**An Assessment of the Effectiveness of Restoration Activities Post-Implementation–
Timberline Proposed Bike Park, Mt. Hood National Forest, OR**

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Introduction

This report assesses the impacts and effectiveness of some of the restoration activities taken in the area of the proposed Timberline Bike Trail Park (Project) that are aimed at reducing existing sediment and hydrologic impacts from ski area development and associated infrastructure within the Project area. These activities and associated measures are described in the "Timberline Restoration Activities Phase 1 (2013) Implementation Plans and Stormwater Pollution Control Plan" by Re-Align Environmental, dated 2013 (RE, 2013).

This evaluation primarily focuses on the restoration measures proposed as part of Phase 1, which Timberline and the MHNF planned on completing by the fall of 2013. Due to budget and time limitations, not all of the Phase 1 attempted restoration activities were reviewed in detail. Instead, this report, and the field reviews upon which it is based, focus on a subset of major Phase 1 activities: a) the Stormin' Norman Service Road decommissioning; b) the Glade Trail conversion from "road" to trail; and, c) the Stormin' Norman Access Road gravel re-surfacing and surface water control treatments (Table 2).

This effectiveness assessment is based on the following sets of information:

- field surveys and measurements of the specific areas proposed for restoration activities, prior to the implementation of restoration activities (Rhodes, 2013);
- field surveys and measurements of conditions after implementation of restoration activities;
- evidence and information on the effectiveness of past restoration activities (Rhodes, 2013);
- existing conditions in the Project area affected by past restoration attempts and the development and operation of the ski area (Rhodes, 2013); and
- salient scientific literature.

More than three decades of my professional experience are also factored into the evaluations in this report.

Field reviews prior to activity implementation: Areas reviewed, measurements, and findings

Three field reviews were conducted on 6/1/13, 6/28/13, and 8/6/13 in the Project area prior to major implementation of restoration activities. The areas assessed, the type of measurements and evaluations performed, and findings are summarized in Table 1, with additional details in Rhodes (2013). These findings provide important context for the evaluation of restoration effectiveness, as well as evidence of potential effectiveness of restoration attempts, as discussed in Rhodes (2013).

Table 1. Areas and elements evaluated, methods, and findings discussed in detail in Rhodes (2013). Areas marked with an "*" are subject to attempted restoration under Phase 1 (RE, 2013).

Date	Area assessed	Elements Assessed	Method	Primary findings
6/1/13	W. Fk Salmon Creek about 100' upstream of	Surface fine sediment levels in the stream	Visual estimate[1]	Surface fine sediment levels in W. Fk. Salmon Creek are at about 40%, well in excess of the <20%

[1] I have many years of experience in visually assessing fine sediment levels in streams. My estimates are reasonably accurate (+/-10%), as statistical assessment of visual estimates and measurements have shown (Rhodes et al., 2000).

	crossing by Timberline Road			standard in the MHNF Plan. This level of fine sediment impairs the survival and production of steelhead and cutthroat trout. (See Fig. 1 in Rhodes, 2013).
6/1/13	Still Creek at several reaches: from crossing by Timberline Road upstream to Jeff Flood lift bottom terminal*	Surface fine sediment levels in the stream	Visual estimate	Surface fine sediment levels in Still Creek are 90-100%, well in excess of the <20% standard in the MHNF Plan (See photos 1 and 2 in Rhodes, 2013). These levels of fine sediment severely impair the survival and production of steelhead and cutthroat trout. (See Fig. 1 in Rhodes 2013).
6/1/13	Jeff Flood lift bottom terminal* and lower runs (Kruser,* Mustang Sally, Uncle Jon's, and Buzz Cut)	Vegetative cover, erosion, and sediment delivery to streams during snowmelt	Visual inspection	The lift terminal and runs are poorly vegetated seven years after construction despite repeated attempts at revegetation, resulting in elevated sediment delivery to Still Creek tributaries. Lift towers have permanently damaged riparian areas and riparian functions along these same tributaries (See photo 3 in Rhodes 2013).
6/28/13	Lower portion of Stormin' Norman Service Road*	Vegetative cover, runoff, erosion	Visual inspection	Relatively low levels of stream-road connectivity.
6/28/13	Glade Trail*	Trail stream connectivity	Length of connected segments measured with hip chain	14% of total trail length connected to stream. Mean length of road segments connected to stream network at points of connectivity = 176 feet.
6/28/13	Still Creek immediately west of Jeff Flood Bottom Lift Terminal	Surface fine sediment levels in the stream	Measured surface fine sediment (grid method)	Purposely measured points in the stream reach with the *lowest* levels of fine sediment. Nonetheless, the measured mean fine sediment = 84.9%, well in excess of the <20% standard in the MHNF Plan. These levels of fine sediment severely impair the survival and production of steelhead and cutthroat trout.
6/28/13	Lower portion of Kruser ski run* to NW of Jeff Flood bottom lift terminal	Vegetative cover and soil conditions	Visual inspection	Ocular estimate of vegetative cover = only 40-50%, despite repeated revegetation attempts in the seven years since initial run clearing. Soil showed diagnostic signs of highly elevated soil

