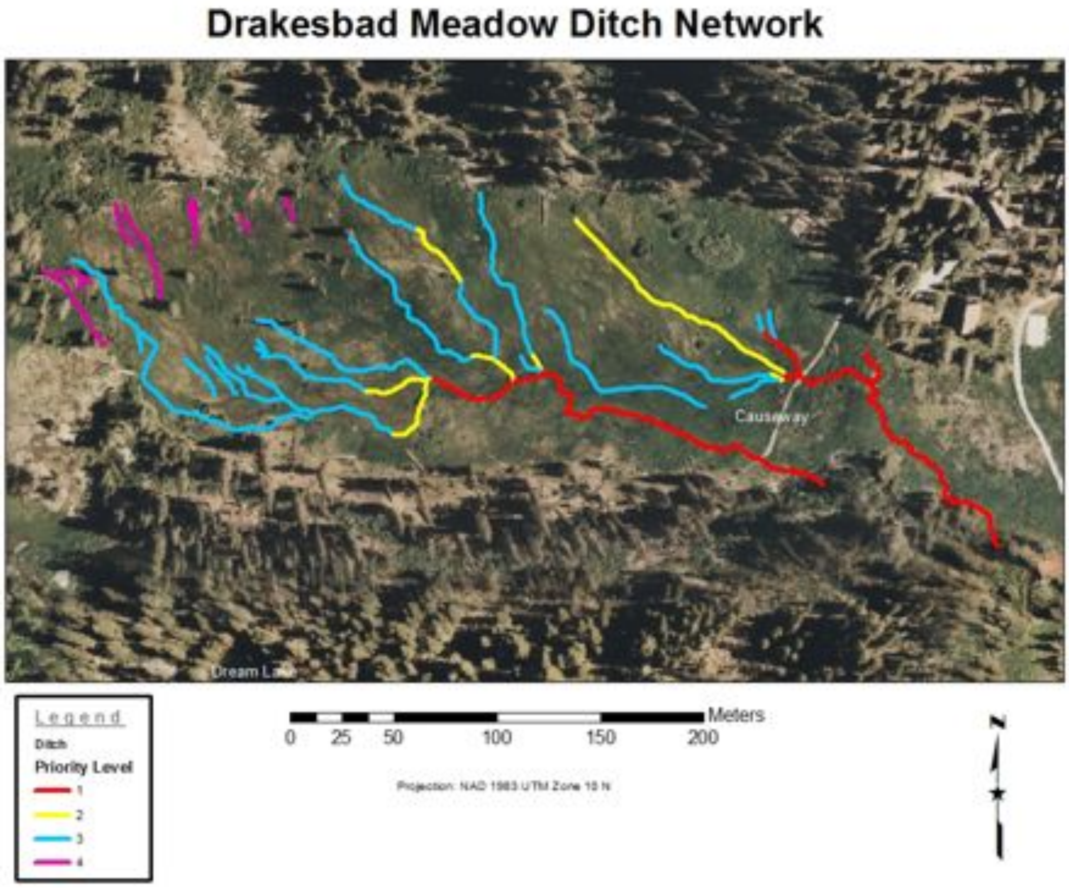


Figure 1. Location of priority 1 (red), 2 (yellow), 3 (blue) and 4 (magenta) ditches in Drakesbad Meadow, Lassen Volcanic National Park, CA.

<u>Fill Sources for Ditch Restoration</u>

Material for filling the Drakesbad Meadow ditches should meet several criteria. The material must not be composed primarily of sand, gravel or larger diameter particles. These materials will promote significant ground water flow through the fill and could effectively keep the meadow drained. The material should also not be primarily clay size particles that would form a complete plug and prevent natural ground water flow through the meadow. This material would also slow the movement of water into fill soils and retard plant growth on the fill. Fine-grained loamy sediment is suitable. The soil need not have high organic matter content, as the plants growing on the fill will be adequately supplied with minerals and nutrients from ground water flowing through the root zone.

Fill material can be moved through Drakesbad Meadow in wheelbarrows or with small soft-wheeled vehicles once the water table drops at least 20-40 cm below the soil surface in late summer. This will limit soil compaction and the formation of rills. It is most desirable to perform the ditch filling in fall (September or October) when the plants are becoming dormant, soils may be frozen and driving over the meadow would have little effect.

Ditch preparation and ditch filling procedures

The first task is to salvage vegetation dominated by species of *Carex, Eleocharis,* or *Scirpus* from the ditch bottom, slopes and banks. Blocks of turf should be cut with shovels or a small excavator, kept intact and stored close to the ditch onto tarps. Turf blocks should be at least 10 cm thick to include rhizomes that will propagate the species once replanted.

The flow of water in many ditch reaches has eroded laterally as well as vertically resulting in undercut banks. The ditch in these areas is wider at the bottom than top. In other locations bank sloughing has created vegetated banks and ditch sides. In these locations the ditch sides should be cut with shovels to create vertical bare mineral soil surfaces. Again, any removed turf should be stored for later replanting. The cuts will widen the ditch by 10-40 cm, but it will allow mineral fill sediments to make contact with the mineral and organic rich sediments exposed on the ditch bottom and sides. This will allow the complete filling of all undercut areas and prevent future piping and failure of the fill.