				erosion (soil pedestals).
8/6/13	Stormin Norman Service Road*	Vegetation and soil conditions; stream-road connectivity	Visual inspection; length of connected segments measured with hip chain	18% of the entire length of the road connected to streams. Mean length of road segments connected to stream network at points of connectivity = 163.4 feet. The lower portion of the road is intensely rilled and gullied, but the runoff from this section does not appear to be connected to be stream system.
8/6/13	Stormin Norman Access Road* (from West Leg Connector)	Vegetation and soil conditions; stream-road connectivity	Visual inspection; length of connected segments measured via pacing	About 60% of road might be connected to stream. Mean length of road segments connected to stream network = 207 feet. Road is currently graveled and does not exhibit signs of major erosion (e.g., intense rill/gullies), above and beyond typical road-accelerated erosion.
6/28/13, 8/6/13	Stormin Norman Access Road* and Service Road* and Glade Trail*	Aggregated stream connectivity	Paced and hip chain	Means of aggregated data for the three routes: Mean length of stream-connected segments = 175.8feet. 21% of routes' lengths connected to streams.
8/6/13	Ski run ("Mustang Sally") directly underneath Jeff Flood lift about 100 feet upslope of crossing by West Leg Connector	Ground cover by vegetation or wood	100 point boot tip transect	51% of the area is bare ground seven years after initial clearing despite several attempts at revegetation. Only 16% of ground covered by live vegetation. 33% of ground covered by wood debris, mainly fine pieces.

Table 2 (from RE, 2013) summarizes the proposed restoration measures. Phase 1 activities were proposed to be completed by the fall of 2013

Table 2 - Watershed Restoration Activities Included in the Approved Action

Road/Project	Phase	Action	Length (ft.)	Width (ft.)	Area (ac.)
Still Creek Basin					
Glade Trail	1	Convert Road to Trail (Decommission Road)	2,512	15	0.9
Alpine Trail	1	Trail Surface Enhancement and Surface Water Management	332	12	0.1
Stormin' Norman Access Road	1	6" lift of gravel, surface water control	686	18	0.3
Stormin' Norman Service Road	1	Decommission	3,937	12	1.1
Jeff Flood Bottom Terminal	1	Surface Water Management and Re-Vegetation	-	-	0.4
Kruser Run Landing	1	Surface Water Management and Re-Vegetation	-	-	0.2
Stormin' Norman Bottom Terminal	1	Surface Water Management and Re-Vegetation	-	-	0.8
Roundhouse - West Leg Road	1	Surface Water Management and Re-Vegetation	-	-	0.6
Still Creek Subtotal					*4.3*
West Fork Salmon					
Pucci Service Road	2	Decommission	3,651	12	1.0
Pucci Bottom Terminal	2	Drainage Control and Re-vegetation	-	-	0.6
West Fork Salmon Subtotal					*1.6*
Total			11,118 (2.1 mi)		**5.9**

Source: EA Table 2 (Phases added from BA)

Post-implementation field reviews: Activities and areas reviewed, measurements, and findings

Two field reviews were conducted in the Project area on 9/8/13 and 10/21/13, after attempted restoration activities had begun. The areas assessed, the type of measurements and evaluations performed, and findings are summarized in Table 3.

Table 3. Areas and elements evaluated, methods, and findings after activity implementation. All areas and activities in the table are Phase 1 restoration attempts (RE, 2013).

Date	Area assessed	Elements Assessed	Method	Primary findings
9/8/13	Stormin' Norman Service Road (SNSR) decommissioning	Implementation of decommissioning measures; soil cover; soil conditions; evidence of runoff, erosion, and stream-route connectivity	Visual inspection; groundcover measured via 79-point boot tip transect on representative section; comparison of before and after photos	• Significant loss of previously established live vegetation on treated road sections • On representative section of SNSR upslope of PCT: 0% of ground covered by live vegetation; 43% of ground covered by applied woody debris, mainly fine pieces, 57% bare ground • Failure to provide adequate groundcover, post-treatment prior to rain events • Treatments failed to hydrologically disconnect the route from the stream

				system • Significantly elevated erosion due to interaction of rain events, soils bared and disturbed by decommissioning, and failure to provide erosion control cover on disturbed soils prior to rain events • Increases in sediment delivery to streams, due to combined foregoing impacts and conditions • Increased damage to fragile vegetation and soils due to additional mechanized disturbance outside of decommissioned route prism • Failure to restore natural, preconstruction grade on the SNSR, which will result in continued elevation of runoff, erosion and sediment delivery
9/8/13	Stormin' Norman Access Road (SNAR) (from West Leg Connector) gravel surface and drainage control	Implementation of measures; soil conditions; evidence of runoff, erosion, sediment delivery impacts	Visual inspection	• Failure to provide adequate groundcover on bared, native-surfaced road prior to September rain events • Failure to implement measures to reduce runoff and sediment delivery prior to rain events • Treatments failed to hydrologically disconnect the route from the stream system • Significantly elevated erosion due to interaction of rain events, re-graded road surfaces temporarily returned to native surfaced condition, and failure to apply groundcover as erosion control prior to rain events • Major increases in sediment delivery to Still Creek system, due to combined foregoing impacts and conditions
9/8/13	Glade Trail (conversion of	Implementation of measures; soil	Visual inspection	• Failure to provide adequate groundcover on bared soils

	road to trail via decommissioning)	conditions; road-stream connectivity; runoff, erosion, sediment delivery impacts		and effective erosion control measures during treatment prior to rain events • Significantly elevated erosion due to interaction of rain events, bared and disturbed soils, and failure to cover soils prior to rain events • Treatments failed to hydrologically disconnect the route from the stream system • Increase sediment delivery to stream system, due to combined foregoing impacts and conditions
10/21/13	Stormin' Norman Service Road (SNSR) decommissioning	Implementation of measures; soil cover; soil conditions; evidence of runoff and erosion	Visual inspection; comparison of before and after photos	• Significant loss of previously established live vegetation on treated road sections • Failure to provide adequate groundcover and other erosion control, post-treatment prior to rain and snowmelt events • Treatments failed to hydrologically disconnect the route from the stream system • Significantly elevated erosion due to interaction of rain and snowmelt events, soils bared and disturbed by decommissioning, and failure to cover soils prior to rain events • Failure to restore natural, preconstruction grade on treated road • Increases in sediment delivery to streams, due to combined foregoing impacts and conditions
10/21/13	Stormin' Norman Access Road (SNAR) (from West Leg Connector) gravel surface and drainage control	Implementation of measures, road-stream connectivity, and evidence of runoff, erosion.	Visual inspection.	• Significantly elevated erosion due to interaction of summer rain events, re-graded road surfaces, removal of gravel surface, and failure to cover soils and implement erosion control measures prior to rain and

				snowmelt events • Treatments failed to hydrologically disconnect the route from the stream system • Major increases in sediment delivery to Still Creek system, due to combined foregoing impacts and conditions
10/21/13	Glade Trail (conversion of road to trail via decommissioning)	Implementation of measures; soil conditions; stream connectivity; evidence of runoff and erosion	Visual inspection; groundcover measured via 58-point boot tip transect on representative section of upper portion of treated route.	• Failure to provide adequate groundcover on bared soils during treatment prior to rain events • On representative section of treated route: only 10% of ground covered by vegetation; 26% of ground covered by wood mulch, mainly fine pieces, and 64% bare ground • Significantly elevated erosion due to interaction of rain and snowmelt events, bared and disturbed soils, and failure to cover soils prior to rain and snowmelt events • Poor implementation of erosion and runoff control measures • Treatments failed to hydrologically disconnect the route from the stream system • Increased sediment delivery to stream system, due to combined foregoing impacts and conditions • Increased soil and vegetation damage due to additional mechanized disturbance outside of route prism

Activity implementation

The post-implementation field reviews found that activity implementation was generally quite poorly executed. The specific attributes of these implementation problems are discussed below in relation to each of the routes evaluated.

Stormin' Norman Service Road (SNSR) decommissioning

There were several implementation problems on the SNSR. First, the bare, heavily disturbed soils resulting from ripping and resultant loss of vegetation on the SNSR did not receive ample cover to control erosion triggered by the exposure of the bare soils to rain and snowmelt events which occurred prior to the 9/8/13 and 10/21/13 field reviews (Figures 1 and 2).

Although some woody material had been spread over the soil surface on the section of the decommissioned SNSR running from the Stormin Norman upper terminal downslope to the Pacific Crest Trail (PCT) by 9/8/13, surface coverage on this section was low and spotty (Photos 1 and 2). Soil cover measurement on 9/8/13 via a 79-point boot tip transect on a reach of this section of the SNSR found that zero percent of soil was covered by live vegetation; only 43% had some cover from scattered fine woody debris; and 57% of the freshly disturbed soils on the SNSR were bare (Photo 1).

By 9/8/13, some straw and some wood had been scattered over the section of the SNSR running from the PCT downslope to Stormin' Norman lift tower 10. However, downslope of tower 10 to the bottom lift terminal, the decommissioned SNSR was devoid of applied erosion protection cover[2] on 9/8/13 (Photos 3, 4, 5).

On 10/21/13, cover remained relatively sparse on the SNSR section running downslope from lift tower 10 to the bottom terminal, although some straw and wood had been scattered on this portion of the SNSR (Photo 6). I estimated that soil cover on this section on 10/21/13 was less than 50%. Based on field conditions, it appeared that the wood and straw had been applied on this section of road after recent rain and snowmelt events occurring between 9/8/13 and 10/21/13 (Figure 2), which again triggered heavy soil erosion due to the bare, disturbed soil conditions on the decommissioned SNSR surface.

At the upper elevation section of this portion of the SNSR, nearer to the Stormin' Norman upper lift terminal, applied soil cover (mainly fine woody material in this section of the SNSR) remained quite low as of 10/21/13 (Photos 7 and 8). I estimated that less than 40% of the SNSR in this area was covered by the applied soil cover of fine woody material on 10/21/13 (Photo 7).