The ditch should have no flowing water at the time of filling. If water is present a diversion must be created to move water out of the ditch and across the meadow surface.

The placement of sediment into the ditch should be in layers no more than 10-20 cm thick. Each layer should be carefully placed onto the ditch bottom and against the ditch sides and packed by walking over the top of the sediment or pounding with a hand held temper. The use of mechanical tamping devices to pack the soil is not necessary, as it will result in excessively compacted soils with reduced hydraulic conductivity. Sheet metal plates placed into the main ditch as part of the pilot project can be left in place or removed if feasible. The fill surface elevation should equal the adjacent ground surface after hand tamping.

Revegetation Specifications for the Ditches

Once each ditch is filled with sediment, plugs of stockpiled turf should be installed into the fill. Filling and turf placement can occur simultaneously. Large blocks of turf could be cut into strips 10-20 cm wide and planted perpendicular to the length of the ditch so that they span the width of the filled ditch. One strip should be installed every 5-10 m of ditch length if possible. The remaining turf should be cut or broken into blocks approximately 10-20 cm in diameter and planted into the fill. A shovel can be used to open a hole in the fill of sufficient size to place the plugs. Each plug should be flush with the fill surface and equal in elevation to the adjacent vegetation. All turf should be used and placing plugs throughout the ditch length is essential.

Causeway Removal

Precise measures of the causeway volume were not made. To determine the final grading elevation for the causeway sediment removal project three data points are necessary to place each grade stake along the length of the causeway. A series of pits should be excavated through the causeway to determine the thickness of gravel material. An elevation point on the upgradient and one on the down gradient portion of the intact meadow should be measured using a full station. The desired elevation of the restored causeway sediment removal would be the approximate midpoint of the up and down gradient measures and should approximately match the elevation of the pre-fill soil beneath the causeway sediments.

Each grade stake should identify the desired ground elevation after sediment removal. Excavation should occur with a mini-excavator or backhoe. Small machine dump trucks could move the sediment to the appropriate disposal site. Excavation should start on the southwest side of the causeway and proceed to the north so that the backhoe and dump vehicles stay largely on the causeway and back their way out so that once the material is removed there will be no further machine activity on the soils. Since a boardwalk will be place in the location of the causeway, plantings under the boardwalk are not needed.

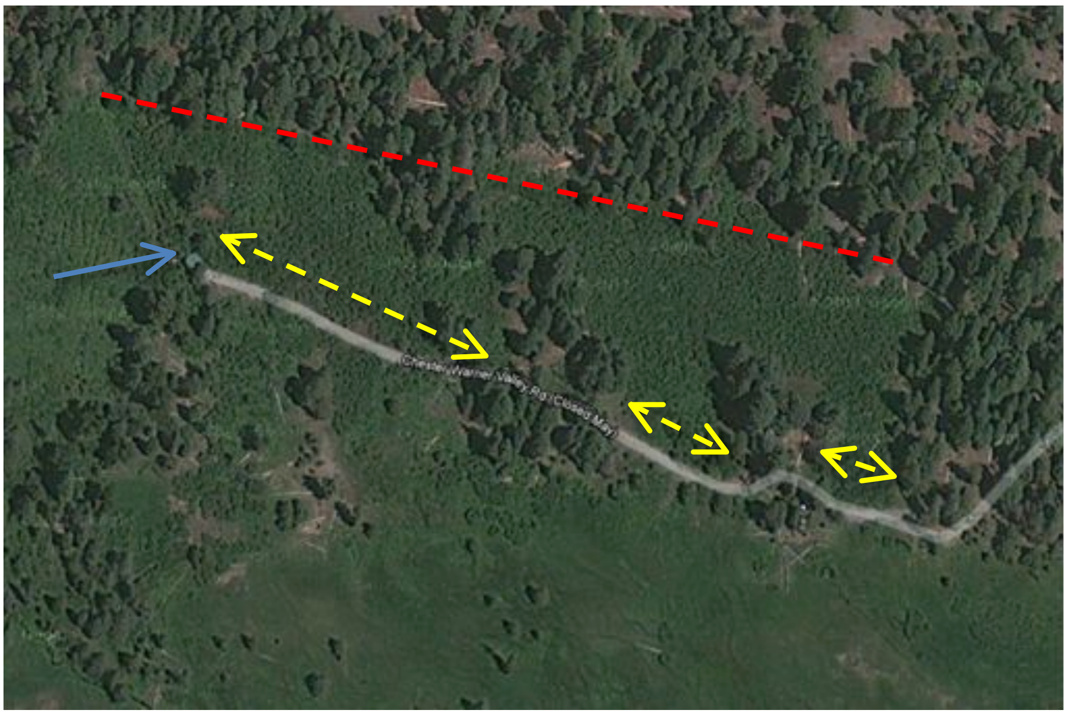
As the causeway is removed, the sediment should be used to fill the ditches adjacent to it. In addition, the culverts should be removed, and any channels associated with them filled. There is sufficient Cyperaceae turf in and on the edges of these ditches and channels that can be removed, stockpiled and planted over the fill as described for the ditch revegetation.