A second problem is that the surface grade was not restored on the decommissioned SNSR (Photos 5, 6, and 9-11). This failure to restore surface grade is contrary to the direction in the EA (p. 30), which states: "For road decommissioning, equipment would first obliterate the road surface and restore the natural grade, to the extent possible."

The failure to restore the natural surface grade is a problem, because, as noted in Rhodes (2013), much of the SNSR downslope of the PCT is located in a longitudinal topographic depression, which

[2] Although some amended soil had been scattered over the disturbed soil surface, this amended soil did not act as effective erosion control because it was easily eroded during rain events, as shown in Photos 4 and 5.

causes runoff to be funneled to the road. The sunken grade on the road further concentrates runoff, contributing to significantly elevated erosion. These problems are likely to continue due to the failure to restore the natural grade on the SNSR.

Figure 1. Daily precipitation measured at the weather station at station at Moen Court, Rhododendron, OR prior to the 9/8/13 field review. While data from this station does not provide a perfect measure of precipitation within the Project Area, it provides a reasonable index of that in the Project Area. It is highly likely that all of the precipitation during period was in the form of rain.

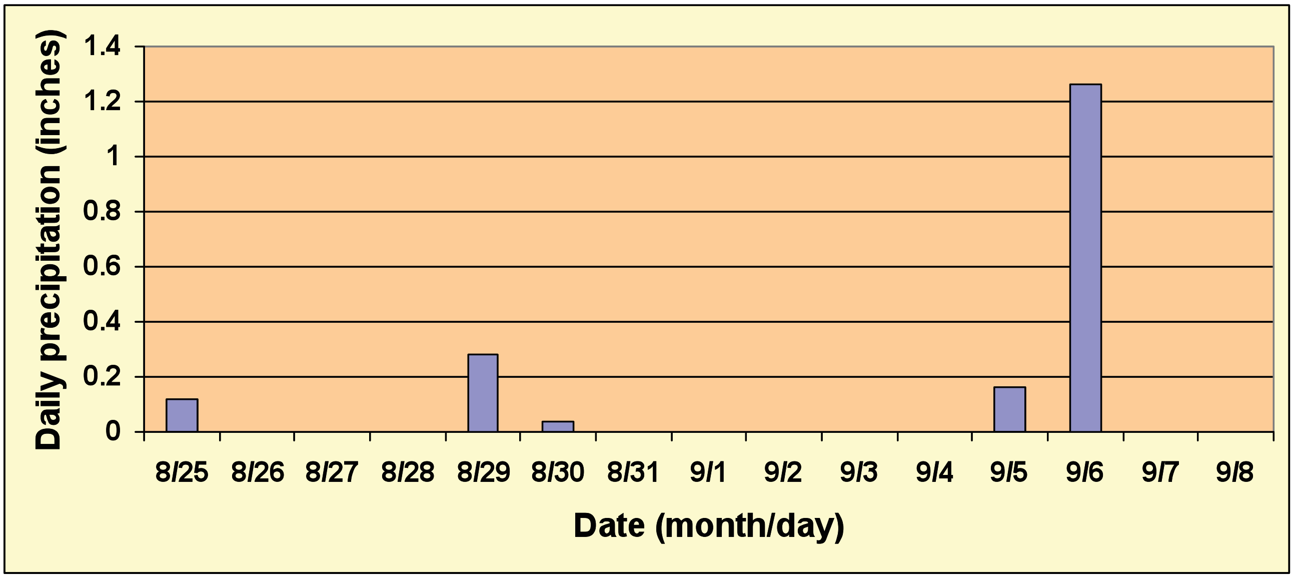
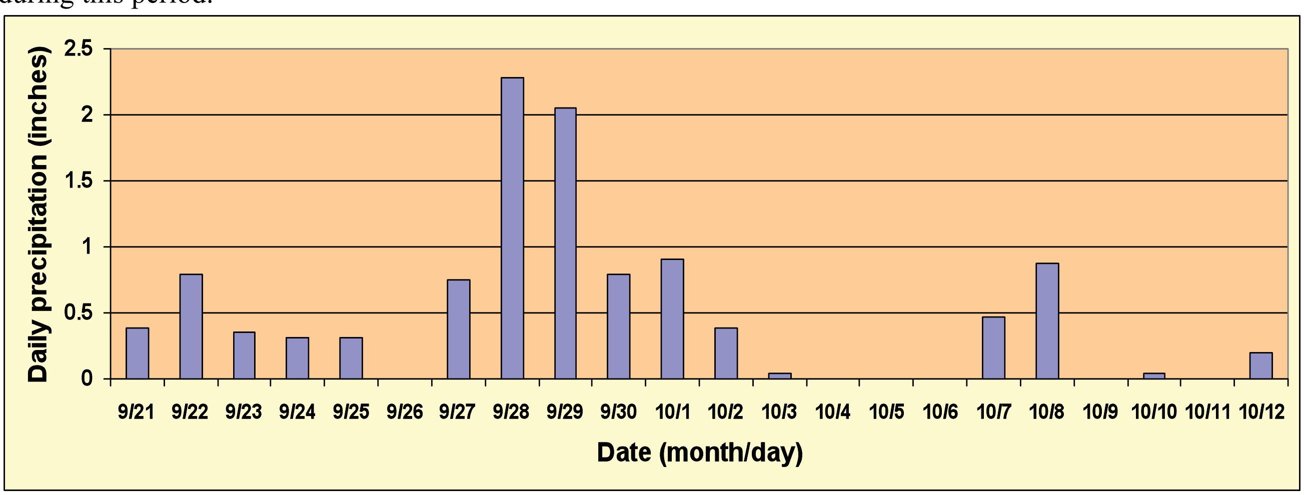


Figure 2. Daily precipitation at the weather station at Moen Court, Rhododendron, OR prior to the 10/21/13 field review. The data from this station provides a reasonable index of that in the Project Area. It is highly likely that much of the precipitation during was in the form of rain, however, some certainly fell as snow, especially in the higher area portions of the Project Area, as webcam images showed significant snowcover in mid-October. There was no precipitation measured at the Moen Court weather station from 10/13/13 through 10/21/13. However, due to weather conditions and snowpack, some snowmelt likely occurred during this period.



A third significant problem on the SNSR is that the vehicular traffic associated with attempted restoration caused additional soil and vegetation damage in areas with fragile soils and vegetation. A new machinery track along the upper section of the SNSR upslope of the PCT was plainly visible along the decommissioned SNSR on 9/8/13 (Photos 6, 12-15). It is likely that the track was created by machinery used in the decommissioning of the SNSR. These tracks provide evidence that the machinery damaged delicate vegetation and fragile soils via compaction, adding to the total area of soil damage in the area.

Glade Trail conversion of road to trail via decommissioning

The attempted restoration measures on the Glade Trail had similar problems to those on the SNSR. First, the bare, heavily disturbed soils resulting from ripping did not receive ample cover to help ameliorate the high levels of erosion caused by the exposure of bared disturbed soils to rain and snowmelt events in August through October.

On 9/8/13, after several rain events (Figure 1), soil cover for erosion protection had still not been applied to the Glade Trail. Some erodible amended soil material had been sporadically spread on a few areas (Photo 16), but it did not provide effective erosion control. Much of the route had obviously been recently and significantly disturbed by machinery traffic and remained native-surfaced (Photos 16, 17). The amended soil material was easily eroded during rain events, and, hence, it did not provide effective erosion control (Photos 18 and 19).

Although some straw and fine woody material had been spread over the soil surface of the decommissioned Glade Trail by 10/21/13, soil cover remained patchy and quite low. Soil cover measurement via 58-point boot tip transect on 10/21/13 on the upper Glade Trail found: a) only 10% of ground covered by vegetation; b) 26% of ground covered by fine woody material or straw; and c) 64% of the heavily disturbed soils on the route were without any soil cover. (See Photos 20-23). On 10/21/13, field evidence indicated that the straw and wood cover was likely applied after significant erosion had occurred in response to bare soils exposed to rain and snowmelt events (Figure 2 and Photo 24).

A second significant problem is that the work expanded the extent of soil damage in the vicinity of the Glade Trail, adding to the existing soil and vegetation damage in this area with fragile soils and vegetation. A new machinery track along the middle section of the Glade Trail was plainly visible on 10/21/13 (Photo 25). This impact plainly damaged soils and vegetation, which is likely to contribute to elevated erosion and sediment delivery in response to runoff from future rain and snowmelt events. It is also significant because vegetation and soil recovery in the area is exceedingly slow on damaged areas (Rhodes, 2013).

A third aspect of implementation problems on the Glade Trail treatments is that there was vehicular traffic over the amended non-native soil that had been spread over the route as of 9/8/13 (Photos 18, 19). The vehicular traffic compacted and rutted the recently applied non-native soil, which increased and concentrated runoff, significantly elevating erosion and sediment delivery in response to rain events prior to 9/8/13 (Figure1), compounding the erosional consequences of the failure to provide effective soil cover prior to these rain events. Studies by the USFS have consistently documented that rutting significantly elevates road erosion on routes by concentrating runoff in the ruts (Burroughs, 1990; Foltz and Burroughs, 1990; Foltz, 1996). Rut development has been documented to increase sediment delivery from surface erosion on roads by about 2-5 times that occurring on unrutted roads (Burroughs, 1990; Foltz and Burroughs, 1990). The field evidence on the Glade Trail on 9/8/13 was consistent with research findings regarding how ruts elevate road erosion.

Fourth, other erosion control measures on the Glade Trail were not effectively implemented with respect to timing and application. By 10/21/13, straw wattles had been placed across one of the steepest sections of the trail. Wattles are typically used with the aim of interrupting channelized runoff and providing sediment detention as a means of reducing sediment transport. Wattles must be flush with the soil surface to have a modicum of effectiveness in realizing these aims. However, the wattles on the treated Glade Trail were not close to being flush with the soil surface on 10/21/13—relatively large gaps between the bottom of the wattles and the soil surface were pervasive (Photos 26-28), rendering the wattles wholly ineffective at reducing runoff, channelized erosion, and sediment delivery.