Water Tank Road Improvements

Patterson and Cooper (2007) identified the water tank access road as a significant hydrologic impact to Drakesbad Meadow. The major water source for Drakesbad Meadow is the hillslope springs located above the road. This report cover photo shows the sedge dominated meadow and conifer forest on the far hillslope. A strip of alder extends from Drakesbad Meadow to the spring discharge points. The alder is a key indicator of ground water discharge and an excellent visual indicator of where the spring discharge and flow occurs. The road bisects the alder stands and captures water in its uphill ditch (Figure 2). This water for many decades flowed down the roadside ditch where a couple of culverts routed water under the road. However, in 2004 a series of culverts were placed where the access road crosses the alder stands to allow spring water to flow toward Drakesbad Meadow in locations that have naturally supplied water to the wetland. This has allowed a temporary and partial restoration of the meadow hydrologic regime.

Figure 2. Profile of current water tank road, showing uphill ditch that intercepts sheet flowing water from springs.

Figure 3. Water tank road and water tank (blue arrow) on hillslope above Drakesbad Meadow. Tall conifers occur on bedrock outcrops that are dry. Between conifer dominated hills are springs that originate at the dashed orange line that is the contact between two volcanic sediment beds. The water flows through alder dominated vegetation, seen as the small dense green clumps. The road crosses three distinct spring flow paths, identified with yellow dashed lines.



The most suitable way to reduce the ongoing hydrologic impacts of the water tank road on the meadow is to construct a road with a water permeable base in the three locations shown in Figure 3. A permeable road is constructed entirely of fill with its base composed of sufficiently sized rock to allow surface water to flow through the road base. Historically, spring water on the hillslope above Drakesbad moved as sheet flow and in numerous small rills to the meadow. Channelizing water behind the road and into culverts resulted in down gradient drying in areas that did not receive water as well as erosion where the concentrated water flows down the hill slope. The three areas identified in Figure 3 could have their road segments rebuilt to reconnect

Drakesbad Meadow with its source water. The current fill should be removed and the uphill and downhill ditches completely filled so that the land surface slopes seamlessly from the intact spring complexes above the road to the hillslope below the road. A geotextile fabric is then laid on the future road location, and rocks 10-40 cm in diameter are laid as the road base (Figure 4). This base should be 40-60 cm thick. A layer of smaller diameter rocks, 5-20 cm in diameter, is then placed on the larger rocks to create a relatively level surface. Another layer of geotextile is then placed on top of the finer rock layer and road surface material is the placed on the geotextile and compacted. The road surface should slope gently toward the meadow so that surface runoff from snow and rain will not run down the road surface producing rilling and erosion.

Figure 4. Sketch drawing shows permeable road with coarse rock base, finer rock middle layer, and road base material on top. Geotextiles can be used below the coarse rock and above the fine rock layers. No uphill ditch is present and surface water will enter the coarse rock road base and flow beneath the road and to the meadow below.

Post Construction Monitoring

Prior to and following ditch restoration, a suite of ground water monitoring wells in the vicinity of and down-gradient from the ditches, causeway, and water tower road should be monitored to measure the water table response to ditch restoration. This could be accomplished using two methods. A student should manually measure water levels twice monthly in all wells in Drakesbad Meadow. In addition, a set of automatically recording pressure transducers installed into key monitoring wells to record water levels every 2-4 hours daily would provide a detailed record of hydrologic characteristics prior to and following restoration. This monitoring is best started in the years prior to restoration, so that pre-restoration data is available to compare with post restoration data.

Hydrologic goals of the ditch filling, causeway removal and water tower road construction are to restore the meadow hydrologic regime to include sheet flow of surface water across the entire meadow in early summer, a water table within 20 cm of the soil surface for most of the summer, and a shallow water table in late summer that rises to near the soil surface through the fall and early winter when rain and snow falls. This high fall through winter water table would prohibit the migration of pocket gophers and voles into the meadow during the winter. Damage from these burrowing and sedge rhizome-consuming rodents will facilitate the growth and spread of clonal plant species in the family Cyperaceae. Before and after the restoration activities the vegetation composition and canopy cover by species in a 2-meter radius plots around all monitoring wells should be analyzed and compared with that occurring in 2004. Vegetation cover should be recorded as canopy cover by plant species in the fill area once each summer to assess the vegetation establishment and spread from the plugs. The vegetation goals are to restore the vegetation to dominance by clonal species of *Carex, Eleocharis* and *Scirpus.*

Literature Cited

Patterson, L. and D. J. Cooper. 2007. The use of hydrologic and ecological indicators for the restoration of drainage ditches and water diversions in a mountain fen, Cascade Range, California. *Wetlands* 27:290-304.