Implementation timing compounded the ineffectiveness of these poorly implemented measures: field evidence clearly indicated that the wattles were put in place well after significant erosion and sediment delivery occurred, prior to 10/21/13, in response to recent rain and snowmelt events (Figures 1 and 2) on bare disturbed soils. These are significant implementation failures with respect to runoff and sediment delivery impacts, because runoff and eroded sediment from this portion of the Glade Trail were delivered directly to the stream system via well-established rill channels on this section of the Glade Trail (Photos 29 and 30). These rill channels, which developed in response to rain and snowmelt events affecting bare, heavily disturbed soils on the recently ripped route, are likely to increase in size in response to future runoff, exacerbating future runoff and sediment delivery impacts on the stream system.

The added straw and wood soil cover observed on the Glade Trail on 10/21/13 provides another example of timing and application rendering the attempted erosion control highly ineffective. Field evidence indicated that soil cover comprised of wood and straw was applied after erosion on the bare soils had been significantly elevated by rain and snowmelt events (Figure 2 and Photos 25 and 29). Due to the timing of application, the applied cover failed to prevent significant increases in erosion and sediment delivery caused by the impacts of the attempted restoration on the Glade Trail.

The rock berm placed across the rill channel that drains the slope with the poorly implemented wattles to the stream is another example of ineffective implementation of an attempted erosion control measure on the Glade Trail (Photo 30). The bottom of the berm, which was ostensibly implemented in an attempt to interrupt runoff and reduce sediment delivery, was not flush with the soil surface on 10/21/13 and had been easily breached by the rill channel which ran under and through the berm and directly to the stream system (Photos 30-32).

The rocks placed in the severely eroded channel downslope of the berm are another example of ineffectively implemented erosion control attempts (Photo 33). These rocks had done very little to reduce channel erosion, runoff, and sediment delivery from the ripped route to the stream system.

Stormin' Norman Access Road (SNAR) gravel surfacing and runoff control

The attempted restoration measures on the SNAR had similar problems to those on the SNSR and the Glade Trail. First, the bare, native surface soils on the road resulting from resurfacing, including temporarily stripping it of gravel, had not receive erosion control cover as of 9/8/13, prior to recent rain events (Photos 34 and 35). As a result, there was no amelioration of the high levels of erosion caused by the disturbed bare soils exposed to recent rain events prior to 9/8/13 (Figure 1). By 10/21/13, the SNAR had been re-graded, erasing the prior rilling, and returned to a gravel surface (Photo 36), but this did not undo the erosional impacts that occurred prior to grading and re-gravelling (Photo 34).

Second, effective controls to reduce sediment delivery from the rain events at points of road-stream connectivity were not in place prior to 9/8/13 (Photos 37 and 38). This was a significant implementation problem, because even though such measures have limited effectiveness, silt fences and other measures of that ilk would have at least had some palliative effect on sediment delivery from bare soils on the SNAR that were without applied erosion control cover in response to the rain events prior to 9/18/13 (Figure 1).

Third, as with the other routes subjected to attempted restoration, the erosion and runoff control measures were ineffective due to timing and application. For instance, the new and reconfigured road drainage relief features on the re-graveled and re-graded SNAR did not hydrologically disconnect the road from the stream system. A newly implemented road drainage relief structure merely routed runoff and sediment from the SNAR to a nearby tributary of Still Creek (Photo 39). Notably, while it would have involved some additional, but tractable, work, a water bar upslope of this point draining route runoff to the opposite side of the road would have done more to reduce the delivery of road runoff and sediment to the stream system. Instead, the drainage relief structure maintained road-stream connectivity, while the re-surfacing work elevated sediment delivery due to road disturbance and bared surfaces affected by rain and snowmelt events.

The reconstructed water bar on the middle section of the SNAR is another example of an ineffectively implemented road runoff drainage feature. The water bar diverts water into an existing road runoff channel, which leads to a stream tributary (Photos 40 and 41). Maintaining the road drainage feature at this location was ineffective at reducing road drainage impacts, because it maintained the road-stream connection of this section of the SNAR, which will result in continuing inputs of elevated runoff and sediment loads to the Still Creek system.

The effectiveness and impacts of the implemented restoration measures in the Project area on the SNSR, SNAR, and Glade Trail as of 10/21/13

Soil damage and loss of and damage to live vegetation

The SNSR decommissioning resulted in the loss of pre-existing live vegetation on the road prism. (Photos 42–46). This loss of vegetation on the SNAR set back soil and erosional recovery on the SNAR. Live vegetation is the most effective type of soil cover for limiting erosion (Dunne and Leopold, 1978; Maidment, 1993). Further, root penetration by live vegetation is an important recovery mechanism on disturbed soils because it helps increase infiltration, which, in turn, helps to reduce runoff and concomitant soil erosion.

These are serious impacts because it likely took a long time for the vegetation eliminated by the treatments to colonize portions of the SNAR, due to its damaged soils and the area's short growing season. There is considerable evidence within the Project Area that vegetative cover is slow to recover from disturbance and loss, especially at higher elevations (Rhodes, 2013). The vegetation elimination on the ripped road prism is also significant because lupins, which comprised much of the vegetative cover on the road prior to decommissioning, are important post-disturbance pioneer plants that fix nitrogen in soils and thereby increase soil fertility, which helps to promote the establishment of additional vegetation.

Activities related to the SNSR decommissioning also caused additional vegetation damage and loss. As previously noted, vehicular traffic near the upper SNSR and the middle portion of the Glade Trail created new tracks with additional damage to soils and vegetation, and vegetation loss (Photos 2, 12-15, 25).

This expansion of damaged soils and vegetation in the Project Area is highly significant for several reasons. First, these additional impacts are highly persistent. Recovery from vegetation loss is slow within the Project Area (Rhodes, 2013). Soil compaction from vehicular traffic persists for decades, even in the absence of additional impacts (Beschta et al, 2004).

Second, both vegetation loss and soil damage contribute to elevated runoff and soil erosion. Third, the streams affected by these impacts are already extremely degraded with respect to sedimentation from elevated erosion from the extensive vegetation loss and soil damage within the Project Area. Fourth, increased soil and vegetation damage and its effects on runoff, soil erosion, and sediment delivery conflict with the avowed goals of the attempted restoration, as described in the MHNF Bike Trail Environmental Analysis (MHNF, 2012).

The significantly elevated soil erosion and sediment delivery from all three treated routes also causes long-term damage to soil functions, especially soil productivity (USFS and USBLM, 1997). The soil loss from accelerated erosion is an essentially permanent negative impact on soil productivity (Beschta et al., 2004). There was abundant and pervasive evidence during both post-implementation field reviews that the treatments' effects on soil baring and disturbance, together with the failure to provide effective cover on these soils prior to rain and snowmelt events (Figures 1 and 2), resulted in quite significant increases in erosion, as previously discussed and shown in Photos 4-7, 10, 11, 18, 19, 23, 24, 26-41, 47-50. These erosional impacts are discussed in greater detail in the following section.

For these combined reasons, the attempted restoration treatments resulted in significant new damage to soils and vegetation.

<u>Soil erosion and sediment delivery to the stream system</u>

As noted in Rhodes (2013), route decommissioning typically elevates erosion and sediment delivery for some years after the activity, due to impacts on soils (Switalski et al., 2004; GLEC, 2008; Grant et al., 2011). In the specific case of the measures assessed in this report, implementation compounded these impacts, further contributing to increased erosion and sediment delivery to streams.

As previously discussed, the 9/8/13 field review after rain events (Figure 1) and the 10/21/13 field review after additional rain and snowmelt (Figure 2) found abundant evidence that the attempted restoration activities on the Glade Trail, the SNAR, and SNSR significantly and pervasively elevated soil erosion on the treated routes (Photos 4-7, 10, 11, 18, 19, 23, 24, 26-41, 47-50). This was due to the following on all three treated routes examined during post-implementation field reviews: 1) soil baring and disturbance; 2), the stage of the treatments when rain and snowmelt events occurred; 3), the failure to consistently provide effective erosion and sediment delivery control measures prior to runoff events; and, 4) ineffectve implementation of the erosion control measures that were ultimately applied, often in an untimely fashion. .

Other factors on some of the treated routes also elevated erosion levels still further. The increased area of vegetation loss and soil damage from vehicular traffic along portions of the SNSR (Photos 2, 6, 12-15) and Glade Trail (Photo 25) likely contributed to increased in soil erosion, because a legion of studies have shown that vegetation loss and soil damage increases runoff and soil erosion (Dunne and Leopold, 1978; Maidment, 1993). In addition, the failure to restore the natural surface grade on the SNSR also contributed to elevated erosion from that route.

The vehicular traffic on the Glade Trail (Photos 16-18) undoubtedly elevated erosion. Many studies have documented that vehicular traffic greatly elevates erosion on roads, by producing mobile fine sediment at the road surface and rutting the road surface (Reid et al., 1981; Reid and Dunne, 1984; Foltz and Burroughs, 1990; Foltz et al., 1996; Gucinski et al., 2001; Luce and Black, 2001; Beschta et al., 2004; GLEC, 2008). The USFS's own summary of road impacts (Gucinski et al., 2001) concluded that "…rates of sediment delivery from unpaved roads are...closely correlated to traffic volume."

The decommissioning of the SNSR did not reduce existing sources of elevated sediment delivery, due to the nature of the measures taken. For instance, Rhodes (2013) noted that the decommissioning of the SNSR was unlikely to arrest channelized route erosion near the base of the Stormin' Norman upper lift terminal and associated access road, because the much of the elevated runoff contributing to the channel erosion is due to the upslope access road and lift terminal, which were not decommissioned. This turned out to be the case after the decommissioning of the SNSR, as shown in Photos 51-54.

The elevation of erosion caused by the treatments and associated lack of effective erosion control measures contributed to elevating sediment delivery to the stream system. As previously discussed, this was the case at many discrete points of stream-route runoff connectivity (Photos 15, 17a, 18, 19, 26-34, 36a-41, 52-56). The adverse impacts of greatly elevated sediment delivery to the stream system due to attempted restoration were particularly obvious and acute downstream of the crossing of a Still Creek tributary by the SNAR on 9/8/13 (Photos 34-38, 55-57). The tributary sediment conditions and channel form exhibited diagnostic signs of acute overloading of fine sediment in response to the Glade Trail treatment, combined with recent rain events.

However, more generally, elevated levels of sediment delivery have occurred because the treatments on all three routes discussed in this report did not disconnect the routes from the streams where such connectivity existed prior to the attempted restoration treatments. As a result, the increases in erosion translated into increases in sediment delivery.

Increased sediment delivery due to the restoration measures' impacts is likely to even be more pronounced during the forthcoming spring snowmelt. This is because the majority of runoff, and thus soil erosion, occurs during spring snowmelt.

Instream aquatic impacts

Due to the already degraded sediment conditions in affected streams (Rhodes, 2013), the increased sediment delivery from the attempted restoration is highly likely to translate into additional degradation in those streams, with adverse impacts on salmonids, and other sediment-sensitive biota.

Fine sediment in the affected streams, West Fork Salmon and Still Creeks, were already at levels that significantly impair the survival and production of imperiled cutthroat trout and ESA-listed steelhead (Rhodes, 2013). The fine sediment levels in these streams already greatly exceeded the fine sediment standard in the Mt. Hood Forest Plan.

The increased sediment delivery caused by the attempted restoration effort described in this report will further degrade fine sediment conditions in the West Fork Salmon and Still Creeks. Field studies and laboratory experiments have repeatedly shown that elevated sediment delivery increases fine sediment levels in stream substrate (Eaglin and Hubert, 1993; Rhodes et al., 1994; Huntington, 1998; Buffington and Montgomery, 1999; Hassan and Church, 2000; Kappesser, 2002; Cover et al., 2008). Increases in fine sediment in streams are particularly likely when the increases in sediment delivery are primarily comprised of fine sediment, as is the case with that from surface erosion the attempted restoration measures discussed in this report.

Increased levels of fine sediment are very likely to further reduce the survival of steelhead and cutthroat trout that inhabit affected streams (Rhodes, 2013). Any increase in fine sediment levels reduces the production of steelhead (Suttle et al., 2004).

Increased sediment delivery also contributes to loss of pool volume, quality, and frequency (Buffington et al., 2002). Loss of pool volume and quality impairs the survival and production of steelhead and cutthroat trout (Meehan, 1991; USFS and USBLM, 1997).

Increased levels of sediment also contribute to increases in channel width (Dose and Roper, 1994; Rhodes et al., 1994). Increases in channel width elevate water temperatures, even the absence of shade loss (Bartholow, 2000). Increased water temperatures impair trout production in a variety of ways (Meehan, 1991; McCullough, 1999).

For the foregoing reasons, it is likely that the attempted restoration approaches have and will cause increased in-stream degradation. This degradation will negatively impact sediment-sensitive biota, including salmonids. It will also contribute to causing further departures between the MHNF Plan standard for fine sediment and fine sediment conditions in the affected streams.

Conclusions

The attempted restoration measures on the SNSR, Glade Trail, and SNAR elevated erosion and sediment delivery significantly. While this in consistent with scientific literature on the impacts of route decommissioning, these sediment-related impacts were compounded by ineffective implementation. The latter includes the failure to: a) implement effective erosion and sediment delivery control measures on bare highly-disturbed soils prior to rainfall and snowmelt runoff events in August through October 2013 (Figures 1 and 2); b) hydrologically disconnect treated routes from the stream system; and, c) restore the natural grade on decommissioned routes. Vehicular traffic impacts on and near the treated routes compounded these problems by damaging soils and vegetation.

These impacts have already plainly affected some stream segments quite significantly (Photos 55-57). These impacts will propagate downstream, resulting in increased degradation of channel substrate and channel form in ways that adversely affect salmonids and other sediment-sensitive biota such as caddisfly.

It is highly that the magnitude of these impacts will be far greater during the forthcoming runoff from spring snowmelt runoff. Due to its duration and magnitude, the majority of erosion and sediment delivery occurs in response to the spring snowmelt runoff, due to its duration and magnitude.

The restoration attempts reviewed in this report may, after many years, begin to contribute to some nominal reduction in sediment delivery in streams, although this not a certainty. At best, this is likely to require many years, consistent with scientific literature (Foltz et al., 2007; Rhodes, 2013). However, any benefits that may accrue are likely to do so particularly slowly within the Project Area, due to exceedingly slow rates of revegetation. Even if the attempted measures ultimately convey some benefit, due to the significant elevation of sediment delivery caused by the attempted restoration, it will take many years after reductions in sediment delivery are manifest before the increases in sediment delivery caused by the activities are offset. The potential benefits of the attempted restoration measures are also likely to be hampered in the long term due to the failure to address significant causes of erosion on the routes (Photos 51-54) and the failure to restore the natural pre-road surface grade on the decommissioned roads.

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